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BY THE
UNITED STATES NUCLEAR REGULATORY COMMISSION'S

ADVISORY COMMITTEE ON NUCLEAR WASTE

JUNE 25, 1996

The contents of this transcript of the proceedings of the United States Nuclear Regulatory Commission's Advisory Committee on Nuclear Waste on JUNE 25, 1996, as reported herein, is a record of the discussions recorded at the meeting held on the above date.

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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84TH MEETING

ADVISORY COMMITTEE ON NUCLEAR WASTE

(ACNW)

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TUESDAY

JUNE 25, 1996

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ROCKVILLE, MARYLAND

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The Advisory Committee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, at 8:30 a.m., Paul W. Pomeroy, Chairman, presiding.

COMMITTEE MEMBERS:

PAUL W. POMEROY, CHAIRMAN

B. JOHN GARRICK, VICE CHAIRMAN

WILLIAM J. HINZE, MEMBER

MARTIN J. STEINDLER, MEMBER

ACNW STAFF PRESENT:

JOHN T. LARKINS, EXECUTIVE DIRECTOR
MICHELE KELTON, TECHNICAL SECRETARY
RICHARD K. MAJOR
HOWARD J. LARSON
ANDREW C. CAMPBELL
RICHARD P. SAVIO
MICHAEL MARKLEY
CAROL A. HARRIS
SAM DURAISWAMY
THERON BROWN
VIRGINIA COLTON-BRADLEY

ALSO PRESENT:

DADE MOELLER
FRED M. PHILLIPS
NORMAN EISENBERG
TOM H. PIGFORD
BOB BACA
RAY A. CLARK
JOHN H. KESSLER
STEVE FRISHMAN
RICHARD CODELL
MARGARET FEDERLINE
PHIL JUSTUS
JOHN THOMA

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

(8:32 a.m.)

CHAIRMAN POMEROY: The meeting will now come to order. This is the first day of the 84th meeting of the Advisory Committee on Nuclear Waste. Today's entire meeting will be open to the public.

During today's meeting, the Committee will first review options under consideration for specifying the critical group and reference biosphere to be used in a performance assessment of a nuclear waste disposal facility.

Secondly, we'll meet with the Acting Director of the Division of Waste Management, NMSS, to discuss items of mutual interest.

Thirdly and very importantly, we'll have a discussion with Dr. Dade Moeller on the open market trading rule, health effects of low levels of ionizing radiation, and defining a critical group for performance assessment.

And fourthly, late this afternoon between 5 and 6, we'll have a preparation hour for our meeting with the Commissioners tomorrow.

This meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act. Mr. Howard Larson is the designated Federal official for today's initial session, to my right.

We have received no written statements from members of the public regarding today's session. Should anyone wish to address the Committee, please make your wishes known to one of the Committee's staff.

It is again requested that each speaker use one of the microphones, 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. And today, they're very brief. Lynn Deering, who is, as most everybody knows, one of our staff people and is serving a three-month rotational assignment in Commissioner Rogers' office.

That assignment will last until the first of September 1996. DOE has issued revision one to its civilian radioactive waste management program plan. It is dated May 1996. And that program plan will be discussed here in the meeting tomorrow.

And finally, the 18th annual low level radioactive waste management conference scheduled for October 1st to the 3rd, 1996 has been postponed. DOE cites budget cutbacks as the reason for the postponement.

The conference will be held in 1997, or at least that's what is planned at this point in time. Those are the items of current interest I have. Do any of the members have anything they wish to add to items of current interest or other commentary?

If not, I would like to move immediately to the first item of our agenda today. Namely, the specificat on of critical group and reference biosphere.

This is part of a working group on the issue of critical group and reference biosphere. The members have read the status report written by Howard Larson for this and recognize that this is a learning experience partially for the Committee.

It is not necessarily the endpoint of the consideration of this issue. And one thing though that I would like to request from you is that, at the end of the discussion today, we spend a few moments in planning for what future activities we want to take in regard to this specific item.

I'd like to proceed then to the first speaker this morning. This is a presentation on the relevant issues addressed in the National Research Council/National Academy of Sciences' publication Technical Bases for Yucca Mountain Standards.

Dr. Fred M. Phillips, who is a member of the National Academy group that wrote the paper that we're dealing with is here with us this morning. And he is in the process of being presented a microphone.

In any case, let me welcome you, Fred, on behalf of the Committee once more. We deeply appreciate your coming out to talk to us this morning. And the floor is yours.

DR. PHILLIPS: As Paul stated, I'm Fred Phillips from New Mexico Tech in Soccorro. And I was a member of the Committee on the Technical Bases report issued by the NRC, the other NRC.

And what I'm going to talk about today, I'm going to focus more on some of the basic issues that are related to the form of a standard for the protection of public health that I have on the nitty-gritty kind of technical details.

Because I think it's really the bigger issues that drive debate over the technical and narrow types of issues. And you know, we can start out at various points actually trying to reconstruct the history of recommendations for geological disposal.

I've sort of chosen this 1957 National Research Council Report. And the important thing out of this is simply the rationale that was put forth for directing a program towards geological disposal of high level nuclear waste.

And I think to me that's something that we should always, at least I try to keep in mind when deciding on a form for a standard.

Will the form of the standard fulfill this rationale that was propounded in the first place or will it be something that tends to contradict it? And the basic rationale is to emplace the waste in a remote place.

And by remote, we mean remote from the biosphere where people live, so that we can take advantage of natural processes for keeping it isolated until at least a large part of the radiation that was originally emplaced has decayed away without doing harm to people.

I won't go anymore into the background than that basic reminder of the purpose of geological disposal.

When we consider the possible forms of a standard, there are some basic questions that need to be considered. And those questions include, "Who are the people to be protected by the standard?

To what extent are they protected? In other words, what level of protection is the standard intended to offer them? And for what period of time?"

Now, I'm not going to deal too much with the period of time today, because that's not the main issue of concern in this meeting. A little bit of terminology. Again, I won't go over this in too much detail except for a few terms that I've kind of come up with to make some distinctions at the end.

Dose, the amount of radiation absorbed; dose equivalent, simply dose weighted for the possible damage that it might do to different organs of the body and so on; a collective dose is doses summed over a population.

Now, here I've come up with terms which I don't mean to be offered as formal terms, but rather simply to make some distinctions that I'd like to maintain in the course of this talk. A lot of what we're going to discuss with regard to the standard that was recommended here involves the use of the term risk.

And unfortunately, I found out through just a lot of conversations and give and take that risk has many different meanings for different people and even within the specific narrow setting of risk associated with exposure to nuclear radiation.

It still can have a wide variety of meanings. So, I've coined the term "individual health risks," for that component of risk which would be due to a specific adsorbed dose or dose equivalent.

So, if you have an individual dose equivalent of so many sieverts, you can multiply that by a coefficient which 5×10^{-4} cancers per sievert is one that seems to be the current value, to get a risk of a cancer to the person as a result of that particular dose equivalent.

If we then multiply that coefficient times a collective dose, that will give a collective health risk. And again, the collective health standard is not really the focus of biosphere scenarios. So, that's somewhat subsidiary to the talk today.

Individual radiation risk is a broader and more inclusive term than the individual health risk in the terminology I've devised here. And that is the risk of a cancer from the combination of the risk of receiving a dose and the risk of the dose itself.

So, mathematically put, we can have some dose here, the probability of getting that dose, and the probability of a cancer resulting from it.

Now, this term "probability of a dose," in the context of high level nuclear waste disposal, I have conceptually, and I don't want to make this a rigorous type of thing at all, but just for broad conceptual purposes, I've broken that down further into three additional categories of risk.

The first one I call the probability of isolation. And this is the probability related to continued containment in the repository. In other words, whether the probabilities that materials are going to leak out of the repository and into some sort of environment where it will be accessible to people.

Then there's another probability that I call the probability of interaction. In other words, the probability related to the likelihood of interactions of people with the escaped waste.

So, this might be the probability that people would drill a well and pump water out of the plume of escaped radioactivity or the probability that people would breathe carbon-14 that is emanating upward or something like that. So, that's a whole sort of category there.

And finally, a probability that I call probability personal, which is that component of the probability of receiving a dose. So, it would be related to personal types of factors.

If a person in fact drank very little water, they drink other beverages instead, then that would cut down on their personal risk of receiving a dose.

So, it's the product of all three of these categories of probability times this coefficient of risk that give rise to the final individual radiation risk. And I think it's important that we sort of explicitly consider these terms in here, especially these.

Because these are related to the fundamental goal of geological disposal, which I discussed earlier, which is to put it in a situation where it will remain isolated for a long period.

VICE CHAIRMAN GARRICK: Fred, just a second. Isn't the "5" here supposed to be 500, and isn't it per year?

MEMBER STEINDLER: It is not per year. You're using sieverts rather than rem.

DR. PHILLIPS: Yes.

MEMBER STEINDLER: So, that number is too high by effective -- the 100. In fact, I understand it as four per rem. And it's not an annual dose. But it's a cumulative.

DR. PHILLIPS: Right. Okay, here I list some of the possible types of standards that we considered during the deliberations of the Committee. And these would include collective dose, which in fact is an indirect basis for the current form of the standard.

The problem that we discussed with collective dose is that it does not necessarily protect the individuals that are most exposed.

In fact, it may afford a large degree of protection to people who receive very, very small doses, large numbers of people who receive very small doses, and not very much protection to the people who would be the most exposed. And that's really the fundamental problem with that.

Individual dose, I'm going to cover on the next page where I've written it out in more detail. The current form of the standard is primarily a derived standard, a cumulative release standard in 40 CFR 191.

The nice thing about a derived standard like that is that it's written in such a way that it is easy to evaluate compliance. However, the problem with it is that obviously it's very difficult to demonstrate that such a derived standard actually provides any degree of protection.

It may be over-protecting more than we would want, or it may be providing very little protection. And without some sort of calculation to link it to interactions with the biosphere and with people, it's not very reassuring.

Here's the individual dose by which I mean the individual health risk term. This would be a standard that would limit the maximum dose that any person could get.

Now, obviously, since the whole objective of the standard is to limit the dose that any particular person might get, it has the potential to protect those most at risk. That's the real core design of it.

And if it protects those who are most at risk, then presumably it protects the rest of the general population. That's good as well.

However, the limitation of it is that I think it's mainly applicable in situations where the dose can be controlled. And I'll give you an example.

If we have regulations for drinking water let's say, and periodically every month or every quarter somebody goes out and samples the drinking water and determines the levels of all of the potential things that we want to control in it.

And they take a measurement that's over the limit, then that well can be shut down or treatment can be installed to lower the dose or whatever the other thing you might worry about is and remediate, basically make sure that the standard is adhered to.

However, if you're in a situation where dose is something, or the consequence, whatever is going to happen is basically something that can't be controlled on a day-to-day basis, then the applicability of a standard based on that principle becomes less clear. And its benefits become less clear.

Finally, this is the form of the standard that we ended up recommending. And that is what I'm calling here the individual radiation risk. Again, this exact terminology is not found in the report.

I'm just trying to clarify some of the different meanings of risk that are intended. And by the way, I'm sort of equating up here individual dose with this individual health risk because the two are directly related to each other through the dose risk conversion factor that we just discussed a second ago.

The individual radiation risk is intended to protect a population that would be most at risk. It differs from the dose of individual health risk approach in that it does not look for the individual who's going to receive the highest dose or the highest individual risk and protect them specifically.

Rather, its goal is to limit the risk to a group of people. And that group of people is the people that are determined to be the most at risk.

So, if it protects that group of people, if it limits the risk of that group of people that are most at risk, then presumably it also is limiting the risk for people who are less at risk.

A minor advantage of it is that it's unaffected by changes in this dose risk coefficient. To me, a very significant advantage of this form of standard is that it allows direct comparison with other societal risks.

So, it puts it not in terms of some number, you know, so many sieverts or whatever, that are pretty much incomprehensible to people who aren't specialists in the field.

Instead, it puts it in terms of risk people can compare with things like driving in automobiles or flying in airplanes or risk of cancer from chemicals in the groundwater or whatever.

And so, I think from the viewpoint of the public at large, it's a significant advantage. It allows evaluation of cost benefits.

In other words, you can propose questions like, "Suppose we were to lower the risk standard by a certain amount?" And we could achieve that by modifying the repository design in some way.

How much would it cost? To do that, how much would the risk be lowered? It gives you some sort of basis for evaluating what the costs and the benefits are which is something that's an increasingly popular approach. Let's put it that way.

Some comparisons of the risk standard, the individual radiation risk standard versus the individual dose or individual health risk, whichever way you want to put it, type of standard.

Unlike the risk standard, the dose standard can offer assurance of protection to the individual. But

I'm going to emphasize again that's only valid when the dose can be controlled.

The risk standard makes no assurance of protection to the individual. On the contrary. That's an important point. And it's important to realize.

It's really quite a fundamental, almost radical difference between these two standards. The risk standard makes no assurance of protection to the individual.

It simply limits the average risk to the group most at risk. Just to give you an illustration of that, at 3:00 this afternoon Myron's going to drive me to Dulles, and I'm going to get on the airplane.

Suppose with all the tornadoes and stuff happening here I become concerned about whether I'm going to make it back to Albuquerque in the airplane? And I go up to the person who's behind the desk all disheveled and worried.

And I say, "Am I going to make it home?" And he says to me, "Well, look. I have this book here. It lists risks to airline passengers, and the risk is only some very low value. One in a million per thousand miles or whatever it is.

So, considering you're only travelling this particular distance, you have a chance of 99.999 percent of arriving safely home."

I say, "No, no. That's not good enough for me. I want you to assure me personally that I will not be killed on an airplane crash before I get home." Can he do that? No, he can't.

I mean, if he's honest, he cannot look me in the eye and say, "I can assure you you will get home." There may be a cargo load full of smoldering oxygen canisters being loaded onto the plane at that moment.

I don't know that. He doesn't know that either. There are risks that cannot be controlled. And if everyone of us demanded complete personal protection when we boarded the airplane, air travel would come to a stop instantly. That's just the facts of life.

Distinction between the risk and the dose standard. Risk standards are increasingly used for regulation of societal problems because it's recognized that basically society would come to a stop if every person had to be assured of complete personal safety in all aspects of what they did.

We know that that is not a feasible goal for most things in life. And a corollary of this is fairly obvious I think, but I just want to make sure is clear. The risk and dose standards are quite different.

Their objectives are quite different, and therefore, it should be pretty obvious that a risk standard is not intended to meet International Commission of Radiation Protection recommendations for dose standards.

Now, this is my own personal viewpoint here. I'm not going to certainly present this as the viewpoint of everybody on the Committee or anything like that.

My own personal viewpoint is that nuclear waste problems should be regulated commensurately with other societal issues, that there should be some sort of balance of the benefits to society from protecting the vast majority of people from the harmful effects of radiation that's contained in the waste with the cost of doing it and a recognition of the wide variety of unknowns.

In other words, uncontrolled types of factors, uncertainties that are involved in the analysis. And this is an example of what I mean that it should be regulated commensurately.

We design and construct highways with the safety of the public in mind. That's a major, major consideration in highway construction. However, the regulations that govern it are intended to limit the risks to people driving on the road.

They are not intended to eliminate risk from driving on highways. Again, if we had to eliminate risk from driving on highways, we would not have any highways.

And my own personal feeling about it is that it is neither possible nor is it necessarily desirable to try and protect every single person all of the time. It would be nice if the world were such that we could do that. But it's not the reality of what we face.

Summary again of the individual radiation risk and some of the advantages and so on. Basically, the material I covered before. The question I'm really addressing here is how to implement an individual risk standard.

And in order to do that, I want to bring up those questions that I mentioned at the first. Who is protected? And the answer is that we should protect the individuals most at risk.

How to define those individuals? One possibility is to come up with a maximally exposed individual to try and sort of skew everything so that we arrive at the absolute extreme of the distribution.

And I think pretty much everyone agrees that that's not a very practical approach. First of all, there's no limit to it. No matter how maximal you make the dose, you can come up with another additional thing to add on that will make it more maximal.

You end up with a ludicrous picture, and it doesn't provide any realistic basis for evaluating risk at all. You just end up with a totally artificial, theoretical construct.

And so, as I say, I'm not aware that anybody is currently advocating this position. The critical group is what we decided should be the basis for evaluating that.

And here's the definition of the critical group from the report. The critical group for risk should be representative of those individuals in the population who, based on cautious, but reasonable assumptions, have the highest risk resulting from repository releases.

The group should be small enough to be relatively homogeneous with respect to diet and other aspects of behavior that affect risk. The critical group includes the individuals at maximum risk and homogeneous with respect to risk.

And with regard to this here, includes the individuals at maximum risk. Actually, it's up here. But there is a footnote down here. And I think it's a very, very important footnote.

And I've highlighted it. That is, the difference between the highest and lowest risk faced by individuals in a group should be relatively small. Should a radiation dose occur, however, it may affect only a few members of the group.

This is the difference between risk, the probability of an adverse health effect, and outcome, a cancer that actually develops. Risk can be homogeneous even when outcomes are quite diverse.

So, it's a very important distinction to maintain. And I'll bring it up again a little bit later.

So, this talks down here about defining hypothetical persons by making assumptions about lifestyle, location, eating habits, and other factors. And that is where the hard decisions come up.

What level of protection? We suggest leaving that up to some public regulatory process starting out discussing in the range of 10^{-5} to 10^{-6} per year, which have been used for a lot of other similar type of risk evaluations.

For how long until peak doses are past? Again, that's a somewhat controversial issue. But I'm not talking about it today.

The methodology for calculating risk to the critical group. This means the exposure scenario and risk calculation approach. The exposure scenario is a quantification of the natural and societal characteristics that affect exposures.

Does this imply that we must be able to predict what society is going to be like thousands of years in the future? And my answer to that is an emphatic, "No."

And if you read the report, you will see that we emphatically emphasize that in the report as well at numerous places. No scientific basis exists to make projections of the future and nature of human society.

It is not possible to predict the basis of scientific analysis of societal factors. It must be specified in a far future exposure scenario.

There is no sound basis for quantifying the likelihood of future society and so on and so on. It's reiterated numerous times. Not just here, but on other pages of the report as well.

So, the exposure scenario is a benchmark. It's something against which we can make a reasonable evaluation of risk. We can't control the future. This is the fundamental fact that we're talking about here.

And this applies not just to high level nuclear waste disposal. It applies to say build up of greenhouse gasses in the atmosphere. It applies to depletion of soils by agriculture, disposal of ordinary toxic waste.

All of these are long-term societal problems which will be impacted -- whose impact will be dependent very strongly on the nature of future society and over which we have no knowledge and no control.

So, all that we can do for any of these things is to do some sort of benchmark analysis. There have been two alternative proposals that were presented in the report.

The subsistence farmer, which is the one that's preferred by Tom Pigford, and the probabilistic critical group that was preferred by the remainder of the Committee.

This is a brief comparison of those two. I think most of you are probably familiar with this. So, I'll skip through it very briefly.

The subsistence farmer gets all his water from a well that is drilled into the maximum concentration of groundwater that is outside of the immediate location of the repository, irrigates crops and animals, lives only on the produce that he farms and the water that's pumped out.

The distribution of maximum concentrations from the transport models to get a distribution of doses from this scenario calculate the health risk and divide by a factor of three.

The probabilistic critical group approach is to obtain data on characteristics of population in the area at the present time. Or we say you can do it with an alternative population if you wanted to.

And I list here some of these factors that are relevant to the dose that would be received by individual persons and who generate Monte Carlo realizations to the population.

Then you allow these numerous realizations to interact with each transport realization. And they have to be numerous because the population is sparse in the area. Divide the -- and I say here, calculate numbers of cancers.

Well, you don't have to go that far in the calculation. But for purposes of illustration, it's convenient to imagine it that way.

So, you could ultimately then divide the numbers of cancers in a particular area by the population that you've calculated over all the realizations in the area to get a spacial distribution of risk and average the results from the highest risk area for all of the transport simulations to get the average risk to the critical group.

MEMBER STEINDLER: Excuse me. Can you help me out? Why do you need the spacial distribution of risk?

DR. PHILLIPS: In some -- you have to define the critical group within some sort of constraint or confine. In other words, you don't take the entire population of the globe and try and calculate a risk for them.

Somehow you have to narrow down who this group is going to be. And the approach that is described here uses the spacial distribution of risk to do that. In other words, we look for the geographical locality where the calculated risk would be the highest.

MEMBER STEINDLER: And the averaging is then done only over that area. Is that what you're saying?

DR. PHILLIPS: In other words, for each transport simulation, you would come up with one particular area that would have the highest level of risk. And you would take the average level of risk within that area.

And then for each transport simulation, you would average the risk from the highest area in each one of those transport simulations to get a total integrated risk for the whole system.

MEMBER STEINDLER: Okay.

DR. PHILLIPS: These risks, that would be the spacial distribution of risk that would be calculated as an intermediate step in the thing. It is not any final estimate of risk. It's just a step in performing the final integration.

I'll go through the approach in a little bit more detail here in a second. I want to emphasize some things up here, that this is intended as an example of how this approach might be implemented, that the main purposes are to outline how it would be done and illustrate the steps necessary to perform the calculation.

We don't intend it as a detailed recommendation. And it was written as a very abbreviated condensed sort of summary to suggest approaches.

And obviously, if this were to be turned into something that would be some kind of regulation, it would have to be laid out in far more explicit detail.

The approach would start with a single transport realization. So, we would take the giant release and transport model that's run for the repository and come up with a distribution.

In this case, this would be picocuries per liter of various radionuclides in groundwater. And you would end up hypothetically with some sort of distribution like that.

The next step would be to generate the realization of the community that's present. And here I've symbolized that by these little things indicating individual farms.

Now, one reaction that I've gotten to the report is that this sort of simulation and so on would be a daunting task to do, very difficult, very complex, and so on.

And I really don't think that that's the case. I think that people have maybe just not having really thought through as necessary in detail have sort of over-exaggerated in their minds the difficulty of what we're talking about.

There's basically two steps to this. The first one is figuring out according to the scenario that's settled on regulatorily where people are going to live. And the example we used was for farmers that are living out there.

And we proposed in this example that the present characteristics of the population be used as a basis for that. Now, I personally really like that.

And the reason that I like it is not because it's necessarily more fundamentally meaningful and significant than alternative proposals. But simply that it provides you with a reference that is objective and also realistic.

In other words, if there's a question, "How much water do people drink from wells out in the area around Yucca Mountain as compared to water -- beer, soda, bottled water, whatever they might drink?"

That's a question that you can answer by going out and getting some data on the people that live there. Whereas, if you're just going to hypothesize, it's going to become a matter of endless controversy.

Some people will say, "They drink every bit of their water from the well." Other people will say, "No, that's not realistic." "They hardly drink any." "The water doesn't taste very good." Whatever.

You can never settle those things. If you have some objective data base and you can go out and do some measurements, then it provides you with a way of settling these things in a relatively realistic and objective fashion.

At any rate, gather the data that you need. You need to decide where people are going to have farms. Well, that depends on what?

A very simple number of factors, where there's soil you can farm, where the slopes aren't too steep to farm, and where it doesn't cost you too terribly much to pump the water out of the ground to irrigate it.

Those are really the factors to determine where to farm. It would be relatively straightforward to put those into a GIS type model that has soil type and slope and so on in it. Not difficult at all.

Then for each individual farm that the model generates, you need some sort of average area so that you can space these out in a quasi-random kind of fashion.

You need to know some of the characteristics of the population that will govern their intake of potentially contaminated water in the end. And that would be things like, "How much water do they drink pumped out of their own wells?

What proportion of people grow their own vegetables? If they grow their own vegetables, how much of their diet does that consist of?" Again, those are relatively straightforward things.

Also, you need to simulate, "How deep is their well? What is the rate of pumping?" Those are things you can gather data on in the area. And so, I don't see it at all as a daunting or formidable task to come up with a Monte Carlo model that would simulate those types of things.

Let me give you sort of an example of a much more daunting model that you can go out and buy somewhere I'm sure within five blocks of here off the shelf for about $35. Have any of you ever used a model called Sim City?

It's a beautiful thing. You put into it all the things that are necessary for developing a community. And then it, on its own, simulates the development of the community and the growth and population and all sorts of things.

What we're talking about here is something that's an order of magnitude less complicated than Sim City that you can buy for $35. So, I don't think it's terribly major.

The final step then is to calculate the risk over this area. So, for each of these places, we calculate the dose that each individual person receives. We do many realizations of this.

And based on the dose-to-risk conversion, you come up with a spacial distribution of risk. So, these black lines are risk in units of 10^{-6} per year. You find out where the risk is highest.

And then there's a little rule that's outlined in the Appendix for figuring out how big of an area. You average that risk over to say that these are the people that are in the critical group for risk.

You do this for a large number of transport simulations. And for each one of these areas that's outlined in red, you average the average risk within each one of those areas to get the ensemble risk.

And that is the number that is then compared against the standard. I think I'm almost done here. There is a comparison of --

MEMBER STEINDLER: Excuse me, recognizing time constraints. But the critical aspect -- sorry for that term, of that methodology is clearly the magnitude of the population that looks like it's even reasonably likely to be exposed.

So, the edges of your contours are a little fuzzy. What I guess I'm having a problem with is if you average this over a population that is large enough, which I think in part was Tom Pigford's point, then while you may be able to show that you've met the standard, the result is that the chaps in the highest exposed area are exposed to very large, relatively large doses.

DR. PHILLIPS: Right.

MEMBER STEINDLER: So, what's the methodology that you use to constrain the total area? In this case area, and hence population. Is that the central focus of the difficulty with that approach?

DR. PHILLIPS: Not really. To me, that's -- I mean, you're right. The point is certainly valid. But you want to make sure that you analyze the problem in sufficient detail that you truly isolate the area of highest risk satisfactorily.

Right? I mean, that's the essence of what you're saying. I agree entirely.

MEMBER STEINDLER: I'm sorry. That's not what

I'm saying.

DR. PHILLIPS: Oh, okay.

MEMBER STEINDLER: The internal risk determination in the plume that you have is, I think as you said, a relatively straightforward process that's been used since the '50s, '40s.

What I'm having some difficulty with is the next step. And that's arithmetic operations of averaging.

DR. PHILLIPS: Right.

MEMBER STEINDLER: How do you determine how big the group is over which you average in order to determine whether or not whatever you conclude does or does not meet some standard?

DR. PHILLIPS: This comes back to the question of the spacial distribution of risk.

MEMBER STEINDLER: No. Well, it does in a sense. But what I'm saying is it's an arithmetic problem.

DR. PHILLIPS: Yes.

MEMBER STEINDLER: It's not a complex dose intake.

DR. PHILLIPS: I understand. You end up with a spacial distribution of doses that you can then convert to a spacial distribution of provisional risk.

So, in terms of the way that it's mapped out up there, the question is then, "How do you make sure that you isolate that particular area that actually has the highest risk and don't end up selecting some bigger area that incorporates a lot of lower risks that you add into the higher risk area?"

And that's simply a problem of spacial resolution of the model.

VICE CHAIRMAN GARRICK: You haven't really presented the criteria for that?

DR. PHILLIPS: No. That is correct.

VICE CHAIRMAN GARRICK: So, your method of controlling the area is essentially the ratio of the highest dose to the lowest dose within an area?

DR. PHILLIPS: The approach that we present would be to basically subdivide the area on a basis that is significantly finer that the spacial gradient of risk.

In other words, suppose you take the limit and you make your grid finer and finer and finer and finer. At some point, you would cease to enhance the resolution of the spacial distribution of risk.

VICE CHAIRMAN GARRICK: But isn't this just following the principle of most finite element type analysis?

DR. PHILLIPS: Yes, exactly.

VICE CHAIRMAN GARRICK: Finite difference calculations where you choose the area on the basis of small change taking place within the area?

DR. PHILLIPS: That's right. The problem is no different to my mind than the problem of a groundwater flow model where you have a potentiometric surface, and you want to say, "How fine a mesh do I need on my finite element model in order to adequately simulate that?"

And the standard way of doing that is subdividing your mesh until you converge to a solution where your spacial gradient doesn't change as it becomes finer.

Then once you have a grid that is finer, then the scale of spacial variation, you start lumping it out by this rule that's outlined in the critical risk thing, the range of one to ten and so on. Does that answer your question?

MEMBER STEINDLER: You were creeping up to it. If you could give me the view graph before this one. I'm sorry to take the time, but my sense of all the reading that they forced us to do was that that's really the central problem.

Now, if you've in fact determined within that red contour the risk at whatever accuracy and precision you like, a precision at least, and you then say, well, I've got a standard.

And you can pick any number, one millirem per year. And you take the average over all the dots you have on that graph as the population, and you say I'm going to equate all the dots, the dose from the population represented by those dots, to the one millirem per year.

Because that's such a large area, that contour within the red confine there could represent a relatively high dose. And if you don't like that, I can go further and further out. It simply increases --

What I guess I'm looking for is what's the rationale or the criteria that says to expand the population, no longer legitimate.

DR. PHILLIPS: There's two questions here now. One of them is, are you going to arrive at a fine enough spacial resolution of the distribution of risk? Which ultimately is mainly going to depend on this spacial distribution of concentration that's underlying it.

So, that's one question. That can be relatively straightforward. The next question then is what's the rule for once you have it finely enough resolved, reexpanding it? Well, that goes back to -- let me find the page here.

MEMBER STEINDLER: I'm sorry to take the time here.

DR. PHILLIPS: That goes back to the statement that defines the critical group for risk. And I didn't highlight it here, but there's this whole paragraph. The group can be considered homogeneous if the distribution of risk lies within a total range of a factor of ten.

MEMBER STEINDLER: Okay. So, that's I guess what I was focusing on.

DR. PHILLIPS: And then --

MEMBER STEINDLER: How did you get to the factor of ten?

DR. PHILLIPS: This is an adaption of the ICRP statement for the critical group for dose.

MEMBER STEINDLER: Oh, okay.

DR. PHILLIPS: Except it's been adapted for risk. But it comes from the ICRP ultimately.

MEMBER STEINDLER: So, you're using the ICRP basis for that factor.

DR. PHILLIPS: Yes.

MEMBER STEINDLER: In the course of your discussion, did you poke into the rationale for that factor of ten?

DR. PHILLIPS: Yes, we did.

MEMBER STEINDLER: And you were satisfied that that's a reasonable way to do it?

DR. PHILLIPS: Yes. I could go through that if you want to take the time to do it.

MEMBER STEINDLER: No, that's all right. All

I want to know is whether or not you considered my factor of ten could be your seven and somebody else's 12.

DR. PHILLIPS: It's arbitrary, but it is a reasonable -- I mean, it involves sort of trying to make a balance between ranges of uncertainty, which are clearly going to be fairly large on the one hand, and trying to narrow things down to a definable range on the other hand.

The other important thing within this here somewhere --

MEMBER STEINDLER: It's the next sentence. The ratio of the mean group risk to the standard.

DR. PHILLIPS: Right. And then this range goes down as the mean goes up. So that as you approach some critical level, which is basically the level of the standard, you are being more rigorous about the analysis is what it comes down to. It seems like a fairly thought-out approach.

So, clearly a lot of thought would need to go into how you're going to implement this in detail. And if I were in charge of doing that, I would get together basically two groups of people.

I'd have one group of people say, "Okay, come up with the details of how you specify it." And then I'd have the other group of people say, "Okay, you try and break the rules." Basically. "You try and bend this. Or you can make it come out to your advantage either way."

And they'll be able to do it. And then after iterating back and forth a few times between the two groups, I think you could come up with a useful way.

Let me real quickly go over as to what I see as a real limitation of the individual health risk or dose or subsistence farmer approach.

And this is in terms of all of the terms that go into the calculation of the actual individual health risk, these probabilities of isolation, of interaction with people, and personal sorts of things.

These are sort of the essence of the rationale for nuclear waste disposal in the first place. Isolation, and I live in New Mexico, and we have the waste isolation pilot plan.

So, the probability of keeping it isolated is really an important part of the whole rationale for it. And if you ignore that, I think it tends to distort the results that you end up with.

And just to illustrate it, I've come up with a cooked up example that's kind of extreme. But I hope it makes the point.

I've compared two different proposed repository settings. And when we go to a real extreme, we bury the repository two miles deep, very low permeability rock.

And as a result, we have a very small amount of what has to be concentrated leachate that moves only a very short distance from the repository down at this tremendous depth.

On the other hand, we propose that we simply dig some trenches on Long Island and dump the stuff in the trenches and cover it up again. And so, here's our repository, and we get this big plume that develops out pretty quickly.

However, it's going to be considerably less concentrated in this case because of the huge volumes of water that flow through that aquifer. The critical group, here's our critical group simulation of the population in the area.

Given normal people's habits, they don't drill wells two miles deep. And so, we end up assessing that there's a very low risk for this particular situation.

In contrast, the subsistence farmer scenario will have us drilling right down two miles down to the highest point of concentration within that concentrated plume. And we will conclude that there's a very high risk from that repository. But it will not meet the standard.

In contrast, on Long Island both approaches will yield approximately the same result which will be an intermediate level of risk, probably not satisfactory neither one.

But nevertheless, I find it discomforting that we would end up assessing that this repository is more risky than that one. And I think that this goes back to the fact that really the stated objective of the subsistence farmer scenario is identical to that of a dose standard which is personal protection.

And this is from the Appendix B I think it is. At any rate, because the subsistence farmer calculation is bounding, it represents the extreme of the actual doses in the entire population -- that's correct.

Protecting the subsistence farmer will ensure that no individual doses are unacceptably high. If indeed you can have confidence -- first of all, if it's possible to come up with the repository that will do that.

And secondly, if you can have true confidence that it really does assure you that it's never going to happen, then yes, it will ensure that no doses are unacceptably high.

But that is the objective of a dose standard. It is not an objective to limit risk to a group. Let me finish up with some concluding thoughts.

First of all, the risk in dose standards are fundamentally different types of standards. And the types of protection that they afford are very radically different.

A dose standard attempts to assure protection to the individual. The risk standard only limits the probability of risk to a group. A relatively small group, a select group.

We try very hard to pick out that group that is at the highest point of risk. But it does not assure any individual that, no, you will never receive an unacceptable dose.

Some corollaries of this. The risk standard will not, and there's no reason that it should, meet with ICRP recommendations for dose standards. And persons with equal risk may encounter vastly different outcomes.

A risk is the average of possible outcomes. It is not the same as outcomes. So, we can have two people, both of whom live side by side right over the most concentrated part of a plume emanating from the repository.

And one may live on beer and have no exposure, and the other one may drink lots of healthy water and get a high dose and die. Their risks in terms of a population characteristic are the same.

But because of particularities of their life habits, the outcomes are very different. Or one person may drink lots and get a very high dose and not get cancer, and another person may drink only a little and get cancer.

Again, the difference between risk and outcome. The degree of conservativeness of a risk standard in my opinion should depend on the level of risk used in the standard, not in manipulation of the risk analysis.

The risk standard can be made arbitrarily conservative. In other words, there's two sets of approaches here.

One is to say we're going to make all kinds of conservative assumptions in the analysis, and then apply some relatively normal, or whatever word you want to use, level for the risk that's employed.

To me, I really, personally do not like that approach because I don't know what it means. I don't know what the number that comes out of that analysis means. Does it really have any relevance?

How conservative have you made the analysis by all these assumptions you've put into it? I much prefer like I say to go out to take surveys of what people actually do, to put those into a model, and come up with a risk number.

And if you feel that risk from nuclear

radiation is for some reason a much worse type of risk than risk say from dying in an airplane accident or risk from arsenic in your groundwater, then make the standard low.

Say, okay, we'll make it 10^{-10} per year, or make it 10^{-20} per year, whatever you want. You can make it as conservative as you want to.

But I think it's far preferable to do that by being straightforward, being up front about it saying the reason that we're setting this standard so low is because ... rather than saying we're putting all of these conservative factors into the analysis that we really, in the end, don't know how conservative they make it.

I just feel that this is much more informative. Finally, risk standards are generally applicable, but standards guaranteeing personal protection in fact are not.

This is just a fact of life. There's very few types of activities that people do that guarantee a personal protection can honestly be made.

First of all, since society doesn't offer these types of personal guarantees to most of us today, it won't offer that guarantee to me when I get on the airplane going back to Albuquerque this afternoon, why should we do that for people who live according to our recommendation at any rate more than 10,000 years into the future? I personally find that hard to justify.

And secondly, even if we feel that we are compelled to make such guarantees, can we realistically and honestly do so? And my feeling would be I don't think that I can.

If you were to say to me, "Can you set up a standard in such a way that you can guarantee that a person 5,000 in the future will not get a cancer that will kill them from radiation coming out -- proposed repository?" I would say, "Absolutely not."

I don't think that we can honestly do that. And for that reason, I think that a risk standard is a more honest standard as well. That concludes what I have to say.

CHAIRMAN POMEROY: Thank you very much, Fred. We really appreciate that. I know there's a lot of desperate writing going on on both sides of me here.

And I suspect that there are many questions. So, I'd like to ask my colleagues who would like to start?

VICE CHAIRMAN GARRICK: Well, I guess one of the things that we're really talking about here is philosophical.

DR. PHILLIPS: Oh, yes.

VICE CHAIRMAN GARRICK: And that is the debate between basically a deterministic approach and a risk-based approach. Whereby risk-based, you have interpreted, if I can use the language, end-to-end with respect to the scenario.

In other words, the risk of a release and then the risk of a dose and then the risk of health effect. And so, as I interpret what you're trying to do is to be consistent throughout that whole process.

DR. PHILLIPS: Yes.

VICE CHAIRMAN GARRICK: And not get into a position of addressing from a risk perspective up to a certain point and then jumping into another domain of practice.

But the other thing that I think is kind of important here is that I hope that whatever method is employed that we're not suggesting that, if in fact the analysis reveals that there is what I'll call a hot spot or a singularity in the dose, that it would somehow be obscured or deluded or uncovered.

In other words, I would hope that the notion of common sense would prevail here, that, if in fact in the conduct of the analysis it turns out that there is something extremely peculiar in terms of the availability of pathway that was not accounted for or what have you and that that resulted in, as I say, a hot spot, that somehow there would be a way to accommodate that regardless of whether we adopted the critical group concept.

DR. PHILLIPS: I think one important point with regard to that is that one of the statements in the assignment of the group for critical risk should include the person at highest risk.

That does not necessarily mean the person who gets the highest dose or the person who gets a cancer. It means the person who stands in the highest probability of a bad outcome.

VICE CHAIRMAN GARRICK: Right.

DR. PHILLIPS: And so, if the analysis is really conducted right, if it does work carefully and thoroughly to make sure that the person or the point location in the way that the model is actually formulated that we suggested, if it makes sure that it includes that, and then this rule that you don't go down by a factor of more than three to ten depending on the level in the averaging is also included, then it would --

I mean, you could conceive a situation where it was just maybe some very, very tiny singularity. You might say in which case it might be hard to identify in a simulation that wasn't sufficiently detailed.

But I guess it seems to me sort of a universal problem. It's the problem of detecting it, not the problem of the standard ultimately.

VICE CHAIRMAN GARRICK: There's a number of ways you could of course do this. You could interpret the area that you subdivide into subareas as a possible outcome with respect to the risk within those subareas.

In other words, you could treat them separately and independently.

DR. PHILLIPS: Right.

VICE CHAIRMAN GARRICK: And just like when you define the end states of any risk assessment, you can define various categories or different types of consequences. You could look at the consequences as a function of subarea.

DR. PHILLIPS: Right.

VICE CHAIRMAN GARRICK: And then of course do your analysis within that subarea to make sure that the subarea's definition is founded to meet your criteria.

DR. PHILLIPS: Yes. Definitely.

VICE CHAIRMAN GARRICK: And that would be a variation on this approach.

DR. PHILLIPS: That's right.

VICE CHAIRMAN GARRICK: But the point here is that it seems to me that the point of debate is that whether or not you adopt an end-to-end scenario risk-based approach, whether or not you adopt a deterministic analysis.

And of course, a deterministic analysis in a lot of people's minds contains within it the calculation of risk in the sense that, if you're calculating the amount of radionuclides delivered to a particular point, you have taken into account implicit in the calculation the likelihood that it gets to that point.

So, I suspect we're going to hear more about that later, that concept.

CHAIRMAN POMEROY: Those probabilities are generally assumed to be one, aren't they?

VICE CHAIRMAN GARRICK: Well, not necessarily. I think that if you're doing a transport calculation, you can embed the notion of likelihood right into the calculation and not really call it so much a risk, but this is your best shot at what is going to be the dose, for example, at a point or a release at a point.

But not necessarily define it as probabilistic. I understand.

CHAIRMAN POMEROY: Are there other questions from the members? Bill?

MEMBER HINZE: Fred, in terms of the critical group come up with the risk as being the average of the maximum risks of the realizations. Is that correct? Does that come close?

DR. PHILLIPS: Yes. I think that that's a fair way of stating it. You take the maximum risk, not the point maximum, but some small integral around that point maximum.

That's the whole idea of the critical group, of course, as opposed to individual. For each transport simulation, in other words, there are sort of two levels on the hierarchy.

Suppose we do 100 transport simulations using different permeability fields and different climate scenario and so on. And we come up with somewhat different plumes emanating from each one.

Then for each of those we do numerous societal realizations. First, we add up the maximum risk from each societal one at the point of maximum risk. That gives us sort of one column that gives you a maximum integrated risk for that particular transport realization.

Then we add up the maximum average risk from all of the transport realizations to get the total integrated average risk.

MEMBER HINZE: Did you consider how one could make certain that you had reasonable bounds on your scenarios? What did you consider in terms of, for example, the movement into a pluvial period?

DR. PHILLIPS: Well, in terms of this and in terms of what I presented here, I'm really focusing on the exposure scenario aspects of the problem. And I'm sort of assuming that the transport aspects, release and transport aspects, are kind of going to be handed --

MEMBER HINZE: Constant.

DR. PHILLIPS: Yes. If you want me to sort of jump over and put on my other hat as a groundwater hydrologist --

MEMBER HINZE: Yes, because we also must be concerned with the biosphere.

DR. PHILLIPS: That's right. My own personal feeling about that, and I think it was at least alluded to in the report, is that over the sorts of time periods that we're talking about, and I don't care whether they're as short as a couple of thousand years or 10,000 years or going out to whenever peak doses are, even if they're anytime short of a million years, there is going to be a very high possibility of major climate change.

And that has to be factored into the analysis. And my own approach to it would be to say that that should be part of your baseline transport simulation. Some transport simulations would have a continuation of today's climate.

Whereas others, probably the vast majority of them, would have a much wetter climate. You might have a few that had a drier climate. It's really sort of my core area of research.

And based on what I see there, the main thing that you can say about change in climate is that it will happen and it will be major. And "When?" is an almost impossible question to answer.

So, if you don't include a lot of realizations that have major climate change especially in the direction of a wetter climate, they're not going to be adequately capturing the probabilities of future states. I feel quite strongly about that.

CHAIRMAN POMEROY: Other questions? Let me ask a devil's advocate kind of question to get your personal response, Fred, to some extent.

Your statement there, society does not offer personal guarantees to most of us today for most of what we do, is certainly true. And using your example when you get on your airplane this afternoon there is no personal guarantee of that.

Nevertheless, in some sense, although we recognize not entirely, that's a choice you make. You don't have to get on that plane this afternoon, and you didn't have to get on one yesterday to come here.

Those are choices you're making. What do we say to the person in Nevada who isn't making a choice in this case? We're creating some risk, perhaps a small risk, but nevertheless a risk.

Why should society not offer personal protection of sufficient magnitude to him given that he has no choice in whether he takes the plane or not? He's on the plane.

DR. PHILLIPS: I think that similar principles apply to all sorts of things that range over all the categories of volition that we can think of. And just to take up the airplane example for a moment, it's true that in a certain sense I am voluntarily taking that risk on myself.

On the other hand, my life and my career would be pretty darn restricted if I ever refused to ever get on an airplane. It's not that much of a choice for me personally right there.

Then let's think about things like, well, in Albuquerque, for example, right now we have a big controversy about arsenic levels in groundwater. It turns out that arsenic is naturally relatively high in groundwater in the Albuquerque area.

And it is below the current limit. But EPA is preparing to lower the limit to the point at which most of the water that's pumped out of the ground at Albuquerque will be above the limit for arsenic.

And it's going to cost the city, it's going to cost the taxpayers in Albuquerque millions and millions of dollars to put in water treatment plants to remove a few parts per billion of arsenic from the water.

The response of most of the people in Albuquerque is to hell with it. They would much rather run whatever risk of adverse health effects from that low level of arsenic that's present in the water than they would to pay out the money to have it removed from their water.

And while on the one hand it is true that the risk due to disposal of nuclear waste has been created. That's a decision that's already been made. And at this point, we have the results of that decision.

And something, some resolution has to be made of the problem. It's going to be a problem no matter where it is. Let's put it that way. We can leave it where it is right now.

And the question is, is that a bigger problem or a lessor problem than putting it under the ground someplace else. And it's true. I mean, it involves subjecting the people in the far future in Nevada to a risk that other people, other places won't be running.

And how high is that risk? That's a very real question. It's not a matter of some sort of games or arbitrary numbers. How high a risk are they likely to be subjected to?

And it's just sort of a societal issue that you have to say if that risk is really fairly appreciable, then, no, it's not fair to them I think. Something else ought to be come up with. Some other solution ought to be come up with.

On the other hand, if it's a very small incremental risk, less than the risk of cancer due to cosmic radiation or something like that, well, we're all paying prices of one sort or another for the mistake that our ancestors made.

And maybe one or two people in the future will do it as well. They almost certainly will, I'll say. No matter what we do with it, they will.

So, where is it going to do the least harm? And how much harm is that? Those are the answers to the questions that we need to get answers to.

CHAIRMAN POMEROY: If there are no other questions, I'd like to thank you first for the answer to that. You've obviously spent a lot of time thinking about it, Fred. And I appreciate that discussion.

I also appreciate your coming and thank you very much. We'll certainly carefully consider what you said. We hope we can get copies of your slides as well.

DR. PHILLIPS: You may.

CHAIRMAN POMEROY: Thank you.

DR. PHILLIPS: Your welcome.

CHAIRMAN POMEROY: If we can, we'll move right along. The next presentation is by the Nuclear Regulatory Commission staff, considerations for specification of the reference biosphere and critical group at Yucca Mountain.

And contrary to your agenda, Dr. Norman Eisenberg will give the presentation. And as always, you're very welcome here, Norm.

MR. EISENBERG: Thank you, Paul.

CHAIRMAN POMEROY: I didn't think when we talked yesterday that I'd see you here today.

MR. EISENBERG: I was going to say that people that know Tim would realize that I'm not Tim. He'd have to get several years older and about twice as big to look like this.

CHAIRMAN POMEROY: Which direction?

MR. EISENBERG: Older and bigger. I should say that staff is at an early phase of fact finding on the issue of critical group. But what this presentation attempts to do is articulate some general principles.

It's not yet proposing a regulatory approach. We're just not there yet. First of all, let me just say what our interpretation of the NAS recommendations in their report were.

First of all, it advocated using the critical group and reference biosphere in formulating the regulations. It also stated that the prediction on societal factors related to the exposure scenario did not appear to have any rational scientific basis and that you really couldn't make those predictions in an accurate way.

Therefore, the report seemed to conclude that the definition of the exposure scenarios should be a policy matter and should be decided in public rule-making by the appropriate regulatory institutions.

And the exposure scenarios would define both the reference biospheres and critical groups. Another point, as was made earlier today, that the exposure scenarios provide a framework for the analysis for doing a calculation of compliance and estimating repository performance.

But they, in no way, would identify all the possible futures that could occur. But it gives you a benchmark. And consistent with ICRP recommendations, the recommendation was to use our present state of knowledge and cautious, but reasonable assumptions.

I'd like to talk about a couple of definitions. And these are definitions that we're using for our purposes.

One of the things the staff found out when we first started grappling with these problems is that there is some syrupiness in the definitions between critical group, reference biosphere, exposure scenarios that there is some lack of clarity about what goes where and a lack of an overall agreement in the scientific community.

But the critical group, again as was indicated earlier today, are those individuals in the population who have the highest risk based on cautious, but reasonable assumptions.

And by specifying the critical group, you specify their diet, the location of the critical group, and the important behavior of the critical group relevant to radiation exposure.

So, for example, if you have a problem where a contamination of the ground and soil with gamma emitters is an important issue, then the amount of time people spend outdoors versus the amount of time they spend indoors would be an important aspect.

The reference biosphere is a standardized set of assumptions about the environment in which the critical group is located. And again, for Yucca Mountain, this seems to come down to climate and land use.

Now, we know that our European colleagues often include the natural biosphere and radionuclide transport by biota in the natural biosphere because northern Europe is a pretty green area.

The Nevada desert is not. And so the amount of radionuclide transfer that we would expect by the biota in the region of Yucca Mountain is minimal. And that's why it's not listed here.

So, part of the problem is to come up with a reasonable definition of the critical group which will serve the purposes of providing a basis for compliance calculation, but not get involved in unlimited speculation which the National Academy report recommended against and which would be certainly unfeasible in a regulatory context.

So, some of the criteria for limiting speculation would be to not consider the impacts due to societal changes. So, for example, we would not consider the anthropogenic effects on climate and geology long term.

And there's lots of arguments for perhaps not considering that. But our purpose is not to debate that here right now.

Also, we assume that there will be no great change in cultural behavior simply because of the inability to predict it. So, we would allow behavior changes, but consistent with current activities.

Perhaps a good example of the kind of thing that we might consider is that the land use in the vicinity of Yucca Mountain has been restricted because the land has been a Federal enclave for many decades.

It's conceivable that if that use were to disappear that the area might be used for private purposes. But that's the kind of thing that is consistent with current cultural behavior, if you will, but does not exactly mirror what the current land use is.

Again, I have to caution that all these things are ideas we're talking about. Another basis for limiting speculation would be to use reasonable assumptions for the reference biosphere in critical group that has a reasonable chance of occurring in the region over the compliance period.

And based on current knowledge, reasonable use would include site-specific data, the existing conditions and current practices, our existing knowledge in analyses and specification of the pathways and events.

We have begun to investigate some of the land use practices in the area. And certainly I've been surprised by some of the things that were found. But this information is available for both the State and Federal Government.

VICE CHAIRMAN GARRICK: Norm, what's the

difference between the first bullet and the fourth bullet?

MR. EISENBERG: The first bullet and the fourth bullet?

VICE CHAIRMAN GARRICK: You say site-specific data in the fourth bullet is pathways and events.

MR. EISENBERG: We've had some discussion about various scenarios. For example, volcanism, seismicity. Certainly volcanism could lead to an air pathway for migration of the radionuclides.

Normally, we think of the migration of the radionuclides occurring in the groundwater. So, there's some consideration of these disruptive events that may introduce pathways that would not be included in the, for want of a better word, base or undisturbed case.

VICE CHAIRMAN GARRICK: Well, okay. But I don't know why you would make a distinction between disturbed and undisturbed when you're referring to site-specific data. I think that you would let the evidence speak for itself regardless of origin.

MR. EISENBERG: I guess the principle that is being articulated is that the critical group one could, I suppose, conceive of a general or generic critical group that would consider all pathways using all radionuclides.

We're not going to do that. And one of the ways to limit it is to only look at the events and the radionuclide migration pathways that they induce in determining what the critical group is.

And I agree with you. I have been arguing that we should not make a distinction between the disruptive and the undisturbed repository performance. I think it leads to more trouble than it's worth. But that's another issue for another day.

VICE CHAIRMAN GARRICK: Yes, we'll discuss that some other time.

MR. EISENBERG: Again, the critical group includes maximum exposed individuals consider with using reasonable assumptions. And it should not be prejudiced by a small number of individuals with unusual habits or sensitivities.

So, for example, if somebody had a very unusual diet and suppose they ate nothing but rice cakes, then that would not be folded into our consideration. It's not clear right now how we would handle the age sensitivity to radiation.

And we may use a standard man approach. But this is something that's still under discussion.

Some of the site-specific information that we're pretty sure of is that the climate is arid. Certainly the rainfall could increase in the future. I guess I was a little puzzled by what the previous speaker said about dramatic changes in climate.

We would expect the climate to still remain arid to semi-arid and not become a garden spot. But of course, that's going to be worked out in our later deliberations.

Certainly the land use is based on an arid environment, and we would consider in determining the reference biosphere the length of the growing season and crop selection, the rates of irrigation necessary for those crops, and rates of irrigation that are possible in that region, and the size and types of farms needed to support wells that go into the deep water table.

Again, I'll make the point that the natural flora and fauna seem to have a limited effect on the reference biosphere in this arid climate. So, that's another simplification that seems to be possible.

Some of the site-specific criteria for the definition of the critical groups. The location of the general population is limited by the practices for obtaining water.

And I'll have a chart at the end that gives depth to the water table. So, it's the depth of the water wells. We believe that the land use is limited by the groundwater obtainable within that hydrogeologic basin.

And then there is a financial cost for

obtaining water. And of course, the deeper the well has to be the greater the cost not just to drill the well, but to pump the water once it's drilled.

We would define the critical group as a subset of the general population that are defined by the exposure pathways and the mechanism for transport of radionuclides.

And right now, we're thinking of two potential critical groups, a limited farming community and a limited community of non-farmers. And we would look to information from --

MEMBER HINZE: What's limited mean there?

MR. EISENBERG: That is, first of all, the size would be limited by the availability of water. The geographical extent would certainly be limited.

The types of activities, for example, on a farm in that region would be limited by the climate and the soil types. All of the above. And we'd look to similar areas to provide additional information.

MEMBER STEINDLER: Excuse me. Does that imply that you would not delimit the critical group based on risk?

MR. EISENBERG: Well, we're concerned about the usual convention that the risk within the critical group not vary widely. But remember what this says. It's a subset of these limited communities.

So, having defined what sort of the nature of the group is, we would then define a critical group which is a subset of that which would likely have the highest exposure.

MEMBER STEINDLER: It gets you into the same discussion I had with the previous speaker. The same caveats it seems to me apply.

MR. EISENBERG: Yes. Some of the sources of information for helping us formulate some of these ideas are the land use practices at Yucca Mountain and in the region. And DOE has complied several reports.

It's not just the Amargosa Valley, but some of the other nearby communities. I recently went on a trip out there and was surprised at the amount of agriculture in the middle of the desert, so to speak.

So, that we would consider that information also. I was surprised to see that there was, I think, one large dairy, and growing of alfalfa, and very interesting kind of agricultural practices.

We have rainfall data from test site information over a relatively long time. And as you know, we have conducted an expert elicitation on future climate, that we would look at the fossil record to estimate future changes in climate.

For the location of the group, critical group, we would use the characteristics of the well in the Yucca Mountain region. As the previous speaker mentioned, the land slope and soil types also limit the ability to farm.

We'd look into the dietary habits of the people in the region to determine the amount of food that's grown locally and what fraction of it would be consumed locally.

Or to put it another way, for the locals, what fraction of their diet comes from the locally grown food. And also, we'd look at water consumption in that area and in similar environments. And, of course, we'd use the general health physics information -- that's standard practice.

Let me just close by --

MEMBER STEINDLER: Before you do that, the Agency, as far as I know, has not used a population specific characteristic when it does its average build calculation before. In this case, you're electing to do that. Are you going to run afoul from people who say, look, you guys have used the average standard man with average intake of water, average food consumption, the standard pathway analyses, the rem per psi tables that are essentially standardized.

Are you deviating from the norm of what I think is the norm of the Agency? And can you justify it?

MR. EISENBERG: Well, I think we would deviate if there were good reason and evidence to do so and after all, the congressional mandate is to produce a Yucca Mountain specific standard and I think that's what we would do.

MEMBER STEINDLER: But you're not in the business of producing the standard.

MR. EISENBERG: Well, we're in the business of producing a regulation which implements the fundamental standard and at least the way --

MEMBER STEINDLER: I guess what I'm asking --

MR. EISENBERG: I understand the staff has interpreted the law, is that we would produce a Yucca Mountain specific regulation promulgated by the Nuclear Regulatory Commission.

MEMBER STEINDLER: All I guess I'm saying is that in all the pathway work that I'm aware of and maybe Dade could make some comments on that, but all the pathway work that I'm aware of have been moderately standardized. In this case, you're saying gee, we ought to focus our attention specifically on the folks that we now see here, say the Amargosa Valley. If you don't consider that to be a deviation from the norm of the Agency, you know, fine, but it is, I think, a different approach.

MR. EISENBERG: I'm not saying it's not a deviation. I'm saying that if there is good reason to deviate, if the pathways are -- certainly I'd expect the biotransfer factors to be quite different in this environment than you would expect in, say, Savannah River.

MEMBER STEINDLER: That's exactly my point. You've not used that difference before that I'm aware of. Maybe I'm not.

VICE CHAIRMAN GARRICK: Marty, isn't the whole issue here the development of Yucca Mountain specific set of regulations to implement Yucca Mountain specific standards. So isn't that by its very nature different than the Agency has ever -- different mission than the Agency has ever had before in terms of creating regulations?

MEMBER STEINDLER: Don't misunderstand my comment. I think it is precisely correct what it is that they're doing. The Agency has in the past averaged because it is easier to average --

VICE CHAIRMAN GARRICK: Right.

MEMBER STEINDLER: The generic man, the generic transport processes, the generic uptake calculations. I think that's -- we're finally get the site specificity and I think that's a great idea. All I want to do is highlight the fact that you may be catching flack from somebody if you, in fact, become site specific.

That's all.

MR. EISENBERG: This is a very interesting map of -- it has several things. There's the outline of the Yucca Mountain repository. The big black irregularly shaped region is the boundary for regional hydrology study performed by DOE. As I understand it, you can basically read these as stream lines so that there would be no passing those -- these boundaries.

As you can see, if there's contamination leaving Yucca Mountain, it's headed for Amargosa Valley under this set of assumptions anyway. And I would expect that if you change some of the parameters of the model things would not change greatly.

These contours are the depth to the water table. The black dots are wells and notice that we've got some clustered up near the mountain and the red dots are irrigation circles, either the center pivot or some other type of irrigation.

If I could just take an opportunity to bring up one of the things I was puzzled by in a previous presentation is that this is a very long distance. As I understand it, the rock in this region is fractured rock and we would expect preferential paths of transport. I would question whether and I'd like to hear an explanation of whether the contours shown are as continuous as indicated in the diagram or whether you would find fingers of contaminate coming all the way down this far because then the picture is not quite as simple as was indicated before, but you may be able to move over ten meters and get greatly different concentrations and if that's the case, then this sort of finding where the averages are is misleading because you can -- you may locate what you think is the center of the plume, but you may have higher concentrations off the center.

So that, and of course, there does seem to be a great deal of difficulty in having to characterize all this territory between the repository and the receptors. That would be a problem also.

MEMBER STEINDLER: Are you suggesting that Beatty is under water?

That's a zero up there and it implies that it's sitting in a swamp. I think that's the last thing those folks would admit to.

MR. EISENBERG: Bob, do you know?

MR. BACA: That is correct.

MEMBER STEINDLER: That is correct?

MR. BACA: The reason for that is simply that the discharge point of the Amargosa River goes to a bedrock narrows there and so the water table rises to the surface. It's probably not as large as is indicated on the map there, but in fact, the depth of groundwater in the bed of the Amargosa River is zero, sustained by perennial inflow of groundwater.

MR. EISENBERG: I think that's all I have to say. I'm sure Tim would have more to say, but --

CHAIRMAN POMEROY: Norm, let's see if there are any other questions before we let you go.

Questions from other Members?

If not, Norm, I'd like to thank you for the presentation and thank you for coming in at the last minute and doing it. We are deeply appreciative. Could I ask you, just as you're going whether or not -- I assume that within the rulemaking that takes place after the standard is issued by EPA that your intention is to include definition of the reference biosphere and critical group or in some manner within that regulation?

MR. EISENBERG: I believe EPA is going to include some indication and then we would carry further and try to be even more specific about specifying its characteristic. That's what we're thinking right now.

MEMBER STEINDLER: Do you believe it's the function of the EPA or the NRC to specify how the critical group is calculated and what the biosphere assumptions would be? Whose job do you think it is?

MR. EISENBERG: I think there's not a bright line between the responsibilities of the two agencies. I understand that the EPA feels it's important in promulgating their fundamental regulation to indicate who is being protected and some indication of a critical group will be incorporated into that. I think the NRC intends to go further and specify perhaps the calculational methodology which would go even further.

CHAIRMAN POMEROY: Fine, thank you very much. I want to thank both of our speakers this morning for staying within the time limits.

The Committee will now take a 14 minute break and reconvene at 10:30.

(Whereupon, the proceedings went off the record at 10:18 a.m. and resumed at 10:34 a.m.)

CHAIRMAN POMEROY: Can I ask us to sit down and reconvene, please?

The meeting will now come to order. The next item on our agenda today is a presentation by Dr. Tom Pigford, who is a member of the TBYMS committee and his title today is "Personal Supplementary Statement on TBYMS Report and Other Relevant Issues."

We were just talking to indicate that our prime focus, of course, today is going to be hopefully on reference biosphere and critical groups.

Welcome here, Dr. Pigford, the floor is yours.

MR. PIGFORD: Thank you. I think to try to focus this, I need to tell you, I come at this from many different backgrounds. One is I have been involved over several decades first in analyzing safety of nuclear power reactors and I was involved in the early days in the development of safety approaches, regulations on those and I want to start off with a disclaimer because people tend to identify me as being mainly doing mathematical analyses of transport which I do and insisting that we do a precise quantitative analysis as far as we can.

I don't believe that the idea that you can achieve safety by having a single safety goal like, for example, a dose limit or a risk limit as well as you define the biosphere and all of that, I don't think that is sufficient. Many people say what an improvement over our present complex regulations on safety and nuclear power reactors. They are there for a reason.

We didn't try in the early days when it was growing up under AEC to predict all of the things that were going, all of the problems that were coming up. We looked at them one by one, made arbitrary decisions, some of them wrong, containment requirements arose that way in the very early 1950s.

The regulations are inconsistent. We have a safety system that keeps our cores from melting down and yet we assume a partial meltdown to analyze the effect of the containment.

I think all of this has given us a good set of approaches towards safety. WE don't know enough about a geologic repository to write down the equivalent nowadays, so I hope we'll view this as the beginning of an expiration, a standard will come out, but we should leave everything open so that as new issues come up, we can change or modify or add and that goes for the biosphere, for the geosphere calculations, climate changes and so forth. That's the essence of what this first slide was trying to say.

Now the issues I'm prepared to talk about, but there won't be enough time are indicated here. Calculating doses to subsistence farmers, doses for conceptual geologic repository, proposals to limit dose rate to the average individual in the vicinity and those are congressional proposals and that goes beyond what is in the TYMS report, but I'm very much concerned with proposed congressional legislation and I've recently written a report pointing out the fallibility of that approach.

Proposals to project probabilistic distributions of habits of future people, mathematical errors in the TYMS report, for how long in the future should doses be calculated, the origin of EPA's 10,000 year cutoff, uncertainty analysis and risk, underground criticality, where during the last year we've done a lot of new calculations to try to make some sense out of the muddle that the technical community is in on that and groundwater protection. This is a shopping list for you and please interrupt as I go along, because I'm not going to be able to cover all of it.

What are the current kinds of performance criteria that we see? First, I'm being a little unfair. I am not going to talk about the EPA standard, 40 CFR 191. I want to say I think there's a lot of sense in that. In fact, in spite of the fact that I've also written some papers criticizing it. We shouldn't throw the baby out with the bathwater and I hope EPA will reserve the good parts of it.

Here, the emphasis seems to be on individual dose and individual risk and so I'm going to talk about that. There's an international consensus and it's not official when you ask where are the official documents for each country working in this. They say very little. I think for a good reason, for the reasons I articulated earlier. The countries that are making good progress, Sweden, consciously did not codify these in regulations. It's only the practice and safety analysis that is growing through each iteration through SKI and the work of SKB. But from that process, I can say there's international consensus in those countries that are really working geologic disposal, to calculate lifetime dose to a maximally exposed individual. The trouble is I find that these three words themselves mean so many different things to different people as has been mentioned this morning and I'll come back to that.

There are various kinds of limits. From my background in reactor safety, the limits that we see in terms of what we call releases to the environment are given in the regulations 10 CFR 50 which are called design limits. Those first originated in 1975 and those limits are like 5 to 10 millirem per year.

If I were redoing this slide today and say for the 4 to 25 millirem per year for the countries because Japan, unofficially, is using 4 in their analyses and some countries are using 25. And I don't have a lot of argument with or against each one of those. And there are corresponding risk limits based upon idea of what the probability is of cancer or some somatic effect per unit dose.

Now this brings up, I think, a problem. I think there's confusion on dose and risk and I may have perpetuated some of that because in 1983 we published the three year study done by the National Research Council on the geologic isolation system and there we included deterministic calculations of the individual doses. We used so-called expected values of parameters and we came out with doses and you can calculate risks if you want to multiply those doses by conversion factor. But as has been pointed out, a real analysis of risk requires the inclusion of probabilities that you get in those doses.

What is being done today? I'll show you in a few minutes. Yucca Mountain is turning out calculations that are very important and very helpful and they are the request of our committee. They turned out in early 1994 some dose calculations. Now those dose calculations are probabilistic calculations of dose. Why probabilistic? By that time they had learned that there are so many uncertainties in each parameter, like permeability, solubility, flow rate and so forth that we need a way of treating those uncertainties and so the approach is to take each parameter and try to quantify the uncertainties and appears as a probabilistic distribution of that parameter.

And there are a lot of parameters and so as was pointed out earlier, the practice, it's not the only way to do it, is to use the Monte Carlo realization and each realization samples a particular value of those parameters. And then if you have enough realization in principle from those results you can create a probabilistic distribution of doses.

I left out something. You have to have a dose model like the biosphere to calculate dose. First, you calculate the probabilistic distribution of concentrations and these will vary also, give you results that vary with time and location out in the environment, probabilistic distribution concentrations.

Then, if you have a dose model like what Yucca Mountain uses is the subsistence farmer as all other countries that I know of working on geologic disposal, then you can calculate a probabilistic distribution of doses probabilistic distribution. Then if we were to use a dose limit, what would we do, what do they report? They take the expected value which is integrating over that distribution. Some people say that's the mean. And that's the dose that is proven. It has deeply embedded already as John Garrick has pointed out earlier, probabilistic distributions. If you have then some idea of probabilistic distributions of people activities, changing with time, climate changes, growing crops and so forth, that must be included in that fundamental probabilistic analysis and doses.

You can't separate them. Well, you could.

You can make a catalog of all your realizations, all your realizations are concentrations and then put that on the shelf and come back and every time you want to do a new realization take that earlier realization out, add your dose or risk model to it.

Fundamentally, there is no separation from the beginning to the final result of dose risk. Now I told you what dose is in terms of the current methodology for calculating for geologic disposal and this is not unique to the United States.

Sweden is doing it. I think now every other country I know of that has gotten mature in this work is doing dose that way.

There are some, still some deterministic calculations going on. I want to point out that the dose calculated this way is not the dose calculated from the most pessimistic choice of all parameters. It is not. It is using your best idea of the probabilistic distribution of parameters. It is not skewed towards the maximum possible dose or the maximum possible concentration. It includes your best idea of those probabilities and any new ones you want to invoke. Now indeed, there have been some estimates in various fields. I haven't seen them actually in geologic disposal of taking the worse case value of each parameter. EPA has during the recent years attempted to clarify these words and that is called a theoretical upper bound estimate. The TUBE, all right? That is when you take the worse case. That's not what we are talking about today, or at least I'm not talking about, nor is that what the TYMS report is talking about. It very clearly defines what it means by calculating dose, the expected value of the probabilistic distribution.

It also defines what is meant by calculating risk. The probabilities that affect risk are included in the probabilities that affect dose. How do you get the risk? There are two -- the fundamental way is to take your probability, probabilistic distribution of dose, convert each dose from each realization or each value under distribution to consequences by multiplying by your -- if you know it -- and this is a big assumption, the conversion factor from dose to consequence, consequence the number of latent cancers. Then you integrate over that distribution, you get the expected value of a distribution of consequences and that's risk.

Now if the conversion from dose to risk is a constant, you could also simply multiply expected value of dose of that conversion factor and get precisely the same number.

I also want to point out there is a fundamental meaning to dose calculated from a given realization. There's a meaning to consequence from a given realization. But if these realizations, these -- each realization is a calculation which includes a continuous distribution of probabilities, like of a parameter, not necessarily all of them, you don't know at the time of each realization what the probability is of that realization. It's not know-able. You can only say that can give you data with all the realizations is applied on the probabilistic distribution curve.

There is no meaning to risk from a given realization, if you don't know the probability of that. There are many definitions of risk. They get defined in different ways, but the TYMS report defines it precisely as I say, is the expected value of the probabilistic distribution of consequences. Please remember, because that affects a lot about what we say.

Now the EPA, bless their heart, have helped me in their current language trying to distinguish between the extreme pessimistic maximally exposed individual, the TUBE, with one where as was said earlier for example, for the subsistence farmer who is usually chosen as that for those calculations, you discount people who have unusual eating habits, like the clam diggers at Selifield who were excluded from the calculations. And certainly the reason we have to make a lot of policy decisions, and a reasonable one, an additional one is to assume that present people, their diet, their habits on eating will give you the thing to use for the future. Is that right? I don't know. It's a reasonable policy decision and I don't argue against it.

We exclude people with unusual sensitivity to radiation. They are there now and they will be there in the future. That's another reason why the reasonable maximum exposed individual is not the individual with maximum exposure. It's like the TUBE is different from this.

So that's what is meant in what I say today and it's using EPA's words. How does EPA does this? They have drinking water standards and of course, we know those are going through a lot of re-look currently, but the way they've done them they can't decide who is going to drink the water and so they take a reasonable person by definition reasonable. You may not think it's reasonable, who has normal sensitivity and drinks the normal amount of water per year and they assume all of this water comes from that contaminated source. They calculate some average allowable concentration and that is the source of the drinking water standards that are published. They have to assume also how much dose he can get and there they assume in the past 500 millirems per year as the allowable, seeming it's consistency, but I think it's explained when we look at the application. It doesn't mean that they don't worry about the outfall from a nuclear power plant, cooling water, if it contains radionuclides that give only say 100 millirems per year. They worry a lot and that is the reason for conditional regulations that NRC imposes.

The traditional subsistence farmer standard, traditional is what Yucca Mountain is doing, what WIPP is doing which is has to do even though 10 CFR 21 still applies and other waste disposal projects. The RMEI is a subsistence farmer or uses contaminated ground water for all drinking water and for growing all or a substantial portion of its food.

Now look, there is a vagueness there. What is substantial? Well, some people say half or a third. Look, we are going to be attempting to estimate doses and risks of people millennia, tens of millennia, hundreds of millennia from now. Factors of 2 or 3 are such small differences compared to our real uncertainty it's not worth arguing about. I don't care if you say he gets half or a third.

That's the definition of the maximum reasonable maximum exposed individual, the subsistence farmer.

Now should the standard limit individual risk or individual dose? Arguments for individual risks are calculation of compliance would have to use updated data on risk which they should, that changes with time. And that's a technical argument for risk. It forces the updating of the conversion factor.

Another reason that's frequently offered is we can compare risk from the repository with other societal risks. Some people say the public will understand risk better than dose. It may be. I'm not an expert on that. However, I spent 14 years serving on the Atomic Safety and Licensing Boards where we got into these issues a great deal and I'm not convinced that the public understands dose risk any better than dose. In fact, my guess is I have an easier time with dose in talking with people in the public and also outside of our particular technical community, but still technical people, if I talk in dose ard compare it with background.

Arguments for individual dose, dose is necessarily calculated anyway. Secondly, and I wish I had known this before the TYMS report came out, there was a 1995 position statement of the Health Physics Society from a committee chaired by Mossman with others on it and it's a statement from the whole Society that recommends a quantitative calculation of risk for doses in the range expected for safe geologic disposal. This range of uncertainty and quantitative conversion to risk is too great for quantification. What do they recommend? Don't quantify it. Don't mislead people. Tell them. In this region of doses we have not observed certain health effects, but don't mislead. Maybe we weren't able to and yet they could still occur.

Now, at the Las Vegas meeting this came up and Steve Brocum gave an excellent presentation. I think those words mean different things to different people. I have talked at length with Mossman about this and he emphasizes it doesn't mean that he thinks or the Committee thinks that things are always less risky than implied with the slope of the linear hypothesis. He says they could be greater.

Remember, we're not trying to calculate the risk from say 25 millirems of radiation with no other radiation there. We're trying to calculate the risk that over and above background and so it's the instantaneous slope of the data if we had data. We don't have it.

So because of that uncertainty and I'm now approaching this as a person who wants to do quantified calculation, calculating uncertainty in the performance measure as a risk, in my view, is equally important as calculating the dose or risk and it should be done and it's not being done, although there are some beginnings of that in other countries.

In UK, the NRPV even explicitly recommends that instead of comparing your expected value of dose to the limit, compare the 95 percent confidence level, the upper level, of that dose to the limit and I think that's good sense because the uncertainties are very large. We have heard many arguments that we shouldn't calculate beyond a certain time like 10,000 years, the uncertainties are too great. Those arguments have sprung up. I think they're from a good innate sense of what may be true, but they have not been quantified and I want to see them quantified before I'm willing to accept that kind of argument on such an important thing as a cutoff time.

They can be quantified and we do quantify them. You must quantify your dose to risk conversion factor uncertainty. Where are you going to get it?

For that reason, I am very torn towards -- I seem to have lost the transparency here, but that will save a little time.

(Laughter.)

Okay, I want to talk about the 10,000 years because in some conversations I know that the Committee is interested in that. All right. Here is the -- this grew up, this appeared in 10 CFR 191 which hit the streets as a standard in the early '80s. I participated through the National Academy's Board on Radioactive Waste Management in evaluating the early drafts of that and in my view terminating dose calculations at 10,000 years gives a false illusion of safety. Why? I'm going to show you in a few moments what we should all look at every year, periodically, repetitively, iteratively, dose calculations from geologic disposal from various concepts, including Yucca Mountain.

If the largest doses occur much later than 10,000 years, cutting off at 10,000 years can give you a false illusion. I'll show you some calculations where the doses at 10,000 years are only one millionth, a million times less than the maximum dose that will occur tens of thousands of years later. I think that would certainly would raise questions on the adequacy of public health question. If we knew that and consciously ignored it, for unquantified reasons that it gets too uncertain.

Here are the calculations that were presented to our Committee. We saw those in March 1994, although we were given samples of it even earlier.

Here is Yucca Mountain's calculation. There were two separate reports. One from Sandia and one from Interra and they use very much the same parameters and plotting the dose from various radionuclides as a function of time. Here are technetium and iodine which, until this calculation, were conventionally thought to be the worst actors. These are rems per year. Technetium around one rem per year, around .1. Why? They're soluble and fission products, long lived, they don't scar very easily. They are not delayed in transport. They, in the current view, are released fairly easily from the waste forms. I question that, but that's the current analysis.

But neptunium-237 reared its ugly head, giving around 30 rem per year and that reflects the fact that in selecting the parameters for solubility, it was not pinned down and so they bent over backwards conservatively to establish your range and a very uncertain probabilistic distribution and as a result of that they came up with pretty high doses.

I'm glad to see that in the current calculation, those doses have gone down but they're still in the rems per year range.

Does this mean the Yucca Mountain is that bad? Not necessarily. My own work for this for the last 15 years has been on developing the source term using mass transfer theory for chemical engineering and I do believe that some of the ideas that have come forward on that will turn out to reduce the calculative releases quite a bit. Yucca Mountain knows about that. It takes times to implement these things and I have no quarrel with that.

Now, where did the 10,000 years originate? It originated from a mistake. And I don't mean to be critical. I make more mistakes, I think, than about anybody around and mine are very large, frequently. Here's what we learned. Draft 1 of the 10 CFR 141 -- 40 CFR 141 came up with 2,000 years and it was based upon use of toxicity calculations. The toxicity is simply you calculate, you take a given piece of waste, calculate its curies, changing with time and divide the curies by the MPC allowable concentration in water. You can calculate the volume of water that could be contaminated at drinking water levels. It's a way of estimating the potential danger from waste.

Now, here the toxicity and I apologize, this is not from my publication. We never called it a risk factor. It has nothing to do with risk. No probabilities. We call it toxicity. I didn't find my curve my so I brought this one along.

This toxicity is normalized. Normalized to the toxicity of the uranium ore that was mined to create the power that created that waste. All right? Here is the high level waste, actinides and fission products and you notice that the actinides are calculated to cross over the toxicity of natural uranium ore at well above one million years. But in 1981, the curve that EPA used was a curve that I published in 1975 with a colleague and at that time the toxicity curve crossed the uranium ore at 10,000 years.

When we saw that we objected strongly on two grounds. First, I'd published in 1980 a revised curve from which this one is calculated which said it should be 10 million years and not 10,000 years. Secondly, there's nothing fundamental by saying uranium ore is the proper reference.

In the 1976 study by the American Physical Society, we attacked that heartily. Uranium ore is not by any measure a safe standard for waste disposal. The water coming through uranium ore which can get saturated with some of the radionuclides is not anywhere near drinking water levels.

So, when we pointed that out to EPA, they dropped those justifications completely and in the second draft they came up with the idea that 10,000 years, beyond that, the uncertainty is too great. They may be right, but I would prefer to use the pools we have in hand, even now, to calculate uncertainty.

Some of you will recognize that uncertainty cannot be completely quantified. I'll say do the best we can and then add our instinct and judgment on top of that and then make a decision. That hasn't been done.

Okay, now there are various approaches. I'm giving this to you chronologically without any implications or motivation. I think all the people involved in this are doing -- want to do the best job they can.

In March, we saw 30 rem per year grater than a 1,000 millirems per year as a calculated dose from Yucca Mountain. In April, EPRI, Electric Power Research Institute, suggested predicting habits, locations, occupancy, food sources, future people and some of the suggested probabilities that they suggested and I want to point out they don't claim that they're right probabilities. They do have a thought process and a methodology behind those that they suggested and so I find them very useful simply to say here's the way it could happen and maybe we need to find a way of really getting probabilities.

We lower the calculated doses at 10,000. That's a very attractive reduction and allow greater concentrations of contaminants in ground water as a result, greater by factors of 10,000. I'll show you some examples.

And I'm going to follow on that on just one of the probabilities and this is going to get me into the congressional issue. Here are the steps in calculating the location probability. Now first, this is not just EPRI. In the August 1995 report of the National Research Council that I served on with Fred Phillips, says that there must be a method incorp rated for calculating the probability that people are present over the contaminated plume of groundwater.

EPRI shows us more specifically how they would do it. That was April 1994. Calculate the probability that a well will intersect the contaminated plume of the groundwater. That's the location probability.

Okay, now what I'm getting at is we have three bills in Congress, one of them is still surviving in the Senate and each one of them says the following: don't, they don't talk about limiting the dose to a reasonably maximally exposed individual. They talk about limiting the dose to an average individual in the vicinity. Well, I wondered is there something -- what is the average individual? I'm not sure what those words mean, but at least I've checked with the people I can, EPRI, NEI and some on the staff in Congress and it sounds like that's the average dose of individuals in the vicinity. At least I'm going to assume that for this discussion.

What is the vicinity? It's a circle of arbitrarily specified radius with a repository at the center. Let's assume now, and these are very simplified calculations. They're better than they may seem as I'll explain later. The plume of groundwater contamination is a rectangle of uniform concentration of width equal to the repository width. There's no dispersion at all in this calculation, no radioactive decay. It's a steady state source which will take many tens of thousands of years, usually, but not necessarily to achieve to steady state and so it extends from the repository all the way back to the edge of the vicinity. Let's assume that the -- there's no radioactive decay. It's a plume of constant concentration. And anyone involved in modeling will raise your hand as an objection to this and I will defend it more than EPRI has done in a few moments.

Let's assume the population density is uniform through the vicinity. I don't know what it will be. It's not likely to be uniform, but this is to show what could happen by invoking these probabilities.

EPRI's location probability then is the ratio of the rectangle area to the circle are, is assuming really that throughout the vicinity there are farmers, uniformly distributed, who want to dig wells. And maybe that should not be uniform for some of the reasons mentioned earlier. Here is the model like this. Here's the plume. And so what do we do? We calculate and assume a repository breadth of about two miles, a vicinity radius of 35 miles. You have to go at least 20 miles to find people, 35 miles is where the water reaches the surface, so you've encompassed the well digging area between 20 and 35 miles of the Amargosa Valley. And as has been pointed out by people in my county near the repository, state of Nevada, subsistence farming is a way of life in the area. It doesn't mean everybody has one, but there are subsistence farmers.

If we take those numbers, it's just a geometric calculation. The location probability is then .018. It's the area of the rectangle, divided by the area of the circle. People outside the rectangle get no dose at all. People in the rectangle all get the maximum dose. They're all subsistence farmers.

Therefore, .018 happens to be the vicinity average dose divided by the maximum dose. And it's the congressional legislation that proposes to limit this vicinity average dose.

All right, we'll see what would happen. If you then take these numbers, the maximum dose would exceed the vicinity average by a factor of 56. If we were to allow 100 millirems per year average dose which is also embedded in the legislation, that would allow some people to get 5.6 rem per year, maximum dose. And if we can knock off the neptunium problem at Yucca Mountain that would say, seem to say everything is okay. Not by a very large factor. Actually, this is so unrealistic because a lot of people in this vicinity would not be subsistence farmers and if we want to get the dose ratio we must take into account that those people who get through, that's uncontaminated from the outside also get no dose. If they're only 10 percent of the people who are subsistence farmers would dilute the ratio which we dilute the average dose which means the maximum to average goes up by a factor of 10. That may seem unphysical or counterintuitive, goes up by a factor of 10 because you diluted the average by a lot of people who ingest no radionuclides whether they are in the rectangle or outside.

If you allow then 100 millirems per year to the average, you're allowing a concentration in the groundwater that could increase the -- from 56 to 560 times greater than if you limited the concentration on the grounds of a subsistence farmer.

Now that's not the only issue. EPRI also has discussed various things that could contribute to even lower probabilities of getting the subsistence farmer dose. The one that -- and I'm going to call these habit probabilities and they with some logic have created the habit probability based upon small surrounding population using current technology for what? For detecting contaminants in ground water and for mitigating any consequences of contaminated ground water.

Now I'm not -- I wouldn't be very comfortable about accepting that philosophically because I've always thought that the goal of geologic disposal is to insure future people don't have to protect themselves. Furthermore, we have pretty darn good techniques of detecting contaminants, radionuclides, chemical contaminants now and knowing they're there doesn't necessarily mean that we can do something about it. Contaminated ground is hard to deal with. Look at the program at Livermore, for example.

But, in the Las Vegas meeting, the person who was presenting the viewpoint of the TYMS panel also pointed out that our calculations are much too conservative if we don't take that probability into account. I disagree, but my point is to show you the thought processes of very responsible people when we start getting those probabilities into the picture of human habits, future human habits and what they can do to the implementation of a standard.

Suppose -- this is the topic of typographical error. This should be large populations advance technology. There, the probability goes way down. Better technology for mitigation which ma certainly occur in the future. Secondly, a large population like a city of Las Vegas has a greater force, a greater infrastructure, strong health department, clean up systems, to be sure that any contaminated water is cleaned up and that's the logic for having that probability about 30 times lower than that for the small population.

When you multiply these two, you take the ratio of the vicinity average dose to the subsistence farmer dose, .002, .47, take the reciprocal of that is our ratio of subsistence farmer to the vicinity average ,500 to 14,000, subsistence farmer average dose and I've left out the factor of 10, taking into account people who are not subsistence farmers on average. So you can multiply these numbers by 10 or whatever you think that rati› is.

That gets you into very high doses. This is a bizarre result, isn't it? It shows that you could get into doses that are so high that they would be acute and surely there must be something wrong by that.

There's another way of interpreting this is that -- and this is what I really fear, that by getting into this business of using probabilities which we are very uncertain about, we are in effect relaxing the performance requirements. Remember, I told you Yucca

Mountain's 1994 estimate of the RMEI dose at 5 kilometers was 30 rem per year. Okay, if I use the -- those probabilities from previous table, if the population surrounding the repository is small population current technology, we would see the vicinity average dose reduced to 60 millirem per year and that would meet Congress's proposed dose standard for the average. We would say everything is okay.

If the 100 millirem per year falls by the wayside because of the things I mentioned earlier, we talked about 10 millirems per year, then that would reduce -- I'm sorry, I'm getting out of order.

Let's take the same data. Large population, advanced technology would reduce the calculated vicinity average does to 2 millirem per year which is below what I say is the normal dose level that we look for in geologic disposal.

Incidentally, I don't think it's at all reasonable to say if I go to an allowable level with 10 millirem per year we calculate 2 millirem per year, that is safe. I would want an uncertainty analysis, not just the expected value of the dose.

The main message is the ideas of using probability can get you in a long way from public health protection. These would say that the repository is safe with an RMEI dose of 30 rem per year. We know that's wrong.

All right, now let's get more into specifically into your issue of critical groups. The International Commission on Radiation Protection has indeed and it came up with this definition of critical groups, mainly historically for operation of facilities. This has been very useful. You can survey the population. You have may be a facility lifetime of 30 years. You can pretty well make an honest projection of what it's going to be like.

And so they want it to include the persons with highest calculated dose. They don't mean the TUBE dose or the person with the greatest sensitivity. That interpretation has been tested enough. We know they don't mean that. So I think they mean the reasonably maximum exposed individual and persons whose doses are within a factor of 10 of the highest dose and then compare the calculated average dose of that critical group to the dose limits.

Well, do they expect you to do that in geologic disposal? In two different reports they have said in geologic disposal we will be looking so far in the future, if there's a great uncertainty of the meaning of this and they suggest, they don't say you should do it, they suggest for the long-term future where you cannot identify habits and location of people assume a critical group is a single, hypothetical individual. In some countries, to be very careful this is understood, call it a reference individual, a reference group. And with that interpretation I can say with confidence that every country I know of and I don't know about Russia, working geologic disposal, Sweden, Switzerland, Finland, UK, Canada, Japan and I just have left off a few, believes that this is the interpretation of ICRP and the hypothetical individual is reasonably represented by a subsistence farmer. Look at their work. That will tell you their practice. You won't find it in the regulations because some of them properly are not codifying this yet.

VICE CHAIRMAN GARRICK: Let me challenge that a little bit on the basis that just because and you and I have talked about this, just because the other countries are doing something, that -- it certainly doesn't follow from that that we shouldn't be reaching for a better representation of the problem and I can harken back to our original occupation in reactor safety where until the late '70s, every country employed a design basis accident approach to calculating reactor safety.

Clearly, we have determined that that's a very narrow view of what reactor safety is all about. Is there not a possible parallel here?

MR. PIGFORD: Oh, of course. I fully agree. That's not sufficient argument. But it tells me that we didn't do it without a reason, without thought and I've been involved with three of the countries in this. There's a lot of thought behind it and we should look into that and learn why.

There are also lots of mistakes. None of them are yet getting into the proper kind of uncertainty analysis of the UK approach, is getting closer. So I fully agree with you and that gets back to my earlier remark. I don't believe we can specify now what is the best approach.

All right, now I must talk a little about the National Research Council report. I've talked so much about it and written so much about it that I think it's probably boring. If you want to save time, tell me to go into criticality and into ground explosions. But I will continue until you do that.

CHAIRMAN POMEROY: I will tell you you need to terminate in about 5 minutes.

MR. PIGFORD: All right, now it's been properly said this morning, the panel believes there's no scientific basis for predicting habits of future people. I agree with them.

However, they do endorse a probabilistic calculation and the reasons for it have been stated. It gives you -- well, I won't try to state the reasons. It ties it to current population.

In my mind, the real question is how do you translate data in current population to predicting the probability of subsistence farmers on non-subsistence people living closer to Yucca Mountain, how do you predict it? More precisely, getting water that is extracted closer to Yucca Mountain.

Frankly, it doesn't make any difference where you live and in the West we transport water. It doesn't make any difference whether the land near Yucca Mountain is arable or not. It does make a difference on how deep you have to dig, but it would be wrong to assume that future wells will be no deeper than those now in existence which has been one of their proposals, although in fairness, not mentioned in the report.

How do you make that translation? And really, what is it we're supposed to translate? We're supposed to come up with probabilistic distribution of future people. Are we attempting to make a prediction of a probability of a subsistence farmer will occur? If we do, what are we going to do with that result? Are we leading ourselves to the question what is the probability that an average person will get the dose of the subsistence farmer? I don't know. To me, it's an enormously complicated area.

However, what is not complicated is the methodology of doing it if hypothetically we were able to calculate probabilistic distributions and I don't mind if you take a reference population, but you still have got to extrapolate. Unless you want to just say those people are static and I don't find that proposed. They want to take it up to the gondras of Yucca Mountain.

Here's the way you would calculate the ICRP critical group on the basis of a dose,if you had dose probabliistic distributions.

You would calculate Monte Carlo realizations of dose for all people in the designated vicinity and my goodness, sure, it extends the hydrologic model, but we're into that already.

It probably would require more because we know by intuition that if you simply use the subsistence farmer, you would concentrate on regions near the Yucca Mountain and I wouldn't go out to further regions except to check on whether there are any preferential pathways.

Calculate the expected value of dose for each person in each location at a given time from each realization. No, you cannot calculate the risk. You can calculate the expected value of the dose and its consequences. And already all your probabilities are in number. Like order, those expected values are doses and pick the ones, exclude those with individuals with unusual diets and sensitivity and select those who have the maximum expected value and all others who are within ten fold, take the average and then question whether it was worth doing in the first place because the average is not going to differ from the maximum, much more than two or three, unless you have some extremely unusual distribution within that factor of 10.

VICE CHAIRMAN GARRICK: And the uncertainty may be 10 to a thousand?

MR. PIGFORD: Yes. I'm going to stop on this. There has been -- I had something to say about the mathematical errors which do exist.

VICE CHAIRMAN GARRICK: Probably for our purposes, Dr. Pigford, we could certainly minimize that treatment because I think all of us at least the members of the Committee have read your papers and the letters that have been written with regard to --

MR. PIGFORD: Okay, I think it's an issue that has been overblown and I want to put that in perspective. In my dissent, yes, I observed that there were mathematical errors and I mentioned one of them. Entirely unknown and independent of me, a professor at the

University of California where I work and I didn't even know him, I never met him, who is a statistician, highly respected, wrote to Dr. Alberts, he read the report and I don't know where he got it. I didn't give it to him. He pointed out that there were some mathematical errors. Dr. Alberts replied to him, he wrote another letter and in his view, in my view, those letters still exist.

Recently, a staff in the Senate committee on Government Relations wrote to Dr. Alberts about that. I finally because it seemed the thing was not converging, wrote a recent report which is available that shows in detail where they are. I think I'll let it go at that.

So in conclusion, there are possibilities of criticality underground which I'm not going to talk about unless you have some questions and there are lots of other views that have been expressed on how to use what items could affect probabilities if you go into the probabilistic calculation and it's those views that bother me. I've given you one example in terms of detecting and cleaning up groundwater for the future.

Some people say look at Yucca Mountain. We'll find subsistence farmers. The two methods will converge. You'll have subsistence farming in every area. I don't believe that. These other views of extrapolating probabilities can change it enormously. That's why I think the two methods do not necessarily converge and we have the danger of initiating something in radiation protection, not just for geologic disposal, but for all of us that we'll regret.

I'm an enthusiast for Yucca Mountain. I've contributed to it. I'm proud of it and I think the worse thing that -- the thing it least needs is a standard that cannot survive attack and careful review and questioning. It must all be transferred. We have hopefully only one shot on it, get into licensing, get it out to the public and my humble opinion from service on similar committees as yours and on the licensing boards, it wouldn't have a prayer in the world if we try to go into these probabilistic analyses of human activities.

Thank you.

CHAIRMAN POMEROY: Thank you, Dr. Pigford. Are there questions from the Committee? Further questions from the Committee?

MEMBER STEINDLER: How much time have we got?

CHAIRMAN POMEROY: I'll give you -- just realize that it's coming out of your lunch hour, lunch half hour.

(Laughter.)

MEMBER STEINDLER: Tom, the discussion this morning indicated that the probabilistic approach that was outlined albeit somewhat briefly in the National Academy report had built into it the limitations of what I guess some people would call common sense limitations that would avoid the same kind of difficulty that you've clearly illustrated in the EPRI model or EPRI protocol, namely, in effect, the ratio of maximally exposed individual to the average is not allowed to drift as far as your table of calculations would indicate from the EPRI model. Doesn't that allow you to inject what I guess I would call a reasonable bounds into a probabilistic calculation so that you don't come up with the kind of absurd maximum doses of the kind that you numerically get simply by dividing the 100 millirem or whatever the standard is by this very small number? Isn't that an adequate protection or bound to the probabilistic calculation?

The thing I'm concerned about is that you've, in effect, I think the message is you've said look, probabilistic calculations are not the way to go.

MR. PIGFORD: In terms of human activity.

MEMBER STEINDLER: Right.

MR. PIGFORD: We're up to our necks properly in terms of what we can calculate.

MEMBER STEINDLER: Yeah. And you're not convinced, is that correct, that the bounds that the committee put on the ratio, for example, maximum to average, which is a factor of what, 10, for low -- for average dose which is fairly far below the standard limit and reduces itself to a factor of 3 when you get close to the, whatever the standard is, if the standard is 100 millirem?

MR. PIGFORD: I don't think, my view is, that only -- it doesn't limit the maximum. It only limits the range with the maximum as the upper part of it. And if you want the average it's some place in between 1 and 10.

I have questioned what is the purpose of that? We don't know things that precisely for geologic disposal.

I know trying to make a different point that it limits the maximum. I don't know how it does. Well, it does in what I would call arbitrary administration decision basis. You pick a number, 10 or you pick a number 3 and in that sense that's an arbitrary limit. That simply puts a calculational bound on it.

Suppose, for example, out of all of this we decide the probability of there being a subsistence farmer in a given generation is .01. Would you say then that that let's us drop off the subsistence farmer dose and take .01 of his dose as the upper part of our critical group? No, I wouldn't either. And that's what I"m afraid of.

Because the subsistence farmer is still there and ICRP has never told us to drop someone, however, they do tell us as was properly said, don't take the extreme. Well, we don't know what the extreme is. And if you had a place, a vicinity, that couldn't be subsistence farmers, you have a pretty good argument.

But remember, it's a hard thing to get into. The time of the maximum concentration in these calculations extends for many tens of thousands of years as if it were a flat top. That was a log scale issue. If you take the approach that you want to include the reasonably maximal exposed individual as we have defined, it says that will he exist during that time if your objective is to protect people for the future and that's a political decision, if that's your objective.

So I worry a lot about devices that can drive him out of the picture. The only argument that's been given besides what I coin to be the incorrect interpretation of ICRP is the subsistence farmer is too extreme. Well, I think it means that those people who wrote that thought it was too extreme, but I don't know why. That's why I urge you, find out why these other countries are still living with us more and more, why we are doing that in other projects in this country. There are reasons.

CHAIRMAN POMEROY: Are there other questions, short questions?

VICE CHAIRMAN GARRICK: I have lots of long questions, but we'll cover those at another time. Let me ask a question of you, Tom. Are you convinced that the decision to go to a Yucca Mountain specific standard was a good decision over the implementation of 40 CFR 191?

MR. PIGFORD: Well, you've given me two choices, neither of which I like. First, on the first one. We say it's a Yucca Mountain specific standard. Look, we're kidding ourselves. It should have logic in it for public health protection. If it has that logic, its' going to be adoptive to other projects. There's no way we can assure our scientific community, let alone the public that logic has such boundaries. That's why this is such an important issue.

All right, what about 46 CFR 191? I have been on record many times, as you know, of saying because I wrote the report that showed how EPA derived those numbers and the assumptions are too simplistic. It says nothing about the local community, the local environment. It's a world-wide average of where surface water is used.

It would allow the release of all the iodine-129 from the repository, if no other radionuclides were released whereas from the dose calculations, iodine-129 in many calculations is the number one individual dose contributor. I think the neptunium one maybe will go away.

However, and I haven't said this before today, but a deficiency in just the individual dose is that it ignores the very important considerations that when a large number of people that even a lower dose, that's worth worrying about. That's the Northern Hemisphere average that was the 40 CFR 191. The Northern Hemisphere average in the regulation some 18 years ago for commercial reprocessing plants, why we had to stop emitting radionuclides. There's logic in that and that logic has not yet been implemented how it's missing in the individual dose, so I say individual dose is not sufficient.

I believe there is a good mathematical approach to that logic. Rather than the rectangular plume, I'm into calculating as best as I can the real plumes and if you ask me a question I can tell you why the rectangular plume is a good approximation. But we would be able to calculate the amount of alfalfa that is grown. What happens to it? It goes to other countries and is fed to cattle which is eaten by people. We can follow these things. Sure, it complicates the project and that's the balance that has to be made, but we don't have to decide on all of these issues now. Put them down as considerations and ask that they be part of the safety analysis.

CHAIRMAN POMEROY: I think we have no other questions, Dr. Pigford. I hope you'll excuse my termination of this extremely interesting discussion. I do want to assure you that this Committee is going to delve much deeper into the investigation of some of the ideas that you've brought up and I'd like to thank you very much for talking to us.

We're now into -- we have on our agenda an approximate 15 minute time frame for wrap up discussions and other types of presentations and Dr. Phillips has asked to speak to us briefly at this point and I would like to ask him to do that.

MR. PHILLIPS: First of all, I'd like to give my perspective on Tom's comments here. First of all, I'd like to start out by saying that I think there's a lot of areas that we are in very considerable agreement on. I agree with him that there is no need to -- that there's been too much hurry and rush in trying to accomplish everything. I think if it's possible to take a slower approach and a more deliberate one, we'd end up with a better result. I also think it would be desirable not to have to have a strict numerical type of standard which would be quantitatively calculated and then sort of a yes or no answer. Unfortunately, I think it's been our social and legal system that that's the way it's going to have to work.

I agree with him about the 10,000 year limit issue and I agree with him that it would also be desirable to have some measure of the uncertainty of the analysis in the compilation of the result, although exactly how to be debated.

However, I would like to strongly disagree and state that I think the one important aspect has been considerably misrepresented and this is the relationship to the EPRI presentation that was made to us during the course of committee deliberations and I'd like to say that I certainly, I personally and so far as I know the rest of the Committee would most certainly not endorse the EPRI model as anything remotely resembling an adequate model for assessment of compliance to a standard. It's an extremely simplistic model and this business of dividing the circle of arbitrary radius and dividing up the area, I see no justification for the inclusion of things such as detecting and mitigating contamination, are not things that we propose to be included at all. And I would vehemently object to a model like the EPRI model being employed for the final compliance assessment.

And so to put something like this in the space of a handout here, no other country has adopted the NRC/EPRI proposal, I think is extremely misleading. There's no NRC/EPRI proposal.

A second thing that I think deserves comment is the issue of predicting the phrase that's frequently used in here and verbally, "predicting future activities" or something like that. I think our report was very clear that we don't see that there's any basis for predicting future activities and that any exposure scenario that's used should be considered to be a benchmark and this is true every bit as much of the subsistence farmer who is a subset of the present population in the area as it is of a more representative distribution of the population in the area which is what we propose to use.

The subsistence farmer, as used, he's not an unrealistic individual at the present moment, but he's a very specialized sort of individual. It's not like an aborigine that could live out there for thousands of years in an essentially static social type of thing, some sort of equilibrium level of society. He's a person who has enough technology to go out and drill a well hundreds of feet deep and pump it and yet who doesn't do most of his shopping and eating of food from the supermarket. He grows his own food. I'm not saying that the person is unreasonable or that it is artificial. It isn't. I think that it's a proportion of the population to be considered, but my point is simply that it is no more some sort of independent ballot representation of people who might be affected by the repository than is the more general representation of the population that we propose.

Finally, the -- oh, I guess one additional thing on the question between the probabilistic critical group approach and the subsistence farmer approach. It's true that the subsistence farmer is a more recent -- I'm sorry, the subsistence farmer has a longer history of application in the radiation protection field, but that doesn't necessarily mean it's better and I think that part of the reason for calling a committee, such as the TYMS committee, by Congress, is to explore and say, can we think of a different way of doing this better than it's been done before? It is a group that is not bound closely to previous precedence, so I think it's part of our responsibility to consider innovations that might be improvements on the way of doing things. My personal opinion is that it is a considerable improvement over previous way and I'd like you to consider it not so much in the viewpoint of what people in Sweden do, as the viewpoint of what is the best way for us to do it, maybe Sweden has reasons that we should consider, but I think we should ultimately base our decisions on what's the best way to do it.

Finally, let me touch on the question of errors, and so-called mathematical errors in the appendix to the report describing the procedure for the calculation of dose to the critical group.

These, to my mind, are not matters of real substance. First of all, as I pointed out carefully in my presentation before, our outline was intended to be illustrative of an approach. It was never intended to be prescriptive of a detailed procedure. That was left out. We consider that the job of NRC and EPA, not the job of the Committee to write a detailed procedure. So I hope that it would be interpreted in that spirit. And just to give you an example of the things, the one that's been discussed the most is this one of the size of the areas. And we had a sentence in the report that said the resolution, something, I'm paraphrasing here, the resolution of the model should be such as to account for the spatial variability of the dose.

Now, just to me as a person who produces models, uses models a lot, if somebody says the resolution of your model is not accurate, is not adequate, my response is I make the resolution higher, I don't make the resolution coarser. But if you interpret that statement to mean that you can make the resolution as course as you want to, yeah, then it's an error, but to me that's sort of silly to argue about those sorts of things. There are substantial issues that are involved here and the real fundamental issue is are we going to try to offer assurance protection to the most exposed person or are we going to try to offer a limitation of risk to a group of the most highly exposed, but not necessarily the very most possible highly exposed individual? Those are really the questions and I mean there's good arguments on both sides of that question. And I certainly would never say that it's an open and shut argument. And I think that those are really issues that you need to consider and if you come out on either side, there's improvements and better ways that the details of the models could be done than either of the appendices that were presented in that report and I would expect that the NRC and EPA would come up with improvements to it, but to me that's not the fundamental, central or critical issue.

Thank you.

MEMBER STEINDLER: One quick question.

CHAIRMAN POMEROY: Thank you, Fred.

MEMBER STEINDLER: Am I allowed a quick question?

CHAIRMAN POMEROY: Yes, Marty.

MEMBER STEINDLER: One quick question, do you believe that subsistence farmer is a person with special habits and comes under that umbrella of folks that you normally would exclude, if there is only one subsistence farmer in your entire population?

MR. PHILLIPS: I would not. Talk about persons that you would exclude I --

MEMBER STEINDLER: I'm using the same criteria of unusual habits.

MR. PHILLIPS: That's right. I understand exactly what you're referring to. To me that would have to be something that is truly anomalous and extreme, for example, a person who has some genetic, rare genetic susceptibility to radiation, something like that. Okay, and so far as I'm concerned the subsistence farmer is a tail on the distribution of lifestyles that's presents and as such he should definitely be included in the range of characteristics of the inhabitants of the region and the importance of the subsistence farmer would be proportionate to representation in the population.

MEMBER STEINDLER: Okay, so the importance is related, in a sense, to the fraction of folks or the fraction of the geometric area that is involved in that kind of activity? Is that what you measure?

MR. PHILLIPS: Yes, in other words --

MEMBER STEINDLER: I think that's -- my

perception is that that's precisely where Tom might argue otherwise. Tom looks at the guy and says this is a guy with 56 rem and therefore you must pay attention to the 56 rem, not because he occupies 1/50th of the area that you're including in your most exposed population.

MR. PHILLIPS: That's right, and again, that's a very legitimate argument and it's one --

MEMBER STEINDLER: I'm just trying to understand where the differences are.

MR. PHILLIPS: But I'll come back to my analysis of airplane travel, you know, however many people were on the airplane Valujet flight that went down in the Everglades are very, very dead and they are real people, children and spouses, all the rest of it, and their risk in the general sense was no worse than anybody else, but the bad consequences were definitely on them.

CHAIRMAN POMEROY: Great. Thank you, Fred. I'd like to thank both of our speakers, post-break speakers and in fact all the speakers this morning for their efforts to stay on schedule. We're relatively on schedule.

The Committee will now take a one half hour recess and we'll reconvene at 12:30.

(Whereupon, the proceedings went off the record at 12:02 p.m. for a lunch break.)

A-F-T-E-R-N-O-O-N S-E-S-S-I-O-N

(12:38 p.m.)

CHAIRMAN POMEROY: The meeting will return to order. I think we had order before. Our first speaker this afternoon, just back from the lunch line, is Ray Clark. And welcome as always, Ray. We're going to have a touch on the perspectives of the Environmental Protection Agency on the reference biosphere critical group.

MR. CLARK: As you can see by the package in front of you which is hardly a package, we'll get you back on a schedule. I'll start with my usual disclaimer. We have not yet -- there's a recorder here. I'll start over. I'll start with my usual disclaimer that since we haven't yet proposed Part 197, our Yucca Mountain standards, unfortunately, frustratingly to some extent, I can't get into what we're doing there.

What I've brought is a very short synopsis of what I've been able to find in the agency regarding critical group and future biosphere. As far as critical group in the agency, it's never been used before. It wasn't used in Part 191, the generic standards for high level waste and spent fuel.

There we used the off maligned this morning maximum individual. I think the standard read any individual in the accessible environment, accessible environment being the five kilometer region that we've all come to know and love. But what compliance criteria, which is more recent, Part 194 didn't use critical group, which makes some sense because that's an implementing standard for Part 191.

And the other -- as I said earlier, other programs in EPA, as far as I can tell, have -- do not and haven't used the critical group concept. And I guess I should say critical group here is the same critical group that we were talking about earlier this morning that everyone's brought up so far.

The Superfund program does use the concept -- Dr. Pigford here at the moment -- that he brought up and fairly well described this morning. This is a concept where you try to, I guess, use judgement. I'm not in the Superfund program, so I hate to speak for them completely. But you use some judgement as to what a realistic dose might be in the spread of -- or potential spread of doses that people could get.

And the way they seem to do that -- and here again, like I say, I'm not in Superfund and I've never been in a situation where this has been implemented. But their description of it is they use parameter values -- well, do a sensitivity study to find the most sensitive parameters. You then maximize some of those parameters --

parameter values, and keep others at their average.

And this way you try to get a dose or an individual dose that's above the average but below the possible maximum. So I think you're something similar to critical group in trying to identify an individual who has a high -- relatively high exposure but not the highest possible. They don't go into things like taking the top 10% of the distribution dose and dividing by three or dividing by two or some factor like that.

But they do attempt to get in that same ball park, I think, is how I interpret their program. Really that's about all we have on critical group.

As far as biosphere, or future biosphere -- I think that's the only difference in your handout from this overhead. Again, as far as I can tell, the agency doesn't explicitly consider future biosphere or hasn't addressed it anyway. Many of the -- well, under same Part 191 and there again the RCRA Superfund area, we didn't address it, as I say here explicitly. I guess there's kind of an implicit assumption that probably similar conditions that they are today.

But in both places, we tried not to make -- say this the right way. We tried not to make biosphere the center of the analysis, or at least future behavior. We thought it was more important to consider down here in the compliance criteria, the bottom bullet there -- it's more important to consider hydrologic, geologic and climatic changes than it is to try to simulate what I think is generally agreed almost infinite possibilities of what could happen in the biosphere.

So in the WIPP criteria, the characteristics were required or maybe assumed to remain what they are at the time of compliance. It's presumably today's climate. Hopefully that won't be 1,000 years from now in determining compliance. I think that's about all we have, although we are at this point -- as I say, it's somewhat frustrating for me and for you that I can't get into our Yucca Mountain standards at this time.

I'd be happy to try to address any questions.

CHAIRMAN POMEROY: Well, thank you, Ray. We appreciate the difficulties under which you're working, believe me. My request is that the committee would like to pose --

MEMBER STEINDLER: Yes, you must have used a critical group, Ray, unless your -- the old Table 2 in Part 191 -- Table 1, Part 191 was totally arbitrary. You must have done some calculation based on dose. You know, reduction -- limitation of cancers to 1,000 in 10,000 years had to involve some kind of population. Now that -- my sense is that that critical group was the North

American global population.

You see, I guess you assumed infinite dilution or whatever. But you can't do dose calculations without assuming some kind of critical group. The issue is what is it and how far does that group deviate from the ICRP standard.

MR. CLARK: My understanding -- if that's what you considered -- yeah, sure, there was a --

MEMBER STEINDLER: Target group.

MR. CLARK: -- population. In the calculations it all divided out, so we didn't come up with a specific population, as I recall. But if you -- I think if you follow the -- I guess the ICRP definition, it's no more than a few tens of people in what's usually considered critical group. So, in that sense, no.

MEMBER STEINDLER: Okay, well let me shift the definition from critical to target. You must have used some kind of target group for which you did dose calculations. And I presume that that's always done, isn't it? I mean, isn't there a target group for arsenic in drinking water or aflatoxin in peanut butter. You guys set limits on a lot of different things.

There has to be some kind of a methodology that's used the by the agency, isn't that right?

MR. CLARK: It's difficult for me to speak for the agency, like your peanut butter comparison. I would guess -- and this is strictly a guess, that that's probably an individual risk on those sorts of things.

MEMBER STEINDLER: So in that case, it may be a true critical group of one person?

MR. CLARK: Okay.

MEMBER STEINDLER: The agency's been accused of using force fed rats as the critical group for a lot of things. But I don't think we're quite focusing on that.

MR. CLARK: Well, unless you wanted to force feed people.

MEMBER STEINDLER: That's a lot of peanut butter.

MR. CLARK: Well, sure. I mean, that's -- I don't think we need to get into the --

MEMBER STEINDLER: Yeah.

MR. CLARK: -- extrapolation from animal to human exposure data. Sure, I think on a site specific basis, you come closer to probably identifying the critical group. In our generic standards, it's -- it would be difficult, I think, for us to try to do that.

MEMBER STEINDLER: Does the EPA make regulations on a site specific basis?

MR. CLARK: In radiation? Not until WIPP came along, no.

MEMBER STEINDLER: Yeah.

MR. CLARK: I'm just saying in general, I think it would be easier than in a generic standard where we had to consider potential facilities anywhere in the country, which is considerably different -- or considerable variability in population demographic.

MEMBER STEINDLER: Does the EPA view the ICRP approach to be useful and reasonable?

MR. CLARK: Like I say, we never used it before. It's a consideration, but I think at least in the past there's always been the problem of trying to define what the critical group is. I think there has been some hesitance to use it because of the possibility of abuse if you were to go beyond these few tens of people to 1,000's of people.

You'd start diluting maximum dose, that sort of thing.

MEMBER STEINDLER: Yeah.

MR. CLARK: That's my understanding of where the --

CHAIRMAN POMEROY: Ray, just help out my memory. After -- when the 197 does leave the EPA, that thing goes to OMB, is that essentially correct? And is there some time frame that they have to work with in theory anyway?

MR. CLARK: Thank you for that. In theory, 90 days.

CHAIRMAN POMEROY: In theory, 90 days?

MR. CLARK: Right. That can vary from anywhere from, I suppose, one day to 90 days and beyond.

MEMBER STEINDLER: And beyond.

CHAIRMAN POMEROY: And beyond.

MR. CLARK: But in theory, 90 days.

CHAIRMAN POMEROY: Go ahead, Bill.

MEMBER HINZE: Ray, in 191, speaking about the accessible environment, was that assumed that it was the present condition?

MR. CLARK: You mean in developing it or in implementing it?

MEMBER HINZE: And in implementing it. Or thinking about implementing.

MR. CLARK: I'm not sure it was explicitly stated in that term, but I think implicitly you could say it was probably present day. I can't think of any -- with the exception of population, which may be as high as ten billion of the world population. Otherwise, I think implicitly it probably was today's condition.

MEMBER HINZE: So implicitly the feature bias there was assumed through the accessible environment -- equivalent to what is present?

MR. CLARK: I think so.

MEMBER HINZE: All right.

MR. CLARK: With the exception of the climate part, which we certainly wanted people to address.

MEMBER HINZE: Sure.

CHAIRMAN POMEROY: Okay, I guess -- thank you very much, Ray. And we hope that someday we'll be able to see you soon when you can speak to 197.

MR. CLARK: That's when I'll wear my Kevlar.

(Laughter.)

CHAIRMAN POMEROY: The next item scheduled on our agenda -- written on our agenda was Steve Brocum from the department -- was to be presented by Steve Brocum from the Department of Energy. As you noticed, we had invited him. At that point, we hadn't a response. We do have a response. The Department doesn't wish to present any further information on the reference biosphere or the critical group at this point in time.

And they have thus with that master stroke saved us a half an hour of time.

MEMBER STEINDLER: We could have had a decent lunch!

CHAIRMAN POMEROY: No, because we need the time at the end of the day. We'd like to proceed, and if Dr. Kessler is here, we'd like to hear the perspectives of the Electric Power Research Institute by Dr. John Kessler from EPRI. Welcome here, Dr. Kessler. The floor is yours as soon as you put on the microphone.

We're very interested in your perspectives, and I know that you've been associated with William Smith in some of these activities, and we'd be interested in any perspective you might want to offer that he might have had had he been here.

MR. KESSLER: Thank you, and after this morning's discussion, I'd be very pleased to give my perspective.

(Laughter.)

I was certainly going to cover a couple of topics. I do intend to cover them, although obviously after this morning's discussion, I would like to provide some insight as to what we were doing with those calculations, why we feel they are not all entirely unreasonable -- what other vilifying words did I hear this morning along those lines that I felt that what we're doing is not completely irrational or whatever.

And certainly what I do want to talk to you about, since I did have a limited amount of time, was just the critical groups portion of what we're talking about. Specifically the who, when and where from our perspective based on what we think society may be telling us in this regard.

I'll just go straight to the two main arguments I'd like to leave you with today. The first one is is that the individual numerical limit needs to be based on the local population average. We still believe in that. We think that's reasonable. And the point I'm trying to make by making this statement is that they go together. What the numerical limit is and what the critical group is or that the population that you're targeting go hand in hand. You can't separate the two.

The second point I'd like to make is that for the characteristics of the critical group, Amargosa Valley as it is today is all we need and all we should use to define the characteristics of the critical group. Now, I'll go on to try to support those two arguments.

I'd like to begin by backing up a bit and just sort of asking the general question well, why is it that we perform dose assessments? Well, from a licensing standpoint, you could just say well, why we perform dose assessments is to demonstrate quantitative compliance with the regulations. Certainly that's the most straightforward answer that one could give.

In addition, you do dose assessments perhaps to show trends and sensitivities. What is dose versus time? Well, what if the permeability, as Tom mentioned, was some other number versus this number? Now what would happen with dose versus time? That helps in design, it helps focus DOE's money in the sense of, you know, being able to go after those key uncertainties or sensitivities that are out there in what to do.

Well, both of those really are going towards assuring that the site is safe, assuming you've got a good site. What you want to do with all that information is show that the site is safe. Well, who is it you're assuring? Certainly the regulator is one. The regulator is -- the regulator will look at some sort of safety philosophy, and Fred Phillips sort of alluded to that this morning in his talk, this idea that there is a safety philosophy.

And certainly EPRI supports that idea. In addition, you're trying to assure the public that the site is safe. And I would tend to argue that the public will only be assured the site is safe if they understand the safety philosophy and they generally accept it. But in a general sense, that's why one performs dose assessments.

Well, what is it that dose assessments do not do? We already heard this this morning, but I want to reiterate it. Dose assessments do not predict the future. They're stylized scenarios based on a lot of assumptions, a lot of assumptions and uncertainties. We try to make them as reasonable or as realistic as we think we can on the -- to make it as site specific for Yucca Mountain as we can, but there's still a lot of assumptions and uncertainties there.

Some of those assumptions and uncertainties are testable. Some are completely untestable. Critical groups clearly falls into that untestable assumptions and uncertainties category. The mix of assumptions and uncertainties between the testable ones and untestable ones will always be there. You can do sensitivities where you look at just the testable ones, but the untestable ones are always in the background or the foreground, wherever you choose to put them.

But they're both there. The subjectivity and uncertainty demand NRC input. First of all, there needs to be a clarification of what is this assessment philosophy or really the safety philosophy that goes into assuring that a site is safe. That needs to come from NRC or even from, in this case, maybe the legislators from the legislation that's out there.

But this sort of idea of what is the philosophy needs to be there. NRC needs to certainly have some input on what reasonable assumptions are based on this assessment philosophy, and we feel that this is certainly an iterative process as DOE proceeds on down the road of demonstrating safety really for the Yucca Mountain site.

Well, we think that this philosophy implies some critical groups and numerical limit musts. We think they both are linked together, and that they both have to be consistent with whatever assessment philosophy is chosen. In addition, they need to consider site specifics as necessary. And finally, they need to consider licensing realities.

And that was brought up quite a bit in the time frame of the regulation. That is, when you go and do an assessment, how long are you doing it for; what is it that your public hearing process requires you to demonstrate. That's what I had in mind when I was thinking licensing realities there.

So you start with what I think is needed, which is a clear assessment philosophy. I put down here a couple options from an infinite spectrum of possible safety or assessment philosophies that are out there. One -- these two labels, cautious and equitable, were -- have been chosen by the reference biospheres working group within BIOMOVS 2, an International Biosphere Modeling Organization, in a report that they're writing on critical groups and trying to make some general recommendations on critical groups.

And just for illustrative purposes, they came up with these two definitions of different kinds of regulatory philosophies that have a clear bearing on the kinds of critical groups and numerical limits you might want to go forward with. The first one is cau ious, which is protects almost everybody. That's sort of a cautious but reasonable -- certainly we see that in ICRP and in most of the NAS recommendations.

That would sort of fall -- you see those words for cautious there. However, there's another one out there which the group has termed equitable, which is protect a widely -- to a widely tolerated risk level, and I'll get into that in a minute. By choosing these two terms, the reference biosphere working group admitted that the English language was failing them.

If you choose an equitable approach, it doesn't mean you're not being cautious. Contrary, if you're choosing a cautious approach, it doesn't mean you're really choosing something that's inequitable. There was just no good words that the group could come up with to talk about these. The idea is it's from a spectrum of philosophies.Certainly you could pick something in between.

I'd like to -- since we've heard so much about what I am terming here the cautious philosophy, I'd like to spend a few more minutes talking about that equitable philosophy because this is what's guided EPRI in their approach a bit more.

When I say equitable, really I'm talking about what are tolerated risks. What does the U.S. society currently tolerate for different kinds of risks? And I've got some examples up here of different kinds of involuntarily risks that society -- that U.S. society broadly tolerates. And you see they're all over the map in terms of the kinds of risks that are there.

But again, all except for the one living in Denver and the one at the very bottom where I've got a Midwest average for tornadoes, these are U.S. averages. Averages over the entire U.S. That means you've got an incredibly heterogeneous risk spectrum buried within that. You've got area averaging, you've got individual characteristics averaging, you've got everything else in these numbers that society currently tolerates.

Now I've got two listed here that have to do with radiation. And just the ideas -- to get an idea of what are these numbers at for these very large populations.

MEMBER STEINDLER: What does that mean, that extra fatal cancer at 10^{-5}?

MR. KESSLER: That's comparing to risk of living in New York. It has to do with the added elevation and other --

MEMBER STEINDLER: New York is one?

MR. KESSLER: No, New York -- it's 10^{-5} plus what it is in New York, and I don't have the New York number here.

MEMBER STEINDLER: We really don't have any idea of whether or not that's a meaningful number. I mean, if New York is 10^{-12}, then it's --

MR. KESSLER: It's still meaningful in a sense that there's heterogeneity in risk. That's all I'm trying to show here is that the risk number for New York is different than it is for Denver. Yes, it could be 10^{-12}. I honestly don't know what it is for New York. But the point I'm trying to make is that there's heterogeneity in risk out there that we tolerate for involuntary risks of all kinds.

VICE CHAIRMAN GARRICK: I guess the question is do you really mean the cancer risk living in Denver as opposed to the extra fatal cancer risk. Is that --

MEMBER STEINDLER: Well, that number 10^{-5} is wrong. If the English language as used, extra fatal cancer risk living in Denver, is normally interpreted by the standard dictionary. It's not the extra fatal cancer. It can't be that low. But that's -- you know, fine.

MR. KESSLER: Okay, we can argue semantics.

MEMBER STEINDLER: We can also argue numbers, I guess is what I'm saying.

MR. KESSLER: My understanding of what this number meant was whatever the risk is in New York, you add 10^{-5} to it if you live in Denver.

MEMBER STEINDLER: Okay, that's not comparable to the other three in that man made source list is what I guess I'm trying to tell you.

MR. KESSLER: I admit that it's not comparable to the other three.

MEMBER STEINDLER: Right.

MR. KESSLER: This is a site specific extra list. I tried to point that out. These are averages over all of U.S. society, different assumptions in there. This is not a perfect list. All I'm trying to show is just some examples of the heterogeneity in risk that's out there and that society is currently tolerating.

VICE CHAIRMAN GARRICK: One's an incremental risk and the other is just risk --

MEMBER STEINDLER: That's right.

VICE CHAIRMAN GARRICK: -- based on average?

MR. KESSLER: Yes, I admit that they're not on the same basis. It was illustrative of the heterogeneity in risk that's out there. Okay, I apologize if I've used the wrong words. Similar down here, you could probably make the same point about tornadoes here. Here is where I was trying to illustrate -- it's the only one I could get. I'm sorry. Which was the idea that if you go to smaller, more exposed groups, yes, the risk goes up for those.

For example, tornadoes, the U.S. average is .6 x 10^{-6}. But if you go to the Midwest where tornadoes are most frequent, an area change, your average risk goes up for that smaller subarea. The point is that we have a heterogeneity in risk that's also -- has something to do with the area and location of where people live that U.S. society currently tolerates.

Well, it seems as if NAS mixes the two philosophies, the cautious and the equitable. The cautious portion, what did they take? They take the small, homogeneous critical group that you've all heard about in some detail this morning. The equitable portion that they take is the numerical standard itself. That is, they recommend for discussion purposes this 10^{-6} to 10^{-5} number.

Well, that number seems to be based on what is tolerated for a large, heterogeneous populations. I mean, you're applying that to a very small population. And the combination of the two is very conservative, and it could -- based on certain calculations that Tom referred to this morning, we would argue is two to six orders of magnitude more conservative than if you just look at this individual who's drinking from the most contaminated part of the aquifer.

What we recommend is an intermediate philosophy between the cautious and the equitable. And for lack of better words again, I describe this as equitable for the local population in the sense that you allow some heterogeneity, but you're only going to look at the population. Do not average in people that live outside the local population.

That's just too incautious (sic), whatever terms you want to look at it. But based on what society tolerates now, it seems quite reasonable to assume that it's okay to average within the local population. So you have numerics that are consistent with this intermediate philosophy. What are those numerics? Critical group size.

We took the entire local population as your critical group size. The individual risk or dose limits -- or in this case risk, you pick 10^{-6} to 10^{-5} per year for the local population average. That seems consistent with what U.S. society currently tolerates for involuntary risks now. Optionally numerics -- Tom talked a lot about when he was inverse calculating from similar illustrative calculations that we talked about, and I'll get into that in a minute.

The fact that you could have certain people that are most exposed with very high doses if you just protect the average. But you could have an ICRP/NAS-style critical group. The idea is that you pick a small critical group most at risk, and you apply some higher risk limit based on what it seems like society accepts or tolerates today.

I threw out there, for example, 10^{-4} per year. I don't know what that number should be. The idea is that you have a different risk number for that small, most exposed group than you do for the average individual in a group. That all seems consistent with what society tolerates today

The next point I'd like to make is well, what -- whose critical group, what characteristics? And I would argue that Armagosa Valley as it is today is all we need for critical groups. We all admit that future behavior is unknown. Therefore, anything you do for critical groups is going to be arbitrary.

So you may as well pick something that's there. Current behavior can be measured. And I think Fred Phillips mentioned this this morning in his discussions. That's a tremendous advantage when you have nowhere to go in terms of being able to hang your hat on a good, solid basis for picking a critical group.

We've already heard that it's the nearest downstream population center. That certainly makes it a likely candidate. And it also has the advantage of forcing both the implementer and the regulator -- their attention on the local population, what is it that they do.

So there's a lot of advantages for picking Armagosa Valley. So to conclude, I would advocate a numerical limit for a local population average where the limit and the population size are formulated together. And Armagosa Valley, as it is today, is all we need to define critical group characteristics.

Questions?

CHAIRMAN POMEROY: Thank you. Bill, go ahead. I'm sure there are several questions.

MR. KESSLER: Oh, before you begin, let me address a couple of comments that were made this morning regarding our calculations and how they can result in high numbers. Yes, I suppose they could if they were -- if one chose to do them that way. Our motivation for doing those illustrative calculations, and I want to emphasize the word illustrative here -- when we did those calculations where we assumed area averages and probabilities of being able to detect and mitigate were merely to point out an alternative approach.

In 1994, when we did those calculations, we were concerned that it seemed like the only dose numbers that were being generated were those for this "maximally exposed individual." We wanted to show that there was a larger population out there, and that we wanted to illustrate that by looking at a variety of different possible parameters.

We threw them all out on the table. We made it very clear what we were doing, just as an illustration of what could be done. That does not mean that we believe in every number. We certainly feel that the regulator should look at every single one of those numbers and say yes, that's consistent with our approach or no, it is not.

But merely to look at the maximally exposed individual we felt was insufficient, and that we threw this calculation out as an illustration of what kind of averages there may really be out there. We do not advocate a dose limit such that it would allow acute doses or anything of the kind for some people. We put this illustrative calculation out there simply to show that there were averages that could be done and to clearly identify each parameter for people to consider as to whether it was an appropriate one or not.

Okay, sorry.

CHAIRMAN POMEROY: Okay. Bill?

MEMBER HINZE: John, you always do a good job of presentations, and I do appreciate that. I would like to go to your conclusion about Amargosa Valley as it is today.

MR. KESSLER: Yes, yes.

MEMBER HINZE: The future behavior unknown is the first bullet under your --

MR. KESSLER: Yes.

MEMBER HINZE: -- overhead on that. And we -- I think we would all agree that the long term future behavior is unknown. However, we should take into account present knowledge. And one of the things that we know is that we have a gradient in terms of the population of this country and people have to be fed. And so one wonders if you shouldn't be concerned that the Amargosa Valley should not be all included in the consideration here.

I'm reminded of the fact that in Indiana, which is hardly an arid climate, and I know that very well for the last month or so, that we find that crops are grown on the very poorest of the soil today by many of the larger farmers. And they do this by virtue of providing irrigation to sand plains and putting in the proper nutrients.

And many -- in real sense, this is equivalent to much of the surface materials -- I hesitate to call them soil because they're sand -- but the surface materials of Amargosa Valley. So perhaps what we should do is consider a larger area for the biosphere group -- for the critical group than just the current area that is covered by the agricultural production today.

MR. KESSLER: My concern is that once you start speculating about different groups, it's just as arbitrary as choosing what you're going to do today. And you have less --

MEMBER HINZE: -- speculating about the rate of growth, aren't we?

MR. KESSLER: Well, okay, in terms of -- you're saying let's apply what's done in Indiana, just for example, to what could be done in Amargosa Valley. And my argument is that's fine, you could do that. That's an arbitrary assumption that could be made, and I would say that that's an arbitrary assumption like millions of other assumptions that could be made about what future critical groups in Amargosa Valley do.

That's fine, you can do that. But where does it end? I think that to be reasonable about what you choose to do and what you choose to look at, you may as well pick what's there, because if you start looking at well, what if they grew a crop a different way, there's no end to that. And what people do in Amargosa Valley today is just as good as picking anything else.

MEMBER HINZE: So you would --

MR. KESSLER: And given the tremendous uncertainties about what could be done, that's a reasonable approach to take.

MEMBER HINZE: So the proximity of the distance between the repository and the nearest critical group then you believe -- if you look at this diagram that Norm passed out this morning, that this should be restricted to the areas that are covered by the irrigation today?

MR. KESSLER: The only fly in the ointment there is the restrictions on land use that exist today that very well may not exist sometime in the future. That seems like a reasonable approach. And so in that sense, -- well, I'm just saying the governmental restrictions on where -- how close you can get to Yucca Mountain today due to land withdrawal that of course may not be there 10,000 years from now.

So in that sense, that's a different problem because there's this artificial limitation. There's two ways you could deal with that problem. You could say well, okay, I'm going to just move some people up there and I'll put them with -- in a place that makes sense. And that's fine, just keep in mind that that's an arbitrary decision what you're doing.

You're basic -- your assumptions behind it -- you're assuming that they will farm like they're farming today. And that's a big assumption. That's why they'll move closer. Another way to say I understand that there's this offset and I may change my dose limit because I'm restricted to looking at Amargosa Valley that has this restriction on how close they can get to Yucca Mountain, and I will accommodate that by a change in my numerical limit.

Again, keeping the two together because they're two possible approaches to deal with the problem.

MR. CODELL: Could I make a -- maybe this will clarify some things. These are some things we've been mulling over. I'm Richard Codell from the NRC staff. I think that one thing's clear when you look at that picture, where are the farms, where are the irrigating -- we're irrigating where water's close to the surface. It's easy to get and it's cheap.

Anywhere else it's much more costly. The water -- I think right now they're reaching a point where you can't take anymore water from the Amargosa farming region. You're already starting the water mine. And if you took much more water, the water table would drop to unacceptable levels.

MR. KESSLER: Unacceptable based on today's society --

MR. CODELL: Well, I'm saying that once you start pulling down the water table, it keeps dropping. There's places in the country where that's happening today.

MR. KESSLER: Sure.

MR. CODELL: So if you take it somewhere else, that means it's not going to be available in the Amargosa farming region -- that is, if you take it from the same source. So I think this is a good, logical reason for picking the Amargosa desert farming region as the place where the farming will be.

CHAIRMAN POMEROY: Dick, let me ask you a question with regard to that in view of what Norm was saying this morning. Are you saying that water can't be brought from some place else? It seems to me that water is not yet the fundamental limitation on Las Vegas. And surely Las Vegas is a densely populated and high water use area.

You're absorbing water from all over the state, I agree with you. But --

MR. CODELL: I'm not sure I understand your question.

CHAIRMAN POMEROY: Well, go ahead.

MR. CODELL: We're talking about the water that's coming from the direction of Yucca Mountain and going toward the discharge areas --

CHAIRMAN POMEROY: Yes.

MR. CODELL: -- in the south of Nevada. And we're only worried about those waters. Now, if Las Vegas is going to develop any water in that region, it isn't going to hurt the critical group argument. That is, suppose Las Vegas took water up gradient. First of all, I don't see any reason to do that if you can get it close to the surface.

That's where you'd want to take it. You reduce your costs. Second of all, if they take it in Las Vegas and mix it with a whole lot of other water, then you're diluting it a lot more. So it's less of a problem in terms of doses.

CHAIRMAN POMEROY: Thank you.

MR. KESSLER: But again, it illustrates the idea that there's an endless variety of speculations as to how future water use might occur. You could have temporary water mining where you actually over extract, and you could say that's happening today or it's certainly plausible it will happen in the future, or all kinds of other possibilities.

But what do we have data for? What can we do for these illustrative stylized dose assessment scenarios that we're going to -- or the DOE is going to be presenting to the NRC perhaps some day? You have to base it on something, and it's going to be based on arbitrary assumptions, even if you choose what happens today.

VICE CHAIRMAN GARRICK: Let me press that point a little bit, John.

MR. KESSLER: Sure.

VICE CHAIRMAN GARRICK: Because the heading you had for that particular slide was dose assessments do not predict the future.

MR. KESSLER: Yes.

VICE CHAIRMAN GARRICK: Can I also then say that the future has nothing to do with the considerations you're going to use to build your scenarios?

MR. KESSLER: I'm not sure I follow you there.

VICE CHAIRMAN GARRICK: Well, I'm just asking. You used the word reasonable when you were discussing this, and I guess I'm trying to push the point a little bit as to the basis for the scenarios. You just said arbitrary, and yet you used the word reasonable.

MR. KESSLER: Yes, okay. I used the word reasonable when I consider the geologic parameters. There is a certain amount of uncertainty there, but I would argue that the variability in those geologic parameters over time is orders of magnitude lower than the potential variability in critical group behavior over time. And therefore, I would say you pick reasonable values because you're much more confident or have much narrower uncertainty bands on those parameters.

And you tie those to more what you'd expect at Yucca -- for Amargosa Valley. That's why I choose reasonable sometimes and arbitrary and other things that I've said today.

VICE CHAIRMAN GARRICK: But I guess the question partly has to do with when you build your scenarios, you're going to be closed minded about future considerations.

MR. KESSLER: There's no end to that. And there's no end to speculating as to what future considerations might be. So I would say in that sense yes, I'll be closed minded. You want to make a safety case for Yucca Mountain ultimately. You're going to want to demonstrate that to the public, especially to the local public. It seems quite reasonable as least a baseline to choose Amargosa Valley as it is today to make that safety case.

That's as reasonable assumption as any -- or as arbitrary, whatever word you want to use -- assumption as anything else you might choose.

VICE CHAIRMAN GARRICK: It seems to me thought that .f that's the basis for your scenario development, that you're able to do much more than the arbitrary. That the scenarios you come up with ought to be pretty well founded. What am I missing here?

If you're not going -- if you're not in the game of trying to figure out how things are going to be tens and hundreds of thousands of years from now and you're only considering what we now know and what we have in total view in terms of our knowledge base, then our scenarios, it would seem to me, could be constructed in such a way that they could e highly defensible -- highly defended.

MR. KESSLER: If you're willing to accept the assumption that we'll use parameters as they are today having to do with critical groups, yes.

VICE CHAIRMAN GARRICK: Okay.

CHAIRMAN POMEROY: Help me out a minute, John, before you go away.

MR. KESSLER: Sure.

CHAIRMAN POMEROY: Are you saying that the numerical standard, whether that might be like 100 millirems per year or whatever, and the local population choice, that is the Amargosa people, --

MR. KESSLER: Right, the characteristics of the critical group, yes.

CHAIRMAN POMEROY: -- are locked together in some way?

MR. KESSLER: Yes.

CHAIRMAN POMEROY: Why are they locked together?

MR. KESSLER: They are locked together because I'm assuming for now that I choose this intermediate safety philosophy. And that is based on what it seems that society -- U.S. society tolerates today for levels of health risk in terms of numerics and the heterogeneity that underlies the numerics of those health risks. That's the basis. You can say that that's -- I showed you numbers that were mostly U.S. society-wide.

I said that's unreasonable to go to U.S. society-wide. You have it at Amargosa Valley. You don't have it spread all over the U.S. So it seemed more reasonable to me, anyway, as you choose an intermediate approach where you allow for this heterogeneity that exists that society tolerates, and you base it on the same numerics that society tolerates, and you apply it to the Amargosa Valley -- the local population group as a whole.

That seems all consistent with what society seems to tolerate.

CHAIRMAN POMEROY: Does that mean if you look at Las Vegas, for example, you may have another numeric standard?

MR. KESSLER: In one sense, no; but it would depend on what the source looked like for Las Vegas. The idea of picking something intermediate is you say that the source is only one place. You can say for lightening strikes -- well, lightening occurs all over the U.S. We only have one repository in one location. So in that sense, it's much more location specific.

So I haven't -- in the sense that you have a population which has a certain amount of heterogeneity that's in Las Vegas and you have a certain source, you may choose to use the same kind of approach. But the idea is you're thinking about what the source is, what the numerics are, and what society tolerates for risk.

CHAIRMAN POMEROY: Doesn't that seem a little strange to think of a different numeric standard for -- if you were considering a Las Vegas population versus the Amargosa Valley?

MR. KESSLER: It does if you just think about the fact that you want to pick one standard. If you think about the fact that we accept society-wide risks that are maybe heterogeneously placed around the U.S. but are in more than one location, it doesn't seem so arbitrary or unreasonable. I hope that's answering your question.

CHAIRMAN POMEROY: Well, maybe we both should think about that a little bit. Are there other questions from the committee?

MEMBER HINZE: Let me try one. We're assuming that all of the leakage here is by virtue of ground water transport. We heard this morning about the possibility of volcanic activity producing air transport.

MR. KESSLER: Yes.

MEMBER HINZE: Should we in any way consider the -- as we look at critical groups and biosphere what might happen in the air transport?

MR. KESSLER: In the sense that I would look at the probability of occurrence of that exposure scenario, that's really what we're talking about here. Perhaps take a quick look at the consequences to what that would happen, and then compare that to what you think your ground water -- or what you would think of as the more of the normal release scenarios would give you.

And if they show that they're orders of magnitude lower, I'd say it's time to neglect them. You might want to look at them, but I would say that certainly in what I've been talking about here, yes, I've been focusing on the ground water exposure scenario.

MEMBER HINZE: Thank you.

CHAIRMAN POMEROY: Okay, thank you very much, John. We appreciate your coming, and we'll be exploring this further. Our next speaker, and we're a little bit ahead of ourselves, but I think Steve is here. Our next speaker will provide us perspectives of the state of Nevada on this issue, and the speaker will be Steve Frishman from the state of Nevada.

And as always, Steve, you're very welcome here, of course. And we look forward to a good and exciting presentation.

MR. FRISHMAN: When I heard the subject of this meeting today, I decided that it was time to maybe find out a little bit more about what we were talking about. And I think I can respond to some of the comments that were made just in what I had planned to say about how things are in Amargosa Valley as of today.

And I think it's important to know; and frankly, I'm a little bit concerned that the academy panel got all the way through their deliberations without making a pretty -- taking a pretty close look, especially if they're going to talk critical group. And I'm also surprised that both the department and the commission staff seemed to have such little grip when they're trying to make decisions about what is ultimately going to affect that valley.

I just have these to pass around so that you can get a little bit of the smell and flavor of Amargosa Valley while I'm telling you about the valley. These are monster garlic. Those are alfalfa cubes. And I'll tell you about the alfalfa cubes a little bit later. Now, first of all, I guess I have to say at the beginning that I've been bothered all along in the discussion and thoughts about critical group and even the origin you have from -- that sort of grew out of the incentive for the 1982 legislative change.

And that's -- it seems to me that the only reason that we're even in this discussion about critical group is that there is just this overwhelming urge on the part of most people dealing with Yucca Mountain to try to find some way to allow for a radiation standard to the exposed people in that valley that somehow is less stringent than what anybody else in the country is willing to accept.

That's the premise. That's what we're doing here. And I don't think that it's going to settle very well in the end, and I think Tom is probably right that at some point the result of this could be essentially fatal to the concept of what we're going to do with the high level waste in the long run if we have to sacrifice communities for it.

Well, let me tell you a little bit about Amargosa Valley so you have a -- just a feel for ultimately the point that I think I'm going to -- or that I am going to make, is that I don't think the population in Amargosa Valley is amenable to the concept of critical group. And I'll give you some reasons why.

First of all, the population today is on the order of 1250 people. The available water for use, meaning the water that is appropriated by the state, is about 22,000 acre feet per year. Right now, contrary to what Dick said -- right now on the order of 5,000 acre feet of that water is being used.

The map that Norm showed that showed the location of all the wells, that's not the location of the people. That's the location of the irrigation wells. People have domestic wells for their homes, and they don't have to record them with the state. These are the big wells that are used for irrigation that produce on a pivot, meaning one of those circular fields that you see with the -- and you'll see pictures -- with the irrigation pipes that are on rollers.

Those things run at about 1,000 gallons a minute.

MEMBER HINZE: Steve, help me here. What Norm has is black dots which I assume to be the wells that we're taking water for domestic use.

MR. FRISHMAN: Those are wells that are taking water for farms, for irrigation.

MEMBER HINZE: What are the red? Because that was what I understood from Norm that the red circles -- large red circles --

MR. FRISHMAN: The large red circles are the pivots.

MEMBER HINZE: Okay.

MR. FRISHMAN: Those are round fields that are 130 acres.

MEMBER HINZE: So one is simply a gully-type of irrigation, the black dots?

MR. FRISHMAN: That's wells that are producing to the surface that can either be piped to a pivot or can go for flood irrigation. The round things -- I think the original of this is what, false color IR? And the fields are red because they're green.

CHAIRMAN POMEROY: And the domestic wells and the irrigation wells are tapping the same --

MR. FRISHMAN: They're all taking water from the same alluvial aquifer. And yeah, the domestic wells don't have to be recorded with the state. The amount of water that they use is not recorded, but it's minuscule compared to irrigation wells. Water levels -- we're on one farm, and I asked about the water level -- he was in the area -- in an area where the water table is at about 40 feet down.

I asked him has there been a draw down, and he's one who is running a number of pivots, each one at about 1,000 gallons a minute. He said in 40 years, and his family has been there longer than that -- in 40 years, the water table has come down about nine feet, and they've been irrigating the whole time.

And from discussions with USGS hydrologists who have looked at the hydrology in the valley, they're not sure that it's really even a draw down from pumping. They think it may be an effect of tectonics in the Ash Meadows. So they're not even sure that it's a true draw down. There's a lot of water there.

MEMBER HINZE: The important thing is there must be a lot of water coming into there.

MR. FRISHMAN: Well, there's a large source of water topographically up higher. And also, the carbonate aquifer farther in the southern end of the valley comes to the surface right there in Ash Meadows. And at the Ash Meadows National Wildlife Refuge, there are a number of springs. The largest of those springs is Crystal Spring. And Crystal Spring right now has -- well, it has been for as long as they've been measuring -- is actually registering a discharge of 10,000 gallons a minute into the spring from the carbonate aquifer.

The total of the springs in the National Wildlife Refuge discharges on the order of 25,000 a minute. And that area is the National Wildlife Refuge, but it also supports recreation and hunting part of the year. The large scale farming is carried out -- there's about 19,000 acres of private land in the Amargosa Valley. There's about 5,000 of it or a little bit more that is in cultivation for large scale farming.

It's sandy alluvium. They rotate crops. So at any given time, there's only about 2,500 to 3,000 acres of it actually in production. And I'll show you an example of a field that's in rotation, and you won't even think it's a field because everything just -- you know, it's either cultivated and irrigated, or it's desert.

Now the primary crop is alfalfa. Contrary to the thought that Norm I think put in about growing times and water availability and so on, there's a long growing season -- a 210 day growing season for alfalfa. That allows them to get seven cuts every year, a total of about 25,000 tons of alfalfa produced every year. And this is not a big farming operation.

This is relatively small compared to how things go in other places. I live in a valley in the northern part of the state that is about -- well, roughly five times the production of this in alfalfa. But it's also the best producer in the state. Now this alfalfa cube represents a technology that farmers have had a very hard time with, but it's in high demand.

So there's one farmer in the valley who, just because he's some kind of a mechanical wizard, has figured out how to make the field cubing machines work well enough to where he can -- it's cost effective for him and they're not breaking down all the time. And he produces cube alfalfa on about 400 acres, and all of that is sold to a broker in Los Angeles who has contracted to sell it to Japan.

And he's been doing this for years. So you have on the order of 4,000 tons of alfalfa cubes coming off of one farm going to Japan just because a guy got lucky and found somebody -- a broker who would contract it. And it's also a lot cheaper to ship the cubes than it is bales. Probably the most fascinating thing in the whole valley, if you start thinking about where doses could arise, is that there's a dairy there.

It employs about 50 people. They milk 4,150 head of cows a day. They're sending five tankers to L.A. for processing every day, which is 32,500 gallons of raw milk. And where it goes from there just depends on what the markets are. I asked the guy why did you put your dairy here -- and there's another one coming in next year from what he says.

I asked him why did you put it here, and he said because of good and available feed and available water. Most of the farmers sell alfalfa to the dairy and then they sell their surplus to dairy farms in California. And that's the major farming and dairy operation. Now, there's a lot of other things going on too, because this area has been farmed for a long time and farmers are pretty innovative and like to do different things and then either talk or not talk to each other about what's successful and what isn't.

One of the things that is proving successful to the people who are good at it is pistachio orchards. And there are a couple of large ones. The largest one has on the order of 2,500 trees, and they're mature now and producing. People raise both for small scale sale and for their own use and also for sale at a farmer's market in the valley -- people raise such things as peaches, apricots.

Onions are garlic are a rotation crop on the alfalfa fields. And you see some of this very specialized garlic. Oats are a rotation crop. Because you have alfalfa, you need beehives, so honey is produced. There's one farm that sells 100 tons a year of a very special alfalfa for herbal tea. It's used as a filler with a company in Los Angeles, and it's one that the farmers don't normally grow.

It's a very thin stem, heavy leaf alfalfa, and it doesn't bale very well. But the herbal tea people want the leaf and not the stem. So I asked the guy well, this must be bringing a pretty good price, and their contract price on alfalfa is $80 or $85 a ton. And he said well, I'm getting $80 a ton for it. And I said well, you know, that doesn't seem to make it worth your trouble.

And he said oh, they come and take it away. All I've got to do is water it. So he's happy. And again, this is a specialized crop that is, just because of marketing factors and people who know people, another 100 tons of alfalfa going to unknown receptors out of a Los Angeles herbal tea market.

All right, so that's sort of a run down on what's going on in agriculture now, except for what's new. And the -- you have the people who are sort of living off their own farms. You have people who raise a few pigs and a few cows, a few chickens. You also have one location that has been a commercial pig farm and apparently is going to go back into production again fairly soon, and again using local feed.

And now there's a few people who are getting really innovative, always looking for new markets for things and things that will eat what they can grow there. So the latest thing, and you probably never would guess it -- the latest thing is they're starting to get together herds of breeder ostriches. And the reason that they're interested in it is the world market is really good.

Apparently Switzerland is a large market for ostrich meat, and the South Africans can't produce enough. So people in this country are starting to watch that and they -- you know, the finances of it looks very favorable to them. So this just sort of points out that you -- if you say that all of our regulatory thinking for like a critical group is going to be based on what it is today, well tomorrow it isn't what it is today.

And today it isn't what it was yesterday. And it's always going to continue to change. Also you have with the distribution of people, you're going to have a very, very hard time doing the statistical gymnastics that they have proposed -- critical group approach talks about. You have places -- first of all, I told you that the wells aren't where the people are.

The people are spread all through this area in houses -- one house on a 5,000 acre farm. Another place where it's actually illegal ror them to do it even under a grandfathering laws. Another place where there are like six houses to an acre. And they're all pretty close to each other. It's just what street you turn down.

So if you try to work out the statistical gymnastics, and I think that's all it is, where you're going to put together this critical group -- no matter what you do, it's going to be debateable. Because all of these people are right down in that same area on this map and the same rough sketch that we saw from Fred. So you're just going to have to sort of pick and choose what kind of a critical group you want.

How many people who live there just because they work in Beatty and they live there in a mobile home, and there's maybe three mobile homes all together next to 2,000 acres of alfalfa, and the farmer lives at the other end of the 2,000 acres. Now how are you going to divide all of this up in a way that is convincing to anybody and also that doesn't do just exactly what I said at the opening?

Just trying to find some way to apply a ground water standard that's less stringent than it is for anybody else in the country. So it seems to me that if you're going to do anything based on what I say about like the distribution of things that are grown there -- most of the water goes to something that goes out of the valley. It doesn't even go to the people there.

So if you're going to do anything, from my view and the view of the people in my office, is you need to be most conservative. And in this case, it seems to me that there is a world view and certainly reason for a local view that the most conservative is the person who is there today, and that is the subsistence farmer sort of defined the way Tom defines a subsistence farmer.

And if that person is protected, the kids in L.A. who drink the milk are protected. And the people in Japan who eat the meat that comes from this alfalfa is protected. If you fool around with the critical group, all you're doing is trying to fool people who aren't going to be fooled.

They know what the safe drinking water standard is now. They also know such things as when there is a perception of contamination, markets dry up. I had one guy call me whose farm that I had visited -- his foreman showed me around. He called me from his other farm in the valley in California and said what's going on. You're talking about water and you're talking about Yucca Mountain?

And I said yeah. And he said well, I'm kind of worried. I export a lot of stuff. He owns a farm that produces this and also exports a lot of other things. He said I've got friends in the state of Washington who went broke when there was the concern over pesticides on apples and the biggest market was in Japan. The market just dried up and went away.

And he said if there's talk of concern from -- or if there's concern and if talk gets around about ground water being contaminated and ground water that is not acceptable as drinking water any place else in the country, even being thought about being used on products here, the markets dry up and we're dead. And the Department of Energy threw out this program -- and I've been, as you know, around a long time and worked in the Texas panhandle, the Smith site, before I came here.

Now, the Department of Energy, in each case, feels that if there is some available limit, this program can be used to absorb that entire limit. Well, in Amargosa Valley, remember -- and this is things that I and other people said to EPA in their consideration. Remember, Yucca Mountain is not going to be the only source. You have the Nevada Test Site where contamination from over 700 underground weapons tests eventually is going to get off that site.

You have Beatty, which is already leaking a little bit. And that's just up-gradient to the north in

Amargosa Valley. So it isn't just Yucca Mountain. How you account for this I'm not really sure. But at the same time, I don't think you can be talking in terms of well, this is just a one time deal and maybe we can dose these people a little bit more than we can get away with dosing people in Las Vegas.

But it isn't just this project. It isn't all there for the Department to take just for Yucca Mountain to make it go. We still are not sure where we're going to come out on a source term for NTS in this environmental impact statement that's being done now. So I think for a lot of reasons, the country would be doing itself a favor to be most conservative on this one of a kind deal.

And if it doesn't work, it doesn't work. But you can't fool people into thinking you can make it work just by sort of shifting the numbers on them or coming out with some absolutely false concept of a critical group that won't even be the same critical group tomorrow. And I understand that you have to draw the line somewhere, and about the only thing you can do is draw it at today knowing that you're going to be wrong.

And why would you want to do that? Well, this tape that I have is just five minutes long, and I can sort of quickly tell you what you're looking at because you're heard it all anyway. It's pictures in your head of the things that are going on that I told you about, and I can point them out quickly.

That's just watering on a garden that is one of the supplies for the farmer's market. And this is drying some of this garlic that they grow there. And this -- it sells at really high price just because there isn't much of it around and there's one garlic restaurant in Las Vegas that wants it. This is what was the pig farm and will be again, and somewhere there is -- well, I brought you a pig.

(Laughter.)

And that's just one being raised for food by the guy who owns the place before he goes back into production. These are pistachios. And those are all mature trees now. They're coming into production. And if you look in the background, there's Lathrop Wells' cone. And more pistachio trees.

This is where there's about 2,500 of them. People growing some grapes for their own use. This is a remote desert. These are pistachios. You can see they're ripening. And this thing just goes on and on. There's the new novel crop.

(Laughter.)

And this is Crystal Spring and the Wildlife Refuge, and you can see some mosquito fish. And if you see -- you can see maybe just a couple little blue flashes. That's one there. Those are the pup fish that are on the endangered list. That's an endangered warden. This is a spring that has a discharge of about 10,000 gallons a minute, and it's coming out of the carbonate aquifer.

This is just a store that's out there, and we're going to pan around. This whole area across here is just a field that's in rotation. Next year that will all be green again. And in the background, there's Lathrop Wells' cone and Yucca Mountain just to the left. So even though the Department takes people to the top of Yucca Mountain and they look out and see nothing, the people in the valley look back and they see Yucca Mountain, and it's close to them.

This is an alfalfa field that is just flood irrigated, and that alfalfa's about waist high. The guy's going to have a real problem cutting it. He's let it go too long. This is a shed full of these cubes ready for shipment to Los Angeles. This is a field that's just been baled. And you see all the debris around on the ground? Well, this is right at the end -- the southern end of 40 Mile Wash.

And there was a flood last year that closed the highway, if you remember; and the flood came through and washed out this whole field, and you'll see when we come around to it -- this is just debris left from 40 Mile Wash flooding through the western end of Amargosa Valley. So water does transfer on the surface.

This is a hay truck weighing in at the dairy. This is the milking barn and half of the dairy. And it's 24 hours a day walking cows through there milking them. They employ about 50 people.

VICE CHAIRMAN GARRICK: Where do these people live?

MR. FRISHMAN: All in Amargosa Valley. And they moved mobile homes in. This is just sort of panning the dairy. When the cows aren't being milked, they're either laying down or eating all the time. And it just goes on and on. This is an irrigation on a pivot. And back to more pistachios. This is just, I think, probably getting ready to put in a lawn or a few more trees.

And again, Yucca Mountain in the background just -- and you can't -- this guy told me that with binoculars from the top of Yucca Maintain, if you know where you're looking, you can see his farm. And I think that's it. Okay, yeah, that's enough.

(Laughter.)

All right, well I think it's probably important at this time to have gone through some of this information, see that and understand. And as I said before, get some kind of a sense of how can you put together a critical group in an area that is pretty dynamic -- things are changing all the time; and also the only real purpose to do that is to somehow not be as protective as the rest of the people of the country right now have for their own protection and expect to continue to have even though we do have some controversy going on it right now.

I guess that's enough. I'm sure you have some questions other than who gets the garlic.

CHAIRMAN POMEROY: Yeah, I was going to ask that.

MR. FRISHMAN: There's enough there for everybody. And I keep the plastic bags.

VICE CHAIRMAN GARRICK: Steve, are there any incentives, federal, state, private, for people to develop the valley?

MR. FRISHMAN: None. No, it's just the land is relatively cheap and farmers go where they want to farm and where they can. There's nothing that is encouraging anybody to go out there and farm. Also, the experience that we have in the rest of the state and especially in the Las Vegas valley is that if there's BLM land that somebody wants for some use, land trades are pretty easy.

So what today is BLM land and considered untouchable -- just about everything's for trade to the BLM.

You know, institutionally it sort of goes in ups and downs. Right now they're talking about calling it off because at least the district in Nevada has been handling it in ways where it appears that the real owners are losing money, meaning that the trades are not being made to the advantage of the public.

So right now it's sort of at a lump. But it will get back. And land trades are, you know, a pretty common thing. So if there's some part other than the Wildlife Refuge or the National Park or somebody wants to farm and can withdraw water without causing problems with endangered species in Ash Meadows, well it can probably be arranged.

VICE CHAIRMAN GARRICK: You may have answered this, but what's the split between private and federal lands in the --

MR. FRISHMAN: Oh, I don't even know the percentage. But it's only about 19,000 acres of private, and that's -- I didn't measure it off. My guess is it's not more than maybe 25% of the valley, if it's even that.

CHAIRMAN POMEROY: Steve, maybe you've answered this one too and I missed it, but you defined something like 1,250 people or so in the valley. Do you have any idea of how many of those might be what we would think of as a pure subsistence farmer in contract to somebody who worked in the dairy and came home at night and drew a few garden vegetables?

MR. FRISHMAN: I would think what you'd probably -- the person that you would find who is that is either a retired person or a person who works some place and raises his own, like, cows and pigs and chickens and has a garden, and probably buys as little as possible in a store just because there are lots of jobs where the wages don't let you go to the store very often.

And especially the guys who work in that dairy. They're all hispanic, and I'm sure there's a reason for that.

CHAIRMAN POMEROY: Dr. Pigford had a question that he wanted to ask. Can you come to a microphone, please?

MR. PIGFORD: Yes, Steve, I thank you for the strong support on the importance of the subsistence farmer. But as I listened to you, it sounded like you were happy to calculate doses of subsistence farmers who live where they are now. Whereas to me, it's more conservative at least and maybe more realistic to recognize in the future they can live closer.

MR. FRISHMAN: Right, and that's why I was saying --

MR. PIGFORD: Did I misunderstand you?

MR. FRISHMAN: Land boundaries today of what is federal and what is private have no meaning for the future.

MR. PIGFORD: So you would then allow them to live closer in the future?

MR. FRISHMAN: Yeah, you could -- well, you could have somebody living in that little community right on 95.

MEMBER HINZE: Well, that was one of my questions. How -- what's the nearest irrigation to 95 at the present time?

MR. FRISHMAN: Pretty close. What is it? Just two or three miles down the road going to the south.

MEMBER HINZE: According to every one of these black dots is where there's irrigation for -- just for subsistence for production?

MR. FRISHMAN: There would be -- if it's not -- every year it's rotated. Most of those wells are, you know, operated as part of the irrigation system. There are some that -- you know, well there's -- you see that, you know, 3/4 of the water that's available is not being used right now. So there are some irrigation wells that are not even being used.

But they can be brought back into service by, you know, anybody who wants to use them, you know, for their own farming.

MEMBER HINZE: The electrical rates in Amargosa Valley -- at the present time, are they high in terms of --

MR. FRISHMAN: I heard people talking, and they -- what they were concerned about was -- they weren't complaining about the rate. They were talking about how undependable the service was. You know, they outages. But also, if you're doing -- you know, when you look at the map that Norm put out, you know, there's an awful lot of this area where the lift is less than 100 feet.

And 100 foot lift is economical. In the valley where I live, they're lifting 180 feet.

MEMBER HINZE: I'm sorry, are these meters or feet?

MR. FRISHMAN: Well, based on what the guy told me at his farm, I'm assuming it's feet. Because he told me where the water table was on his farm.

MEMBER HINZE: Dick, do you have any --

MR. CODELL: Steve, where are you talking about where the lift is 180 feet? Is that very much closer to Yucca Mountain?

MR. FRISHMAN: No, I live up in the northern part of the state.

MR. CODELL: Oh, yeah; we're really only concerned here about this particular problem, and that's flow from Yucca Mountain toward the south.

MR. FRISHMAN: I was just answering a question on the cost of electricity for lifting a well.

MR. CODELL: Yeah, well, I think that -- I don't see any -- unless I'm mistaken, I didn't see any areas that weren't similar to the Amargosa Desert farming region where they're much closer to Yucca Mountain where you had the water table close to the surface.

MR. FRISHMAN: Well, what I'm saying is if you look at this map, you can get pretty close to Yucca Mountain and still only have 100 foot lift.

MR. CODELL: Okay, well I --

MR. FRISHMAN: And if you go up to the -- if you go up to Highway 95A or 95, you can see the boundary of the test site.

MEMBER HINZE: Those have to be meters, I would think. They're feet? Well, take a look at the 500 feet at Yucca Mountain. That doesn't seem right for Yucca Mountain, does it?

MR. FRISHMAN: That's way down to the south end.

MR. CODELL: The scale on the map is

kilometers. So, I mean, I don't know first hand if it's feet or meters.

MEMBER HINZE: Well, let me ask you another question.

MR. FRISHMAN: I just assumed it was that because he told me what the lift was in his well, and I looked down about where he lives and that's where that contour is.

MR. CODELL: I think our point was -- I'm fairly sure that this is meters. And the idea was that the farms are concentrated in the area where it's still economically feasible to pump, except for the few wells that are on the test site where cost is not an object and they're not farming there. They just need water.

MEMBER HINZE: But Dick, excuse me. Just underneath the printing of Amargosa Valley, we see a number of those black dots. You see --

MR. FRISHMAN: Yeah, there are wells that supply that place.

MEMBER HINZE: Oh.

MR. FRISHMAN: And I think before you make -- this points it up very well. Before you make assumptions like that, it would probably be worth getting out there and finding out because that assumption alone could drive you one way or another in your thinking if you're going to stay on with this critical group idea.

MEMBER HINZE: Let me ask you a question if I might, Steve. You've told us a lot about what is the present situation. Could you give us a bit of perspective about what the situation was ten or 20 years ago in Amargosa Valley and what is the potential for growth of the irrigated farming in the valley?

MR. FRISHMAN: From what I heard, the population has been increasing, but not necessarily as farmers. It's people who, you know, have jobs like in Perump or in Beatty, and land is relatively cheap and it's not too far to drive. And you know, from there to go to work in Beatty is, what, maybe 25 miles, 30 miles. And that's an acceptable drive.

But it has been growing. The numbers of farms, I think, probably has decreased through time, but the farms are bigger. And the dairy has, I think, probably put some people into better production than they used to be because otherwise they were baling and having to haul stuff to California to sell.

So the dairy has been good for the farmers, and the farmers have been good for the dairy.

MEMBER HINZE: Well, lack of growth, is that in any way physical or is it --

MR. FRISHMAN: I think for lack of farm growth it's probably because of the constraint on farm land.

MEMBER HINZE: Constraint on farm land?

MR. FRISHMAN: Yeah, just the constrained amount of private land that's available. And if people don't want to farm it and don't want to sell it, it just sits there. So --

MEMBER HINZE: I understood in this discourse between you and John that land -- that it was relatively easy to get a hold of land for farming. Did I miss that?

MR. FRISHMAN: No, I'm saying if you wanted to do a land trade with BLM, --

MEMBER HINZE: Right.

MR. FRISHMAN: -- in the future it's not out of the question that you could develop more farm land if you found land someplace else that BLM wanted to have, and they would trade. So you can -- it's not out of the question that farm land would be expanded. At this point, it seems to be sort of maxed out in terms of what's available as private land.

If more dairies comes in, people want to grow more alfalfa, then we're going to see more alfalfa production right there. And maybe, you know, possibly in the future out of a land trade situation so you could be getting closer to Yucca Mountain since, as Dick was saying, the shallow wells are -- you know, they're cheaper to run. But if you run out of space, then it's all the economics.

How far up gradient you can go before the depth of the well makes it uneconomical. And it's -- like I said, where I live, the farmers -- they don't like it, but they still make a ton of money.

CHAIRMAN POMEROY: Just roughly, Steve, what kind of money is involved per acre if you want to wander out and buy a few acres? Do you have an idea?

(Laughter.)

MR. FRISHMAN: When I asked about it, I think the answer I got was depending on where you are, anything from about $1,500 to $2,500 an acre. But that probably doesn't include -- or that wouldn't include any water rights. You could put a domestic well on. But if you wanted water rights, you'd have to buy them from somebody because there are no more available. The valley is totally appropriated.

So if you want water rights, you've got to find somebody who's willing to sell their water rights to you, and then it has to be in a location where it's acceptable to switch the point of discharge. It's fairly complicated.

MR. CODELL: Steve, I had a different source of information probably than you did. I'm not questioning your firsthand knowledge of this, but my understanding was that there was already signs of water mining. But the other thing is that the appropriations and the safe yield of that aquifer are two separate things. The appropriations don't seem to have anything to do with the safe yield.

They were just sort of made up.

MR. FRISHMAN: Well, it's over appropriated, and that's why it's closed now. But it's being used at a level that from -- you know, the people that I've talked to, they're not exceeding safe yield and they're not even close. Because at one point -- well, a couple of years ago, there was an investor who came in and tried to get the state engineer to forfeit 15,000 acre feet of water rights that weren't being used because he wanted to pick them all up and start shipping 15,000 acre feet a year to the Las Vegas Valley.

And the state engineer I think wisely declined. What he did was he didn't refuse the guy a permit, he just refused to forfeit the wells because he felt it was in the public interest to keep those wells available for additional farming when people want to farm or want to increase the farming that's going on there. And that's within his discretion.

CHAIRMAN POMEROY: Are there other questions from the committee? If not, I'd like to thank you, Steve, especially for the garlic.

(Laughter.)

MR. FRISHMAN: I'll leave the plastic.

MS. COLTON-BRADLEY: Do you have parsley to go with it?

CHAIRMAN POMEROY: And especially, Steve, for the firsthand information on the valley.

MR. FRISHMAN: Well, I think it's important.

CHAIRMAN POMEROY: Thanks a lot. The committee's next item of agenda is a meeting with Margaret Federline at 2:30. And this is the last point that we have of a chance to have any break time. So I'd like to take a 20 minute break until 2:30 and reconvene at that time. And then we're going to have to be prepared to go until 6:00.

(Whereupon, the proceedings went off the record from 2:11 p.m. until 2:36 p.m.)

CHAIRMAN POMEROY: I'd like the meeting to come to order, please. The next item on our agenda is a discussion with Margaret Federline from the Division of Waste Management, Office of Nuclear Materials Safety and Safeguards. We'll discuss recent items of interest of which there are several.

Margaret, I'll leave it to you to tell us what we're going to talk about today.

MS. FEDERLINE: Okay, good. I'll just run through sort of a summary of what I had planned to touch on. I have a couple of quick items. I wanted to give you a status of our expert elicitation branch technical position, because we'll be meeting with you in August on that, just sort of a little vignette on that.

I had an opportunity, I spoke to the National Conference of State Legislatures in Las Vegas, and I had an opportunity to visit the site while I was there. So I just wanted to give you some feedback of what I saw and what my perceptions were about my visit.

I also wanted to talk about, we had an appendix 7 meeting focusing on tectonics models. I wanted to give you a little feedback on what we learned there and what progress we had made.

We also owe you from the last meeting, a discussion, you had asked a question on were there going to be independent analysis done on the geophysics data. Phil Justus is here and is prepared to give you a response on that.

You had also asked on the LSS, the status of the LSS. You know, we're prepared to just give you a few minutes update on that.

Talk about what we know about the status of the chlorine-36 work and just sort of give you an update on where we stand with or where EPA -- what we know about where EPA stands on the development of the rule.

Are there any of those subjects that the Board would --

CHAIRMAN POMEROY: In the course of describing your site visit, can we get a geological update?

MS. FEDERLINE: Yes. As a matter of fact, Phil just walked into the room, so I'll give a call in a minute. If you want to pull up this chair, you are more than welcome.

Okay. On the staff's branch technical position on the expert elicitation, you are aware that the comment period closed in mid-May. We received comments from three organizations, from DOE from the Nuclear Waste Technical Review Board, and from the State of Nevada. In general, all three sets of comments supported the BTP. You know, which is unusual.

The state indicated that the BTP was generally responsive to the state's concerns. They urged us to provide guidance that the process be thoroughly documented and transparent to future reviewers. Of course this is something that we agree with.

They were concerned that the BTP places too much emphasis on the use of cost considerations and practicality in determining when expert elicitation can be used. We're going to go back and look at the various positions, because we felt that we did take a position that DOE should depend upon the collection of data when it was practical and feasible to do so.

DOE indicated that they had no substantive disagreements with the NRC on the process. They believe that the introductory and background material should be deleted, but the state disagreed with that. So we're going to be looking at that more carefully. We will be prepared when we speak to you. I am just trying to give you a sense of where the comments were coming from, talk about where we end up on these.

The technical review board said that the BTP was organized in a thoughtful and well-argued manner, but they asked us, challenged us to think about a few things. These were particularly useful questions I thought.

Can the NRC identify areas where expert elicitation either should not be used or its use should be very limited? So this is something we have to think about, if that's an appropriate role for the BTP.

Can the NRC identify any case where if the BTP guidance was fully followed, the NRC still would not find the expert elicitation acceptable.

Can the NRC provide additional guidance as to when it's infeasible or impossible to collect data, and that the data has become prohibitively expensive. So they are just asking us more to clarify the modifiers that we had put onto the collection of data.

So these were a few questions that they threw out. We will be thinking about those in responding to comments. We'll be prepared to talk to you about those when we come in August.

CHAIRMAN POMEROY: One of the thoughts I had on that, Margaret, was that as they are fond of saying around here, the devil is in the details of course. There may be within that second question that the TRB framed, some thought may be useful in terms of what happens.

I can think of a situation, for instance, where we still might have comments on how DOE has gone forward, even though it's still consistent with the BTP, the details make it more unacceptable. It seems to me, that's something we need to know how to -- what the procedure might be to do that, to go forward.

MS. FEDERLINE: Yes. Okay. Well we'll certainly be prepared to entertain your comments as we walk through that.

Let me touch very briefly on as I say, I did visit the Yucca Mountain site. The two areas that I found most interesting as part of my visit were Alcove number five, the thermal test facility. That access observation drift is completed, about 136 meters. Now additional excavation is planned to directly support the heater testing.

I actually witnessed the large block that has been carved out. I think it's about 10 by 13 meters. The instrumentation holes have been drilled for the thermal mechanical experiment. This is supposed to start in August, I believe.

They are going to be continuing to conduct or to construct the alcove for another experiment which will focus on thermal hydrologic interactions. That experiment will start in 1997 as I understand it.

We are trying to work now to set up an appendix 7 meeting with DOE to discuss the -- we have not seen the final test plans for the thermal mechanical test. I think it's very important that we at least understand clearly what that test is going to accomplish and what data is going to come out of it, because I think these are two of the most important experiments that are going to be conducted before viability assessment. We need to make sure if we have any concerns about data that will not be collected, that we get our oar in the water early. So that's going to be the focus of our discussions with DOE.

CHAIRMAN POMEROY: Is it your understanding that the plans right now will call for having that data available from those tests by the viability assessment in 1998?

MS. FEDERLINE: Yes. As I understand, there will be one cycle of the thermal-hydrologic experiment that will be available. I don't know if there's someone here from DOE that would like to clarify that, but that was my understanding of it.

Let's see. Phil, why don't you, could you follow up on the question about the geophysics data and also Dr. Pomeroy, if you have an update on geologic work that's going on at the site, anything additional you want to add.

CHAIRMAN POMEROY: Yes. Welcome, Phil.

MR. JUSTUS: Thank you. I'm Philip Justus, structural deformation seismicity, key technical issue team leader, co-leader.

You had asked for an update on whether we are doing an independent analysis of various geophysical data that the DOE has generated. I'd like to just briefly summarize what we are doing in independent analysis of DOE geophysics data. But I should say that we're not prepared at this time in this forum to express it in any detail that would, hopefully would elicit -- therefore would not elicit, detailed questions on at this point the veracity of the data and things.

But basically, what does our program right now consist of in this regard. We became aware of DOE's seismic reflection lines that they completed earlier this year. When we had an appendix 7 meeting on the subject of tectonic models in May, we actually discussed some of the seismic reflection data. In addition, DOE had completed some magnetic and gravity surveys. We were privy to interpretive maps of that data and they were also discussed at the May meeting.

At that meeting, the center and headquarters staff recognized the great potential for the use of the geophysical data to discriminate between various tectonic models and the characterization of faults of various types and depths and locations. This of course is not a new revelation about such data. We have been seeking to get the data and interpret it ourselves of course only after DOE had done so, basically. They have done so.

There is a for example, a report that we received, that was issued I believe only last month. This is the so-called geophysics white paper number two. This was issued as I indicated, a few -- I believe last month as USGS open file report 1995-74. It's called "Major Results of Geophysical Investigations at Yucca Mountain and Vicinity in Southern Nevada" by Oliver, Pontz, and

Hunter, who are editors of this compilation.

We will be reviewing this document and various references within it that the USGS has now compiled for us all, as we need to review DOE's specific tectonic models or conclusions, that we will be getting in reports from DOE.

Specifically now with regard to DOE's seismic reflection data, the data are ambiguous, or at least give ambiguous interpretations. This was much discussed at the tectonics appendix 7. It's important to try to converge the utility of the data to discriminate amongst viable tectonic models.

Suffice to say, that DOE has used the data to converge its thinking on what it thinks are viable models. We have done the same. Basically, we agree with what are viable models.

Now we would like to on our own, acquire the seismic reflection data and reprocess it using our own filers, focusing mechanisms, to extract our independent analysis and interpretation.

That turns out to be expensive, or at least we're finding that it could be very expensive. We're in the process of finding out through out centers, contacts with oil companies in Texas, universities that do this kind of thing, to see what it would take for us to get and reprocess the seismic reflection data itself.

We are doing better on the gravity and magnetics right now.

CHAIRMAN POMEROY: Who would do the interpretation of that reprocessed data? Folks at the center?

MR. JUSTUS: We have staff at headquarters and at the center who would be involved intimately in the interpretation. We don't have expertise in actually manipulating the seismic reflection data to the extent that other experts in the field do, at oceanographic institutions and oil company service companies and such.

However, I suspect you are getting at the point that it's one thing to reprocess. It's another to interpret. When you have different people doing it, why you may lose something in the translation so to speak. We are aware of this, and would fully -- would work closely with the data, manipulators, not meant in a negative context, this word manipulation.

We are actually -- we have acquired, we bought the gravity data. We're in the process of reprocessing it now. This is being done at the center. We have expertise at the center to do this.

Our principle investigator on this, as a matter of fact is Chuck Conner. One of our structural geologists, David Farrell, actually also John Stematikos are working with him on the interpretation, reinterpretation.

We have completed magnetic surveys across Bare Mountain Fault in Crater Flat, actually across Crater Flat, only in the past few weeks. This is a center project. We have utilized for an optically pumped cesium vapor magnetometer. I'm sure anyone here would know a lot more about it than I would at this point instrumentally. Basically, it's a portable magnetometer that takes continuous readings. Actually one reading every two seconds. So you just turn it on and start walking.

We have got tens of thousands of data points on this, preliminary feedback are along these exciting lines. We believe we have imaged the Bare Mountain fault in the southern part of Bare Mountain. This is good news. I mean by independently imaging this major structure, we could compare our results to that of DOE's, in a truly independent fashion.

We have reoccupied DOE's magnetic lines. Actually, those that are along its seismic line, line one in particular, that runs from roughly Steve's Pass to Yucca Crest. We have reoccupied that line using the cesium magnetometer. Our readings would give data points about every meter or less compared to the 50 meter stations that DOE had taken. So we can do an independent analysis there. That of course would be compared to the seismic reflection data along the same line.

I don't want to steal any thunder to come, but since we've had quite a bit these days, I'll just add a little bit here. You can anticipate getting some reports that show that the center staff appears to have actually discovered some buried volcanic centers in southern Crater Flat and in Amargosa Desert. These Amargosa sites were a detailed survey of existing known anomalies. They have gotten some details that are very interesting. We'll all hear more about that in time, hopefully just months.

We have the magnetic data. We have magnetic data on hand from the survey now. We have acquired it from Ms. Langenheim. We have it already on ARCINFO. We are beginning to essentially reprocess it independently. We have the capability at the center to do that.

There you have the gist of our ongoing work and an update from what you heard last month.

CHAIRMAN POMEROY: Bill?

MEMBER HINZE: Can I ask a question about the gravity analysis? Is Chuck going to do a constrained regional on that? I know he has been wanting to do that.

MR. JUSTUS: Yes. I guess I can't answer that directly. I didn't put that particular point to him. I'm not sure exactly what you mean by a constrained --

MEMBER HINZE: The pre-tertiary rocks.

Well, the second question is, what's the time frame on the gravity and magnetic analysis, and is there any thought of doing some type of depth determination on the magnetics? Is this a focus of the work?

MR. JUSTUS: Yes. One of the goals will be depth determinations. We haven't done it yet. On the gravity, that is essentially done. We did discuss this at the Appendix 7, to which you also were present. That was used to show our relative position of volcanic centers and gravity gradients.

CHAIRMAN POMEROY: I wonder, just to jump in there for a second, addressing a question both you both Bill, and to Margaret and Phil.

At some later point, is there going to be a methodology whereby some of us could look at and talk with some of the people after this interpretation is done to see what the data look like?

MS. FEDERLINE: Oh yes. Definitely.

CHAIRMAN POMEROY: Is that going to be useful, Bill?

MEMBER HINZE: Yes. I would think so. That was what prompted my question about when this might be.

CHAIRMAN POMEROY: Right.

MR. JUSTUS: Yes. This was done recently. There's a lot of early milestones that are falling due. I'm afraid I can't at this moment give you any specific schedule, but I will definitely get back to you on when we have one, which should be just a matter of a week.

MEMBER HINZE: One of my concerns there is that in addition to as you very well know, is in addition to the tectonic implications, those tectonic implications also have significant ramifications to the volcanic hazards concerns. That is something to get a look at, wondering how far that -- whether that will be, the results will be ready by this fall.

MS. FEDERLINE: I think it was scheduled to meet with you in December.

CHAIRMAN POMEROY: November.

MS. FEDERLINE: Somewhere in that vicinity. Let us get back. Let us make a schedule of this. We'll get back to you.

MEMBER HINZE: Margaret, if I might. Could I, since Phil is here, could I ask a couple of questions that might be directed to Phil? I am wondering two things.

Where do we stand with the PVHA report? Is that now on the street or near to being on the street?

MS. FEDERLINE: When I was out there, it still had not been received by DOE, but they were expecting it very shortly. That's been about a week.

MR. JUSTUS: Basically, I would have liked to have answered your question, but I haven't been following the volcanism aspects as closely.

MEMBER HINZE: My second question is related to the fractured zone that ESF encountered last month. Is there any further information on whether that is a result of ubiquitous cooling joints, or is this a result of a fracture zone as some critical --

MR. JUSTUS: There has been an update on this that came out of the ESF meeting, ESF rather technical exchange a week or so ago.

Mark Tinan made a presentation on the subject. I can summarize a theory that he has laid on the table, so there are basically two concepts that DOE is evaluating. The bottom line though is that DOE does not yet know or does not have enough information to state what its preference is, either or because -- when they have one, they'll tell us. They haven't told us yet so I'm sure they haven't gotten one yet.

I can tell you though this subject is also on the agenda for DOE's briefing of TRB July 9th or 10th. We expect to get further information at that meeting along with you.

Actually, you did organize the competing concepts into two schools of thought. One is that this high density fracture zone may be dominated by nearly vertical closely spaced smooth-walled cooling joints, in which case they would be primary features of the cooling of the Topopah Spring volcanic unit or sheet. If that's the case, this feature would be confined to the Topopah Spring unit itself.

Alternatively, because it's unusual for cooling joints to occur vertically, closely spaced like this, I think the earlier interpretation, potential interpretation was that they were tectonic in nature, unusual tectonic set, smooth walled and so forth. If they were tectonic, they should be perhaps pervasive vertically, up both above and below, unless they were just growth, results of earlier tectonic events, certainly post-cooling of the Topopah Spring.

As I indicated, DOE is clearly working to resolve this and to get at the question of how pervasive, therefore how predictable, and to work them into their models. We expect this. They are indeed working on this important matter.

CHAIRMAN POMEROY: Phil, can you go a little further along that line? Is there any other thing, for instance, where is the TBM right now? What is the total extent of that fracture zone? Are there other geologic features that have been seen recently that we haver t -- that we're not aware of?

MR. JUSTUS: The initial report of geologic conditions on this subject have the fracture zone, high density fracture zone running from station 42 plus 10 to 53 plus 60.

MEMBER STEINDLER: That's quite a ways.

MR. JUSTUS: And I understand now from Chad Glenn, our on-site rep. that there was a gap. I frankly while I wrote it down, I have forgotten what it is and I don't have it with me. There was a gap in this densely space zone. DOE encountered another closely spaced fracture zone after 53 plus 60.

I believe -- I guess I'm not sure if they are still in it or not. I have not gotten an update on that frankly.

MEMBER HINZE: Any water sample from that zone?

MR. JUSTUS: Water as in flowing water? Not to my knowledge, no. There is no flowing water that's been found in this zone or any other zone.

However, I think to your point, samples are being taken by June Fabrica-Martin's group and others.

MEMBER HINZE: You mean 36.

MS. FEDERLINE: Yes. I was going to get to a follow-up on that in just a few minutes.

I wanted to follow on while we're having this discussion. You are aware that we -- and you participated in the Appendix 7 meeting that we had on the tectonics models. I guess we had felt that a lot of progress was achieved in that meeting. There was an open discussion, a lot of data was brought to the table. There was some general agreement on narrowing the scope of the number of conceptual models that were feasible. I just wanted to get the ACNW's view as to whether you felt that had been a useful dialogue and was actually making progress.

MEMBER HINZE: Well, I felt that certainly all those things were true. I think the impressive thing to me was the fact that DOE was the recipient of a lot of good information and new ideas regarding tectonics of the site. So it's not just a matter of really bringing the NRC up to date. PIs from USGS and other places, but also that there was industry. I think it spoke very well of the staff and the center.

MEMBER STEINDLER: Is there some advantage to narrowing the number of models at this stage of the game?

MR. JUSTUS: Yes. There were approximately 13 models that had been in the literature. Some of them indicate that -- some of them were relatively benign in their prospects for future tectonism, such as the so-called Crater Flat is a collapsed Caldera model, in which case it would have -- it would be dormant or actually extinct at this point and not the subject or locus of the tectonic activity.

So the implications for what models are viable are with this, just one example, are important for directing -- for DOE to direct its work towards establishing future tectonic hazards from volcano tectonics and seismo tectonic aspects. Not only that, the development of future fracture networks as a result of tectonic activity. That of course would bear on fracture flow predictions.

MEMBER STEINDLER: So you think there is enough data being obtained automatic with rates to be able to close out loans, by something other than arbitrary processes?

MR. JUSTUS: I guess I --

MEMBER STEINDLER: You can't decline to answer.

MR. JUSTUS: I can't answer the matter of adequate rate, adequacy of rate at this point, or decline to answer that one.

Yes, I think there's definitely a convergence of DOE and NRC's mutual thinking of what are reasonable tectonic models of the site. This Appendix 7 essentially made that a statement of fact.

Nevertheless, we don't want to leave this on a totally optimistic note, although we'd like to. Five viable tectonic models all indicate a dynamism about this site, whether the models are purely extensional in nature as some of them are, or whether they tend to be strike slip or shear motion dominant.

Both of them have implications for future tectonic activity at the site, which remains to be constrained.

MEMBER STEINDLER: This is a generic question. Do you believe that the residual models left in the pot, so to speak, are all reasonably testable by getting observations from the field within some reasonable period?

MR. JUSTUS: They are reasonably testable in that deep structures can be imaged remotely if enough time, effort, and money were placed on specifically doing so. Now whether that aspect of the project is -- or whether that can be done, or is not a reasonable matter or that's an administrative matter, that's something separate from can the models be better distinguished by better or higher resolution data, which is the question I was addressing.

MS. FEDERLINE: And I think another alterative exists to bound the models when you reach a reasonable number of models, to bound the impacts, because I think we're not going to be able to identify the correct concept in all cases, and that it will be reasonable to bound a reasonable range of these models.

MEMBER STEINDLER: I might be plowing ground that Bill has already touched on, since I think that's an issue that --

MR. JUSTUS: If I may expound a little on my answer. I didn't want to give the impression that there is a quest for unique solution to the matter of is there a tectonic model. If the truth of this site be known in purely scientific terms, there would be just one model, it would be the truth.

As with many complex parts of the earth where not just surface, but deep structures need to be known, there isn't yet very many unique solutions about the three-dimensional geologic structure of dynamic regions, including the Yucca Mountain in southern Nevada. However, decisions can be made on the basis of an array of viable models for which there is support for this range of models. We would be looking for DOE, in the absence of a unique solution to what is the tectonic picture of the site in a predicted sense, to develop a reasonable and conservative range of options, of alternative models to make their decisions from.

CHAIRMAN POMEROY: Okay, let's -- shall we go on, Margaret?

MS. FEDERLINE: Okay. I just wanted to follow up a bit on -- thanks, Phil. Follow up a bit on the chlorine 36. As you'll recall, in April I think when last we talked, we discussed the fact that DOE had detected the bomd pulse chlorine 36 in about five locations in the ESF. The question was raised as to whether this demonstrates that there are some fast pathways by which water can flow at the repository depth. We indicated that we needed to follow this. In fact, additional samples are continuing to be taken as the ESF moves forward. DOE is continuing to check for other radioactive materials.

To date, technetium-99 has been found in the samples from the Bow Ridge Fault. They have looked for plutonium, but they have not found any yet.

They are also looking for cesium, iodine-129, and tritium. They expect the results for cesium in the next few weeks. They expect results later in the summer for the other isotopes.

Now we will be conducting tests or a QA audit the week of June 23, and will be following up on much of this. So we'll have a much more complete picture after that audit is complete.

Okay, I wanted to touch just a minute on what we know of the development of the EPA standard. We have been following this on a weekly basis. As far as we know, the standard has not gone over to OMB as yet. We understand that there have been some changes made to the standard. Larry Weinstock had indicated that he will get a draft of the standard over to us because we have had this cooperative working relationship prior to it going to OMB. So that's the latest on the high level waste standard.

We are developing, as I had mentioned I think earlier, a strategy to go to the Commission of how we will adapt our regulations to be consistent with the EPA standard. We would plan on sharing that with the Commission at the same time we go up with comments on the proposed rule so that the Commission will have an idea of what our plan is as well as our recommendation for comments on EPA's proposed rule. We would hope to work with ACNW and get your suggestions for our strategy so that we can go up to the Commission. We'll have to work that out.

We do have a few significant meetings coming up that I wanted to call to your attention. We have a management meeting with DOE on July the first. We have a meeting with the TRB staff on July 2. The TRB meeting is of course July 9 through 10th. Then DOE is briefing the

Commission on the 15th. TRB is briefing the Commission on July 30th. So it's a busy month of July for us.

I had also committed to just follow-up. The question had been raised as to plans for the LSS. I think John Thoma is here and can probably answer any questions that you have. But as we understand it, that DOE currently plans to begin purchasing equipment for LSS in January of 1997, and installing the equipment by the end of the calendar year. They plan to have the LSS system fully acquired by 1999.

Now the NRC LSS senior management team is preparing recommendations for the Commission. That could significantly change what the LSS looks like. I think at the LSS ARP meeting it was discussed the concept of shared data bases. Rather than configuring the LSS as it was previously thought to be sort of a stand-alone piece of equipment that was administered by one group of people, that rather, we might go to a shared data base. DOE using its data bases on its side. NRC would use CDOCs is our data base. They would relate by communications protocol. Of course all this information would be available to the public through Internet access.

So that concept is being explored. John Thoma is working on putting a pilot up which can be used by folks.

John, is the goal on the pilot by the end of the year? I can't remember the date.

MR. THOMA: By the end of this calendar year or this fiscal year, we hope to have a functional system on the Internet, and then refined it by the end of the calendar year so it will be a little bit better. But it would basically allow a full text search or author, date, subject search capability for selected data. It's only going to be a pilot program right now. So it will not have full data entry.

MS. FEDERLINE: And what this would involve is public access to some piece of our CDOC system where we've put some documents for the purposes of pilot testing, just to ensure that the capabilities are there. This concept has been discussed with the advisory panel members. So we're moving ahead with that.

Any questions on that?

MEMBER HINZE: I'm wondering how readily the access is going to be in terms of the speed of access. Is this going to be controlled at your end to any degree or will this be controlled simply by the modems that are employed?

MR. THOMA: That is part of the protocol to be worked out. But basically, it will be controlled by the Internet modems that the individuals have when they come in. Some of the things that I will have to reach resolution with, and the center is working with me to do that, is we may have some very detailed graphics. Their system may not be able to take it. So we're having to work to re-load software so they can download our graphics package or just tell them it's a read-only package for right now. Those are things that have to be worked out in the next month or two.

MEMBER HINZE: If there will be both a NRC and a DOE node essentially, will those be compatible in terms of access software and readability and all those good things?

MR. THOMA: The end result is to have them compatible. We're looking at designing ours and ours, we would have an external server perhaps that once you went through the Internet and you punched our button, you would come into our external server. It would service whatever needs a person had, because I don't necessarily have control over what the public is using to get into the system.

I would assume the DOE would have the same thing. So we would have a button for DOE. They would go into the DOE system. Then the DOE server would control searches on their system. But they should be compatible, in that we should be able to do the same type of searches.

That would be something that the LSS administrator, if a standard was developed, would say this is the standard that we're going to use. We're just proposing a pilot program as a test to see how it would work.

MEMBER STEINDLER: Can you imagine a numeric GIS coming at you at 9600 baud?

MEMBER HINZE: I don't want to imagine. The purchase of equipment, does this include reading equipment to get some of these materials into a digital format?

MS. FEDERLINE: You're talking about the DOE purchase of equipment?

MEMBER HINZE: Yes. The DOE purchases. Is this a Sparks stations or what is involved here?

MR. THOMA: When you get into the details, sometimes some of those things like that, they say oh, the person that's putting the data in will do that. So that has to be worked out.

What they are talking about basically is the computer that's going to house it and the operating system for once people get into the system, if it's a centralized computer data base. That's something we have to be very conscious about, because taking a historical data base and trying to put it into a computer system can be fairly expensive.

MS. FEDERLINE: John, I understood DOE's costs and schedules were based on the centralized data base, the original access as planned?

MR. THOMA: That's correct. Theirs was on the centralized data base, as is currently required by Subpart J of Part 2. That's something that would have to be looked at if we wanted to get away from that system, you are talking about a regulation change.

But the agency as an agency, is looking at changing to an electronic submittal system. That raises a fundamental question if they do that. Do I need to have an independent system for high level waste? That's for the higher ups in OGC and IRM to determine.

MEMBER HINZE: But there is a commitment to go ahead with the LSS? Is that correct?

MS. FEDERLINE: Yes.

MEMBER HINZE: That is correct?

MS. FEDERLINE: The discussions are now being had, has technology overtaken original plans and should we go back and reconfigure. But there is a definite commitment on DOE's part to go ahead.

I am going to have to participate in a briefing for the chairman at 3:30. So --

CHAIRMAN POMEROY: Yes. I think we'll let the rest of the things that we discussed go by, except I will get back to you on the one specific matter that you asked me about.

MS. FEDERLINE: Okay good. Thank you. I appreciate it.

CHAIRMAN POMEROY: I'd like to thank you, Margaret, Phil and John, and everybody that participated in this briefing. It's always extremely useful. We appreciate it greatly. Thanks, Margaret.

Our next presenter this afternoon is a stranger to us all, one who we're very, very pleased to see here, of course. We certainly have missed you, Dade. We would like very much to hear your comments on almost anything, but three items that we do have on the agenda are open market trading rule, the health effects of low levels of ionizing radiation, the defining a critical group for the performance assessment of a waste repository.

Dr. Dade Moeller is known to us all. He is currently President of Moeller and Associates, Incorporated, and I can't tell you how pleased we are to have you with us. The floor is yours.

MR. MOELLER: Thank you, Paul. My presentation will be a change from what you've been hearing thus far today, and what I would like to discuss with you initially will be new policies that might be applied to the cleanup of nuclear facilities or to reducing their doses to the public from various types of radionuclide releases into the environment.

If you look at the efforts of the Nuclear Regulatory Commission, or look at the efforts of groups such as the U.S. Department of Energy, in terms of reducing doses to the population, you will generally find -- and I think almost exclusively find -- that these efforts are directed toward new technical developments in order to reduce those doses.

And so to repeat, this afternoon I would like to discuss with you one policy approach, or one change in policy, or one application of an existing policy, that might be used to reduce these doses.

And the policy that I want to discuss with you is not a brand-new policy. It is one that has been applied quite widely in the control of toxic chemical releases into the environment, and that policy is the open market trading rule.

And, for example, if you were a major industrial organization, and you wanted to move into, say, the Rockville area, and you wanted to build a new plant here, and let's say that the air in the Rockville area is already polluted to the maximum, so there is no room for you to -- well, there's room to build your plant, but no room for you to release toxic chemicals into the air.

Well, then you have two choices.

One I'd say here, reduce your own releases. In essence, you'd have to build a plant with zero release, because there is no room for you. Or, if you cannot do that, or not economically, if that's not technologically or economically feasible, you have the choice of coming into this area and either purchasing other industries that release similar pollutants and shutting them down, or assisting other -- assisting a sufficient number of other generators of pollutants in that area, so that you can help them reduce the amount of their releases to make room for the releases that your plant will generate.

So, in other words, it is just a method which some people call the method of trading exposures, and the more formal name, as I say, is the open market trading rule. And this is not something new. It's a policy that is being widely applied, and I'll give you some examples.

When the policy was first applied -- it is one that is used by the Environmental Protection Agency and by various state organizations -- when it was first applied you traded off a single pollutant in a single medium. For example, if you were discharging sulfur dioxide into the air, you had to make room by reducing other sulfur dioxide releases into the atmosphere.

Then they moved into multiple pollutants within a single medium, where you could trade off oxides of nitrogen versus oxides of sulfur and various other combinations, say, again, within the atmosphere, or combinations of pollutants within the liquid or aquatic pathway.

And then, in areas such as the Chesapeake Bay, right now they are applying this concept on a regional basis to multi-pollutants into multimedia. So you would look at a tradeoff of a release of something into the atmosphere. It could be lead into the atmosphere. You could tradeoff in terms of the releases of lead to the aquatic or liquid pathway.

And then, going beyond that, we find that as I have just said at the Chesapeake Bay, and in terms of multi-pollutants and multimedia, we are now looking at applying -- or it is being applied on a regional basis. It is also being applied globally in terms of emissions to reduce global warming, say CO_2. It's being applied through, for example, the Montreal Protocol in reducing the emissions of chloroflourocarbons that lead to reduction in the atmospheric ozone levels.

And then it is even being applied in wetlands. For example, if you wanted to build an industrial plant somewhere, and I don't know the reasons, but assume that you must destroy some wetlands in order to build your plant.

Today, regulatory organizations will let you create artificial wetlands to replace those -- the natural ones that you're destroying. And, indeed, carrying this further, we see a widespread application today of sewage, treated sewage effluents to the land, which create artificial wetlands. So we see the whole concept being expanded farther and farther.

And my point today is that it is widely accepted, and I -- in a few minutes, I am going to discuss some of the ways that it can be applied in the radiation field, and to control the doses to the public from radionuclide releases into the environment.

Now, I say it is being endorsed. I have had extensive discussions with Dan Ryker, who was formerly -- well, excuse me, first here with EPA with Ramona Trovado, who is the Assistant Secretary for Air and Radiation within EPA, and she is excited about this particular concept and the application of it, because as I'll show you in a few minutes it could well lead to a renovation or a reencouragement of the move to control radon within homes in the United States -- a program which in many senses is somewhat in the doldrums.

Within DOE, I've discussed it with Dan Ryker, who at the time was Assistant Secretary for Planning and

Evaluation and Policy. He is now the Chief of Staff there. But he is very excited about the plan, or about the application of the concept, to the control of radionuclide releases. And so is Steve Gallson, who is the Chief Medical Officer within DOE.

And then if you read the reports from the GAO, or the Council on Environmental Quality, or even read some of the many other reports of the Electric Power Research Institute, you will find articles endorsing the open market trading rule and showing how it is saving the nation and industry, and so forth, millions of dollars in cleanup costs, because what does it permit you to do?

It permits you to clean up where you can remove the pollutant at the least cost. It permits you to clean up in those areas where you can be most cost effective.

And I'm mentioning endorsements. I was just invited last month, in May, to appear before the Conference of Radiation Control Program Directors. They had their annual meeting in Albuquerque, and they asked me to come out and discuss this concept with them. I'm appearing here this month.

In July, I've been invited -- the DOE and NRC, Nuclear Regulatory Commission, every two years hold their international nuclear air cleaning conference. And the meeting this year, in July, will be in Portland, Oregon, and they've asked me to come out and be a plenary speaker the first morning and present this idea in terms of what it could mean in improving the cleanup of airborne releases from various nuclear installations.

And then, I have also been invited -- we haven't yet set a date -- to appear before the Federal Interagency Committee on Radiation Protection and discuss with them how this concept might be useful.

Now, so much for background. How would you apply the concept in a real world situation? Well, let's say you have a nuclear facility. It is either operating now, or it has been operating. You've shut it down, but radionuclide releases are still occurring. So the population around that facility is receiving dose either externally or internally or a combination, due to these releases. Now, how would you apply this policy? How would you apply the open market trading rule?

Well, the first thing you would have to do is do a careful study of the population living near that facility and determine what sources, what radiation sources are causing them to receive dose. And secondly, as you see here, you would need to rank each of the sources according to the dose that it is contributing. Then you would rank them according to the ease for the cleanup or the reduction of that particular dose.

Now, you would not go by NCRP or ICRP or NRC or EPA or anybody, or DOE's work orders. You wouldn't go by any of those. You would look at all of the sources that are contributing dose to that population, whether they're medical X-rays, dental X-rays, chiropractors, or natural background, radon in the home, cosmic radiation, terrestrial sources. You would add all of these up. You would weigh them one at a time, what dose do they contribute, how -- what is the ease of cleaning them up, and so forth.

And once you have that type of data, and concurrent you might say with the obtaining of that kind of data, you would need obviously to clean up the facility itself to some minimum level, meaning in terms of the dose that it contributes to the public.

I'm saying here you couldn't allow a nuclear facility to operate and give the public one rem a year, or whether operating or shutdown. You would have to clean it up to some minimal level of contaminant release. And in just a moment I'll talk a little more about that. But just to throw a number out on the table, and one we've heard here this morning, the ICRP, NCRP, NRC all have a rule -- that members of the public should not be exposed to a total of more than 100 millirem a year.

Well, obviously that would be a benchmark. That nuclear facility would certainly have to be cleaned up so it would not alone, by itself, yield or cause the population living near it to receive more than 100 millirem a year. Now that -- I'm just throwing that out as a hypothesis, but I think I could defend that.

Then, once the facility had been cleaned up to this minimal level, then you'd begin to apply your tradeoffs to reach your desired lower level, because the public is going to say to you, particularly the public living around this facility, is going to say to you, "We don't want 100 millirem from that facility. That's too much. We want 10 or 15 or 25," or whatever it is they want.

Well, from the 100 on down to whatever it is they want, that's where you would apply -- begin to apply your tradeoffs. And so what would be some of the tradeoffs? Well, here they are, just a couple. Indoor radon. Indoor radon contributes to the average member of the U.S. public an effective dose of 200 millirem a year.

So I'm jumping ahead a little bit, but let's say the nuclear facility contributes 100, and say I go into all of the neighboring homes and I totally -- and I realize, you know, don't hold me to this. It may only be a 90 percent or 70 percent reduction. But let's say I totally remove all of the radon in all of the homes around the facility.

Well, I'm talking 200 millirem reduction, so I'm going to -- those people then will be left with 100 millirem less than they received before the facility was ever constructed, before the facility was ever constructed and operated. They're now getting 100 millirem less. And for those of you who believe in hormesis, you're going to be quite upset by my proposal, but I have to go ahead with it.

Now, let's say -- talk about finances, and I'll have more on finances in a moment. But let's say there are 5,000 homes. You could say to me, "Well, Dade, how far out from the facility are you going to go?" I don't know. We've got to do some pilot studies and see. But let's say I'm in a -- most nuclear facilities, or many of them, are in remote areas.

And let's say I go out far enough to where there are 5,000 homes in some radius around that facility, and I don't need to spend this much but say I spend $1,000 per home to remove the radon. I'm spending $5 million. That is peanuts compared to what you would spend cleaning that facility on up from 100 down to 10, or whatever it is. So I'm going to look at medical radiation, radon. I'm going to look at anything that is affecting those groups or the population around there.

Now, these are data -- these are not mine -- they are data that Bill Dornsife gave me, where he has done -- he is the Director of the Radiation Control Program in the Commonwealth of Pennsylvania. And he gave me these data where he compares the cost -- the cost effectiveness of reducing doses from various sources of radiation.

Now, I can't defend the numbers. He can. I can't even tell you all of the factors that went into the numbers, but he can do that. He has written papers on it.

Now, in terms of X-rays, he shows that for $2,220 per cancer -- each of these -- all of the remaining are per life saved. The first one is for cancer prevented. It's $2,220. Okay. Let me say that 50 percent -- and I asked Bill if this was a reasonable number, and I asked several other people and they said yes, it is.

Assume that cancers are 50 percent fatal. So I'm talking about $5,000 that it would take me in the way of cost to reduce the doses from medical X-ray machines, $5,000 will save me one cancer fatality. So it's a very cost effective source of radiation to remedy.

Now, for CT studies, diagnostic X-ray studies, it is $29,000 -- say $30,000 per life saved. Radon mitigation, he estimates about $100,000 per life saved. Don't ask me -- I guess you should have him appear some time and tell you where he got the number, how he calculated. For a low level rad. waste disposal facility, it's about $8 million per life saved. That's discounted, and if you don't discount it it is almost double that. Or, no, it's more like 16 -- yes, that's right, about -- it goes from $8 million to about $16 million per life saved.

So all I'm trying to point out to you is that there are ways to reduce the dose to the public that are a whole lot more cost effective and a whole lot better, I think, than spending all of our time on sources that are not that easy to control.

Now, I thought I would summarize first some of the benefits of the use of the open market trading rule in the nuclear field. And the first one I would point out to you is it represents a risk-based approach. That is to say, you are going out into the population, and you are evaluating all of the sources that are causing dose. And you are comparing them one to the other, and you're looking at the cost effectiveness of cleaning them up.

You are looking at the risk. By doing this, you'll be able to tell the public what it is that is contributing the greatest dose to them. You can tell them what is their greatest source of radiation risk. So it's definitely a risk-based approach.

It also requires a holistic approach. You don't just go in and say, "I am from the NRC. I'm only responsible for licensed facilities. Don't tell me about anything else. Here is the dose you're getting." You know, so many microrem per year. You would be required to look at every source there.

And the states are jubilant about a plan like this, because it would permit -- well, all of the states, if you move from the NRC or EPA or DOE, if you move down to the level of the states you'll find that a state radiation control program is responsible for X-rays and for radon and for the full gamut of sources.

And yet, because of the way certain federal funds are filtered down to them, and because of the ways in which their own state legislatures appropriate funds for the control of the doses from various radiation sources, they are required by law to place emphasis where they shouldn't be placing emphasis.

And when I spoke to the state radiation control program directors, they said, "This is exactly what we need. This would permit a risk-based approach. It would permit us to get out there and do some good instead of wasting our time on sources that don't really need remediation, or sources in which I really can't do a good job with the limited funds." In other words, my funds are limited. Let me apply my limited resources where they will do the most good.

Thirdly, it provides direct interaction with your stakeholders. Instead of sitting there at your own facility and calculating the dose to the public, you are out there surveying the houses. You are visiting the houses. You are finding out -- you are visiting the local hospital. You are finding out what it is that contributes to their dose. So immediately, the stakeholders are being heard. You're interacting with them. You don't have to force any type of a dialogue. It's natural through this system.

Fourthly, it permits immediate remediation. You do not have to wait for the EIS to be completed on the XYZ facility. You can move now and start cleaning it up. There is no legislative or other types of restrictions on what you do.

I've already mentioned to you it would provide a stimulus for the control of indoor radon -- something that we really need, EPA really needs. The states really need it.

Bill Dornsife, again from Pennsylvania, says to me, "I'm out there spending money on these nit-picking sources that aren't of any consequence whatsoever. If the people who control the funds would let me control radon, I could really be doing some good. I could be saving lives. I could be significantly reducing dose."

Now, for those of you involved in the cleanup of nuclear facilities, and those of you responsible for the disposal of waste, think of the significant reductions in the volumes of low level waste that would be generated if you could stop after you've cleaned up that facility to a level of 100 millirem or so, instead of going on down and removing the last atom of radioactive material there.

So we have a tremendous savings in cost and a tremendous savings in the volumes of waste being generated.

We hear so much, particularly within DOE, that we can't move now. We can't clean up this facility. We've got to do research on better, more sophisticated techniques for remediation of contaminated soil, and so forth.

If you only had to bring it down to 100 millirem a year, you could use existing technology in many cases. We wouldn't have to spend the money on it. We wouldn't have to wait to do it. It provides a cushion for errors or for unexpected development.

So let's say I built this low level waste disposal facility, and I have engineered barriers that protect the public, and somehow an engineered barrier fails or some natural barrier fails in the future. Well, I could tell the public -- I'm not sure they would buy it totally -- but I certainly could stand here and I could say to members of the public, I could say to the stakeholders, the people living around that facility, "If anything unexpected happens, we can rapidly move in there and reduce your radon, your medical doses, these other doses, to more than compensate for anything we possibly estimate that a disturbed situation could yield in terms of dose to you."

I've already mentioned this one to you. It would readily, in most every case, permit you to reduce the dose to less than it was prior to the operation of the facility. And we often hear, and Dr. Steindler and others may not agree, but I've often heard that the DOE -- and, in fact, I read in Science and a few other magazines that the DOE laboratories are searching for a mission, and they want something new -- new challenges.

Well, I'll give them a new challenge -- get out there and look at some of these facilities. Look at your own. DOE national labs -- look at some of your own facilities. Do an analysis of this type, move in there and see what you can do. Then if it doesn't save you cost, don't do it. If it doesn't save money, don't do it. I don't care, but I know good and well, basically, in terms of gut reactions, that it is going to save them a tremendous amount of money.

I always believe in a dozen even benefits, so I'll stop with my 12 and then go on to some of the negative aspects.

I really had to dig for the negative side. I think today, though, with this committee I will probably get a few negatives, maybe even from members of the public who are here.

It could ultimately -- you know, we are moving toward a risk-based approach. We heard in terms of the Yucca Mountain standards that, you know, we are -- they recommend a risk basis for those standards. We are moving toward that goal, and I could see the day come that instead of just reducing radiation -- let's say I've got this facility, and it's dosing the public and they're getting too much. And then I move in and I put in a better mammography unit in the hospital, so I reduce the dose to all of the women over 40 by, you know, XYZ millirem per year.

And then Marty Steindler comes to me and says, "Oh, Dade, your whole thing is loused up. You only are helping the women over 40. What about all of these children here that -- in this town? You haven't done anything for them."

All right. For the children, when I reach the day that I can trade off between radiation toxic chemicals, and so forth, I would move in and I would go to all of the playgrounds of the children in that area, and I would make sure there is soft grass, or, you know, soft sand beneath the swings and the slides and everything. And I'd cut down on the injuries and the deaths to the children from that, and I would trade that off. I'm talking about utopia down the way. But I would trade that off.

I would purchase helmets for children when they ride their bicycles and distribute them in the community. And I could show a tremendous reduction in injuries, and so forth, and I would balance that off toward the radiation.

And then, lastly, to me it's an outstanding vehicle for public education and good will. Think what would happen if you went into an area and you -- with the public's input. You would finally give each one of them a sheet of paper and say, "Here are the sources of your dose," you know, natural background, medical radiation, on down the line. And here is what it would cost per millirem reduction for each of these sources. And there would be some, of course, who would still argue with it, but I think ultimately it could lead to a really wonderful tool for educating the public.

Now, problems with it. First, with the question of the cleanup standards, I want to discuss each of these. A second would be the relevant time scales involved. And the third is the equity of the exposures, which I've already mentioned briefly, helping the women versus the children, and so forth.

So let me talk a little bit about each of these problem areas. In terms of the cleanup standards, I have here the guides on the various doses that we have to date. The annual cumulative limit -- this is not the NRC's Title X, Part 20. This is the recommended limit, cumulative, for workers. The NCRP, in their report number 116, recommends that no member -- that no person occupationally exposed to radiation receive more than one rem, 10 millisieverts per year of life.

Now, obviously, since you don't begin working or you're not legally permitted to begin working with radiation until age 18, it is not exactly one rem a year. But I put that down just as one benchmark.

The second benchmark -- one millisievert or 100 millirem a year -- is the annual limit for members of the public, whether it's ICRP, NCRP, NRC, or what. Then, the one-tenth of a millisievert per year, the 10 millirem, is the annual limit for airborne emissions as recommended by EPA. And then .01, the one-hundredth of a millisievert, the one millirem a year, is the negligible annual individual dose as prescribed by the NCRP in their latest report.

And this leads back to what I was saying earlier. I would think you would have to reduce any site to less than the hundred millirem, the one millisievert per year. And how low you would reduce it would be somewhere between 100 and down to one, and I would presume it would be 10, 15, 20, 25, somewhere in that range.

Now, relevant time scales. Okay. Several people had pointed out to me that in terms of the mode of exposures due to radionuclide releases, you have releases into the atmosphere, of course, and releases into the groundwater, and perhaps later into the food pathway, and so forth.

Now, it is quite obvious in most cases that an atmospheric release would lead to immediate doses, because if you inhaled it, I mean, the dose would be relatively soon after the exposure. Groundwater, it would take a while for the radionuclide releases from the facility to contaminate the groundwater. So, in a sense, those would be somewhat delayed. So one could say, when is it that you're going to do your remediation?

I would hope to do my -- do the remediation before groundwater was even contaminated. Now, at many facilities it is already contaminated, so that is not a question. But there are differences there, and those would have to be factored into your plan fc [illegible] lying the open market trade rule.

Now, another key ingredient would be the half-life of the radionuclide. I personally see the open market trading rule only useful in terms of shorter lived radionuclides. And what do I mean by that? Well, I see it as being very beneficial in balancing exposures from radionuclides such as strontium-90 and cesium-137, which have a 30-year half-life. I would have no problem, personally, in using the idea to compensate for those.

Long lived -- if the contamination is plutonium, with a 23,000-year half-life, I would have a lot of problems with it, because I cannot guarantee you that the technique that I put into the home for reducing radon is going to last for thousands or tens of thousands of years. So there are limitations on the application of the open market trading rule.

However, if you had a situation in which plutonium has been released, and the environment is contaminated, you could certainly apply the open market trading rule until such time as you could finish cleaning up the environment, so that you no longer needed those tradeoffs. So the relevant time scale, that is certainly something of importance.

Another one is in terms of the equity of the exposures. You must be sure that to some degree, and to the maximum possible degree, that the population that you're exposing, that is being exposed from the nuclear facility, is the same population that you're remediating.

Well, in my example, I think I -- obviously, I'd go in a concentric circle around the facility. So I think I would be pretty safe in terms of that, because obviously if they're not being dosed by the facility, then perhaps I wouldn't consider, you know, the regulatory agency, or whoever it is that is doing this, would not be interested or too concerned about remediating that particular population.

But I personally, unless I don't fully understand that particular question, I don't see much problem in assuring that I am going to remediate the same population that is exposed.

Now, another question that members of the public would say is, well, some of the radionuclides being released from the facility cause external exposure, and some of them cause internal exposure. And some of the internal is through breathing, and some is through ingestion. And some cause doses to the lungs, some cause doses to the thyroid, others cause doses to the skeleton or the bone marrow, and so forth. How am I going to, on an equitable basis, trade off these apples and orange situations?

Well, fortunately, through the concept of the effective dose equivalent, which the NRC uses in the new -- well, it's no longer new now, 1991 I guess, revised Title X, Part 20. The EPA uses it in their population guidance. You have the concept of the effective dose equivalent. And through that concept you can equate a dose to the thyroid with a dose to the lung. You can equate a dose from inhalation to a dose from ingestion. You can equate a dose from an external source to an internal source.

So back in terms of public education, this would be a good system for helping the public to understand that there are ways, there are scientifically-based ways, to equate these various types of exposures. And, therefore, the trading that you do is effective and it is equitable.

Lastly here, I could look at the equity of exposures in terms of men versus women. I mentioned the mammography unit, which would only help the women. You could help with perhaps dental X-ray units, or you could help with chest X-ray units. There is a variety of medical -- well, if you just -- if you had a hospital near this nuclear facility with antiquated X-ray machines, you could go in and replace some of those machines and both men and women would be helped, and perhaps children.

I don't know how in every case to balance out doses to children versus adults. We'd have to look at it and see what comes out. And if we encounter some problems we'd have to face them at that time. And then other people will have problems, undoubtedly, in the tradeoffs between residential versus environmental versus medical exposures.

And I would hope there or I would presume that the approach scientifically that you would take is to just look at the effective dose of radon in the home, or consumer products in the home, versus whatever is in the environment, versus whatever they are receiving medically.

And there are techniques -- they're not readily available, but they are being developed -- to equate partial body exposures from medical X-ray exams. There are techniques being developed to convert those into an effective whole body equivalent dose, and thereby permit an equitable comparison and tradeoff in terms of those particular sources.

So that was my message. I certainly -- that's the initial portion. I am certainly open to any questions or comments that you have.

VICE CHAIRMAN GARRICK: Dade, when you talk about reducing our doses that we receive, such as radon and medical, are you talking about that reduction coming entirely from improved technology? Or are you seeing some radiation in the bank there as a result of an excessive use of radiation therapy or diagnostics, or what have you?

MR. MOELLER: Initially, I would view it as coming from technology -- in other words, improved systems. However, once -- and you've raised a very good point and a good insight. Once the public began to understand that medical radiation was the greatest source of man-made exposure, and you showed them how much reduction could be accomplished technologically, I think then they would start seeing the light and saying, "Ah ha." Not only that, but are there better procedures and faster film and higher kilovoltages, and all of these things? Greater filtration.

VICE CHAIRMAN GARRICK: Yes. Well, I can see a benefit coming out of this of increased consistency.

MR. MOELLER: Yes.

VICE CHAIRMAN GARRICK: And consciousness of the --

MR. MOELLER: Yes.

VICE CHAIRMAN GARRICK: -- use of radiation, especially in medical diagnostics.

MR. MOELLER: Right.

VICE CHAIRMAN GARRICK: Yes.

MR. MOELLER: And there is a lot of room, as you well know, for improvement there. And they have done a lot, though. If you look back over the progress reports, or the doses that the Center for Devices and Radiological Health has put out to their next program, the national exposure trends, X-ray exposure trends program, there have been dramatic reductions in the amount of the body, say for a chest X-ray, the proportion of the body that is exposed. They columnate the beam, and so you don't expose from the head to the toe for that.

VICE CHAIRMAN GARRICK: Yes.

MR. MOELLER: So, yes. But you're correct. That's another good idea.

MEMBER HINZE: Dade, you spoke about this in terms of a systems approach, too. That's a very useful and intriguing idea. But it's obvious that not all of the sources of radiation are within the same system, and they may not have the same spatial distribution.

Your comment -- analogy to, for example, Chesapeake Bay. They have the atmosphere being loaned to the east and the waters headed south. So there -- in dealing with these different media, in particular there would be a number of problems. We consider -- the system is being considered as one.

MR. MOELLER: I agree. And that, again, is something we -- you know, that needs to be evaluated. In terms of a single nuclear facility, and, you know, whether it's a DOE facility or a decommissioned nuclear power plant, think of what this might could save in terms of the cost of decommissioning a nuclear power plant. In terms of that, I am hoping that it is not quite as complicated as the Chesapeake Bay.

But sure, you're right. The wind will blow one way, and the liquids will go another way.

MEMBER HINZE: In terms of this -- the complications from the various elements of the system, there would be, I imagine, conflicting or different organizations that are in charge.

MR. MOELLER: Yes.

MEMBER HINZE: And it would seem to me that one of the potential benefits -- it would certainly be a problem to begin with, but one of the potential benefits would be to get these groups working and talking to each other.

MR. MOELLER: Good point. And, fortunately, at least on the basis of having met with the state people, I gain the impression that at the state level most -- in many cases, it is much better coordinated than here. They don't have the strict separation of organizations responsible for -- certainly for radiation. Usually in the states, those groups are responsible for all radiation. So you're correct. We could begin there and hopefully start communicating.

VICE CHAIRMAN GARRICK: Just one more. With the radiation phobia that exists among a lot of people, wouldn't you anticipate this would be kind of -- as logical and sensible as it is -- a difficult concept to sell because the public would say, "Well, if you can reduce my exposures that much from improved medical practices, and from getting the radon out of my home, and reducing the radiation carrying effluents in the atmosphere," it will do that and clean up the facility, too.

MR. MOELLER: Correct.

VICE CHAIRMAN GARRICK: I suspect that a lot of the public would see this as maybe just another angle on the part of, say, the DOE to not clean up its facilities to a point where there was unrestricted use of the land.

MR. MOELLER: I think that's going to be a major problem.

VICE CHAIRMAN GARRICK: Yes.

MR. MOELLER: I'm with you. I believe that many members of the public are going to say that, "I want the DOE facility," or the nuclear, whoever, "I want it cleaned up to four millirem, or 10, or something, and I want all of these other things, too." I don't know how to overcome that. I would I guess get with a -- you know, a media -- communications and public education specialist.

I would hope, too, by -- as the plan moved forward, and the pilot study moved forward, that you would have a series of public meetings. And, you know, we all hope that the outcome would be good, but, no, I can't guarantee it. It may backfire.

MEMBER STEINDLER: Well, I guess I have a couple of problems. I think the general notion of being able to trade off remediation costs and impact is probably a good one. The thing that bothers me is that the bank that you're -- is largely populated by radon. The next level -- as you know, you keep going down this priority list -- is maybe medical.

Let me take radon for a minute. Number one, the criticism that people have levied against the EPA -- you know, which you are well aware of -- about the dosimetry that they have pronounced is sufficiently severe, and I think has been sufficiently viable, so that the average dose that is attributed to radon may, in fact, be off by quite a bit.

Secondly, radon remediation is not only not particularly cheap, and 1,000 bucks for an existing house may not, in fact, be such a bad number, but what do you do when you do that? The most effective way at the moment that I'm aware of is you basically blow it out some stack. And do you know where that goes? That goes into your neighbor's house.

And so remediation in the case of radon is technically a very difficult thing to do in the same -- with the same permanence as, for example, dose reduction from faster X-ray film, where you can do that in a positive sort of way.

Radon is hard to trap. And except for the device that you put together some -- in your former life, trapping of radon and subsequent disposal is not a very simple thing to do.

What I'm concerned about is that the bank against which you now want to trade off is kind of an ephemeral bank that may give you, in the long haul, when you do a system study, significant difficulties because you can't move that source far enough away from the affected population fast enough.

The other --

MR. MOELLER: Excuse me. Let me respond to that, Marty, because, you know, those are good comments.

You're correct that if you do the sub-basement floor exhaust, you know, sub-slab exhaust system, it does blow the radon up into the atmosphere, and then it -- in fact, in the early EPA drawings, they showed you blowing it out at ground level over the sand box.

MEMBER STEINDLER: Right.

(Laughter.)

MR. MOELLER: Where the children were playing.

But the EPA, 20 years ago, financed research on looking at a variety of simple methods for handling radon in the home. And one of the outcomes of that research, which I'm familiar with as you know, was that a simple overhead ceiling fan in a room, or a table fan, anything that will gently move the air in a room, will reduce the airborne concentration of the solid, electrically charged radon decay products by over 50 percent. Any kind of a fan in a room.

Well, I certainly -- and EPA -- I know there are people here from EPA, and I've had extensive discussions with them down through the years. They simply never would recognize the results of the research that they financed.

I am pleased to say that over the past year the University of California at Berkeley, Bill Nazaroff and Richard Seckstro, who are faculty members there, and Dr. Phillip Hopke at Clarkson University, the two have independently redone all of that work and reached the same conclusions. So I am hoping now that EPA will listen.

So I'm saying to you you could -- 90 percent is going to be difficult. Fifty percent to 60 percent is quite straightforward.

CHAIRMAN POMEROY: Could I just ask you to expand on that, Dade? How does that actually work?

MR. MOELLER: Okay. If you -- when radon -- well, radium is in the soil. It's a solid. When it decays by alpha emission, it produces radon, a decay product, which is a gas. The radon then bubbles up out of the ground, bubbles into the house, if it is beneath the house.

Radon is also an alpha emitter. And when it decays, as the alpha particle blasts through the electron cloud around the radon. it strips off electrons. It I guess is like firing a cannon through something, but it just tears away electrons from the cloud. And so it leaves the residual decay product of the radon.

Now, the radon decays by alpha emission into a solid radioactive decay product. It leaves a decay product that is electrically charged, and it's positively charged because of this removing the electrons. The dust in a room, the normal -- you know, this room is full of dust -- is negatively charged. I don't know why, but God made dust negatively charged.

The radon decay products then immediately, within seconds, jump onto a dust particle, and from that moment on -- well, even if they don't jump on, but if they do jump on, they -- then their behavior is controlled by the behavior of that giant dust particle. But whether they jump on the dust particle or not, just gently moving the air in a room causes these charged particles to touch the wall or this table and chair, your clothing, anything, and it is just -- you know, you clean your TV screen off periodically, the dust. It is that same type of plate out.

And once the decay products are plated out, you can blow a fan over. You cannot -- you can, but with great difficulty, remove them. They are alpha emitters. They couldn't hurt anybody unless you went around and licked the table tops or something. And so they're removed from the air, they don't get in the lungs, and you don't have a problem.

Marty?

MEMBER STEINDLER: Yes, there are a couple of other issues. To a large extent, some of the remediation consists of turning things back into a flat site, not a green field site because that's not -- that's what you're trying to avoid. But turning it back into a site. And whether you do it the way some landfills do when they promise you a golf course, or a children's playground, you know, is an issue.

But I guess I am concerned about the difference -- first off, the access to that site by populations that are outside of whatever the boundary is that you fix. And secondly, even more important, I think the radiosensitivity of children is significantly higher than people like us. It gets -- we -- you know, I think that's well established, and there is no mechanism at this stage of the game in the uniformly applied radiation standards, which don't distinguish between children --

MR. MOELLER: Correct.

MEMBER STEINDLER: -- and others. And so that issue needs to be at least settled in some fashion or another, or at least taken into account. You can't be silent on that.

MR. MOELLER: I hear you, and I agree.

MEMBER STEINDLER: The other comment that I was going to make was -- oh. How do you set the threshold? You know, you set the threshold at 100 millirem.

MR. MOELLER: I would --

MEMBER STEINDLER: How do you do that?

MR. MOELLER: -- need input from someone. You know, I threw out just the number of 100 millirem. If people decided it should be 50 millirem, fine. I mean, it's subject to discussion. I presume one way you could do this -- and I'm benefitting by discussions that I had with John Greeves a few months ago.

One thing you could do is do a pilot study and show that if you reduced it to 100 millirem it would cost this much and produce this much waste, and 75 millirem and 50 millirem. And then when you have your pilot study done, and you need confidence, you know, to now move ahead and try implementing it at a site, you could submit the whole thing to the National Academy of Sciences, you know, National Research Council and say, "Give me an independent review of this, and give me your recommendations on what that threshold level should be," and see what the wise people say.

But no, I would not -- I do not have the answer, but I am open to suggestions.

MEMBER STEINDLER: Well, one last point, and that is radon is probably more ubiquitous than a chest X-ray.

MR. MOELLER: Yes.

MEMBER STEINDLER: And so --

MR. MOELLER: And I would be helping the children, incidentally, on the radon. But go ahead.

MEMBER STEINDLER: Yes, okay.

MR. MOELLER: Okay. I wanted to win one.

(Laughter.)

MEMBER STEINDLER: That's no problem.

But I guess my problem is I'm worried about the bank. I continue to be worried about the bank against which you draw to offset the costs. It seems to me that the medical bank is a little iffy. I mean, there are people in this country, unfortunately, who will not see the inside of either a clinic or a hospital for the first 60 years of their lives. Then the last one year it doesn't make any difference.

MR. MOELLER: No, right.

MEMBER STEINDLER: And so I don't know how you can -- I mean, there is no doubt that for some people that would be a useful argument, but not -- and not too broadly applicable. So I continue to worry that the scheme, which I think has merit, draws on a bank that is somewhat limited.

MR. MOELLER: What I would recommend as a beginning, and I hear you and you've got a -- you know, you're right as rain. I'm with you 100 percent. What I would probably propose as a measure of the bank, and it does not answer your question, but I would calculate the collective dose and initially use that as my bank and guarantee that I would reduce the collective dose by more than the plant was contributing, the facility was -- you know, the collective dose off-site.

MEMBER STEINDLER: So if you believe that 200 millirem number as the average, all you have to do for almost anything you can think of is take all of the radon out, and everybody else can go home free, because hardly anybody runs more than a couple hundred millirem per year in a contaminated site.

MR. MOELLER: And what DOE should be doing instead of spending all of their money on research on improved technological methods of cleanup, they should be -- and they are working on improved technological methods for radon removal, or, you know, whatever -- negation. And maybe they ought to triple or by a factor of 10 that budget and come up with some new better ways of doing it.

CHAIRMAN POMEROY: Dade, I think we could continue this conversation, but I think --

MR. MOELLER: I know you have two other topics and --

CHAIRMAN POMEROY: Yes. I think we're looking for your guidance on both of those topics, so I think we'd like to hear that, too.

MR. MOELLER: I had a few slides, but I don't think I'll bother with them. There are two things that I hope will be helpful to you.

In terms of the critical group, I did go through ICRP reports -- I think it's 42, 43, and 46 -- and I xeroxed out of those reports every statement that they made about the critical group and wanted to share that with you. I hope those will be helpful.

One thing you will notice in there which I was a little -- I kept watching for this morning when the various people were talking about the critical group, and that is in the ICRP discussion of the critical group, they say in terms of a repository and looking toward the future that you need to consider such things as improvements in medical treatment, like a cure for cancer.

But when I heard this morning the reviews of the probabilities of this and that, I saw no probability in the equation that cancer -- a cure for cancer will be brought about. And, therefore, I don't even worry about radiation.

And, again, I am sort of talking about things of which I know very little. But if you're talking 10,000 or even 1,000 or even 100 years into the future, why aren't we factoring in what the ICRP suggests? So that was one thing on critical group, and that is about all I have. As I say, do read those ICRP definitions very carefully, and you'll find, as Dr. Pigford pointed out, they say exactly what he said. And I just thought it would be helpful to have all of them there.

Now, in terms of the linear non -- or no threshold concept, Dr. Steindler and I did go down and hear the presentation by Dr. Kenneth Mossman. And I would -- and Marty I think probably I'm pretty sure will agree -- I found it to be a very neutral, objective, unbiased review of the subject. He did a nice job.

And the one thing that he brought forth, one of many things, the one that stuck most with me, was that in terms -- well, first of all, keep in mind that the NCRP has appointed a scientific committee to do a comprehensive review of this, and they will be coming forth with a report.

Now, some people might say, "Well, I'm not sure the NCRP is that unbiased. Will they give us an objective report, a balanced consideration and recommendations?" Well, I believe they will if, for no other reason, than that Arthur Upton is the chairman of that committee, and he was, you know, former director of the National Cancer Institute and just an internationally respected scientist. So you will receive a very objective report. And didn't he chair BIER V, as I recall? So you'll get a good report.

The highlight that stuck with me, among many things that Dr. Mossman said, was that in considering this subject keep in mind at all times the principles of good science. Keep in mind the principles of good science. And what did he mean by that?

Well, he said in a number of instances where the people say, "Oh, there are beneficial effects of low doses," or, you know, some other reason not -- some other reason to discard them in your no threshold concept, he said, "If you apply good science to that you'll ask the following questions. Has that particular study," and he said in most cases it is almost a single study they're counting on or basing their recommendations on. He said, "Has that single study been replicated by other scientists under other conditions? Unless it has, you should question it." That was his first point.

The second one he made was is there a plausible scientific explanation of the effect that you've noticed or observed? And unless there is a scientific plausible explanation, then you should question it. And he said, "Was the experiment itself that led to those conclusions properly designed? And was it well planned?

Was it well executed -- the design -- or the plan designed and executed? Unless it was, you should question it."

He said, "Are the" -- not only has it been replicated by others, but are the results consistent with the results that others are producing? Well, that's a little bit of the same, but he said that. Then he said, "Was this study peer reviewed? And has it been subjected to criticism of the National Research Council or some other committee?" And I think those were, to me, the key points.

Marty, were there others?

MEMBER STEINDLER: Repeatability is --

MR. MOELLER: Repeatability, yes.

MEMBER STEINDLER: Somebody else did the same thing.

MR. MOELLER: Well, not only that, but have the same designers who did the first one been able --

MEMBER STEINDLER: To do it twice.

MR. MOELLER: -- to repeat it. So I found that very helpful.

VICE CHAIRMAN GARRICK: Of course, the same questions have to be asked of the experimental evidence for the linear theory.

MR. MOELLER: Yes. But I think in that case -- well, let me say, too, you know, if you look at what the NCRP says when they discuss the linear no threshold concept -- let me find my slides here. I said I wasn't going to show them, but here is what the NCRP says in NCRP report 116.

And this doesn't answer the question, but I talked to Charles Meinhold just a week or so ago about this, and they say, "Based on the hypothesis that genetic effects in some cancers may result from damage to a single cell, the Council assumes" -- and then in italics -- "for radiation protection purposes," you know, "they assume a linear hypothesis."

Well, Professor Meinhold justifies the NCRP's position on the basis of that statement. The problem is that doesn't answer in terms of how you evaluate it for health effects.

VICE CHAIRMAN GARRICK: That's a policy observation.

MR. MOELLER: Right. That's a policy, and that's all it is.

And, you know, we hear so much about this, and I just wanted to show you one other slide. I was looking through -- many of you remember Herb Parker, who really, if anybody, was the grandfather or the father of health physics, modern health physics. It was Herb Parker. I was in Battelle -- you know, Pacific Northwest Lab --

Battelle Press published a compendium of all of Herb Parker's papers, and it is wonderful.

I was looking in there the other day, flipping through, about a 1960 or some time paper by Herb Parker, and this curve was in there. And here we talk about, you know, hormesis and he did not say, "I believe in hormesis." He merely said, "If, indeed, there are beneficial effects due to low doses of radiation, how would you express it in a graph?" And he drew this graph, and that -- and he then drew graphs where there isn't, and so forth. But I just found it interesting that here this fellow which is so wise and so far ahead of his time that he did this.

So, to me, I do not -- if I were the NRC, the Nuclear Regulatory Commission, I certainly, if I were Chairman or a Commissioner, I certainly would not launch the NRC into trying to settle the linear no threshold concept. They don't have the talent or, you know, the -- and it would be a -- you know, they would be subject to bias. Turn it over to someone like the NCRP, and maybe when their report comes out have that report be reviewed by the National Academy or someone, and then see where we come out with it.

I don't know if --

MEMBER STEINDLER: Let me just add one other thing. There was an interesting discussion which didn't get any place, which is exactly what you would expect. The question -- let's see if I can phrase it right. Is there evidence for no effect at low dose, or is there no evidence for an effect at low dose? And I don't know why Mossman had a little trouble following that logic, but eventually I think they tried to explain that to him. And the answer was (honks horn). I don't know how you're going to write that, but that's --

(Laughter.)

That simply never got settled, but I think that's a key issue.

MR. MOELLER: Yes, a key issue.

MEMBER STEINDLER: That's precisely the key question.

The other comment that he made, just as a numerical target, he said that the indication of the data out there are that there is no evidence for cancer initiation -- 10 millisieverts per year.

MR. MOELLER: Yes, he said that.

MEMBER STEINDLER: Any kind of --

MEMBER HINZE: Is that consistent with what we're reading here in this NCRP report?

MEMBER STEINDLER: I don't know what you're reading.

MR. MOELLER: Well, see, they say for purposes of radiation protection, and as John said, it's a policy decision.

Now, Dr. Mossman did not mention, but Shirley Frye, Dr. Shirley Frye at Oak Ridge has just published a study, an epidemiological study. And, of course, there have been many, many epidemiological studies published. But she took all of the DOE workers who had received more than five rem in a single year -- that was her criterion -- you must have in some year of your career, you know, been a radiation worker and received more than five rem.

I think she took all of the DOE workers, and she may have taken naval shipyard workers. You know, but everybody in the pool was more than five rem at least in one year. And she looked at all kinds of cancers and everything, and she found absolutely no difference between that group and their co-workers.

MEMBER STEINDLER: One other point. There was one Commissioner attending the lecture.

VICE CHAIRMAN GARRICK: Good. I would guess Brewster?

MEMBER STEINDLER: No. We sat in the front, so she may have been in the back and I didn't see her. But no, it was Ken Rogers.

MR. MOELLER: Well, she was at the conference of -- the radiation control program directors meeting.

CHAIRMAN POMEROY: Okay. Dade, thank you very much. You've done an excellent job as always and given us a little bit of time as well.

MEMBER STEINDLER: That constitutes an excellent job.

(Laughter.)

CHAIRMAN POMEROY: What I think it might be useful to do at this point -- our next item on the agenda is to prepare for the meeting with the Commissioners from 5:00 to 6:00. I need my packet of slides, which is in the other room. Oh, you've got packets here?

(Whereupon, at 4:32 p.m., the proceedings went off the record.)

C E R T I F I C A T E

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: 84TH ACNW MEETING

Docket Number: N/A

Place of Proceeding: ROCKVILLE, MARYLAND

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.

Corbett Riner

CORBETT RINER
Official Reporter
Neal R. Gross and Co., Inc.

BACKGROUND

Geological Disposal

1957 Nat. Res. Council Report

Basic Rationale:

To emplace waste in a remote (from the biosphere) environment so as to take advantage of natural processes for keeping it isolated until it decays away.

History

1982 Nuclear Waste Policy Act

- Preliminary investigations of many potential sites

- Narrow down to 3 "finalists"

Some Concluding Thoughts

- Risk and dose standards are fundamentally different
  - Dose standard attempts to assure protection to the individual
  - Risk standard only limits probability of harm
    - ⇒ Risk std will not (and should not) accord with ICRP standards for <u>dose</u>
    - ⇒ Persons with equal risks may encounter vastly different <u>outcomes</u>. Risk is <u>average</u> of outcomes.

- Degree of conservativeness of a risk standard should depend on the level of risk used for the standard, not on manipulation of the risk analysis. A risk std can be made arbitrarily conservative.

- Risk standards are generally applicable, but standards guaranteeing personal protection are not.
  - Society does not offer personal guarantees to most of us today for most of what we do, why should it try to do so for individuals >10,000 yrs in the future?
  - Even if we want to make such guarantees, can we realistically and honestly do so?

unlikely that the applicant can demonstrate scientifically that the proposed design achieves a result that meets an ALARA test, since assessing the reasonableness of additional costs taking other social considerations into account involves social judgments not amenable to scientific analysis.

[From Tab 2:] The proposed EPA standard and USNRC regulations should not include a formal requirement that the applicant demonstrate that the disposal system has been rigorously optimized in an ALARA fashion. The difficulties of demonstrating legal compliance with any such requirement for pre- or post-closure phases would be insuperable even if it were restricted to engineering and design issues.

However, it is nothing other than sound engineering practice to consider whether further reductions in dose or risk can be achieved through engineering measures that can be implemented in a cost effective manner. It would therefore be appropriate for the regulator to encourage but not require the applicant to review his or her project before submission for licensing with the explicit objective of identifying potential optimization measures leading to a reduction in potential radiation exposures in the pre-closure phase where the considerations involved are more comparable to those in conventional nuclear facilities.

Subsystem Requirements

In its own regulations governing the licensing of high-level radioactive waste repositories, the USNRC has imposed detailed requirements on the performance of portions of the repository system (cite USNRC regs). These so-called subsystem

My Critique of Exposure Methodologies

Subsistance Farmer

- NOT a risk standard
  - actually closer to a dose standard
- ignores rationale for geological disposal
  - ⇒ rewards poor site selection or design
- attempts to protect all persons at all times
- Uninformative with regard to benefits for costs of meeting standard

Probabalistic Critical Group

- truly a risk analysis
- based on objective data
- avoids basing protection on a very unlikely individual
- quantifies degree of protection from geological disposal
- encourages comparison of risks reduced with costs.

Technical Standards

To be addressed.

As Low as Reasonably Achievable

The concept of "as low as reasonably achievable" (ALARA) is embedded in regulatory policies of both EPA and the U.S. NRC. While the interpretations differ in different circumstances, both agencies regard ALARA as an additional design criterion over and above the requirements needed to meet the specific numerical formulations of standards. It is often used where uncertainties exist about the effectiveness of technological controls to limit emissions or risks and where the costs of achieving lower emissions or risks through technological means are acceptable, taking risks, costs, and other social factors into account. Applying ALARA implies achieving an additional margin of safety, so long as the costs incurred are not unreasonable. The suggestion by EPRI -- that the standard be based on health risks to individuals in a critical population but that in addition a strict, technological, no-release requirement be imposed for the near term (cite EPRI correspondence, April 8, 1994) -- can be interpreted as applying the ALARA principle to the design for near-term performance, where EPRI inherently assumes that the costs of achieving the extra margin of safety of zero releases in the near term would be reasonable and acceptable. A zero release requirement is, however, a very special case -- and some observers would say an extreme extrapolation -- of the ALARA concept.

We conclude that, regardless of the potential merits of the EPRI suggestion, the concept of ALARA is one that applies to design considerations. It is unlikely to be useful incorporated explicitly into a health-based standard because it is

Stated objective of subsistence-farmer scenario is identical to that of a dose (not risk) standard

On the basis of the above quotes from ICRP, I concur with UK's NRPB and others that the subsistence farmer is the appropriate single hypothetical individual to be considered for dose and risk calculations for the distant future. The diet and dose response of the subsistence farmer are to be based on present knowledge, as recommended by ICRP. It is cautious and reasonable that there can exist in the future a farmer whose food intake is largely that grown in contaminated water. Because the subsistence-farmer calculation is bounding, it represents the extreme of the actual doses in the entire population. Protecting the subsistence farmer will ensure that no individual doses are unacceptably high. [Emphasis shows connection to ICRP-46 and ICRP-43 recommendations.]

Those wishing to identify a critical group can imagine a group that would include the subsistence farmer, subject to ICRP's homogeneity criterion that the dose or risk to individuals within the group should vary no more than tenfold.[9]

The full-time subsistence farmer, who receives no food and water from noncontaminated sources, is obviously the bounding scenario. We assign a probability of unity that he can exist. Some part-time farmers will be included in the data for the Committee's probabilistic analysis, because they exist now in the Amorgosa Valley. However, because the Committee's method is expected to synthesize a continuous probabilistic distribution function of occupancy and exposure to radiation, the full-time subsistence farmer will not be found on that distribution. Speculation that the Committee's probabilistic approach will yield the full-time subsistence farmer as the individual with maximum exposure is not valid. Methods of Appendices C and D do not converge.

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[9] The Committee makes much of the claim that the probabilistic exposure scenario of Appendix C can predict the dose/risk variation within the calculated critical group, so that the average dose within the group can be calculated. However, the ratio of maximum to average dose/risk must lie between one and ten, if the critical group meets ICRP's homogeneity criterion. An assumed linear variation results in a ratio of two, as assumed in the subsistence-farmer approach. I have already noted that the large uncertainties in calculating geosphere performance, together with the additional uncertainties inherent in the Committee's proposed probabilistic exposure calculations do not justify such attempts to refine the ratio beyond that assumed above. Again, calculated exposures from the probabilistic scenario are of questionable validity, whereas the subsistence-farmer results are conservative and bounding.

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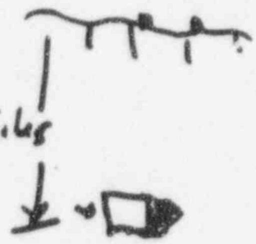
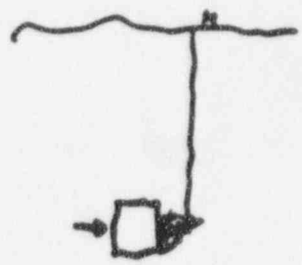
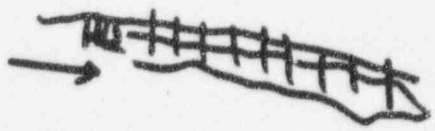
Comparison of Bases and Consequences

Critical Group

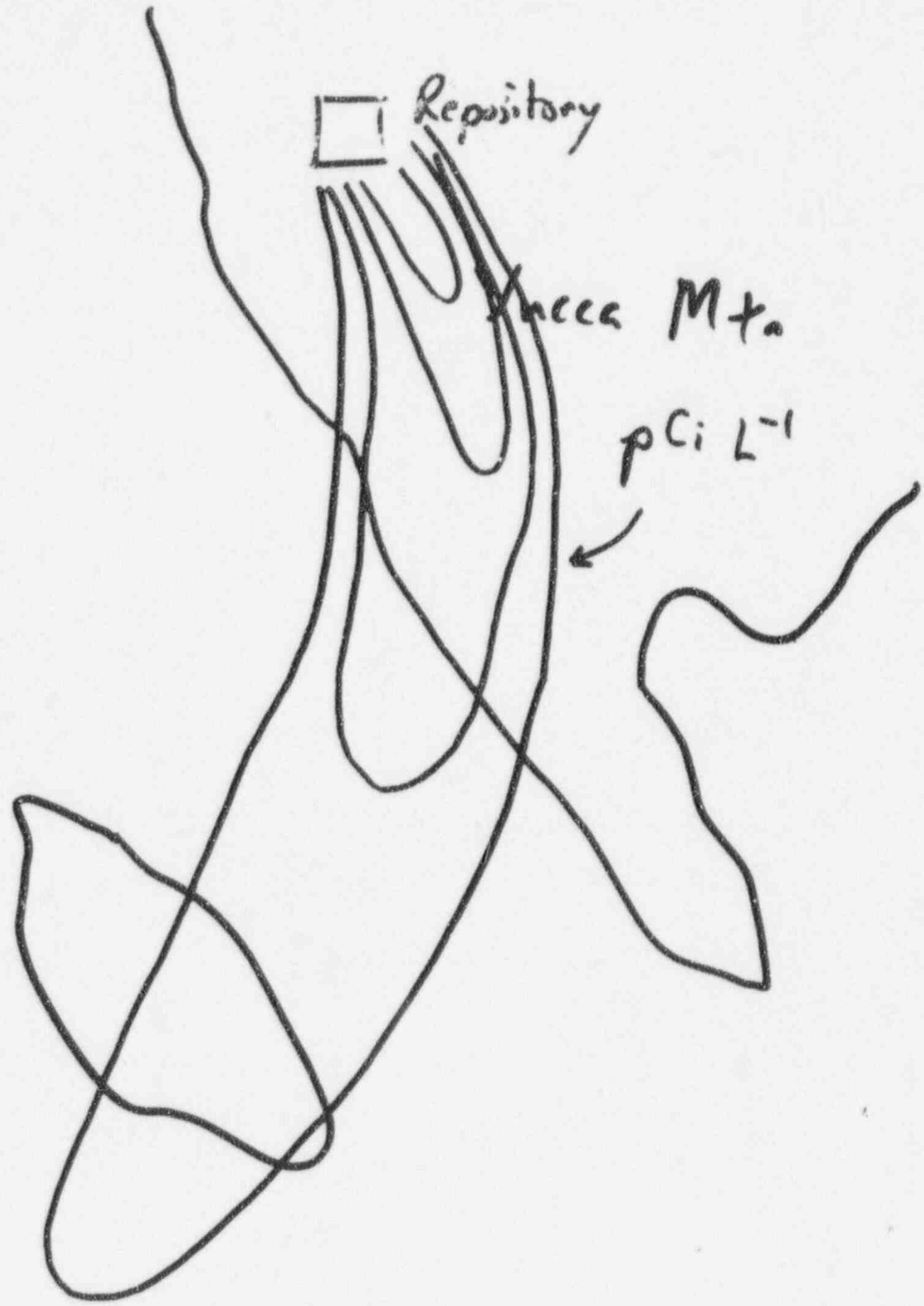
"Indiv Radiation Risk" $= P_{iso} \times P_{int} \times P_{pres} \times 5 \times 10^{-4} \times$ unit dose

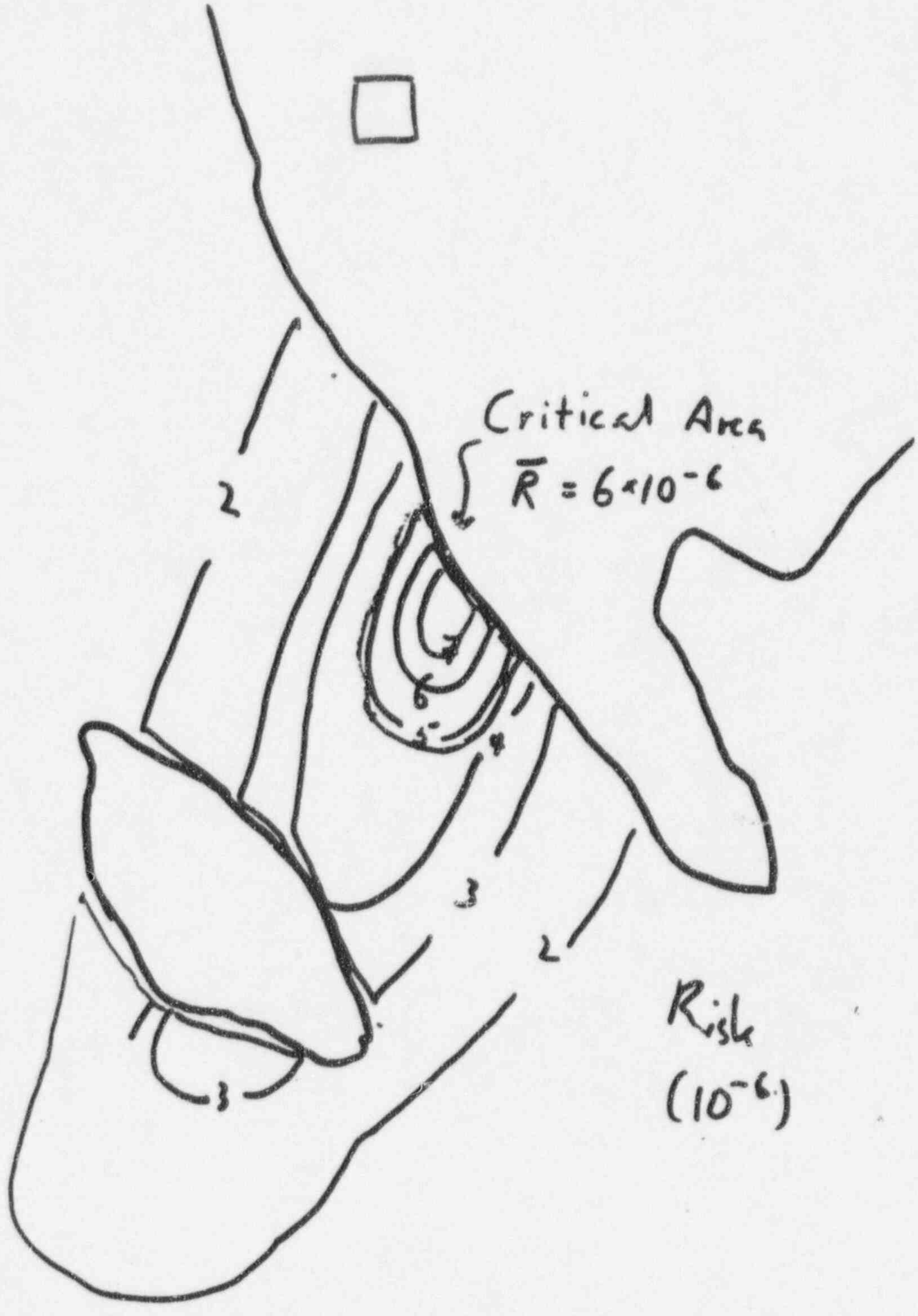
"Subsistence Farmer Risk $\cong P_{iso} \times 1 \times 1 \times 5 \times 10^{-4}$

Result

Repository Setting	Critical Group	Subsistence Farmer
2 miles deep very low-K rock ⇒ small amount of concentrated leachate	 Very low risk	 Very high risk!
Long Island Shallow trenches ⇒ large amount diluted leachate	 Intermediate Risk	 Intermediate Risk

regulations address such issues as anticipated lifetime of the disposal casks and the retention time of wastes in the ground water system within the repository (??). The USNRC argues that subsystem requirements provide additional margins of safety through "defense in depth." We conclude, however, that such requirements may unnecessarily constrain the repository developer to design for subsystem performance without guaranteeing optimal performance of the overall system, which is what truly matters. We therefore recommend that the USNRC not impose subsystem performance requirements but judge the application on its overall merits.


Repository
Yucca Mtn
pCi L⁻¹


Critical Area
$\bar{R} = 6 \times 10^{-6}$
2
7
6
5
4
3
2
3
Risk
(10^{-6})

APPENDIX C

A PROBABILISTIC CRITICAL GROUP

Although the components of a probabilistic computational approach have considerable precedent in repository performance, we are not aware that they have previously been combined to analyze risks to critical groups. We have therefore outlined in this appendix a fairly explicit example of how this approach might be implemented for the case of exposure through contaminated ground water. The main purposes of this example are to show that the approach is feasible and to illustrate the steps necessary to perform such a calculation. The example uses a Monte Carlo method for modeling exposure consistent with that employed in the hydrologic modeling of radionuclide transport. In presenting this appendix, we do not intend it as a detailed recommendation, but an exploration of at least the more important issues that are likely to arise in an actual compliance calculation. The additional detail in this appendix is warranted because the technique has not been applied to this problem in the past, as far as we are aware.

The following outline of steps is designed to provide an illustrative example of the types of calculations that could be employed in an exposure scenario analysis. The specific process described here is only one of a variety of alternatives that EPA might consider during its rulemaking. It is based on a number of choices and general considerations, some of which are reviewed below prior to a description of the steps themselves.

a. Technical feasibility of the calculations requires specification of one or more exposure scenarios. As described in Chapter 3, a scenario includes parameter values or distributions that provide quantitative descriptions that include where people live, what they eat and drink, and what their sources of water and food are. A given scenario might include the lifestyle and activities of only farmers or a mix of economic lifestyles and activities of farmers, miners, defense workers, and casino operators, for example. It might be based on actual current activities in the area of interest, on current activities in some adjacent area, or potentially on any

RELEVANCE OF THE ALARA PRINCIPLE IN THE REGULATION OF RADIOACTIVE WASTE DISPOSAL

Origins and Objectives of the ALARA principle

The ALARA principle is a basic feature of radiation protection and is intended to be applied after threshold regulatory limits have been met. Thereafter, it intends that additional measures be taken to achieve further reduction in the expected health effects resulting from radiation exposure of a population so that final exposures are "as low as reasonably achievable taking account of economic and social factors".

This principle has been a feature of basic radiation protection standards for nearly 30 years. The International Commission on Radiological Protection Publication 9 (1965) and subsequent publications 22 (1973), 37 (1982) and 46 (1985) as well as IAEA Safety Series 99 (1989) have been consistent in their treatment of optimization and ALARA for radiation protection generally including those standards devoted specifically to waste disposal activities. ICRP 9 as quoted in ICRP 22 states

"(a) as any exposure may involve some degree of risk, the Commission recommends that any unnecessary exposure be avoided; and

(b) as any exposure may involve some degree of risk, the Commission recommends that all doses be kept as low as is reasonably achievable, economic and social considerations being taken into account."

Having been articulated since early nuclear developments ALARA appears in regulation of nuclear reactors world wide.

Application of this principle to the geological disposal of radioactive waste has been advocated as philosophically desirable but often impracticable primarily because of the time frames involved and the already extremely low exposures (doses) expected from a repository meeting requirements of proposed standards.

Subsistence Farmer

- gets all water from well into max concentration groundwater
- irrigates crops and animals from this water
- lives only on this produce and water
- use distribution of max concentrations from transport models to get a distribution of doses → calculate health risk → divide value by 3.

Probabelistic Critical Group

- obtain data on characteristics of population in area at present time (or possibly alternative population), e.g., family size, farm size, factors in siting farms (soil, depth to water, etc.), well depths and pumping rates, and so on.
- generate Monte Carlo realizations of population
- allow numerous population realizations to interact with each transport realization (due to sparse population) and calculate numbers of cancers.
- divide numbers of cancers by population to get spatial distribution of risk
- average risks (from highest risk area) for numerous transport simulations to get average risk to critical group

considered. These factors must be included in an exposure scenario that specifies the pathways by which persons are exposed to radionuclides released from the repository.

As we note in Chapter 4 with regard to the feasibility of making projections of future human intrusion into a repository, based on our review of the literature we believe that no scientific basis exists to make projections of the nature of future human societies to within reasonable limits of certainty. Therefore, unlike our conclusion about the earth science and geologic engineering factors described in Part II of this chapter, we believe that it is not possible to predict on the basis of scientific analyses the societal factors that must be specified in a far-future exposure scenario. There are an unlimited number of possible human futures, some of which would involve risks from a repository and others that would not.

Although the nature of future societies cannot be predicted, it is possible, at least conceptually, to consider several characteristics of future society that would indicate whether a repository is likely to pose a risk to people. A repository would be unlikely to pose significant risks to future people. A repository would be unlikely to pose significant risks to future societies: if the area near the repository were not occupied, if future societies do not use ground water from the contaminated region, or if future societies routinely monitor ground-water quality and either treat or avoid use of contaminated sources. Conversely, exposures would result if water wells were drilled into the contaminated areas and the water consumed by people or used to irrigate crops. As far as we are able to determine, there is no sound basis for quantifying the likelihood of future scenarios in which exposures do or do not occur; about all that can be said is that both are possible.

It is our view, however, that once exposure scenarios have been adopted, performance assessment calculations can be carried out for the specified scenarios with a degree of uncertainty comparable to the uncertainty associated with geologic processes and engineered systems. The more difficult task is the specification of reasonable scenarios for evaluation. Any particular scenario about the future of human society near Yucca Mountain that might be adopted for purposes of calculation is likely to be arbitrary, and should not be interpreted as reflecting conditions that eventually will occur. Although we recognize the burden on regulators to avoid regulations that are arbitrary, we know of no scientific method for identifying these scenarios.

Selection of Exposure Scenarios for Performance Assessment Calculations

Any approach to assessing compliance with the standard must make assumptions about the nature of the human activities and lifestyles that provide pathways for exposure. For example, people could drink water containing radionuclides, irrigate crops with the water, eat these crops, and bathe in the water. Quantification of the doses received from the various pathways requires detailed data on these pathways. For the example above, the average amount of water ingested per day (not including other beverages constituted with uncontaminated water) should be known, as should the type of crops grown, the amount eaten, and the frequency of bathing. The set of circumstances that affects the dose received, such as where people live, what they eat and drink, and other lifestyle characteristics including the state of agricultural technology, are part of what we refer to as the exposure scenario.

Unfortunately, many human behavior factors important to assessing repository performance vary over periods that are short in comparison with those that should be considered for a repository. The past several centuries (or even decades) have seen radical changes in human technology and behavior, many or most of which were not reasonably predictable. For example, within the past one hundred years, our society has evolved from one in which drilling and pumping technology did not exist for production of water from the depths of ground water at Yucca Mountain to a level of technology where such production is feasible. Within this same time period, we have seen U.S. demographic patterns shift from a time where a majority of U.S. residents were engaged in farming and grew their own food to the present day in which only a few percent of the work force is employed in farming, and in which most people's diet includes food produced outside their local area.

Given this potential for rapid change, it is unknowable what patterns of human activity might exist 10,000 or 100,000 years from now. Indeed, the period during which repository performance might be relevant, on the order of a million years, is sufficiently long that any number of different societies might reside near the repository site. Several glacial periods probably will have occurred, making estimates of human society even more difficult. Given the unknowable nature of the state of future human societies, it is tempting to seek to avoid the use of such assumptions

On the basis of the above quotes from ICRP, I concur with UK's NRPB and others that the subsistence farmer is the appropriate single hypothetical individual to be considered for dose and risk calculations for the distant future. The diet and dose response of the subsistence farmer are to be based on present knowledge, as recommended by ICRP. It is cautious and reasonable that there can exist in the future a farmer whose food intake is largely that grown in contaminated water. Because the subsistence-farmer calculation is bounding, it represents the extreme of the actual doses in the entire population. Protecting the subsistence farmer will ensure that no individual doses are unacceptably high. [Emphasis shows connection to ICRP-46 and ICRP-43 recommendations.]

Those wishing to identify a critical group can imagine a group that would include the subsistence farmer, subject to ICRP's homogeneity criterion that the dose or risk to individuals within the group should vary no more than tenfold.[9]

The full-time subsistence farmer, who receives no food and water from noncontaminated sources, is obviously the bounding scenario. We assign a probability of unity that he can exist. Some part-time farmers will be included in the data for the Committee's probabilistic analysis, because they exist now in the Amorgosa Valley. However, because the Committee's method is expected to synthesize a continuous probabilistic distribution function of occupancy and exposure to radiation, the full-time subsistence farmer will not be found on that distribution. Speculation that the Committee's probabilistic approach will yield the full-time subsistence farmer as the individual with maximum exposure is not valid. Methods of Appendices C and D do not converge.

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What level of protection?

Leave up to public regulatory process,

but suggest starting discussion at 10^{-5} to 10^{-6} yr^{-1}

For how long?

Til peak doses are past

Methodology for Calculating Risk to Critical Group

Must specify "exposure scenario" and risk-calculation approach

"Exposure scenario" is quantification of natural/societal characteristics that affect exposure

Does this imply we must be able to predict society thousands of years in the future? NO!!!

Scenario is a benchmark

Alternative Proposals

1) "Subsistence Farmer" (preferred by 1 committee member;

2) "Probabilistic Critical Group" (preferred by 14 committee members)

In the context of an individual-risk standard, similar conditions would apply for the same reasons. Based on cautious, but reasonable, assumptions, the group would include the persons expected to be at highest risk, would be homogeneous in risk[6], and would be relatively small. The critical-group risk calculated for purposes of comparison with the risk limit established in the standard would be the mean of the risks of the members of the group.

More specifically, we recommend the following definition of the critical group for use with the individual-risk standard:

> The critical group for risk should be representative of those individuals in the population who, based on cautious, but reasonable, assumptions, have the highest risk resulting from repository releases. The group should be small enough to be relatively homogeneous with respect to diet and other aspects of behavior that affect risks. The critical group includes the individuals at maximum risk and is homogeneous with respect to risk. A group can be considered homogeneous if the distribution of individual risk within the group lies within a total range of a factor of ten and the ratio of the mean of individual risks in the group to the standard is less than or equal to one-tenth. If the ratio of the mean group risk to the standard is greater than or equal to one, the range of risk within the group must be within a factor of 3 for the group to be considered homogeneous. For groups with ratios of mean group risk to the standard between one-tenth and one, homogeneity requires a range of risk interpolated between these limits.

This definition requires specifying the persons who are likely to be at highest risk. In the present and near future, these persons are real; that is, they are the persons now living in the near vicinity of the repository that lies in the direction of the flow of the ground water plume of radionuclides that would occur far in the future. The expected containment capability of an undisturbed repository at Yucca Mountain means, however, that no significant risks would likely arise until at least thousands of years in the future. At such times, it will be necessary to define hypothetical persons by making assumptions about lifestyle, location, eating habits, and other factors. ICRP recommends use of present knowledge and cautious, but reasonable, assumptions in making projections far into the future. These assumptions are part of the exposure scenarios[7] that must be defined as a basis for determining whether the repository performance is judged to comply with the standard. Exposure scenarios are discussed further in the next chapter.

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[6] That is, the difference between the highest and lowest risk faced by individuals in the group should be relatively small. Should a radiation dose occur, however, it may affect only a few members of the group. This is the difference between risk (the probability of an adverse health effect) and outcome (a cancer that actually develops). Risk can be homogeneous, even when outcomes are quite diverse.

Difficulties in applying ALARA to waste disposal

ALARA is intended to be applied to any "practice" involving the application of radioactive materials. For waste disposal, it is difficult to separate the specific practice from the overall application, in particular the use of nuclear power which leads to the production of radioactive wastes. As in any total system analysis, caution must be exercised in applying optimization principles to an isolated part of the system.

ALARA's successful application to nuclear reactors occurs where the incremental additional costs of improvements can be accurately determined and balanced immediately against dose reductions achieved which can also be relatively well estimated. In similar fashion, ALARA could be applied in a relatively straight forward manner to the design and operational phase of a geological repository.

However, for far-future performance predictions, i.e. the post-closure period of a repository, ALARA would require balancing real additional radiation exposures or financial costs imposed at present (e.g. by process workers involved in increased handling or treatment of wastes, by increased strength of waste containers or by utilization of more costly materials and repository designs) against the potential for reduction of far-future exposures, often at very much reduced dose levels. This present actual cost versus future potential benefit comparison invokes concepts of discounting future benefits for present value analyses with attendant difficulties.

Margaret V. Federline of the US Nuclear Regulatory Commission provided the USNRC staff position on this issue to the Committee as follows:

> "EPA's 1985 standards did not contain a specific requirement that projected releases be ALARA. EPA's containment requirements, which were derived from analyses of the waste isolation capabilities of hypothetical repositories, were effectively 'generic' ALARA levels. In contrast, an explicit ALARA requirement is a prominent feature of the recommendations of international advisory organizations.

Individual Radiation Risk ("Individual Risk")

- Based on demonstrable effects and direct impacts
- Intended to protect individuals most at risk
- Should also ensure very low risk for rest of population
- Unaffected by revisions of dose/risk coefficient
- Allows direct comparison of risk reduction with associated costs
- Allows direct comparison with other societal risks

How to implement individual risk standard?

Who is protected? "Individuals most at risk"

How to define?

"Maximally Exposed Individual"? No!

- often ludicrous
- does not provide a basis for realistically evaluating risk

"Critical Group"? Yes!

'The principal advantage of an explicit ALARA requirement would be consistency with other radiation protection standards. The disadvantage would be significant difficulties in evaluating compliance with with such a criterion. The large uncertainties in projected repository performance would make any case-specific ALARA analysis highly speculative, especially if the performance or real or hypothetical alternative sites were to be considered.

"The NRC staff would object to any broad-based requirement that repository releases be demonstrated to be ALARA, especially if such a requirement were applied to site selection. The NRC's regulations now contain a requirement for consideration of alternatives to the major design features of a repository. Any more extensive ALARA analysis is likely to prove speculative and unworkable."

In a letter from Kitty Dragonette to Ray Wassel dated June 16, 1993, the USNRC transmitted Appendix A to its "Analysis of EPA's Standards", an August 8, 1991 paper SECY-91-242 to the Commission. This Appendix includes the same staff position as provided by Ms. Federline.

It is also apparent that levels usually proposed for allowable long term radiation exposure from geologic repositories (~0.1 mSv per year) are already so low that further ALARA requirements would add insignificant benefits unworthy of the complexities required and accordingly are unnecessary.

Current Scientific Consensus on ALARA in waste disposal

ALARA continues to be recommended as a philosophically desirable goal in newer-criteria devoted to radioactive waste disposal such as ICRP46 (1985) and IAEA Safety Series 99 (1989). Under its Principle No. 7, IAEA acknowledges that

"The principle that exposures should be kept as low as reasonably achievable remains valid for geological disposal of high level wastes, but application of the principle requires special considerations." and "The alternatives available when disposing of high level waste in a geological repository are likely to be quite limited".

Problems associated with modern agriculture

- soil depletion
- soil erosion
- soil contamination
- global climate effects
- effect of genetically altered organisms

Nuclear waste disposal should be regulated commensurately with other societal issues

- balance of benefits, costs, and unknowns

Example: Highway design and construction

- regulations are intended to limit, but not eliminate, risks of use.

It is neither possible nor desirable to protect everybody, all of the time

With respect to the second question of Section 801, we conclude that it is not reasonable to assume that a system for post-closure oversight of the repository can be developed, based on active institutional controls, that will prevent an unreasonable risk of breaching the repository's engineered barriers or increasing the exposure of individual members of the public to radiation beyond allowable limits. This conclusion is founded on the absence of any scientific basis for making projections over the long term of the social, institutional, or technological status of future societies. Additionally, there is no technical basis for making forecasts about the long-term reliability of passive institutional controls, such as markers, monuments, and records.

With respect to the third question in Section 801, we conclude that it is not possible to make scientifically supportable predictions of the probability that a repository's engineered or geologic barriers will be breached as a result of human intrusion over a period of 10,000 years. We reach this conclusion because we cannot predict the probability that a future intrusion would occur in a given future time period or the probability that a future intrusion would be detected and remediated, either when it occurs or later. In addition, we cannot predict which resources will be discovered or will become valuable enough to be the objective of an intruder's activity. We cannot predict the characteristics of future technologies for resource exploration and extraction, although continued developments in current noninvasive geophysical techniques could substantially reduce the frequency of exploratory boreholes.

Although there is no scientific basis for judging whether active institutional controls can prevent an unreasonable risk of human intrusion, we think that, if the repository is built, such controls and other activities might be helpful in reducing the risk of intrusion, at least for some initial period of time after a repository is closed. Therefore, we believe that a collection of prescriptive requirements, including active institutional controls, record-keeping, and passive barriers and markers would help to reduce the risk of human intrusion, at least in the near term.

Moreover, because it is not technically feasible to assess the probability of human intrusion into a repository over the long term, we do not believe that it is scientifically justified to incorporate alternative scenarios of human intrusion into a fully risk-based compliance assessment. We do, however, conclude that it is possible to carry out calculations of the consequences for particular types of intrusion events.

Individual Dose (≡ "Individual Health Risk")

- Can protect those most at risk
- Presumably protects those in general population, therefore
- But, applicability is mainly to situations where recipient can be identified and dose controlled.

"Individual Radiation Risk"

- Intended to protect population most at risk (and thus also others)
- Unaffected by changes in dose/risk coefficient
- Allows direct comparison with other societal risks
- Allows evaluation of risk reduction with associated costs

Risk vs. Dose Comparison

- Dose standard can offer assurance of protection to the individual
  But, only valid when dose can be controlled
- Risk std makes no assurance of protection to the individual - it simply limits average risk

Risk standards are increasingly used because it is recognized that society could not function if every individual had to be promised complete protection

Risk and dose standards are quite different ⇒ A risk std will not meet ICRP recommendations for dose stds!

IAEA seems to confine its recommended use of ALARA to site selection, waste conditioning and repository design. It defines its compromise by recommending retention of ALARA while recognizing that the principle must be applied

> "in a qualitative manner making significant use of engineering judgment rather than rigorous analyses of repository impacts".

Guidance published by the CEC in its document on disposal standards also recommends application of ALARA. On the other hand, the OECD-NEA in 1984 recorded that no consensus on ALARA had been reached by a working group on radiation protection standards for disposal.

In national legislation or regulation outside the USA, ALARA is required in some cases (e.g. France) and explicitly excluded in others (Canada, Switzerland). In the Euradwaste series No.1 document of the European Community (EUR 12570EN, 1989), ALARA-type optimization is also discussed. However, the optimization principle is

> "mostly applicable to the comparison of different options"

and it is recognized that

> "cost-benefit techniques have a very limited applicability .....in the decision-making process".

A specific exclusion of an ALARA requirement for the post-closure phase of a repository is found in the recently revised Swiss legislation Guideline R-21 (Rev. 1993) where it is stated that

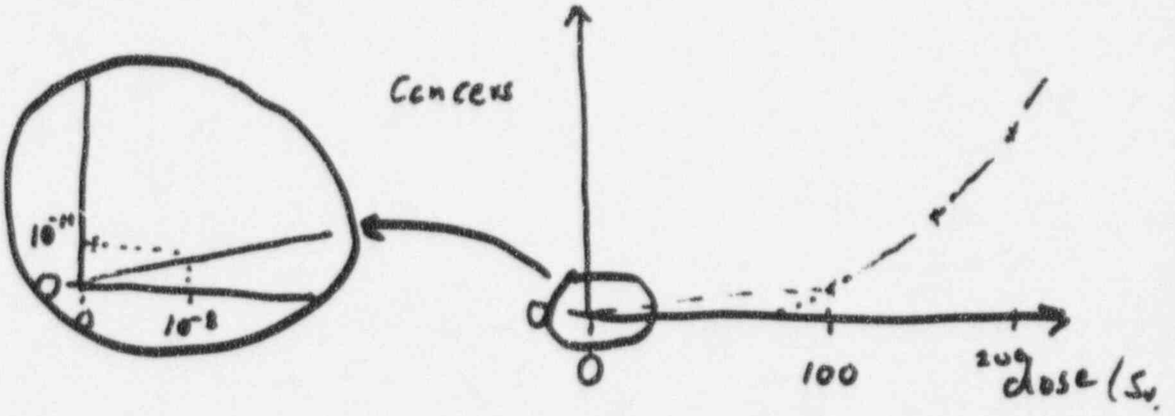
> "in the light of uncertainties in the calculation of potential doses, there is no requirement for a quantitative optimization process".

In its report A Study of the Isolation System for Geologic Disposal of Radioactive Wastes the Waste Isolation Systems Panel in 1983 made no determination as to whether the individual dose rate criterion of 0.1 mSv per year is as low as is reasonably achievable. The WIPP panel concluded at that time that it was not possible to determine what doses and dose rates would be as low as reasonably achievable.

Possible Types of Standards

Collective Dose

- does not protect individuals that are most exposed
- depends on scientifically dubious "linear hypothesis"



- not consistent with other areas of regulation

Individual Dose

- does protect those most at risk
- also probably protects those less at risk (population)
- <u>BUT</u> how to apply to future individuals?

Derived Standard (e.g., 40CFR191 cumulative release)

- easy to evaluate compliance

  but may well end up irrevalent to protecting public health

In the submissions made to the Committee by technical experts, The ALARA question was raised several times. In his presentation, Dade Moeller called for the same ALARA considerations as given by IAEA in citing "basic concepts...of radiation protection". He noted that a technology-based standard would eliminate ALARA considerations.

David Kocher also stated to the Committee that the "ALARA principle could be used to reduce expected releases well below limits in standards".

In material prepared for the Swedish Inspectorate, Smith and Hodgkinson equate ALARA with optimization and call for its application as a guide but not for decision making. While acknowledging the difficulties of applying ALARA to post-closure time frames, they ask whether excluding ALARA would not signal acceptance of less-than-optimal criteria.

Recommendation of TYMS with respect to ALARA

The proposed EPA standard and USNRC regulations should not include a formal requirement that the applicant demonstrate that the disposal system has been rigorously optimized in an ALARA fashion. The difficulties of demonstrating legal compliance with any such requirement for pre- or post-closure phases would be insuperable even if it were restricted to engineering and design issues.

However, it is nothing other than sound engineering practice to consider whether further reductions in dose or risk can be achieved through engineering measures that can be implemented in a cost effective manner. It would therefor be appropriate for the regulator to encourage but not require the applicant to review his project before submission for licensing with the explicit objective of identifying potential optimization measures leading to a reduction in potential radiation exposures in the pre-closure phase where the considerations involved are more comparable to those in conventional nuclear facilities.

"Individual Health Risk" - risk of cancer resulting from a known individual dose equivalent

$$\cong 5 \times 10^{-4} \text{ cancers } Sv^{-1} yr^{-1} \times Sv$$

"Collective Health Risk" - Numbers of cancers expected in a population as a result of a specific collective dose

$$\cong 5 \times 10^{-4} \times CD$$

"Individual Radiation Risk" - risk of cancer from a combination of risk of receiving a dose and risk of dose

$$\cong \underbrace{Prob_{Dose}} \times Sv \times 5 \times 10^{-4}$$

$$\cong P_{iso} \times P_{int} \times P_{pers} \times Sv \times 5 \times 10^{-4}$$

- P_{iso}: Prob related to containment in repository
- P_{int}: Prob related to liklihood of human interaction with escaped waste
- P_{pers}: Prob related to personal characteristics

Releases to Ground Water

In performance assessments conducted thus far, attention to ground water protection has focussed on various circumstances in which individuals, families, or communities withdraw water from a contaminated aquifer and use this resource for irrigating food crops and for drinking water. This approach is consistent with the purposes of EPA's ground water protection regulations.

Contaminants in the aquifer that are not withdrawn via wells, however, may also reach the biosphere and become available to humans and other biota. According to current understanding, the aquifer under the proposed repository reaches the surface at Franklin Playa, a region roughly (??) km southwest of the Yucca Mountain site. Consequently, all of the materials released from the repository ~~and~~ or their decay products will eventually reach the surface in that location. We recommend that DOE include this possibility in its site characterization program and that the Nuclear Regulatory Commission take account of it in its licensing procedures. While our report is focussed on a radioactive waste management standard, we note that the ultimate non-radioactive decay product of this waste, lead, is itself a hazardous substance regulated under other authority.

Gaseous Releases from the Yucca Mountain Site

In addition to releases via ground water, the repository will also be the source of gaseous emissions of radionuclides. These releases will be of at least two types.

POSSIBLE FORMS OF A STANDARD

Questions to answer:

Who is to be protected?

To what extent are they to be protected?

For how long are they to be protected?

<u>Terminology</u>

Dose - amount of radiation energy absorbed by a single body $1\,Gy = 1\,J\,kg^{-1}$

Dose Equivalent - dose weighted for amount of damage done by different types of radiation

$$Sv = \sum_i Gy_i Q_i \quad i = \alpha, \beta, \gamma, \text{etc.}$$

Collective Dose - All doses summed over population receiving them $= \sum_j Sv_j$ $\quad j$ = individuals in populat.

occur near the waste solid in dissolution experiments. However, in many geologic settings filtration can result in very large attenuation of colloids as they transport through porous and fractured rock.

Effect of Backfill

Some repository projects propose to surround each waste container with a porous backfill, such as pulverized rock or bentonite clay. The claimed functions are (a) to delay the release of radionuclides into the surrounding rock sufficiently for radioactive decay durinmg backfill transport, (b) to cushion the waste container from mechanical interaction with surrounding rock, and (c) to provide a low-permeability medium to reduce groundwater flow rate in the vicinity of the waste container. Calculations of diffusive transport through such backfill shows negligible transport delay for nonsorbing species. Delays of a few thousand years are predicted for strongly sorbing species, such as cesium-135. If longer-time performance predictions of long-lived radionuclides are more important, sorptive delays in backfill appear to accomplish little for the radionuclides that are most troublesome in dose and risk calculations.

Analyses for Sweden's geologic repository show that, for the relatively fast groundwater flows expected in their granitic rock, a low-permeability backfill such as compressed bentonite can reduce convective transport at the surface of the waste. However, the net overall release rates are not necessarily reduced, as compared to emplacement in a smaller-diameter borehole without backfill. The principal impedance to mass transport of dissolved radionuclides from a failed container in granite results from the low porosity of the surrounding fractured rock. Even compressed bentonite is of much higher porosity than the surrounding granite, so replacing rock by backfill introduces more pathways for radial and vertical diffusion and can even increase the net release rate of long-lived radionuclides.

In an unsaturated environment, such as that of Yucca Mountain, the diffusive pathways through granular backfill are very tortuous, because of no interstitial water between granules, resulting in low expected values of the effective diffusion coefficients. Release rates of dissolved species through pore water could be much lower than now predicted using more conservative values for diffusion in a continuous medium, but present knowledge of the

NRC STAFF CONSIDERATIONS FOR SPECIFICATION OF REFERENCE BIOSPHERE AND CRITICAL GROUP AT YUCCA MOUNTAIN

Presentation to
The Advisory Committee on Nuclear Waste
June 25, 1996

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Division of Waste Management
Office of Nuclear Material Safety and Safeguards
Phone: 415-7285

SPECIFICATION OF REFERENCE BIOSPHERE EXPOSURE AND CRITICAL GROUP(S)

NAS Recommendation

- Use critical group and reference biosphere concepts

- Prediction of societal factors related to exposure scenarios has no scientific basis

- The definition of exposure scenarios (i.e., reference biospheres and critical groups) are policy matters that should be specified in a public rulemaking

- Exposure scenarios should only provide a framework for analysis of repository performance, they do not identify all the possible futures

  - ICRP recommends use of present knowledge and cautious, but reasonable, assumptions

DEFINITIONS

- Critical Group (those individuals in the population who, based on cautious, but reasonable assumptions, have the highest risk)

    - diet
    - location
    - behavior

- Reference Biosphere (standardized set of assumptions about the environment in which the critical group exists)

    - climate (e.g.; annual rainfall)
    - land use (e.g; types of farms, community size)

General Criteria
for
Limiting Speculation

- Impacts due to societal changes not considered

- Reference Biosphere and Critical Group should be based on reasonable assumptions
  - reference biosphere has reasonable chance of occurring in the region over the compliance period
  - specification based on reasonable use of current knowledge (minimize speculation)
    * site specific data
    * existing conditions / current practices
    * existing knowledge / analyses
    * pathways and events

- Critical group includes maximally exposed individual considering reasonable assumptions
  - not prejudiced by a small number of individuals with unusual habits or sensitivities

Site Specific Criteria
for
Definition Reference Biosphere

- Climate is arid

    - rainfall could increase in the future, however, the region would remain arid to semi-arid

- land use based on arid environment

    * length of growing season and crop selection
    * irrigation rates
    * size and types of farms / communities
      (deep water table)

Site Specific Criteria for Definition of Critical Group(s)

- Location of general population limited by practices for obtaining water in arid environments
  - depth of water wells
  - land use limited by ground-water basin yield
  - financial considerations for obtaining water

- Critical group is a subset of the general population as defined by the exposure pathway and transport of radionuclides

- Two potential critical groups will be investigated
  - limited farming community
  - limited community of non-farmers

NOTE: information from similar environments may be used to supplement site specific information

Sources of Information for Yucca Mountain

- Land use is based on current practices at Yucca Mountain and similar environments (e.g.; Amargosa Valley, Pahrump Valley, Oasis Valley)

- Current farming practices in arid and semi-arid environments
  - crop selection, livestock
  - irrigation rates
  - growing season
  - foraging and feeding practices

- Rainfall rates
  - rainfall data for test site over past 40 years
  - future conditions based on paleohydrologic data

- Location of critical group
  - survey well characteristics in YM region and other similar environments
  - topography limits land use in the region
  - soil type association with land use

- Dietary information
  - survey YM region to determine use of locally grown food in diet
  - water consumption in similar environments

- Health physics and lifestyle parameters based on commonly accepted values when site specific information is limited

1A

Vegetation Map and Depth to Water in the Yucca Mountain Region

Scale

Kilometers
10 0

1 : 280000

THE YUCCA MOUNTAIN STANDARD FOR PROTECTING PUBLIC HEALTH

Thomas H. Pigford
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PRESENTED TO THE

ADVISORY COMMITTEE ON NUCLEAR WASTE

U.S. NUCLEAR REGULATORY COMMISSION

June 25, 1996

A SYSTEMATIC MULTI-FACETED APPROACH TO COMPLIANCE DETERMINATION

DETERMINING COMPLIANCE AND ADEQUACY OF PUBLIC HEALTH PROTECTION SHOULD BE BASED ON MORE THAN COMPARING A PERFORMANCE LIMIT (DOSE) WITH A PERFORMANCE CALCULATION (MAXIMUM DOSE OR ITS 95% CONFIDENCE LIMIT). OTHER REASONABLE SAFETY ISSUES AND ANALYSES (BOTH QUANTITATIVE AND QUALITATIVE) SHOULD BE TAKEN INTO ACCOUNT.

AS CUMBERSOME AS THEY SEEM, REGULATIONS ON REACTOR SAFETY DO OFFER REASONABLE ASSURANCE OF SAFETY. THEY EVOLVED OVER DECADES OF LICENSING MANY REACTORS, AS EXPERIENCE WAS GAINED AND NEW CONCERNS APPEARED.

EPA AND THE NUCLEAR REGULATORY COMMISSION SHOULD NOT ATTEMPT NOW TO DEFINE ALL THE SAFETY ISSUES AND PARAMETERS FOR GEOLOGIC DISPOSAL. TOO LITTLE IS NOW KNOWN. LEAVE ROOM FOR LEARNING.

FOLLOW SWEDEN'S PROGRAM IN WASTE DISPOSAL. PROGRESS IS MADE WITH LITTLE IN THE WAY OF OFFICIAL "SPEED-LIMIT" SAFETY GOALS. SWEDEN'S PROGRAM COMMUNICATES THE LOGIC AND DEFENSE OF SAFETY TO THE SCIENTIFIC COMMUNITY AND TO THE PUBLIC.

SHOULD THE STANDARD LIMIT INDIVIDUAL RISK OR INDIVIDUAL DOSE?

Arguments for Individual Risk

Calculation of compliance would have to use up-dated data on risk from a given dose.

The resulting risk could be compared with societal risks from other sources.

Arguments for Individual Dose

Dose is necessarily calculated anyway.

The 1995 Position Statement of the Health Physics Society (Mossman, *et al.*) recommends against quantitative calculation of risk for doses in the range expected for safe geologic disposal. In this range the uncertainty in the quantitative conversion to risk is too great. (The TYMS committee was not so informed before its report was issued.)

Calculating uncertainty in the performance measure (dose or risk) is equally important as calculating dose or risk itself. Compliance determination should emphasize uncertainty in the calculated performance measure, e.g., compare the 95% confidence level of dose with a dose limit. According to the Health Physics Society, uncertainty in risk at the expected levels is too large for quantification of risk (or of its uncertainty).

ISSUES

CALCULATING DOSES TO SUBSISTENCE FARMERS: THE REASONABLE MAXIMALLY EXPOSED INDIVIDUAL

CALCULATED DOSES FOR A CONCEPTUAL GEOLOGIC REPOSITORY AT YUCCA MOUNTAIN

PROPOSALS TO LIMIT THE DOSE RATE TO THE AVERAGE INDIVIDUAL IN THE VICINITY: OTHER INDIVIDUAL DOSES THAT COULD OCCUR

PROPOSALS TO PROJECT PROBABILISTIC DISTRIBUTIONS OF HABITS OF FUTURE PEOPLE

MATHEMATICAL ERRORS IN THE TYMS REPORT

FOR HOW LONG IN THE FUTURE SHOULD DOSES BE CALCULATED? ORIGIN OF EPA'S 10,000-YEAR CUTOFF

UNCERTAINTY ANALYSIS AND RISK

UNDERGROUND CRITICALITY

GROUND-WATER PROTECTION

THE REASONABLE MAXIMALLY EXPOSED INDIVIDUAL (THE RMEI)

TRADITIONAL DRINKING WATER STANDARD (ALSO EPA STANDARD FOR GROUND WATER PROTECTION)

THE RMEI DRINKS ONLY CONTAMINATED WATER. CALCULATE ALLOWABLE CONCENTRATIONS OF CONTAMINANTS FOR A SPECIFIED DOSE LIMIT

TRADITIONAL SUBSISTENCE-FARMER STANDARD FOR WASTE DISPOSAL

THE RMEI IS A SUBSISTENCE FARMER WHO USES CONTAMINATED GROUND WATER FOR ALL DRINKING WATER AND FOR GROWING ALL (OR A SUBSTANTIAL PORTION) OF HIS FOOD.

NEW LENIENT STANDARDS PROPOSED BY U.S. CONGRESS AND NUCLEAR INDUSTRY

Limit Dose Calculations to 10,000 Years

But, calculated annual dose in a few 100,000's of years is millions of times greater than 10,000-year annual dose.

Limit Calculated Annual Dose to 100 mrem (1 mSv).

A limit of 100 mrem is 4 to 25 times greater than present practice in the U.S. and abroad.

Calculate as dose for the "average individual in the vicinity".

NEI and EPRI interpret this as meaning the average of doses to all persons in the surrounding vicinity.

Calculated <u>average</u> dose can be 1000's of times less than the reasonable maximum dose.

The calculation is poorly defined and can be manipulated. To calculate smaller dose and obtain compliance, extend hypothetical boundaries of the "vicinity".

MAXIMUM INDIVIDUAL DOSE AT A FEW HUNDREDS OF THOUSANDS OF YEARS IS OVER TEN MILLION TIMES LARGER THAN THE MAXIMUM DOSE AT 10,000 YEARS

Terminating dose calculations at 10,000 years gives a false illusion of safety of geologic disposal!

10,000-YEAR CLAIMS BY DOE AND NEI

CLAIM: It is sufficient to terminate calculations of doses for compliance at 10,000 years, because the 10,000-year cut-off was adopted by EPA in promulgating 40 CFR 141.

FACT:

EPA first selected the 10,000-year cut-off because of a technical error. In draft 1 (1981) of its proposed Standard, EPA stated that the 10,000-year cut-off was obtained from calculations of Pigford and Choi, which showed that the ingestion toxicity of unreprocessed spent-fuel (the principal repository waste) became less than that of the ore consumed to produce the spent fuel at about 10,000 years. The National Research Council objected, on the grounds:

1. Ingestion toxicity is not a valid measure of relative hazards from a geologic repository,

2. The toxicity from uranium ore is not a suitable reference for a safe geologic repository, and

3. The Pigford-Choi calculation that EPA used was published in 1975. It had been updated in 1979 to reflect new information on the dose-response of various radionuclides. The new calculations showed a cross-over time of over a million years!

EPA subsequently changed its argument for the 10,000 year cutoff. It claimed, without calculation or analysis, that uncertainties of calculation become too great after 10,000 years.

INTERNATIONAL COMMISSION ON RADIATION PROTECTION

Critical Group Approach: Identify group of people to include persons with highest calculated doses and persons whose doses are within a factor of ten of the highest dose. Compare calculated average dose of this critical group to the dose limit.

For the long-term future cannot identify habits and location of people.

Assume critical group is a single hypothetical individual.

Current international consensus is that this hypothetical individual is reasonably represented by a subsistence farmer of reasonable diet and normal response to radiation.

STEPS IN CALCULATING THE LOCATION PROBABILITY

The National Research Council's TYMS Panel Majority (August 1995):

"... a method must be incorporated for calculating the probability that people are present over the contaminated plume of ground water." (p. 146)

(A method for calculating the "location probability" is not shown.)

The method of the Electric Power Research Institute (April 1994):

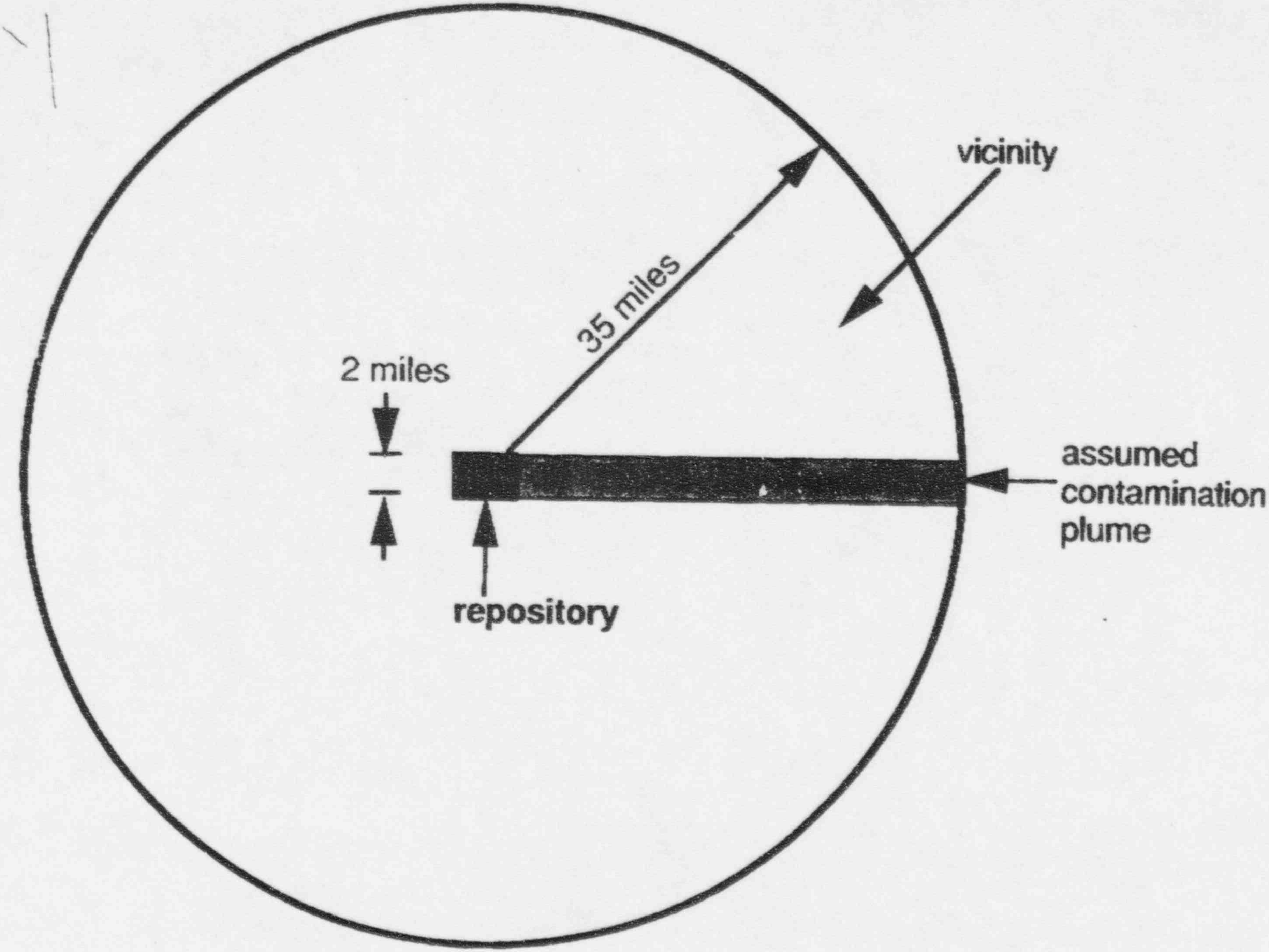
Calculate the probability that a well will intersect the contaminated plume of ground water (the "location probability")

Assume that the "vicinity" is [redacted] within a circle of (arbitrarily) specified radius, with the repository at the center.

Assume that the plume of ground water contamination is a rectangle of uniform concentration, of width equal to the repository width, and extending from the repository to the vicinity boundary in the direction of ground water flow. This assumes steady state, no dispersion, and no radioactive decay. (see Figure 1)

Assume population density is uniform throughout the vicinity.

EPRI's location probability is the ratio of the rectangle area to the circle area.


35 miles
vicinity
2 miles
repository
assumed
contamination
plume

THE LOCATION PROBABILITY (CONT.)

Assume: **repository breadth = 2 miles**
vicinity radius = 35 miles

The calculated location probability is 0.018

Assume that people in the vicinity are subsistence farmers. Assume no transport of well water across the rectangular boundary. Then the location probability is:

$$0.018 = \frac{\textit{vicinity average dose}}{\textit{maximum dose}}$$

The ratio of maximum dose to average dose would be 1/0.018 = 56. Allowing 100 mrem/year average dose would allow 5.6 rem/year maximum dose.

If 10 percent of the people are subsistence farmers, the maximum dose would become 56 rem/year.

Subsistence-Farmer Doses that Could Result From 100 mrem/year Vicinity-Average Dose

(Assumes 35 mile outer radius of population zone)

	Small population, current technology	Small population, advanced technology
EPRI's habit probability	0.11	0.0038
EPRI's location probability	0.018	0.018
Calculated ratio of vicinity-average dose to subsistence-farmer dose *	0.002	0.00007
Calculated ratio of subsistence-farmer dose to vicinity-average dose	500	14,000
Subsistence-farmer dose for 0.1 rem/year average dose, rem/year	50	1,400

Table note * : The dose ratio is equal to the product of the location probability and the habit probability. The subsistence-farmer dose is for a subsistence farmer who uses contaminated ground water from a well near the repository.

RELAXING PERFORMANCE REQUIREMENTS

Yucca Mountain Project's 1994 estimate of maximum individual (RMEI) dose (at 5 km):
30 rem/year

Estimate of vicinity-average dose, using EPRI method:

Small population, current technology for water purification: 60 mrem/year

Large population, advanced technology for water purification: 2 mrem/year

The vicinity-average doses would become tenfold lower if no more than 10 percent of the people are subsistence farmers.

Conclusion: A repository with an unacceptably high individual dose could be perceived to be safe if compliance focuses on protection of the average individual.

PROBABILISTIC FUTURE POPULATIONS CAN RESULT IN LOWER CALCULATED DOSES AND HIGHER ALLOWED CONCENTRATIONS IN GROUND WATER

Current calculated individual doses for Yucca Mountain are high

> 1000 mrem/year (10 mSv/year)

Electric Power Research Institute (EPRI) suggests predicting habits, locations, occupancy, and food sources of future people. Suggested probabilities would lower calculated doses (ca. by 10^4) and allow greater concentrations of contaminants in ground water.

(greater than now allowed under ground-water protection requirements).

(NRC)

The National Research Council's TYMS Panel believes that there is *no* scientific basis for predicting such habits of future people. However, the Panel *recommends* a probabilistic calculation of future human activities, claiming it would be acceptable *policy* even though *not* scientifically valid. EPRI first proposed such a calculation.

EPRI's method of calculating the probability that a person in the surrounding vicinity will access contaminated ground water results in calculation of the *average dose to all individuals* in the surrounding vicinity.

The NRC Panel's proposed method will *not* yield a calculated average dose to the critical group as claimed.

The proposed calculational technique is *not* mathematically valid. When calculated directly for all individuals in the surrounding vicinity (???), it will yield the *average* dose to all individuals in that vicinity.

The proposed calculation can be easily manipulated to produce artificially low calculated doses and risks

No other country has adopted the NRC/EPRI proposal. A strong dissent has been published by a panel member (THP).

HOW THE ICRP CRITICAL GROUP COULD BE CALCULATED (IF HUMAN HABITS WERE KNOWN)

Assume that valid probabilistic distributions of habits of future populations could be estimated:

1. Calculate Monte Carlo realizations of dose for all people in the designated vicinity.

2. Calculate the expected value of dose for each person in each location at a given time.

3. Rank order the calculated expected values of doses at a given time.

4. Exclude doses to any individuals with unusual diets and sensitivity to radiation.

5. Select the individuals who have the maximum expected value of dose and all other individuals whose expected-value doses are within tenfold of the maximum.

MATHEMATICAL ERRORS IN THE TYMS REPORT

Even if it were possible to estimate habits of future people, a critical group consistent with ICRP recommendations could not be calculated by the method described in Appendix C of the TYMS report.

The dissent in the TYMS report pointed out mathematical errors in Appendix C.

Professor Peter Bickel, a statistician at the University of California, Berkeley, points out some of the mathematical errors, in two letters to Dr. Bruce Alberts, President of the National Academy of Science.

Dr. Alberts, National Research Council staff, and three members of the TYMS committee claim that no mathematical errors occur.

Staff of the Senate Committee on Governmental Relations have agreed with Professor Bickel, in a letter to Dr. Alberts.

A recent report (UCB-NE-4215) points out four mathematical errors in Appendix C.

MATHEMATICAL ERRORS COULD EASILY BE CORRECTED. HOW TO PREDICT HABITS OF FUTURE PEOPLE REMAINS A SERIOUS PROBLEM.

MATHEMATICAL ERRORS IN APPENDIX C OF THE TYMS REPORT

The purpose of the Appendix C calculation is to yield a critical group for the vicinity, to meet ICRP criteria that the group include the individual of maximum exposure and all other individuals whose doses are within tenfold of the maximum dose. The average dose for that critical group is to be calculated.

TYMS p. 151: "..the individual doses of the combined plume and exposure simulations could be divided into subsets based on geographic location of the inhabitants. The sizes of the subareas should be adjusted to provide adequate resolution of the spatial variation in individual doses and to account for variations in the scenario-specific population density over the simulation region. ......For each subarea, an average individual dose could be computed as the arithmetic mean of the individual doses in that subarea generated by the exposure simulations." [emphasis added]

> ***ERROR: Any subarea can be expected to include individuals whose habits result in low dose. Their doses should not be included in calculating the average dose for the subarea.***

ERRORS (CONT.)

TYMS p. 151: "The procedure for identifying the critical subgroup for <u>one</u> of the plume realizations would begin by delineating the subarea of the simulation region with maximum average <u>risk</u> plus additional subarea in which the risk is greater than or equal to one-tenth the risk in the maximum risk." [emphasis added]

> ***ERROR: There is no meaning to "risk" for a single realization. The transition from dose to risk has not been explained.***

TYMS p. 151: "These subareas constitute a trial area for a critical subgroup that is homogenous with respect to risk. The average risk in this trial area is calculated as the <u>arithmetic mean of the subarea risks.</u>" [emphasis added]

> ***To avoid propagating the previous error, substitute "dose" for "risk".***
>
> ***ERROR: Calculating the arithmetic mean of the subarea-average doses cannot produce a correct population-weighted average for the subareas considered. Each subarea average must be weighted by the number of individuals in each subarea who contribute to that average.***
>
> ***ERROR: Because of the incorrect use of subarea averages, the resulting critical group for that realization cannot be assured to include both the individual of maximum dose and to not include individuals whose doses are less than one tenth of the maximum dose. ICRP's two criteria will not be simultaneously fulfilled (except for some fortuitous set of data).***

ERRORS (CONT.)

Demonstration:

Assume two subareas, each with a linear variation of doses.

Subarea 1 contains the individual with maximum dose of 100 (arbitrary units). The average of all doses from 100 to 10 is 55.

In subarea 2 the maximum dose is 10. The average of all doses from 10 to 1 is 5.5.

Doses in other subareas are all less than unity.

Following Appendix C, the critical subgroup for the entire area will have an average dose of:

$$(55 + 5.5)/2 = 30.2$$

with a reported maximum dose of 55 and a minimum dose of 5.5. This would seem to satisfy ICRP's homogeniety criterion, but it would not satisfy the maximum-dose criterion.

The actual data for the entire vicinity, if selected according to a procedure that would meet the ICRP criteria, will yield a true critical group with maximum dose of 100 (not 55), a minimum dose of 10 (not 5.5), and an average dose of 55 (not 30.2).

HOW TO MANIPULATE THE NATIONAL RESEARCH COUNCIL'S PROBABILISTIC CRITICAL GROUP EXPOSURE SCENARIO

Members of the National Research Council's Panel and others have suggested:

1. Arbitrarily choose any reference population of present, past, or future, such as the population down gradient of Yucca Mountain or the population in Las Vegas.

2. Assume that during the next few hundred thousand years no people in the vicinity of Yucca Mountain will live closer to Yucca Mountain than present inhabitants.

Presently no one lives closer than 20 miles, because of public lands.

3. Assume that if future people do live closer to Yucca Mountain, their wells will be no deeper than present wells in Amorgosa Valley.

> ***This will reduce the probability of intersecting ground water, because the water table is lower the closer to Yucca Mountain.***

4. Assume that no ground water will be extracted from an area that is not suitable for growing crops.

> ***The practice in the West is to extract ground water where it is available and to transport it if farms are located elsewhere.***

5. Place no limit on the outer boundaries of population groups that are to be including in the dose averaging.

> ***By increasing the distance to the outer boundary, more people with zero or negligible dose will be included in calculating the average dose.***

6. The traditional calculation of the dose to the maximally exposed individual is too conservative. Future people will have improved methods to detect contamination in ground water. They can treat the water to protect themselves.

Fact: *Very sensitive methods of detection exist today, yet many people now suffer from excessive contamination of carcinogens in ground water. Once the large underground area (> 30,000 acres) is contaminated, it will be very difficult to remove the hazards to future people. The task of repository designers is to avoid contaminating the underground and above-ground environment to the extent that future people must protect themselves.*

7. Some people now receive radiation doses from radioactive radon entering their dwellings that are much larger than doses expected from a future geologic repository. Thus, using traditional standards for protecting public health from a geologic repository are too conservative.

Fact: *The objective of geologic disposal is to ensure that future people will not have to protect themselves from the high-level waste. Are we to set aside these goals because there are other instances wherein people now are exposed to hazards greater than predicted for geologic disposal? No! We should work also towards achieving public health protection in other areas, rather than relaxing health standards for geologic disposal.*

8. The traditional calculation of doses to the maximally exposed subsistence farmer will rule out any geologic repository.

This claim was made by an individual from a country that has adopted the traditional subsistence-farmer calculation of dose. All countries working on geologic disposal of high-level waste are using the traditional subsistence-farmer calculation of dose as a performance criterion. None has concluded that its project cannot meet this criterion.

9. The traditional subsistence-farmer approach will result in undue emphasis on small isolated "hot spots" of radioactive contamination.

The field of contaminated ground water will be extensive, about 8000 acres for concentrations varying from the maximum at the repository edge to 0.25 of the maximum; 23,000 acres for a tenfold variation. These are not "isolated hot spots"!

CONCLUSION

Some radioactivity can eventually be released from Yucca Mountain. The standard for protecting public health should limit the annual radiation dose to the reasonable maximally exposed individual. For estimating compliance with radiation protection standards for geologic disposal, national and international radiation protection agencies and bodies have long calculated reasonable maximum exposures for future subsistence farmers, who drink contaminated ground water and obtain a substantial portion of their food from crops irrigated by that ground water. If the reasonable maximum dose estimate is within acceptable limits, the doses to others, who by definition should receive lower doses, will also be acceptable. This is accepted international practice for protection of public from disposal of radioactive waste in geologic repositories. Countries and organizations that are using the subsistence-farmer calculation for waste disposal projects are the U.S., Sweden, Finland, UK, Switzerland, Canada, Japan, and the International Atomic Energy Agency. Subsistence farming is not a rare event. Family farms are a way of life for many residents in the Amargosa Valley, who utilize ground water from an aquifer that flows under Yucca Mountain.

The Yucca Mountain project needs a standard that is stringent enough to build confidence in the face of legal and political challenges. At present no scientific bases exist to support a policy less stringent than the subsistence-farmer approach now used in the U.S. and in other countries. Policy makers must reject pressures for short-term expediency and economy lest, by enacting policy that compromises scientific validity and credibility, they undermine public confidence and end needed nuclear research and application.

Critical Group
and
Future Biosphere

for

The Advisory Committee on Nuclear Waste

Ray Clark
June 1996

Critical Group

- Was not used in Part 191
- Was not used in WIPP Compliance Criteria
- Is not used in EPA
- Superfund uses RMEI
  - "Reasonably maximally exposed individual"
  - Gives doses that are likely to occur
  - Not worst case
  - Some parameter values at max. or near max., others use mean values
  - Dose well above average but within realistic range

CG1

Future Biosphere

- Agency does not explicitly address future biosphere

- 40 CFR Part 191
  - Did not explicity address biosphere

- WIPP Compliance Criteria
  - "...characteristics...remain what they are at the time of compliance application"
  - Does not apply to hydrology, geology, climate

BIOSPH1

The Who, When and Where of Critical Groups

John H. Kessler

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Presented to the Advisory Committee on Nuclear Waste
25 June 1996

Main Arguments

- Individual Numerical Limit based on Local Population Average
- Critical Group: Amargosa Valley, as it is Today

Why Perform Dose Assessments?

- Demonstrate Quantitative Compliance with Regulations
- Show Trends and Sensitivities
- Assure the Site is "Safe"
  - Regulator (Meets the Safety Philosophy)
  - Public (if Safety Philosophy is Clear and Accepted)

Dose Assessments do *Not* Predict the Future

- Stylized Scenarios

- Based on Many, Many Assumptions and Uncertainties
  - some testable
  - some untestable (critical groups)

Subjectivity and Uncertainty Demand NRC Input

- Clarification of "Assessment" (Safety) Philosophy
- Guidance on Reasonable Assumptions
- Iterative Process

Critical Groups and Numerical Limits "Musts"

- Consistent with the Assessment Philosophy
- Consider Site Specifics
- Consider Licensing "Realities"

Start with a Clear Assessment Philosophy

- "Cautious": Protect (Almost) Everybody
- "Equitable": Protect to a Widely-Tolerated Risk Level
- Something in Between

"Tolerated" Involuntary Individual Risk Levels

Risk Source	Annual Risk[1]	Reference
Man-Made:		
Motor vehicle pedestrian collisions	4.2×10^{-5}	1
Extra Fatal Cancer Risk Living in Denver[2]	$\mathbf{1.0 \times 10^{-5}}$	**2**
Poisonings (not drugs/medications)	6.0×10^{-6}	1
Electrocution	5.3×10^{-6}	1
Natural:		
Radon	$\mathbf{5.6 \times 10^{-5}}$	**3**
Floods	6×10^{-7}	1
Lightning	5×10^{-7}	1
Tornadoes	$\mathbf{0.6 \times 10^{-6}}$	**1**
Tornadoes (Midwest US average)	$\mathbf{2.2 \times 10^{-6}}$	**4**

[1] average for ***entire*** US population

[2] Compared to living in New York.

NAS Mixes the Two Philosophies

- "Cautious": Small, Homogeneous Critical Group
- "Equitable": Numerical Standard
  - Basis: Tolerated for Large, Heterogeneous Populations
- Combination is *Very* Conservative

EPRI Recommendation: An Intermediate Philosophy

- "Equitable" for Local Population

Numerics Consistent with the Intermediate Philosophy

- Critical Group size:
  Entire Local Population
- Individual Risk (Dose) Limit
  - ~10^{-6} to 10^{-5} per year
  - For local population average
- Optional Numerics
  - ICRP/NAS-style critical group
  - Higher risk limit (e.g., 10^{-4} per year)

Amargosa Valley, as it is Today, is All We Need

- Future Behavior Unknown
- Current Behavior can be Measured
- Nearest Downstream Population Center
- Forces Attention on Local People

Conclusion

- Numerical Limit for a Local Population Average

- Amargosa Valley: as it is Today

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INNOVATIVE POLICIES FOR RADIOACTIVE WASTE MANAGEMENT

PRESENTATION BY DADE MOELLER

AT THE 84th MEETING OF THE

ADVISORY COMMITTEE ON NUCLEAR WASTE

JUNE 25, 1996

OPEN-MARKET TRADING RULE

1. Reduce Your Own Releases

2. Reduce Someone Else's

TRENDS IN APPLICATIONS

1. Single Pollutant -- Single Medium

2. Multiple Pollutants -- Single Medium

3. Multiple Pollutants -- Multiple Media

TRENDS IN APPLICATIONS

4. Now Being Applied Regionally

5. Being Applied To Emissions Causing Global Warming

6. Being Expanded to Other Issues Such as Wetlands

ENDORSEMENTS

1. EPA -- Asst. Sec. for Air & Rad

2. DOE -- Asst. Sec. for Policy

3. U.S. GAO, CEQ, EPRI, etc.

APPLICATION TO NUCLEAR FACILITIES

1. Assess All Sources

2. Rank According to Dose and Ease of Reduction

APPLICATION (Continued)

3. Clean Up Facility to Minimum Requirements

4. Apply Trade-Offs to Reach Desired Lower Level

EXAMPLES OF TRADE-OFFS

1. Indoor Radon

2. Medical Radiation

Summary of Results for Pennsylvania Radiation Programs

Program	$/effect
X-ray	$2220/cancer prevented
CT study	$29,000/life saved/yr
Radon mitigation	$103,000/life saved
LLRW discounted	$8.18E+06/life saved
LLRW undiscounted	$1.63E+07

BENEFITS

1. Represents A Risk-Based Approach

2. Requires An Holistic Approach

BENEFITS

3. **Provides Direct Interactions With Stakeholders**

4. **Permits Immediate Actions to Accomplish Reductions**

BENEFITS

5. Provides Stimulus for Control of Indoor Radon

6. Provides Significant Reductions in Costs & Waste Volumes

BENEFITS

7. Requires Less Sophisticated Cleanup Technology

8. Provides Cushion for Errors Or Unexpected Developments

BENEFITS

9. **Permits Reductions In Dose To Less Than Those Prior to Facility Operation**

10. **Represents New Challenges for DOE National Laboratories**

BENEFITS

11. Could Lead to System Permitting Trade-Offs Between Radiation and Toxic Chemicals

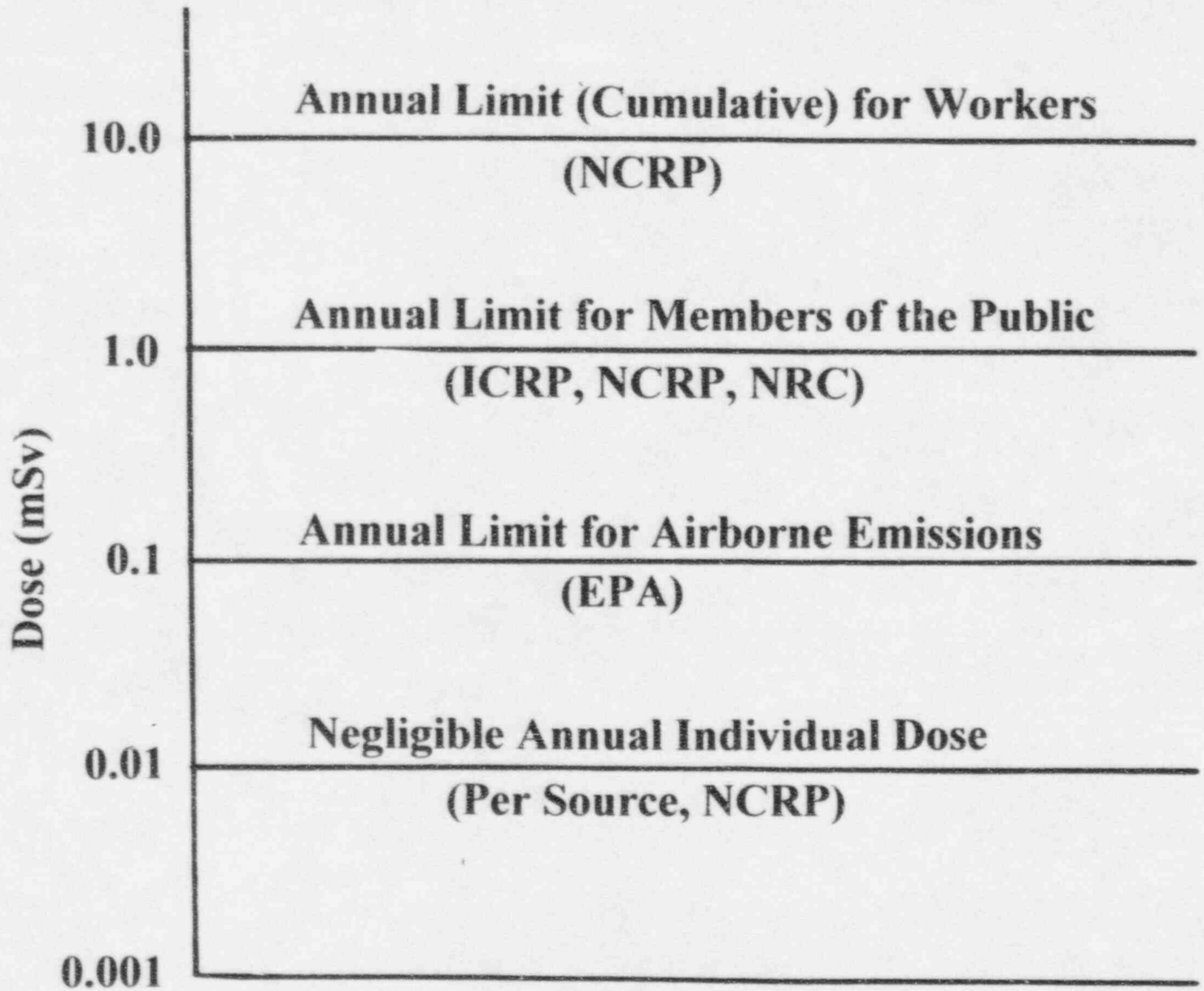
12. Represents Outstanding Vehicle for Public Education and Good Will

PROBLEM AREAS

1. Cleanup Standards

2. Relevant Time Scales

3. Equity of Exposures


Annual Limit (Cumulative) for Workers
(NCRP)
10.0
Annual Limit for Members of the Public
(ICRP, NCRP, NRC)
1.0
Annual Limit for Airborne Emissions
(EPA)
0.1
Negligible Annual Individual Dose
(Per Source, NCRP)
0.01
0.001
Dose (mSv)

RELEVANT TIME SCALES

1. **Mode of Exposures**
   - **Atmospheric**
   - **Groundwater**

2. **Radionuclide Half Life**
   - **Short Lived**
   - **Long Lived**

EQUITY OF EXPOSURES

Population Exposed vs.

Population Remediated

PUBLIC PERCEPTIONS

1. **External Exposures**
   Whole Body

2. **Internal Exposures**
   Inhalation vs. Ingestion
   Lung vs. Thyroid

EQUITY OF EXPOSURES

1. Men vs. Women

2. Children vs. Adults

3. Residential or Environmental vs. Medical

5A

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Telephone (919) 633-3352
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INNOVATIVE POLICIES FOR RADIOACTIVE WASTE MANAGEMENT

PRESENTATION BY DADE MOELLER

AT THE 84th MEETING OF THE

ADVISORY COMMITTEE ON NUCLEAR WASTE

JUNE 25, 1996

Based on the hypothesis that genetic effects and some cancers may result from damage to a single cell, the Council assumes that, *for radiation-protection purposes, the risk of stochastic effects is proportional to dose without threshold, throughout the range of dose and dose rates of importance in routine radiation protection*. Furthermore, the probability of response (risk) is assumed, for radiation-protection purposes, to accumulate linearly with dose. At higher doses, received acutely, such as in accidents, more complex (nonlinear) dose-risk relationships may apply.

NCRP Report No. 116, page 10 (1993).

NRPB

National Radiological Protection Board

The role of radiation-induced damage in carcinogenesis is ". . . well established and broadly consistent with the thesis that, at low doses and low-dose rates, the risk of induced neoplasia rises as a **simple function of dose** and does **not** have a DNA damage or DNA repair related **threshold-like component.**"

According to John R. Johnson, "In simpler terms: there is **no scientific evidence** that provides a basis for **rejecting the LN-T concept** upon which radiation protection is based."

ICRP

Committee 1: Sept. 1995 Meeting

"There was unanimity that, at present and for the purposes of radiation protection, there are no good scientific reasons to depart from the current consensus of linearity for low dose carcinogenesis."

The BEIR V Report (NAS/NRC, 1990) used a linear-quadratic model to fit age-specific mortality data for leukemias and a linear-dose response for solid cancers in their estimates of risk of excess cancer and life shortening in persons exposed to a single acute exposure of 0.1 Sv or a continuous lifetime exposure to 1 mSv y^{-1} and 0.01 Sv y^{-1} from age 18 to 65 y of age. The estimates were based on data for exposures at a high-dose rate with no reduction of the risk of solid cancers for exposures at low-dose rates and using a neutron RBE of twenty.

•March 1996: HPS issues position statement

Did not specifically address the LN-T model.

Recommended that quantitative risk assessment be limited to doses at or above 5 rem per year or 10 rem lifetime.

Recommended that NCRP and ICRP should further examine the issue of the model.

French Academy of Sciences

"The new contributions from molecular biology lead to the concept that the process of induction of potentially carcinogenic persistent genomic lesions is significantly different at low or high doses and likewise at low and high dose rates."

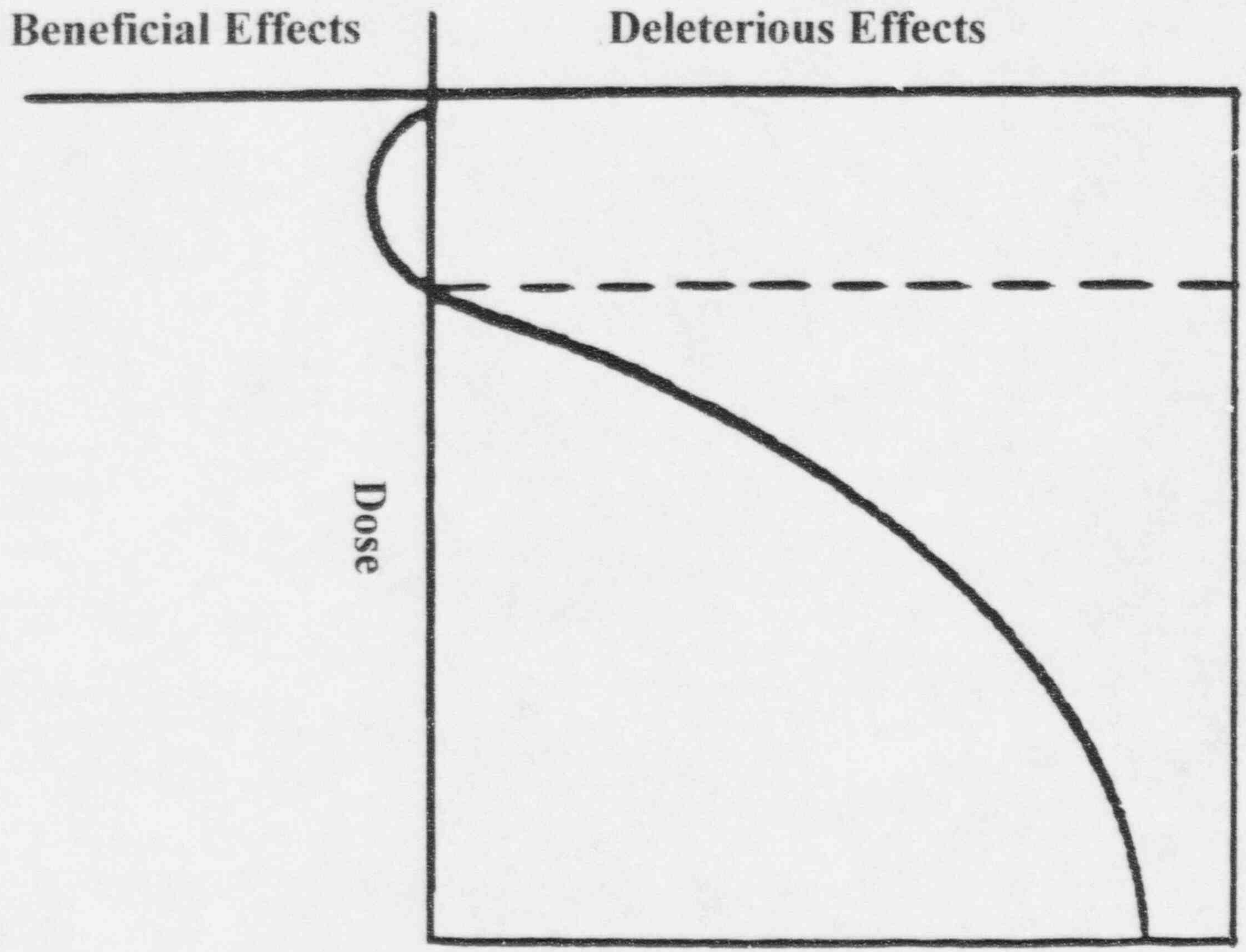
The Academy doesn't like the LN-T Model. They believe it is not supported by science.

ANS

- Special Sessions at Meetings
  - 1994 Winter Meeting
  - 1995 Summer Meeting
  - 1995 Winter Meeting

"Disputed linear, non-threshold models and discussed ways of alleviating the serious costs to the nuclear industry and the nation of exaggerated risk assessments and overzealous applications of the linear hypothesis."

Summary: Nuclear News Vol. 38, No. 11, 26-30, 1995.


Beneficial Effects
Deleterious Effects
Dose