Official Transcript of Proceedings

NUCLEAR REGULATORY COMMISSION

Title: Advisory Committee on Nuclear Waste
148th Meeting

Docket Number: (not applicable)

Location: Rockville, Maryland

Date: Tuesday, February 24, 2004

Work Order No.: NRC-1331 Pages 1-305

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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON NUCLEAR WASTE (ACNW)

148th MEETING

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TUESDAY,

FEBRUARY 24, 2004

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ROCKVILLE, MARYLAND

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The committee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, at 8:00 a.m., B. John Garrick, Chairman, presiding.

COMMITTEE MEMBERS:

B. JOHN GARRICK, Chairman

MICHAEL T. RYAN, Vice Chairman

JAMES CLARKE, Consultant

GEORGE M. HORNBERGER, Member

RUTH F. WEINER, Member

ACRS/ACNW STAFF:

JOHN T. LARKINS, Executive Director, ACRS/ACNW

HOWARD J. LARSON, Special Assistant, ACRS/ACNW

EXPERT PANEL:

DADE MOELLER, Keynote Speaker, Dade Moeller and Associates

JEFFREY DANIELS, Lawrence Livermore National Laboratory

KEITH ECKERMAN, Oak Ridge National Laboratory

DAVID KOCHER, SENES Oak Ridge, Inc.

MICHAEL THORNE, Mike Thorne and Associates (UK)

JOHN TILL, Risk Assessment Corporation

NRC STAFF:

ANDY CAMPBELL

KEITH COMPTON

RICHARD CORELL

DAVID ESH

CHRIS GRUSSMAN

LATIF HAMDAR

PHILIP JUSTUS

MATT KOZAK

BRET LESLIE

TIM McCARTIN

CHRIS McKENNEY

JOCELYN MITCHELL

TIN MO

PHIL REED

NRC STAFF: (cont'd)

A. CHRISTIANNE RIDGE

JAMES RUBENSTONE

CHERYL TROTTIER

MITZI YOUNG

I-N-D-E-X

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

(8:00 a.m.)

CHAIRMAN GARRICK: Good morning. The meeting will come to order.

This is the first day of the 148th meeting of the Advisory Committee on Nuclear Waste. My name is John Garrick, Chairman of the ACNW. The other members of the committee present are Michael Ryan, George Hornberger, and Ruth Weiner. We also have one of our consultants here today, Jim Clarke from Vanderbilt University.

During today's meeting the committee will conduct a working group on biosphere dose assessments for the proposed Yucca Mountain high-level waste repository. John Larkins is the Designated Federal Official for today's initial session, but seems to be absent, so we'll appoint Howard Larson as the interim. We'll also be introducing the rest of the head table here as we proceed into the working group session.

This meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act. We have received no requests to make oral statements. We have received one request for tomorrow, and we'll announce it at that time.

Should anyone wish to address the

committee, please make your wishes known to one of the committee staff. It is requested that speakers use one of the microphones, identify themselves, and speak clearly and loudly, so that they can be heard.

Before starting the first session, I'd like to cover some items of interest. We are pleased to announce one of the distinguished members of our committee -- namely, Dr. George Hornberger -- has won election to the post of president-elect of the Hydrology Section of the American Geophysical Union. There's a lot more information on here that I could read you, but I'm not going to. We are proud of George's accomplishments, and we wish him well in his new post.

Other personnel matters that we want to mention: on February 23, Sher Bahadur departed from the ACRS/ACNW office and assumed the position of Deputy Director, Division of Systems Analysis and Regulatory Effectiveness in Research. His replacement has not yet been announced. The staff and the committee will surely miss Sher. He was a very valuable part of the team.

On February 12 of this year, President Bush announced his intention to nominate Gregory Jaczko, Senator Reid's Appropriations Director to

serve the remainder of the term opened by the departure of Commissioner Greta Dicus. The term expires on June 30, 2008.

Mr. Noble Green has assumed the position of Administrative Secretary to the Executive Director, ACRS/ACNW. He comes from Commissioner Dicus' office.

While Jenny Gallo is on her three-month rotation to NRR, Sharon Steele will be filling in for her. Sharon, like Jenny, was recently selected to NRC's Leadership Potential Program, which requires a rotational assignment.

Keith McConnell has been appointed Director of the newly-established commission, Adjudicatory Technical Support Program with the Office of General Counsel. This organization will provide a source of technical expertise for the Commission, independent of staff involved in the review, and adjudication of DOE's application for the high-level waste repository as the agency proceeds with its review of the repository application.

Some other news worth mentioning. DOE has identified two rail corridors as top choices for a rail spur to Yucca Mountain. The preferred corridor is a 319-mile route from Caliente, Nevada, to Yucca Mountain. The second choice is a 323-mile route from

Carlin, Nevada, to Yucca Mountain.

DOE has announced an intention to release a draft Request for Proposals for conceptual cask designs to move utility spent fuel and defense high-level waste to Yucca Mountain. Under a mostly real scenario, the cask fleet would be comprised of 10 legal weight truck casks and 90 rail casks.

On January 14, 2004, a three-man U.S. Appeals Court panel in Washington heard oral arguments involving 13 lawsuits related to the proposed Yucca Mountain repository. The court, for three hours, heard arguments on issues from EPA's Part 197 to the State's constitutional challenge of the federal government's right to site a repository there. A decision by the Court is expected sometime in mid- to late 2004.

John Arthur, Technical Deputy Director of the DOE Yucca Mountain Waste Program, stated last month that DOE is developing an internal licensing plan to review and approve the Yucca Mountain license application. The plan, which is expected to be completed by March or April, will give the Yucca Mountain program a clear indication of whether it can meet the license application December of this year's submittal target date.

Larry Camper, Deputy Director of the Spent Fuel Project Office, Program Office, recently stated that the NRC, rather than relying on DOE funding, will use its own money to cover the $30 million cost of a package performance study. The study would test the full-scale spent fuel truck cask and a rail cask to evaluate their performance during crashes and fires.

Now let's turn to the activity of the day. The Advisory Committee on Nuclear Waste has adopted the practice of holding working group sessions on selected topics based on the committee's action plan. The action plan is a product the committee generates every one to two years to serve as a road map of issues and activities on which the committee should focus. It is based on input from the Commission, the Commission staff, committee members, and consultants, and, of course, stakeholders.

The main purpose of the working group sessions is to bring in experts and stakeholders to discuss and exchange knowledge, ideas, and concerns about issues of high priority to the Commission. The results of the working group sessions have been valuable source material for ACNW reports to the Commission on technical and safety issues.

As you might expect, most of the working

group sessions the past few years have related to the proposed Yucca Mountain repository for high-level waste. They have included such topics as the near-field environment and the performance of engineered barriers in 1998, June; total systems performance in March of 2003; and performance confirmation, July 2003.

Non-Yucca Mountain specific working group sessions have included such topics as transportation and linear no-threshold hypotheses. We had two workshop working group sessions on transportation, one in November of 2002 and one in April of last year. And the linear hypothesis/no-threshold was in 1999.

Today is the start of a two-day working group session on biosphere dose assessments for the proposed Yucca Mountain high-level waste repository. One interesting aspect of this working group session is the somewhat prescriptive nature of the Yucca Mountain biosphere and the uptake conditions of the radiation to the receptor. It will be interesting to see how this characteristic plays out in the discussions.

As is the practice with working group sessions, the committee assigns a committee member to chair the session on the basis of their expertise.

Clearly, Mike Ryan is our expert on radiation and dose calculations, and I am pleased to turn the session over to Mike to serve as its Chairman.

Dr. Ryan?

VICE CHAIRMAN RYAN: Thank you, Mr. Chairman, and welcome to the Working Group on Biosphere Dose Assessments for the proposed Yucca Mountain high-level waste repository.

Just a few things about our structure and how we'll proceed. We have, to my right, a panel that will be offering comment and questions and their views as we go through the working group session. And we have later tomorrow a panel discussion for -- so that each member can summarize what they've heard and offer comment to the committee and to the entire audience.

Let me introduce the panel. Chairing the panel is Dade Moeller, no stranger to this room. He served 21 years, both on the ACRS and the ACNW. He is now President -- I'm sorry, Chairman and Chief Executive Officer of Dade Moeller and Associates, and a Professor Emeritus at Harvard University School of Public Health.

Dr. Moeller's work is widely known in environmental health physics and lots of other areas and is most recently known for his newest addition of

his book Environmental Health, which will be hopefully coming out soon, in the fourth edition, is it not?

DR. MOELLER: Third.

VICE CHAIRMAN RYAN: Third edition. So that's -- that new edition will be out soon.

Dr. Moeller received his MS from the Georgia Institute of Technology and his Ph.D. from North Carolina State University. Welcome, Dade.

I might also add that he's a recent recipient of the Robely D. Evans Commemorative Medal from the Health Physics Society, which is the most prestigious award offered by the Health Physics Society. Congratulations for that.

Seated to Dade's right is Dr. Keith Eckerman. Keith is a member of the RNL staff in the biosystems modeling group, and Keith is an internationally recognized expert on internal dosimetry and biokinetic modeling, radiation dosimetry, radiation protection, radiological assessment, and the application of mathematical models to radiation dosimetry, physiology, and metabolism.

Anybody that has anything to do with internal dose has certainly run into Dr. Eckerman's work in their career, and it's a pleasure to have you with us here today, Keith.

Sitting to Dr. Eckerman's right is Dr. Dave Kocher, and Dr. Kocher is now at the SENES Group in Oak Ridge, Tennessee, has experience in the areas of environmental health physics involving development of models and databases for assessing radiation dose to the public of various radiation types.

He has special expertise in evaluations of dose and risk assessment models for regulatory and decisionmaking purposes. His work in these areas has been concerned with routine and accidental releases from operating nuclear facilities, performance assessment of waste disposal facilities, and impacts of consumer products containing radioactive material.

Particularly noteworthy accomplishments include development of widely-used databases on radioactive decay and external dosimetry, a widely-recommended model of global transport and population dose assessment for I-129, and risk-based classification systems for radioactive and hazardous chemical waste. Welcome, Dr. Kocher. It's a pleasure to see you.

Sitting to Dr. Kocher's right is John Till. John is the President of Radiological Assessment Corporation -- I'm sorry, Risk Assessment Corporation, formerly known as Radiological Assessment

Corporation. And since its formation, RAC has played a key role in the evolution and methodologies for environmental risk analysis.

Dr. Till has published more than 175 publications, including editing the first textbook on radiation dose analysis titled Radiological Assessment, and other documents that stress new approaches to applied and simplified transport mechanisms in environment for risk analysis.

Dr. Till is a graduate of the U.S. Naval Academy. He served in the U.S. Nuclear Submarine Program and retired as a Rear Admiral from the United States Naval Reserve in 1999. Welcome, Dr. Till. Thank you.

Next to Dr. Till is Jeffrey Daniels. Dr. Daniels is -- has worked as an environmental scientist at the Lawrence Livermore National Laboratory for almost 25 years. He is currently in the Risk Sciences Group. He is currently the Risk Sciences Group Leader in the Environmental Sciences Division of the Energy and Environment Directorate.

As Project Leader for studies assessing health risks associated with drinking water quality sponsored by the U.S. Army Medical Research and Development Command, he prepared and edited numerous

publications, including a comprehensive nine-volume report that serves as the basis for military field water quality standards.

The research included a risk assessment of chemical and biological agents, as well as radioactivity, in drinking water supplies. Welcome, Dr. Daniels.

And, finally, Dr. Michael Thorne is with us. He is a Visiting Fellow at the Climactic Research Unit, the School of Environmental Sciences, at the University of East Anglia. He is a Fellow of the Radiological Society -- I'm sorry, the Society for Radiological Protection and a past president of that society, and a member of the Editorial Board of the Journal of Radiological Protection.

He is currently involved with his own company, Mike Thorne and Associates, Limited, that has a wide variety of consulting activities in a wide variety of topics of interest to this working group today, to a variety of clients across the UK and the world. So welcome, Dr. Thorne. Thank you very much.

That introduces our panel. Our first speaker will be our panel chair, Dr. Dade Moeller, and then he will take us from there. Good morning and welcome.

DR. MOELLER: Thank you, Mike.

Could we have the first slide? It's an honor to be here, and I look forward to the discussions that take place. I wanted -- we're ahead one slide. Back up one, please.

I wanted to begin by acknowledging that I'm a member of the Science and Technology Review Panel for the Office of Civilian Radioactive Waste Management within the Department of Energy. This is not an advisory panel.

It is a collection of consultants, each of whom is a specialist in a given area, and we are working with the Office of Civilian Radioactive Waste Management to help them identify issues that will arise or that may arise during the three-year planned time span during which the Nuclear Regulatory Commission will be reviewing the license application submitted by the Department of Energy for the proposed repository.

Our role is once those issues are identified is to help DOE plan research activities on these various issues, so that when the questions -- when questions arise during the licensing review, hopefully they will have enriched the database of the DOE, the existing database, so that they will be able

to respond to these issues and document their positions.

The next slide, please.

What we're going to do during the next two days is look at one segment of the biosphere assessments. We're going to begin with assuming that the groundwater is contaminated and move on from there. In other words, how is that groundwater used? How does it interact with the public? And what are the estimations of the doses that the public may receive?

The objectives are to understand more in-depth what the accompanying assumptions being made -- what those are, what the uncertainties are associated with those assumptions, and the degree to which these uncertainties may affect or do affect the dose estimates.

We're seeking to learn what are the issues, what do we know, as well as what do we not know, and what do we need, as the slide says, to adequately address these issues. We will also be looking at related questions, and Dr. Ryan has urged me to urge the panel members to address these types of questions. Are we analyzing the right things? And will the results of the work that's described to us --

will it be useful from the various aspects or perspectives shown on this slide? And, again, will the documentation be adequate for the license review?

In terms of this, Chairman Diaz of the Nuclear Regulatory Commission, during the October 2003 Nuclear Safety Research Conference, gave a paper on what he called realistic conservatism -- realistic conservatism. And this was such a good paper, in my personal opinion, and reviewed the subject so well that I thought I would take a few minutes and summarize what he said. And I hope I am not in any way, you know, changing what he meant.

But he described conservatism. Its purpose is to provide an adequate margin of safety. Then he described realism as anchoring that conservatism in the real world of physics, technology, and experience. And above all, he opposed or told us to avoid, and encouraged us to avoid, what he would call the worst-case syndrome. He points out that recognizing that unrealistic conservatisms, meaning taking a worst-case approach, can skew the results very significantly.

He also has asked us to understand that uncertainties should be understood to the maximum practical -- practicable extent. He is urging that

they be quantified, so they can be properly addressed in the decisionmaking process, and he points out that otherwise we could have a situation in which the uncertainties remain hidden under what he calls a mantle of conservatism, meaning that, oh, we've put in enough conservatisms to take care of those uncertainties. Well, we need to know whether indeed that is true.

He has also gone on to point out that properly applied, realistic conservatism goes hand-in-hand with a risk-informed or risk-based approach to regulation. Now, that is the foundation of the Nuclear Regulatory Commission's approach, and so, indeed, it is extremely important that we keep these things in mind.

And he concluded by pointing out that the risk significance of an issue cannot be determined without a realistic understanding of that issue.

I'd like to move on by sharing with you some personal thoughts. The annual dose -- or the dose -- I put "annual" because most of them are expressed either in terms of a dose rate per year or an annual dose. It represents a subject that is of keen interest to the public, and often times people will say, "Well, what's the efficiency, or what will

be the effectiveness of this engineered barrier?"

Well, all of that -- those things are important, as well as the natural barriers. All of these are important. But I think I certainly keep in mind, and always try to keep in mind, that the public is going to be intensely -- they already are -- intensely interested in this proposed repository, and they're going to be asking questions. And I personally believe that -- and I could be wrong, but I believe that the bulk of those questions will relate to, what dose am I receiving? Tell me the number.

And so I am asking and suggesting that this represents a primary area in which the public will not hesitate to ask questions. And one of the questions they're going to ask will be -- in my opinion will be the following. The reasonably maximally exposed individual, as designated by EPA and by the USNRC, is to be an adult.

Well, it will not be very long until there will be one of the first public meetings, and a woman -- I was going to say in the back of the room. Maybe she'll be on the front seat. She'll stand up with her infant child, and she'll say, "Okay. You gentlemen -- ladies and gentlemen -- you're assuring me that you're protecting an adult. But what about my child?"

And that is very important for several reasons. First of all, if you take Dr. Eckerman's dose coefficients and look at those for an infant versus an adult, you will find quite routinely the dose per unit intake for an infant is some 10 times that for an adult.

Now, there are many ramifications that need to be discussed on this subject. But I simply wanted to share that with you as a type of issue. In my opinion, that will be an issue that will come up. And to the extent that EPA and the NRC considered this fact in setting their standards, the extent to which they considered it, in my opinion, needs to be documented, so that that can be shared with the public.

Now, here I pointed out that, although complicated, the NRC's regulations exist. And so over the next couple of days we may talk to some degree about complications within the regulations, but our main goal is to look at how the dose calculations are being made.

I did want to offer a personal comment, again, in terms of EPA, which established its standards. And that comment simply is that EPA, as I -- as it appears to me as an outsider looking in, is

not always free to do what even they may consider to be best. For example, they are told to use the best science, and yet at the same time they are told, as I understand, never to relax an existing environmental standard or limit.

Well, frequently those two goals or those two charges are in conflict. And I simply wanted to remind people of that.

The exposure pathways -- we're looking at direct exposure, you know, through the consumption of the drinking water. We also will be looking at indirect pathways, such as the irrigation of the crops, irrigation of pasture, the consumption of contaminated milk, and so forth.

The program, as Dr. Ryan pointed out, is a two-day program or two-day agenda. We're going to be talking about intake and dose, and in terms of the metabolism of the radionuclides that will be one subject which is generally described in terms of the biokinetics. And we'll be talking about the dosimetry of the radionuclides once they're inside the body.

I wanted to comment on the metabolism or the uptake of radionuclides in terms of the complexity. I say the regulations are complex. Well, all of this work, what we'll be discussing over the

next two days, is extremely complex. Otherwise, we wouldn't be here discussing it.

Now, one complexity which several of us have looked at over the past six months or so is in terms of the uptake of Iodine-129. Of course, one of the key factors is, what is the GI track absorption coefficient or factor? And, furthermore, what is it you're absorbing?

Well, we looked at I-129 as a -- one of the -- it's one of the five radionuclides we'll be discussing over the next two days. And what stimulated my interest was the NCRP had stated that Iodine-129 -- that based on the data that they have reviewed they do not believe it's carcinogenic in man. I changed it to in humans. I think they meant women as well as men.

But in so doing, that led me and others -- led us to the following realization. When you consider the average member of the U.S. public today, they consume iodized salt. In fact, I believe it's difficult to even go to a grocery store and buy non-iodized salt. And they also consume salt in the milk they drink and fish they eat, and many other foods.

Well, what does this show us, or what does this indicate? One of the things it indicated was

that if you take the total amount of stable iodine that the average member of the U.S. public consumes each day, and compare that to the maximum amount of iodine as represented by I-129, it will be in the groundwater and consumed by the public over the first 10,000 years projected dose estimates for this repository, the amount of stable iodine will be more than two billion to one, the quantity of radioactive iodine.

And the mere fact is the ratio of stabilized to radioactive iodine in your thyroid can never be lower than that in your diet, regardless of whether you eat a carload of this food per day or two grams or two pounds, whatever a typical daily diet is.

Now, what we hope to learn over the next two days, in terms of biosphere assessments, is to hear what the NRC expects and is going to require, what the DOE response is to those expectations, and if there are issues -- and I know the DOE and NRC have jointly resolved many issues that have developed.

But to the degree that during the next two days we can help resolve any issues, then more to the good. We certainly want to do that. And during the two days there will be opportunities, of course, for public comments.

Furthermore, there will be interactive sessions as well as formal presentations. And if the ACNW and this panel of consultants is anything like I know they are, there will be lots of interaction and lots of questions. And we encourage that. And so we want to ask questions such as those shown on the board.

Now, what key factors govern intake? These are other questions that we want to talk about. What are their associated conservatisms and uncertainties? And looking on one half of the balance -- in other words, can we quantify the conservatisms, and can we quantify the uncertainties?

And I would just mention a couple that are well known -- a couple of conservatisms that are well known to certainly everyone sitting around this table.

The first one is that neptunium, plutonium, and americium all have reasonably or very long half-lives, radioactive half-lives, and they all have relatively long half-lives in the body. In other words, their retention -- their biological half-life is very long.

And if you use Federal Guidance Report Number 11, or Federal Guidance Report Number 13, and estimate the committed dose, in one case you use 50

years, in the other case you use 70 years, you'll find that most of us -- and I am probably the most prominent example at the table -- will die before my 50 or 70 years take -- fully occur.

In other words, if I ingest plutonium today, they'll tell me they'll project 50 to 70 years. Well, although I hope against it, I sort of doubt -- I may not be here in another 70 years.

Furthermore, all of these dose coefficients -- and Keith Eckerman can correct me if I'm wrong, and he -- as Dr. Ryan points out, he is the number one person, certainly, worldwide in this field. But another point is those dose coefficients are based upon acute intakes. Well, the intakes that we project for Yucca Mountain will be chronic, low level, drink a little bit of water each day, eat a little bit of contaminated food each day.

Well, that will give us a factor of two conservatism, and so will this long half-life that I previously described will give us a factor of two conservatisms.

And we want to talk about the uncertainties, we want to address the questions on the slide, we want to know how realism can be achieved as urged by Dr. Diaz, and we also want to know the

implications of these conservatisms and uncertainties in terms of reasonable expectation, which is what the USNRC is asking that DOE demonstrate. In other words, a reasonable expectation that the repository will perform in a manner so as to comply with the regulations.

In terms of uncertainties, we throw these on the board or on the slide just for your consideration. A factor of two, such as those that -- the two items, examples that I described, are interesting, but in general they are well within a reasonable range of uncertainty, and they are well within a reasonable range of certainty. So they are of interest, but they are certainly not going to be dominated.

Now, if you have an uncertainty in a -- within a range of a factor of two to 20 -- or 10 to 20, excuse me -- we certainly should pay attention. If we have a factor of uncertainty of as much as 100, that certainly needs to be addressed.

Now, in terms of that last one, a factor of 100 uncertainty, one item that is of interest to me -- and I'm sure it has been a real challenge to DOE -- is to evaluate the uptake of plutonium, because, again, if you look at FGR 11, Federal Guidance

Report 11, it points out the absorption factor or the dose coefficient for soluble plutonium is more than 50 times that for insoluble plutonium, simply because you don't absorb as much of the insoluble.

Well, if you multiply that by either one of the other two factors of two that I illustrated, you have a factor of 100 or so, either conservatism or uncertainty. And, in fact, with plutonium I gather to some degree it's an uncertainty. In other words, maybe the plutonium is there as a colloid, but is it insoluble or soluble, and so forth.

So none of this is easy. We're not here to criticize people. We're here to learn what's going on, to seek the truth, and to be of assistance if we can.

This one we can go over pretty rapidly. What is it? The key factors that govern metabolism or biokinetics and dosimetry. We want to know as much as we can about the magnitudes, and so forth, want to know what can be done to reduce these uncertainties. And that's where, again, we reflect back to our science and technology panel, as well as to ongoing research that DOE has underway. They are trying to reduce these -- the magnitudes of these uncertainties.

Day two we're going to be hearing from the

NRC, and I'm very excited awaiting that presentation. It's called or titled "The Risk Insights Perspective or Initiative." And in reality, for the layperson such as myself, what they're going to do, as I understand it, is list some of the conservatisms and the uncertainties, and they're going to quantify them or rank them in terms of their importance. So to me that is a very important item.

And then there's going to be ample opportunity for stakeholder input, as Dr. Garrick pointed out, and we're going to hear the perspective of the NRC's Office of Nuclear Regulatory Research.

And so with that, I believe that's the last slide. No, here's one more.

Well, we will have the panel discussion. And, again, I'm very much looking forward to the panel's discussion, because, again, hopefully I can gain concepts, ideas, which I will take back to the science and technology panel for DOE. And at the end of the day, we'll also have an opportunity for public comments.

So I personally am looking forward to an exciting two days.

Thank you, Mr. Chairman.

VICE CHAIRMAN RYAN: Thank you, Dr.

Moeller.

We have a few minutes before our first presentation for comments from members of the panel. And I guess we'll just start at Dade's right and go down and offer you a chance to make any comments or --

DR. ECKERMAN: Dade mentioned a number of things related to the information in Federal Guidance 11 and -- well, 11 and 13, and there are some points there that we'll need to expand and discuss further.

Some of the issues aren't quite as -- as clear cut, and there's a great number of options, of course, available for further analysis. So I think that's -- that's one that we'll come back to. But I think your -- your characterization of where we should put our focus in our -- in the deliberations and in our thinking, as well as the guidance you've suggested to us with respect to looking at the magnitude of the uncertainties and focusing on those that are significant, they are going to be very helpful.

VICE CHAIRMAN RYAN: Thank you, Dr. Eckerman.

Dr. Kocher? Okay. Nothing yet.

John Till? Dr. Till? No.

DR. TILL: No.

VICE CHAIRMAN RYAN: No, sir? No? Dr. Thorne?

DR. THORNE: I think just to pick up from one or two of Keith's points, I think there is an interesting question that you've raised, which is this business of doses to infants and children.

I think perhaps a useful discussion is the distinction between compliance calculations that are relevant directly to the rule, and supplementary calculations, which I think the question of infants is, to inform members of the public about what the issues are and how the uncertainties and distinctions arise.

And I think in some ways the question of Iodine-129 comes into the same framework. It's an issue that we looked at in the British program for the Nyrex repository, where we asked exactly the same question about sources of iodine in the environment and the fact that salt intakes were typically of the order of 50 percent of total intakes, and, therefore, application of a specific activity model in the simple sense overestimated. But the degree of conservatism was of that order of factor, too.

I think there are some other questions that one should ask about whether it's proper to make

comparisons between the radionuclide content expressed on a mass basis and the stated content on a mass basis. I think that has the potential to confuse rather than to eliminate, if you are talking dose and risk terms. But we -- so we have -- it's a useful comparison, but it has to be used fairly carefully I think.

VICE CHAIRMAN RYAN: Any other opening comments?

Dr. Moeller, are you ready to go?

Okay. If we could turn our attention for our first presentation, please. Our first speaker is Dr. Keith Compton, who will talk about the introduction of biosphere dose assessments, the framework and process for the U.S. Nuclear Regulatory Commission staff review of a potential Yucca Mountain license application.

Dr. Compton is with the System Performance -- he's a Systems Performance Analyst in the Division of Waste Management, and he is moving quickly to the podium.

DR. COMPTON: If you don't mind, I'll ask to stand while I make my presentation.

VICE CHAIRMAN RYAN: Sure.

DR. COMPTON: All right. I'd like to

introduce myself. Again, my name is Keith Compton. I'm a research addition to the Performance Assessment Section. I started in September. And I have spent the last five years in Austria at the International Institute for Applied Systems Analysis doing a variety of risk analyses. I am very happy to be here at an interesting time for performance assessment.

Today I would like to review the regulatory requirements for dose assessment that are laid out in Part 63 of the rule. And after I review those requirements I would like to discuss the review process that is laid out in guidance contained in a document called the Yucca Mountain Review Plan.

Now, I would like to acknowledge at this point that the committee has far more expertise and knowledge of this than I do. I'm probably not going to tell you much that you don't already know.

However, it would be useful at this point to start with a discussion of the requirements in the regulation to provide a background for the ensuing discussions that we will have over the next few days, and also to ensure that there is at least some basic level, a common level, of understanding for members and participants who were not part of development of the rule or of the Yucca Mountain Review Plan.

The first part of my talk will be to provide the regulatory framework. These are contained in Part 63.

The second objective of my talk is to, again, as I mentioned, to discuss how the NRC staff will ensure that those requirements are met. And, again, those are -- the guidance for those is largely in the Yucca Mountain Review Plan.

One thing that I want to emphasize at the beginning is that the objective of my talk is only to describe the regulatory framework and the requirements. I will not be going into the underlying rationale or basis for the rules in this talk.

Next slide.

I'll cover the regulatory framework in the first three bulleted items. The first thing that I would like to talk to are some overarching concepts that connects the area of dose assessments to the larger process of reviewing the license application.

Next I simply want to provide a reminder of what the quantitative performance objectives are.

Third, I want to discuss the nature and scope of information that must be submitted by the Department of Energy. And particularly I'm going to focus on identifying the elements that are specified

by the rule.

The fourth part of my talk is a discussion of our review process.

And then, finally, of course, I'll close with a summary of what I've said.

The first concept that I would like to ask the participants to keep in mind is that the regulatory process is a multi-step process that anticipates the development of new information. It's an iterative process, and there will be opportunities to incorporate new and evolving information into regulatory decisionmaking prior to permanent closure of the repository.

Next slide.

The license application will require a safety analysis report. A key aspect or a key element of the safety analysis report is a quantitative performance assessment, and two of the major elements or attributes of the post-closure performance assessments are identification of barriers and a quantitative estimation of the performance of the repository.

Today I am only going to focus on the second of those two, the quantitative estimation of performance. And I would like to acknowledge that the

quantitative performance assessment is only one of several elements that are required as part of the license application.

The final general concept that I would like to bring to your attention is that of reasonable expectation. And this concept acknowledges that absolute proof of compliance is not possible in light of the large uncertainties associated with making long-term projections.

Of particular importance to biosphere dose assessments are the very large uncertainties associated with future human behavior. And because of those uncertainties, the National Academy of Sciences recommended in their technical basis for Yucca Mountain standards that certain aspects of the performance analysis -- of the performance assessments be specified in a rulemaking process. And, again, it's those aspects that I'm going to bring up and identify.

Just a reminder as to what the quantitative performance objectives are. There are three in the rule. The first is an individual protection standard. The exact words are contained in the backup slides. I'm not going to read the definitions. I'm going to -- to summarize those.

First, there is an individual protection standard, which is 15 millirems per year. It's an all-pathways dose from an undisturbed repository. There is a quantitative performance objective for the human intrusion scenario. That is also a 15 millirem dose from all pathways, but it is resulting from a stylized intrusion scenario.

And, finally, there are separate standards for the protection of groundwater. Those specify concentration limits for alpha-emitting radionuclides. There is a dose standard associated with beta- and photon-emitting radionuclides of a four millirem organ dose.

Turning to how dose assessment fits into the overall quantitative performance assessments, this slide illustrates the concepts of dose assessment as a process that combines the characteristics of the reasonably maximally exposed individual. In the future, I may refer to that as the RMEI, because it's difficult for me to say that phrase too frequently. So if I mention RMEI, then that's what I'm referring to.

It combines the characteristics of the RMEI and the characteristics of the biosphere with the environmental concentrations that are the result of

the preceding performance assessment calculations and uses those to compute a dose to the reasonably maximally exposed individual, and that computed dose is then compared to the quantitative performance objectives in order to make a judgment of whether compliance can be demonstrated.

Now, as I mentioned, there are two major aspects to dose assessment. It is identifying the characteristics of the RMEI and the characteristics of the biosphere. In the rule, the characteristics of the reasonably maximally exposed individual are specified on the slide.

Some things that I'd like to draw your attention to is that the location of the RMEI is specified in the rule. The diet and lifestyle are specified to be typical of the current inhabitants of Amargosa Valley. The average concentrations in well water used to determine doses are based on reasonable estimate of water demand, and, finally, as has been mentioned, the RMEI is specified to be an adult.

DR. MOELLER: Excuse me. Can we --

VICE CHAIRMAN RYAN: Sure.

DR. MOELLER: In your bullet there on the previous slide that has the diet and the lifestyle representative of the current population of Amargosa

Valley, as I recall it says resident of the town of Amargosa Valley. And I'm nitpicking, but to me there is a difference in the two.

DR. COMPTON: Yes, sir, I believe that's correct. Thank you.

My next slide -- the other major aspects of the performance assessments -- or the dose assessments is to apply characteristics of the biosphere. And again, as mentioned, the factors that are associated with human behavior are inherently difficult to predict due to the lack of a long-term historical record, the lack of a scientific basis for predicting those characteristics far into the future.

And, therefore, those are fixed by rule to be constants and consistent with conditions at the time of the license application. On the other hand, the factors associated with the physical environments can be estimated in a scientific way on the basis of a long-term record. And those, therefore, must be varied in a cautious way and must be defended on their technical basis, on their scientific basis.

Now, finally, I'll discuss the requirements of the performance assessment that must be included in the safety analysis report. In the rule, DOE is required to provide the technical basis

for their choice of the scenarios to be analyzed and the models used to analyze them. They must account for uncertainties, and they must consider alternative conceptual models.

Of particular importance, again, to biosphere is that these analyses are limited in important areas by the regulation in Part 63.

Now, the guidance as to whether these requirements are met are laid out in the Yucca Mountain Review Plan, which is -- next slide, please -- which I will turn to. This brings us to the process by which the NRC staff will review the information that has been submitted as discussed in the previous slides.

I want to point out on this slide that the Yucca Mountain Review Plan and the use of risk insights is a complementary approach. The Yucca Mountain Review Plan provides guidance on the subject matter and the review process for staff review of a potential license application. The risk insights are used, on the other hand, to determine the depth of the review of the information provided and will also guide the NRC staff in developing requests for additional information, if those are determined to be necessary.

I'd like to remind members of the panel

that Tim McCartin has recently discussed the role and use of risk insights and technical exchange on the level of design detail. And, furthermore, Patrick LaPlante is going to be providing a discussion or an example of the use of risk insights in agreement resolution in a prelicensing phase.

Within the Yucca Mountain review plan, there are sections that describe how to review the important model abstractions, and the biosphere dose assessment is one of the important model abstractions.

The areas that we will review are listed on the slide, and they include, for example, a review of DOE's description of the Yucca Mountain sites and their description of the reasonably maximally exposed individual and the reference biosphere.

We will look at how well features, events, and processes that affects the potential for compliance have been characterized, and the extent to which those affect waste isolation. We will look at an evaluation of the uncertainty in both -- both data uncertainty and model uncertainty. And we will analyze the extent to which the analyses provided by the Department of Energy has been supported by objective comparisons.

The review methods that are in the Yucca

Mountain Review Plan are -- have been developed in order to provide a detailed review of the license application, if that should be necessary. The acceptance criteria in the review plan are based on meeting requirements for performance assessment and the extent to which the analysis complies with the requirements that are laid out in the rule.

There are many specific detailed questions that are laid out in the review methods. I'm not going to go through the several-page list of those questions in detail. I've tried to pick out some typical types of questions that are asked in the Yucca Mountain Review Plan. And the determination of -- or the acceptance criteria essentially consists in making determination that these questions can be answered affirmatively.

And a few examples under -- going back to the areas that I had discussed in the previous slide, under system description, with respect to consistency we would verify that the reference biosphere is consistent with arid or semi-arid conditions. For model integration, an example is to ensure that the physical and chemical properties of radionuclides are consistent with assumptions in the other abstractions.

For data justification, parameter values,

such as the plant uptake factors or mass loading, are consistent with the site characterization and are technically defensible. On the other hand, behavioral parameters of the RMEI should be consistent with the definition in the regulations. That is, that they should be based on present knowledge of the RMEI behavior.

For data uncertainty, an example of something that we would look for is that correlations between infant values have been appropriately established in the total system performance assessments. An example on model uncertainty is they should provide evidence that they have considered alternative models -- for example, models of soil resuspension.

And, finally, an example for model support is that we should look at -- to whether the results from DOE's performance assessments have been compared and are supported by alternative modeling codes, such as GENII.

This brings me to the end of my talk. Again, I have tried to in the talk point out that many of the characteristics of the reasonably maximally exposed individual and the reference biosphere that are used in the dose assessment are specified by the

regulation, and, furthermore, that the Yucca Mountain Review Plan, together with risk insights developed by the staff, will guide NRC review of the DOE's biosphere attraction.

And that's the end of my presentation. If anyone has any questions, I'd be happy to answer them.

VICE CHAIRMAN RYAN: That's great. I think what I'd like to do is just to kind of get our order. We've got the panel here, and what I would ask is that the panel first express their views or questions, and so forth, and then we'll ask members of the ACNW to have questions and comment as well.

So I'll turn the first part over to you, Dade, to --

DR. MOELLER: Okay. John? John Till?

DR. TILL: Just two clarification questions, because I have other things to talk about tomorrow. One, Keith, is since you are taking a probabilistic approach to estimating the dose to the RMEI -- in other words, you're going to come up with a distribution of possible doses to that individual, correct?

DR. COMPTON: That's correct.

DR. TILL: Okay. Does the standard specify where on that curve you make the comparison to

the .15 millisievert?

DR. COMPTON: Yes, sir. That's in the -- in DOE's performance assessments, it is specified that the value should be the mean value, the expected value of that dose curve. However, it's the peak within a 10,000-year period. So at each time period within the compliance, you estimate the average or the expected dose, and then it's the highest of those that will be used to determine --

DR. TILL: Okay.

DR. COMPTON: -- to compare.

DR. TILL: Okay. The other question is -- and this goes back to the issue of adult that you raised earlier, Dade. Are these the standards that were mandated by EPA? In other words, is this the way the standard came from EPA, that it was an adult?

DR. COMPTON: I believe that's correct. I'd like to -- because I've only been here a short time, I'd like to make sure that I don't misspeak and ask Tim, maybe to --

DR. McCARTIN: Actually, we're the ones that put the adult in Part 63. The EPA standard did not specify --

DR. TILL: Okay.

DR. McCARTIN: -- in adults. It was done

in our statements of consideration. We believe the dose limit is predicated on a lifetime risk, limiting the lifetime risk and that -- that limit is protective of all individuals and the environment.

DR. TILL: We'll come back and discuss it. Actually, I agree with that, but that was a surprise to me.

DR. MOELLER: Well, thank you. Any other questions? Dr. Kocher?

DR. KOCHER: I'd like to hear a little bit more about the definition of the reference biosphere, because in Part 63 it seemed like the definition was pretty skimpy.

DR. COMPTON: Well --

DR. KOCHER: Maybe ask the question a different way. What elements of the reference biosphere have you defined in regulations?

DR. COMPTON: Well the reference biosphere is -- are -- is defined largely as I presented it. There are not specific elements of that that are defined in the regulation. It essentially says that certain parameters should be related to human factors, should be held constant and consistent with the time of license application, and that the factors related to the physical environment should be varied. There

is -- in the rule there is not much more specification in the regulation.

DR. KOCHER: So absent humans, really, the only specification of the biosphere in the regulation is the semi-arid/arid conditions?

VICE CHAIRMAN RYAN: I think if you put up slide 9, that might help.

DR. KOCHER: Or I guess there may be something in there about, you know, assuming the kind of biota and soils that you have at the present time, something like that.

DR. COMPTON: I believe that's correct. For the physical environment, that would be consistent with the sites and consistent with what is -- I'm sorry. Yes. The factors that are related, for example, to the flora and fauna should be consistent with the current knowledge. Factors such as climate can be very cautiously but reasonably -- I don't know if that answers your question.

DR. KOCHER: Well, I assume you want to give the license applicant some leeway here and not -- unless -- I mean, one thing we can discuss during the two days is, you know, to what extent do you really want a stylized calculation here for everything. That's a possibility.

DR. COMPTON: Well, the reference biosphere is not intended particularly for the physical environment to generate a stylized calculation. It's like any license application review. It would -- they would have to defend it. They would have to provide their description of the biosphere.

They have to come in and describe -- and present their characterization, and then the staff would review that and determine whether they were technically justified. And that's, in contrast, a more stylized calculation that cannot be defended or justified on the basis that it's generic.

I think this also may be an area where risk insights would be used to -- aspects that were important to dose would need to be fairly solidly justified. For example, the use of national kind of generic data on rainfall or infiltration would not be appropriate. You would need to get more site-specific data.

But many of that -- much of that will -- would determine as to what -- what the Department of Energy submitted and that would be reviewed based on our knowledge of the sites and our use of risk insights to determine whether that was an adequate

characterization.

VICE CHAIRMAN RYAN: Keith, I think -- I appreciate your -- Dave, I mean. Excuse me. Dave, I appreciate your question. If you do look at slide 9, I think there's two parts to your question. The first is what we just talked about, which I think Dr. Compton has told us about, but also to me this is the stylized part, where the water use and what develops the concentration then is assessed, and the environment is also kind of a second part to that question.

So I guess let's keep your question in mind, because I think as we hear information over the two days we'll probably revisit that from time to time. That's a good start.

Yes, Dr. Thorne.

DR. THORNE: Could I just come back to this? Because I think the concept of reference biosphere has a long history in some international discussions in biomass. And I was partly responsible for this, so I can talk to this briefly.

The idea originally, I think, was that reference biospheres would be very much like reference man. There was a well-defined, highly-specified entity.

And I think there are some people in the international community who believed in a one size fits all biosphere, that we would simply plug this in as a measuring instrument in the back of an assessment, and it would turn all of these radionuclide fluxes into a dose. And that's what you'd compare with compliance standards.

I think it was fairly rapidly realized that one size didn't fit all, and that, therefore, what came out of biomass was very much a methodology that the applicant would use to define a reference biosphere for their particular assessment and their particular context.

And I think that's what we're seeing here, that there are high-level rules given here for identifying the reference biosphere, but it is not prescribed in detail. It's for the applicant to work through their methodology and for the reference biosphere to emerge from that to then be suitably audited and reviewed.

VICE CHAIRMAN RYAN: Thank you.

Tim?

DR. McCARTIN: Tim McCartin. Actually, I couldn't have said it better than Dr. Thorne. And that really was the intent of the rule. And as Keith

pointed out, the one direction very strongly from the National Academy of Sciences that -- in terms of speculation of human behavior, etcetera, in the portion of the reference biosphere, that -- when we described it, that's what we were trying to eliminate, as Dr. Kocher said, absent humans. And so fix it on what people are doing there today and do not speculate on what might happen in the future with humans, because it's kind of an endless possibility.

DR. MOELLER: I'd like to pick up on Dr. Till's comment about the adult. I, too, was intrigued that it was not in EPA's standards as far as I could tell. And I'm pleased to hear that the NRC -- that that's the source of the word for the adult.

That raises another question in my mind. When I first was asked to come here today, I, of course, read the regulations, and so forth, and tried to learn as much as I could to prepare for the meeting. And the first conclusion -- or first assumption I made was that the USNRC is licensing this repository, and I believe I'm -- you know, they're either to license it or not. They're reviewing the application.

Well, that being the case, then the NRC has Title 10, Part 20, which I read it and it says it

applies to all USNRC licensees. Well, so I did some dose estimations using Title 10, Part 20, and I was pleased to see that it had special considerations of infants and children, and so forth.

And then, I don't remember where I heard it, but I suddenly was told, "Well, no, we're not going to use Part 20. We're using Federal Guidance Report Number 11." Well, I thought, well, now, I wonder why, and I began to realize that one justification at least was that it's for an adult, and RMEI is an adult. So that makes sense.

But, and it has also been approved by the President, and I'm sure many others can tell me a lot more about it. But then I wondered, well, in terms of best science, I wonder what Federal Guidance Report 13 says in terms of dose estimates. In other words, if there's flexibility in what dose coefficients we use, then I want to know what the doses are using any type of guidance.

I even went back and did the calculations for Handbook 69, because the drinking water standards say that Handbook 69 shall be used. Well, when they've moved the drinking water standards and applied them to the groundwater standards I thought, well, they moved the whole thing. Well, apparently not.

Let me close by commenting -- when I looked at Federal Guidance Report Number 13 applied to dose coefficients, and we're talking today and tomorrow about technetium, iodine, neptunium, plutonium, and americium, well, if I look at those last three alpha emitters, the doses in Federal Guidance 13 are a factor of 10 -- four to 10 less than those in FGR 11.

Well, that's pretty important, at least it seems to me. Is there anyone who wants to -- John, please.

DR. TILL: Well, I assume we don't want to get on a discussion of that right now. I understand the philosophy of using the adult for prospective calculations. And the bottom line is we are making -- we are setting a standard based on a lifetime exposure, and I think -- well, we really mess ourself up with this by not making it clear why.

It's based on lifetime risk. Am I right? And, therefore, it ought to be an adult in my view. So I think the problem, Dade, is not with the -- with the philosophical basis. I think the problem is the way the standards are written. I think we've gotten ourself in a mess with that. We'll come back to it and maybe talk about it some more.

VICE CHAIRMAN RYAN: Yes. I think we have some spots on the agenda, particularly later today, where Dr. Eckerman is going to lead us through these various dose calculation sets. I think the general point that strikes me is that dose conversion factors are not necessarily in an absolute vacuum. They're done for a purpose, and they're done under a particular scenario, and keeping that straight is important.

You know, for example, ICRP 30 is limits of intakes of radionuclides by workers. And we forget that "by workers" has some very specific implications of how things are calculated and how things are estimated, because it's in that context. So hopefully we'll elucidate some of those details as we go through the next couple of days.

But I think whether it's -- it's the dose conversion factors or other aspects of either the specific data that we'll hear about a little bit from DOE, or whether it's the evaluation tools, we have to keep in mind some of the things that you just mentioned, John, and other information, and hopefully we can sort through that over the next couple of days.

Dr. Thorne.

DR. THORNE: Perhaps one more general

point to lay down. Reasonably maximally exposed individual -- and I lay a little stress on the last word, because when I look at the calculations that are done in characteristics of the receptor, I see four population groups picked out from the Amargosa Valley population, and then I see the results calculated as an average over those groups. And I think I'd like to explore at some point whether we have genuinely got an individual related standard here or a population average related standard.

VICE CHAIRMAN RYAN: Thank you.

Any other questions from panel members? Yes, Tim.

DR. McCARTIN: Just one quick comment on that. Tim McCartin, NRC staff. I forgot to introduce myself for the reporter before.

The rule does say -- and EPA specified this -- that the RMEI is a hypothetical person. So, and that's why, you know, it's not an individual. It's a hypothetical person with these average characteristics.

VICE CHAIRMAN RYAN: Thank you.

Questions from -- comments from committee members? Dr. Garrick?

CHAIRMAN GARRICK: I'd just make a

comment. I was very pleased to hear Dade Moeller put as much emphasis as he did on understanding as best we can the uncertainties, because this committee has been accused of being obsessed with uncertainty. And it's nice to have an outsider come in and make a similar comment.

The one thing that I think we really would like to learn from this exercise the next couple of days is get some insights on the relative contribution to uncertainty of the uptake calculation itself in the biosphere. This committee has heard a large number of presentations on uncertainties associated with the movement of the material out of the waste package and into the biosphere. And there has been a tremendous amount of information discussed, presented, and challenged in that area.

What we're really hungry for is much better insight with respect to the health effects model, which hasn't been in the spotlight very much in the course of the discussions over the last couple or three years. So I'm hopeful that one bottom line that we get out of this is some sense of what the relative contribution is.

When we see, finally, a bottom line calculation of a distribution of maximum averages of

the dose, that we have some sense of how much of that uncertainty distribution is coming from two major components -- namely, the health effects model on the one hand and the transport of material on the other hand.

VICE CHAIRMAN RYAN: George?

MEMBER HORNBERGER: Just one quick comment, again, following up on what John said. It also -- I think that we probably all agree, but just for the record, it strikes me that if a calculated dose is one millirem per year, a factor of 100 uncertainty could be important. If a calculated dose is 10^{-10} millirem per year, a factor of 100 uncertainty may not be of much importance.

MEMBER WEINER: I just have one very simple question. What's the difference between cautious and conservative?

DR. COMPTON: I am going to try and defer that to McCartin, to make sure that I don't mislead you.

DR. McCARTIN: I don't think that's a simple question, really. But anyway, I don't see much distinction between the two words.

MEMBER WEINER: Well, then --

DR. McCARTIN: I mean, I would have to

have a particular context or something more I guess to draw a distinction between cautious and conservative. In a public meeting, I would say for the general public it's -- they mean the same.

MEMBER WEINER: Well, then, I'd hark us back to what the Chairman said and what Dr. Moeller reiterated, that we need to look at realism -- realistic scenarios rather than conservative ones. And I was just hoping that we were not simply using cautious as a synonym for conservative. But I guess we are.

DR. McCARTIN: Well, without more context, to me the words are very similar.

MEMBER WEINER: Okay.

DR. COMPTON: I will just add that this is somewhat discussed and possibly addressed in the concept of reasonable expectation, which -- in which it's required to focus performance assessments on the full range of defensible and reasonable parameter values. So I would just offer that as something to think about.

VICE CHAIRMAN RYAN: Dr. Clarke?

MEMBER CLARKE: Just one quick question to clarify my own understanding. Your first backup slide that you didn't show speaks to the requirement to

calculate a peak dose after the compliance period.

DR. COMPTON: Yes.

MEMBER CLARKE: There is no corresponding standard for that dose. Is that correct?

DR. COMPTON: On the -- are you saying the second bullet?

MEMBER CLARKE: Yes.

DR. COMPTON: No. This is -- if the -- this goes to the question of when the peak dose occurs. If the peak dose occurs after the 10,000-year compliance period, it must be calculated, but there is not -- as you point out, there is not a compliance standard associated beyond the 10,000-year compliance period.

VICE CHAIRMAN RYAN: Thank you.

Any other questions? Yes, Dave.

DR. KOCHER: This is not 100 percent related to what we're about, but I do think there is potentially some confusion about what the groundwater protection standards really are. The standard for beta-gamma emitters is not four millirem to whole body or any organ. The standard is the MCLs that the EPA published back in 1976 or '77.

The four millirem is a shorthand so that you can get the standard into a single table. But

you're not -- you don't have the leeway, for example, to choose a different set of metabolic models to calculate a concentration in water. The standard is the MCLs, and the reason they did that is because the operator of a municipal water system has to be able to judge compliance. And he can't sit there with his ICRP dose calculator. He measures radioactivity in water.

VICE CHAIRMAN RYAN: Dave, you used the term that four millirem is a shorthand. Would you tell everybody what that means, please?

DR. KOCHER: Well, as Dade pointed out, the rule says that the standard for beta-gamma emitters is a certain dose, and it's four millirem to whole body or any organ. But that same statement prescribes how you shall go from that dose standard to a concentration in water.

You shall assume two liters per day intake of water, and you shall assume those coefficients from NBS Handbook 69, which is ICRP 2 vintage. And so the real standard, the real operational standard, is the MCLs that are so calculated.

VICE CHAIRMAN RYAN: You know, I think that's -- that's really an important point, because that gets back to what Dr. Thorne talked about I think

earlier is that -- that's a prescribed calculation or a prescribed value compliance demonstration. But that may or may not reflect the 40 years of metabolic model improvements from that point forward.

So I think it's helpful to point that out as we go along. And, again, I'm sure Dr. Eckerman is going to address that. But before he does, let me go back behind you to Tim McCartin.

DR. McCARTIN: Tim McCartin, NRC staff. I guess the question I would have, is there a reference in the regulation that you're referring to in drawing this reference to MCLs? Right now there is no reference to MCLs. The regulation states --

DR. KOCHER: Yes. This is complicated.

DR. McCARTIN: -- four millirem.

DR. KOCHER: This is complicated.

DR. McCARTIN: Is there a reference you have in mind?

DR. KOCHER: The standard prescribes how you shall use that number. I mean, I didn't bring Part 141 with me, obviously. You need to read the --

DR. McCARTIN: It's Part 197 for Yucca Mountain.

DR. KOCHER: Well, be careful. We're going to get off in the weeds here if we're not

careful.

DR. McCARTIN: Okay.

DR. KOCHER: The standard is MCLs. I mean, you're stuck with one picocurie per liter for Iodine-129 whether you like it or not.

VICE CHAIRMAN RYAN: I've got a good idea. Let's do a little homework and we'll visit this sometime within a couple of days. How's that?

But I think this is an interesting point, and it -- to me the theme of the point is that we need to be real clear about, you know, what's a reference calculation for the purpose of compliance demonstration and what's a metabolic model that may reflect the science of the metabolic model, and kind of sort that out. So let's agree to come back to that question.

Any other questions or comments? We are at a point -- thank you, Dr. Compton. Appreciate it very much.

We, on our agenda, are scheduled for a break, and I think we'll probably just do that early, Mr. Chairman.

CHAIRMAN GARRICK: Sure.

VICE CHAIRMAN RYAN: And we're scheduled for a 20-minute break, so why don't we come back at,

say, 9:45 and pick up from there.

Thank you.

(Whereupon, the proceedings in the foregoing matter went off the record at 9:21 a.m. and went back on the record at 9:47 a.m.)

VICE CHAIRMAN RYAN: On the record. If we could come to order please. We are now scheduled for presentations by representatives from the U.S. Department of Energy and the Department's overall approach to conducting dose assessments called for the NRC's site specific regulation for Yucca Mountain. We will have two speakers. First, it will be Dr. Peter Swift of The Sandia National Laboratory who's Manager for Performance, Assessment Strategy and Scope for Bechtel SAIC followed by Dr. Kurt Rautenstauch who is a Senior Environmental Specialist. So let me turn it over to you, Dr. Swift.

DR. SWIFT: Thank you.

VICE CHAIRMAN RYAN: Just before you begin, I might add if I could ask everybody in the audience. There are two sign-up sheets behind the pillar here and if you would sign in please, we'd appreciate it. Thank you very much.

DR. SWIFT: Is the microphone working?

Not working now. Thank you. Well, I'm Peter Swift and my role here is as the manager of the group that does the total system performance assessment. I'm going to give you a very short overview that I hope will put the rest of the presentation in the DOE in context.

For many of you, this will be a review of material. Some of you heard me present it before, but for some, in particular I think we have some of our panel members, this is going to be a very short trip through a whole of material that we're not covering in this workshop. Then I'll turn it over to Kurt Rautenstrauch and Maryla Wasiolek to actually talk about biosphere stuff.

Just by way of background of myself, I'm a geologist. If you want to ask of me, be aware that's the direction which I come. I've worked in performance assessment for 15 years now. The next slide please.

A very quick review coming up here of the current status of the total system performance assessment, a summary of the methodology and then a little bit about the role of the biosphere model and those conversion factors that we'll hear more about, how the conversion factors play into the total system

performance assessment. Thank you.

A little disclaimer here. This is important. Anything that I present that comes from the total system performance assessment is old news. It comes from existing and publicly available TSPA analyses. I apologize for using the abbreviation TSPA, but there it is. There they are back in December of 2000. There was a total system performance assessment done to support the site recommendation. It was updated in the summer of 2001 and again in the fall of 2001. All three of those form the basis for the DOE's site recommendation.

Then there was further analyses done in the year 2002 which had been reported to this group and elsewhere. There should at the back of this handout be a list of references that give you the proper citations for all those.

I'm not going to show any results from the models that are currently under development and I'll be pretty limited in how I field questions on those. Those models are still under development right now and we do not have results ready to present yet. Next slide. Thank you.

Just a quick review here of what is the total system performance assessment process what we're

doing here. Working down these steps here, first we start off by screening features, events and processes. You hear the acronym, FEP, to describe those things. Features, events and processes all those are potentially relevant to the future performance of the site. It is in a sense perhaps a philosophically unbounded list of things. This step is done to determine those that must be retained in a quantitative performance assessment. It's an attempt to put some useful bounds on the speculative list of everything that might happen. What are those things that really matter? There are rules on how to do that screening which are outside the scope of this meeting probably, but it's done.

Develop models along with our scientific basis for each process that was retained and included. That phrase along with their scientific basis is of course where a wealth of scientific research is done. But from my perspective in the total system performance assessment, years of scientific research produce a model which then goes into the analysis. Obviously there are many other reasons to do the scientific research, but that's how they enter into the TSPA.

Identify uncertainty in those models and

parameters. Build the integrated model with all the retained processes. And then we calculate performance for three different major scenario types: a nominal scenario class that contains all the features, events and processes that are likely to occur that's essentially certain to occur; a disruptive event scenario class or classes containing the low probability events, the volcanic disruption, extreme seismic disruption of the site, those we build separate modelings for those and we model their consequences separately.

This workshop does not address volcanism or seismic disruption. That's an important point to note. We're limited here to the performance of the site taking into account those processes and events and features that are likely to occur. There's also the stylized human intrusion model which again is outside the scope of this workshop, but is required in regulation and deem we do it.

After the models are built for these scenario classes, we evaluate total system performance against the three standards, individual protection, ground protection, human intrusion. We evaluate uncertainty in our results from Monte Carlo simulation. The model here is a series of linked

computation codes that can be run, a deterministic mode, each set of input values versus a single output result. But if you run it in a Monte Carlo technique with multiple sample inputs, you get multiple outputs resulting from the uncertainty in those inputs.

And there's a consequences calculator for each of these scenarios are weighted by the probability of that scenario occurring and they are combined. That probability weighting's important with respect to - it's specified in the rule - volcanism and seismic disruption because those are very low probability events. So larger consequences of those events get weighted by that smaller probability and combine with this nominal scenario which has essentially a probability of one of occurring. Next slide please.

A quick review of what is in the nominal performance scenario class. It's just a schematic of what the mountain might look like. There's a huge misrepresentation to scale here. That's 18 kilometers from here to there and only several thousand feet from there to there. All right.

The repository is in unsaturated zone of rock here well above the water table. The water table is shown down here at the bottom. Precipitation that

falls on top of the mountain infiltrates through the surface soil into the rock. It percolates downward through the rock in unsaturated zone flow. The water is moving in fractures. Some of it remains trapped in pores. Some of it moves on down through fractures. In general the rock appears to be dry though with relative small amounts of moisture moving through it. Some of that water will reach the repository and will under the drifts result in corrosion of the packages, may result in holes in the packages which would allow radionuclides to be dissolved or transported by as colloids in that water. That water can then carry them on down to the water table where they could be moved out through flowing groundwater, saturated zone flow to the hypothetical withdrawal well where they would enter the biosphere. Next slide please.

This and the next slide are in here mostly just to give a sense of the level of detail in the entire systems model. If one were to start here, this just sort of tracks the components I went through visually on the previous slide. It tracks them through unsaturated zone flow, engineered barrier performance and so on. Eventually each of the components is modeled separately and you come out here at the far end with a biosphere model and a dose

calculation.

In our modeling system, there is actually a computational model with equations that are solved and put parameters and outputs for each one of the things that are listed here. And each one of those could be and has been subject of extensive discussion with the NRC staff because this is the 22nd version of this slide. Next please.

For those who wanted to see how the computation models are actually linked together, note that this is out of date. It's from the site recommendations. It's a four year old slide, but I don't have a current version of it yet. We haven't quite finished all those linkages. Each one of these circles represents a computer code.

At the time the slide was made, if you could read the fine print on it and see what all those things are on the arrows connecting them, those were accurate for the hand-offs between codes as of the time that slide was made. So each one of these models was run, feeds something to another model. As I say, this is now out of date.

One thing worth noting however on this slide, the GENI Code used until last year is not what is now used for the biosphere. However it still

occupies that same location in linkage of the modeling system. The biosphere code calculates those conversion factors completely independently of all the rest of this stuff and it comes in as a feeder right at the end. All the rest of these models basically calculate radionuclide concentrations around the water to which the biosphere model was then applied in a sense as a post processor to the whole thing.

MEMBER HORNBERGER: Peter, I assume when you say this slide is out of date that it doesn't mean that the whole thing has to be scraped, but rather than you've made some fine tuning.

DR. SWIFT: Yes, thank you. That will do fine. The tuning is fine in some places and a little coarser in others, but yes, models will change. You'll find most of the computer code names are the same in most of the locations. In fact, they may all be the same except for the biosphere. But the linkages are a little different. Some of the hand-offs are different. Next slide please.

There are two pieces of those components on the previous slide or the previous two slides that I want to talk about just briefly because they are important to this group. One of them is the saturated zone groundwater flow path analysis. And this is a

false color satellite image of the Decca Mountain region. The repository is here. The blue lines here are the calculated groundwater flow paths from the site recommendation in the year 2001. They have not changed significantly on that.

Things to see on this slide right off, the red colors, you see them up here and down here, actually are the measurement of moisture in this false color image. They are vegetation. So up here, we're seeing vegetation in the relatively higher country. Down here these circles are irrigated fields in the Amargosa Valley. Other red dots in here are not vegetation. Those are test well locations.

Something else to see on this slide while we have it up here, those with good eyes can just make out Highway 95 coming along like this. The location of the reasonably maximally exposed individual, the RMEI, is 18 kilometers south of the site over the center of this plume. It turns out to be just north of the highway, right about in there somewhere. I think for those with really good eyes you might even be able on a better print of this pick out the satellite image of the defense line that marks the test site boundary in there. So that the RMEI would be right about in there somewhere.

So the dose assessment we're talking about here today is based on assumption that, this second bullet here, the annual dose is based on the total mass flux of radionuclides at 18 kilometers basically crossing a fence in the model right there. All of the mass flux radionuclides mixed in 3,000 acre feet of groundwater. That approach to taking all of the radionuclides and mixing them in groundwater is a bit of a simplification, but it's based on the observation that the draw-down from well or wells pumping at that rate would span the entire width of this plume. Therefore rather than trying to worry about the details of what radionuclides are capture by what well or what draw-out.

CHAIRMAN GARRICK: Peter, do you have any sense of what the impact of that assumption is in terms of conservatism or realism?

DR. SWIFT: The 3,000 acre feet or the assumption that --

CHAIRMAN GARRICK: No, the assumption that the radionuclides are all in the 3,000 acre feet.

DR. SWIFT: Yes, a few points on that. One is that if we actually had wells pumping at 3,000 acre feet per year at that location, they probably would get almost all the radionuclides. The other

point is that there is data available on water pumping in Amargosa Valley down here and the range of pumping is inconsistent with that. At the time of the site recommendation, the project actually sampled on a range of water pumping rates which varies slightly smaller than that, I think. The NRC may, Tim McCartin, may have a better answer on that than I do. Sorry to put you on the spot, Tim. Do you want to field it? Sorry, Tim.

DR. McCARTIN: Well, Tim McCartin. Going with memory, generally there's been a range of pumping rates in the Amargosa Valley area and I think it goes up potentially as high as 13,000 acre feet depending on the year. It is variable. I think at least at SR you guys use the mean value of 2,000 acre feet.

DR. SWIFT: It's 2,000 and something.

DR. McCARTIN: But the actual pumping rates in the valley further south there have been as high as 10 to 13 thousand acre feet, I believe.

CHAIRMAN GARRICK: Yes. The point of my question is two issues here. One is the 3,000 acre feet itself and how representative that is and then the other would be the radionuclides that enter that region are all assumed to be in solution so to speak.

DR. McCARTIN: Tim McCartin again. I

guess when EPA specified 3,000 acre feet for the drinking water standard they used the irrigation of two average alfalfa farms and a population use of 100 people I believe on that order.

CHAIRMAN GARRICK: I see.

DR. McCARTIN: So that's how they got to the 3,000 approximately.

CHAIRMAN GARRICK: Thank you.

DR. SWIFT: So just to finish on this slide here, the biosphere dose conversion factors down here that Kurt and Maryla will be talking about are applied directly to the concentrations of radionuclides in groundwater. Those concentrations are as shown here. They are simply all the mass in a given year or time step crossing that boundary mixed in 3,000 acre feet. That's all on this one. Next slide please.

VICE CHAIRMAN RYAN: Before you leave that one.

DR. SWIFT: Yes, sir.

VICE CHAIRMAN RYAN: I want a follow up question. When I think about intakes which lead to dose, I think about concentration. So the real action to me is what's the concentration that this results in and is that concentration going to be representative

of a rate withdrawal concentration year by year?

DR. SWIFT: Well --

VICE CHAIRMAN RYAN: I'm not sure you can answer the question, but I think the focus to me on certainty is what's the concentration and how does that concentration vary as it's withdrawn and used?

DR. SWIFT: Right.

VICE CHAIRMAN RYAN: It's not so much the amount of water or the use of the water but it's the combination of the two things. Dr. Garrick asked about did you capture all the radioactive material in that volume and then what concentration develops of that in a time dependent way?

DR. SWIFT: The 3,000 acre feet is one of the stylized assumption. We had assumptions made in stylizing the calculation to make it consistent or comparable from one point to the next. But in a real groundwater plume, there will be places where concentrations are higher or lower than some very large regional average. So the question then would be is the 3,000 acre feet - again we're talking about the regulation here - an appropriate way to take a local average rather than in the worst case would be to assume that someone pumped directly into the center of a very narrow tight plume.

VICE CHAIRMAN RYAN: You hit my question on the head. That's why I think the stylized calculation for the purpose of compliance demonstration certainly has value and that needs to be done. Then a second question is some exploration of is that conservative or not and if it is conservative, by how much that gives you some insight into margin. So I think that's what we're looking to explore.

MEMBER WEINER: Peter, I have just a quick – Go on.

VICE CHAIRMAN RYAN: I'm looking to that exploration. Can you give me any insight there?

DR. SWIFT: To me we're venturing here into the realm of speculation heading towards worse case. Conservative with respect to what? I can imagine a situation in which a future human would get a concentration much less than from this method or greater.

VICE CHAIRMAN RYAN: And again I would borrow from my colleague, Dr. Garrick's view, that systematic assessment of that uncertainty would be a useful thing.

MEMBER WEINER: Do you distribute the pumping rates? Do you have a distribution of pumping rates and distribution concentrations?

DR. SWIFT: No, the 3,000 acre feet is a regulatory specification.

MEMBER WEINER: Yes, I know that, but in your TSPA.

DR. SWIFT: No.

MEMBER WEINER: You simply use a single value.

DR. SWIFT: Yes. Prior to the regulation specifying it, we did indeed instead of looking at possibilities and uncertainty in that. But that's the regulatory prescription.

DR. McCARTIN: Tim McCartin, NRC. When EPA specified the 3,000 acre feet for groundwater protection, they also suggested that we might adopt a similar approach for the individual protection which is what we did. In looking at 3,000 acre feet, part of their basis was that trying to estimate concentrations in small volumes of water would be extremely difficult if not technically impossible. There's a lot of variability. Clearly plumes are not uniform and depending on where you pump, the depth, there's all kind of factors.

But part of the basis for specifying 3,000 feet and use this average, we'll use that as a representative concentration to determine the dose.

They certainly stated in the preamble to the standard that when you got down to smaller volumes of water, they said really 100 acre feet was pretty much the minimum in terms of getting a defendable concentration. So there was this 3,000 acre feet while as Peter indicated you could do all kinds of scenarios of the way people withdraw water, the desire was to not try to get into that kind of speculation.

VICE CHAIRMAN RYAN: Okay.

DR. SWIFT: Next slide please. The other piece of the rest of the modeling system that needs to be brought into this discussion is the treatment of future climates. We saw the words early on the definition of what's held constant in the reference biosphere and what's changed. Climate is one of those things that we are expected to consider reasonable future changes in it.

The main reason we developed a climate change model was to look at its effect on groundwater flow. Its climate is at the very upstream end of all of the rest of the water flow related models. However the future climate also is used directly as input to the biosphere model now where -- I think Kurt is going to talk more about this. Climate change is used to establish values for the climate dependent input

parameters in our biosphere model, for example, the growing season and irrigation rates which we do believe will vary with changes in future climate.

So what are those changes in future climate? During the regulatory period of 10,000 years we recognize three climate states: a present day state that runs out the next 600 years, a monsoon -- It actually states an enhanced monsoonal climate. Southern Nevada has a weak monsoon now. At the following 2,000 years a climate is transitioning towards a future full glacial climate. The monsoonal climate is quite a bit wetter but not much colder than the present. And the glacial transition climate is wetter and quite a bit colder.

DR. MOELLER: Excuse me.

DR. SWIFT: Yes.

DR. MOELLER: You know we hear so much about global warming. Are you assuming that global warming will occur, but that for this region it's different? Help me with that.

DR. SWIFT: No, this model is based paleoclimate data from the Pleistocene. I think if you were to interview the project paleoclimatologists who developed this model, they would probably all agree that global warming at some scale seems to be

occurring. But no, global warming climate changes are on a scale of hundreds of years, not thousands of years.

There is an assumption here. I should be careful because this is not my work. But there is an assumption in this work that human induced climate change will not invalidate the paleoclimate analogue. We won't see climate changes in the future unlike any of those in the past. If that's the case, then this future climate model is not a very good one. So if global warming disrupts the next glacial cycle so 40,000 years from now, then basically we had a bad model here.

DR. THORNE: Excuse me. Dr. Thorne.

VICE CHAIRMAN RYAN: Could I briefly come in on this from the European side? We've just completed a three year European Union project BEOCLIM which is looked with the latest generation of earth model of intermediate complexity plus GCMs on this question. And I know there is a contentious debate about the significance of greenhouse warming, but if you take the current generation of models, we find that the persistence of greenhouse warming effects is on a time scale of tens of thousands to hundreds of thousands of years and there are two broad reasons for

this, one of which is that the long term component of persistence of carbon dioxide in the atmosphere constitutes about eight percent of the releases which means that although 90 percent of the concentrations drop off on time scales of hundreds of years, there is residual component. That with the present generation of models leads to knock on effects like significant oblation of ice sheets which then in turn move the system from its present day state.

So the bottomline is that when we did the analysis for Central England and also for Central Spain which is perhaps more analogous to what we're talking about here we found that we had to invoke what I would describe as nonanalog climates through to approximately 60,000 years after present. I think perhaps although outside the remit of this discussion at the moment that whole issue of what we understand by greenhouse warming and what the current status of the scientific community is on it perhaps needs looking at a little further.

DR. SWIFT: Next slide please. Did we lose something here? We lost something here. We're not going to get it back. You have it in your handouts. Now it came back. Do we know why? For those who want to see the actual dose calculations, my

presentation I believe is the only place we will see them in this workshop. For of all, 2002, these are old results. They've been shown before many times. This little paragraph here actually tells you what model run these come from, what the set of assumptions were.

First thing, it's nominal scenario. There is no volcanic disruption, no extreme seismic event in here. I'm showing these because I think the workshop probably does want this kind of information. The time scale here it's a logarithmic time scale so 10,000 years that's the regulatory period. Out there 100,000. One billion years. The general shape of the curves is what you're seeing here. First of all, the red is the mean curve. That is the curve which would be the basis for regulatory comparison.

It's a little hard for me to see on the ties here. But until sometime, it might around 70,000 years I think there's a dramatic break in that. In the models run at that time - this would have been 2001, 2002 - this dramatic increase in slope here was when we started seeing widespread failure of waste packages due to general corrosion. Until that time, we had a small number of waste packages that were failing in the model due to well defects so the

relatively early phase, 10,000 years and beyond.

The doses expressed in milligrams per year were small. The mean was on the order of 10^{-4} per year. What else do you need to know about that? Regulatory period again of 10,000 years there. This came up briefly in Dr. Compton's slide with the note that beyond 10,000 years the DOE shall present the peak dose and include it in the environmental impact statement. However, the NRC sets no limit on that. There would be an example of what was. Next slide please.

DR. TILL: Excuse me.

DR. SWIFT: The next two slides are more of the same here. Go ahead.

DR. TILL: Well two questions. One is you say one early package failure per realization so the source term occurs with a probability of one. Take the inventory of that package and release it.

DR. SWIFT: Yes.

DR. TILL: That's what this is based on. Right?

DR. SWIFT: Yes. It goes through all the various transport pathways and in fact we had one package. It wasn't entirely released. It had a specified size hole assumed in it, basically the loss

of an endcap and the drip shield was intact above it. So these are the diffusive pathway releases. But the answer is yes to your question.

DR. TILL: Okay. So your calculation starts when the source term begins. That's the initial phase of the transport part of it.

DR. SWIFT: Yes.

DR. TILL: Okay. I think it's incredibly significant that those doses jump by four orders of magnitude at 10,000 years. The reason that's significant is it just begs the question "Are we tweaking this model here?" So I want you to be prepared for that.

DR. SWIFT: Sure. They jumped -- I see. They jumped at 100,000 years out here. The regulatory limit of 10,000 is here.

DR. TILL: Okay that's my mistake. I was looking at that incorrectly, but I guess it still is a valid question because how much can you tweak this model to get it to move out another thousand years? Do you see what I mean?

DR. SWIFT: I know. I do. A comment on that. The spread in time out here is largely dependent on that general corrosion rate of the Alloid. If general corrosion is relatively fast, this

steep jump moves back this way. At this point on the curve we have one package failed. By the time we're out here, we have 95 percent of the packages have holes in them. I'm sorry. That was overstated. It might be 60 percent of the packages have holes in them. That's an imprecise guess on my part. But this is the period when many packages are failing and it's a function of that corrosion rate.

DR. TILL: Okay. Thank you.

DR. KOCHER: I have a slightly different question. If it's not possible to give us a short answer, you can pass. I acknowledge George Hornberger's comment about if the dose of all uncertainty doesn't matter. But the thing that struck me was how small the uncertainty is. So I'm thinking. What are the key drivers that are leading to a low uncertainty? Is the 3,000 acre feet per year draw-down really responsible for this? What are you averaging over that's causing these uncertainties to be as low as they are? That's remarkably low to me for a geosphere system over a long time.

DR. SWIFT: Sure. David, and by that you are referring to the 95 percentile band.

DR. KOCHER: Yes, the difference between them.

DR. SWIFT: I just want to be clear.

DR. KOCHER: The difference between the median and the 95 percentile being as low as it is.

DR. SWIFT: The difference in the early time here is not perhaps as small as it looks because if I were to continue to scale down, you discover there are still very low numbers of offscale there. The fifth percentile hasn't shown up yet there. The place where it's strikingly narrow to me is in the time dimension out in here. My answer to the previous question applies there that a key parameter driving this is uncertainty in the corrosion rate of the alloid 22.

CHAIRMAN GARRICK: But even that doesn't look small to me. That's a logged scale.

DR. KOCHER: I beg to differ about something. The median does appear on that curve unless I'm misreading it.

DR. SWIFT: The median is a fifth. This is a fifth. The median is in here.

DR. KOCHER: The difference between the median and the upper confidence limit is about two orders of magnitude. That strikes me as pretty darn small. I'm curious if there's an easy answer as to why.

DR. SWIFT: I do know where much of that uncertainty comes from. It has various sources. It's in travel times in the saturated zone. It's in retardation coefficients. It's in diffusion coefficients. This assumption here, one early failure per realization is a large source of less uncertainty in there if we had a larger number of packages. That was specified for the purposes of the analysis. Obviously we don't know what the early failure rate would be. I don't know. I think I don't have a short answer.

DR. KOCHER: That's fair enough. This is obviously a complicated problem.

DR. SWIFT: Yes.

DR. KOCHER: But there are things that we know quite a bit about out there in the real world where we get that kind of uncertainty also.

DR. SWIFT: Sure.

DR. KOCHER: Now you have a system that you don't know what's down there.

CHAIRMAN GARRICK: But I still think that's quite a bit of uncertainty. It's not even showing the fifth percentile below approximately 100,000 years. So you could still be having five to seven orders of magnitude of uncertainty between the

fifth and the 95th and that sounds like a lot of uncertainty.

VICE CHAIRMAN RYAN: Now the interesting thing to me is beauty is in the eye of the beholder. What's 10^2 for one person might be a small uncertainty. It might be huge for somebody else in a different context. I think the interesting thing is to think about the component parts of that uncertainty and to focus your question, Dave, on the biosphere component of it. I would be curious what elements of the biosphere calculation really contribute to uncertainty. Is that major one or the package degradation and the time of failure and so on? In the bigger context, it's really what fraction of the uncertainty is what we're talking about today. Although it's not an unimportant question to the system as a whole.

DR. SWIFT: Let me –- I'm sorry. Go ahead.

DR. KOCHER: Dr. Garrick made a good point. I have a bias as to how I'm looking at these things.

CHAIRMAN GARRICK: I can tell.

DR. KOCHER: I think of the world as being log normally distributed.

CHAIRMAN GARRICK: Right.

DR. KOCHER: But I'm guessing that it's far from the case here. So I'm wondering if there is some kind of hybrid analytical function that more or less describes these probability distribution functions that you are generating to help focus my thinking as to what this distribution really looks like because it is apparently logged normal if the fifth is down at 10^{-20} or whatever.

DR. ECKERMAN: It certainly is not logged normal.

CHAIRMAN GARRICK: You're right.

DR. SWIFT: Can I make more comment on that? Because we've limited this to the nominal scenario class, we have already excluded the largest single contributor to a spread in overall performance which would be the low probability disruption by an igneous or extreme seismic event. If we were to include that in this, you would see most realizations essentially producing zeros compared to relatively larger ones coming out of those rare events. You'd have an enormous spread in the range of outcomes.

DR. KOCHER: It's a whole other issue as to how you do that statistically, but that's beyond your charge.

DR. SWIFT: Sure. It's a different subject.

MEMBER WEINER: Peter, this looks remarkably like the retardation breakthrough curve. Is there a major influence by your distribution of Kds? Is that what is influencing that?

DR. SWIFT: It is a factor in these early times here. Actually, can I have the next slide because this may give you more information on that?

MEMBER WEINER: Okay. That looks even more like it.

DR. SWIFT: This and the next slide. I'm not going to spend an particular time on the second one. I hope you have them in color. At least, the panel does.

MEMBER WEINER: Yes.

DR. SWIFT: They are harder to interpret in black and white. When looking at these two slides, be aware that the two slides page 1 and page 2 repeat quite a lot of the same key species. That was done deliberately so you would be able to find technetium and neptunium and iodine on both of the two pages.

So what do we see here? We see that in early times the main driver and remember it was a couple of years ago was technetium 99 far and away.

Basically it tracks with -- The black curve here is the mean on the previous page. At later times, it's neptunium 237. But not too far below in the order of magnitude, or more below neptunium, you'll find the other actinides at later times. And technetium is still out there at other times and you'll find that iodine is out there also.

One of the reasons I mention this in response to Dr. Weiner's question is that technetium is not strongly retardant anywhere in the system. So what we're seeing here is a travel time for an unretarded particle. Whereas the neptunium coming in about here somewhere and the plutonium are retarded in a natural system and we see later arrivals of those.'

If we were to break out the 100 realizations or 300 realizations under lye, these are all means. If we show the uncertainly about those means, Dr. Weiner is right. What we would see in part would be the spread of the breakthrough travel times on the technetium and neptunium and the plutonium.

This is one that I think the panel may want to keep this slide in mind or refer back to it through the course of the meeting. There are also in the backups to this presentation for those who like this kind of information I simply put in what the

inventory is or repository is through time. Curves that just show what species are present as they decay and grow in through time. I'm not going to put them up here. Next slide please.

DR. MOELLER: Excuse me. All of those are effective doses. Like of the technetium, it's the whole body equivalent.

DR. SWIFT: Yes, these are all calculated by the process that Kurt and Maryla are going to describe of ***10:30:27 concentration through their BDCS. Go back to the previous one. I'm sorry. One other point I wanted to make here since I have it up here is the carbon 14 dose here. Note the footnote down here. Carbon 14 shows up as significant in the early times and of course due to its 5,000 year half life it starts to drop off.

We choose for simplicity to treat carbon 14 in our geosphere models as a non reactive species. This is not realistic. Carbon obviously reacts with carbonate in groundwater with carbonate minerals in the rock. It moves back and forth from the paper phase to water phase.

But rather than develop a full reactive transport model for carbon 14, we went ahead and treated carbon 14. Literally what we did was we used

the same breakthrough curve for carbon 14, the same transport properties that we used for technetium and iodine. So it is treated as something that transports with groundwater. This can only overstate the importance of carbon 14. That's a conservatism.

DR. TILL: Peter, before you go on.

DR. SWIFT: Yes.

DR. TILL: I just have to get this clear and apologize for being so stubborn about this. I still don't understand what happened 100,000 years because I thought we said it's one package that fails.

DR. SWIFT: Yes.

DR. TILL: And then did you say that at 100,000 years more packages fail?

DR. SWIFT: Sure. There are say 11,000 to 12,000 packages in the repository.

DR. TILL: Then the slide is not correct and your calculation is not correct. Correct? Am I wrong?

MEMBER HORNBERGER: The one package is an early failure.

DR. TILL: The one package is the early failure. Okay.

MEMBER HORNBERGER: The rest of them corrode slowly over time.

DR. TILL: Okay. Well, that explains what's going on. Thank you.

VICE CHAIRMAN RYAN: My question is more on the implications of the carbon 14 decision. That's an example where you've made an assumption based on not having a detailed model perhaps or not wanting to invest in a detailed model. But is there any way to explore the implications of that decision with regard to particularly the early contribution of carbon 14 from a couple thousand years on? I mean it's a big fraction of the total dose even though it is low.

DR. SWIFT: It's not that big a fraction.

VICE CHAIRMAN RYAN: It's one of the top --

PARTICIPANT: Total dose.

VICE CHAIRMAN RYAN: I'm sorry.

DR. SWIFT: It adds less than a line width to the total dose basically. I shouldn't try to argue the point. At the time we made the assumption we did not realize it would even be as large a contributor as it is. We were surprised by that. However, we felt we could live with it. We're dealing with doses at the 10^{-4}, 10^{-5} level and omitting carbon 14 completely from this analysis would have the effect pretty much of lowering the black curve so that would overlay with

the purple curve.

VICE CHAIRMAN RYAN: You know that's an example I think of what Dr. Hornberger cautioned us about. At the 10^{-6} milliram per year and knowing what you just said, the answer is who cares.

DR. SWIFT: Right, but if it were up here.

VICE CHAIRMAN RYAN: It's not important to the dose contribution. But if it's later on or if it's at a compliance point. I guess what I'm asking is have you or will you sort through those kinds of uncertainty estimations in this kind of a biosphere component to let us know what's important and what isn't? Then if it is important, how you've assessed what you've done in a stylized calculation versus what you think is a best guess of reality?

DR. SWIFT: That would be done in the context of Dr. Hornberger's does it matter.

VICE CHAIRMAN RYAN: Right.

DR. SWIFT: I don't have an answer for you right now. Does this one matter or not? I can tell you that as of two years ago when we did this, we decided it didn't matter.

VICE CHAIRMAN RYAN: Didn't matter, yeah.

DR. SWIFT: And we weren't going to show it.

CHAIRMAN GARRICK: I think this is a good example. We don't want to belabor it too much, but this is a good example of the issue of realism versus unrealism especially considering that carbon 14 is very visible at least in terms of the calculation in the compliance period. And it's not a realistic calculation. So the question here is why in the compliance period do we have some contributors to dose handled very realistically and others very unrealistically? I think just the concept that's presented is kind of disturbing that there's the lack of consistency of things that are contributing to the dose during the compliance period. That's my concern.

DR. KOCHER: I assume something else that's going on here is no airborne releases of C-14 whatsoever.

DR. SWIFT: The assumption is - thank you - made here that all carbon 14 enters the water phase. We did not have a realistic model for how to partition carbon 14 between the gas phase and the water phase. We looked at both pathways independently, making the assumption that for either pathway the boundary was to put it all in that pathway. We did look at a side calculation where we put all the carbon 14 into the vapor phase, put it out in the air and showed that it

also would produce a dose considerably smaller than this at 18 kilometers.

DR. THORNE: Could I raise a question on that? When I did the calculations for the Nairex (phonetic) assessment, I did calculations for C-14 by the gas pathway. My concern was not so much with direct release to air in the sense of an inhalation dose, but with the biotic interactions in the soil zone and in the subcanopy atmosphere and uptake to plants and the consequent ingestion dose. Was that included in the calculations?

DR. SWIFT: No. The one we looked at looked at the direct exposure to carbon 14 in the air.

DR. THORNE: I think that might be an interesting one.

DR. SWIFT: May I make a question on that? Were you looking at a population dose or individual dose?

DR. THORNE: No, I was looking individual dose in respect of the compliance targets for the UK site.

DR. SWIFT: Other questions? Next slide and the next one. Now this is quite an old slide. This goes back to the year December 2000 but this is the only example I had actually to find a good clear

open literature example of what the impact of uncertainty in our biosphere dose conversion factors was doing to total dose. Dr. Garrick asked this question almost directly. This is the best I have for an answer.

Explain first of all what these are. The black curve here is a mean from 100 to realizations taken from the year 2000 performance assessment. It's different dose history than the one I just showed you, but to me with a broad uncertainty band around it. These are what we call one-off calculations. We varied one input parameter in both these two examples here on the screen to fixed values. Everything else we treated exactly as it had been the base case. So all the other sample parameters were still sampled. The black mean here reflects uncertainty in every input except the biosphere dose conversion factors. We took the biosphere dose conversion factors and we pushed them to their 95th and 5th percentile values and you don't really see much of a change.

VICE CHAIRMAN RYAN: Can you help us? When you say 95th and 5th percentile, how did you distribute them?

DR. SWIFT: Actually I'll let Maryla answer that one in a minute here.

VICE CHAIRMAN RYAN: Okay.

DR. SWIFT: But let me go on for just a second. Okay? I think Maryla developed those distributions. I am not in this slide making any claim that the 95th and 5th represent the correct bound of uncertainty on our biosphere dose conversion factors. It's an important point when showing results like this. All I can show you is the change in the output caused by the change in the input. So if the model input had that much spread in its uncertainty in this particular parameter, the biosphere dose conversion factors, that's the change you got in the output. I think a purpose of this workshop is to examine what is the range of uncertainty in those biosphere dose conversion factors. This was the range we used in this analysis.

This is an example of a parameter which had a much larger effect. Here I've taken the alloid 22 conversion rate that I've talked about. This again is from a somewhat earlier analysis. We pushed that one to its 95th and 5th percentiles and proves it's a much broader spread. Don't go back in the slides but if you were to go back to one of those horsetail plots a few pages back most of the spread in that horsetail is coming out of other parameters. Almost

none of it is coming out of biosphere dose conversion factors. Now Maryla, do you want comment on what 95th and 5th meant in those or is that something you're going to talk in detail?

DR. WASIOLEK: Maryla Wasiolek. We have a pathway contribution discussion after the break. I will discuss uncertainties in particular components of biosphere dose conversion factors. So giving specific examples for important radionuclides. So I will give you exact numbers. Hopefully this will answer the question.

DR. MOELLER: Excuse me. Back on the carbon 14 and Dr. Garrick's comments, it brings me back to what Professor Thorne was saying early this morning that you have calculations that you do for compliance and then you have calculations you do to really inform people. I think that falls under that category because if you show a slide and say "We didn't bother. We did it on a simplified approach and we didn't bother correcting it" that reduces whether correct or not my faith in what you're doing.

DR. SWIFT: I'm essentially done here. One more slide. Just some summary points here. We have detailed models for the entire system. The overall system performance assessment links those

models and some of them are simplified. Our goal is to provide estimates of overall system performance. My group's goal.

To me, the biosphere dose conversion factors are just one of many inputs to my group and the contribution to uncertainty in overall dose estimates from the uncertainty in those BDCFs. It's less than that from your other sources. If a system perspective, we don't see the biosphere as a major source of uncertainty in the overall performance. Part of that of course is because it is largely specified or much of it specified for us. That's it.

VICE CHAIRMAN RYAN: Just on that last point and then I appreciate what you showed that biosphere does conversion factors, a big contributor to overall uncertainty but that's in the context of the assumption that you have not evaluated the fixed parts of the calculation for whether or not they represent reality and how that reality may vary in time. Is that right? Did I understand that right?

DR. SWIFT: Yes, that's essentially right. I want to be very clear that when I say that it's caveated by my uncertainty and certainly in my results, it's depended on the uncertainty in those inputs. Where the inputs were not varied, there would

be no uncertainty in the output. That's just the nature of the Monte Carlo analyses. But you usually don't get out anything that you didn't put in.

VICE CHAIRMAN RYAN: Sure. So you're evaluating certain aspects of calculational uncertainty by varying certain models but not all of them.

DR. SWIFT: Right.

VICE CHAIRMAN RYAN: Okay. Thanks.

DR. RAUTENSTRAUCH: Good morning. I'm Kurt Rautenstrauch. I'm an ecologist with Bechtel SAIC's Environmental Sciences Department and now that Peter has put our biosphere model in the perspective of total system performance assessment, what I'd like to do is introduce to you the biosphere model that the Department of Energy will be using for the post-closure performance assessment for the license application.

What I'm going to do is describe to you some of the important information and methods that we used to develop our conceptual biosphere model, describe to you the structure and function of the model and briefly summarize uncertainty and results. I'm going to be focusing primarily on our conceptual model. Later this afternoon, Dr. Wasiolek will be

presenting to you in more detail some of the mathematical methods and results and pathway analyses. This will be primarily conceptual.

The purpose of our biosphere model is to track and transport of, once it leave the groundwater well, calculate radionuclides through the biosphere, in other words concentrations in important environmental media which I'll identify in a few moments and then to calculate annual exposure to the human receptor, in our case, the reasonably maximally exposed individual from those radionuclides.

We have a new model that the Department of Energy will be using for the license application, new relative to the site recommendation. It's titled "The Environmental Radiation Model for Yucca Mountain, Nevada" or ERMYN model. We've developed it over the past 18 months. The primary reason we did that is because our previous model which was based on the GENII S software program wasn't flexible enough to do all that was necessary to meet the requirements.

Some of the improvements that we've had are we've added additional pathways, such as consequences of use of evaporative coolers. This model allows us to define and stochastically sample all parameter values and we feel we've greatly

improved the transparency of our biosphere model.

The mathematical methods that are included in the biosphere model for the most part are not new. The mathematical methods we used were selected from a review of 12 or so other environmental radiation models. We selected the methods that we felt were most applicable to our requirements, our site-specific conditions and our needs, and if necessary we adapted those to those needs and site-specific conditions. Finally, we have revisited all of our parameter distributions that are used in the biosphere model for the license application.

As Peter said, the biosphere model has run independently of the total system performance assessment. We did that for a number of reasons, one of which is so that we could complete the documentation for that independently of the TSPA. One of the consequences of that is that radionuclide concentrations are not known at the time the biosphere model is run.

Therefore, we calculate biosphere dose conversion factors which are the annual total effective dose equivalent per unit concentration of radionuclides in the source of those radionuclides. We have two sources to consider. One of them is

groundwater and the other one is volcanic ash. As Peter said, those biosphere dose conversion factors are multiplied by the predictive concentration in the total system performance assessment to estimate those. Go ahead.

We consider in our model two biosphere exposure scenarios. The groundwater exposure scenario is to be used in all TSPA modeling cases that consider radionuclide contamination in groundwater, no matter what the cause of that contamination is. That includes nominal performance and igneous intrusion and other intrusive cases. Our volcanic ash exposure scenario is intended only to be used to evaluate the consequences of deposition of volcanic ash and associated radionuclides in the biosphere. I'm going to be focusing on our groundwater scenario for the remainder of this talk. Next slide.

This slide shows the four primary steps we followed to develop the model and it's the outline of much of the rest of this presentation. Our first step was to characterize the referenced biosphere in human receptor to ensure that we met the requirements of Part 63 that have already been discussed. I will be showing you some of the information we used on that. Next.

After that, we identified the features, events and processes that must be included in our model. We then developed a radionuclide transfer interaction matrix to identify the important transfer processes that needed to be included and finally developed the submodels and important assumptions that were necessary to execute this model. Go ahead.

A few slides on characterizing the referenced biosphere. The map here shows locations of residences in Amargosa Valley and the surrounding region. Each black dot is a residence based on local electrical company information. As you can see, most of the people in Amargosa Valley live in the southwest portion of the valley. We get our population information from this light grey area with the Amargosa Valley Census District. There is no town of Amargosa Valley per se. So we derive much of our information on the reference population from that census area, the light grey box. Most of the people in that area live in what's known as the farming triangle or the farming area in southwestern Amargosa Valley.

This region has only a couple of small grocery stores. It has a part time medical clinic. Therefore our model considers or includes the

possibility that people will spend some time out of the valley shopping, for medical treatment, and for recreation. In addition, most of the employment centers such as the Nevada Test Site, mines up near Beatty, Perump, Las Vegas are more than 20 miles away. So our model also includes the possibility that people will spend time out of the valley while working. Finally on this slide, there is no municipal water treatment system in the area or water delivery system. All the water comes from groundwater wells and we did not consider water treatment prior to use.

Amargosa Valley has about 2,000 acres that are commercially farmed. This has been consistent for the past five or more years and is likely to remain so for a while because of limits on availability of groundwater permits. Most of the commercial agriculture is for production of alfalfa and other hays. There's not very many human food stuffs in Amargosa Valley.

Of course, there's a large dairy at the southern end of the valley and there was a catfish farm operational during the 1990s. The ponds for that fish farm currently are still there but there is no commercial production at that site at this moment because the person who owns that farm is off working

somewhere at the moment. All farmland in the area is irrigated and the soils are deep, sandy to sandy loams. We use this information to characterize agricultural practices and to calculate irrigation rates. Okay.

Finally a little information on climate. Our current climate data comes from a weather station in Northern Amargosa Valley that has about 100 millimeters of precipitation per year. The dominant future climate upper-bound analogue is eastern Washington, the area around Spokane. That's the analogue we use to calculate irrigation for the upper bound of the future climate. At that site, precipitation is four times as high, and temperatures are about 10 degrees per month cooler. Okay.

Some information on the receptor. Our information on consumption of locally produced foods comes from a 1997 survey of the people of Amargosa Valley where they were asked how often they ate locally produced foods or frequency of consumption.

The graph at the bottom here is just about the simplest way you can display that information. It's essentially the proportion of people that consumed tap water or consumed locally produced food at any time during the year prior to the survey.

Although this shows that at least a large portion of people consumed locally produced foods at least sometime during the previous year. They did not consume them very often during the year.

This is to be expected from a community where most of the agricultural production is in non-human food stuffs. People therefore are getting their locally produced food from seasonal gardens. The last bit of information on here. We also asked during that survey how many glasses of tap water people consumed. Assuming that a glass of tap water is eight ounces. The average amount of tap water that was consumed in Amargosa Valley is 1.9 L per day. Okay.

This graph on unemployment is from the 2000 census. About 39 percent of the population in Amargosa Valley in 2000 was retired or otherwise unemployed. Sixteen percent worked in mining likely in mines around Beatty. Some of them probably worked at the clay mines at south end of Amargosa Valley. Four percent of population worked in agriculture. We used this information to develop the time budgets that I'll be showing you later in my talk.

DR. MOELLER: A couple questions to help me with understanding the life style.

DR. RAUTENSTRAUCH: Sure.

DR. MOELLER: Do they each have a well or do they have a well that serves ten homes?

DR. RAUTENSTRAUCH: For the most parts, they each have a well.

DR. MOELLER: Each have a well. Now when you said they do not consume much local food, I thought I read in that 1997 survey that 40 percent or some of them have a home garden.

DR. RAUTENSTRAUCH: Forty-seven percent. That's going to be one of the next slides.

DR. MOELLER: Okay, but you said they don't eat what they grow.

DR. RAUTENSTRAUCH: I'm sure they do. But when you compare it to the total proportion of diet for the year, it's a relatively small amount.

DR. MOELLER: I see.

DR. RAUTENSTRAUCH: For example, locally produced fruits in the previous slide which we don't need to go back to are consumed by a lot of people. But if you compare consumption to the national average consumption of fruits, it comes out to be about 17 percent or less of the total annual diet. That's because a person's fruit tree is only going produce for part of the year. So they are only going to get their peaches or whatever for that part of the year.

Okay. Next.

Forty-six percent of household surveys had garden. We used this information to help us develop agricultural practices and we also considered garden crops in our calculation of irrigation rates. A relatively large proportion of the population commute. Before the groundwater scenario, we assume that if people communed more than ten minutes, they were outside the area potentially contaminated by 3,000 acre feet of water. By the way, ten minutes of driving would get most people out of the residential area in all of Amargosa Valley.

Most of the people in the valley lived in mobile homes. We used that information to select shielding factors for our external exposure scenario. Finally a large proportion of the population use evaporative coolers. Evaporative coolers are a relatively effective way to cool buildings in areas that have 25 percent humidity or less. They are cost effective. They are operated by having a large volume fan forcing air across wet pads. As the water evaporates, it cools the air. Obviously there might be consequences of that and we considered that in our model.

Of the 48 biosphere related features,

events and processes in the Yucca Mountain database of features, events and processes that were linked to biosphere, 13 were excluded because they are inconsistent with the regulations and Part 63. Four were excluded because they clearly had low consequences or low probability. The other 31 formed the basis of our biosphere conceptual model.

DR. THORNE: Sorry. Could I take a clarification?

DR. RAUTENSTRAUCH: Yes.

DR. THORNE: So if you move to the climate state that's Washington analog, you don't change change the receptor practices.

DR. RAUTENSTRAUCH: The only things we change are irrigation rates and parameters related to irrigation like overwatering, growing seasons of crops, but not the crops that are grown and those shift just a little bit and are pretty inconsequential and the other thing that you change is the pushing of the year that evaporative coolers would be used.

DR. THORNE: Yes, I guess it was the crop shift that was one that I was thinking about. Because when you get to 400 millimeters, it's looking more like a sort of sudden Spanish climate than the very airy climate that you have at the moment. I'm just

conscious of the sort of bodegas that you have in Spain where pretty well all the food crops for a household may be grown within a small area. That seems to be a potential shift in the practice of the receptor group.

DR. RAUTENSTRAUCH: For our compliance calculations, we do not consider change in diet. We consider change in environmental parameters, but not change in diet for those compliance calculations.

MEMBER HORNBERGER: It's also true, isn't it, that eastern Washington is a good bit colder than southern Spain.

DR. THORNE: Yeah. It's just this question of what is a correct analog because eastern Washington is further north. You can just jump the climate.

MEMBER HORNBERGER: No, that's right, but they made the assumption that the temperature was also going to go down by 10 degrees.

DR. THORNE: It won't necessarily work quite that way.

MEMBER HORNBERGER: I'm not sure that any of these assumptions are how things will work quite that way, but that is the assumption.

VICE CHAIRMAN RYAN: Kurt, maybe you can

help us and I was thinking of a similar question. What's the time frame of that change from 100 to 400 millimeters and from a given temperature to ten degrees cooler?

DR. RAUTENSTRAUCH: Peter had that in one of this slides. I think that the answer is the way TSPA models that is in his slide on climate change where I believe he lists specifically the years that the TSPA switches from one climate to the other.

DR. THORNE: Okay. I'll go back and look.

DR. RAUTENSTRAUCH: But it is a switch. So I think it's 400 years for modern climate, in the order of 1200 years.

DR. THORNE: Yes, I remember that. Thank you.

DR. SWIFT: The change to the climate analogous to eastern Washington occurs at 2000 years.

VICE CHAIRMAN RYAN: I guess that's sort of the root of some of the caution that I have about these. I think the problem isn't so much that you've made a shift. The problem is you're trying to say it's like eastern Washington. Who cares what its like is my point. You're try to evaluate what does an increase in watering rate and a decrease in temperature have in terms of dose impact. Isn't that

the result?

DR. SWIFT: And you'll see in one of my very last bullets that it's not much.

VICE CHAIRMAN RYAN: Right. Okay.

DR. KOCHER: One of the effects of that assumption is that you're not doing any dose calculations based on present day climate in Nevada.

DR. RAUTENSTRAUCH: Beyond 600 years, that is correct.

DR. KOCHER: Because you don't have any releases.

DR. RAUTENSTRAUCH: That is correct.

DR. KOCHER: So people might be curious.

DR. RAUTENSTRAUCH: That is the way that is working. Next slide, please. Based on those features, events and processes, we've identified six environmental media that may be contaminated by radionuclides and result in exposure to a receptor: groundwater, irrigated soil, indoor and outdoor air, crops, animal products and fish consumed by the receptor. These six environmental media and the three exposures pathways listed on the slide form the basis of the structure of our conceptual model. Okay.

Using those six environmental media, we constructed a radiation transfer interaction matrix.

I've included this primarily for your reference and am not going to spend much time on it, but will say that this matrix uses a clockwise convention, so the transfer processes above the diagonal represent transfer from a media higher on the diagonal to one lower, and those below the diagonal represent loss from one of the boxes or one of the media. I have included also in my backup slides a conceptual diagram of these transfer processes. I've also included the transfer matrix and that conceptual diagram for the volcanic scenario if anyone is curious. Okay.

MEMBER WEINER: Could you go back to the last slide? Do you mean radiation transfer or radioactive materials?

DR. RAUTENSTRAUCH: Radioactive material.

MEMBER WEINER: Thank you.

DR. RAUTENSTRAUCH: This slide shows the structure of our conceptual and mathematical model. It's based on those environmental media and exposure pathways. We do not consider the groundwater as one of our submodels because there are no calculations for us to do concerning groundwater in the biosphere model. We assume that groundwater is constant at one becqeurel per cubic meter. Therefore that's why we calculate biosphere dose conversion factors that are

fed to the TSPA.

We have five submodels for calculating concentrations in environmental media; three submodels for exposure pathway. We also have a special mathematical submodel for carbon 14 because of the different transfer pathways for that radionuclide. Other than carbon 14 and some additional calculations of radon, we use the methods to calculate concentrations and exposure for all other radionuclides.

MEMBER HORNBERGER: Kurt, just a quick clarification for a novice here on this.

DR. RAUTENSTRAUCH: Yes.

MEMBER HORNBERGER: Can I assume that what you're doing here is running a unit concentration of groundwater through to get your conversion factor?

DR. RAUTENSTRAUCH: That's exactly what we're doing.

DR. THORNE: I'm sorry. Just for further clarification. That calculation is run through to equilibrium, isn't it? So the vast reduced conversion factor is the number that you would get if you maintain that unit concentration indefinitely in the groundwater.

DR. RAUTENSTRAUCH: Yes. All right. Our

soil submodel calculates concentrations in soil from a distribution of irrigation water. Irrigation water is the only input to this model. We have three lost pathways, erosion, leeching and radionuclide decay. The assumption I have listed here that concentrations in soil are at saturation or equilibrium conditions is what allows us to separate the biosphere model from the total system performance assessment model.

This assumption is reasonable for the radionuclides that likely will contribute to the dose at 10,000 years, technetium and iodide because those likely will reach saturation conditions in a matter of tens of years. It certainly is conservative for radionuclides such as neptunium and plutonium which have reached saturation conditions on the order of hundreds of years. Irrigation rate for the upper bound of the future climate is about –

DR. ECKERMAN: Why are you doing it this way? Why are you throwing away all the dynamics? The question was why are you coming out with just a single number out of this exercise? You're throwing away all the dynamics of the pathways, right, by running them all to saturation? I don't understand your approach here. Am I missing something?

DR. RAUTENSTRAUCH: The only thing that's

held constant is the soil concentration and saturation assuming that irrigation has occurred long enough for saturation conditions to have been reached.

DR. ECKERMAN: But that's driving all the terrestrial. The food chain pathways are all driven by that.

DR. RAUTENSTRAUCH: That's true that the all the food chain pathways past that are based on the assumption that it's at the high concentration.

DR. KOCHER: What is it that's saturated and how do you define it?

DR. RAUTENSTRAUCH: The concentrations in soil are at equilibrium or saturated.

DR. KOCHER: Equilibrium or saturation is two different things.

DR. RAUTENSTRAUCH: Maryla, would you like to help with this?

DR. KOCHER: The equilibrium I can understand. It's the saturation I'm having a real hard time with.

DR. WASIOLEK: Well it is radioactive equilibrium. Basically we assume that sources in this case irrigation are balanced by losses which in this case is leeching, erosion and radioactive decay. So we assume that we have a constant value of mass

activity concentration in the surface soil.

DR. KOCHER: That explains it a lot. The term "saturation" is just not right here.

DR. WASIOLEK: It is radioactive equilibrium in the surface soil. This is what it is and we assume this equilibrium for what we called primary radionuclides which are radionuclides that are trapped in the TSPA model and make additional assumptions that they are short-lived decay products are in equilibrium with long-lived radionuclides.

DR. TILL: I actually think that makes sense for irrigation. That's what you have to think of. You're putting your water in your crop continuously out there and that's all they're talking about. It's a constant concentration in that surface layer of soil than in the root zone.

VICE CHAIRMAN RYAN: So that the real crux to the issue there is what is the source water from which plants have an uptake and it's a constant concentration. Is that right?

DR. WASIOLEK: Well, it is slightly more complicated than that. We are presenting sort of a simplistic version of the biosphere model here. Yes, we do assume that there is a constant value of activity concentration in the water which is one in

this case. And we assume that there was semi-continuous process of irrigation of the soil that continues until the equilibrium in the surface soil is obtained. We use this value only for the soil because we have additional calculations for crops and for the position of the crops.

This is slightly different, but these are the details of our model. We use different values for annual average irrigation which are only used to determine what will be this equilibrium activity concentration in the soil. But we also use daily or sort of incident based, episode based values of irrigation for the purpose of deposition on the crops for the leaf uptake. So we developed different values of irrigation depending on how they are using the model.

VICE CHAIRMAN RYAN: You know again this maybe one that we'll get into some more detail discussion, but it strikes me that this is an example where the model and its construct and relation to reality would be something that would be interesting to know. You said a couple of times it's conservative. My question is why and by how much. I'm not asking for a specific answer. Hopefully it's something that we can explore as we go on.

DR. RAUTENSTRAUCH: I understand. I want to speak to that. The reason we chose to do this is to be able to run this model independent with TSPA.

VICE CHAIRMAN RYAN: And that's okay. But I guess it still begs the question "well you did it for that reason," but what does it mean in terms of your true representation of what is a likely reality versus a constructed model of reality?

DR. RAUTENSTRAUCH: And I'll repeat. For the radionuclides, likely to contribute greatly during the compliance period. Those radionuclides would reach equilibrium condition in tens of years.

VICE CHAIRMAN RYAN: Right.

DR. RAUTENSTRAUCH: Or approach equilibrium conditions in tens of years. So for those, it likely is a fairly reasonable assumption.

VICE CHAIRMAN RYAN: Well we're back to the equilibrium of what?

MEMBER WEINER: Maybe Dr. Wasiolek can answer this question. I'm having a lot of trouble with terminology. Is it a constant soil concentration or an equilibrium soil concentration? Those are not the same thing. Furthermore, the concentration is a concentration of things of radionuclides. It is not a concentration of radioactivity. So when you're

talking about equilibrium, you're not talking about the secular equilibrium of radioactive decay. You're talking about chemical equilibrium or am I getting this all wrong?

I'm really confused at this point about the terms that you're using. In particular, are you assuming that there is an equilibrium of certain radionuclides absorbed on the soil that then as they move into the plants more is absorbed? That's what equilibrium is. Or are you assuming a constant concentration of those on the soil? I'm just confused about the terms you're using.

DR. WASIOLEK: Okay. The quantity that remains constant throughout the time and of course it differs from radionuclide to radionuclide. It is a radionuclide specific quantity because the loss's turn of our radionuclide specific. The sources are not because the source is irrigation and it's one unit of activity concentration per unit volume. The losses are radionuclide or element specific. Element in terms of leeching. Radionuclide specific in terms of radioactive decay constant. What we keep at constant value in the soil is mass activity concentration of a primary radionuclide.

VICE CHAIRMAN RYAN: What do you mean

"mass activity"?

DR. WASIOLEK: Backril per kilogram.

VICE CHAIRMAN RYAN: That's an activity point. It's not a mass.

DR. WASIOLEK: Well per unit mass. If you have Backril per volume it's volume activity concentration. ICRU report. I'm using ICRU. Actually ICRU using density, but we have grown up with activity concentration which is also given as an option in the most recent ICRU report that defines units and quantities use in radiological assessment models. I apologize. I think NSI. So Michael will understand me. The rest of you folks.

MEMBER WEINER: It's not the Backrils. It was the use of the term equilibrium.

DR. WASIOLEK: Okay.

MEMBER WEINER: But thank you for straightening that out.

MEMBER HORNBERGER: I'm sure we'll get into this later. I know we can defer this. I guess this bit of conversation, the part that confuses me now, is whether or not this whole operation will conserve mass, something that our friend, Milt Levinson used to sit here and actually worry about. So I would like to be convince at some time probably

after lunch that we don't have the possibility of actually ingesting more radionuclides than were reposited in the repository.

DR. RAUTENSTRAUCH: My apologies for the confusion over terminology.

DR. THORNE: Could I just come on that? I had to look at the model. I don't think conservation of mass is any problem. This is fairly standard international practice and it's been said already that this is based on review of the models.

I think one of the things that perhaps is worth bringing out is that the model itself is a mixture of proper representation of kinetics of the system, a solve to equilibrium and equilibrium assumptions. I'll give you an example of what I mean. I think in the model you deal with flow of water through the soil which gives you a leeching component. And that is properly represented as a kinetic process which you then solve to equilibrium to give you the concentration in soil.

But the partitioning between the solid phase and the liquid phase is represented through a KD rather than a kinetic forward and back reaction process. So in a sense the flow and transport is represented kinetics, but an underlying driver of that

flow and transport which is the absorption is represented in equilibrium sense. That's done for a very good reason because that's what's available in the literature and you don't have the kinetic forward and backward coefficients so you use the KD values because that's what you have.

Similarly with soil/plant transfers because most soil/plant transfers that are available in the literature are expressed as exactly that. The concentration in plants ratio to the concentration in soil, you use that sort of quantity rather than a kinetic representation of uptake in plants.

But I think we ought to be clear that the model combines both genuine kinetic components and kinetic processes represented in an equilibrium sense. I hope I didn't do any violence to the model with that statement.

DR. RAUTENSTRAUCH: Thank you. My last point down here was going to be that it's an absorption coefficient or KD values that have the greatest uncertainty in all of our input and parameters. Our air submodel calculates concentrations in air from three pathways, the suspension of dust, the consequences of use of evaporative coolers or generation of aerosol from

evaporative coolers and exhalation of radon from the soil.

For this and for the external exposure and inhalation submodels, we divided the reference biosphere up into indoor and outdoor environments and the environment around plants. The outdoor environment is further divided into active and inactive depending on whether a person is actively disturbing soil. So the active outdoor environment is representative conditions when a person is actively disturbing soil. We did that primarily because of the large variation in mass loading or concentrations of dust in the area among these environments.

For this submodel we have moderate uncertainty and the resuspension of the Hasman factor included in the dust resuspension calculation and large uncertainty in the evaporative cooler transfer fraction relative to the other parameters.

VICE CHAIRMAN RYAN: Could you help us with what's large?

DR. RAUTENSTRAUCH: You know this afternoon Maryla is going to be showing some of those distributions. Our evaporative cooler transfer fraction to show what large is ranges from zero to 100 percent. We are completely uncertain about the

proportion of radionuclides that would transfer from water to air.

VICE CHAIRMAN RYAN: Well, if it's zero to 100 percent, that's not uncertainty. That's an unknown.

DR. RAUTENSTRAUCH: I'll go along with that.

DR. WASIOLEK: That's exactly what it is. I will address that.

VICE CHAIRMAN RYAN: Okay, great. The other thing in this kind of review of dust resuspension, that's also if I look at Lynn Anspaugh's recent work and others a big wide swing of many orders of magnitude. Perhaps overall it's a small thing because inhalation components dose may be a small component but dust resuspension is again one of those things where people talk about orders of magnitude of uncertainty. Finally in that area, the dose conversion factor switch Dr. Moeller talked about earlier very often people will make the conservative assumption which is actually a bounding case that it's soluble which is two or three orders of magnitude based on the radionuclide different from insoluble inhaled radionuclide. So just in the dose numbers there can be wide swings based on those three things.

And hopefully we'll get into some of that this afternoon.

DR. RAUTENSTRAUCH: To address the second one of those, the uncertainty in mass loading or resuspension, that's the primary reason we divided it into environments. It's in that outdoor active environment where that uncertainty exists.

VICE CHAIRMAN RYAN: Right. Exactly.

MEMBER WEINER: What model did you use for resuspension?

DR. RAUTENSTRAUCH: We used mass loading values so our calculation of concentrations in the air is that product of concentrations of dust in the air, measurements of dust or mass loading in the air, multiplied by the concentrations of radionuclides in the soil.

MEMBER WEINER: So you had actual measurements of airborne dust.

DR. RAUTENSTRAUCH: That is correct and the airborne dust concentrations were environment specific. So for the outdoor active environment, our measurements were typical for farming activities and other activities were dust concentrations were measured while soil was being disturbed.

MEMBER WEINER: And you assume that the

radionuclides on that airborne dust came from radionuclide that got into the soil via the groundwater. Is that correct?

DR. RAUTENSTRAUCH: That is correct.

MEMBER WEINER: Thank you.

DR. THORNE: And I think do you not also use an enrichment factor to allow for the small particle fraction?

DR. RAUTENSTRAUCH: Yes, we do. That's the resuspension enhancement factor that I mentioned.

DR. THORNE: Okay. I'm clear on that now.

DR. MOELLER: Help me with the radon. Now of course the soil has naturally occurring uranium and radium, while radium being the parent of the radon. What are you doing with radon?

DR. RAUTENSTRAUCH: I'm going to let Maryla help you with that.

DR. MOELLER: No, my point is if you're computing an effective dose from the radon, naturally occurring radon doesn't count.

DR. WASIOLEK: We don't know the count for naturally occurring. The source of radon including in our biosphere dose conversion factor in this case for radium 226 is the radon that was produced out of the radon 226 that was introduced there from radionuclides

relieved by the repository, we do not include naturally occurring radon. We have our own source of radon that is repository derived rather than natural radon.

DR. MOELLER: Where does the radium -- It's not a fission product. The uranium has been purified perhaps. Well it has a 4.5 billion year half life for 238. How much radium is in spent fuel?

DR. WASIOLEK: Well maybe Peter has graphs in his.

DR. SWIFT: Peter Swift. The very last slide in my handout from earlier. I don't know the decay change. Somebody's business here probably does. The radium is showing up as a ingrowth product to one of the decay chains.

DR. WASIOLEK: Well for us it is.

DR. SWIFT: It's coming in. It's one of the species.

DR. WASIOLEK: 1600 years is short lived relative to the geological timescale that we are doing. It's probably coming in from the uranium 234. So this is the source of radon. We consider radon in both indoor and outdoor environment with the appropriate equilibrium factors.

DR. MOELLER: And you can distinguish or

you have estimated how much radium and radon then might be released from the repository.

DR. WASIOLEK: Yes, we have equilibrium concentration of radium in the surface soil according to the model that Kurt has just described and out of this soil we calculate radon flux density for the outdoor environment and then of course make appropriate corrections for the indoor atmosphere. We correct for the ventilation and so forth. Then again we are using site specific conventions to calculate ventilation rates again depending on the circumstances with evaporative coolers are in operation or not. So there was a whole deal of site specific information that goes into these calculations as well.

DR. THORNE: Right. Could I just clarify on the radium? Sorry. You actually have two sources into the biosphere. At equilibrium in the well water, you have thorium 230 and you have radium 226. You then take the radium 226 from the well as a constant source and you put that into soil so you have a radium concentration from that. Do you also do the calculation where you take the thorium 230 from the well water, put that into the soil and let the radium 226 grow into the thorium 230 that's been added to the soil because the thorium 230 presumably has a very

long retention half life?

DR. WASIOLEK: We do carry long-lived decay products. So if what we call a primary rate radionuclide is also a decay product of some other guy that is higher up in the chain, we do carry separate calculations of the soil for this radionuclide. We separate them. So for example if TSPA model tracked radium and also radium were produced out of one of the predecessor we would track these two fractions independently and then add them up according to the source.

VICE CHAIRMAN RYAN: Mindful of time, we're actually a little bit into comment period. What I would like to do is ask Kurt to finish up your slide presentations with as fewer interruptions as possible. Make a note of your questions and we'll then pick up after lunch with Maryla's presentation and perhaps more discussion of these points. I realize you're overlapping a little bit with her and we're asking her questions. Maybe we should reserve them until you're done.

DR. RAUTENSTRAUCH: Thank you. The plant submodel concentrations includes stuff or the consequences of concentrations includes stuff from deposition of irrigation water, deposition of dust and

root uptake for five crop types. The parameter that we have the greatest uncertainty relative to all of our other parameters in this model are the transfer factors. Next slide please.

The animal submodel calculates concentrations in animal products from ingestion of feedwater in soil for four types of animal products. We assume that animals consume locally produced foods. This is a reasonable assumption especially for cattle because most people in Amargosa Valley who are raising their own cattle for food likely are to be raising their whole alfalfa or go to their neighbors for that alfalfa and feed rather than driving into the nearest feed stores in Pahrump or elsewhere. And we have large uncertainty in our transfer coefficients.

The fish model is included because there was a fish farm in Amargosa Valley during the 1990s. The calculations in this fish model are based on the operation of that specific catfish farm where catfish were raised from one to two years. All fish were then harvested. The ponds were drained and cleaned. The filled and started over again. We include an increase in concentrations due to evaporation or replacement of water. This results in a two to six times increase for current climate and a much smaller 1.5 and three

times increase for future climate. We have our factor with the largest uncertainty here which is the bioaccumulation factor.

MEMBER HORNBERGER: Do all the fish get eaten by people in Amargosa Valley?

DR. RAUTENSTRAUCH: No, they do not. Very few fish get eaten by people in Amargosa Valley. Those fish were sold to the Nevada Department of Wildlife and trucked to other parts of the state to stock the ponds. Next.

Our carbon 14 special submodel is used to calculate carbon concentrations in the environmental media. Our calculations were based on a proportion of carbon 14 to stable carbon in those environmental media. After we calculated concentrations, we used then the same methods to evaluate exposure as we did for other radionuclides.

VICE CHAIRMAN RYAN: I would really ask. We do have comment period. So if you could hold your questions until after lunch, that would be great. Thank you.

DR. RAUTENSTRAUCH: Our exposure calculations in simplistic form are based on exposure rates times the media concentration times dose conversion factors. We relied upon dose conversion

factors in Federal Guidance Reports 11 and 12. We include the dose contributions of short-lived decay products, in those dose conversion factors and track long-lived decay products separately and added those at the end of the calculations.

Ingestion exposure as I said earlier consumption rates were based on the 1997 survey of Amargosa Valley. We held water consumption at 2.0 liters. Our model includes inadvertent soil ingestion and this is an important parameter as Maryla will be showing you later for technetium and iodine.

Inhalation exposure includes exposure of resuspended particles, aerosols for evaporative coolers and gaseous emissions. Evaporative cooler use calculated based on temperatures in Amargosa Valley currently and predicted future temperatures range from 39 percent of the year for moderate climate down to about 10 percent for the upper bound of the future climate. We calculated exposure for five environments based on employment characteristics. This is an important pathway for the actinides. Next.

This graph shows how we calculate exposure rates or at least summarizes it. We divided the population up into four groups based on census data from 2000. You saw this number earlier. Thirty-nine

percent of the population doesn't work. For the groundwater scenario, 39 percent of the population for this calculation works outside of areas potentially contaminated by use of groundwater for irrigating crops. Sixteen percent of the population work in that local environment and six additional percent work outdoors in soil disturbing activities in that environment.

In this slide on the right, I have a rather consequential mistake. This should be active indoors. This should be active outdoors. I have mixed those two up. I apologize for that. This shows that most of time people in Amargosa Valley spend their time indoors. Seventy-five percent of them more of their time is spent indoors with only a small part of their time spent active outdoors because only a small part of the population is involved in farming and similar activities. As I note at the bottom, we have different exposure rates for the volcanic ash exposure scenario because ash would be spread over a much larger area.

External exposure is calculated using those same time budgets and exposure rates and assumes the receptors expose to contaminated soils at all times within the referenced biosphere. Air submersion

and water emergence are not included because they do not contribute to the dose for any of the radionuclide substantially. We do include a shielding factor for indoor environments and this is an important pathway for only a few radionuclides such as cesium.

A summary slide on our parameter values. I believe it was 270 or so of the input parameters to this model were stochastically sampled. Our receptor parameters were based on distributions of mean values in accordance with 10 CFR 63312 and our environmental parameters are based on the entire range variation in the region.

Our goal was to select reasonable ranges of values when possible based on the site specific conditions and site specific population and to provide bounds that incorporate a reasonable variation in uncertainty. We tried to use conservative bounds only when there was great uncertainty such as for our radionuclide specific parameters, those transfer factors, bioaccumulation factors that I pointed out earlier in the presentation.

A summary of uncertainty, I believe that our conceptual model uncertainty is relatively low because we've included the relevant transport and exposure pathways. To discuss mathematical model

uncertainty, I will reference our model validation method where we compared our mathematical models to five other mathematical models calculation by calculation. We found that very few of those differences in mathematical methods among models result in a difference of greater than a factor of two when we use the same input parameters. So there is very low or relatively low uncertainty in mathematical methods and our uncertainty is in mathematical methods and therefore is similar to what we find in other environmental radiation models.

Finally parameter uncertainty. Our parameter uncertainty is relatively low for receptor characteristics and for some environmental parameters in agricultural practices such as irrigation rates and much higher for radionuclide specific parameters such as transfer factors.

Here is the only results slide that I'm going to present. The box shows 95th percentile and 100 percent or total range of BDCFs that have been normalized to the mean or divided by the mean value. Our total variation ranges from just over an order of magnitude for technetium and carbon to just under, well a half, to suggest under an order of magnitude for some other radionuclides.

Biosphere dose conversion factors for the future climate which are calculated using different input parameters for those few parameters that vary do not differ very much, four percent for carbon 14 and up to 20 percent for plutonium 239. So climate change is not a very important factor in biosphere modeling and Maryla will explain part of the reason for that during her presentation this afternoon.

Finally our summary. We have a new biosphere model. The environmental radiation model for Yucca Mountain. It's based on site specific information about the biosphere and population. It includes relative transport pathways and most of the uncertainty in our model was associated with input parameters, particularly those that are radionuclide specific.

VICE CHAIRMAN RYAN: Thank you, Kurt. That was a great finish. Hopefully when we hear Maryla's presentation we can maybe ask you both questions after lunch.

DR. RAUTENSTRAUCH: Thank you.

VICE CHAIRMAN RYAN: I guess at this point we've had a request for a comment at this point from the middle of the audience. Steve Frishman is here and would like to make a comment.

MR. FRISHMAN: I'm Steve Frishman with the State of Nevada. I'd like us just to do a couple of observations on what's happened up until now and start out with a question. This is for you, Dade. You mentioned fairly early this morning when there was a discussion of whether it's Amargosa Valley for the RMEI or whether it's the town of Amargosa Valley. You said that you thought there was a difference. How did you come to that conclusion and what difference do you think there is?

DR. MOELLER: My comment was based upon the following. I realized in the 1997 Food Consumption Survey that they surveyed the entire Amargosa Valley as well as the regions out to 50 miles in all directions from the site of the proposed depository in terms of the Amargosa Valley I think if I had done the survey I think that I would have done the same thing that was done in that 1997 report, namely do the entire valley because the number of people was so small, the total, that I would be searching for as many people as possible. I would gather that probably anyone who lived within the Amargosa Valley would be of interest in terms of computing doses.

The reason I questioned the term was one

in terms of a regulatory sense. I'm not a lawyer. I just was trying to think through that if at some time later when the license application is submitted and some lawyer finds that they based the living styles on the people within the entire Amargosa Valley whereas the regulations state that it should be a typical resident within the town of Amargosa Valley. See I assumed since the regulations said that that was a town. However we heard a few moments ago that there is no town. Does that respond?

MR. FRISHMAN: Yes, because I was thinking about it in the broader terms of the regulatory question of who is the RMEI. It's correct that there is no town. There is a political subdivision of Nye County which is under –- The way things are divided up in Nevada there's a township and there is a town board. That town board is drawn from all residents of Amargosa Valley. So I think the regulatory distinction for town versus Amargosa Valley probably without argument goes away. Then you look at the entire population of Amargosa Valley for your base.

I was interested to hear because I thought that you probably were going on that about the reliance on the 1997 survey. That survey from at least our observation should not be relied upon.

There should be a new survey and a new survey that is done in a much more definitive way than that survey. That survey among other things appears to have missed the entire Hispanic population of the valley because they don't have telephones. It also appears to have missed the fact that there are people in the valley who do grow a lot of their own food and they also coincidentally don't have telephones.

That survey also if I remember the results that are used in the model are weighted results. They are some mixture of the results for Amargosa Valley as well as the other areas that were sampled even as far away as the other side of the Nevada test site I believe. So the real thing I'm getting at is I think that it probably is very fairly closed to say the bottomline that was in that last talk. The rough difference that can be made over all of these different variables associated with the biosphere. But it seems to start with who you think is the RMEI. That seems to be the biggest factor because then what you're doing depending on who that RMEI is you're stacking more and more or less and less uncertainties.

So I think it's important that before you get into the varied details of how everything is calculated out you need to first understand who it is

that you're talking about. The rule has never been satisfactory to me in terms of being prescriptive enough to where we're not going to end up in an argument over who the RMEI is if we get down to having to argue this in a licensing hearing. I think it's important to maybe come back at some point and dwell on that not necessarily in terms of guidance to an answer for both DOE and the NRC staff, but in terms of guidance to what the intricacy of that question really is.

One other point that I thought was interesting. I think, John, you mentioned that it was important to look at uncertainties in two major areas, one of the being the transport release area, the other one being in the biosphere area. It is important to do that but also the idea that you can separate them is not entirely true because you get into this question of the significance of the difference depending on whether you're talking small amounts or large amounts.

Just as an example if you look at some factors like the difference between what was proposed in Part 197 for the acre feet of water in which to dilute the radionuclides, it was proposed if I recall that 1460 or 1480 acre feet. It ended up in the final

rule at 3,000 for reasons that were not entirely clear. But at the time, my judgement was "Well it's only a factor of two" and that's pretty small compared to the overall uncertainty in the system which is true.

But a little later on, you do things like look the one on and one off calculations. Look at what the release of technetium would be if you had no containers and convert that using the dose conversion factor that DOE used, put all that technetium into first availability. Then just use DOE's release model. What you end up with is technetium alone exceeding the groundwater standard and also exceeding the individual standard by a relatively small amount. But that's putting it all into 3,000 acre feet of water.

If you take the 1460, well then you're exceeding it by twice that amount. So when you're dealing with looking for uncertainties in the two areas of analysis, release and then converting that release to dose, with this system and its complications, you have to look at the two of them together at points where they really are significant, where they really do make a difference. Technetium was one that became pretty obvious once you do a very

simple calculation.

VICE CHAIRMAN RYAN: Steve, that's a little risky because you're mixing bounding calculations and nominal calculations by making the assumption that all the Technetium enters the system directly instantaneously at the beginning. That's a bounding analysis. So I'm cautious.

MR. FRISHMAN: No, I'm not dumping it all in there. All I'm saying is --

VICE CHAIRMAN RYAN: That it all becomes available.

MR. FRISHMAN: It all becomes available because there are no containers.

VICE CHAIRMAN RYAN: Right.

MR. FRISHMAN: So it becomes available at whatever rate it becomes available from its solubility and so on.

VICE CHAIRMAN RYAN: I think it's risky because that bounding case arbitrarily assumes containers go away.

MR. FRISHMAN: I was hoping you would ask because the answer to that is a real simple one. That's that because of the half-life of technetium the same thing will happen at 100,000 years out.

VICE CHAIRMAN RYAN: But it's a rate

process. So again I'm just very cautious to try and take a bounding type assumption and then apply it to a nominal calculation. That's a risky thing to do.

MR. FRISHMAN: It's not bounding because we know the container's going away and the number they used in the current model I think is like 13 percent.

VICE CHAIRMAN RYAN: At the rate of release from becoming a container failure model is really --

MR. FRISHMAN: You saw how steep that was. Very, very steep and people remarked on how steep it was. As soon as you start failing those containers, the release becomes very steep. So I disagree. I don't believe it's bounding. It's a statement of reality. It's just a matter of when. I say you take them all away at the beginning because of the half-life of Technetium. It's really no different if you take them all away later. The same thing happens.

VICE CHAIRMAN RYAN: -- results later.

MR. FRISHMAN: Why would you?

VICE CHAIRMAN RYAN: I don't.

MR. FRISHMAN: You do.

VICE CHAIRMAN RYAN: I guess I misunderstood.

MR. FRISHMAN: Look at the release curves.

But my point is that there are ways of showing that the site regardless of when you look at it. If you took away the 10,000 years, there are ways of showing that who the RMEI is and the way you mix the uncertainties add up to numbers that in fact are make-or-break numbers or sometimes really way beyond accedence of a standard and something that no one would ever propose as a standard in the first place where you can run doses over a factor of two, higher than the standard by putting together these combinations of things that right now the performance assessment shows happen but only show happen beyond the loss of the waste container. So the separation is an important one, but also putting them back together and how you put them back together and who you impose that on add up to numbers that are not in this realm of worst case to worry about. They are numbers that the performance assessment says are not unlikely. It's just a matter of when they are going to happen.

CHAIRMAN GARRICK: Yes, but when you put them back in the context of the period of compliance it still looks like a bounding case to say that --

MR. FRISHMAN: Well, there's a period of compliance but there is also the period when you have to look hard to make some judgments about how this

site works and that goes out to the period of stability.

CHAIRMAN GARRICK: Right.

MR. FRISHMAN: That's an error I believe in the EPA's rule, but we won't go into that. If you are going to make a reasonable expectation type judgment the only reason to look at that period beyond the period of compliance is to learn everything you can and find out what's reasonable. If the site is beyond the period of compliance is going to go vastly out of compliance then that analysis is necessary and tells you something. What it tells you in this case is that the container is the compliance mechanism.

I think there were questions about why are the median and the 95 percent so close together or appear to be. They partly appear to be close together because you're dealing in orders of magnitude and they partly are close together because when you get failures you get big failures. What that tells you once again is that the failure mode is the container. Because if you get a container failure, they're big. You saw the dose curve for just one container. Suppose there were ten. You could see it. You're high enough on the curve. You could see it. If there's 100, it's high on the curve so you could see

that. The failure mode that drives the appearance and questions like "Why is the median and the 95 so close" is because it's an phenomenon the container. It's linear when it fails, linear in terms of if you fail ten times more the dose is ten times more. That's enough observations for now.

VICE CHAIRMAN RYAN: Okay. We're have a couple more opportunities during the day. So we'll hear from other members that might want to speak. That's brings us to the close of our morning session. We now have a one hour and six minute lunch break scheduled. We'll reconvene at 1:00 p.m. Thank you very much. Off the record.

(Whereupon, at 11:51 a.m., the above-entitled matter recessed to reconvene at 1:02 p.m. the same day.)

VICE-CHAIRMAN RYAN: If we could get everybody convened, please? We will start our afternoon session. We have presentations. I think first up is Mr. Pat LaPlante, senior scientist from the Center for Nuclear Waste Regulatory Analyses.

MR. LaPLANTE: As he mentioned, my name is Patrick McPlante. I work for the Center for Nuclear Waste Regulatory Analyses. We are the technical support contractor for NRC in the high-level waste

program. Today I am going to provide an overview of biosphere pathway analyses supporting NRC's pre-licensing activities.

Next slide, please. In general, I am just going to provide an overview of the biosphere model. Then I will discuss key radionuclides and exposure pathways.

Before I start, I would like to emphasize the NRC role with the biosphere modeling is to develop review capabilities to review NRC's license application. In this regard, the aim is to develop flexible tools and to develop a basic understanding of system behaviors.

Next slide. As you know, biosphere modeling requires an understanding of site characteristics. DOE already did a fairly good job at outlining the characteristics of the Yucca Mountain region.

I provide this chart. Yucca Mountain site is here. And approximately 35 kilometers to the south is the Armagosa Farms area, which is the nearest populous center to the south along the flow path, as we have seen it in previous presentations.

In general, this area could be characterized as a rural residential farming

community. As we have seen in previous presentations, there is livestock and farming activities as well as gardening and so forth. The characteristics of the area help us conceptualize potential exposure pathways from postulated release scenarios.

Next slide, please. Once we have conceptualized the potential exposure scenarios, we have to implement those exposure pathways in a biosphere model. This flowchart provides sort of the basic outline of the processes that we are modeling in our biosphere model. We can start with either contaminated groundwater or contaminated soil.

This chart tends to emphasize the groundwater, but we start with a soil concentration as well as a groundwater concentration. The pathways are fairly obvious. They are probably familiar to most.

We have direct drinking water ingestion, irrigation of crops and livestock. To be complete, there probably should be an arrow between crop concentration and livestock. And we have resuspension of soil leading to inhalation and external radiation dose.

In the ingestion dose calculation, there is much more detail that is shown there. We can estimate intakes for a variety of food products,

including eggs, meat, milk, leafy vegetables, root vegetables, fruits, grains, as well as soil ingestion.

Next slide, please. So we implement this biosphere model. Most of the pathway models are based on the GENII, Version 1.485 dose code. We're only using the executable portion of that code that calculates the intakes. And then we're doing the conversion to dose using the federal guidance dosimetry values within our TPA code.

We have also developed a separate mass loading and inhalation model for the ground surface igneous activity exposure scenario. We wanted to refine the model a little bit more than what was in the GENII code. And so we account for factors such as ash blanket thickness, impact on mass loading. If you have a very thin ash blanket, you will be resuspending clean soil along with contaminated ash.

We also have a time dependence, a time-dependent mass loading value. The literature shows that over time as the fine resuspends, mass loading will decay exponentially over time to somewhat of a steady state.

We also account for loss routes from the soil, including erosion, leeching, and decay processes. And we have developed a human

activity-weighted soil disturbance and exposure model, essentially different types of disturbances, high, medium, low, and different levels of exposure, how much time do you spend outdoors and indoors and so forth?

Next slide. I already mentioned the federal guidance values. Chris McKenney will be discussing the dosimetry in much greater detail in his following presentation this afternoon.

So in order to run the biosphere model, obviously we need to come up with a number of input parameters. In general, the objective is to enhance realism by using site-specific parameter values where possible and try to avoid implausible assumptions within the context of the regulatory requirements and the somewhat abstracted nature of the model.

To give you an idea of the magnitude of the modeling effort, we have about on the order of 600 individual numbers that we have to come up with and input into this model.

A number of these are radionuclide and element-specific. And since we want a flexible model where we have the ability to model doses from 43 radionuclides as well as which are comprised by 26 elements, it is worth noting that even though there is

a large number of input parameters, few of them are highly significant to determining the dose. But we need to come up with them anyway.

I am not going to go into the parameters in detail, but I have provided this list of parameter categories with parentheticals sort of paraphrasing the general type of information sources that we are using for those parameters. And if people have additional questions, perhaps we can do that after I finish.

VICE-CHAIRMAN RYAN: Will you take a general question?

MR. LaPLANTE: Sure.

VICE-CHAIRMAN RYAN: It is interesting that you looked at a variety of sources. And obviously some thought has gone into perhaps different sources and you pick one. When you develop, for example, mass loading factors, do you actually get a specific value or do you try and get a distribution?

MR. LaPLANTE: Oh, yes.

VICE-CHAIRMAN RYAN: A sampling distribution?

MR. LaPLANTE: We are sampling a distribution. And that is a parameter that, as I will discuss a little later, is fairly important in the

calculation. And so we are continuously looking at data and trying to get the best characterization for that value.

If you look at the literature, obviously it can range about eight orders of magnitude.

VICE-CHAIRMAN RYAN: Sure.

MR. LaPLANTE: So depending on the situation, it becomes a little more complicated when you are dealing with volcanic ash, which is a very fine particulate.

There aren't a lot of people out there collecting mass loading data on volcanic ash. So you have to look for analogues and so forth.

VICE-CHAIRMAN RYAN: Is it fair to say just again in general that all of these kinds of categories, you are looking for not only the best value but what is the nature of the distribution of appointed values and circumstances?

MR. LaPLANTE: Oh, yes. From the very beginning, we have been doing this biosphere modeling since the early '90s.

VICE-CHAIRMAN RYAN: Right.

MR. LaPLANTE: And we started off with the idea that we would try to characterize the uncertainty and variability in the input parameters.

This slide provides some additional aspects of our current approach. Most of these could be called assumptions. It is important to qualify that these shouldn't be interpreted as expectations on how DOE should be doing the modeling. These are just how we are presently doing the modeling to give you an idea of basically how we are doing it.

I have listed the first bullet. Inhalation dosimetry, as you know, assumes a mean particle size of one micron. We are certainly aware that the air transport at deposition and mass loading models that we are using generally apply to larger particles.

And so essentially we are putting more mass into the air for inhalation, but we are assuming that its finer particles when we run the inhalation dosimetry. That is a conservative approach. We are currently looking into getting better estimates on how conservative that actually is, but that is how we are doing it at present.

We are also assuming adult dosimetry. We have gone through that before, earlier in the morning. The third tic sounds very conservative, but it should be put in the context of most of the key radionuclides that are dominating our dose do not have choices for

chemical form as it impacts the dosimetry in the federal guidance. So, for instance, americium-241 and tritium-247, technetium-99, iodine-129, there is only one value in the federal guidance. They don't provide D, W, or Y solubilities.

And so this assumption doesn't apply to those. Those just happen to be terminating the dose. So it is conservative for some of the other radionuclides that aren't dominating the dose, but, then, if it is not dominating the dose, then it doesn't really matter.

VICE-CHAIRMAN RYAN: Let's kind of boil that question down because that is an example of an important one, I think. Is the guidance based on W class for americium and plutonium? Is that right?

MR. LaPLANTE: Let's see. I wrote down some notes. I believe plutonium does have a choice, and it is W or Y.

VICE-CHAIRMAN RYAN: Okay.

MR. LaPLANTE: But the difference between W and Y for plutonium is about 35 percent at most.

VICE-CHAIRMAN RYAN: Right.

MR. LaPLANTE: So that is the only one that has a choice. I can't remember what exact solubilities there were. All I know is that there

were only single values.

DR. ECKERMAN: Strontium would be a choice. Titanate, strontium titanate, is N-11 because of its importance occupationally.

MR. LaPLANTE: Right.

DR. ECKERMAN: I don't remember which one has been --

VICE-CHAIRMAN RYAN: I'm thinking specifically about the ignitant. I am thinking that if something comes out with that temperature, it is probably going to end up as a Y class article. I guess I am sensitive to the fact that if you were constrained to use a W class conversion factor, you could be off by a factor of 50.

MEMBER HORNBERGER: Did I just sleep through that chemistry freshman class when they talked about W and Y and N-11? What is that?

MR. LaPLANTE: These are solubility, body, essentially body solubility, for materials going into the bloodstream.

VICE-CHAIRMAN RYAN: If it would help, I will let Dr. Eckerman answer. He is the authority.

MR. LaPLANTE: He would probably be the best person to answer.

DR. ECKERMAN: This is a case where the

system has changed in time, too. D, W, and Y referred to clearances, half-times from the deep lung. And so an aerosol that was classified as a D class aerosol would have a residence time in a deep lung on the order of days and weeks and years.

It is a real gross classification. It includes both the mechanical clearance as well as absorption, the later lung models that were current state-of-the-art, as we separate those and talk about another classification that relates simply to the absorption, to the chemistry. And you would have probably had that lecture in today's systems.

That was it. So it is just a way of classifying aerosols.

VICE-CHAIRMAN RYAN: But the new system is kind of independent of what is done here because that has not invoked the regulations.

DR. ECKERMAN: Yes, right.

VICE-CHAIRMAN RYAN: It is best practice, but it is not what the guidance is based on if I recall right.

MR. LaPLANTE: Yes. The practical aspect from a modeler standpoint is if you have got three choices based on different solubilities of the material, you need to decide what is the chemical form

of the material that is inhaled and make that consistent with the choices you have, D, W, or Y.

And what I was trying to point out was for most of the radionuclides that are important, given a choice, in those where we do have a choice, this bullet is saying we are choosing the one that causes the highest dose because there are so many uncertainties in determining the chemical form of the material more so, I think, for a groundwater pathway, for the material.

You have an idea what it might be in the groundwater in terms of chemical form, but when you spray it into the air, it could react. It could react with the soil. It could react with the plants. It goes into the plants. It could be transformed.

There are all kinds of places for that chemical transformation to occur. And so it becomes a very uncertain process to determine, well, what is chemical form once it goes into a food product that somebody eats?

Rather than get into that level of complex chemistry, a lot of modelers just assume the higher values.

VICE-CHAIRMAN RYAN: That is risky, I think. Let me tell you why. I think if you just pick

a single value and assume it because it is conservative, that is inconsistent with what you have done in all of the other categories, where you have sampled some distribution.

Now, you can at least construct this in your mind and whether it makes sense or not. You would be the judge.

MR. LaPLANTE: Right.

VICE-CHAIRMAN RYAN: You take the soluble and the insoluble numbers. And you sample between the two.

MR. LaPLANTE: Yes.

VICE-CHAIRMAN RYAN: Why do we pick multi single value dose conversion factors when we sample every other parameter? Why do we pick one micron and not sample across a whole range of particle sizes? Particle size has a huge swing in dose conversion factor, too.

MR. LaPLANTE: Right. Well, one of the reasons we don't sample the dose conversion factors is because the reports that provide them don't really have much of the uncertainty information documented.

It is true that for D, W, and Y, you understand there is a range there and you could do some sort of sampling.

VICE-CHAIRMAN RYAN: The way to adjust those is fairly well-established in current practice. I just wonder why we single them out as single values of the conservative.

By the way, if something is extremely conservative, it is not conservative. It is wrong.

MR. LaPLANTE: Yes. But if it is extremely conservative and the licensee demonstrates compliance of that calculation, then is there a need to spend money in research?

VICE-CHAIRMAN RYAN: Why do we do it two ways? Again, I say that rhetorically to think about it as we go through the two days. But it is an example where we do something different without really in my view justifying why that different approach is okay.

MR. LaPLANTE: Right. It is definitely not informative. If you fail the standard and you are conservative, it doesn't tell you anything other than you need to do more precise modeling to see if --

DR. ECKERMAN: Part of the differences that are introduced here comes from the occupational experience. In the occupational setting, you knew what the compound was that the worker was dealing with. So you could pick a chemical form and deal with

it.

The difficulty here in the environment situation is that the radionuclide probably is a trace component to the aerosol. And so the characteristic that you have brought to the table from your occupational experience really has nothing to do with the problem.

VICE-CHAIRMAN RYAN: It is all the more reason to sample.

DR. ECKERMAN: All the more reason to sample, all the more reason to question the applicability of that particular set of dose coefficients that we have got.

DR. KOCHER: A similar issue for your volcanic ash is all of these lung models assume that your radionuclides are attached to the surface of particles.

MR. LaPLANTE: That is true.

DR. ECKERMAN: No. It's volume-distributed. They are all volume-distributed. The radionuclide is sitting in the volume of the particle, not on the surface.

Otherwise, that's the assumption when you calculate the activity media distribution of aerodynamic diameter, that the radionuclide is in the

volume of the particles that you measured with your cycle.

VICE-CHAIRMAN RYAN: John?

DR. TILL: Well, this is a discussion that I would like to have. The question is this, exactly what is assumed to be uncertain in these calculations and what is not? What is assumed to be a fixed value? Okay?

I mean, that is something I would love to see a list of. And I would like to see the assumptions regarding whether it is uncertain or not and the rationale for the decision.

Now, I personally believe that those conversion factors themselves ought to be fixed. I personally believe that all of the parameters associated with the hypothetical scenario in the future that you are assuming is fixed, like two liters of water, is fixed and that all of the other values that characterize that scenario should be fixed, not the environmental coefficients but things like breathing rates, ingestion rates.

And that also includes the dose conversion factors because uncertainties come in differences in human beings. And we have got hypothetically a single person out there.

This is a key philosophical but scientific question that I think we need to talk about, the commission needs to consider, and all of the people doing the calculations need to make it very clear. So maybe we can come back to this.

VICE-CHAIRMAN RYAN: Yeah, I think we can. And I agree with you. I would probably agree with everything you said except just think about the fact of what Keith said with regard to dose conversion factors.

In the workplace, I feel very comfortable saying they are fixed because that is a relatively narrow range of environmental possibilities. It is usually very dilute to us. It is usually very specific.

We can kind of hone in on solubilities and things like that, but when you take it into a chronic outdoor environmental setting, I am not too sure that sampling wouldn't be at least informative of potential doses over things like ranges of solubility or ranges of particle distributions into which the activity is distributed.

DR. TILL: To me, that is different, Michael.

VICE-CHAIRMAN RYAN: Okay.

DR. TILL: I mean, when you talk about whether it is a soluble compound or an insoluble compound, I agree. Okay? You deal with that separately. Okay?

VICE-CHAIRMAN RYAN: Right.

DR. TILL: But now it's one or the other. What dose conversion factor do you use? You use one value is what I see.

VICE-CHAIRMAN RYAN: I am not sure we will know that answer. It is one or the other.

DR. TILL: Yes, right. I see what you are saying, but we need to discuss this.

VICE-CHAIRMAN RYAN: We may or may not. I mean, that is a great question, and I am sure our current speaker is going to give us a full and complete answer.

MR. LaPLANTE: I am moving in the direction of talking about uncertainties, but I am not quite there yet.

CHAIRMAN GARRICK: There is one thing we want to be very much on guard for. That is you don't take away uncertainties by taking a variable that has uncertainty with it and making it constant.

You see that all the time. You see people writing about uncertainty. And then you see something

there that you wonder how come it doesn't enter into the uncertainty. And you discover in many cases, "Well, it was assumed to be a constant." Well, that is masking the uncertainty. We don't want to do that either.

DR. THORNE: If I could comment, I think you don't have to mask it. What you can do is to move it into another category.

CHAIRMAN GARRICK: Yes.

DR. THORNE: For some of these things, it may be better to do a sensitivity analysis, where you move from, say, class D to class W and do an alternative calculation, rather than folding it into a PDF distribution function, which you know even less about than you know the fact that it could be either D or W.

VICE-CHAIRMAN RYAN: And that is the alternative, is it not, sensitivity study? Maybe it is the blend of PRA-type approaches to insensitivity studies to really get at things. So let's hold those questions and press on.

MR. LaPLANTE: Yes. It does become more of an issue with things perhaps like transportation accidents, where you are just blowing out a lot of radionuclides, immediately out into the exposure

realm; whereas, like for a groundwater transport pathway for this program, we have relatively few radionuclides actually making it to their receptor locations.

VICE-CHAIRMAN RYAN: More importantly, it is chronic versus acute.

MR. LaPLANTE: Right. Okay. To keep going here, we don't explicitly in our model correlate the soil leeching parameters with the plan update parameters. It is obviously a good thing to do.

The data itself that we are using may have some implicit correlation in there, but this could lead to the situation where elements that absorb to the soil could be more available for plant uptake because they are in the root zone.

And, in reality, if they are absorbed to the soil, they may be locked and wouldn't go into the plant. So that is somewhat conservative there.

We haven't gone into the level of detail necessary to resolve that just because the pathway in the total system calculation is not particularly important.

The radionuclides leech below the roots on exit at the biosphere. That is just sort of a given assumption. In our experience, first use, pathways

tend to create the highest doses. So we don't feel a need to account for the material that is leeched out of the root zone.

We have no washing of harvest or crops, no filtering or treatment of water. And we assume 15 years of irrigation deposition before exposure. That 15 years could be compared with the DOE approach that was discussed at length, where they take it to equilibrium, I guess, as they called it.

They will irrigate. If it takes 1,000 years to reach equilibrium, they are irrigating for 1,000 years. We just made the assumption that 15 years of farming seemed reasonable and leave it at that.

Okay. Next slide. As I mentioned before, we do run the biosphere model stochastically. And we do try to propagate as much uncertainty that we know about in the input parameters. Essentially we run the model iteratively with sampled input parameters to create variable output.

As I said, we are sampling. Essentially we have done sensitivity analyses in the past, trying to propagate as much uncertainty as we can in the input parameters. And then we identify the important input parameters.

And the model that we currently have in our TPA code, we are sampling essentially all of the parameters we found to be important in those prior sensitivity analyses except for those that are fixed by regulation or are the dosimetry factors that we just discussed.

This chart here gives you an idea of the variability that is propagated only through the biosphere calculations. And this is for iodine-129 dose calculations. This should be a little bit wider than some of the other radionuclides but generally representative of the amount of variation that we propagate.

As you can see, this is less than an order of magnitude. It is lower. It is low relative to other abstractions in out total system performance, system model.

This is essentially why the biosphere, at least for the groundwater release pathway, doesn't tend to be particularly important in the total system calculation because this level of variation isn't significant given all of the other variation going on within all of the other abstractions in the total system calculation.

Now, there would be more variability in

the igneous activity biosphere calculations with mass loading and so forth, but this is for groundwater.

Now, the next three slides, I am just going to run through an example analysis for how we would determine key exposure pathways in the biosphere. In this example, we start off with doing just a base case stochastic total system performance assessment calculation with our code. And then we identify the key radionuclides that are driving the dose calculation.

Here we see we have technetium is over half of the dose and neptunium and iodine are the remainder.

DR. MOELLER: Is that for the first, what, 10,000 years?

MR. LaPLANTE: Ten thousand-year calculation expected dose, sort of a base case, fully stochastic calculation.

VICE-CHAIRMAN RYAN: Dose in the 10,000th year?

MR. LaPLANTE: Generally, yes, it is. It tends to go up with time.

Once we have identified the key radionuclides, then we can look at the biosphere dose results stratified by radionuclide and exposure

pathway to get an idea for those important radionuclides with exposure pathways for dominating.

In this case, we can see for technetium-99, which is dominating our dose, the pathways that contribute to that dose are predominantly drinking water and crop ingestion. It is about 50 percent from each.

You see similar behavior for neptunium-237. And iodine is similar. Yet, there is a little more animal product consumption-related dose because iodine is more mobile in those systems.

So the conclusion from this is, well, for these radionuclides to dominate the dose, the important pathways are drinking water and crop ingestion.

Now, DOE when they present these results, you will notice they will be somewhat different because they have recently changed their crop ingestion input parameters to be lower. And so that crop ingestion pathway becomes deemphasized. I think inhalation tends to become more important, inhalation and drinking water, in their calculations.

Next slide, please. If we do a similar type of analysis for the igneous activity release scenario, we see that the key radionuclides -- and

this would be for an early eruption, around 200 years -- americium-241 tends to dominate the dose with the remainder of the dose dominated by the 3 plutoniums.

Now, since americium has as shorter half-life than plutonium, if you have later eruptions, the plutonium will tend to dominate almost completely after the americium has decayed away from the inventory.

With this, the early eruptions tend to drive the expected dose from igneous activity. So this would be representative of the dose results.

Now, for these radionuclides in this particular calculation, the pathways that dominate are inhalation, basically. It is over 90 percent for each radionuclide. So that is basically the insight there.

VICE-CHAIRMAN RYAN: If I understand, you are allowing inhalation all the way up to 100 microns.

MR. LaPLANTE: Well, like I said before, the mass loading model, I believe, is capturing particles that could go up to 100 microns, yes. And so we are inhaling more particles, essentially more mass than the dosimetry model would.

VICE-CHAIRMAN RYAN: And, again, I defer to Dr. Eckerman's knowledge, but there is a mechanism to make that calculation. I guess at some point it

becomes an ingestion, not an inhalation.

MR. LaPLANTE: Right. Larger particles, I think generally above 20 microns, get trapped in the nasal pharynx. And then --

VICE-CHAIRMAN RYAN: You swallow.

MR. LaPLANTE: Swallow. An ingestion dose is I think generally a couple of orders of magnitude below inhalation. And so --

VICE-CHAIRMAN RYAN: Particularly if it's insoluble.

MR. LaPLANTE: Within this calculation, that becomes sort of a loss mechanism that would lower the dose.

VICE-CHAIRMAN RYAN: But do you do that? I mean, do you assume it's inhaled or do you --

MR. LaPLANTE: We are not explicitly accounting for the ingestion portion. So, like I said before, the inhalation calculation is conservative. And we are currently looking at an alternative dosimetry model, some of the later models that have been developed by CRP, to try and get a better handle on how much are we overestimating that if we use more refined models to account for some of these processes, like the nasal pharynx ingestion?

DR. MOELLER: Could you go back to number

10, the previous one?

MR. LaPLANTE: Sure.

DR. MOELLER: Do any of them have inhalation or direct exposure? You know, it is a little difficult.

MR. LaPLANTE: Oh, yes. Well, I guess the thing about this that I didn't mention is those two pathways, crop ingestion and drinking water, generally dominate the dose so much that you don't even see the direct exposure and the inhalation for the groundwater pathway. It's there, but that is why it is on the key. Those are the pathways we model.

VICE-CHAIRMAN RYAN: We have a question, I think, from Chris McKenney.

MR. McKENNEY: No. This is Chris McKenney for the staff.

It is more of a comment on the other side, which was the other side, of course, for the mass loading issue, there are two sides. We can have dose conversion factors of different particle sizes.

But, in addition, we have to first be able to differentiate the mass loading for different size particles, too. And we are currently investigating how much that can be done and what sort of level data we can justify partitioning the mass loading into

different particle sizes because that is what is really the heart of the matter.

You have to partition the mass loading factor, first of all, so that you can come up with what are you going to compare to the different dose conversion factors.

I mean, both are theoretically possible, but whether you can get more volcanic ash with a justifiable partitioning of the mass loading term is a real difficulty.

VICE-CHAIRMAN RYAN: Thank you.

MR. LaPLANTE: Okay.

DR. MOELLER: Again, one of the evaporative coolers included in the groundwater is inhalation.

MR. LaPLANTE: We don't have that model directly in our TPA code, but we have done analyses off-line. We actually in the past based on our analyses, it didn't come up as really, really important, but it was important enough to ask DOE to consider that. And so now they are modeling it.

Next slide, please. In summary, the important biosphere pathways include inhalation and resuspended volcanic ash and consumption of contaminated drinking water in local crops.

Obviously the biosphere pathway modeling is an ongoing activity. We have been doing it for a long time. It is a learning process. Risk insights five years ago were cruder than they are now. And we are continuing to develop some of these additional insights for the inhalation pathway, for example.

In general, the biosphere modeling supports our prelicensing review activities and prepares the staff for the license application review.

We are emphasizing, of course, protection of public safety as well as increasing realism, flexibility, and efficiency of our code. If we put all of the details in there, it will never stop running, uncertainty reduction and eliminating implausible assumptions.

The results, risk-inform our staff activities. Early efforts in biosphere modeling helped us develop the Yucca Mountain review plan, which was discussed in the first talk today, and focus our document reviews, which led to some of these agreements that I am actually going to talk about in tomorrow morning's presentation, risk insights and DOE document reviews or our reviews of DOE documents.

In general, our risk insights focus our technical work on the most significant and uncertain

areas. Some things can be very significant, but if they have no uncertainty, there is no point in going further with them.

VICE-CHAIRMAN RYAN: Ruth, did you have a question?

MEMBER WEINER: Yes. Pat, could you summarize briefly what the major differences between your approach and DOE's approach are?

MR. LaPLANTE: Well, I guess if I would have to give a general comment, I would say in general, we are modeling pathways in the biosphere in a fairly similar manner.

For years, they used the same code that we did. They recently just changed their model by inputting all of the mathematical models into GoldSim.

We just got that document. So we obviously haven't had a chance to digest this big, thick new biosphere model document. My understanding is they didn't radically change the mathematics, they just sort of implemented the models within GoldSim to allow more stochastic flexibility and so forth.

MEMBER WEINER: Are there any major differences in the assumptions that you make or, for instance, that you can point out that would lead to different results?

MR. LaPLANTE: I think if I look at the magnitude of like their BDCFs versus our BDCFs, I think they are generally pretty similar. In some cases, they may make certain assumptions for certain parameters that are quite a bit different than ours, but some things go up, some things go down. And they all kind of balance out. So I don't see any major differences.

Again, we just got a bunch of new documentation in. Much of the stuff we reviewed recently has just been to deal with the past comments that we had on the SR model. So we got the new documentation in and reviewed.

We reviewed the portions of those documents that related to our past comments. We did not do a complete, comprehensive review of all seven AMRs that recently were produced.

We are going to continue to monitor what they are doing and look for differences. I don't see any major differences. I did note the one thing. They changed the way they were averaging their survey data for consumption rates, for instance.

They used to choose a higher value based on, I believe, averaging among the group of people that is consuming the crops. Now they are averaging

among the entire population, I believe, whether they consume crops or not.

There are a lot of zeros in there. So it tends to lower the consumption rate. And that is what dropped out that leafy vegetable consumption pathway.

But since that drinking water dose calculation is largely fixed, 2 liters per day, it's just concentration times intake, and that is 50 percent of the dose. We are very consistent on that part of it. You don't have much to change in that other 50 percent.

VICE-CHAIRMAN RYAN: Let's turn our questions to the panel. Yes, please?

DR. DANIELS: I would like to ask, you may have spoken about it, but I am not clear. Are you using the internal capability of the GENII model to calculate the dose conversion factors or are you selecting them? Do you know a lot of the fed guidance?

MR. LaPLANTE: We're using the values out of the federal guidance. The GENII code basically has three executables in that package. The first one does input processing. The second one does the pathway calculations, which outputs intakes, curies per year for each crop type and all of that.

We are using that. And then we are multiplying the federal guidance values to those intakes to convert to dose within our TPA code.

The GENII code is a deterministic code. And we have got it linked into the stochastic sampling capabilities of our TPA code. So we include the GENII parameters as input parameters for our TPA runs. We can sample them, just like we can sample all of the other TPA parameters.

And it writes the input file for each realization for that GENII code, runs through the pathway calculations, gets the intakes, and then grabs the federal guidance values from a look-up table, multiplies it out, and gets a dose for each radionuclide and pathway. That is just for one realization. Then it just iterates over and over again.

So we are running the GENII code with unit groundwater concentrations just for that execution to get out of BDCF, but it is all pretty nicely integrated into the calculations. So the dose calculations are fully integrated into our TPA code.

VICE-CHAIRMAN RYAN: Any other questions?

CHAIRMAN GARRICK: I'm going to ask Ruth's question just a little differently. You qualified

your model at the outset with the expression along the lines that you were preparing yourself to review, rather than necessarily to model the biosphere. What did you do differently if you were not doing that?

MR. LaPLANTE: Well, I guess the point there was if I were a licensee, I would be more interested in developing my client's case. And, as you know, many licensees out there are using very simplistic and conservative models to make their compliance demonstrations for NRC licensing actions.

And they can make wildly conservative assumptions. And they don't have anything to do with reality, but if they comply with the standards, that could pass because it gives you confidence, gives NRC confidence that they are not underestimating the consequences.

Now, from our standpoint, we are preparing to review. We want to do things as realistically as we can to get a handle on what are the processes that are important in the biosphere, what should we focus on, what maybe do we not need to focus as much attention on. And I think that is sort of the distinction.

A licensee may not be that focused on modeling reality to demonstrate compliance. They look

at the standards, see what they need to demonstrate, and then do their modeling and make all kinds of decisions on which baskets they want to put their eggs in and where they want to spend their resources.

CHAIRMAN GARRICK: So your carbon-14 results would be different?

MR. LaPLANTE: Well, our carbon-14 results were not incorporated in the model. We used to model carbon-14, but we didn't see it as important for an individual dose calculation for this particular site.

So that was one of those aspects that we considered early on, and it didn't really make it into the final model.

CHAIRMAN GARRICK: Just one other question. You indicated that you considered 43 radionuclides and 26 elements. Was it the TPA that was the basis for your choice?

MR. LaPLANTE: Are you asking the radionuclides of the TPA code models to be consistent?

CHAIRMAN GARRICK: Yes.

MR. LaPLANTE: Yes.

CHAIRMAN GARRICK: Yes. Okay.

DR. DANIELS: Could I just ask one last question? Did you run the conservative deterministic case as well as a sensitivity?

MR. LaPLANTE: The conservative deterministic case? Which case are you referring to?

DR. DANIELS: Well, you mentioned that if you were a licensee, that you --

MR. LaPLANTE: Oh, okay. Did we pretend in our due bounding analyses?

DR. DANIELS: Yes.

MR. LaPLANTE: I think our biosphere modeling has evolved over the years. Like I said, we started looking at this closely in the early '90s. At the time, there were no regulations. I think what we had to go on were the WIPP regulations that were maximally exposed individual, I think.

So we started out with pretty conservative assumptions. Over the years, we have refined and backed away from unrealistic assumptions and so forth, but we have done those calculations early on.

So I think we started out pretty conservative. And as we go into more details, we are able to back off on the conservatism.

VICE-CHAIRMAN RYAN: Ruth? Jim? Questions? Thank you very much.

MR. LaPLANTE: Thank you.

VICE-CHAIRMAN RYAN: Next up, Maryla Wasiolek. Maryla's title is environmental transport

and receptor exposure pathways for the biosphere model.

7.1.2) PRESENTATION BY DOE REPRESENTATIVE(S)

DR. WASIOLEK: I am going to present pathway and parameter importance analysis or results of pathway and importance analysis for the DOE biosphere model, the model Kurt explained.

Next slide. Thank you. I will start off with presenting overall results of pathway analyses just to sort of put the whole presentation into perspective.

I will limit the discussion to the groundwater release. I am not going to discuss the volcanic case, just the groundwater case. The source of radionuclides is the groundwater.

Then I will discuss important pathways and important radionuclides for the important pathways and parameters for radionuclides that are identified by ACNW as a candidate for the discussion.

Our sensitivity and importance analysis results, we told them preliminary, although the model runs exist and they are documented. But we are currently working on the document that summarizes the results of sensitivity and pathway analysis.

Maybe as a brief answer to some comments

and sort of to put this discussion into perspective, our model is a similar model to the model that we had before.

We basically had explained it accurately. We took the core of our previous model and put it in the different shelling so we could make our model more transparent, we could show exactly how various pathways are modeled.

We have very thorough documentation of the model, including all of its input parameters. So it is really a lot of documentation, like just the description of how we developed distributions for the input parameters of almost 900 pages. And it is all online, just the most critical way.

Because the model is so complex, I mean, what we are going to discuss here will just barely scratch the surface. Whenever it is necessary, we will try to sort of pull the thread and try to get to the bottom of why we have certain pathways and certain mechanisms, transport mechanisms, that are more important than others.

This slide shows this is an overview of the pathway analysis results for the six radionuclides that were selected by the ACNW. And these are carbon-14, technetium-99, iodine-129, neptunium-237,

plutonium-239, and americium-241. They are in the order of increasing mass numbers. This will help us show trends that are in the behavior of the radionuclides and in the pathway importance.

The first thing that we can notice is that pathway ingestion, water ingestion pathway, is by far the most important, regardless of radionuclide. It is the one that is furthest to the left.

So the results are average percentage pathway contribution. These are average results because we run the model using 1,000 realizations. Every bar is an average of 1,000 results.

VICE-CHAIRMAN RYAN: At what time are these calculated? Closure? Because it is the 10,000th year?

DR. WASIOLEK: Oh, this is biosphere dose conversion factors.

VICE-CHAIRMAN RYAN: Oh, these are the factors?

DR. WASIOLEK: Yes.

VICE-CHAIRMAN RYAN: Oh, okay. All right.

DR. WASIOLEK: These are biosphere and their contribution. So we take a biosphere dose conversion factor for a radionuclide and dissect it into water ingestion component, other food components,

inhalation, soluble ingestion. And these would show percent pathway contributions for the BDCF.

MEMBER WEINER: How big is your uncertainty band there? Those are averages.

DR. WASIOLEK: I will show uncertainties for selected radionuclides later.

MEMBER WEINER: Thank you.

DR. MOELLER: In the first row, again, for tap water, what is 60 percent?

DR. WASIOLEK: Sixty percent of the BDCF for given radionuclides comes from the drinking water.

DR. MOELLER: Okay. I see what you mean. All right.

DR. WASIOLEK: So, for example, for technetium-99, 40-some, or 50 percent, -- it is a prospective thing here -- is from the drinking water and about 15 or 20 will be from leafy vegetables. So this is how to --

DR. MOELLER: So class horizontal and total --

DR. WASIOLEK: But it is in such a way of showing the results because we can see patterns among the radionuclides. We see the light radionuclides, those that are modeled in the environment, tend to have a relatively good appearance of ingestion across

the various food products that we consider in the model.

And then as we move towards actinides, ingestion practically disappears except for the groundwater. But what appears is we have this island here of inhalation, which is part of that. It is only 40 actinides. So there was a general pattern, ingestion for radionuclides like technetium, iodine, inhalation per actinides, and water for just about everybody.

VICE-CHAIRMAN RYAN: Is it fair to say that is driven by their relative environmental insolubilities?

DR. WASIOLEK: Oh yes, absolutely. Absolutely. That is exactly what this graph reflects, how they behave in the environment.

Could I have the next slide, please? This slide shows a very similar graph for the future climate, for the upper bound of the glacial transition climate.

What are the differences? Because we reviewed it last, the field of the radionuclides in the soil goes down. So everything that is related to the soil is pretty much suppressed. Water becomes more important became it is a factor that does not

vary.

So the relative contribution from the water pathway goes up, and everything else pretty much goes down: inhalation because it is driven by the concentration in the soil, also food consumption. But it is not a major difference.

DR. MOELLER: And, once again, the inhalation is due to these evaporative coolers?

DR. WASIOLEK: No. Well, I will get to the inhalation pathway later, but it depends on the climate. Evaporative coolers are less important for the future planet, but regardless of that, inhalation is primarily driven by the inhalation of particulate matter, not the evaporative coolers.

Exposure of the receptor is driven by the concentration of radionuclides in the environmental media the receptor comes into contact with. And also it is driven by the parameters which describe receptor exposure, such as assumption rates or how long the receptors dispense at a given environment or the nature of the contact of this individual with confining media.

So in the next slides, we will try to explore more into how important individual environmental transport pathways are in the overall

picture. And, again, the graph shows the same or suspect five radionuclides. Carbon-14 is not included. I will get to this in just a while.

So what this graph shows, these are fractions, average fractions, of radionuclide concentration in crops. This is only for the crops that result from a given environmental transport pathway. And for radionuclide transport to crops, we distinguish three environmental transport pathways, which is uptake by the roots and deposition by recessed particulates and deposition of irrigation water on plants.

That is the orange. Orange cylinders are doused. The next one, towards the background, is root uptake. Irrigation are the tallest blue cylinders, the bars in the back.

What we can see is that, by far, radionuclide deposition on plant surfaces dominates from the irrigation water. It is a dominant environmental transport pathway.

This again got averaged over four individual crop types that we consider crop types for human consumption, which are leafy vegetables, other vegetables, fruits, and grains.

VICE-CHAIRMAN RYAN: David, you had a

question?

DR. KOCHER: Yes. We are back to the equilibrium concentration business again because that is critical to this result. The irrigation water part of this calculation comes to equilibrium very quickly because -- I don't know -- mean residence time on a plant surface is 10 days, 20 days, something like that.

So the key here is what are you assuming about how long it takes to reach equilibrium in the soil because the longer it takes, the more buildup you get and the more important root uptake gets.

The irrigation part of it just sort of stays constant after a few days. Over time, the root uptake increases. So it is really critical what you are assuming for how long is this irrigation going on as root uptake occurs.

DR. WASIOLEK: Well, this is the part of our assignment that we tried to explain before the break.

DR. KOCHER: I understand how you do it, but what do you assume?

DR. WASIOLEK: How long it takes for the --

DR. KOCHER: Yes. How long did it take?

DR. WASIOLEK: It depends on the radionuclides.

DR. KOCHER: For example?

DR. WASIOLEK: Well, for technetium, it takes I think 20. We have a table. I don't remember the exact numbers, but these are like -- I don't know -- 20-30 years for technetium and maybe 1,000 years for plutonium.

DR. THORNE: If I could comment? I think there is a key question here actually, about the chemical form. I think when you do technetium, because this is a sandy soil, you are effectively assuming that it is the protectonate and, therefore, it has a low retardation and, therefore, it comes to equilibrium on the order of a few years.

DR. WASIOLEK: Yes,

DR. THORNE: Fundamental to both the technetium and iodine questions to my mind is the change in redux state as you move down the soil profile and the degree of change absorption that may occur as you move from technetium as protectant to CTO_2 minus.

I've gotten what you said this morning. You know, it is possible that availability decreases as Kd increases.

DR. WASIOLEK: Yes. Technetium is very sensitive to redux conditions. We assume the technetium is TCO_4 protectonate. And we do so consistently throughout the whole food chain. It also comes up as a problem or potential problem in animal uptake, whether it gets converted into TCO_2 or not, which is insoluble, which increases the intake. And if this question comes up later, I would be glad to elaborate on that.

So yes, we do assume that we have TCO_4, that we do not account for a possible reduction of TCO_4 to TCO_2 as it travels through the profile.

VICE-CHAIRMAN RYAN: I'm sorry? You did or did not account for that?

DR. WASIOLEK: Excuse me?

VICE-CHAIRMAN RYAN: You did or did not account for that?

DR. WASIOLEK: We did not account for that.

VICE-CHAIRMAN RYAN: Okay. Ruth?

MEMBER WEINER: Since your results are so sensitive to the chemical nature of the solubility, the equilibrium and so on, have you considered doing a distribution or a sensitivity analysis? What if you did use TCO_2? How would that make your results

different?

It seems to me this is a logical point for some sort of sensitivity analysis or uncertainty distribution because, really, you are making the assumptions which appear to drive your results.

DR. WASIOLEK: Well, there is a graph later on that shows how sensitive will the results be to how quickly the technetium is removed from the root zone. When I get to this point, I hope I will have answered your question.

MEMBER WEINER: Okay. Thank you.

DR. WASIOLEK: There is a graph of it.

VICE-CHAIRMAN RYAN: Yes, please?

DR. THORNE: I think I would like to comment on that before we get there because I think there is a conceptual modeling problem.

It is not a question of whether it is TCO_4 minus throughout the system or TCO_2 minus throughout the system. It is a question of whether within the soil profile there are transformations between the two and the storage compartment; that is, at the free acting surface and below, is actually TCO_2 minus and that is what retains it. But as the soil dries out and it becomes oxygenated, there is a conversion to TCO_2 minus. And plant uptake occurs from that phase.

It is the kinetics of that process that seem to me to be the question and not simply a one or the other.

VICE-CHAIRMAN RYAN: Other questions? Comments? Yes, John?

DR. TILL: So just to make it clear, plutonium-239, for example, is based on essentially 1,000 years of buildup in the soil --

DR. WASIOLEK: That's correct.

DR. TILL: -- through irrigation practices, right?

DR. WASIOLEK: That's right.

DR. TILL: Okay. This will be important later on in the calculation of the inhalation dose because that would affect it significantly.

DR. WASIOLEK: Absolutely, absolutely.

DR. TILL: So I think I understand now what they have done. I am not sure I agree.

VICE-CHAIRMAN RYAN: Well, let's ask Maryla to continue. I think we will have some of our questions as she goes along.

DR. WASIOLEK: So just to finish with this graph, root uptake is, for example, important for taking assume and not quite so for other radionuclides. And the importance goes down as the

atomic number goes up.

The deposition from dust is a relatively insignificant contributor. And it does increase as we go towards actinides just because there is a stronger accumulation in the soil for these guys.

Carbon-14 is not included on the graph because it has different transport mechanisms. And in the case of carbon-14 transfer to crops, almost 100 percent is from air, from the air. And very little of it is through the roots.

VICE-CHAIRMAN RYAN: David?

DR. KOCHER: Are you aware that somebody has actually measured root uptake of carbon-14?

DR. WASIOLEK: Well, we found a few articles I think with Shepherd.

DR. KOCHER: Yes, quite illuminating.

CHAIRMAN GARRICK: How so?

DR. KOCHER: Well, BV is on the order of .1 to 1. So, I mean, I think this assumption just isn't right. Carbon is not magic. It works just like everything else with a few exception. It buffers in water. You know, not everything does that. Not everything makes bubbles in champagne.

In terms of behavior in the environment, it is very little different from other things. And it

gets absorbed through the roots just like everything else.

DR. THORNE: I think the other thing, though, is irrigation is quite an interesting question because if it is also in the soils, though, and you have capture under the canopy, when you put a canopy in front of it, you have got your prior concentration.

DR. WASIOLEK: This is exactly what we do.

DR. THORNE: So there is a driving force the other way for the enhanced folia uptake simply because the concentrations are seen as enhanced in that sub-canopy atmosphere. That is only at the stage that you have got a mature aplomb with a fully fledged canopy.

I think it is a difficult one to model.

DR. WASIOLEK: Yes. This is exactly what we do. We allow carbon escape from the soil. We assume a mixing cell in which we predict wind velocities that are for the canopy. So they are much lower.

Not much mixing occurs because we model it as wind speed in the new surface environment. And we let the plants absorb carbon from that mixing cell.

DR. THORNE: That is what I did. That is what brought it up, the same thing.

DR. WASIOLEK: Right or wrong. Animals. For the animals, I couldn't have lumped them all together, the animal products, which is meat, milk, poultry, and eggs. These are four animal products considered in the model.

I couldn't have lumped them all together like I did with the crops because there were just more differences between them, pretty much between meat and milk and poultry and eggs. That is why I divided them into two graphs.

What we can see is that for meat and milk contribution from animal, feed is the most important. And the importance goes down with the atomic number of radionuclides.

Consumption of soil goes up with the atomic number, again, for the same reasons that we pointed out before. And the water ingestion is not a very significant pathway. By the way, soil ingestion is a new pathway that we added to the model that we did not have before in the JNES because JNES just did not have the staff link. And it turns out that it is quite important.

JNES only has feed and water. And, as you can see, especially for poultry and eggs, I suppose maybe because chickens go around and look for soil, it

is quite an important pathway.

DR. KOCHER: I am having a lot of trouble with this. I am probably completely wrong, as always. Go back to the last slide. On the top there, you are telling me that most of the radioactivity that ends up in animal products comes from their eating feed, rather than drinking water from the source, that the animals are consumed to be drinking this contaminated water from the well, right?

DR. WASIOLEK: Do you mean for technetium? It is more because we have --

DR. KOCHER: Well, the blue is high for everything on the top.

DR. WASIOLEK: Yes.

DR. KOCHER: I find that really hard to reconcile with the previous one, which for humans was just the other way around. In fact, I don't think this is possible.

Ask yourself the following question. I am a cow out there, and I am drinking water and I am eating grain. Which is the bigger source of water for me? Do I get more water from drinking out of the tank or do I get more water by eating alfalfa?

DR. WASIOLEK: Well, don't forget that for human consumption, we have to remember that not all

fruit that is eaten comes from a contaminated source, which throws this balance off completely.

For animals, every blade of grass that they eat and every grain of corn that they pack on is contaminated. For humans, just because we base their consumption rates on local population, only a small fraction of their food is contaminated, but all of the drinking water is contaminated.

A cow will eat 100 kilograms or whatever of contaminated feed. And a person will only eat two.

DR. KOCHER: I just don't believe that most of the water in a cow comes from eating food. I just don't believe it.

DR. ECKERMAN: It's the same deal here. Most of the technetium is coming from the feed, cow, right, because that is what this graph is saying, --

DR. WASIOLEK: Yes.

DR. ECKERMAN: -- which, of course, goes back again to your question about the equilibrium because you have forced the feed concentrations if we had equilibrium, --

DR. WASIOLEK: That's right.

DR. ECKERMAN: -- whatever they took, from the irrigation pathway, where it is drinking the water. Now, the unit concentration, the other one,

has been amplified by the continued deposition.

DR. WASIOLEK: Yes.

DR. ECKERMAN: So I think it makes sense when you figure out how it is all normalized back to unit concentration of water.

DR. KOCHER: Root uptake of plutonium is virtually zero.

DR. WASIOLEK: Yes. But this is the key. This graph does not show mechanism for transport to feed. So when you are looking at this graph, the fact that they get a lot from feed does not mean that plutonium in the feed came from root uptake. It didn't. It came from the same mechanisms that were shown in the previous graph, which is very similar for the feed.

Most of it for plutonium because you were asking about plutonium is from irrigation water and dust deposition. Root uptake was very, very small, almost nonexistent.

DR. KOCHER: The residence time, you cannot accumulate plutonium on the surface of that plant for longer than 60 days.

DR. WASIOLEK: It is deposition of contaminated dust. It is a dynamic process that we model, also because we consider growth time and

weathering factor. So we are continuously depositing contaminating soil on the plant surface and continuously removing it.

DR. KOCHER: It doesn't hold up.

DR. WASIOLEK: It comes to an equilibrium.

DR. KOCHER: No. She just told me that that is not it.

DR. ECKERMAN: But I think she --

DR. WASIOLEK: I am explaining.

DR. ECKERMAN: I think you are mixing the two. You have got to take out the part about the water, the irrigation of plant, and then the irrigation of the soil.

DR. WASIOLEK: Oh, yes. They are two different things.

DR. ECKERMAN: Yes, right. And I think you haven't explained both of those to us. That is why there is some confusion.

DR. WASIOLEK: Okay. Irrigation of the soil is a long-term process that leads to this equilibrium concentration. Irrigation of the plant is a dynamic process that reduces water with the current concentration, which is unit concentration.

DR. ECKERMAN: So at the end of the day, most of the activity that is on the plant has come

from first when its deposit was on the soil and then resuspended.

DR. WASIOLEK: Some of it will be deposited on the soil and resuspended. Some of it will come from the irrigation water that --

VICE-CHAIRMAN RYAN: I'm going to make the suggestion in the interest of time, we have to move on. We could probably spend the rest of the day working through these irrigation models, but I think we really would maybe like to ask Maryla to move on with one last question.

DR. TILL: Not a question.

VICE-CHAIRMAN RYAN: Observation.

DR. TILL: It's important to know that, even in cattle feed, you have got 10 to 14 percent moisture. Alfalfa usually runs eight percent, ten percent moisture. Silage will run 14-15 percent moisture.

So you do have a way to get moisture in cattle feed. Plus, you are compounding it with this buildup in soil, resuspension on the plant, and the deposition through the water on top of the corps. So it doesn't look logical, but I see how that could happen.

VICE-CHAIRMAN RYAN: Okay. Well, let's

press on. We can talk about this in the discussion.

DR. WASIOLEK: Well, we are not really renting these models. These are models that are commonly used. It is the same model as in ten years, for example.

Just a brief summary of receptor exposure pathway. It is very similar to the bar graph that I started my presentation with. Just the ingestion and inhalation pathways are summarized. I mean, they are all added up.

It shows that the water ingestion is an important pathway. Ingestion of locally produced food is also an important pathway, especially for light model radionuclides. And then as we move to inhalation, it becomes more important for actinides because of the accumulation in the soil.

DR. THORNE: Could I just qualify that one? The carbon-14, the ingestion is dominated by fish, though, is it not, rather than the plant? There is an interesting question there because I think you use a specific activity model between carbon-14 and water --

DR. WASIOLEK: That's right.

DR. THORNE: -- and carbon-14 in fish. And hiding under that number is the whole question

about whether we should represent other sources of carbon for fish because if we are talking about fish farming, most of the carbon comes from external sources and not from carbon-14 in water.

DR. WASIOLEK: Yes. We had a problem with this because this is not a natural system. It is a farm. And we interviewed people who used to run this farm. This buy commercial pellets. They don't grow fish food locally. And most of the carbon in fish comes from the food and not from the water.

But we were limited by our sources of bioaccumulation factors for carbon to whatever exists in the literature. And we are sort of stuck with this.

VICE-CHAIRMAN RYAN: Did you evaluate what that meant in terms of either sensitivity or uncertainty?

DR. WASIOLEK: Well, the uncertainty in the distribution is included.

VICE-CHAIRMAN RYAN: Using fish pellets versus contaminated feed?

DR. WASIOLEK: Well, fish pellets are not contaminated. They come from the outside.

VICE-CHAIRMAN RYAN: That is my point.

DR. WASIOLEK: They are externally

produced. They are not contaminated at all.

VICE-CHAIRMAN RYAN: But this ingestion is of what exactly?

DR. WASIOLEK: It is primarily --

VICE-CHAIRMAN RYAN: Contaminated fish. Yes, please?

DR. SWIFT: This is Peter Swift. I just wanted to reiterate something that came up earlier this morning, that because of the repositories in the unsaturated rock 18 kilometers from the exposure point, we had a choice back there to make also as to what to do with the carbon-14.

The choice there, the moment when it leaves the waste package, was to put it all into the water phase. So it reaches the receptor point with all of the issue inventory of carbon-14, essentially all of it because we don't retard it en route, is still in the water.

So the water is pumped out on the fields. It then goes through this pathway near the crops or on the fish, contains all of the carbon-14 that was available on the system. We have lost none to the atmosphere until we get to the receptor point.

VICE-CHAIRMAN RYAN: We really have to press on. We are getting low on time. So if you

would continue, Maryla, please?

DR. WASIOLEK: Okay. This graph is a slice from the first graph that I showed, the carbon-14 slice. I superimposed it with the consumption rates just to show how the consumption rates of locally produced food influences the individual pathways for carbon-14.

The carbon model is based on relative concentrations of carbon-14 and carbon in various environmental media. The transport of carbon through the food chain reflects these ratios. So basically carbon-14 concentrations are related to carbon concentration in a given environmental medium of food or whatever it is.

So if you look at the pattern of consumptions of locally produced food, it is pretty much which led to the pattern of percentage of contribution of this pathway to the BDCF for carbon-14.

This is just a summary. Let's move on. Let's skip this one. Fish, as we noted before, is an important, consumption of locally produced fish is an important, pathway. This is how we calculate activity concentration in the fish.

If it is a product of activity

concentration in the water, what we call a modifying factor, which accounts for evaporation and possibly concentration of the radionuclide in the fish pond.

And the bioaccumulation factor in the case of carbon, this concentration concentrates for a factor, a modifying factor. It is equal to one. We do not concentrate carbon.

Technetium pathways. In essence, it is very similar to carbon in that for technetium, water is more important than it was for carbon and fish is not a player, but the consumption rates are pretty much reflected in the relative contributions of individual food consumption pathways.

External exposure, inhalation are not important. Neither is the soil. So I suppose we can move on. If there are questions, just for the sake of keeping up, the following slide just showed the summary of what was said about the contributions of technetium pathways.

This slide shows where the uncertainties are coming from. The BDCFs got broken into major components. First, we have a total, but then we have a drinking water, inhalation, ingestion. The symbols, the most top one is the maximum. The lowest one is the minimum of 1,000 values for that value of BDCF,

approximately BDCF. The symbols in between are the 95th percentile, and the green trend goes to meat.

So if we look at where the uncertainties are in the technetium pathway distribution are coming from, well, the uncertainty in the BDCF, for instance, is almost entirely due to the uncertainty in the non-water consumption pathway.

Water is fixed. So there is no uncertainty here because it is prescribed by the regulation. And the uncertainty, since inhalation is external, the absolute values are so low, although they are relatively uncertain, they don't contribute to the total BDCF to any significant degree.

Now, let me read my numbers. The BDCF for technetium varies by a factor of 16 between minimum and maximum -- so this is the first group of symbols -- and less than a factor of 4 between the 5th and 95th percentiles.

For the non-water ingestion, we have a variability range of about 200 between the minimum and maximum. So this is what contributes most to the distribution for the final distribution of the BDCFs for technetium.

Now, if we take a closer look at the root uptake, which was an important environmental pathway

for technetium, we calculate activity in concentration in plant by multiplying activity concentration in the soil, soil-plant transfer factor, and dry-to-wet ratio.

The values of transfer factors for concentration ratios come from the literature, not only for technetium but for most of our environmental transport parameters. We do a literature search and select the values. In this case, there were many different values. So we have chosen a distribution that pretty much encompasses the whole range of values, which is marked on these graphs by this dashed line. This would be the range of our distribution around the value.

As far as we can, we are trying to recite specifics. So, for example, dry-to-wet ratios were developed on selection of representative crops for the region.

If we start drilling deeper, how do we get to specific quantities in the equation? A very important equation is obviously the one that determines activity concentration in the soil but has been discussed numerous times already. And this is the very equation that we used to calculate activity concentration in the soil.

In the numerator, we have a product of activity coefficient in the water, one, in this case and irrigation rate. So this is our source.

The same terms are represented by an effective loss factor, which is a sum of three removal constants, representing removals by radioactive decay leeching from the surface soil and soil erosion. Among the three, leeching is the most important.

The second equation shows how we calculate leeching removal constant.

DR. KOCHER: What is the value of $lambda_e$?

DR. WASIOLEK: That is the value of $lambda_l$.

DR. KOCHER: What is the value of $lambda_e$ that you assume?

DR. WASIOLEK: $Lambda_e$? Soil erosion. I don't remember what the value is. It is a distribution again of some values. I am not the person who developed this value. So I don't know what is the exact number. But it is in the report that you can look it up online within --

DR. RAUTENSTRAUCH: This is Kurt Rautenstrauch. It is on page 39 of my presentation. I have some distributions of some of our parameter values in that.

DR. WASIOLEK: Okay. Luckily this one was included.

VICE-CHAIRMAN RYAN: Maryla, I'm just looking at the clock, and I want to be respectful to our time for public comments. Maybe I could ask you to move through the rest of your slides a little bit and we can finish up.

DR. WASIOLEK: Okay.

VICE-CHAIRMAN RYAN: Thank you.

DR. WASIOLEK: Well, let's move on. This graph shows dependance of BDCF of some over-watering rate, which is an important parameter that controls leeching removal concentration. It is a quite interesting graph, too.

The next one is also interesting. It sort of addresses the question that Ruth has asked before, how the uncertainties in values of parameters that will control removal of technetium in this case from the soil affect BDCFs.

It actually is a very interesting graph. We do have a correlation between Kd and transfer coefficients, unlike the NCRP model. These two values are correlated in our model.

One thing that we can see is that the orders of magnitude variations in Kd values do not

cause a lot of variability in the BDCFs. It is very small variability, actually.

There is a very interesting effect that we see between BDCFs and Kd. What we have, low values of Kd, plants just suck it up from the technetium from the liquid phase because it is all practically there.

And then, as Kd increases, the less technetium becomes available for root uptake. But then, as we Kd increases, activity concentration in the soil increases, then the BDCFs go up again. So it is a pretty neat graph.

Iodine pathway is very similar to the technetium pathway. So we can probably skim over these. Consumption of animal products is more important for iodine just because the transfer coefficients are higher for iodine than they are for technetium.

As was the case with technetium variability in the iodine, pathway comes almost entirely from the variability in the non-water component, non-water food ingestion.

Because of the relatively large contribution of drinking water, which is a fixed component, there isn't much variability in the BDCF for iodine.

For the transuranics, food consumption is virtually nonexistent. What counts is the inhalation and consumption of water. If we look at the inhalation for these three radionuclides and split it into particulate matter and evaporative cooler, which answers Dave's question, what fraction comes from which inhalation component, the majority is from the inhalation of suspended particulate matter; evaporative cooler, not very important. These values are for the modern climate. So for the future climate, evaporative coolers are going to be even less important.

If we look closer at the inhalation pathway, inhalation, if we spread the contribution to the inhalation pathway, this is the inhalation of particulates, suspended particulate matter. Almost entire inhalation dose comes from people spending their time in what we call an active outdoor environment, which is the environment in which people disturb soil, enhanced soil resuspension perfectly by mechanical means.

The other environments, like inactive outdoors, which is outdoor without taking dust pretty much, or indoor do not contribute that much to the inhalation dose. Again, if we start drilling and

looking at what individual parameters cause this high inhalation dose in the active outdoor environment, we will see that activity concentration in air is high in active outdoor environment, much higher than in the remaining environments.

If we look at the population-weighted time spent in the environments, which is the graph that is similar to the pie chart that Kurt showed in his presentation, people don't spend all that much time in the active outdoor environment, population-weighted time, but the activity concentration is so much higher in this environment.

The breathing rate is a little bit higher, too, in this environment. We use ICRP-60 reference values for the breathing rates. So this pretty much is what drives inhalation dose.

This slide shows how individual parameters were developed for the inhalation pathway. So we can skip through this one.

The following slide shows inhalation pathway for the evaporative coolers. There are two parameters that are site-specific which control a fraction of houses that have evaporative coolers, which is a survey quantity. And evaporative cooler use factor, which is driven by the climate, we make a

determination when for a given temperature people will use evaporative coolers.

The important parameter is activity concentration in the air. Activity concentration in the air is calculated as a product of some specs for an evaporative cooler, how quickly it moves and how much of it.

What we call this FE stop, which is a fraction of the radionuclides in water transfer in the air, this is something that Mike mentioned in the morning. It is the parameter that we could not find any reference in the literature to.

So because this was a very new pathway that did not exist in our previous model and we had absolutely no sense of how important it will play in the overall model, neither to just say, "I don't know what is the value of it" -- so theoretically it can be between zero and one. Let's see how it matters. Let's move two slides. And this is how it matters.

For the modern climate, if we change the fraction of radionuclides transfer to the indoor air, I mean, the full swing from zero to one, we are changing BDCF for neptunium, which had the highest contribution from evaporative coolers by a factor of 1.35. And because modern climate is hardly used in

TSPA because it exists for such a short period of time, the lower slide, the bottom graph will better represent contributions from evaporative coolers.

So this full range of possible values of the fractions of radionuclides transferred to indoor air only changes the BDCF by a factor of 1.12. So it has a negligible effect on the BDCF.

The summary, basically it is just the summary of the pathway contributions, which we can see that there is a limited number of pathways and parameters that control the doses.

Again, because of the nature of our model and the way it ties with the TSPA model, we do not know what the concentration of radionuclides is.

These values or the pathway analysis applies only to individual radionuclides. It does not apply to the TSPA importance, pathway importance, analysis because --

VICE-CHAIRMAN RYAN: These are all unit concentrations, yes.

DR. WASIOLEK: All unit concentrations. For example, for us, technetium, for example, which is a very important player and comes at the top of every TSPA analysis, BDCF for technetium is the lowest of them all because there was a lot of technetium. It

comes out as an important player.

VICE-CHAIRMAN RYAN: Before we have additional questions from the panel members or ACNW members, are there any questions or comments from the audience? Do members of the public or staff have comments at this point?

(No response.)

VICE-CHAIRMAN RYAN: Okay. Hearing that, more questions? I am sorry to cut you off, but I wanted to make sure we had time for further questions as well. John?

7.1.3) DISCUSSION

DR. TILL: Just a quick one. What is the fraction of food generated locally versus imported in? What is that, food produced locally versus brought in from the outside? What is the --

DR. WASIOLEK: It varies. It is based on the results of the survey.

DR. TILL: So what is it? Give me a ballpark figure of what we are talking about.

DR. WASIOLEK: On the slide, you will see the exact numbers on slide 9. It is in kilograms.

DR. TILL: Slide 9 of?

DR. WASIOLEK: Slide 9. Here we go, the bottom, the lower graph. These are the actual

consumption rates in kilograms per year of locally produced food consumed.

DR. TILL: That does not mean it is --

DR. WASIOLEK: It is not the percentage. These are the actuals. The one thing that we need to stress out is Pat made a comment that our consumption rates went down, but the receptor has changed.

In the previous assessments, our receptor was the average number of the critical group. Now our receptor is an average number of the valid percent. And this does include people who do not consume any food from a given food type.

VICE-CHAIRMAN RYAN: Kurt, I think --

DR. RAUTENSTRAUCH: Kurt Rautenstrauch. Yes. I can answer that in a simplistic way. For fruit, it is less than 18 percent of average daily intake would come from locally produced crops. For other products, it is much less than that, certainly less than ten percent, probably less than five. I don't remember the numbers right off. Fruit is the highest one, and it is less than 18 percent.

VICE-CHAIRMAN RYAN: That is what I wanted. David, do you have any questions?

DR. KOCHER: It doesn't really matter in the grand scheme of things, but the bioaccumulation

factor for carbon in fish is fishy.

DR. WASIOLEK: Well, it is fishy.

DR. KOCHER: It is fishy.

DR. WASIOLEK: I agree. It is way too high.

DR. KOCHER: I am wondering. Specific egg models are widely misused, but I am wondering if this isn't a place where it really applies, that if you know the specific activity of carbon in that water, which you ought to because the water quality should be known --

DR. WASIOLEK: Fifty micrograms per liter.

DR. KOCHER: Surely, the fishes are not going to accumulate carbon-14 --

DR. WASIOLEK: No more than there is in the water.

DR. KOCHER: -- and not accumulate carbon-12.

DR. WASIOLEK: Yes, but I look at --

DR. KOCHER: There is only one exposure medium for those critters.

DR. WASIOLEK: Basically, these bioaccumulation factors reflect exactly what you are saying except that the poor fish take all of the carbon from the water.

DR. THORNE: Now, that concentration factor, say if they go up to 50,000 or 100,000 were derived on exactly that basis. They took the carbon content of fish. They divided it by the stable carbon concentration and divided by the stable content of water. That is where that number comes from.

DR. WASIOLEK: Exactly.

DR. THORNE: And that is why it is orders of magnitude out.

DR. WASIOLEK: Stable carbon in fish is about 20 percent. Stable carbon in water is about 50 micrograms. There you have it, 4,500.

DR. ECKERMAN: But I think what David was saying is that model isn't applicable to this situation.

DR. WASIOLEK: Yes. And we agree because the components of the fish environment are not in equilibrium with carbon. But there was not a single study that I know of that somebody would calculate bioaccumulation factors for farmed fish, where their food is not contaminated.

VICE-CHAIRMAN RYAN: To bring it back to one of our central questions of uncertainty and/or sensitivity and margin, this seems to be something that is right for that sort of an evaluation, where it

sounds like -- and correct me if I am wrong -- you are overestimating the dose from consumption of fish.

DR. WASIOLEK: We do. That is correct.

VICE-CHAIRMAN RYAN: And that could be an upper limit or a bounding value.

DR. WASIOLEK: It is.

VICE-CHAIRMAN RYAN: Have you thought about ways to sample that somehow or to create some kind of an evaluation that is an upper limit? What does it more properly look like?

MEMBER HORNBERGER: Remember your dictum?

DR. ECKERMAN: Yes, sir.

MEMBER HORNBERGER: If it is too conservative --

DR. ECKERMAN: It is wrong.

MEMBER HORNBERGER: -- it is wrong. This is wrong.

DR. ECKERMAN: Okay. Well, thank you. I have a convert.

VICE-CHAIRMAN RYAN: Yes, sir.

DR. KOCHER: I did want to go back and figure out what your loss rate constant for soil erosion is because I don't get the answer from looking on page 39 of the previous talk.

CHAIRMAN GARRICK: In fact, my question

was this was labeled kilograms per cubic meter. How is that a rate?

DR. KOCHER: That is not a rate constant.

CHAIRMAN GARRICK: That is not a rate constant. You noticed that, too. Not per year.

DR. WASIOLEK: I don't have the report with me. So I don't want to make up numbers. I don't know what it is.

CHAIRMAN GARRICK: I suppose we can get that tomorrow.

DR. KOCHER: I suppose we could figure it out. I am sure it will work. It's going to be not hard.

CHAIRMAN GARRICK: Yes. Let's make it a homework problem.

DR. WASIOLEK: It's a line. It is on the open Web site.

VICE-CHAIRMAN RYAN: Yes? I'm sorry.

DR. THORNE: Could I? Just two points. I would like to return to the point I was talking about about are we talking about an individual or a population, which is one I raised this morning?

I think that one on the inhalation of neptunium, if we could possibly go back to that slide, makes that point absolutely perfectly. It is the

inhalation of particulate matter slide. Can we go back? Keep on going.

Now, if you look at that, what drives that is time active outdoors. And the weighted time in the environment for the average person in the survey is about 0.3 hours per day. But the man who works on the soil who is included in that is the guy who is going to be out there eight hours a day.

So there is a factor of potentially 25 depending on whether you talk about an individual or a population-weighted average value. I think we can't do anything about it in terms of the definition of the RMEI, but I think you have got to be aware of that distinction between individuals in populations because of those sorts of differences.

VICE-CHAIRMAN RYAN: That is interesting.

DR. WASIOLEK: Well, probably it would not be quite as high multiplier because the person would not stand eight hours every single day of conducting work in highly dusty activities. They would spend a fraction of their time. So even for a person who is an agricultural worker, the multiplier would likely be much lower than that.

VICE-CHAIRMAN RYAN: Dr. Weiner?

MEMBER WEINER: I have, really, two

questions. The first one refers to an evaporative, your evaporative cooler question, because that is the way I cool my house in the summertime.

The water circulates through a spongy pad, normally wood fibers. Now, I can't believe that that won't pick up any particulate matter because it certainly would.

It seems to me also that given the large number of evaporative coolers in existence, you could measure. You could simply measure the particulate uptake in the pads of a normal evaporative cooler and get some kind of bound, some kind of distribution that is not, as Dr. Ryan says, simply so conservative it is wrong. I would suggest you do that.

DR. WASIOLEK: Well, to answer your question, this concern, I said in the beginning this is a new pathway. Before you embark into conducting a wide survey and measure people's outputs, you are trying to determine whether it is worth your effort or not. And what we are trying to show here is that it is not worth the effort because even this value, that is why we let it swing from zero to one to see whether it matters.

And the answer is no, it doesn't really matter, even if it is overestimated So why would we

go and conduct a survey of a parameter that is not very important?

MEMBER WEINER: That is a perfectly good answer if it is not important.

My other question has to do with the animal feed. Having visited the Armagosa Valley, as we did, I am not convinced that all of the animal feed, even all of the alfalfa, these animals in the valley consume is grown locally, I don't think they can grow enough. I wondered what kind of effect that has on your --

DR. WASIOLEK: We did not conduct animal consumption surveys in the valley, just human consumption surveys. Our model does conservatively assume that every kind of food that animals eat is locally produced.

MEMBER WEINER: That is my point.

DR. WASIOLEK: It is a conservative assumption. I agree.

VICE-CHAIRMAN RYAN: We have two former farmers on this side of the table who want to talk to you also about feed. John?

DR. TILL: Actually, Dr. Weiner's question about the evaporative cooler, what you are losing here is a chance to get credibility with people. All

right? I mean, if it is a simple thing to do, it is something that is going to come up. And just saying, "Well, it isn't important," okay. It isn't important. But if you could get the data, get it.

One of the things I believe that worries me the more I hear about this is that all of these analyses being done by DOE are being based on other people's work. And there is a lack of originality to it. Okay?

Now, going back to the animal feed, that is a huge question. And it is a very important question. It is a credibility issue. It is very simple to get the answer. You know that. Go to the farmer and ask.

But also you can make a pretty quick calculation. I can tell you you can't get enough alfalfa for 5,000 cows out of 2,000 acres.

DR. WASIOLEK: There was a commercial operation, this huge farm, which products milk that goes elsewhere. Apart from the farm, not enough alfalfa grown in the valley that can provide food for those thousands of cows, we can have individual farmers that may grow enough food for one or two cows.

DR. TILL: The question is, is there enough food and can there be enough food grown if you

are basing it on current statistics? You have 2,000 irrigated acres out there, right? I believe that is what I saw. You can't produce enough food on 2,000 acres to feed those 5,000 cows, no matter what.

DR. WASIOLEK: The milk out of these cows is not consumed locally. It is a commercial operation; whereas, individual farmers or individual people have been farmers. They can have a couple of animals, and they may indeed produce enough food.

DR. TILL: So you are saying this is for the RMEI.

DR. WASIOLEK: Yes, for the RMEI.

DR. THORNE: I'm sorry. There is a logical inconsistency there. We have just had the RMEI has average consumption rates over the whole population. And now we have got one or two farmers drinking their own milk. One of those can be the RMEI or the other one can. They can't both be the RMEI.

DR. ECKERMAN: And your equation for the evaporators deals with the fraction of the population that is using the coolers. So it is back to this further confusion of the population or individual are we addressing here because if it is an individual, the cooler thing may look a whole lot different to you when you change that fraction to one, rather than what

you have got.

DR. WASIOLEK: We have to be careful about the parameters that apply to an individual and parameters that apply to the environment. The parameters that apply to individuals are average value. It was the subject was brought up in the morning.

DR. ECKERMAN: You also have to be not only sensitive to the parameter values, but you have to be sensitive to the formulation of the model because the formulation you have for the evaporative coolers is not the right formulation to be applied to an individual.

So you have to keep your story. You have got to stay consistent across the way. You have got to use the right model formulation for the subject that you are addressing. We have shown examples that we have got problems with that right now.

DR. WASIOLEK: Parameters such as behavioral and dietary characteristics are averaged for the population. Parameters that are related to environmental media, we allow them to vary. They are not averages. We allow them to vary over whatever ranges are tweakable.

So there will be a difference in the way

we develop, say, evaporative cooler usage factor because it will be an average for the RMEI.

DR. ECKERMAN: You understand what I am saying. If you look at slide 27, now, why is the fraction of coolers there?

DR. WASIOLEK: It is the RMEI. It is the RMEI value. It reflects behaviors of the RMEI. It is the average value. The rule directs us to keep dietary and lifestyle characteristics for the individual for the RMEI of their mean values.

So we do take the entire population and create this hypothetical individual that has average characteristics for the entire population in Armagosa Valley. This does the work like this for the environmental.

VICE-CHAIRMAN RYAN: I think the difficulty that we are having -- and I am glad you are explaining it a bit -- is that there are certain things -- and I think you said this -- that apply to the RMEI as an average construct.

DR. WASIOLEK: That is right.

VICE-CHAIRMAN RYAN: We sometimes talk about the RMEI as if it were an individual, --

DR. WASIOLEK: It's not.

VICE-CHAIRMAN RYAN: -- which it is not.

So I think it is as much a matter of semantics in looking at each one of these parameters as it is -- we have to be careful not to confuse ourselves or anybody else that the RMEI is a reference individual like, say, reference man calculations are for internal dose. It is a construct of an average circumstance.

I think the second thing is to me -- and I am summarizing a bit -- that we have to be careful that if we have this construct of an average individual, the RMEI to whom we are calculating a dose, we have to check and make sure that various parameters like alfalfa that is used on farms is that average circumstance as well, do we not? I think that is really the question that you heard in several different forms here.

DR. SWIFT: This is Peter Swift. Commenting on the alfalfa and the 5,000 cows, I think that is a bit of a red herring or a red cow. The cow in question here is not the cow that lives in the valley. It is the cow that is eaten in the valley.

And if 5,000 cows are grown in the valley but eaten in California, we don't really care where their feed came from. It is the feed that was given to the cows that were eaten in the valley that matters. And there may very well be enough alfalfa to

feed those cows.

VICE-CHAIRMAN RYAN: We have time for one or two more. Maryla, did you want to sum up in any way?

DR. WASIOLEK: Well, I suppose --

DR. TILL: I still want to --

VICE-CHAIRMAN RYAN: Hang on. Let her go ahead. Yes, please? Did you have any final comments or, John, did you have a question?

DR. TILL: Well, I think we have really hit on something that is key here. I am not sure I fully understand what the regulation is, what you have to do, as opposed to what you have chosen to do.

What you have said is because it is in the regulation that you have to take all of those people in the valley, 1,800 or so persons, and derive average characteristics based on those 1,800 persons. You have to do that? The regulation says that?

DR. McCARTIN: Yes, the regulation does specify mean values. In relation just to continue the discussion about the alfalfa, what would be allowed by what is specified in the regulation?

If indeed the alfalfa farms in Armagosa Valley currently use, let's say, 10 percent of the feed grown in Armagosa Valley, 90 percent of the feed

that the cows use come from outside the valley, then they could assume 10 percent of the feed was contaminated and 90 percent was not because that is the practice on average if that was the average for it.

From a regulatory standpoint, assuming all of it is contaminated, it would be conservative if that was the practice.

DR. TILL: Well, what I'm trying to clarify is what you have to do versus what you have chosen to do. If I had 1,800 people in this valley, the way I would do a risk assessment on those 1,800 people is to find what you know of as the critical group of individuals, which is a smaller group of people.

It is a group. It is not one person. It is not an extreme. But it might be your farmers who have those single cows, who have their evaporative cooler and who drink the water from the well.

You might have 30 of these farmers. And then that is the way I would select my parameters for my individual for compliance.

DR. WASIOLEK: This was in the draft regulations. And in the previous assessment, we used an average number of the critical group. But, then,

the receptor that an average member of the critical group got replaced with the RMEI.

This is when we had to change the way we calculated dietary and lifestyle characteristics for that receptor. We did use an average member of the group in the previous calculations. This is when, as Pat pointed out, our consumption rates were higher.

DR. TILL: I don't understand. There is a big difference between the two approaches.

DR. WASIOLEK: There is.

DR. TILL: Why was the change made? And who made the decision?

DR. McCARTIN: The language in the current regulation is the language in the EPA standard that NRC was required by law to adopt. So we have adopted the language of the RMEI.

There was discussion both in the EPA standard and NRC regulations that in general, we feel the RMEI and the average member of the critical group would be approximately the same. Would they be exactly the same? No. But they are approximately the same. But right now the RMEI is what is specified in the standard, and that is in the regulation.

DR. THORNE: But I think when we show some examples here where you can construct cases where the

critical group representative of the RMEI can diverge substantially because we can have a farmer who produces all of his own milk. That is a perfectly good critical group-type member. The RMEI is defined.

DR. McCARTIN: It depends. If you want to include speculation on what can happen, yes, you can, but I would maintain the regulations were written to preclude the kind of speculation in terms of what I could have this person do this, this person do that.

I would still maintain if you look at reasonable assumptions, the RMEI and the average members of the critical group I don't believe diverge that much. However, the ISRP construct of the average member of the critical group was that there was an order of magnitude range. And that would still be considered an average member of the critical group. So there is a fair amount of variation.

VICE-CHAIRMAN RYAN: And I think to me, it comes back to the question of some of these key parameters, some of which we have touched on through the day, of thinking about sensitivity and uncertainty analysis.

I am instructed by Maryla's observation that certain ones are not important, whether they range from zero to one. That is an interesting one to

focus on for a second. And if it is not important to what is ultimately calculated for dose, then it is not important.

I take George Hornberger's caution that if it is a factor of 100; yet, it is at 10^{28} millirem per year, then it doesn't matter if it is a factor of 100 or 1,000. It is only when it gets up to the compliance case that we take note of that.

The other aspect of this to me -- and it is one of the things that Professor Thorne said this morning -- is that there is a compliance calculation.

I think have all sort of drifted off the compliance case to "All right. If we are going to model the true environment, what would we do?" And I think those are two different things that we have to also be mindful that they both have different purposes. So I think that is helpful to think about.

We are at a point in our agenda where we are due for about a 15-minute break. So why don't we plan to come back right at 20 after 3:00? Thank you.

(Whereupon, the foregoing matter went off the record at 3:05 p.m. and went back on the record at 3:22 p.m.)

VICE CHAIRMAN RYAN: Our next session is about metabolic models. The human response to

radionuclides is assessed. Participants will be asked to describe metabolic roots and exposure duration for each of the environmental pathways that we've talked about and again, the discussions will be in the context of the six key radionuclides of interest.

Our first speaker is Chris McKinney from the Division of Waste Management and his title is Dosimetry and Metabolic Models. Welcome.

MR. McKINNEY: Well, hopefully, I won't have many questions. You guys went over this about six or seven times so far today. So we'll try to get through this fast. Wishful thinking.

I tried to break up also in the title the fact that we got -- there's a synergy of two different things in this part of the one value we have in the dosimetry codes. We've got both the dosimetry or the weighting factors, the various assumptions that ICRP makes on those things and we got the metabolic models which is like the lung model, the gastrointestinal model.

I'm a systems performance analyst for the Division of Waste Management so I'm going to try to go through focusing more on what are the requirements for dosimetry models and somewhat what we assume in ours. So I'm going to go over these topics, the regulatory

requirements, the Federal Guidance, the new dosimetry systems, some sources of uncertainty, examples using that uncertainty and some conclusions.

Part 20 and Part 63 both use effective dose equivalent, stay in dose limits. That's defined by the dosimetry system is defined by ICRP 26, using weighting factors to translate organ doses into effective whole body dose that would have the equivalent cancer risk.

Metabolic models were derived in ICRP 30 and later in 48 and 56 and so forth. We create new and better models all the time on calculating organ doses.

Federal Guidance on how to use -- for dosimetry systems. Part 20 is consistent with 1987 Presidential Orders on occupational exposure. So Part 63 is build upon Part 20.

We have the current Federal Guidance on dose convergent factors in Federal Guidance Report 11 which tabulates the internal dosimetry ones consistent with ICRP 2630 and Federal Guidance 12 which tabulates dose convergent factors external dosimetry which use the weighting factors from 26.

And also there is a more modern risk factor based Federal Guidance Report which is Federal

Guidance Report 13, however, that's not used get for the Federal Government for dose factors, but it is used for risk factors in programs like CRCLA.

ICRP recommendations put out new recommendations in 1990 to calculate effective dose which is slightly different terminology. It uses different weighting factors, also newer advanced lung models came out for the various organs and how various new metabolic data on how things travel through the body. And these are tabulated -- have tabulated dose conversion factors in 68 and 72.

While we've not updated the part 20 to meet or to use these dosimetry systems, we do allow exemptions for definitions of weighting factors which unfortunately was put in our regulations so that licensees on a request basis can use the new dosimetry models.

Uncertainties. Effective dose equivalent is a radiation protection term. It is not a measurable quantity in any stretch of the imagination. It's taking organ doses which potentially could be measured, but probably not, but in quantifying times a weighting factor which is based off of organ radiosensitivity.

VICE CHAIRMAN RYAN: Dose directly to a

body can never be measured.

MR. McKINNEY: Dose directly to a body?

VICE CHAIRMAN RYAN: Cannot be measured. You can infer it, but you can measure it.

MR. McKINNEY: Okay. The metabolic models are relatively simple, yet conservative models for complex case. You know, there's various degrees of understanding metabolism. I mean our iodine model hasn't changed in 40 or 50 years, has pretty much stayed similar. The lung model has gotten more and more complex as we understand more. Plutonium models, americium models have gotten more and more complex over the years as more and more understanding of how that -- how the body utilizes or doesn't utilize these elements and issues such as the ICRP 2630 pretty much ignores homeostatic controls. And of course, it's divided up by chemical forms.

Weighting factors. For uncertainty examples, in one study they did for external dose at the weighting factors made less than about 10 percent difference for most photon emitters. Obviously, for internal dosimetry this is all over this place, depending on what is the primary organ that is exposed by that radionuclide.

For chemical form, the difference can be

a factor of 2 to 10 or so, between different chemical forms for inhalation. If you go to the most extreme for soluble to completely insoluble, you can get quite a different for like uranium, but for like the plutonium, you're using -- like Class W which is all non-oxide forms of plutonium to Class Y, there's about 35 percent difference at one micron. At higher microns, they tend to diverge even further.

VICE CHAIRMAN RYAN: Chris, could I just ask a quick question here. This is an interesting point to get to our focus. What's the range of variation in the parameter like it does conversion type? If I look at W Class plutonium 239, it's non-oxide compounds, I'm assuming already valent state, plutonium can exist in.

MR. McKINNEY: Right.

VICE CHAIRMAN RYAN: And yet we have a two decimal place accuracy in the dose conversion factor.

MR. McKINNEY: Well --

VICE CHAIRMAN RYAN: Could you speak to that? Would you? I mean that's fairly important --

(Laughter.)

VICE CHAIRMAN RYAN: On the one hand, recognizing there's a wide range of values in this parameter, yet we show -- and it's not just you, we

often show a lot more significance to that than we deserve.

MR. McKINNEY: That's the tabulated values. Whether I personally would agree that we could ever go that far --

VICE CHAIRMAN RYAN: My point is is that if there's no difference between either of those with the precision with which we know --

MR. McKINNEY: That's true, the culture is two decimal places.

VICE CHAIRMAN RYAN: And there is a distribution. I'm not talking about -- I'm talking about both values. They're really the same number within the range of what we truly know about --

MR. McKINNEY: At that point.

DR. ECKERMAN: But do your rounding at the appropriate place. You have to carry some extra digits --

VICE CHAIRMAN RYAN: For the calculation.

DR. ECKERMAN: So the third digit is just a guard digit because then you run into these things where you can't convert units back and forth.

MR. McKINNEY: They're coming.

DR. ECKERMAN: You guys want to always work in non-SI units so we have to give you an extra

place so that you can --

VICE CHAIRMAN RYAN: That's fair.

(Laughter.)

DR. ECKERMAN: The problem is at the end of the calculation.

VICE CHAIRMAN RYAN: However, my point still stands and if we look over the range of chemical compounds at oxidation states, for all the things that are classed in that W class and then look at oxides, how do we differentiate the two numbers.

DR. ECKERMAN: I also would add one more note of caution in your deliberations here. One of the things is the effective dose and I use a newer term, is a very robust quantity. If you look at lung dose, you'll see a bigger difference here and you think about health risk, the health risk is probably dictated by the dose by lung cancer and not by effective. You don't get cancer of the effective. You get cancer at particular sites. And so you're seeing part of this, the robustness of the effective dose quantity.

MR. McKINNEY: Right, the uncertainties in the weighting factors, unfortunately, can sometimes again cover up some of the actual uncertainty in the overall dose. I mean it's back to like the previous

presentation where we had a wide range in KDs, but we don't have a wide range in the dose conversion factors because there's not very much ingestion. If you don't have very much of a weighting factor, then the uncertainty is going to be tempered by that.

VICE CHAIRMAN RYAN: Well, I think the other thing is these factors are not on the board are actually applied to an intake and it's a risk that's assigned 50 years of exposure, some intake. It's not annualized or organ specific.

MR. McKINNEY: No, those are committed over 50 years.

VICE CHAIRMAN RYAN: And my question about robustness is is it's robust because of that 50 year integration, more than anything else.

MR. McKINNEY: Okay, this one is just a comparison between some of the newer models and ICRP 30. And I broke out the five of the six radionuclides. Carbon 14 really doesn't become too much of importance in our calculations and I broke them out by where they tend to show up in our assessments. So for inhalation we got americium 241 and plutonium 239. These are both at 1 AMAD. You start getting into, depending on what AMAD you classify and which chemical form becomes an issue

where Class W increase the micron size of the particle. The dose factor doesn't drop off as very fast while the Class Y, it drops off right away.

For the two factors, you have basically the same plutonium 239 while for americium going to the new dose conversion factors will give you a factor of -- well, a factor of about three or so, maybe.

And meanwhile, over here for ingestion you have similar dose factors or factor of 2 or 3 for these where you have a factor of 10 for neptunium 237. Just to show -- if you use the ICRP 72 being more modern models and more data and everything else as being potentially more realistic versus the assumptions we are using in the code, to characterize possibly as a surrogate to characterize level of conservatism and level of uncertainty versus what real dose are being used for these dose conversion factors, I mean that's what this is to be used as.

DR. THORNE: Can I cut in, Chris? That's the key. I think that neptunium one is all do to a change in the gastrointestinal absorption.

DR. ECKERMAN: A good part of that is.

DR. THORNE: It's almost exactly an order of magnitude.

DR. KOCHER: My reaction to this is these

comparisons have very little, if anything, to do with uncertainty. That's just my reaction. You're comparing point estimates while using different models.

MR. McKINNEY: Modeling needs more than --

DR. KOCHER: You're comparing the effect of changing a model and your second little tick up there is important for plutonium because if you -- you know, I haven't memorized these tables, but if you keep the same chemical form and compare the ICRP models, you're going to get a different one than for the one for americium because they are almost the same. So it's

-- be careful here.

DR. TILL: Dave's point is very important and it gets back to this issue in my mind of what is uncertain and what is not uncertain. And for me, for a given radionuclide, for a given class of chemical compound, for a member of the public exposed in the future hypothetically, the uncertainty in the dose conversion factor is zero. It is a number you pick out of the book.

And if it isn't zero, then the question is have you evaluated this thoroughly for all of the radionuclides? Because I don't think you have and I

don't think we can. I think it would be very tough.

So is that right?

MR. McKINNEY: Yes, I mean that basic assumption and that basic explanation is the basically the working way we deal with why we don't propagate uncertainty in the dose conversion factors.

DR. TILL: Okay.

MR. McKINNEY: Is that it's considered just a part of the stylized calculation.

VICE CHAIRMAN RYAN: It is true that there are a set of reference calculations of dose conversion factors that are accepted as facts, but they are not. There's uncertainty in them.

DR. TILL: Okay and listen -- for the purposes of compliance, for a future calculation and this may be a policy decision, all right? I say that the uncertainty should be zero. That you ought to pick a value from a book and go with it.

VICE CHAIRMAN RYAN: And I'm not arguing about one point or the other. I think the key thing, John, is that you've been given a construct. Yes, it's a stylized calculation. Yes, it's a compliance demonstration. But I think the focus is, to me, well, you have to somehow be sure of where you stand on the -- is a reality question. Is it very conservative?

Is it so conservative it's long? Is it not conservative? Or where do you stand on that scale? You somehow have to, I think, appreciate where you are on that scale, even if it's in a qualitative way. I'm not saying I don't accept your construct for the purpose you've stated it, but I think you still need to understand where that construct sits and why. From a technical standpoint, I understand that fully.

CHAIRMAN GARRICK: From a technical standpoint, I don't accept the construct. That's the problem I have with compliance is that if it comes out of a look up table that's offered by the regulator, then from the point of view of complying, the risk is zero, as you say or the uncertainty is.

DR. TILL: Uncertainty is zero.

CHAIRMAN GARRICK: But from a science standpoint, it's a bad practice.

DR. TILL: I don't disagree with that, but you know in this realm of what you're doing is trying to demonstrate compliance for a facility and I think this is a huge question and if you're going to deal with uncertainty in dose coefficients you've got a lot of work to do.

CHAIRMAN GARRICK: Oh yes.

DR. TILL: We all recognize it's there,

but that's why this kind of goes back to my suggestion that you consider a hypothetical person, some person that you create in the future to be the person you demonstrate compliance, use to demonstrate compliance that the characteristics of that individual are also fixed.

And I know a lot of people don't agree with me on this, but I have reasons for suggesting it as a way to think. That means the breathing rate is fixed. The ingestion rate is fixed. It's because you assume that person exists. You assume that person lives in a certain place at a certain time. That's -- there's no uncertainty in that. And therefore, you assume that his heart weighs so much, his lung weighs so much. That's all very exact and assumed to be well known.

That's a little bit different way of thinking, I know, that I'm suggesting here. And I know everybody doesn't agree with it.

VICE CHAIRMAN RYAN: Sir?

DR. KOCHER: This is maybe a question more for Keith than anybody else, but I found myself reacting a big negatively to the assertion that the metabolic models are conservative. My understanding is that they weren't set out to be that way and I

guess I would like Keith to maybe weigh in on this question.

DR. ECKERMAN: I was going to hit that one a little later, but yes. That's a touch point with me because ever since we started with particularly after the Chernobyl period, that's kind of a marker when things changed from being focused just on occupation on the worker to dealing with the general public and the intent has now been to be realistic because once you produce that number with our many figures, significant figures you show it with, it's going to be used by people in different senses and so you can't -- you can't automatically decide whether the conservatism is in the direction you think it is or not or actually being nonconservative.

And so the whole focus in the ICRP system which most of this is inherited has been now to be as realistic as you can.

Now at the same time we're trying to be constrained by having models that could be implemented by people and so forth and do the job at the end of the day and come up with a point value just as John -- the number of reasons that John was talking about. But it isn't true that -- we do not construct models to be conservative.

MR. McKINNEY: I wouldn't say that especially with current models. I mean when you look at how the weighting factors are created --

DR. ECKERMAN: That's another story.

MR. McKINNEY: That's part of the whole thing.

DR. ECKERMAN: Right.

MR. McKINNEY: Altogether where you are taking, based on which sex you're picking for each organ --

DR. ECKERMAN: Unfortunately, I have a comment on that one.

DR. THORNE: But even if we go back to ICRP 30 they weren't conservative. We took a --

DR. ECKERMAN: Don't know.

DR. THORNE: A partitioning for plutonium, for example, between liver and bowel, stick 45 percent in each, but if you didn't know very much better, but it wasn't conservative.

DR. ECKERMAN: It wasn't conservative, that's right.

DR. MOELLER: Let me offer not to wear you out, but offer a couple of comments.

CHAIRMAN GARRICK: He's not doing anything. He's just standing there.

(Laughter.)

MR. McKINNEY: You're the ones who are doing all the conversation. It's great.

DR. MOELLER: You say ICRP 30 is based upon the risk of cancer, well so is ICRP 72, but there's a major difference. The ICRP 30 is based on the risk of fatal cancer. ICRP 72 is based upon the risk of cancer morbidity as well as mortality as well as years of life lost. That's a major difference.

One other comment, we're talking about tissue weighting factors. Well, what do they do and I don't disagree with what they've done, but they took, they calculate the tissue weighting factors and they create four hoppers, four or five, I forget, you know. And you throw each one, it has to go in this hopper. Some of them you throw in a higher weighting factor hopper, some in a lower weighting factor hopper. And you fix it up so the total is 1.0. So that has to be taken into consideration.

And lastly, I wanted to say I'm with John Till. I believe looking at it from a regulatory point of view the fact they drink two liters water a day is non-negotiable. I mean we're not -- we shouldn't even be discussing it. That's in the regulations. The fact there are RMEIs in adult, that's there. These

other factors that John pointed out, I agree with him.

Don't waste our time talking about them. I mean I'm not talking to you.

(Laughter.)

DR. KOCHER: I'm glad you mentioned the issue of whether a license applicant can use a newer dosimetry system because my understanding was that licensees could apply to do that.

MR. McKINNEY: Yes, they can.

DR. KOCHER: And that you intend as far as you know now that the Commission will allow this in this license application?

MR. McKINNEY: Their general policy has been to accept exemptions from the weighting f actors.

DR. KOCHER: DOE, go for it. Don't fool around. Just go for it. Do it.

MR. McKINNEY: It's up to them.

DR. KOCHER: That is the basic conclusion on the end.

MR. McKINNEY: We use effective dose. We have FGR 11 and 12 out there and that is the basic guidance to show compliance with part 20 now. However, just like any other licensee, a licensee can come in and request to use the new stuff.

And that's always an option for them.

DR. MOELLER: Well, whose decision was it to choose FGR 11? DOE's? Yours?

MR. McKINNEY: No, FGR -- it's all because of just NRC has never upgraded. In 1992, 1991, 1994, effective, but 1991, part 20 was changed to use FGR 11 and 12, basically in the dose conversion factors.

We have over the years considered whether to go through the rule making factors to actually make a change to all regulations upgrade. Now there's a big cost benefit analysis has to be done about the cost to all of our current licensees about how much it would be to change over to the new system and that has not yet been ever shown to be very effective. That's why we allow on a licensee by licensee basis for them to make the decision that it's beneficial for them.

There may be a policy called at some other point that we're just going to say it's going to have to be done, but we haven't done that yet.

DR. KOCHER: This is fairly important, actually, for Yucca Mountain in the following sense. This change in dosimetry system for several important radionuclides will greatly change the importance of the drinking water pathway in the all pathways dose limit. Plutonium, especially.

MR. McKINNEY: Yes.

DR. KOCHER: And Plutonium 2. I mean it makes a difference, but that also, it will make no difference if the doses are as low as the projected values we saw today.

MR. McKINNEY: Right.

DR. KOCHER: But it could in our hypothetical world.

VICE CHAIRMAN RYAN: David, I think that exemplifies the key point that in an absolute sense is a difference, but in a context of a dose that's so low that it's way below any kind of threshold of concern, whether it's a compliance level or some other measure, then I think you get into the judgment of is it worth it or not.

DR. KOCHER: Except --

VICE CHAIRMAN RYAN: Do you agree to that?

DR. KOCHER: Ninety-nine percent I agree with you, but what we've been told here is that the biosphere modeling is basically decoupled from everything else which I think is not a good idea, but given that they've made that decision, they don't know what the concentrations in water are and they shouldn't if they have a decoupled system.

VICE CHAIRMAN RYAN: Well, that's right. They're working in that per unit concentration basis

and that's something to think about.

But it also gets me back to the -- if you accept some parameters as single point values, and you could do that in the context of the compliance case and I don't disagree with either Dave or John on that point, but you lose the ability to inform yourself of where you are if you can't talk about that as where is it on the margin of certainty or uncertainty.

DR. THORNE: I'm not sure that I agree with that. The fact that you do a particular calculation for compliance purposes does not preclude you doing other calculations to inform that value through sensitivity --

VICE CHAIRMAN RYAN: If you allow me to do that, i agree. I agree. If you guys accept that as a friendly amendment, I'm okay.

MEMBER HORNBERGER: It strikes me if I'm not mistaken too, Mike, even if the doses are very low in the compliance period. They do have to do a calculation beyond the compliance period. And if there is a change, that is at least to me, psychologically helpful.

VICE CHAIRMAN RYAN: Yes. Other questions from Panel Members for Chris or HNW members?

DR. TILL: Along the same lines, I think

it's important what we're discussing and it is an idea of do you use the best science or not? And if you're going to use the best science, you it across the board and that's why -- and it goes back to credibility thing with DOE, which I think they ought to be using the best science. Yes. I think they ought to be using it consistently. Yes.

VICE CHAIRMAN RYAN: But that wasn't a question for you, Chris. That's okay.

Let's see, any other questions?

MR. McKINNEY: Or comments?

VICE CHAIRMAN RYAN: Any other comments? Thank you, sir, very much.

Again returning, Maryla Wasiolek. Welcome back after a short breather.

DR. WASIOLEK: Well, actually I do not have a whole lot to say about the biokinetic and dosimetry models because we picked the number out of the book.

(Laughter.)

This is exactly what we do.

VICE CHAIRMAN RYAN: You've got two --

DR. WASIOLEK: It is a stylized hypothetical individual. It has all of the parameters as far as those that are derived from biokinetic and

dosimetry models. They are out of the book. We do not include any variabilities. We use -- we calculate annual doses in terms of total effective dose equivalent which is for our purposes, it is dose effective equivalent and cumulative effective dose equivalent which is different from the definition of total effective dose equivalent from 10 CFR 20. That is the document that allows us to use effective dose equivalent in place of peak dose equivalent.

And we use dose coefficient for internal exposure from Federal Guidance 411 and for external from Federal Guidance 312.

There was a lot of discussion already how these values came into being. We looked a little bit -- we do use the most conservative values for values of dose calculations which seems to be the common practice.

As far as the choice of inhalation, dose coefficients, it was brought up here that there is an easy method for recalculation of dose coefficients for inhalation for particulates with sizes different than one micrometer ADAM. We looked at the distribution of particle sizes in various environments and just one short comment that I would like to offer is if you recall the slides from my previous presentation, the

majority of the inhalation dose was coming from the active outdoor environment which is the environment that we say -- it is basically related to just generating activities, mechanical disturbance of the soil.

What happens in this environment is that in terms of particle size distribution for this environment, we have this transient component where particle sizes are much higher than one micrometer AMAD. It's a transient component if you look at the long-term effect. However, this is exactly where our receptor gets its dose. It's in this environment where there was a lot of dust that was respirated just temporarily.

So what we did was we looked at the dose coefficients for different size particles --

CHAIRMAN GARRICK: Something bad is happening to our recorder.

(Off the record.)

DR. WASIOLEK: So we are looking at dose coefficients for large particles because the distribution is basically by model. We have one mode that is around like 2, 3, 5 micrometers AMAD, which is there in the other environment and on top of this mode we are adding this transient several tenths of

micrometer AMAD.

Since this is where our dose is coming from, we compare the dose coefficients and of course we had to use the ICRP 30 model and for most of the transuranic, it doesn't matter by much, at least when this model is used.

So like plutonium, there is a small reduction compared to a micrometer, but not really a lot. Uranium goes down dramatically, but uranium was not a major player. But for most transuranics, if you just looked at just your calculations without reference to anything else, just plugging the numbers and look at the relative values of dose coefficients, we're doing pretty well just by using one micrometer, especially considering what was already discussed here overall uncertainties in the dose coefficients. But we're not -- we are not addressing these. We just use the values the way they are.

VICE CHAIRMAN RYAN: Keith, you may have better insight having been involved in much of the history, but I imagine that 1 AMAD was picked for a reason, that probably being the one. It covered a wide range of circumstances. Is that right?

DR. ECKERMAN: Well, that's true. The early classification was based on the deep lung and

one micron you were getting most of the material into the deep lungs. But I'd like to think more about what you've just said because one of the things -- the old lung model that you're using was based on deposition studies on volunteers and they were all mouth breathers. Because they put a mouthpiece in and they breathe the aerosol in and out and so while the population has modeled it more with the newer lung model has a combination of mouth breathing and nose breathing. And the deposition patterns will get changed drastically.

Because you're really putting another filter, if you will, up front. So of course the whole structure of the lung with regard to dosimetry changes. Right.

DR. WASIOLEK: It's for soluble radionuclides, there isn't much --

DR. ECKERMAN: Oh, for soluble there won't be. Right. For soluble there won't be much difference.

This was an ICRP on the lung model, recent commentary and even if you use the -- there is a huge difference when you're in the submicron particle ranges between particle sizes, but once you move towards the particles that are basically, micrometer

and larger, AMAD.

DR. ECKERMAN: But you have to be a bit careful on how you interpret these graphs because what's on the X axis is the median of the distribution.

DR. WASIOLEK: Oh yes.

DR. ECKERMAN: Not particle sizes themselves.

DR. WASIOLEK: Absolutely.

DR. ECKERMAN: So you have to be careful how you fold these things together.

DR. WASIOLEK: It's just a concept. We're not using -- why didn't anybody tell me we could use newer models.

DR. ECKERMAN: You didn't ask.

(Laughter.)

DR. ECKERMAN: It's in my slide because I've been getting calls from people for a long time, particularly the folks that knew of thorium. They've asked us this question and it's been in the NRC and DOE both have been giving people exemptions if they ask and a lot of us asked.

DR. WASIOLEK: For us it was a very simple concept. We have our standard that is expressed in terms of total efficient dose equivalent and then

there's virtually one source of the dose coefficients such that you are getting this quality. So this is what we use.

DR. MOELLER: Did you say earlier on the first slide something about you always adopted a conservative approach or something?

DR. WASIOLEK: Well, if there was a choice of dose coefficients, then it is a quite common practice to -- when you cannot justify specific chemical form to just pick the highest.

DR. MOELLER: A second question, the Panel a few minutes ago said, you know, go for FGR 13. How much would that set you back or is that a tremendous -- assuming you, you know, DOE agrees, whoever makes the decision to use FGR 13 dose coefficients?

DR. WASIOLEK: This is not my decision. I'm just the lowly contractor.

DR. MOELLER: But how much work would that entail? Is it an enormous effort or what? Can you say?

DR. WASIOLEK: I really cannot comment on that.

DR. MOELLER: You just copy down a new set of numbers.

DR. WASIOLEK: Well, it's not just that.

It's very easy in academia. In our structure we have a very -- the way we documents things, the way the changes are propagated through the model. I mean it would have to come from a DOE person.

DR. THORNE: It's one set of numbers, so I would have seen it compared with other changes that were made in the model. They're all cut loose with the QA system. It has to be one of the smaller changes rather than one of the bigger changes.

VICE CHAIRMAN RYAN: Questions? Comments?

DR. WASIOLEK: Well, the last slide was -- the second slide was the models that we used for the groundwater standard and we pretty much used the same model for consistency.

VICE CHAIRMAN RYAN: Anyone else? Dr. Eckerman?

Now you're going to sort out all 17 systems of dose calculations and constants, right?

Thank you, Maryla, we appreciate it.

DR. WASIOLEK: Thank you.

DR. ECKERMAN: Maybe I should start with my last slide.

(Laughter.)

I wasn't exactly sure I was to present here so I just threw a number of slides together under

this context of the Federal Guidance and if you could change the next slide there.

Just remind you back what the Federal Guidance says. Most of you know this better than I do, but a set of guidelines developed by EPA for use by the federal agencies in the protection of the public from the harmful effects of radiation.

The next one -- there's actually two types of guidance documents that come out. There's what's called guidance documents which really define the principles and policies of the radiation protection that are to be applied in the U.S.

This is the kind of a document that gets signed by the President. The President doesn't review our technical reports, fortunately.

(Laughter.)

And so the technical reports provide current scientific and technical information regarding radiation dose and health effects. So all of these federal documents, numbers that we've been kicking around here are the technical reports.

So next slide -- well, this goes back to the authority in the system, what used to be under the Federal Radiation Council which was established in 1959, so maybe Handbook 69 has an origin back here.

In 1970, this was transferred to EPA under that reorganization act.

Next slide. So the guidance documents are signed by the President and issued by EPA and of course that's the guidance that led in to 10 CFR 20 and the last one was signed by President Reagan.

Next slide. So then periodically or on some schedule EPA issued some technical reports that provide the details with respect to the protection system and the next slide then lists these. So since 1984, we've been involved at Oak Ridge in generating these documents. 10 was a short-lived, little special purpose thing that got superseded by 11 which was the one that you folks are currently using with which was issued in 1988 and really is just the information that was sitting in electronic files after Pergaman published for ICRP 10 and we published further details and including the dose coefficients because you won't find it, a very detailed set in the ICRP publications.

12, which deals with -- gives you dose coefficients for external exposure pathways, radionuclides in the environmental media. That report addressed the topic that actually ICRP really never had touched at the time and hasn't touched yet. And so that gave current state of the art calculations for

the external exposures.

Thirteen is the most recent and of course that's the one we recognize as we're discussing here as having the current -- representing the current state of the art and the unusual thing of 13 which now I have to go through the details here because Dave set me up on all of this, is that 13 actually doesn't present committed dose coefficients. It's a document that goes straight to risk. And as a document it gives you the risk associated with an intake of a radionuclide. And it didn't -- we didn't put any dosimetric information in because we weren't using the committed dose coefficients and there was some concern among the different federal agencies that if we put dose coefficients in that document, it would confuse a lot of people. Well, it confused a lot of people anyway.

(Laughter.)

People think we're -- that these risks were derived from the ICRP dose coefficients and they, of course, were not.

Next slide I think amplifies this a little bit. What we did was look at the risk, just focused on the cancer risk. Now in the W sub Ts that we've been talking about from ICRP, there is a genetic risk

as well, that has, of course, has changed over the years in different context as ICRP has defined it. But this document focuses strictly on cancer as a risk. We consider the age structure of the U.S. population. We used U.S. life tables, that is U.S. natural mortality rates and background cancer rates in the population. We had intake scenarios for the radionuclides. We used the age-dependent dosimetry models that were coming out and we didn't do the dose coefficients.

So what -- there's two ways -- because of the linear nature of the system, there's two ways you can look at this. One way is that you can think of this starting with a population of live born cohort population and let them live their life out and have use, breathe air, eat food in proportion to their age criteria, their age demands, and live their life out in an environment that has a uniform concentration of the radionuclide.

Or the other way to look at it is to say you've got a standing population and they have an intake of the radionuclide. So there's age aspects both in the importance of the dosimetry that's considered there which can be as much as a factor of 10, in the dosimetry itself, but of course, it's

negated a little bit by the intake because an adult consumes more food than a newborn and so forth. So all of these are rolled together in these calculations.

And it comes out with then strictly rick per unit activity ingested or inhaled. Or exposure to the environmental sources of the radionuclide. As a backup to this, the agencies wanted us to put the dose coefficients out on a CD so there is a CD that's available. That's where you can find the age specific dose coefficients. There's a whole lot of numerical information that's actually archived on that CD that a lot of people don't notice, but for example, the dose rates as a function of age in each of the organs is actually archived on those files and people can take these apart and find all sorts of little additional details.

This is -- so the end of the day here is that there are -- under that disguise of the Federal Guidance 13, there is age-dependent information on exposures for members of the public. This was not workers. This was entirely members of the public.

Next slide. I think we all know this, the differences here between internal and external, particularly the one that we have to keep in mind is

the protracted nature of the internal exposure.

Next slide. This is just a little detail on Federal Guidance 12's calculations. We did a detailed calculation of the radiation field above the contaminated ground surface and so forth and then you transport those radiations into the body and look at the doses to the various organs and this is probably one of the first times there's a real heavy duty detail of calculation of the field was carried out.

Next slide, well, this is a suite of anatomical bottles stylized as you can for different age individuals.

Next slide. I don't know why some of these were thrown in here because I just wasn't exactly sure. I think we can skip this one. This is just the details of our computational system.

I have got a few slides that deal with the models they're involved in. I think they may be worthwhile to run over these a bit.

This is -- when you're doing these kind of calculations, of course the -- we typically deal with just an intake by inhalation and ingestion, although there are cases not in the environment, but workers' situations where we worry about a wound kind of a case, but anyway, in the inhalation there's, of

course, going to be a whole model details of the lung and the respiratory system, the radionuclide, some of it's going to be mechanically cleared and be ingested, so even for an inhalation exposure you need a gastrointestinal model.

There's a transfer to blood from the lung as well as coming in from absorption there and it then eventually excretes, one of the new things later on in the later models is to deal with the doses along the pathway of excretion which wasn't addressed in publication 30, for example.

And of course, underneath all of this is there is, of course, models that deal with the conversion from the number of decays that are occurring to what the energy deposition is in the tissues.

Next slide. I think I switched over here and spoke a bit more on the systemic behavior of the material once it's reached blood and what we generally have now are two types of models here. We have really a retention kind of model which is actually sort of an empirical fit to observations. And then we have another set of models that are physiologically based and the motivation was to deal with age as an issue because we have lots, probably a lot more information

on the physiology of changes with change and anatomical changes with age, than what we have on nuclide specific information across the ages.

The data sources that you have to deal with, of course, the information comes specific from human studies, animal studies and then there's the physiological processes probably going on their analog information that you use.

One of the characterizations that we do on certainty is to think about the characterizing the quality of the information that you have to bring to bear on the modeling process and rather than just the usual parameter kind of uncertainty is actually to characterize the quality of the information that you had to work with because that really captures how well you're able to do the modeling.

Next slide. Well, early on the physiological model we had deal with – it’s actually shown here – was the iodine because that model really included the fact that the material came in the body – uptake in thyroid, some of it excreted -- but there was a recycling of the iodine as the body reused the iodine because of its importance for normal body function.

A lot of the work that's been done dealing

with the age processes has focused on the bone seekers, because that's the site of tenacious retention of many of the radionuclides, so what was taken in as a child may be with you for the rest of your life or still be present. And, of course, we had a great deal of information from the physiologist with regard to the growth and development of the skeleton, so that's why you see a lot of the newer models hitting actually the actinides that are important to considerations here.

Next slide. Well, let's skip on. I've already talked about this.

What happens when you go into this process is things become a little bit more complicated, and this was a big step for a lot of people in this business as we went from ICRP Publication 30 which really dealt with pretty simple – characterized the behavior in terms of a fraction going to an organ and staying there for some half-time for the bulk of the model. So here's the actinide model. The yellow skeleton region is actually put together largely from the physiological processes. When bone is formed and the radionuclide – the actinides are deposited, that action occurs along the surfaces of the bone. And in Publication 30, we knew that that was happening and we

had a class that said these nuclides are surface-seekers.

Well, what we did in 30 was they were laid down on that surface and they never left that surface, only by radioactive decay. There was no remodeling in growth and development of the skeleton. And so what happens, of course, is that as new bone is formed, this deposit starts to move into -- begin to look like it's volume-distributed. It gets away from some of the sensitive target tissues that we're concerned with. However, the body, in order to maintain exquisite control on calcium content in blood, which it has to maintain a tight tolerance on that, it calls upon the skeleton for calcium. And so some of this can return back into the blood. The other tissues of importance here are competing for a plutonium ion that's in blood or the liver processes and of course, the kidney and the excretion.

The significance of much of the reduction in dose that you see for the actinides for ingestion is associated with this burial process. Of course, over the time there have been some adjustments on what the F1 value is that this fraction is coming -- that's absorbed from blood.

I think the next slide is a alkaline

earth, which of course is calcium-strontium-radium. So it hits some of the target, some of the high-end radionuclides that we're concerned with. But, again, the action in the skeleton is on the surface, but things get buried, moved into the volume rather quickly and although we've got arrows coming back to the surfaces there, the dominant thing is to go into this nonexchangeable area and you really have isolated those -- that activity from some of the target tissues that are of concern.

So the point in showing these to you is that one, they become a lot more complicated to deal with. Thinking about doing parameter uncertainty on this kind of model and propagating uncertainty through a -- into a dose coefficient is a major task.

Next slide, I think -- what we have of course realized now and everybody has to keep in mind is that what we're really dealing with here is today's modern computing environment. When we put these models together they're all displayed as first order differential equations and we're solving on the order of 160 differential equations at a time. But you can do that on our desktops, so it's -- so the idea, the stimulus for sort of isolating the dosimetry off in a handbook kind of environment had always been it's too

complicated and let's do these calculations on the side and everybody just go into the book and look them up. There's no need for that any longer.

We've demonstrated in Federal Guidance 13 that you can couple the dosimetry and the risk considerations and bring in the living habits of the population and do that all -- you can couple it together. You don't need to have -- restrict yourself just to having dose coefficients to work with, if you're looking at things outside the regulatory environment. I'm talking here, taking you outside of the regulatory environment.

Next slide. This is the one that -- this is the flow chart that usually when I'm giving classroom lectures I use to end things up because this is the important box here is that you have to ask, when you're doing regulatory focus. If you ask NRC or DOE, they will grant you an exemption to use the new dosimetry material.

And so this is -- first question is is it a regulatory compliance question or not? If you're not doing -- if the answer is yes, but if you've asked for the exemption, you can use the later dose coefficient. If you haven't asked for the exemption, you're tied to 11 and 12 and at the end of the day, of

course, if you're really doing -- my point is if you're -- and I think for transparent with the public, there is an aspect that you need to address I think that borders on consequence analysis or risk analysis or whatever you want to cal lit, where you should really be doing probably the best kind of calculation that you can. No matter whether you've got to dismiss it, that's that second kind of analysis that you need.

And eventually, you may want to call the dosimeters and find out what the current state of the art is at the time and clearly, folks doing epidemiological studies can't use any of this stuff.

Now the only other caution that I wanted to mention, I think you should be concerned about also using the effective dose quantity. It's the sole measure, not again -- I'm talking about outside of the regulatory kind of analysis because you know, when we changed the -- when we went to the weighting factors of ICRP 60 from 26, the medical folks were up in arms because that changed for iodine, that changed the effective dose.

We only changed -- one of the hoppers the thyroid weight went to was .05 and it had been .03, so it wasn't a big change, but the difficult -- there was no information that would suggest that we had any

newer information on the risk of thyroid cancer. That changed because the other organs changed.

And I think you are going to see in the next set of recommendations, I don't know the numbers yet, but you're going to see probably another big swing in some of the weighting factors because we probably -- we've been overestimating the genetic contributions, so that's going to change.

So you're going to -- you can have people nailing you about the fact that you've under-estimated this dose or over-estimated it strictly by looking at what the changes in the tissue weighting factors are. So somewhere you should have at least a backlog of what the organ doses are because that's really the fundamental quantity here. The other is a real transient to deal with.

So effective dose is nice and robust, but it's a little bit tricky. I think that's the last, yes.

VICE CHAIRMAN RYAN: Keith, I'm reminded on this slide, in particular, that this is a much different case and maybe folks in the room who haven't experienced that, they dealt with exposure in the workplace where you have enough in a bioassay sample to actually measure something. I think we're in a

real in these situations where individual exposures would likely be so small as to be immeasurable in any useful way.

DR. ECKERMAN: Right.

VICE CHAIRMAN RYAN: So this is strictly a calculational construct.

DR. ECKERMAN: Correct, this is strictly calculational.

VICE CHAIRMAN RYAN: So, you know, I'm cautioned that any time there is a workplace exposure where there's any measurable significance, we end up doing an individual specific model, typically.

Could you talk about how that works out for individual cases versus these reference models?

DR. ECKERMAN: I don't know what you want.

VICE CHAIRMAN RYAN: It might not be a fair comparison.

DR. ECKERMAN: I'm having some difficulties with some aspects of this because the effective -- well, I guess this actually goes back to the early question about are we dealing with a population here or are we dealing with an individual?

The effective dose is a gender/age population weighted quantity. So it isn't applicable to an individual. Those weighted factors don't belong

to any one of us. They belong to us collectively and so that's actually the rub of the thing. I think even in the occupational setting, the -- in the past when we used to -- we would talk about the dose with a worker, you'd say we have calculated your dose based -- we have calculated the dose based on the bioassay samples that you gave us.

Had the referenced individual experienced this intake, this is the dose he would have received. And so it's -- I was kind of curious in getting the sense here of what this individual really is or he's a -- whether he's a real individual or is he part of the population and I guess he's part of the population.

That's probably an answer to a different question, but that's --

VICE CHAIRMAN RYAN: That's okay. I'll get back to my question. I guess what I'm trying to focus on is when you look at whatever version of the stylized calculations you want to hone in on, whether it's FRG 11 and 12 or ICRP 2 or ICRP 72, they're all stylized under some construct and I'm always mindful of when you get a real exposure in the workplace which is where most -- nuclear medicine, they're individual models.

For example, in the clinical trials for monoclonal antibody tagged iodine, they give a scaling dose. They give some small amount of the pharmaceutical to each patient to calibrate their uptake bracket. That's disease-process specific, but it's something for the patient because there's no certainty in the reference model and there's some wide swing and how any individual would measure up against the reference model.

And I guess what I'm trying to probe is your experience or your insights on that range of certainty or uncertainty. It gets back to my decimal point question.

DR. ECKERMAN: Even in the case of medical exposures, we have difficulties. You can do it, just as you say, give a trial dose and so forth, but you're not sure of all the other health conditions and status of the immune system of the individual, we see cases where people are calculating the dose to the red marrow which is the sensitive target in the body, but the individual has already been subjected to a history of chemotherapy and his red marrow is highly compromised at that time.

So there we may be able to do the physics of the calculation exquisitely, and put him in a PET*

(4:31:57) unit and get all sorts of time distributions, but we're at a bit of a loss, even there to explain what the significance, the biological nature of the responses.

But there is a complete difference here, as you pointed out between the kind of thing that we deal with in the workplace setting versus what we have to do with the members of the general public because you can't make these assessments from bioassays exposure data and so forth.

VICE CHAIRMAN RYAN: One other follow-up question is you mentioned that metabolic modeling tends to be at least try to be more realistic today versus say ICRP 2 or earlier versions. Could you expand on that and give us some more insight as to where we're doing well and where we might not be as well along and so forth?

I value your insight there. Pick our radionuclides of interest. Which ones are good and conservative or nominal or where are we on americium and plutonium.

DR. ECKERMAN: Actually, well, let me just say that the publication 2 kind of models where not only were they responsive to the information they had available at the time, but they were really focused in

on the long -- the sites of long-term retention in the body that committed dose, although it didn't use committed dose at that time, but the idea of where in the long sense is the -- the long-lived radionuclide is the dose coming from.

I think and so -- well, often now we have maybe a little greater uncertainty on some of the shorter lived radionuclides, but that's not in our menu here. It's the long-lived ones.

I think the ones that you had up there that we've been talking with, the plutonium is probably one of the better biokinetic models that we have available and there's plenty of studies that even recent injection data with non-alpha emitting plutonium isotopes that have been really shown -- helped that modeling process and convinced us of it.

I think plutonium is probably a good model. The members of the alpha earth family -- strontium and radium that are here, uranium is probably good. We saw that TM-126, I'm not sure our TM model is very good at all.

DR. THORNE: I think there is a major issue of speciation on TM.

DR. ECKERMAN: That's right. What else? Technetium model probably isn't that good either and

there, of course, we get those stable analogs. There are no other naturally occurring --

DR. THORNE: One thing I found with Technetium which was surprising was the degree of variability in gastrointestinal absorption even if you restricted yourself to the * (4:35:39) and dietary forms and that seemed -- that was surprising to me.

DR. KOCHER: And even for the same individual.

DR. THORNE: Yes.

DR. KOCHER: And we still should use a single value.

DR. ECKERMAN: Yes, 1.0. Right on the dot or .9 what it is. And the F1 is probably -- of the biokinetic parameters, the F1, the fraction absorbed from the GI tract, this probably is our most uncertainty. That's a difficult experiment to do, especially when you get down to the actinides and when the reabsorption is almost nil. It's hard to quantify it.

So that's the -- actually, I think once some of these materials get to blood, we handle them pretty well.

The lung model, I think is or the new lung model is much more realistic in its design and

incorporated a lot more of the physiological information that was available with regard to the respiratory systems, so it's -- and the ability to actually consider nose breathing as well as mouth breathers is an important --

VICE CHAIRMAN RYAN: You kind of quickly reviewed a key point which I think needs a little amplification, if I may, and that's intake and uptake. Metabolic models deal mainly -- well, they can deal with both, but I think the focus you've offered is once it gets to blood, we're pretty good. Well, that's the uptake.

DR. ECKERMAN: That's uptake.

VICE CHAIRMAN RYAN: So we can then take something from the blood and distribute it in body in a time-dependent way and pretty much figure out where it's going to go and what organ doses in red, if you'll met me, or gray are going to be. So that's one part. But a part where we're doing the environmental assessment or an assessment of a particular technology or Yucca Mountain or anything else for that matter is what's the intake. I think what we heard from our speakers today was more about what is the intake.

DR. ECKERMAN: Yes, yes.

VICE CHAIRMAN RYAN: So I think that's a

very important distinction and I guess, in my mind, that kind of factors in to what John and Dave talked about. I have no problem with fixing the uptake and making that very clear, but I think there's room to assess the intakes and in a span of possibilities in the world of intakes versus uptakes.

Maybe that's a breakpoint where we can see the assessment that Michael talked about earlier to say well, there's no reason you can't inform yourself about those variations and it's the variations in the intakes that I think are the key because that's what the environmental parameters drive is the intake, not the uptake, whereas on the backside of the metabolic models that deal with, at least in my mind, you can have a clean breakpoint at the uptake.

Would you agree with that?

DR. ECKERMAN: Yes.

DR. THORNE: I think there's an implication that that as well is worth studying explicitly. We saw in the calculations, I think, all the pathways treated as if the relationship between intake and uptake is the same. It didn't matter whether the radionuclide came in in drinking water or incorporated in food or on soil, but I think if you're going to make that distinction then it makes a

considerable difference on bioavailability which of those ways the radionuclide comes in on. And that could change the sort of weighting that we saw between pathway.

VICE CHAIRMAN RYAN: Sure. Thank you. Other comments?

Questions?

MEMBER HORNBERGER: If I could just be clear on this, this assembled group. Did I just hear everyone agree that there was a subset of the parameters in dose models that should be sampled in a stochastic fashion?

VICE CHAIRMAN RYAN: I don't think you heard that. It's a nice speech.

MEMBER HORNBERGER: I thought I just heard you say that you were making a distinction between intake and uptake and you wanted to fix intake, but let uptake be --

VICE CHAIRMAN RYAN: It's the other way around.

MEMBER HORNBERGER: Sorry, the other way around, sorry.

VICE CHAIRMAN RYAN: But to me that's where you can best inform your calculation of potential uncertainty and sensitivity is to deal with

those things that change the intake.

MEMBER HORNBERGER: But if those parameters are really uncertain, why shouldn't we treat them as uncertain parameters? I'm still a little lost.

VICE CHAIRMAN RYAN: I agree with you. That's what I'm saying.

MEMBER HORNBERGER: But John Till didn't disagree, that's what I'm worried about.

VICE CHAIRMAN RYAN: There's only two.

(Laughter.)

But the point is there is a breakpoint to think about if you want to look at a risk insight, it's kind of on the intake side where you have the opportunity to actually do something about it. Once you get into the metabolic, we're not going to excise lungs and cut them into pieces and figure out what went where. It just doesn't work that way. We have to do inference from bioassay and all of that.

And again, I think Keith is kind of representative of 50 years of that work sitting here at the table and it's good to hear that some of these key models for the long-lived radionuclides are pretty good.

So if we maybe try to get away from

struggling with the dose conversion factors that focus and focus on the intake part, what actually gets into the body and in what form and so on, that might be an instructive breakpoint.

I guess in trying to find summary points for the day, I think that's maybe something we can think about toward tomorrow is maybe that's something we can focus on, if we looked at intakes.

Yes, Ruth.

MEMBER WEINER: Dr. Eckerman, I've always had a problem with going from dose to risk in these models because it seems to me you're introducing another dimension of uncertainty which is very large and I have a lot of problem with reporting this in a document because everybody looks at it and says oh, my goodness, you know, I'm going to get cancer from this.

I'd really like to have your comment on the reporting of results of these models.

DR. ECKERMAN: Well, you're indeed right, of course. That translation of a dose, no matter how it's distributed in time over to a risk is -- has lots of uncertainty and you'd have to deal with the -- most of our information comes to bear to that question is from the Hiroshima/Nagasaki studies. And the first thing you wind up is worrying about how well can you

transfer that information from that population to the population you're interested in and so on.

And so we talked about this in 13 and we have another report that's going further in looking at the uncertainties in the risk values themselves, the whole thing put together, because it is difficult.

However, we're tending to be risk-based in our decision making and so forth, so it seems that you need at least somewhere along the line to look at the -- not just stay with just a pure dose assessment, but actually have to wrestle with the question of risk and indeed look at these uncertainties.

In 13, we actually used a lot of the information from the National Academy of Sciences, of course, in doing that and they're poised to -- and have a committee together to now reexamine the state of the information. There were questions, that whole exercise has been pushed back because of some questions with regard to the dosimetry for the A-bomb survivors.

Now that issue has been pretty well brought to a resolution and so the Academy will now go forward with that estimate, but it's fraught with uncertainties along the way, yes.

MEMBER WEINER: I guess the problem is

isn't there a way and I'm asking this, isn't there a way to express risk without just kind of linear conversion to cancer? I mean that's the thing that gives me a problem. I'm not at all concerned that we express these doses as risks in some fashion. It's the end product, the way we now express the end product that I think hides the uncertainty, if you will.

DR. ECKERMAN: There are parts of this -- the conversion is not -- is often done in an inappropriate manner in that especially with regard to the internal emitters because the committed dose is a legislated quantity over which we average. That's why Publication 13 couldn't use committed dose.

We only calculated doses to people who the life table told us were alive at the time, so you had to survive. One of the benefits of cancer is that, of course, you have to survive to get it. Forget that. But you have to have include that in a rigorous calculation. So it's difficult to make the whole -- all of this quite transparent to everybody because it's deeply involved in the mathematical models and the linearity in these models and so forth, but the information is there to do it and you can do it in a process that overcomes some of the obvious criticisms

that people will put you to.

CHAIRMAN GARRICK: With all this expertise here, I want to ask a question. How do the intake models involving other toxic substances compare in terms of comprehensiveness and completeness with the intake model for radiation?

DR. ECKERMAN: I think we know a lot more about radiation than probably any other pollutant that man is subjected to.

MEMBER HORNBERGER: And part of the problem there is the world thinks that the only way you get cancer is radiation.

DR. ECKERMAN: Right.

MEMBER HORNBERGER: I read Dade Moeller's book and it talks about a lot of other things that threaten our health.

And again, the question is where are we with respect to the comprehensiveness and technical quality of those models and do they contribute anything to what we're -- is there one of them that's way ahead of the radiation intake community?

DR. KOCHER: In terms of the modeling effort?

MEMBER HORNBERGER: Right.

DR. ECKERMAN: In terms of the modeling

effort, no.

DR. KOCHER: There are very few that could be considered comparable like carbon tetrachloride.

MEMBER HORNBERGER: Right. There's all kinds of toxic substances in the work place.

VICE CHAIRMAN RYAN: They have some problems to deal with that we don't.

MEMBER HORNBERGER: Yes. Even something that has as much notoriety as asbestos, do we have comparable models for asbestos that we do for radiation?

VICE CHAIRMAN RYAN: Well, even simple things, I think, John, like dosimetry, how do you do dosimetry for asbestos? Well, it's fiber accounting and that sort, so it really, how would you even get and I know some attempts have been made as an NCR peer report that took a crack at talking about chemicals and radiation on the same page, but I guess my view is like Keith's that that's probably a beginning step rather than a well matured step along the way of figuring out the chemicals.

John, you've done a lot of work on both, so maybe you can address that.

DR. TILL: I can't add any more to the conversation. We know far, far less about the

chemicals.

This goes back to that whole question about the uncertainty. It exists. It's huge. It is unknown as far as conversion to risk is concerned and that's why I recommend for compliance, don't go there. That's the point.

DR. MOELLER: Well, and the history of this is pretty -- I was going to say wild. That's not the correct word, but Ruth is correct. The ICRP and the NCRP estimated the risk from radiation in order to calculate the tissue weighting factors. They say in their reports everything we did is very conservative and you should not use these numbers to estimate risk. Well, they did it themselves when they did it for the tissue weighting factors.

What I believe should be done is -- and what NCRP and ICRP have done would be a good start. Could not someone take all of their sequences of calculations and estimating the risk for cancer in each individual organ and you know sharpen up the numbers or you know try to put some uncertainty and so forth on them and come up with a whole lot better risk estimate.

DR. ECKERMAN: Well, the Federal Guidance 13, organ specific risks were attempting to be right

on the A-bomb survivor data and they didn't have hoppers. They didn't use hoppers.

That was our objective.

DR. MOELLER: Well, let me compliment. I've read, looked at FTR 13 and that is an excellent digest, but even so we were mentioning or Keith mentioned that our basic epidemiological data, I mean we have data on radium which showed conclusively that there's a threshold for cancer, Robley Evans to his dying said and his publications show it. But we use predominantly the Japanese data. Well, as Keith pointed out the Japanese normal rates of cancer and in different organs are entirely different than ours. The bomb was, as you know, a short-term high dose exposure. It was external. They've even acknowledged that there are missed diagnoses of the types of cancer, people who have died got, you know. Or whatever the word. "Got" is a very poor word, whatever -- substitute in the record whatever is the correct word. And the NCRP, bless them, so far as I know is the only group, Warren Sinclair chaired the group, that tried to take those Japanese data and move them over to the U.S. and put in the uncertainties and so forth. And they finally came up with a factor of 2. They said take the risk of cancer suffered by the

Japanese, divide by two and say that's okay for low dose in a chronic situation.

But then he also plotted the distribution in the 95th and 5 percentile and it's pretty wide, pretty wide margin.

DR. KOCHER: I guess I disagree with that last statement. For uniform, whole body irradiation, their conclusion was that the risk of any cancer was known to less than a factor within a factor of 3. The difference between the median and an upper or lower confidence limit was less than a factor of 3 and I call that pretty tight.

DR. MOELLER: I agree.

DR. KOCHER: There are many complications in all of this. If you really want to amuse yourself, look at the basic data from which risk factors for chemicals are derived. It's a hoot. It's absolutely a hoot.

VICE CHAIRMAN RYAN: So we've got the easy one.

DR. KOCHER: You know, whoever said we know a heck of lot more about radiation risks than anything else, that's true. Of course the organ specific risk coefficients can vary widely and if you want to get sort of the latest NCI thinking on that,

it's available.

To me, the issue of risk really boils down to if you're going to compare radiation with anything else, there is no other coin of the realm. You can't compare grays with anything else out there for any other insult, so you've got to bite the bullet and talk about risk. There's no other measuring stick.

DR. MOELLER: Well, in Bill Bair's Lauriston S. Taylor's lecture of 1997, you know is a good place to start. It's not the only thing, but it's certainly a good document to read to understand the differences between external radiation and internal radiation of the body.

VICE CHAIRMAN RYAN: I think we're at a point where we can probably close this discussion session. I wanted to offer any time for members of the public that wanted to make public comments. I think we have at least one and only one.

Would you introduce yourself to everybody, please?

MS. TREICHEL: Judy Treichel, Nevada Nuclear Waste Task Force. I think at the very beginning of the day when Dave Moeller started out and said we're going to be -- the public is going to ask what dose am I getting, I don't think that's probably

the case. The question is going to be why am I being dosed?

And that's an entirely different question, but in listening to the whole conversation that's gone on here today, and knowing that this isn't just theoretical and it's not something that's just being done on paper, I know the people in Amargosa Valley. I know a lot about that area and it's very hard to sit here and listen to the discussion about the receptor when you know what it's name is.

And it seems to me that if this whole thing works out and Yucca Mountain is licensed and it's built and the rating standards are applied and so forth, there should certainly be a disclaimer -- not a disclaimer, there should certainly be an explanation that goes out to those people letting them know who it is that this regulation applies to, that it's an adult. That's the big thing. Because children are very, very different. They're more susceptible and at the same time they're more exposed.

You talked about how these people eat that they go off and commute to work. Well, an infant and a child don't commute to work. They're right at home and they play outside and they drink sometimes regular milk, sometimes mother's milk and they put everything

in their mouth and they play in the dirt. So it's very difficult and even knowing that, taking the surveys that were used, as Steve said, partially they were bad surveys. They only talked to people that had telephones. I think, I remember, that they were only done in English and there's a large Spanish-speaking population out there that is difficult to even find sometimes, but you can't find them by phone.

And a lot of the crops are changing and I realize that this whole thing is being taken in a snapshot in time where you take exactly what's going on right now and you apply it thousands of years into the future, but at this point, pistachios are becoming a big deal and people are coming back from there with commercial pistachios, things that you buy in the store that are grown in Amargosa Valley and there's a whole lot of them.

There's also honey that's coming out of that area. I don't know if it's being sold or I got it as a gift, so I'm not sure if it's commercial or not. But that's another crop. And it may be that the people there aren't eating a lot of these things. I'm sure they don't eat the majority of their pistachios because they're a very valuable commercial crop and they're doing pretty well on them and it's going to

increase. It takes a long time for pistachios to start producing. And they're going now and they're going to keep going, but so you may not be killing them with radiation. You might just kill them economically because there's a huge and growing organic farming situation going on out there where you have organic milk. You've got organic vegetables. All of those sorts of things. And that just dies if you mention the word radiation.

So that's a factor that I suppose is not relevant here, but it's extremely relevant to those people and they aren't going to understand a conversation about is conservatism caution and that if you're overly conservative, you're wrong. Well, in their minds, if you're overlay cautious, that's great. And that's what they're looking for.

So a lot of the word games are really problematic when you're actually talking about the people and avoiding the worse case is not something that should be done. Nevadans know what the worse case is and we've got a real good one going right now, very currently. And you can find out a lot more about how other things, how other toxics work. If you take a look at the people who have died already at Yucca Mountain digging the tunnel.

There's the silicosis out there and that's a lung thing and it was mentioned that we're still just learning how lungs work. Well, there's a good study. We've got people that have inhaled toxic dust and have already been affected.

So it's just very difficult when you have to understand that you're talking about real people and perhaps it's a really bad thing to combine a repository and a farming community. There are a lot of people working on this project that have come from WIPP that are very familiar with WIPP and WIPP did not combine farming, heavy water use and a repository. And I'm not sure you should ever do that. And particularly, not when you can throw a volcano in just as frosting on the cake.

So thank you.

VICE CHAIRMAN RYAN: Thank you for your comments. It is at the hour of five o'clock and I think what I'd like to do is -- yes, I'm sorry.

DR. WASIOLEK: Just for the record, the Spanish and English was used in the survey. So there were two sets of questions, one set was in Spanish and the other set was in English.

VICE CHAIRMAN RYAN: Thank you for that clarification. Anything else? Thank you.

I think what I'd ask is to challenge each of the Panel Members to digest and think about what you've heard through the day and then maybe we can start with an introduction and kind of a review of the key points and what you see as summary points that you'd like us to take away from the first day's activities leading into the second and then we'll hear tomorrow and kind of finish up with a similar summary toward the end of the day. So I won't try and press into service for summary information today. It's probably best to digest and think about it.

Are there any questions from ACNW members? From the fact that the brief cases are coming up off the floor -- that tells me it's time to bang the gavel and I'll turn it back to the chairman for the gavel at the end of the day. There we go.

Thank you very much. See you in the morning.

(Whereupon, at 5:01 p.m., the meeting was concluded.)