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1 UNITED STATES OF AMERICA

2 NUCLEAR REGULATORY COMMISSION

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4 ADVISORY COMMITTEE ON NUCLEAR WASTE (ACNW)

5 148th MEETING

6 + + + + +

7 TUESDAY,

8 FEBRUARY 24, 2004

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10 ROCKVILLE, MARYLAND

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12 The committee met at the Nuclear
13 Regulatory Commission, Two White Flint North,
14 Room T2B3, 11545 Rockville Pike, at 8:00 a.m., B. John
15 Garrick, Chairman, presiding.
16 COMMITTEE MEMBERS:
17 B. JOHN GARRICK, Chairman
18 MICHAEL T. RYAN, Vice Chairman
19 JAMES CLARKE, Consultant
20 GEORGE M. HORNBERGER, Member
21 RUTH F. WEINER, Member
22 ACRS/ACNW STAFF:
23 JOHN T. LARKINS, Executive Director, ACRS/ACNW
24 HOWARD J. LARSON, Special Assistant, ACRS/ACNW
25

1 EXPERT PANEL:

2 DADE MOELLER, Keynote Speaker, Dade Moeller and

3 Associates

4 JEFFREY DANIELS, Lawrence Livermore National

5 Laboratory

6 KEITH ECKERMAN, Oak Ridge National Laboratory

7 DAVID KOCHER, SENES Oak Ridge, Inc.

8 MICHAEL THORNE, Mike Thorne and Associates (UK)

9 JOHN TILL, Risk Assessment Corporation

10 NRC STAFF:

11 ANDY CAMPBELL

12 KEITH COMPTON

13 RICHARD CORELL

14 DAVID ESH

15 CHRIS GRUSSMAN

16 LATIF HAMDAR

17 PHILIP JUSTUS

18 MATT KOZAK

19 BRET LESLIE

20 TIM McCARTIN

21 CHRIS McKENNEY

22 JOCELYN MITCHELL

23 TIN MO

24 PHIL REED

25

1 NRC STAFF: (cont'd)

2 A. CHRISTIANNE RIDGE

3 JAMES RUBENSTONE

4 CHERYL TROTTIER

5 MITZI YOUNG

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1 I-N-D-E-X

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

2 (8:00 a.m.)

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

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

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

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

25 Should anyone wish to address the

1 committee, please make your wishes known to one of the
2 committee staff. It is requested that speakers use
3 one of the microphones, identify themselves, and speak
4 clearly and loudly, so that they can be heard.
5 Before starting the first session, I'd
6 like to cover some items of interest. We are pleased
7 to announce one of the distinguished members of our
8 committee -- namely, Dr. George Hornberger -- has won
9 election to the post of president-elect of the
10 Hydrology Section of the American Geophysical Union.
11 There's a lot more information on here that I could
12 read you, but I'm not going to. We are proud of
13 George's accomplishments, and we wish him well in his
14 new post.
15 Other personnel matters that we want to
16 mention: on February 23, Sher Bahadur departed from
17 the ACRS/ACNW office and assumed the position of
18 Deputy Director, Division of Systems Analysis and
19 Regulatory Effectiveness in Research. His replacement
20 has not yet been announced. The staff and the
21 committee will surely miss Sher. He was a very
22 valuable part of the team.
23 On February 12 of this year, President
24 Bush announced his intention to nominate Gregory
25 Jaczko, Senator Reid's Appropriations Director to

1 serve the remainder of the term opened by the
2 departure of Commissioner Greta Dicus. The term
3 expires on June 30, 2008.
4 Mr. Noble Green has assumed the position
5 of Administrative Secretary to the Executive Director,
6 ACRS/ACNW. He comes from Commissioner Dicus' office.
7 While Jenny Gallo is on her three-month
8 rotation to NRR, Sharon Steele will be filling in for
9 her. Sharon, like Jenny, was recently selected to
10 NRC's Leadership Potential Program, which requires a
11 rotational assignment.
12 Keith McConnell has been appointed
13 Director of the newly-established commission,
14 Adjudicatory Technical Support Program with the Office
15 of General Counsel. This organization will provide a
16 source of technical expertise for the Commission,
17 independent of staff involved in the review, and
18 adjudication of DOE's application for the high-level
19 waste repository as the agency proceeds with its
20 review of the repository application.
21 Some other news worth mentioning. DOE has
22 identified two rail corridors as top choices for a
23 rail spur to Yucca Mountain. The preferred corridor
24 is a 319-mile route from Caliente, Nevada, to Yucca
25 Mountain. The second choice is a 323-mile route from

1 Carlin, Nevada, to Yucca Mountain.

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

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

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

1 Larry Camper, Deputy Director of the Spent
2 Fuel Project Office, Program Office, recently stated
3 that the NRC, rather than relying on DOE funding, will
4 use its own money to cover the $30 million cost of a
5 package performance study. The study would test the
6 full-scale spent fuel truck cask and a rail cask to
7 evaluate their performance during crashes and fires.
8 Now let's turn to the activity of the day.
9 The Advisory Committee on Nuclear Waste has adopted
10 the practice of holding working group sessions on
11 selected topics based on the committee's action plan.
12 The action plan is a product the committee generates
13 every one to two years to serve as a road map of
14 issues and activities on which the committee should
15 focus. It is based on input from the Commission, the
16 Commission staff, committee members, and consultants,
17 and, of course, stakeholders.
18 The main purpose of the working group
19 sessions is to bring in experts and stakeholders to
20 discuss and exchange knowledge, ideas, and concerns
21 about issues of high priority to the Commission. The
22 results of the working group sessions have been
23 valuable source material for ACNW reports to the
24 Commission on technical and safety issues.
25 As you might expect, most of the working

1 group sessions the past few years have related to the
2 proposed Yucca Mountain repository for high-level
3 waste. They have included such topics as the near-
4 field environment and the performance of engineered
5 barriers in 1998, June; total systems performance in
6 March of 2003; and performance confirmation, July
7 2003.
8 Non-Yucca Mountain specific working group
9 sessions have included such topics as transportation
10 and linear no-threshold hypotheses. We had two
11 workshop working group sessions on transportation, one
12 in November of 2002 and one in April of last year.
13 And the linear hypothesis/no-threshold was in 1999.
14 Today is the start of a two-day working
15 group session on biosphere dose assessments for the
16 proposed Yucca Mountain high-level waste repository.
17 One interesting aspect of this working group session
18 is the somewhat prescriptive nature of the Yucca
19 Mountain biosphere and the uptake conditions of the
20 radiation to the receptor. It will be interesting to
21 see how this characteristic plays out in the
22 discussions.
23 As is the practice with working group
24 sessions, the committee assigns a committee member to
25 chair the session on the basis of their expertise.

1 Clearly, Mike Ryan is our expert on radiation and dose
2 calculations, and I am pleased to turn the session
3 over to Mike to serve as its Chairman.
4 Dr. Ryan?
5 VICE CHAIRMAN RYAN: Thank you, Mr.
6 Chairman, and welcome to the Working Group on
7 Biosphere Dose Assessments for the proposed Yucca
8 Mountain high-level waste repository.
9 Just a few things about our structure and
10 how we'll proceed. We have, to my right, a panel that
11 will be offering comment and questions and their views
12 as we go through the working group session. And we
13 have later tomorrow a panel discussion for -- so that
14 each member can summarize what they've heard and offer
15 comment to the committee and to the entire audience.
16 Let me introduce the panel. Chairing the
17 panel is Dade Moeller, no stranger to this room. He
18 served 21 years, both on the ACRS and the ACNW. He is
19 now President -- I'm sorry, Chairman and Chief
20 Executive Officer of Dade Moeller and Associates, and
21 a Professor Emeritus at Harvard University School of
22 Public Health.
23 Dr. Moeller's work is widely known in
24 environmental health physics and lots of other areas
25 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.

1 Sitting to Dr. Eckerman's right is Dr.
2 Dave Kocher, and Dr. Kocher is now at the SENES Group
3 in Oak Ridge, Tennessee, has experience in the areas
4 of environmental health physics involving development
5 of models and databases for assessing radiation dose
6 to the public of various radiation types.
7 He has special expertise in evaluations of
8 dose and risk assessment models for regulatory and
9 decisionmaking purposes. His work in these areas has
10 been concerned with routine and accidental releases
11 from operating nuclear facilities, performance
12 assessment of waste disposal facilities, and impacts
13 of consumer products containing radioactive material.
14 Particularly noteworthy accomplishments
15 include development of widely-used databases on
16 radioactive decay and external dosimetry, a widely-
17 recommended model of global transport and population
18 dose assessment for I-129, and risk-based
19 classification systems for radioactive and hazardous
20 chemical waste. Welcome, Dr. Kocher. It's a pleasure
21 to see you.
22 Sitting to Dr. Kocher's right is John
23 Till. John is the President of Radiological
24 Assessment Corporation -- I'm sorry, Risk Assessment
25 Corporation, formerly known as Radiological Assessment

1 Corporation. And since its formation, RAC has played
2 a key role in the evolution and methodologies for
3 environmental risk analysis.
4 Dr. Till has published more than 175
5 publications, including editing the first textbook on
6 radiation dose analysis titled Radiological
7 Assessment, and other documents that stress new
8 approaches to applied and simplified transport
9 mechanisms in environment for risk analysis.
10 Dr. Till is a graduate of the U.S. Naval
11 Academy. He served in the U.S. Nuclear Submarine
12 Program and retired as a Rear Admiral from the United
13 States Naval Reserve in 1999. Welcome, Dr. Till.
14 Thank you.
15 Next to Dr. Till is Jeffrey Daniels. Dr.
16 Daniels is -- has worked as an environmental scientist
17 at the Lawrence Livermore National Laboratory for
18 almost 25 years. He is currently in the Risk Sciences
19 Group. He is currently the Risk Sciences Group Leader
20 in the Environmental Sciences Division of the Energy
21 and Environment Directorate.
22 As Project Leader for studies assessing
23 health risks associated with drinking water quality
24 sponsored by the U.S. Army Medical Research and
25 Development Command, he prepared and edited numerous

1 publications, including a comprehensive nine-volume
2 report that serves as the basis for military field
3 water quality standards.
4 The research included a risk assessment of
5 chemical and biological agents, as well as
6 radioactivity, in drinking water supplies. Welcome,
7 Dr. Daniels.
8 And, finally, Dr. Michael Thorne is with
9 us. He is a Visiting Fellow at the Climactic Research
10 Unit, the School of Environmental Sciences, at the
11 University of East Anglia. He is a Fellow of the
12 Radiological Society -- I'm sorry, the Society for
13 Radiological Protection and a past president of that
14 society, and a member of the Editorial Board of the
15 Journal of Radiological Protection.
16 He is currently involved with his own
17 company, Mike Thorne and Associates, Limited, that has
18 a wide variety of consulting activities in a wide
19 variety of topics of interest to this working group
20 today, to a variety of clients across the UK and the
21 world. So welcome, Dr. Thorne. Thank you very much.
22 That introduces our panel. Our first
23 speaker will be our panel chair, Dr. Dade Moeller, and
24 then he will take us from there. Good morning and
25 welcome.

1 DR. MOELLER: Thank you, Mike.

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

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

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

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

1 to respond to these issues and document their
2 positions.
3 The next slide, please.
4 What we're going to do during the next two
5 days is look at one segment of the biosphere
6 assessments. We're going to begin with assuming that
7 the groundwater is contaminated and move on from
8 there. In other words, how is that groundwater used?
9 How does it interact with the public? And what are
10 the estimations of the doses that the public may
11 receive?
12 The objectives are to understand more in-
13 depth what the accompanying assumptions being made --
14 what those are, what the uncertainties are associated
15 with those assumptions, and the degree to which these
16 uncertainties may affect or do affect the dose
17 estimates.
18 We're seeking to learn what are the
19 issues, what do we know, as well as what do we not
20 know, and what do we need, as the slide says, to
21 adequately address these issues. We will also be
22 looking at related questions, and Dr. Ryan has urged
23 me to urge the panel members to address these types of
24 questions. Are we analyzing the right things? And
25 will the results of the work that's described to us --

1 will it be useful from the various aspects or
2 perspectives shown on this slide? And, again, will
3 the documentation be adequate for the license review?
4 In terms of this, Chairman Diaz of the
5 Nuclear Regulatory Commission, during the October 2003
6 Nuclear Safety Research Conference, gave a paper on
7 what he called realistic conservatism -- realistic
8 conservatism. And this was such a good paper, in my
9 personal opinion, and reviewed the subject so well
10 that I thought I would take a few minutes and
11 summarize what he said. And I hope I am not in any
12 way, you know, changing what he meant.
13 But he described conservatism. Its
14 purpose is to provide an adequate margin of safety.
15 Then he described realism as anchoring that
16 conservatism in the real world of physics, technology,
17 and experience. And above all, he opposed or told us
18 to avoid, and encouraged us to avoid, what he would
19 call the worst-case syndrome. He points out that
20 recognizing that unrealistic conservatisms, meaning
21 taking a worst-case approach, can skew the results
22 very significantly.
23 He also has asked us to understand that
24 uncertainties should be understood to the maximum
25 practical -- practicable extent. He is urging that

1 they be quantified, so they can be properly addressed
2 in the decisionmaking process, and he points out that
3 otherwise we could have a situation in which the
4 uncertainties remain hidden under what he calls a
5 mantle of conservatism, meaning that, oh, we've put in
6 enough conservatisms to take care of those
7 uncertainties. Well, we need to know whether indeed
8 that is true.
9 He has also gone on to point out that
10 properly applied, realistic conservatism goes hand-in-
11 hand with a risk-informed or risk-based approach to
12 regulation. Now, that is the foundation of the
13 Nuclear Regulatory Commission's approach, and so,
14 indeed, it is extremely important that we keep these
15 things in mind.
16 And he concluded by pointing out that the
17 risk significance of an issue cannot be determined
18 without a realistic understanding of that issue.
19 I'd like to move on by sharing with you
20 some personal thoughts. The annual dose -- or the
21 dose -- I put "annual" because most of them are
22 expressed either in terms of a dose rate per year or
23 an annual dose. It represents a subject that is of
24 keen interest to the public, and often times people
25 will say, "Well, what's the efficiency, or what will

1 be the effectiveness of this engineered barrier?"

2 Well, all of that -- those things are

3 important, as well as the natural barriers. All of

4 these are important. But I think I certainly keep in

5 mind, and always try to keep in mind, that the public

6 is going to be intensely -- they already are --

7 intensely interested in this proposed repository, and

8 they're going to be asking questions. And I

9 personally believe that -- and I could be wrong, but

10 I believe that the bulk of those questions will relate

11 to, what dose am I receiving? Tell me the number.

12 And so I am asking and suggesting that

13 this represents a primary area in which the public

14 will not hesitate to ask questions. And one of the

15 questions they're going to ask will be -- in my

16 opinion will be the following. The reasonably

17 maximally exposed individual, as designated by EPA and

18 by the USNRC, is to be an adult.

19 Well, it will not be very long until there

20 will be one of the first public meetings, and a woman

21 -- I was going to say in the back of the room. Maybe

22 she'll be on the front seat. She'll stand up with her

23 infant child, and she'll say, "Okay. You gentlemen --

24 ladies and gentlemen -- you're assuring me that you're

25 protecting an adult. But what about my child?"

1 And that is very important for several
2 reasons. First of all, if you take Dr. Eckerman's
3 dose coefficients and look at those for an infant
4 versus an adult, you will find quite routinely the
5 dose per unit intake for an infant is some 10 times
6 that for an adult.
7 Now, there are many ramifications that
8 need to be discussed on this subject. But I simply
9 wanted to share that with you as a type of issue. In
10 my opinion, that will be an issue that will come up.
11 And to the extent that EPA and the NRC considered this
12 fact in setting their standards, the extent to which
13 they considered it, in my opinion, needs to be
14 documented, so that that can be shared with the
15 public.
16 Now, here I pointed out that, although
17 complicated, the NRC's regulations exist. And so over
18 the next couple of days we may talk to some degree
19 about complications within the regulations, but our
20 main goal is to look at how the dose calculations are
21 being made.
22 I did want to offer a personal comment,
23 again, in terms of EPA, which established its
24 standards. And that comment simply is that EPA, as I
25 -- as it appears to me as an outsider looking in, is

1 not always free to do what even they may consider to
2 be best. For example, they are told to use the best
3 science, and yet at the same time they are told, as I
4 understand, never to relax an existing environmental
5 standard or limit.
6 Well, frequently those two goals or those
7 two charges are in conflict. And I simply wanted to
8 remind people of that.
9 The exposure pathways -- we're looking at
10 direct exposure, you know, through the consumption of
11 the drinking water. We also will be looking at
12 indirect pathways, such as the irrigation of the
13 crops, irrigation of pasture, the consumption of
14 contaminated milk, and so forth.
15 The program, as Dr. Ryan pointed out, is
16 a two-day program or two-day agenda. We're going to
17 be talking about intake and dose, and in terms of the
18 metabolism of the radionuclides that will be one
19 subject which is generally described in terms of the
20 biokinetics. And we'll be talking about the dosimetry
21 of the radionuclides once they're inside the body.
22 I wanted to comment on the metabolism or
23 the uptake of radionuclides in terms of the
24 complexity. I say the regulations are complex. Well,
25 all of this work, what we'll be discussing over the

1 next two days, is extremely complex. Otherwise, we
2 wouldn't be here discussing it.
3 Now, one complexity which several of us
4 have looked at over the past six months or so is in
5 terms of the uptake of Iodine-129. Of course, one of
6 the key factors is, what is the GI track absorption
7 coefficient or factor? And, furthermore, what is it
8 you're absorbing?
9 Well, we looked at I-129 as a -- one of
10 the -- it's one of the five radionuclides we'll be
11 discussing over the next two days. And what
12 stimulated my interest was the NCRP had stated that
13 Iodine-129 -- that based on the data that they have
14 reviewed they do not believe it's carcinogenic in man.
15 I changed it to in humans. I think they meant women
16 as well as men.
17 But in so doing, that led me and others --
18 led us to the following realization. When you
19 consider the average member of the U.S. public today,
20 they consume iodized salt. In fact, I believe it's
21 difficult to even go to a grocery store and buy non-
22 iodized salt. And they also consume salt in the milk
23 they drink and fish they eat, and many other foods.
24 Well, what does this show us, or what does
25 this indicate? One of the things it indicated was

1 that if you take the total amount of stable iodine
2 that the average member of the U.S. public consumes
3 each day, and compare that to the maximum amount of
4 iodine as represented by I-129, it will be in the
5 groundwater and consumed by the public over the first
6 10,000 years projected dose estimates for this
7 repository, the amount of stable iodine will be more
8 than two billion to one, the quantity of radioactive
9 iodine.
10 And the mere fact is the ratio of
11 stabilized to radioactive iodine in your thyroid can
12 never be lower than that in your diet, regardless of
13 whether you eat a carload of this food per day or two
14 grams or two pounds, whatever a typical daily diet is.
15 Now, what we hope to learn over the next
16 two days, in terms of biosphere assessments, is to
17 hear what the NRC expects and is going to require,
18 what the DOE response is to those expectations, and if
19 there are issues -- and I know the DOE and NRC have
20 jointly resolved many issues that have developed.
21 But to the degree that during the next two
22 days we can help resolve any issues, then more to the
23 good. We certainly want to do that. And during the
24 two days there will be opportunities, of course, for
25 public comments.

1 Furthermore, there will be interactive
2 sessions as well as formal presentations. And if the
3 ACNW and this panel of consultants is anything like I
4 know they are, there will be lots of interaction and
5 lots of questions. And we encourage that. And so we
6 want to ask questions such as those shown on the
7 board.
8 Now, what key factors govern intake?
9 These are other questions that we want to talk about.
10 What are their associated conservatisms and
11 uncertainties? And looking on one half of the balance
12 -- in other words, can we quantify the conservatisms,
13 and can we quantify the uncertainties?
14 And I would just mention a couple that are
15 well known -- a couple of conservatisms that are well
16 known to certainly everyone sitting around this table.
17 The first one is that neptunium,
18 plutonium, and americium all have reasonably or very
19 long half-lives, radioactive half-lives, and they all
20 have relatively long half-lives in the body. In other
21 words, their retention -- their biological half-life
22 is very long.
23 And if you use Federal Guidance Report
24 Number 11, or Federal Guidance Report Number 13, and
25 estimate the committed dose, in one case you use 50

1 years, in the other case you use 70 years, you'll find
2 that most of us -- and I am probably the most
3 prominent example at the table -- will die before my
4 50 or 70 years take -- fully occur.
5 In other words, if I ingest plutonium
6 today, they'll tell me they'll project 50 to 70 years.
7 Well, although I hope against it, I sort of doubt --
8 I may not be here in another 70 years.
9 Furthermore, all of these dose
10 coefficients -- and Keith Eckerman can correct me if
11 I'm wrong, and he -- as Dr. Ryan points out, he is the
12 number one person, certainly, worldwide in this field.
13 But another point is those dose coefficients are based
14 upon acute intakes. Well, the intakes that we project
15 for Yucca Mountain will be chronic, low level, drink
16 a little bit of water each day, eat a little bit of
17 contaminated food each day.
18 Well, that will give us a factor of two
19 conservatism, and so will this long half-life that I
20 previously described will give us a factor of two
21 conservatisms.
22 And we want to talk about the
23 uncertainties, we want to address the questions on the
24 slide, we want to know how realism can be achieved as
25 urged by Dr. Diaz, and we also want to know the

1 implications of these conservatisms and uncertainties
2 in terms of reasonable expectation, which is what the
3 USNRC is asking that DOE demonstrate. In other words,
4 a reasonable expectation that the repository will
5 perform in a manner so as to comply with the
6 regulations.
7 In terms of uncertainties, we throw these
8 on the board or on the slide just for your
9 consideration. A factor of two, such as those that --
10 the two items, examples that I described, are
11 interesting, but in general they are well within a
12 reasonable range of uncertainty, and they are well
13 within a reasonable range of certainty. So they are
14 of interest, but they are certainly not going to be
15 dominated.
16 Now, if you have an uncertainty in a --
17 within a range of a factor of two to 20 -- or 10 to
18 20, excuse me -- we certainly should pay attention.
19 If we have a factor of uncertainty of as much as 100,
20 that certainly needs to be addressed.
21 Now, in terms of that last one, a factor
22 of 100 uncertainty, one item that is of interest to me
23 -- and I'm sure it has been a real challenge to DOE --
24 is to evaluate the uptake of plutonium, because,
25 again, if you look at FGR 11, Federal Guidance

1 Report 11, it points out the absorption factor or the
2 dose coefficient for soluble plutonium is more than 50
3 times that for insoluble plutonium, simply because you
4 don't absorb as much of the insoluble.
5 Well, if you multiply that by either one
6 of the other two factors of two that I illustrated,
7 you have a factor of 100 or so, either conservatism or
8 uncertainty. And, in fact, with plutonium I gather to
9 some degree it's an uncertainty. In other words,
10 maybe the plutonium is there as a colloid, but is it
11 insoluble or soluble, and so forth.
12 So none of this is easy. We're not here
13 to criticize people. We're here to learn what's going
14 on, to seek the truth, and to be of assistance if we
15 can.
16 This one we can go over pretty rapidly.
17 What is it? The key factors that govern metabolism or
18 biokinetics and dosimetry. We want to know as much as
19 we can about the magnitudes, and so forth, want to
20 know what can be done to reduce these uncertainties.
21 And that's where, again, we reflect back to our
22 science and technology panel, as well as to ongoing
23 research that DOE has underway. They are trying to
24 reduce these -- the magnitudes of these uncertainties.
25 Day two we're going to be hearing from the

1 NRC, and I'm very excited awaiting that presentation.
2 It's called or titled "The Risk Insights Perspective
3 or Initiative." And in reality, for the layperson
4 such as myself, what they're going to do, as I
5 understand it, is list some of the conservatisms and
6 the uncertainties, and they're going to quantify them
7 or rank them in terms of their importance. So to me
8 that is a very important item.
9 And then there's going to be ample
10 opportunity for stakeholder input, as Dr. Garrick
11 pointed out, and we're going to hear the perspective
12 of the NRC's Office of Nuclear Regulatory Research.
13 And so with that, I believe that's the
14 last slide. No, here's one more.
15 Well, we will have the panel discussion.
16 And, again, I'm very much looking forward to the
17 panel's discussion, because, again, hopefully I can
18 gain concepts, ideas, which I will take back to the
19 science and technology panel for DOE. And at the end
20 of the day, we'll also have an opportunity for public
21 comments.
22 So I personally am looking forward to an
23 exciting two days.
24 Thank you, Mr. Chairman.
25 VICE CHAIRMAN RYAN: Thank you, Dr.

1 Moeller.

2 We have a few minutes before our first

3 presentation for comments from members of the panel.

4 And I guess we'll just start at Dade's right and go

5 down and offer you a chance to make any comments or --

6 DR. ECKERMAN: Dade mentioned a number of

7 things related to the information in Federal

8 Guidance 11 and -- well, 11 and 13, and there are some

9 points there that we'll need to expand and discuss

10 further.

11 Some of the issues aren't quite as -- as

12 clear cut, and there's a great number of options, of

13 course, available for further analysis. So I think

14 that's -- that's one that we'll come back to. But I

15 think your -- your characterization of where we should

16 put our focus in our -- in the deliberations and in

17 our thinking, as well as the guidance you've suggested

18 to us with respect to looking at the magnitude of the

19 uncertainties and focusing on those that are

20 significant, they are going to be very helpful.

21 VICE CHAIRMAN RYAN: Thank you, Dr.

22 Eckerman.

23 Dr. Kocher? Okay. Nothing yet.

24 John Till? Dr. Till? No.

25 DR. TILL: No.

1 VICE CHAIRMAN RYAN: No, sir? No? Dr.
2 Thorne?
3 DR. THORNE: I think just to pick up from
4 one or two of Keith's points, I think there is an
5 interesting question that you've raised, which is this
6 business of doses to infants and children.
7 I think perhaps a useful discussion is the
8 distinction between compliance calculations that are
9 relevant directly to the rule, and supplementary
10 calculations, which I think the question of infants
11 is, to inform members of the public about what the
12 issues are and how the uncertainties and distinctions
13 arise.
14 And I think in some ways the question of
15 Iodine-129 comes into the same framework. It's an
16 issue that we looked at in the British program for the
17 Nyrex repository, where we asked exactly the same
18 question about sources of iodine in the environment
19 and the fact that salt intakes were typically of the
20 order of 50 percent of total intakes, and, therefore,
21 application of a specific activity model in the simple
22 sense overestimated. But the degree of conservatism
23 was of that order of factor, too.
24 I think there are some other questions
25 that one should ask about whether it's proper to make

1 comparisons between the radionuclide content expressed
2 on a mass basis and the stated content on a mass
3 basis. I think that has the potential to confuse
4 rather than to eliminate, if you are talking dose and
5 risk terms. But we -- so we have -- it's a useful
6 comparison, but it has to be used fairly carefully I
7 think.
8 VICE CHAIRMAN RYAN: Any other opening
9 comments?
10 Dr. Moeller, are you ready to go?
11 Okay. If we could turn our attention for
12 our first presentation, please. Our first speaker is
13 Dr. Keith Compton, who will talk about the
14 introduction of biosphere dose assessments, the
15 framework and process for the U.S. Nuclear Regulatory
16 Commission staff review of a potential Yucca Mountain
17 license application.
18 Dr. Compton is with the System Performance
19 -- he's a Systems Performance Analyst in the Division
20 of Waste Management, and he is moving quickly to the
21 podium.
22 DR. COMPTON: If you don't mind, I'll ask
23 to stand while I make my presentation.
24 VICE CHAIRMAN RYAN: Sure.
25 DR. COMPTON: All right. I'd like to

1 introduce myself. Again, my name is Keith Compton.
2 I'm a research addition to the Performance Assessment
3 Section. I started in September. And I have spent
4 the last five years in Austria at the International
5 Institute for Applied Systems Analysis doing a variety
6 of risk analyses. I am very happy to be here at an
7 interesting time for performance assessment.
8 Today I would like to review the
9 regulatory requirements for dose assessment that are
10 laid out in Part 63 of the rule. And after I review
11 those requirements I would like to discuss the review
12 process that is laid out in guidance contained in a
13 document called the Yucca Mountain Review Plan.
14 Now, I would like to acknowledge at this
15 point that the committee has far more expertise and
16 knowledge of this than I do. I'm probably not going
17 to tell you much that you don't already know.
18 However, it would be useful at this point
19 to start with a discussion of the requirements in the
20 regulation to provide a background for the ensuing
21 discussions that we will have over the next few days,
22 and also to ensure that there is at least some basic
23 level, a common level, of understanding for members
24 and participants who were not part of development of
25 the rule or of the Yucca Mountain Review Plan.

1 The first part of my talk will be to
2 provide the regulatory framework. These are contained
3 in Part 63.
4 The second objective of my talk is to,
5 again, as I mentioned, to discuss how the NRC staff
6 will ensure that those requirements are met. And,
7 again, those are -- the guidance for those is largely
8 in the Yucca Mountain Review Plan.
9 One thing that I want to emphasize at the
10 beginning is that the objective of my talk is only to
11 describe the regulatory framework and the
12 requirements. I will not be going into the underlying
13 rationale or basis for the rules in this talk.
14 Next slide.
15 I'll cover the regulatory framework in the
16 first three bulleted items. The first thing that I
17 would like to talk to are some overarching concepts
18 that connects the area of dose assessments to the
19 larger process of reviewing the license application.
20 Next I simply want to provide a reminder
21 of what the quantitative performance objectives are.
22 Third, I want to discuss the nature and
23 scope of information that must be submitted by the
24 Department of Energy. And particularly I'm going to
25 focus on identifying the elements that are specified

1 by the rule.

2 The fourth part of my talk is a discussion

3 of our review process.

4 And then, finally, of course, I'll close

5 with a summary of what I've said.

6 The first concept that I would like to ask

7 the participants to keep in mind is that the

8 regulatory process is a multi-step process that

9 anticipates the development of new information. It's

10 an iterative process, and there will be opportunities

11 to incorporate new and evolving information into

12 regulatory decisionmaking prior to permanent closure

13 of the repository.

14 Next slide.

15 The license application will require a

16 safety analysis report. A key aspect or a key element

17 of the safety analysis report is a quantitative

18 performance assessment, and two of the major elements

19 or attributes of the post-closure performance

20 assessments are identification of barriers and a

21 quantitative estimation of the performance of the

22 repository.

23 Today I am only going to focus on the

24 second of those two, the quantitative estimation of

25 performance. And I would like to acknowledge that the

1 quantitative performance assessment is only one of
2 several elements that are required as part of the
3 license application.
4 The final general concept that I would
5 like to bring to your attention is that of reasonable
6 expectation. And this concept acknowledges that
7 absolute proof of compliance is not possible in light
8 of the large uncertainties associated with making
9 long-term projections.
10 Of particular importance to biosphere dose
11 assessments are the very large uncertainties
12 associated with future human behavior. And because of
13 those uncertainties, the National Academy of Sciences
14 recommended in their technical basis for Yucca
15 Mountain standards that certain aspects of the
16 performance analysis -- of the performance assessments
17 be specified in a rulemaking process. And, again,
18 it's those aspects that I'm going to bring up and
19 identify.
20 Just a reminder as to what the
21 quantitative performance objectives are. There are
22 three in the rule. The first is an individual
23 protection standard. The exact words are contained in
24 the backup slides. I'm not going to read the
25 definitions. I'm going to -- to summarize those.

1 First, there is an individual protection
2 standard, which is 15 millirems per year. It's an
3 all-pathways dose from an undisturbed repository.
4 There is a quantitative performance objective for the
5 human intrusion scenario. That is also a 15 millirem
6 dose from all pathways, but it is resulting from a
7 stylized intrusion scenario.
8 And, finally, there are separate standards
9 for the protection of groundwater. Those specify
10 concentration limits for alpha-emitting radionuclides.
11 There is a dose standard associated with beta- and
12 photon-emitting radionuclides of a four millirem organ
13 dose.
14 Turning to how dose assessment fits into
15 the overall quantitative performance assessments, this
16 slide illustrates the concepts of dose assessment as
17 a process that combines the characteristics of the
18 reasonably maximally exposed individual. In the
19 future, I may refer to that as the RMEI, because it's
20 difficult for me to say that phrase too frequently.
21 So if I mention RMEI, then that's what I'm referring
22 to.
23 It combines the characteristics of the
24 RMEI and the characteristics of the biosphere with the
25 environmental concentrations that are the result of

1 the preceding performance assessment calculations and
2 uses those to compute a dose to the reasonably
3 maximally exposed individual, and that computed dose
4 is then compared to the quantitative performance
5 objectives in order to make a judgment of whether
6 compliance can be demonstrated.
7 Now, as I mentioned, there are two major
8 aspects to dose assessment. It is identifying the
9 characteristics of the RMEI and the characteristics of
10 the biosphere. In the rule, the characteristics of
11 the reasonably maximally exposed individual are
12 specified on the slide.
13 Some things that I'd like to draw your
14 attention to is that the location of the RMEI is
15 specified in the rule. The diet and lifestyle are
16 specified to be typical of the current inhabitants of
17 Amargosa Valley. The average concentrations in well
18 water used to determine doses are based on reasonable
19 estimate of water demand, and, finally, as has been
20 mentioned, the RMEI is specified to be an adult.
21 DR. MOELLER: Excuse me. Can we --
22 VICE CHAIRMAN RYAN: Sure.
23 DR. MOELLER: In your bullet there on the
24 previous slide that has the diet and the lifestyle
25 representative of the current population of Amargosa

1 Valley, as I recall it says resident of the town of
2 Amargosa Valley. And I'm nitpicking, but to me there
3 is a difference in the two.
4 DR. COMPTON: Yes, sir, I believe that's
5 correct. Thank you.
6 My next slide -- the other major aspects
7 of the performance assessments -- or the dose
8 assessments is to apply characteristics of the
9 biosphere. And again, as mentioned, the factors that
10 are associated with human behavior are inherently
11 difficult to predict due to the lack of a long-term
12 historical record, the lack of a scientific basis for
13 predicting those characteristics far into the future.
14 And, therefore, those are fixed by rule to
15 be constants and consistent with conditions at the
16 time of the license application. On the other hand,
17 the factors associated with the physical environments
18 can be estimated in a scientific way on the basis of
19 a long-term record. And those, therefore, must be
20 varied in a cautious way and must be defended on their
21 technical basis, on their scientific basis.
22 Now, finally, I'll discuss the
23 requirements of the performance assessment that must
24 be included in the safety analysis report. In the
25 rule, DOE is required to provide the technical basis

1 for their choice of the scenarios to be analyzed and
2 the models used to analyze them. They must account
3 for uncertainties, and they must consider alternative
4 conceptual models.
5 Of particular importance, again, to
6 biosphere is that these analyses are limited in
7 important areas by the regulation in Part 63.
8 Now, the guidance as to whether these
9 requirements are met are laid out in the Yucca
10 Mountain Review Plan, which is -- next slide, please
11 -- which I will turn to. This brings us to the
12 process by which the NRC staff will review the
13 information that has been submitted as discussed in
14 the previous slides.
15 I want to point out on this slide that the
16 Yucca Mountain Review Plan and the use of risk
17 insights is a complementary approach. The Yucca
18 Mountain Review Plan provides guidance on the subject
19 matter and the review process for staff review of a
20 potential license application. The risk insights are
21 used, on the other hand, to determine the depth of the
22 review of the information provided and will also guide
23 the NRC staff in developing requests for additional
24 information, if those are determined to be necessary.
25 I'd like to remind members of the panel

1 that Tim McCartin has recently discussed the role and
2 use of risk insights and technical exchange on the
3 level of design detail. And, furthermore, Patrick
4 LaPlante is going to be providing a discussion or an
5 example of the use of risk insights in agreement
6 resolution in a prelicensing phase.
7 Within the Yucca Mountain review plan,
8 there are sections that describe how to review the
9 important model abstractions, and the biosphere dose
10 assessment is one of the important model abstractions.
11 The areas that we will review are listed
12 on the slide, and they include, for example, a review
13 of DOE's description of the Yucca Mountain sites and
14 their description of the reasonably maximally exposed
15 individual and the reference biosphere.
16 We will look at how well features, events,
17 and processes that affects the potential for
18 compliance have been characterized, and the extent to
19 which those affect waste isolation. We will look at
20 an evaluation of the uncertainty in both -- both data
21 uncertainty and model uncertainty. And we will
22 analyze the extent to which the analyses provided by
23 the Department of Energy has been supported by
24 objective comparisons.
25 The review methods that are in the Yucca

1 Mountain Review Plan are -- have been developed in
2 order to provide a detailed review of the license
3 application, if that should be necessary. The
4 acceptance criteria in the review plan are based on
5 meeting requirements for performance assessment and
6 the extent to which the analysis complies with the
7 requirements that are laid out in the rule.
8 There are many specific detailed questions
9 that are laid out in the review methods. I'm not
10 going to go through the several-page list of those
11 questions in detail. I've tried to pick out some
12 typical types of questions that are asked in the Yucca
13 Mountain Review Plan. And the determination of -- or
14 the acceptance criteria essentially consists in making
15 determination that these questions can be answered
16 affirmatively.
17 And a few examples under -- going back to
18 the areas that I had discussed in the previous slide,
19 under system description, with respect to consistency
20 we would verify that the reference biosphere is
21 consistent with arid or semi-arid conditions. For
22 model integration, an example is to ensure that the
23 physical and chemical properties of radionuclides are
24 consistent with assumptions in the other abstractions.
25 For data justification, parameter values,

1 such as the plant uptake factors or mass loading, are
2 consistent with the site characterization and are
3 technically defensible. On the other hand, behavioral
4 parameters of the RMEI should be consistent with the
5 definition in the regulations. That is, that they
6 should be based on present knowledge of the RMEI
7 behavior.
8 For data uncertainty, an example of
9 something that we would look for is that correlations
10 between infant values have been appropriately
11 established in the total system performance
12 assessments. An example on model uncertainty is they
13 should provide evidence that they have considered
14 alternative models -- for example, models of soil
15 resuspension.
16 And, finally, an example for model support
17 is that we should look at -- to whether the results
18 from DOE's performance assessments have been compared
19 and are supported by alternative modeling codes, such
20 as GENII.
21 This brings me to the end of my talk.
22 Again, I have tried to in the talk point out that many
23 of the characteristics of the reasonably maximally
24 exposed individual and the reference biosphere that
25 are used in the dose assessment are specified by the

1 regulation, and, furthermore, that the Yucca Mountain
2 Review Plan, together with risk insights developed by
3 the staff, will guide NRC review of the DOE's
4 biosphere attraction.
5 And that's the end of my presentation. If
6 anyone has any questions, I'd be happy to answer them.
7 VICE CHAIRMAN RYAN: That's great. I
8 think what I'd like to do is just to kind of get our
9 order. We've got the panel here, and what I would ask
10 is that the panel first express their views or
11 questions, and so forth, and then we'll ask members of
12 the ACNW to have questions and comment as well.
13 So I'll turn the first part over to you,
14 Dade, to --
15 DR. MOELLER: Okay. John? John Till?
16 DR. TILL: Just two clarification
17 questions, because I have other things to talk about
18 tomorrow. One, Keith, is since you are taking a
19 probabilistic approach to estimating the dose to the
20 RMEI -- in other words, you're going to come up with
21 a distribution of possible doses to that individual,
22 correct?
23 DR. COMPTON: That's correct.
24 DR. TILL: Okay. Does the standard
25 specify where on that curve you make the comparison to

1 the .15 millisievert?

2 DR. COMPTON: Yes, sir. That's in the --

3 in DOE's performance assessments, it is specified that

4 the value should be the mean value, the expected value

5 of that dose curve. However, it's the peak within a

6 10,000-year period. So at each time period within the

7 compliance, you estimate the average or the expected

8 dose, and then it's the highest of those that will be

9 used to determine --

10 DR. TILL: Okay.

11 DR. COMPTON: -- to compare.

12 DR. TILL: Okay. The other question is --

13 and this goes back to the issue of adult that you

14 raised earlier, Dade. Are these the standards that

15 were mandated by EPA? In other words, is this the way

16 the standard came from EPA, that it was an adult?

17 DR. COMPTON: I believe that's correct.

18 I'd like to -- because I've only been here a short

19 time, I'd like to make sure that I don't misspeak and

20 ask Tim, maybe to --

21 DR. McCARTIN: Actually, we're the ones

22 that put the adult in Part 63. The EPA standard did

23 not specify --

24 DR. TILL: Okay.

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

1 in our statements of consideration. We believe the
2 dose limit is predicated on a lifetime risk, limiting
3 the lifetime risk and that -- that limit is protective
4 of all individuals and the environment.
5 DR. TILL: We'll come back and discuss it.
6 Actually, I agree with that, but that was a surprise
7 to me.
8 DR. MOELLER: Well, thank you. Any other
9 questions? Dr. Kocher?
10 DR. KOCHER: I'd like to hear a little bit
11 more about the definition of the reference biosphere,
12 because in Part 63 it seemed like the definition was
13 pretty skimpy.
14 DR. COMPTON: Well --
15 DR. KOCHER: Maybe ask the question a
16 different way. What elements of the reference
17 biosphere have you defined in regulations?
18 DR. COMPTON: Well the reference biosphere
19 is -- are -- is defined largely as I presented it.
20 There are not specific elements of that that are
21 defined in the regulation. It essentially says that
22 certain parameters should be related to human factors,
23 should be held constant and consistent with the time
24 of license application, and that the factors related
25 to the physical environment should be varied. There

1 is -- in the rule there is not much more specification
2 in the regulation.
3 DR.. KOCHER: So absent humans, really, the
4 only specification of the biosphere in the regulation
5 is the semi-arid/arid conditions?
6 VICE CHAIRMAN RYAN: I think if you put up
7 slide 9, that might help.
8 DR. KOCHER: Or I guess there may be
9 something in there about, you know, assuming the kind
10 of biota and soils that you have at the present time,
11 something like that.
12 DR. COMPTON: I believe that's correct.
13 For the physical environment, that would be consistent
14 with the sites and consistent with what is -- I'm
15 sorry. Yes. The factors that are related, for
16 example, to the flora and fauna should be consistent
17 with the current knowledge. Factors such as climate
18 can be very cautiously but reasonably -- I don't know
19 if that answers your question.
20 DR. KOCHER: Well, I assume you want to
21 give the license applicant some leeway here and not --
22 unless -- I mean, one thing we can discuss during the
23 two days is, you know, to what extent do you really
24 want a stylized calculation here for everything.
25 That's a possibility.

1 DR. COMPTON: Well, the reference
2 biosphere is not intended particularly for the
3 physical environment to generate a stylized
4 calculation. It's like any license application
5 review. It would -- they would have to defend it.
6 They would have to provide their description of the
7 biosphere.
8 They have to come in and describe -- and
9 present their characterization, and then the staff
10 would review that and determine whether they were
11 technically justified. And that's, in contrast, a
12 more stylized calculation that cannot be defended or
13 justified on the basis that it's generic.
14 I think this also may be an area where
15 risk insights would be used to -- aspects that were
16 important to dose would need to be fairly solidly
17 justified. For example, the use of national kind of
18 generic data on rainfall or infiltration would not be
19 appropriate. You would need to get more site-specific
20 data.
21 But many of that -- much of that will --
22 would determine as to what -- what the Department of
23 Energy submitted and that would be reviewed based on
24 our knowledge of the sites and our use of risk
25 insights to determine whether that was an adequate

1 characterization.

2 VICE CHAIRMAN RYAN: Keith, I think -- I

3 appreciate your -- Dave, I mean. Excuse me. Dave, I

4 appreciate your question. If you do look at slide 9,

5 I think there's two parts to your question. The first

6 is what we just talked about, which I think Dr.

7 Compton has told us about, but also to me this is the

8 stylized part, where the water use and what develops

9 the concentration then is assessed, and the

10 environment is also kind of a second part to that

11 question.

12 So I guess let's keep your question in

13 mind, because I think as we hear information over the

14 two days we'll probably revisit that from time to

15 time. That's a good start.

16 Yes, Dr. Thorne.

17 DR. THORNE: Could I just come back to

18 this? Because I think the concept of reference

19 biosphere has a long history in some international

20 discussions in biomass. And I was partly responsible

21 for this, so I can talk to this briefly.

22 The idea originally, I think, was that

23 reference biospheres would be very much like reference

24 man. There was a well-defined, highly-specified

25 entity.

1 And I think there are some people in the
2 international community who believed in a one size
3 fits all biosphere, that we would simply plug this in
4 as a measuring instrument in the back of an
5 assessment, and it would turn all of these
6 radionuclide fluxes into a dose. And that's what
7 you'd compare with compliance standards.
8 I think it was fairly rapidly realized
9 that one size didn't fit all, and that, therefore,
10 what came out of biomass was very much a methodology
11 that the applicant would use to define a reference
12 biosphere for their particular assessment and their
13 particular context.
14 And I think that's what we're seeing here,
15 that there are high-level rules given here for
16 identifying the reference biosphere, but it is not
17 prescribed in detail. It's for the applicant to work
18 through their methodology and for the reference
19 biosphere to emerge from that to then be suitably
20 audited and reviewed.
21 VICE CHAIRMAN RYAN: Thank you.
22 Tim?
23 DR. McCARTIN: Tim McCartin. Actually, I
24 couldn't have said it better than Dr. Thorne. And
25 that really was the intent of the rule. And as Keith

1 pointed out, the one direction very strongly from the
2 National Academy of Sciences that -- in terms of
3 speculation of human behavior, etcetera, in the
4 portion of the reference biosphere, that -- when we
5 described it, that's what we were trying to eliminate,
6 as Dr. Kocher said, absent humans. And so fix it on
7 what people are doing there today and do not speculate
8 on what might happen in the future with humans,
9 because it's kind of an endless possibility.
10 DR. MOELLER: I'd like to pick up on Dr.
11 Till's comment about the adult. I, too, was intrigued
12 that it was not in EPA's standards as far as I could
13 tell. And I'm pleased to hear that the NRC -- that
14 that's the source of the word for the adult.
15 That raises another question in my mind.
16 When I first was asked to come here today, I, of
17 course, read the regulations, and so forth, and tried
18 to learn as much as I could to prepare for the
19 meeting. And the first conclusion -- or first
20 assumption I made was that the USNRC is licensing this
21 repository, and I believe I'm -- you know, they're
22 either to license it or not. They're reviewing the
23 application.
24 Well, that being the case, then the NRC
25 has Title 10, Part 20, which I read it and it says it

1 applies to all USNRC licensees. Well, so I did some
2 dose estimations using Title 10, Part 20, and I was
3 pleased to see that it had special considerations of
4 infants and children, and so forth.
5 And then, I don't remember where I heard
6 it, but I suddenly was told, "Well, no, we're not
7 going to use Part 20. We're using Federal Guidance
8 Report Number 11." Well, I thought, well, now, I
9 wonder why, and I began to realize that one
10 justification at least was that it's for an adult, and
11 RMEI is an adult. So that makes sense.
12 But, and it has also been approved by the
13 President, and I'm sure many others can tell me a lot
14 more about it. But then I wondered, well, in terms of
15 best science, I wonder what Federal Guidance Report 13
16 says in terms of dose estimates. In other words, if
17 there's flexibility in what dose coefficients we use,
18 then I want to know what the doses are using any type
19 of guidance.
20 I even went back and did the calculations
21 for Handbook 69, because the drinking water standards
22 say that Handbook 69 shall be used. Well, when
23 they've moved the drinking water standards and applied
24 them to the groundwater standards I thought, well,
25 they moved the whole thing. Well, apparently not.

1 Let me close by commenting -- when I
2 looked at Federal Guidance Report Number 13 applied to
3 dose coefficients, and we're talking today and
4 tomorrow about technetium, iodine, neptunium,
5 plutonium, and americium, well, if I look at those
6 last three alpha emitters, the doses in Federal
7 Guidance 13 are a factor of 10 -- four to 10 less than
8 those in FGR 11.
9 Well, that's pretty important, at least it
10 seems to me. Is there anyone who wants to -- John,
11 please.
12 DR. TILL: Well, I assume we don't want to
13 get on a discussion of that right now. I understand
14 the philosophy of using the adult for prospective
15 calculations. And the bottom line is we are making --
16 we are setting a standard based on a lifetime
17 exposure, and I think -- well, we really mess ourself
18 up with this by not making it clear why.
19 It's based on lifetime risk. Am I right?
20 And, therefore, it ought to be an adult in my view.
21 So I think the problem, Dade, is not with the -- with
22 the philosophical basis. I think the problem is the
23 way the standards are written. I think we've gotten
24 ourself in a mess with that. We'll come back to it
25 and maybe talk about it some more.

1 VICE CHAIRMAN RYAN: Yes. I think we have
2 some spots on the agenda, particularly later today,
3 where Dr. Eckerman is going to lead us through these
4 various dose calculation sets. I think the general
5 point that strikes me is that dose conversion factors
6 are not necessarily in an absolute vacuum. They're
7 done for a purpose, and they're done under a
8 particular scenario, and keeping that straight is
9 important.
10 You know, for example, ICRP 30 is limits
11 of intakes of radionuclides by workers. And we forget
12 that "by workers" has some very specific implications
13 of how things are calculated and how things are
14 estimated, because it's in that context. So hopefully
15 we'll elucidate some of those details as we go through
16 the next couple of days.
17 But I think whether it's -- it's the dose
18 conversion factors or other aspects of either the
19 specific data that we'll hear about a little bit from
20 DOE, or whether it's the evaluation tools, we have to
21 keep in mind some of the things that you just
22 mentioned, John, and other information, and hopefully
23 we can sort through that over the next couple of days.
24 Dr. Thorne.
25 DR. THORNE: Perhaps one more general

1 point to lay down. Reasonably maximally exposed
2 individual -- and I lay a little stress on the last
3 word, because when I look at the calculations that are
4 done in characteristics of the receptor, I see four
5 population groups picked out from the Amargosa Valley
6 population, and then I see the results calculated as
7 an average over those groups. And I think I'd like to
8 explore at some point whether we have genuinely got an
9 individual related standard here or a population
10 average related standard.
11 VICE CHAIRMAN RYAN: Thank you.
12 Any other questions from panel members?
13 Yes, Tim.
14 DR. McCARTIN: Just one quick comment on
15 that. Tim McCartin, NRC staff. I forgot to introduce
16 myself for the reporter before.
17 The rule does say -- and EPA specified
18 this -- that the RMEI is a hypothetical person. So,
19 and that's why, you know, it's not an individual.
20 It's a hypothetical person with these average
21 characteristics.
22 VICE CHAIRMAN RYAN: Thank you.
23 Questions from -- comments from committee
24 members? Dr. Garrick?
25 CHAIRMAN GARRICK: I'd just make a

1 comment. I was very pleased to hear Dade Moeller put
2 as much emphasis as he did on understanding as best we
3 can the uncertainties, because this committee has been
4 accused of being obsessed with uncertainty. And it's
5 nice to have an outsider come in and make a similar
6 comment.
7 The one thing that I think we really would
8 like to learn from this exercise the next couple of
9 days is get some insights on the relative contribution
10 to uncertainty of the uptake calculation itself in the
11 biosphere. This committee has heard a large number of
12 presentations on uncertainties associated with the
13 movement of the material out of the waste package and
14 into the biosphere. And there has been a tremendous
15 amount of information discussed, presented, and
16 challenged in that area.
17 What we're really hungry for is much
18 better insight with respect to the health effects
19 model, which hasn't been in the spotlight very much in
20 the course of the discussions over the last couple or
21 three years. So I'm hopeful that one bottom line that
22 we get out of this is some sense of what the relative
23 contribution is.
24 When we see, finally, a bottom line
25 calculation of a distribution of maximum averages of

1 the dose, that we have some sense of how much of that
2 uncertainty distribution is coming from two major
3 components -- namely, the health effects model on the
4 one hand and the transport of material on the other
5 hand.
6 VICE CHAIRMAN RYAN: George?
7 MEMBER HORNBERGER: Just one quick
8 comment, again, following up on what John said. It
9 also -- I think that we probably all agree, but just
10 for the record, it strikes me that if a calculated
11 dose is one millirem per year, a factor of 100
12 uncertainty could be important. If a calculated dose
13 is 10^{-10} millirem per year, a factor of 100 uncertainty
14 may not be of much importance.
15 MEMBER WEINER: I just have one very
16 simple question. What's the difference between
17 cautious and conservative?
18 DR. COMPTON: I am going to try and defer
19 that to McCartin, to make sure that I don't mislead
20 you.
21 DR. McCARTIN: I don't think that's a
22 simple question, really. But anyway, I don't see much
23 distinction between the two words.
24 MEMBER WEINER: Well, then --
25 DR. McCARTIN: I mean, I would have to

1 have a particular context or something more I guess to
2 draw a distinction between cautious and conservative.
3 In a public meeting, I would say for the general
4 public it's -- they mean the same.
5 MEMBER WEINER: Well, then, I'd hark us
6 back to what the Chairman said and what Dr. Moeller
7 reiterated, that we need to look at realism --
8 realistic scenarios rather than conservative ones.
9 And I was just hoping that we were not simply using
10 cautious as a synonym for conservative. But I guess
11 we are.
12 DR. McCARTIN: Well, without more context,
13 to me the words are very similar.
14 MEMBER WEINER: Okay.
15 DR. COMPTON: I will just add that this is
16 somewhat discussed and possibly addressed in the
17 concept of reasonable expectation, which -- in which
18 it's required to focus performance assessments on the
19 full range of defensible and reasonable parameter
20 values. So I would just offer that as something to
21 think about.
22 VICE CHAIRMAN RYAN: Dr. Clarke?
23 MEMBER CLARKE: Just one quick question to
24 clarify my own understanding. Your first backup slide
25 that you didn't show speaks to the requirement to

1 calculate a peak dose after the compliance period.

2 DR. COMPTON: Yes.

3 MEMBER CLARKE: There is no corresponding

4 standard for that dose. Is that correct?

5 DR. COMPTON: On the -- are you saying the

6 second bullet?

7 MEMBER CLARKE: Yes.

8 DR. COMPTON: No. This is -- if the --

9 this goes to the question of when the peak dose

10 occurs. If the peak dose occurs after the 10,000-year

11 compliance period, it must be calculated, but there is

12 not -- as you point out, there is not a compliance

13 standard associated beyond the 10,000-year compliance

14 period.

15 VICE CHAIRMAN RYAN: Thank you.

16 Any other questions? Yes, Dave.

17 DR. KOCHER: This is not 100 percent

18 related to what we're about, but I do think there is

19 potentially some confusion about what the groundwater

20 protection standards really are. The standard for

21 beta-gamma emitters is not four millirem to whole body

22 or any organ. The standard is the MCLs that the EPA

23 published back in 1976 or '77.

24 The four millirem is a shorthand so that

25 you can get the standard into a single table. But

1 you're not -- you don't have the leeway, for example,
2 to choose a different set of metabolic models to
3 calculate a concentration in water. The standard is
4 the MCLs, and the reason they did that is because the
5 operator of a municipal water system has to be able to
6 judge compliance. And he can't sit there with his
7 ICRP dose calculator. He measures radioactivity in
8 water.
9 VICE CHAIRMAN RYAN: Dave, you used the
10 term that four millirem is a shorthand. Would you
11 tell everybody what that means, please?
12 DR. KOCHER: Well, as Dade pointed out,
13 the rule says that the standard for beta-gamma
14 emitters is a certain dose, and it's four millirem to
15 whole body or any organ. But that same statement
16 prescribes how you shall go from that dose standard to
17 a concentration in water.
18 You shall assume two liters per day intake
19 of water, and you shall assume those coefficients from
20 NBS Handbook 69, which is ICRP 2 vintage. And so the
21 real standard, the real operational standard, is the
22 MCLs that are so calculated.
23 VICE CHAIRMAN RYAN: You know, I think
24 that's -- that's really an important point, because
25 that gets back to what Dr. Thorne talked about I think

1 earlier is that -- that's a prescribed calculation or
2 a prescribed value compliance demonstration. But that
3 may or may not reflect the 40 years of metabolic model
4 improvements from that point forward.
5 So I think it's helpful to point that out
6 as we go along. And, again, I'm sure Dr. Eckerman is
7 going to address that. But before he does, let me go
8 back behind you to Tim McCartin.
9 DR. McCARTIN: Tim McCartin, NRC staff.
10 I guess the question I would have, is there a
11 reference in the regulation that you're referring to
12 in drawing this reference to MCLs? Right now there is
13 no reference to MCLs. The regulation states --
14 DR. KOCHER: Yes. This is complicated.
15 DR. McCARTIN: -- four millirem.
16 DR. KOCHER: This is complicated.
17 DR. McCARTIN: Is there a reference you
18 have in mind?
19 DR. KOCHER: The standard prescribes how
20 you shall use that number. I mean, I didn't bring
21 Part 141 with me, obviously. You need to read the --
22 DR. McCARTIN: It's Part 197 for Yucca
23 Mountain.
24 DR. KOCHER: Well, be careful. We're
25 going to get off in the weeds here if we're not

1 careful.

2 DR. McCARTIN: Okay.

3 DR. KOCHER: The standard is MCLs. I

4 mean, you're stuck with one picocurie per liter for

5 Iodine-129 whether you like it or not.

6 VICE CHAIRMAN RYAN: I've got a good idea.

7 Let's do a little homework and we'll visit this

8 sometime within a couple of days. How's that?

9 But I think this is an interesting point,

10 and it -- to me the theme of the point is that we need

11 to be real clear about, you know, what's a reference

12 calculation for the purpose of compliance

13 demonstration and what's a metabolic model that may

14 reflect the science of the metabolic model, and kind

15 of sort that out. So let's agree to come back to that

16 question.

17 Any other questions or comments? We are

18 at a point -- thank you, Dr. Compton. Appreciate it

19 very much.

20 We, on our agenda, are scheduled for a

21 break, and I think we'll probably just do that early,

22 Mr. Chairman.

23 CHAIRMAN GARRICK: Sure.

24 VICE CHAIRMAN RYAN: And we're scheduled

25 for a 20-minute break, so why don't we come back at,

1 say, 9:45 and pick up from there.

2 Thank you.

3 (Whereupon, the proceedings in the

4 foregoing matter went off the record at

5 9:21 a.m. and went back on the record at

6 9:47 a.m.)

7 VICE CHAIRMAN RYAN: On the record. If we

8 could come to order please. We are now scheduled for

9 presentations by representatives from the U.S.

10 Department of Energy and the Department's overall

11 approach to conducting dose assessments called for the

12 NRC's site specific regulation for Yucca Mountain. We

13 will have two speakers. First, it will be Dr. Peter

14 Swift of The Sandia National Laboratory who's Manager

15 for Performance, Assessment Strategy and Scope for

16 Bechtel SAIC followed by Dr. Kurt Rautenstauch who is

17 a Senior Environmental Specialist. So let me turn it

18 over to you, Dr. Swift.

19 DR. SWIFT: Thank you.

20 VICE CHAIRMAN RYAN: Just before you

21 begin, I might add if I could ask everybody in the

22 audience. There are two sign-up sheets behind the

23 pillar here and if you would sign in please, we'd

24 appreciate it. Thank you very much.

25 DR. SWIFT: Is the microphone working?

1 Not working now. Thank you. Well, I'm Peter Swift
2 and my role here is as the manager of the group that
3 does the total system performance assessment. I'm
4 going to give you a very short overview that I hope
5 will put the rest of the presentation in the DOE in
6 context.
7 For many of you, this will be a review of
8 material. Some of you heard me present it before, but
9 for some, in particular I think we have some of our
10 panel members, this is going to be a very short trip
11 through a whole of material that we're not covering in
12 this workshop. Then I'll turn it over to Kurt
13 Rautenstrauch and Maryla Wasiolek to actually talk
14 about biosphere stuff.
15 Just by way of background of myself, I'm
16 a geologist. If you want to ask of me, be aware
17 that's the direction which I come. I've worked in
18 performance assessment for 15 years now. The next
19 slide please.
20 A very quick review coming up here of the
21 current status of the total system performance
22 assessment, a summary of the methodology and then a
23 little bit about the role of the biosphere model and
24 those conversion factors that we'll hear more about,
25 how the conversion factors play into the total system

1 performance assessment. Thank you.

2 A little disclaimer here. This is

3 important. Anything that I present that comes from

4 the total system performance assessment is old news.

5 It comes from existing and publicly available TSPA

6 analyses. I apologize for using the abbreviation

7 TSPA, but there it is. There they are back in

8 December of 2000. There was a total system

9 performance assessment done to support the site

10 recommendation. It was updated in the summer of 2001

11 and again in the fall of 2001. All three of those

12 form the basis for the DOE's site recommendation.

13 Then there was further analyses done in

14 the year 2002 which had been reported to this group

15 and elsewhere. There should at the back of this

16 handout be a list of references that give you the

17 proper citations for all those.

18 I'm not going to show any results from the

19 models that are currently under development and I'll

20 be pretty limited in how I field questions on those.

21 Those models are still under development right now and

22 we do not have results ready to present yet. Next

23 slide. Thank you.

24 Just a quick review here of what is the

25 total system performance assessment process what we're

1 doing here. Working down these steps here, first we
2 start off by screening features, events and processes.
3 You hear the acronym, FEP, to describe those things.
4 Features, events and processes all those are
5 potentially relevant to the future performance of the
6 site. It is in a sense perhaps a philosophically
7 unbounded list of things. This step is done to
8 determine those that must be retained in a
9 quantitative performance assessment. It's an attempt
10 to put some useful bounds on the speculative list of
11 everything that might happen. What are those things
12 that really matter? There are rules on how to do that
13 screening which are outside the scope of this meeting
14 probably, but it's done.
15 Develop models along with our scientific
16 basis for each process that was retained and included.
17 That phrase along with their scientific basis is of
18 course where a wealth of scientific research is done.
19 But from my perspective in the total system
20 performance assessment, years of scientific research
21 produce a model which then goes into the analysis.
22 Obviously there are many other reasons to do the
23 scientific research, but that's how they enter into
24 the TSPA.
25 Identify uncertainty in those models and

1 parameters. Build the integrated model with all the
2 retained processes. And then we calculate performance
3 for three different major scenario types: a nominal
4 scenario class that contains all the features, events
5 and processes that are likely to occur that's
6 essentially certain to occur; a disruptive event
7 scenario class or classes containing the low
8 probability events, the volcanic disruption, extreme
9 seismic disruption of the site, those we build
10 separate modelings for those and we model their
11 consequences separately.
12 This workshop does not address volcanism
13 or seismic disruption. That's an important point to
14 note. We're limited here to the performance of the
15 site taking into account those processes and events
16 and features that are likely to occur. There's also
17 the stylized human intrusion model which again is
18 outside the scope of this workshop, but is required in
19 regulation and deem we do it.
20 After the models are built for these
21 scenario classes, we evaluate total system performance
22 against the three standards, individual protection,
23 ground protection, human intrusion. We evaluate
24 uncertainty in our results from Monte Carlo
25 simulation. The model here is a series of linked

1 computation codes that can be run, a deterministic
2 mode, each set of input values versus a single output
3 result. But if you run it in a Monte Carlo technique
4 with multiple sample inputs, you get multiple outputs
5 resulting from the uncertainty in those inputs.
6 And there's a consequences calculator for
7 each of these scenarios are weighted by the
8 probability of that scenario occurring and they are
9 combined. That probability weighting's important with
10 respect to - it's specified in the rule - volcanism
11 and seismic disruption because those are very low
12 probability events. So larger consequences of those
13 events get weighted by that smaller probability and
14 combine with this nominal scenario which has
15 essentially a probability of one of occurring. Next
16 slide please.
17 A quick review of what is in the nominal
18 performance scenario class. It's just a schematic of
19 what the mountain might look like. There's a huge
20 misrepresentation to scale here. That's 18 kilometers
21 from here to there and only several thousand feet from
22 there to there. All right.
23 The repository is in unsaturated zone of
24 rock here well above the water table. The water table
25 is shown down here at the bottom. Precipitation that

1 falls on top of the mountain infiltrates through the
2 surface soil into the rock. It percolates downward
3 through the rock in unsaturated zone flow. The water
4 is moving in fractures. Some of it remains trapped in
5 pores. Some of it moves on down through fractures.
6 In general the rock appears to be dry though with
7 relative small amounts of moisture moving through it.
8 Some of that water will reach the repository and will
9 under the drifts result in corrosion of the packages,
10 may result in holes in the packages which would allow
11 radionuclides to be dissolved or transported by as
12 colloids in that water. That water can then carry
13 them on down to the water table where they could be
14 moved out through flowing groundwater, saturated zone
15 flow to the hypothetical withdrawal well where they
16 would enter the biosphere. Next slide please.
17 This and the next slide are in here mostly
18 just to give a sense of the level of detail in the
19 entire systems model. If one were to start here, this
20 just sort of tracks the components I went through
21 visually on the previous slide. It tracks them
22 through unsaturated zone flow, engineered barrier
23 performance and so on. Eventually each of the
24 components is modeled separately and you come out here
25 at the far end with a biosphere model and a dose

1 calculation.

2 In our modeling system, there is actually

3 a computational model with equations that are solved

4 and put parameters and outputs for each one of the

5 things that are listed here. And each one of those

6 could be and has been subject of extensive discussion

7 with the NRC staff because this is the 22nd version of

8 this slide. Next please.

9 For those who wanted to see how the

10 computation models are actually linked together, note

11 that this is out of date. It's from the site

12 recommendations. It's a four year old slide, but I

13 don't have a current version of it yet. We haven't

14 quite finished all those linkages. Each one of these

15 circles represents a computer code.

16 At the time the slide was made, if you

17 could read the fine print on it and see what all those

18 things are on the arrows connecting them, those were

19 accurate for the hand-offs between codes as of the

20 time that slide was made. So each one of these models

21 was run, feeds something to another model. As I say,

22 this is now out of date.

23 One thing worth noting however on this

24 slide, the GENI Code used until last year is not what

25 is now used for the biosphere. However it still

1 occupies that same location in linkage of the modeling
2 system. The biosphere code calculates those
3 conversion factors completely independently of all the
4 rest of this stuff and it comes in as a feeder right
5 at the end. All the rest of these models basically
6 calculate radionuclide concentrations around the water
7 to which the biosphere model was then applied in a
8 sense as a post processor to the whole thing.
9 MEMBER HORNBERGER: Peter, I assume when
10 you say this slide is out of date that it doesn't
11 mean that the whole thing has to be scraped, but
12 rather than you've made some fine tuning.
13 DR. SWIFT: Yes, thank you. That will do
14 fine. The tuning is fine in some places and a little
15 coarser in others, but yes, models will change.
16 You'll find most of the computer code names are the
17 same in most of the locations. In fact, they may all
18 be the same except for the biosphere. But the
19 linkages are a little different. Some of the hand-
20 offs are different. Next slide please.
21 There are two pieces of those components
22 on the previous slide or the previous two slides that
23 I want to talk about just briefly because they are
24 important to this group. One of them is the saturated
25 zone groundwater flow path analysis. And this is a

1 false color satellite image of the Decca Mountain
2 region. The repository is here. The blue lines here
3 are the calculated groundwater flow paths from the
4 site recommendation in the year 2001. They have not
5 changed significantly on that.
6 Things to see on this slide right off, the
7 red colors, you see them up here and down here,
8 actually are the measurement of moisture in this false
9 color image. They are vegetation. So up here, we're
10 seeing vegetation in the relatively higher country.
11 Down here these circles are irrigated fields in the
12 Amargosa Valley. Other red dots in here are not
13 vegetation. Those are test well locations.
14 Something else to see on this slide while
15 we have it up here, those with good eyes can just make
16 out Highway 95 coming along like this. The location
17 of the reasonably maximally exposed individual, the
18 RMEI, is 18 kilometers south of the site over the
19 center of this plume. It turns out to be just north
20 of the highway, right about in there somewhere. I
21 think for those with really good eyes you might even
22 be able on a better print of this pick out the
23 satellite image of the defense line that marks the
24 test site boundary in there. So that the RMEI would
25 be right about in there somewhere.

1 So the dose assessment we're talking about
2 here today is based on assumption that, this second
3 bullet here, the annual dose is based on the total
4 mass flux of radionuclides at 18 kilometers basically
5 crossing a fence in the model right there. All of the
6 mass flux radionuclides mixed in 3,000 acre feet of
7 groundwater. That approach to taking all of the
8 radionuclides and mixing them in groundwater is a bit
9 of a simplification, but it's based on the observation
10 that the draw-down from well or wells pumping at that
11 rate would span the entire width of this plume.
12 Therefore rather than trying to worry about the
13 details of what radionuclides are capture by what well
14 or what draw-out.
15 CHAIRMAN GARRICK: Peter, do you have any
16 sense of what the impact of that assumption is in
17 terms of conservatism or realism?
18 DR. SWIFT: The 3,000 acre feet or the
19 assumption that --
20 CHAIRMAN GARRICK: No, the assumption that
21 the radionuclides are all in the 3,000 acre feet.
22 DR. SWIFT: Yes, a few points on that.
23 One is that if we actually had wells pumping at 3,000
24 acre feet per year at that location, they probably
25 would get almost all the radionuclides. The other

1 point is that there is data available on water pumping
2 in Amargosa Valley down here and the range of pumping
3 is inconsistent with that. At the time of the site
4 recommendation, the project actually sampled on a
5 range of water pumping rates which varies slightly
6 smaller than that, I think. The NRC may, Tim
7 McCartin, may have a better answer on that than I do.
8 Sorry to put you on the spot, Tim. Do you want to
9 field it? Sorry, Tim.
10 DR. McCARTIN: Well, Tim McCartin. Going
11 with memory, generally there's been a range of pumping
12 rates in the Amargosa Valley area and I think it goes
13 up potentially as high as 13,000 acre feet depending
14 on the year. It is variable. I think at least at SR
15 you guys use the mean value of 2,000 acre feet.
16 DR. SWIFT: It's 2,000 and something.
17 DR. McCARTIN: But the actual pumping
18 rates in the valley further south there have been as
19 high as 10 to 13 thousand acre feet, I believe.
20 CHAIRMAN GARRICK: Yes. The point of my
21 question is two issues here. One is the 3,000 acre
22 feet itself and how representative that is and then
23 the other would be the radionuclides that enter that
24 region are all assumed to be in solution so to speak.
25 DR. McCARTIN: Tim McCartin again. I

1 guess when EPA specified 3,000 acre feet for the
2 drinking water standard they used the irrigation of
3 two average alfalfa farms and a population use of 100
4 people I believe on that order.
5 CHAIRMAN GARRICK: I see.
6 DR. McCARTIN: So that's how they got to
7 the 3,000 approximately.
8 CHAIRMAN GARRICK: Thank you.
9 DR. SWIFT: So just to finish on this
10 slide here, the biosphere dose conversion factors down
11 here that Kurt and Maryla will be talking about are
12 applied directly to the concentrations of
13 radionuclides in groundwater. Those concentrations
14 are as shown here. They are simply all the mass in a
15 given year or time step crossing that boundary mixed
16 in 3,000 acre feet. That's all on this one. Next
17 slide please.
18 VICE CHAIRMAN RYAN: Before you leave that
19 one.
20 DR. SWIFT: Yes, sir.
21 VICE CHAIRMAN RYAN: I want a follow up
22 question. When I think about intakes which lead to
23 dose, I think about concentration. So the real action
24 to me is what's the concentration that this results in
25 and is that concentration going to be representative

1 of a rate withdrawal concentration year by year?

2 DR. SWIFT: Well --

3 VICE CHAIRMAN RYAN: I'm not sure you can

4 answer the question, but I think the focus to me on

5 certainty is what's the concentration and how does

6 that concentration vary as it's withdrawn and used?

7 DR. SWIFT: Right.

8 VICE CHAIRMAN RYAN: It's not so much the

9 amount of water or the use of the water but it's the

10 combination of the two things. Dr. Garrick asked

11 about did you capture all the radioactive material in

12 that volume and then what concentration develops of

13 that in a time dependent way?

14 DR. SWIFT: The 3,000 acre feet is one of

15 the stylized assumption. We had assumptions made in

16 stylizing the calculation to make it consistent or

17 comparable from one point to the next. But in a real

18 groundwater plume, there will be places where

19 concentrations are higher or lower than some very

20 large regional average. So the question then would be

21 is the 3,000 acre feet - again we're talking about the

22 regulation here - an appropriate way to take a local

23 average rather than in the worst case would be to

24 assume that someone pumped directly into the center of

25 a very narrow tight plume.

1 VICE CHAIRMAN RYAN: You hit my question
2 on the head. That's why I think the stylized
3 calculation for the purpose of compliance
4 demonstration certainly has value and that needs to be
5 done. Then a second question is some exploration of
6 is that conservative or not and if it is conservative,
7 by how much that gives you some insight into margin.
8 So I think that's what we're looking to explore.
9 MEMBER WEINER: Peter, I have just a quick
10 - Go on.
11 VICE CHAIRMAN RYAN: I'm looking to that
12 exploration. Can you give me any insight there?
13 DR. SWIFT: To me we're venturing here
14 into the realm of speculation heading towards worse
15 case. Conservative with respect to what? I can
16 imagine a situation in which a future human would get
17 a concentration much less than from this method or
18 greater.
19 VICE CHAIRMAN RYAN: And again I would
20 borrow from my colleague, Dr. Garrick's view, that
21 systematic assessment of that uncertainty would be a
22 useful thing.
23 MEMBER WEINER: Do you distribute the
24 pumping rates? Do you have a distribution of pumping
25 rates and distribution concentrations?

1 DR. SWIFT: No, the 3,000 acre feet is a
2 regulatory specification.
3 MEMBER WEINER: Yes, I know that, but in
4 your TSPA.
5 DR. SWIFT: No.
6 MEMBER WEINER: You simply use a single
7 value.
8 DR. SWIFT: Yes. Prior to the regulation
9 specifying it, we did indeed instead of looking at
10 possibilities and uncertainty in that. But that's the
11 regulatory prescription.
12 DR. McCARTIN: Tim McCartin, NRC. When
13 EPA specified the 3,000 acre feet for groundwater
14 protection, they also suggested that we might adopt a
15 similar approach for the individual protection which
16 is what we did. In looking at 3,000 acre feet, part
17 of their basis was that trying to estimate
18 concentrations in small volumes of water would be
19 extremely difficult if not technically impossible.
20 There's a lot of variability. Clearly plumes are not
21 uniform and depending on where you pump, the depth,
22 there's all kind of factors.
23 But part of the basis for specifying 3,000
24 feet and use this average, we'll use that as a
25 representative concentration to determine the dose.

1 They certainly stated in the preamble to the standard
2 that when you got down to smaller volumes of water,
3 they said really 100 acre feet was pretty much the
4 minimum in terms of getting a defendable
5 concentration. So there was this 3,000 acre feet
6 while as Peter indicated you could do all kinds of
7 scenarios of the way people withdraw water, the desire
8 was to not try to get into that kind of speculation.
9 VICE CHAIRMAN RYAN: Okay.
10 DR. SWIFT: Next slide please. The other
11 piece of the rest of the modeling system that needs to
12 be brought into this discussion is the treatment of
13 future climates. We saw the words early on the
14 definition of what's held constant in the reference
15 biosphere and what's changed. Climate is one of those
16 things that we are expected to consider reasonable
17 future changes in it.
18 The main reason we developed a climate
19 change model was to look at its effect on groundwater
20 flow. Its climate is at the very upstream end of all
21 of the rest of the water flow related models. However
22 the future climate also is used directly as input to
23 the biosphere model now where -- I think Kurt is going
24 to talk more about this. Climate change is used to
25 establish values for the climate dependent input

1 parameters in our biosphere model, for example, the
2 growing season and irrigation rates which we do
3 believe will vary with changes in future climate.
4 So what are those changes in future
5 climate? During the regulatory period of 10,000 years
6 we recognize three climate states: a present day state
7 that runs out the next 600 years, a monsoon -- It
8 actually states an enhanced monsoonal climate.
9 Southern Nevada has a weak monsoon now. At the
10 following 2,000 years a climate is transitioning
11 towards a future full glacial climate. The monsoonal
12 climate is quite a bit wetter but not much colder than
13 the present. And the glacial transition climate is
14 wetter and quite a bit colder.
15 DR. MOELLER: Excuse me.
16 DR. SWIFT: Yes.
17 DR. MOELLER: You know we hear so much
18 about global warming. Are you assuming that global
19 warming will occur, but that for this region it's
20 different? Help me with that.
21 DR. SWIFT: No, this model is based
22 paleoclimate data from the Pleistocene. I think if
23 you were to interview the project paleoclimatologists
24 who developed this model, they would probably all
25 agree that global warming at some scale seems to be

1 occurring. But no, global warming climate changes are
2 on a scale of hundreds of years, not thousands of
3 years.
4 There is an assumption here. I should be
5 careful because this is not my work. But there is an
6 assumption in this work that human induced climate
7 change will not invalidate the paleoclimate analogue.
8 We won't see climate changes in the future unlike any
9 of those in the past. If that's the case, then this
10 future climate model is not a very good one. So if
11 global warming disrupts the next glacial cycle so
12 40,000 years from now, then basically we had a bad
13 model here.
14 DR. THORNE: Excuse me. Dr. Thorne.
15 VICE CHAIRMAN RYAN: Could I briefly come
16 in on this from the European side? We've just
17 completed a three year European Union project BEOCLIM
18 which is looked with the latest generation of earth
19 model of intermediate complexity plus GCMs on this
20 question. And I know there is a contentious debate
21 about the significance of greenhouse warming, but if
22 you take the current generation of models, we find
23 that the persistence of greenhouse warming effects is
24 on a time scale of tens of thousands to hundreds of
25 thousands of years and there are two broad reasons for

1 this, one of which is that the long term component of
2 persistence of carbon dioxide in the atmosphere
3 constitutes about eight percent of the releases which
4 means that although 90 percent of the concentrations
5 drop off on time scales of hundreds of years, there is
6 residual component. That with the present generation
7 of models leads to knock on effects like significant
8 oblation of ice sheets which then in turn move the
9 system from its present day state.
10 So the bottomline is that when we did the
11 analysis for Central England and also for Central
12 Spain which is perhaps more analogous to what we're
13 talking about here we found that we had to invoke what
14 I would describe as nonanalog climates through to
15 approximately 60,000 years after present. I think
16 perhaps although outside the remit of this discussion
17 at the moment that whole issue of what we understand
18 by greenhouse warming and what the current status of
19 the scientific community is on it perhaps needs
20 looking at a little further.
21 DR. SWIFT: Next slide please. Did we
22 lose something here? We lost something here. We're
23 not going to get it back. You have it in your
24 handouts. Now it came back. Do we know why? For
25 those who want to see the actual dose calculations, my

1 presentation I believe is the only place we will see
2 them in this workshop. For of all, 2002, these are
3 old results. They've been shown before many times.
4 This little paragraph here actually tells you what
5 model run these come from, what the set of assumptions
6 were.
7 First thing, it's nominal scenario. There
8 is no volcanic disruption, no extreme seismic event in
9 here. I'm showing these because I think the workshop
10 probably does want this kind of information. The time
11 scale here it's a logarithmic time scale so 10,000
12 years that's the regulatory period. Out there
13 100,000. One billion years. The general shape of the
14 curves is what you're seeing here. First of all, the
15 red is the mean curve. That is the curve which would
16 be the basis for regulatory comparison.
17 It's a little hard for me to see on the
18 ties here. But until sometime, it might around 70,000
19 years I think there's a dramatic break in that. In
20 the models run at that time - this would have been
21 2001, 2002 - this dramatic increase in slope here was
22 when we started seeing widespread failure of waste
23 packages due to general corrosion. Until that time,
24 we had a small number of waste packages that were
25 failing in the model due to well defects so the

1 relatively early phase, 10,000 years and beyond.

2 The doses expressed in milligrams per year

3 were small. The mean was on the order of 10^{-4} per

4 year. What else do you need to know about that?

5 Regulatory period again of 10,000 years there. This

6 came up briefly in Dr. Compton's slide with the note

7 that beyond 10,000 years the DOE shall present the

8 peak dose and include it in the environmental impact

9 statement. However, the NRC sets no limit on that.

10 There would be an example of what was. Next slide

11 please.

12 DR. TILL: Excuse me.

13 DR. SWIFT: The next two slides are more

14 of the same here. Go ahead.

15 DR. TILL: Well two questions. One is you

16 say one early package failure per realization so the

17 source term occurs with a probability of one. Take

18 the inventory of that package and release it.

19 DR. SWIFT: Yes.

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

21 Right?

22 DR. SWIFT: Yes. It goes through all the

23 various transport pathways and in fact we had one

24 package. It wasn't entirely released. It had a

25 specified size hole assumed in it, basically the loss

1 of an endcap and the drip shield was intact above it.
2 So these are the diffusive pathway releases. But the
3 answer is yes to your question.
4 DR. TILL: Okay. So your calculation
5 starts when the source term begins. That's the
6 initial phase of the transport part of it.
7 DR. SWIFT: Yes.
8 DR. TILL: Okay. I think it's incredibly
9 significant that those doses jump by four orders of
10 magnitude at 10,000 years. The reason that's
11 significant is it just begs the question "Are we
12 tweaking this model here?" So I want you to be
13 prepared for that.
14 DR. SWIFT: Sure. They jumped -- I see.
15 They jumped at 100,000 years out here. The regulatory
16 limit of 10,000 is here.
17 DR. TILL: Okay that's my mistake. I was
18 looking at that incorrectly, but I guess it still is
19 a valid question because how much can you tweak this
20 model to get it to move out another thousand years?
21 Do you see what I mean?
22 DR. SWIFT: I know. I do. A comment on
23 that. The spread in time out here is largely
24 dependent on that general corrosion rate of the
25 Alloid. If general corrosion is relatively fast, this

1 steep jump moves back this way. At this point on the
2 curve we have one package failed. By the time we're
3 out here, we have 95 percent of the packages have
4 holes in them. I'm sorry. That was overstated. It
5 might be 60 percent of the packages have holes in
6 them. That's an imprecise guess on my part. But this
7 is the period when many packages are failing and it's
8 a function of that corrosion rate.
9 DR. TILL: Okay. Thank you.
10 DR. KOCHER: I have a slightly different
11 question. If it's not possible to give us a short
12 answer, you can pass. I acknowledge George
13 Hornberger's comment about if the dose of all
14 uncertainty doesn't matter. But the thing that struck
15 me was how small the uncertainty is. So I'm thinking.
16 What are the key drivers that are leading to a low
17 uncertainty? Is the 3,000 acre feet per year draw-
18 down really responsible for this? What are you
19 averaging over that's causing these uncertainties to
20 be as low as they are? That's remarkably low to me
21 for a geosphere system over a long time.
22 DR. SWIFT: Sure. David, and by that you
23 are referring to the 95 percentile band.
24 DR. KOCHER: Yes, the difference between
25 them.

1 DR. SWIFT: I just want to be clear.

2 DR. KOCHER: The difference between the

3 median and the 95 percentile being as low as it is.

4 DR. SWIFT: The difference in the early

5 time here is not perhaps as small as it looks because

6 if I were to continue to scale down, you discover

7 there are still very low numbers of offscale there.

8 The fifth percentile hasn't shown up yet there. The

9 place where it's strikingly narrow to me is in the

10 time dimension out in here. My answer to the previous

11 question applies there that a key parameter driving

12 this is uncertainty in the corrosion rate of the

13 alloid 22.

14 CHAIRMAN GARRICK: But even that doesn't

15 look small to me. That's a logged scale.

16 DR. KOCHER: I beg to differ about

17 something. The median does appear on that curve

18 unless I'm misreading it.

19 DR. SWIFT: The median is a fifth. This

20 is a fifth. The median is in here.

21 DR. KOCHER: The difference between the

22 median and the upper confidence limit is about two

23 orders of magnitude. That strikes me as pretty darn

24 small. I'm curious if there's an easy answer as to

25 why.

1 DR. SWIFT: I do know where much of that
2 uncertainty comes from. It has various sources. It's
3 in travel times in the saturated zone. It's in
4 retardation coefficients. It's in diffusion
5 coefficients. This assumption here, one early failure
6 per realization is a large source of less uncertainty
7 in there if we had a larger number of packages. That
8 was specified for the purposes of the analysis.
9 Obviously we don't know what the early failure rate
10 would be. I don't know. I think I don't have a short
11 answer.
12 DR. KOCHER: That's fair enough. This is
13 obviously a complicated problem.
14 DR. SWIFT: Yes.
15 DR. KOCHER: But there are things that we
16 know quite a bit about out there in the real world
17 where we get that kind of uncertainty also.
18 DR. SWIFT: Sure.
19 DR. KOCHER: Now you have a system that
20 you don't know what's down there.
21 CHAIRMAN GARRICK: But I still think
22 that's quite a bit of uncertainty. It's not even
23 showing the fifth percentile below approximately
24 100,000 years. So you could still be having five to
25 seven orders of magnitude of uncertainty between the

1 fifth and the 95th and that sounds like a lot of
2 uncertainty.
3 VICE CHAIRMAN RYAN: Now the interesting
4 thing to me is beauty is in the eye of the beholder.
5 What's 10^2 for one person might be a small
6 uncertainty. It might be huge for somebody else in a
7 different context. I think the interesting thing is
8 to think about the component parts of that uncertainty
9 and to focus your question, Dave, on the biosphere
10 component of it. I would be curious what elements of
11 the biosphere calculation really contribute to
12 uncertainty. Is that major one or the package
13 degradation and the time of failure and so on? In the
14 bigger context, it's really what fraction of the
15 uncertainty is what we're talking about today.
16 Although it's not an unimportant question to the
17 system as a whole.
18 DR. SWIFT: Let me -- I'm sorry. Go
19 ahead.
20 DR. KOCHER: Dr. Garrick made a good
21 point. I have a bias as to how I'm looking at these
22 things.
23 CHAIRMAN GARRICK: I can tell.
24 DR. KOCHER: I think of the world as being
25 log normally distributed.

1 CHAIRMAN GARRICK: Right.

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

10 DR. ECKERMAN: It certainly is not logged
11 normal.

12 CHAIRMAN GARRICK: You're right.

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

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

1 DR. SWIFT: Sure. It's a different
2 subject.
3 MEMBER WEINER: Peter, this looks
4 remarkably like the retardation breakthrough curve.
5 Is there a major influence by your distribution of
6 Kds? Is that what is influencing that?
7 DR. SWIFT: It is a factor in these early
8 times here. Actually, can I have the next slide
9 because this may give you more information on that?
10 MEMBER WEINER: Okay. That looks even
11 more like it.
12 DR. SWIFT: This and the next slide. I'm
13 not going to spend an particular time on the second
14 one. I hope you have them in color. At least, the
15 panel does.
16 MEMBER WEINER: Yes.
17 DR. SWIFT: They are harder to interpret
18 in black and white. When looking at these two slides,
19 be aware that the two slides page 1 and page 2 repeat
20 quite a lot of the same key species. That was done
21 deliberately so you would be able to find technetium
22 and neptunium and iodine on both of the two pages.
23 So what do we see here? We see that in
24 early times the main driver and remember it was a
25 couple of years ago was technetium 99 far and away.

1 Basically it tracks with -- The black curve here is
2 the mean on the previous page. At later times, it's
3 neptunium 237. But not too far below in the order of
4 magnitude, or more below neptunium, you'll find the
5 other actinides at later times. And technetium is
6 still out there at other times and you'll find that
7 iodine is out there also.
8 One of the reasons I mention this in
9 response to Dr. Weiner's question is that technetium
10 is not strongly retardant anywhere in the system. So
11 what we're seeing here is a travel time for an
12 unretarded particle. Whereas the neptunium coming in
13 about here somewhere and the plutonium are retarded in
14 a natural system and we see later arrivals of those.'
15 If we were to break out the 100
16 realizations or 300 realizations under lye, these are
17 all means. If we show the uncertainly about those
18 means, Dr. Weiner is right. What we would see in part
19 would be the spread of the breakthrough travel times
20 on the technetium and neptunium and the plutonium.
21 This is one that I think the panel may
22 want to keep this slide in mind or refer back to it
23 through the course of the meeting. There are also in
24 the backups to this presentation for those who like
25 this kind of information I simply put in what the

1 inventory is or repository is through time. Curves
2 that just show what species are present as they decay
3 and grow in through time. I'm not going to put them
4 up here. Next slide please.
5 DR. MOELLER: Excuse me. All of those are
6 effective doses. Like of the technetium, it's the
7 whole body equivalent.
8 DR. SWIFT: Yes, these are all calculated
9 by the process that Kurt and Maryla are going to
10 describe of ***10:30:27 concentration through their
11 BDCS. Go back to the previous one. I'm sorry. One
12 other point I wanted to make here since I have it up
13 here is the carbon 14 dose here. Note the footnote
14 down here. Carbon 14 shows up as significant in the
15 early times and of course due to its 5,000 year half
16 life it starts to drop off.
17 We choose for simplicity to treat carbon
18 14 in our geosphere models as a non reactive species.
19 This is not realistic. Carbon obviously reacts with
20 carbonate in groundwater with carbonate minerals in
21 the rock. It moves back and forth from the paper
22 phase to water phase.
23 But rather than develop a full reactive
24 transport model for carbon 14, we went ahead and
25 treated carbon 14. Literally what we did was we used

1 the same breakthrough curve for carbon 14, the same
2 transport properties that we used for technetium and
3 iodine. So it is treated as something that transports
4 with groundwater. This can only overstate the
5 importance of carbon 14. That's a conservatism.
6 DR. TILL: Peter, before you go on.
7 DR. SWIFT: Yes.
8 DR. TILL: I just have to get this clear
9 and apologize for being so stubborn about this. I
10 still don't understand what happened 100,000 years
11 because I thought we said it's one package that fails.
12 DR. SWIFT: Yes.
13 DR. TILL: And then did you say that at
14 100,000 years more packages fail?
15 DR. SWIFT: Sure. There are say 11,000 to
16 12,000 packages in the repository.
17 DR. TILL: Then the slide is not correct
18 and your calculation is not correct. Correct? Am I
19 wrong?
20 MEMBER HORNBERGER: The one package is an
21 early failure.
22 DR. TILL: The one package is the early
23 failure. Okay.
24 MEMBER HORNBERGER: The rest of them
25 corrode slowly over time.

1 DR. TILL: Okay. Well, that explains
2 what's going on. Thank you.
3 VICE CHAIRMAN RYAN: My question is more
4 on the implications of the carbon 14 decision. That's
5 an example where you've made an assumption based on
6 not having a detailed model perhaps or not wanting to
7 invest in a detailed model. But is there any way to
8 explore the implications of that decision with regard
9 to particularly the early contribution of carbon 14
10 from a couple thousand years on? I mean it's a big
11 fraction of the total dose even though it is low.
12 DR. SWIFT: It's not that big a fraction.
13 VICE CHAIRMAN RYAN: It's one of the top
14 --
15 PARTICIPANT: Total dose.
16 VICE CHAIRMAN RYAN: I'm sorry.
17 DR. SWIFT: It adds less than a line width
18 to the total dose basically. I shouldn't try to argue
19 the point. At the time we made the assumption we did
20 not realize it would even be as large a contributor as
21 it is. We were surprised by that. However, we felt
22 we could live with it. We're dealing with doses at
23 the 10^{-4}, 10^{-5} level and omitting carbon 14 completely
24 from this analysis would have the effect pretty much
25 of lowering the black curve so that would overlay with

1 the purple curve.

2 VICE CHAIRMAN RYAN: You know that's an

3 example I think of what Dr. Hornberger cautioned us

4 about. At the 10^{-6} milliram per year and knowing what

5 you just said, the answer is who cares.

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

7 VICE CHAIRMAN RYAN: It's not important to

8 the dose contribution. But if it's later on or if

9 it's at a compliance point. I guess what I'm asking

10 is have you or will you sort through those kinds of

11 uncertainty estimations in this kind of a biosphere

12 component to let us know what's important and what

13 isn't? Then if it is important, how you've assessed

14 what you've done in a stylized calculation versus what

15 you think is a best guess of reality?

16 DR. SWIFT: That would be done in the

17 context of Dr. Hornberger's does it matter.

18 VICE CHAIRMAN RYAN: Right.

19 DR. SWIFT: I don't have an answer for you

20 right now. Does this one matter or not? I can tell

21 you that as of two years ago when we did this, we

22 decided it didn't matter.

23 VICE CHAIRMAN RYAN: Didn't matter, yeah.

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

25 it.

1 CHAIRMAN GARRICK: I think this is a good
2 example. We don't want to belabor it too much, but
3 this is a good example of the issue of realism versus
4 unrealism especially considering that carbon 14 is
5 very visible at least in terms of the calculation in
6 the compliance period. And it's not a realistic
7 calculation. So the question here is why in the
8 compliance period do we have some contributors to dose
9 handled very realistically and others very
10 unrealistically? I think just the concept that's
11 presented is kind of disturbing that there's the lack
12 of consistency of things that are contributing to the
13 dose during the compliance period. That's my concern.
14 DR. KOCHER: I assume something else
15 that's going on here is no airborne releases of C-14
16 whatsoever.
17 DR. SWIFT: The assumption is - thank you
18 - made here that all carbon 14 enters the water phase.
19 We did not have a realistic model for how to partition
20 carbon 14 between the gas phase and the water phase.
21 We looked at both pathways independently, making the
22 assumption that for either pathway the boundary was to
23 put it all in that pathway. We did look at a side
24 calculation where we put all the carbon 14 into the
25 vapor phase, put it out in the air and showed that it

1 also would produce a dose considerably smaller than
2 this at 18 kilometers.
3 DR. THORNE: Could I raise a question on
4 that? When I did the calculations for the Nairex
5 (phonetic) assessment, I did calculations for C-14 by
6 the gas pathway. My concern was not so much with
7 direct release to air in the sense of an inhalation
8 dose, but with the biotic interactions in the soil
9 zone and in the subcanopy atmosphere and uptake to
10 plants and the consequent ingestion dose. Was that
11 included in the calculations?
12 DR. SWIFT: No. The one we looked at
13 looked at the direct exposure to carbon 14 in the air.
14 DR. THORNE: I think that might be an
15 interesting one.
16 DR. SWIFT: May I make a question on that?
17 Were you looking at a population dose or individual
18 dose?
19 DR. THORNE: No, I was looking individual
20 dose in respect of the compliance targets for the UK
21 site.
22 DR. SWIFT: Other questions? Next slide
23 and the next one. Now this is quite an old slide.
24 This goes back to the year December 2000 but this is
25 the only example I had actually to find a good clear

1 open literature example of what the impact of
2 uncertainty in our biosphere dose conversion factors
3 was doing to total dose. Dr. Garrick asked this
4 question almost directly. This is the best I have for
5 an answer.
6 Explain first of all what these are. The
7 black curve here is a mean from 100 to realizations
8 taken from the year 2000 performance assessment. It's
9 different dose history than the one I just showed you,
10 but to me with a broad uncertainty band around it.
11 These are what we call one-off calculations. We
12 varied one input parameter in both these two examples
13 here on the screen to fixed values. Everything else
14 we treated exactly as it had been the base case. So
15 all the other sample parameters were still sampled.
16 The black mean here reflects uncertainty in every
17 input except the biosphere dose conversion factors.
18 We took the biosphere dose conversion factors and we
19 pushed them to their 95th and 5th percentile values
20 and you don't really see much of a change.
21 VICE CHAIRMAN RYAN: Can you help us?
22 When you say 95th and 5th percentile, how did you
23 distribute them?
24 DR. SWIFT: Actually I'll let Maryla
25 answer that one in a minute here.

1 VICE CHAIRMAN RYAN: Okay.

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

17 This is an example of a parameter which
18 had a much larger effect. Here I've taken the alloid
19 22 conversion rate that I've talked about. This again
20 is from a somewhat earlier analysis. We pushed that
21 one to its 95th and 5th percentiles and proves it's
22 a much broader spread. Don't go back in the slides
23 but if you were to go back to one of those horsetail
24 plots a few pages back most of the spread in that
25 horsetail is coming out of other parameters. Almost

1 none of it is coming out of biosphere dose conversion
2 factors. Now Maryla, do you want comment on what 95th
3 and 5th meant in those or is that something you're
4 going to talk in detail?
5 DR. WASIOLEK: Maryla Wasiolek. We have
6 a pathway contribution discussion after the break. I
7 will discuss uncertainties in particular components of
8 biosphere dose conversion factors. So giving specific
9 examples for important radionuclides. So I will give
10 you exact numbers. Hopefully this will answer the
11 question.
12 DR. MOELLER: Excuse me. Back on the
13 carbon 14 and Dr. Garrick's comments, it brings me
14 back to what Professor Thorne was saying early this
15 morning that you have calculations that you do for
16 compliance and then you have calculations you do to
17 really inform people. I think that falls under that
18 category because if you show a slide and say "We
19 didn't bother. We did it on a simplified approach and
20 we didn't bother correcting it" that reduces whether
21 correct or not my faith in what you're doing.
22 DR. SWIFT: I'm essentially done here.
23 One more slide. Just some summary points here. We
24 have detailed models for the entire system. The
25 overall system performance assessment links those

1 models and some of them are simplified. Our goal is
2 to provide estimates of overall system performance.
3 My group's goal.
4 To me, the biosphere dose conversion
5 factors are just one of many inputs to my group and
6 the contribution to uncertainty in overall dose
7 estimates from the uncertainty in those BDCFs. It's
8 less than that from your other sources. If a system
9 perspective, we don't see the biosphere as a major
10 source of uncertainty in the overall performance.
11 Part of that of course is because it is largely
12 specified or much of it specified for us. That's it.
13 VICE CHAIRMAN RYAN: Just on that last
14 point and then I appreciate what you showed that
15 biosphere does conversion factors, a big contributor
16 to overall uncertainty but that's in the context of
17 the assumption that you have not evaluated the fixed
18 parts of the calculation for whether or not they
19 represent reality and how that reality may vary in
20 time. Is that right? Did I understand that right?
21 DR. SWIFT: Yes, that's essentially right.
22 I want to be very clear that when I say that it's
23 caveated by my uncertainty and certainly in my
24 results, it's depended on the uncertainty in those
25 inputs. Where the inputs were not varied, there would

1 be no uncertainty in the output. That's just the
2 nature of the Monte Carlo analyses. But you usually
3 don't get out anything that you didn't put in.
4 VICE CHAIRMAN RYAN: Sure. So you're
5 evaluating certain aspects of calculational
6 uncertainty by varying certain models but not all of
7 them.
8 DR. SWIFT: Right.
9 VICE CHAIRMAN RYAN: Okay. Thanks.
10 DR. RAUTENSTRAUCH: Good morning. I'm
11 Kurt Rautenstrauch. I'm an ecologist with Bechtel
12 SAIC's Environmental Sciences Department and now that
13 Peter has put our biosphere model in the perspective
14 of total system performance assessment, what I'd like
15 to do is introduce to you the biosphere model that the
16 Department of Energy will be using for the post-
17 closure performance assessment for the license
18 application.
19 What I'm going to do is describe to you
20 some of the important information and methods that we
21 used to develop our conceptual biosphere model,
22 describe to you the structure and function of the
23 model and briefly summarize uncertainty and results.
24 I'm going to be focusing primarily on our conceptual
25 model. Later this afternoon, Dr. Wasiolek will be

1 presenting to you in more detail some of the
2 mathematical methods and results and pathway analyses.
3 This will be primarily conceptual.
4 The purpose of our biosphere model is to
5 track and transport of, once it leave the groundwater
6 well, calculate radionuclides through the biosphere,
7 in other words concentrations in important
8 environmental media which I'll identify in a few
9 moments and then to calculate annual exposure to the
10 human receptor, in our case, the reasonably maximally
11 exposed individual from those radionuclides.
12 We have a new model that the Department of
13 Energy will be using for the license application, new
14 relative to the site recommendation. It's titled "The
15 Environmental Radiation Model for Yucca Mountain,
16 Nevada" or ERMYN model. We've developed it over the
17 past 18 months. The primary reason we did that is
18 because our previous model which was based on the
19 GENII S software program wasn't flexible enough to do
20 all that was necessary to meet the requirements.
21 Some of the improvements that we've had
22 are we've added additional pathways, such as
23 consequences of use of evaporative coolers. This
24 model allows us to define and stochastically sample
25 all parameter values and we feel we've greatly

1 improved the transparency of our biosphere model.

2 The mathematical methods that are included

3 in the biosphere model for the most part are not new.

4 The mathematical methods we used were selected from a

5 review of 12 or so other environmental radiation

6 models. We selected the methods that we felt were

7 most applicable to our requirements, our site-specific

8 conditions and our needs, and if necessary we adapted

9 those to those needs and site-specific conditions.

10 Finally, we have revisited all of our parameter

11 distributions that are used in the biosphere model for

12 the license application.

13 As Peter said, the biosphere model has run

14 independently of the total system performance

15 assessment. We did that for a number of reasons, one

16 of which is so that we could complete the

17 documentation for that independently of the TSPA. One

18 of the consequences of that is that radionuclide

19 concentrations are not known at the time the biosphere

20 model is run.

21 Therefore, we calculate biosphere dose

22 conversion factors which are the annual total

23 effective dose equivalent per unit concentration of

24 radionuclides in the source of those radionuclides.

25 We have two sources to consider. One of them is

1 groundwater and the other one is volcanic ash. As
2 Peter said, those biosphere dose conversion factors
3 are multiplied by the predictive concentration in the
4 total system performance assessment to estimate those.
5 Go ahead.
6 We consider in our model two biosphere
7 exposure scenarios. The groundwater exposure scenario
8 is to be used in all TSPA modeling cases that consider
9 radionuclide contamination in groundwater, no matter
10 what the cause of that contamination is. That
11 includes nominal performance and igneous intrusion and
12 other intrusive cases. Our volcanic ash exposure
13 scenario is intended only to be used to evaluate the
14 consequences of deposition of volcanic ash and
15 associated radionuclides in the biosphere. I'm going
16 to be focusing on our groundwater scenario for the
17 remainder of this talk. Next slide.
18 This slide shows the four primary steps we
19 followed to develop the model and it's the outline of
20 much of the rest of this presentation. Our first step
21 was to characterize the referenced biosphere in human
22 receptor to ensure that we met the requirements of
23 Part 63 that have already been discussed. I will be
24 showing you some of the information we used on that.
25 Next.

1 After that, we identified the features,
2 events and processes that must be included in our
3 model. We then developed a radionuclide transfer
4 interaction matrix to identify the important transfer
5 processes that needed to be included and finally
6 developed the submodels and important assumptions that
7 were necessary to execute this model. Go ahead.
8 A few slides on characterizing the
9 referenced biosphere. The map here shows locations of
10 residences in Amargosa Valley and the surrounding
11 region. Each black dot is a residence based on local
12 electrical company information. As you can see, most
13 of the people in Amargosa Valley live in the southwest
14 portion of the valley. We get our population
15 information from this light grey area with the
16 Amargosa Valley Census District. There is no town of
17 Amargosa Valley per se. So we derive much of our
18 information on the reference population from that
19 census area, the light grey box. Most of the people
20 in that area live in what's known as the farming
21 triangle or the farming area in southwestern Amargosa
22 Valley.
23 This region has only a couple of small
24 grocery stores. It has a part time medical clinic.
25 Therefore our model considers or includes the

1 possibility that people will spend some time out of
2 the valley shopping, for medical treatment, and for
3 recreation. In addition, most of the employment
4 centers such as the Nevada Test Site, mines up near
5 Beatty, Perump, Las Vegas are more than 20 miles away.
6 So our model also includes the possibility that people
7 will spend time out of the valley while working.
8 Finally on this slide, there is no municipal water
9 treatment system in the area or water delivery system.
10 All the water comes from groundwater wells and we did
11 not consider water treatment prior to use.
12 Amargosa Valley has about 2,000 acres that
13 are commercially farmed. This has been consistent for
14 the past five or more years and is likely to remain so
15 for a while because of limits on availability of
16 groundwater permits. Most of the commercial
17 agriculture is for production of alfalfa and other
18 hays. There's not very many human food stuffs in
19 Amargosa Valley.
20 Of course, there's a large dairy at the
21 southern end of the valley and there was a catfish
22 farm operational during the 1990s. The ponds for that
23 fish farm currently are still there but there is no
24 commercial production at that site at this moment
25 because the person who owns that farm is off working

1 somewhere at the moment. All farmland in the area is
2 irrigated and the soils are deep, sandy to sandy
3 loams. We use this information to characterize
4 agricultural practices and to calculate irrigation
5 rates. Okay.
6 Finally a little information on climate.
7 Our current climate data comes from a weather station
8 in Northern Amargosa Valley that has about 100
9 millimeters of precipitation per year. The dominant
10 future climate upper-bound analogue is eastern
11 Washington, the area around Spokane. That's the
12 analogue we use to calculate irrigation for the upper
13 bound of the future climate. At that site,
14 precipitation is four times as high, and temperatures
15 are about 10 degrees per month cooler. Okay.
16 Some information on the receptor. Our
17 information on consumption of locally produced foods
18 comes from a 1997 survey of the people of Amargosa
19 Valley where they were asked how often they ate
20 locally produced foods or frequency of consumption.
21 The graph at the bottom here is just about
22 the simplest way you can display that information.
23 It's essentially the proportion of people that
24 consumed tap water or consumed locally produced food
25 at any time during the year prior to the survey.

1 Although this shows that at least a large portion of
2 people consumed locally produced foods at least
3 sometime during the previous year. They did not
4 consume them very often during the year.
5 This is to be expected from a community
6 where most of the agricultural production is in non-
7 human food stuffs. People therefore are getting their
8 locally produced food from seasonal gardens. The last
9 bit of information on here. We also asked during that
10 survey how many glasses of tap water people consumed.
11 Assuming that a glass of tap water is eight ounces.
12 The average amount of tap water that was consumed in
13 Amargosa Valley is 1.9 L per day. Okay.
14 This graph on unemployment is from the
15 2000 census. About 39 percent of the population in
16 Amargosa Valley in 2000 was retired or otherwise
17 unemployed. Sixteen percent worked in mining likely
18 in mines around Beatty. Some of them probably worked
19 at the clay mines at south end of Amargosa Valley.
20 Four percent of population worked in agriculture. We
21 used this information to develop the time budgets that
22 I'll be showing you later in my talk.
23 DR. MOELLER: A couple questions to help
24 me with understanding the life style.
25 DR. RAUTENSTRAUCH: Sure.

1 DR. MOELLER: Do they each have a well or
2 do they have a well that serves ten homes?
3 DR. RAUTENSTRAUCH: For the most parts,
4 they each have a well.
5 DR. MOELLER: Each have a well. Now when
6 you said they do not consume much local food, I
7 thought I read in that 1997 survey that 40 percent or
8 some of them have a home garden.
9 DR. RAUTENSTRAUCH: Forty-seven percent.
10 That's going to be one of the next slides.
11 DR. MOELLER: Okay, but you said they
12 don't eat what they grow.
13 DR. RAUTENSTRAUCH: I'm sure they do. But
14 when you compare it to the total proportion of diet
15 for the year, it's a relatively small amount.
16 DR. MOELLER: I see.
17 DR. RAUTENSTRAUCH: For example, locally
18 produced fruits in the previous slide which we don't
19 need to go back to are consumed by a lot of people.
20 But if you compare consumption to the national average
21 consumption of fruits, it comes out to be about 17
22 percent or less of the total annual diet. That's
23 because a person's fruit tree is only going produce
24 for part of the year. So they are only going to get
25 their peaches or whatever for that part of the year.

1 Okay. Next.

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

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

25 Of the 48 biosphere related features,

1 events and processes in the Yucca Mountain database of
2 features, events and processes that were linked to
3 biosphere, 13 were excluded because they are
4 inconsistent with the regulations and Part 63. Four
5 were excluded because they clearly had low
6 consequences or low probability. The other 31 formed
7 the basis of our biosphere conceptual model.
8 DR. THORNE: Sorry. Could I take a
9 clarification?
10 DR. RAUTENSTRAUCH: Yes.
11 DR. THORNE: So if you move to the climate
12 state that's Washington analog, you don't change
13 change the receptor practices.
14 DR. RAUTENSTRAUCH: The only things we
15 change are irrigation rates and parameters related to
16 irrigation like overwatering, growing seasons of
17 crops, but not the crops that are grown and those
18 shift just a little bit and are pretty inconsequential
19 and the other thing that you change is the pushing of
20 the year that evaporative coolers would be used.
21 DR. THORNE: Yes, I guess it was the crop
22 shift that was one that I was thinking about. Because
23 when you get to 400 millimeters, it's looking more
24 like a sort of sudden Spanish climate than the very
25 airy climate that you have at the moment. I'm just

1 conscious of the sort of bodegas that you have in
2 Spain where pretty well all the food crops for a
3 household may be grown within a small area. That
4 seems to be a potential shift in the practice of the
5 receptor group.
6 DR. RAUTENSTRAUCH: For our compliance
7 calculations, we do not consider change in diet. We
8 consider change in environmental parameters, but not
9 change in diet for those compliance calculations.
10 MEMBER HORNBERGER: It's also true, isn't
11 it, that eastern Washington is a good bit colder than
12 southern Spain.
13 DR. THORNE: Yeah. It's just this
14 question of what is a correct analog because eastern
15 Washington is further north. You can just jump the
16 climate.
17 MEMBER HORNBERGER: No, that's right, but
18 they made the assumption that the temperature was also
19 going to go down by 10 degrees.
20 DR. THORNE: It won't necessarily work
21 quite that way.
22 MEMBER HORNBERGER: I'm not sure that any
23 of these assumptions are how things will work quite
24 that way, but that is the assumption.
25 VICE CHAIRMAN RYAN: Kurt, maybe you can

1 help us and I was thinking of a similar question.
2 What's the time frame of that change from 100 to 400
3 millimeters and from a given temperature to ten
4 degrees cooler?
5 DR. RAUTENSTRAUCH: Peter had that in one
6 of this slides. I think that the answer is the way
7 TSPA models that is in his slide on climate change
8 where I believe he lists specifically the years that
9 the TSPA switches from one climate to the other.
10 DR. THORNE: Okay. I'll go back and look.
11 DR. RAUTENSTRAUCH: But it is a switch.
12 So I think it's 400 years for modern climate, in the
13 order of 1200 years.
14 DR. THORNE: Yes, I remember that. Thank
15 you.
16 DR. SWIFT: The change to the climate
17 analogous to eastern Washington occurs at 2000 years.
18 VICE CHAIRMAN RYAN: I guess that's sort
19 of the root of some of the caution that I have about
20 these. I think the problem isn't so much that you've
21 made a shift. The problem is you're trying to say
22 it's like eastern Washington. Who cares what its like
23 is my point. You're try to evaluate what does an
24 increase in watering rate and a decrease in
25 temperature have in terms of dose impact. Isn't that

1 the result?

2 DR. SWIFT: And you'll see in one of my

3 very last bullets that it's not much.

4 VICE CHAIRMAN RYAN: Right. Okay.

5 DR. KOCHER: One of the effects of that

6 assumption is that you're not doing any dose

7 calculations based on present day climate in Nevada.

8 DR. RAUTENSTRAUCH: Beyond 600 years, that

9 is correct.

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

11 releases.

12 DR. RAUTENSTRAUCH: That is correct.

13 DR. KOCHER: So people might be curious.

14 DR. RAUTENSTRAUCH: That is the way that

15 is working. Next slide, please. Based on those

16 features, events and processes, we've identified six

17 environmental media that may be contaminated by

18 radionuclides and result in exposure to a receptor:

19 groundwater, irrigated soil, indoor and outdoor air,

20 crops, animal products and fish consumed by the

21 receptor. These six environmental media and the three

22 exposures pathways listed on the slide form the basis

23 of the structure of our conceptual model. Okay.

24 Using those six environmental media, we

25 constructed a radiation transfer interaction matrix.

1 I've included this primarily for your reference and am
2 not going to spend much time on it, but will say that
3 this matrix uses a clockwise convention, so the
4 transfer processes above the diagonal represent
5 transfer from a media higher on the diagonal to one
6 lower, and those below the diagonal represent loss
7 from one of the boxes or one of the media. I have
8 included also in my backup slides a conceptual diagram
9 of these transfer processes. I've also included the
10 transfer matrix and that conceptual diagram for the
11 volcanic scenario if anyone is curious. Okay.
12 MEMBER WEINER: Could you go back to the
13 last slide? Do you mean radiation transfer or
14 radioactive materials?
15 DR. RAUTENSTRAUCH: Radioactive material.
16 MEMBER WEINER: Thank you.
17 DR. RAUTENSTRAUCH: This slide shows the
18 structure of our conceptual and mathematical model.
19 It's based on those environmental media and exposure
20 pathways. We do not consider the groundwater as one
21 of our submodels because there are no calculations for
22 us to do concerning groundwater in the biosphere
23 model. We assume that groundwater is constant at one
24 becqeurel per cubic meter. Therefore that's why we
25 calculate biosphere dose conversion factors that are

1 fed to the TSPA.

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

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

13 DR. RAUTENSTRAUCH: Yes.

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

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

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

25 DR. RAUTENSTRAUCH: Yes. All right. Our

1 soil submodel calculates concentrations in soil from
2 a distribution of irrigation water. Irrigation water
3 is the only input to this model. We have three lost
4 pathways, erosion, leeching and radionuclide decay.
5 The assumption I have listed here that concentrations
6 in soil are at saturation or equilibrium conditions is
7 what allows us to separate the biosphere model from
8 the total system performance assessment model.
9 This assumption is reasonable for the
10 radionuclides that likely will contribute to the dose
11 at 10,000 years, technetium and iodide because those
12 likely will reach saturation conditions in a matter of
13 tens of years. It certainly is conservative for
14 radionuclides such as neptunium and plutonium which
15 have reached saturation conditions on the order of
16 hundreds of years. Irrigation rate for the upper
17 bound of the future climate is about -
18 DR. ECKERMAN: Why are you doing it this
19 way? Why are you throwing away all the dynamics? The
20 question was why are you coming out with just a single
21 number out of this exercise? You're throwing away all
22 the dynamics of the pathways, right, by running them
23 all to saturation? I don't understand your approach
24 here. Am I missing something?
25 DR. RAUTENSTRAUCH: The only thing that's

1 held constant is the soil concentration and saturation
2 assuming that irrigation has occurred long enough for
3 saturation conditions to have been reached.
4 DR. ECKERMAN: But that's driving all the
5 terrestrial. The food chain pathways are all driven
6 by that.
7 DR. RAUTENSTRAUCH: That's true that the
8 all the food chain pathways past that are based on the
9 assumption that it's at the high concentration.
10 DR. KOCHER: What is it that's saturated
11 and how do you define it?
12 DR. RAUTENSTRAUCH: The concentrations in
13 soil are at equilibrium or saturated.
14 DR. KOCHER: Equilibrium or saturation is
15 two different things.
16 DR. RAUTENSTRAUCH: Maryla, would you like
17 to help with this?
18 DR. KOCHER: The equilibrium I can
19 understand. It's the saturation I'm having a real
20 hard time with.
21 DR. WASIOLEK: Well it is radioactive
22 equilibrium. Basically we assume that sources in this
23 case irrigation are balanced by losses which in this
24 case is leeching, erosion and radioactive decay. So
25 we assume that we have a constant value of mass

1 activity concentration in the surface soil.

2 DR. KOCHER: That explains it a lot. The

3 term "saturation" is just not right here.

4 DR. WASIOLEK: It is radioactive

5 equilibrium in the surface soil. This is what it is

6 and we assume this equilibrium for what we called

7 primary radionuclides which are radionuclides that are

8 trapped in the TSPA model and make additional

9 assumptions that they are short-lived decay products

10 are in equilibrium with long-lived radionuclides.

11 DR. TILL: I actually think that makes

12 sense for irrigation. That's what you have to think

13 of. You're putting your water in your crop

14 continuously out there and that's all they're talking

15 about. It's a constant concentration in that surface

16 layer of soil than in the root zone.

17 VICE CHAIRMAN RYAN: So that the real crux

18 to the issue there is what is the source water from

19 which plants have an uptake and it's a constant

20 concentration. Is that right?

21 DR. WASIOLEK: Well, it is slightly more

22 complicated than that. We are presenting sort of a

23 simplistic version of the biosphere model here. Yes,

24 we do assume that there is a constant value of

25 activity concentration in the water which is one in

1 this case. And we assume that there was semi-
2 continuous process of irrigation of the soil that
3 continues until the equilibrium in the surface soil is
4 obtained. We use this value only for the soil because
5 we have additional calculations for crops and for the
6 position of the crops.
7 This is slightly different, but these are
8 the details of our model. We use different values for
9 annual average irrigation which are only used to
10 determine what will be this equilibrium activity
11 concentration in the soil. But we also use daily or
12 sort of incident based, episode based values of
13 irrigation for the purpose of deposition on the crops
14 for the leaf uptake. So we developed different values
15 of irrigation depending on how they are using the
16 model.
17 VICE CHAIRMAN RYAN: You know again this
18 maybe one that we'll get into some more detail
19 discussion, but it strikes me that this is an example
20 where the model and its construct and relation to
21 reality would be something that would be interesting
22 to know. You said a couple of times it's
23 conservative. My question is why and by how much.
24 I'm not asking for a specific answer. Hopefully it's
25 something that we can explore as we go on.

1 DR. RAUTENSTRAUCH: I understand. I want
2 to speak to that. The reason we chose to do this is
3 to be able to run this model independent with TSPA.
4 VICE CHAIRMAN RYAN: And that's okay. But
5 I guess it still begs the question "well you did it
6 for that reason," but what does it mean in terms of
7 your true representation of what is a likely reality
8 versus a constructed model of reality?
9 DR. RAUTENSTRAUCH: And I'll repeat. For
10 the radionuclides, likely to contribute greatly during
11 the compliance period. Those radionuclides would
12 reach equilibrium condition in tens of years.
13 VICE CHAIRMAN RYAN: Right.
14 DR. RAUTENSTRAUCH: Or approach
15 equilibrium conditions in tens of years. So for
16 those, it likely is a fairly reasonable assumption.
17 VICE CHAIRMAN RYAN: Well we're back to
18 the equilibrium of what?
19 MEMBER WEINER: Maybe Dr. Wasiolek can
20 answer this question. I'm having a lot of trouble
21 with terminology. Is it a constant soil concentration
22 or an equilibrium soil concentration? Those are not
23 the same thing. Furthermore, the concentration is a
24 concentration of things of radionuclides. It is not
25 a concentration of radioactivity. So when you're

1 talking about equilibrium, you're not talking about
2 the secular equilibrium of radioactive decay. You're
3 talking about chemical equilibrium or am I getting
4 this all wrong?
5 I'm really confused at this point about
6 the terms that you're using. In particular, are you
7 assuming that there is an equilibrium of certain
8 radionuclides absorbed on the soil that then as they
9 move into the plants more is absorbed? That's what
10 equilibrium is. Or are you assuming a constant
11 concentration of those on the soil? I'm just confused
12 about the terms you're using.
13 DR. WASIOLEK: Okay. The quantity that
14 remains constant throughout the time and of course it
15 differs from radionuclide to radionuclide. It is a
16 radionuclide specific quantity because the loss's turn
17 of our radionuclide specific. The sources are not
18 because the source is irrigation and it's one unit of
19 activity concentration per unit volume. The losses
20 are radionuclide or element specific. Element in
21 terms of leeching. Radionuclide specific in terms of
22 radioactive decay constant. What we keep at constant
23 value in the soil is mass activity concentration of a
24 primary radionuclide.
25 VICE CHAIRMAN RYAN: What do you mean

1 "mass activity"?

2 DR. WASIOLEK: Backril per kilogram.

3 VICE CHAIRMAN RYAN: That's an activity

4 point. It's not a mass.

5 DR. WASIOLEK: Well per unit mass. If you

6 have Backril per volume it's volume activity

7 concentration. ICRU report. I'm using ICRU.

8 Actually ICRU using density, but we have grown up

9 with activity concentration which is also given as an

10 option in the most recent ICRU report that defines

11 units and quantities use in radiological assessment

12 models. I apologize. I think NSI. So Michael will

13 understand me. The rest of you folks.

14 MEMBER WEINER: It's not the Backrils. It

15 was the use of the term equilibrium.

16 DR. WASIOLEK: Okay.

17 MEMBER WEINER: But thank you for

18 straightening that out.

19 MEMBER HORNBERGER: I'm sure we'll get

20 into this later. I know we can defer this. I guess

21 this bit of conversation, the part that confuses me

22 now, is whether or not this whole operation will

23 conserve mass, something that our friend, Milt

24 Levinson used to sit here and actually worry about.

25 So I would like to be convince at some time probably

1 after lunch that we don't have the possibility of
2 actually ingesting more radionuclides than were
3 reposited in the repository.
4 DR. RAUTENSTRAUCH: My apologies for the
5 confusion over terminology.
6 DR. THORNE: Could I just come on that?
7 I had to look at the model. I don't think
8 conservation of mass is any problem. This is fairly
9 standard international practice and it's been said
10 already that this is based on review of the models.
11 I think one of the things that perhaps is
12 worth bringing out is that the model itself is a
13 mixture of proper representation of kinetics of the
14 system, a solve to equilibrium and equilibrium
15 assumptions. I'll give you an example of what I mean.
16 I think in the model you deal with flow of water
17 through the soil which gives you a leeching component.
18 And that is properly represented as a kinetic process
19 which you then solve to equilibrium to give you the
20 concentration in soil.
21 But the partitioning between the solid
22 phase and the liquid phase is represented through a KD
23 rather than a kinetic forward and back reaction
24 process. So in a sense the flow and transport is
25 represented kinetics, but an underlying driver of that

1 flow and transport which is the absorption is
2 represented in equilibrium sense. That's done for a
3 very good reason because that's what's available in
4 the literature and you don't have the kinetic forward
5 and backward coefficients so you use the KD values
6 because that's what you have.
7 Similarly with soil/plant transfers
8 because most soil/plant transfers that are available
9 in the literature are expressed as exactly that. The
10 concentration in plants ratio to the concentration in
11 soil, you use that sort of quantity rather than a
12 kinetic representation of uptake in plants.
13 But I think we ought to be clear that the
14 model combines both genuine kinetic components and
15 kinetic processes represented in an equilibrium sense.
16 I hope I didn't do any violence to the model with that
17 statement.
18 DR. RAUTENSTRAUCH: Thank you. My last
19 point down here was going to be that it's an
20 absorption coefficient or KD values that have the
21 greatest uncertainty in all of our input and
22 parameters. Our air submodel calculates
23 concentrations in air from three pathways, the
24 suspension of dust, the consequences of use of
25 evaporative coolers or generation of aerosol from

1 evaporative coolers and exhalation of radon from the
2 soil.
3 For this and for the external exposure and
4 inhalation submodels, we divided the reference
5 biosphere up into indoor and outdoor environments and
6 the environment around plants. The outdoor
7 environment is further divided into active and
8 inactive depending on whether a person is actively
9 disturbing soil. So the active outdoor environment is
10 representative conditions when a person is actively
11 disturbing soil. We did that primarily because of the
12 large variation in mass loading or concentrations of
13 dust in the area among these environments.
14 For this submodel we have moderate
15 uncertainty and the resuspension of the Hasman factor
16 included in the dust resuspension calculation and
17 large uncertainty in the evaporative cooler transfer
18 fraction relative to the other parameters.
19 VICE CHAIRMAN RYAN: Could you help us
20 with what's large?
21 DR. RAUTENSTRAUCH: You know this
22 afternoon Maryla is going to be showing some of those
23 distributions. Our evaporative cooler transfer
24 fraction to show what large is ranges from zero to 100
25 percent. We are completely uncertain about the

1 proportion of radionuclides that would transfer from
2 water to air.
3 VICE CHAIRMAN RYAN: Well, if it's zero to
4 100 percent, that's not uncertainty. That's an
5 unknown.
6 DR. RAUTENSTRAUCH: I'll go along with
7 that.
8 DR. WASIOLEK: That's exactly what it is.
9 I will address that.
10 VICE CHAIRMAN RYAN: Okay, great. The
11 other thing in this kind of review of dust
12 resuspension, that's also if I look at Lynn Anspaugh's
13 recent work and others a big wide swing of many orders
14 of magnitude. Perhaps overall it's a small thing
15 because inhalation components dose may be a small
16 component but dust resuspension is again one of those
17 things where people talk about orders of magnitude of
18 uncertainty. Finally in that area, the dose
19 conversion factor switch Dr. Moeller talked about
20 earlier very often people will make the conservative
21 assumption which is actually a bounding case that it's
22 soluble which is two or three orders of magnitude
23 based on the radionuclide different from insoluble
24 inhaled radionuclide. So just in the dose numbers
25 there can be wide swings based on those three things.

1 And hopefully we'll get into some of that this
2 afternoon.
3 DR. RAUTENSTRAUCH: To address the second
4 one of those, the uncertainty in mass loading or
5 resuspension, that's the primary reason we divided it
6 into environments. It's in that outdoor active
7 environment where that uncertainty exists.
8 VICE CHAIRMAN RYAN: Right. Exactly.
9 MEMBER WEINER: What model did you use for
10 resuspension?
11 DR. RAUTENSTRAUCH: We used mass loading
12 values so our calculation of concentrations in the air
13 is that product of concentrations of dust in the air,
14 measurements of dust or mass loading in the air,
15 multiplied by the concentrations of radionuclides in
16 the soil.
17 MEMBER WEINER: So you had actual
18 measurements of airborne dust.
19 DR. RAUTENSTRAUCH: That is correct and
20 the airborne dust concentrations were environment
21 specific. So for the outdoor active environment, our
22 measurements were typical for farming activities and
23 other activities were dust concentrations were
24 measured while soil was being disturbed.
25 MEMBER WEINER: And you assume that the

1 radionuclides on that airborne dust came from
2 radionuclide that got into the soil via the
3 groundwater. Is that correct?
4 DR. RAUTENSTRAUCH: That is correct.
5 MEMBER WEINER: Thank you.
6 DR. THORNE: And I think do you not also
7 use an enrichment factor to allow for the small
8 particle fraction?
9 DR. RAUTENSTRAUCH: Yes, we do. That's
10 the resuspension enhancement factor that I mentioned.
11 DR. THORNE: Okay. I'm clear on that now.
12 DR. MOELLER: Help me with the radon. Now
13 of course the soil has naturally occurring uranium and
14 radium, while radium being the parent of the radon.
15 What are you doing with radon?
16 DR. RAUTENSTRAUCH: I'm going to let
17 Maryla help you with that.
18 DR. MOELLER: No, my point is if you're
19 computing an effective dose from the radon, naturally
20 occurring radon doesn't count.
21 DR. WASIOLEK: We don't know the count for
22 naturally occurring. The source of radon including in
23 our biosphere dose conversion factor in this case for
24 radium 226 is the radon that was produced out of the
25 radon 226 that was introduced there from radionuclides

1 relieved by the repository, we do not include
2 naturally occurring radon. We have our own source of
3 radon that is repository derived rather than natural
4 radon.
5 DR. MOELLER: Where does the radium --
6 It's not a fission product. The uranium has been
7 purified perhaps. Well it has a 4.5 billion year half
8 life for 238. How much radium is in spent fuel?
9 DR. WASIOLEK: Well maybe Peter has graphs
10 in his.
11 DR. SWIFT: Peter Swift. The very last
12 slide in my handout from earlier. I don't know the
13 decay change. Somebody's business here probably does.
14 The radium is showing up as a ingrowth product to one
15 of the decay chains.
16 DR. WASIOLEK: Well for us it is.
17 DR. SWIFT: It's coming in. It's one of
18 the species.
19 DR. WASIOLEK: 1600 years is short lived
20 relative to the geological timescale that we are
21 doing. It's probably coming in from the uranium 234.
22 So this is the source of radon. We consider radon in
23 both indoor and outdoor environment with the
24 appropriate equilibrium factors.
25 DR. MOELLER: And you can distinguish or

1 you have estimated how much radium and radon then
2 might be released from the repository.
3 DR. WASIOLEK: Yes, we have equilibrium
4 concentration of radium in the surface soil according
5 to the model that Kurt has just described and out of
6 this soil we calculate radon flux density for the
7 outdoor environment and then of course make
8 appropriate corrections for the indoor atmosphere. We
9 correct for the ventilation and so forth. Then again
10 we are using site specific conventions to calculate
11 ventilation rates again depending on the circumstances
12 with evaporative coolers are in operation or not. So
13 there was a whole deal of site specific information
14 that goes into these calculations as well.
15 DR. THORNE: Right. Could I just clarify
16 on the radium? Sorry. You actually have two sources
17 into the biosphere. At equilibrium in the well water,
18 you have thorium 230 and you have radium 226. You
19 then take the radium 226 from the well as a constant
20 source and you put that into soil so you have a radium
21 concentration from that. Do you also do the
22 calculation where you take the thorium 230 from the
23 well water, put that into the soil and let the radium
24 226 grow into the thorium 230 that's been added to the
25 soil because the thorium 230 presumably has a very

1 long retention half life?

2 DR. WASIOLEK: We do carry long-lived

3 decay products. So if what we call a primary rate

4 radionuclide is also a decay product of some other guy

5 that is higher up in the chain, we do carry separate

6 calculations of the soil for this radionuclide. We

7 separate them. So for example if TSPA model tracked

8 radium and also radium were produced out of one of the

9 predecessor we would track these two fractions

10 independently and then add them up according to the

11 source.

12 VICE CHAIRMAN RYAN: Mindful of time,

13 we're actually a little bit into comment period. What

14 I would like to do is ask Kurt to finish up your slide

15 presentations with as fewer interruptions as possible.

16 Make a note of your questions and we'll then pick up

17 after lunch with Maryla's presentation and perhaps

18 more discussion of these points. I realize you're

19 overlapping a little bit with her and we're asking her

20 questions. Maybe we should reserve them until you're

21 done.

22 DR. RAUTENSTRAUCH: Thank you. The plant

23 submodel concentrations includes stuff or the

24 consequences of concentrations includes stuff from

25 deposition of irrigation water, deposition of dust and

1 root uptake for five crop types. The parameter that
2 we have the greatest uncertainty relative to all of
3 our other parameters in this model are the transfer
4 factors. Next slide please.
5 The animal submodel calculates
6 concentrations in animal products from ingestion of
7 feedwater in soil for four types of animal products.
8 We assume that animals consume locally produced foods.
9 This is a reasonable assumption especially for cattle
10 because most people in Amargosa Valley who are raising
11 their own cattle for food likely are to be raising
12 their whole alfalfa or go to their neighbors for that
13 alfalfa and feed rather than driving into the nearest
14 feed stores in Pahrump or elsewhere. And we have
15 large uncertainty in our transfer coefficients.
16 The fish model is included because there
17 was a fish farm in Amargosa Valley during the 1990s.
18 The calculations in this fish model are based on the
19 operation of that specific catfish farm where catfish
20 were raised from one to two years. All fish were then
21 harvested. The ponds were drained and cleaned. The
22 filled and started over again. We include an increase
23 in concentrations due to evaporation or replacement of
24 water. This results in a two to six times increase
25 for current climate and a much smaller 1.5 and three

1 times increase for future climate. We have our factor
2 with the largest uncertainty here which is the
3 bioaccumulation factor.
4 MEMBER HORNBERGER: Do all the fish get
5 eaten by people in Amargosa Valley?
6 DR. RAUTENSTRAUCH: No, they do not. Very
7 few fish get eaten by people in Amargosa Valley.
8 Those fish were sold to the Nevada Department of
9 Wildlife and trucked to other parts of the state to
10 stock the ponds. Next.
11 Our carbon 14 special submodel is used to
12 calculate carbon concentrations in the environmental
13 media. Our calculations were based on a proportion of
14 carbon 14 to stable carbon in those environmental
15 media. After we calculated concentrations, we used
16 then the same methods to evaluate exposure as we did
17 for other radionuclides.
18 VICE CHAIRMAN RYAN: I would really ask.
19 We do have comment period. So if you could hold your
20 questions until after lunch, that would be great.
21 Thank you.
22 DR. RAUTENSTRAUCH: Our exposure
23 calculations in simplistic form are based on exposure
24 rates times the media concentration times dose
25 conversion factors. We relied upon dose conversion

1 factors in Federal Guidance Reports 11 and 12. We
2 include the dose contributions of short-lived decay
3 products, in those dose conversion factors and track
4 long-lived decay products separately and added those
5 at the end of the calculations.
6 Ingestion exposure as I said earlier
7 consumption rates were based on the 1997 survey of
8 Amargosa Valley. We held water consumption at 2.0
9 liters. Our model includes inadvertent soil ingestion
10 and this is an important parameter as Maryla will be
11 showing you later for technetium and iodine.
12 Inhalation exposure includes exposure of
13 resuspended particles, aerosols for evaporative
14 coolers and gaseous emissions. Evaporative cooler use
15 calculated based on temperatures in Amargosa Valley
16 currently and predicted future temperatures range from
17 39 percent of the year for moderate climate down to
18 about 10 percent for the upper bound of the future
19 climate. We calculated exposure for five environments
20 based on employment characteristics. This is an
21 important pathway for the actinides. Next.
22 This graph shows how we calculate exposure
23 rates or at least summarizes it. We divided the
24 population up into four groups based on census data
25 from 2000. You saw this number earlier. Thirty-nine

1 percent of the population doesn't work. For the
2 groundwater scenario, 39 percent of the population for
3 this calculation works outside of areas potentially
4 contaminated by use of groundwater for irrigating
5 crops. Sixteen percent of the population work in that
6 local environment and six additional percent work
7 outdoors in soil disturbing activities in that
8 environment.
9 In this slide on the right, I have a
10 rather consequential mistake. This should be active
11 indoors. This should be active outdoors. I have
12 mixed those two up. I apologize for that. This shows
13 that most of time people in Amargosa Valley spend
14 their time indoors. Seventy-five percent of them more
15 of their time is spent indoors with only a small part
16 of their time spent active outdoors because only a
17 small part of the population is involved in farming
18 and similar activities. As I note at the bottom, we
19 have different exposure rates for the volcanic ash
20 exposure scenario because ash would be spread over a
21 much larger area.
22 External exposure is calculated using
23 those same time budgets and exposure rates and assumes
24 the receptors expose to contaminated soils at all
25 times within the referenced biosphere. Air submersion

1 and water emergence are not included because they do
2 not contribute to the dose for any of the radionuclide
3 substantially. We do include a shielding factor for
4 indoor environments and this is an important pathway
5 for only a few radionuclides such as cesium.
6 A summary slide on our parameter values.
7 I believe it was 270 or so of the input parameters to
8 this model were stochastically sampled. Our receptor
9 parameters were based on distributions of mean values
10 in accordance with 10 CFR 63312 and our environmental
11 parameters are based on the entire range variation in
12 the region.
13 Our goal was to select reasonable ranges
14 of values when possible based on the site specific
15 conditions and site specific population and to provide
16 bounds that incorporate a reasonable variation in
17 uncertainty. We tried to use conservative bounds only
18 when there was great uncertainty such as for our
19 radionuclide specific parameters, those transfer
20 factors, bioaccumulation factors that I pointed out
21 earlier in the presentation.
22 A summary of uncertainty, I believe that
23 our conceptual model uncertainty is relatively low
24 because we've included the relevant transport and
25 exposure pathways. To discuss mathematical model

1 uncertainty, I will reference our model validation
2 method where we compared our mathematical models to
3 five other mathematical models calculation by
4 calculation. We found that very few of those
5 differences in mathematical methods among models
6 result in a difference of greater than a factor of two
7 when we use the same input parameters. So there is
8 very low or relatively low uncertainty in mathematical
9 methods and our uncertainty is in mathematical methods
10 and therefore is similar to what we find in other
11 environmental radiation models.
12 Finally parameter uncertainty. Our
13 parameter uncertainty is relatively low for receptor
14 characteristics and for some environmental parameters
15 in agricultural practices such as irrigation rates and
16 much higher for radionuclide specific parameters such
17 as transfer factors.
18 Here is the only results slide that I'm
19 going to present. The box shows 95th percentile and
20 100 percent or total range of BDCFs that have been
21 normalized to the mean or divided by the mean value.
22 Our total variation ranges from just over an order of
23 magnitude for technetium and carbon to just under,
24 well a half, to suggest under an order of magnitude
25 for some other radionuclides.

1 Biosphere dose conversion factors for the
2 future climate which are calculated using different
3 input parameters for those few parameters that vary do
4 not differ very much, four percent for carbon 14 and
5 up to 20 percent for plutonium 239. So climate change
6 is not a very important factor in biosphere modeling
7 and Maryla will explain part of the reason for that
8 during her presentation this afternoon.
9 Finally our summary. We have a new
10 biosphere model. The environmental radiation model
11 for Yucca Mountain. It's based on site specific
12 information about the biosphere and population. It
13 includes relative transport pathways and most of the
14 uncertainty in our model was associated with input
15 parameters, particularly those that are radionuclide
16 specific.
17 VICE CHAIRMAN RYAN: Thank you, Kurt.
18 That was a great finish. Hopefully when we hear
19 Maryla's presentation we can maybe ask you both
20 questions after lunch.
21 DR. RAUTENSTRAUCH: Thank you.
22 VICE CHAIRMAN RYAN: I guess at this point
23 we've had a request for a comment at this point from
24 the middle of the audience. Steve Frishman is here
25 and would like to make a comment.

1 MR. FRISHMAN: I'm Steve Frishman with the
2 State of Nevada. I'd like us just to do a couple of
3 observations on what's happened up until now and start
4 out with a question. This is for you, Dade. You
5 mentioned fairly early this morning when there was a
6 discussion of whether it's Amargosa Valley for the
7 RMEI or whether it's the town of Amargosa Valley. You
8 said that you thought there was a difference. How did
9 you come to that conclusion and what difference do you
10 think there is?
11 DR. MOELLER: My comment was based upon
12 the following. I realized in the 1997 Food
13 Consumption Survey that they surveyed the entire
14 Amargosa Valley as well as the regions out to 50 miles
15 in all directions from the site of the proposed
16 depository in terms of the Amargosa Valley I think if
17 I had done the survey I think that I would have done
18 the same thing that was done in that 1997 report,
19 namely do the entire valley because the number of
20 people was so small, the total, that I would be
21 searching for as many people as possible. I would
22 gather that probably anyone who lived within the
23 Amargosa Valley would be of interest in terms of
24 computing doses.
25 The reason I questioned the term was one

1 in terms of a regulatory sense. I'm not a lawyer. I
2 just was trying to think through that if at some time
3 later when the license application is submitted and
4 some lawyer finds that they based the living styles on
5 the people within the entire Amargosa Valley whereas
6 the regulations state that it should be a typical
7 resident within the town of Amargosa Valley. See I
8 assumed since the regulations said that that was a
9 town. However we heard a few moments ago that there
10 is no town. Does that respond?
11 MR. FRISHMAN: Yes, because I was thinking
12 about it in the broader terms of the regulatory
13 question of who is the RMEI. It's correct that there
14 is no town. There is a political subdivision of Nye
15 County which is under -- The way things are divided up
16 in Nevada there's a township and there is a town
17 board. That town board is drawn from all residents of
18 Amargosa Valley. So I think the regulatory
19 distinction for town versus Amargosa Valley probably
20 without argument goes away. Then you look at the
21 entire population of Amargosa Valley for your base.
22 I was interested to hear because I thought
23 that you probably were going on that about the
24 reliance on the 1997 survey. That survey from at
25 least our observation should not be relied upon.

1 There should be a new survey and a new survey that is
2 done in a much more definitive way than that survey.
3 That survey among other things appears to have missed
4 the entire Hispanic population of the valley because
5 they don't have telephones. It also appears to have
6 missed the fact that there are people in the valley
7 who do grow a lot of their own food and they also
8 coincidentally don't have telephones.
9 That survey also if I remember the results
10 that are used in the model are weighted results. They
11 are some mixture of the results for Amargosa Valley as
12 well as the other areas that were sampled even as far
13 away as the other side of the Nevada test site I
14 believe. So the real thing I'm getting at is I think
15 that it probably is very fairly closed to say the
16 bottomline that was in that last talk. The rough
17 difference that can be made over all of these
18 different variables associated with the biosphere.
19 But it seems to start with who you think is the RMEI.
20 That seems to be the biggest factor because then what
21 you're doing depending on who that RMEI is you're
22 stacking more and more or less and less uncertainties.
23 So I think it's important that before you
24 get into the varied details of how everything is
25 calculated out you need to first understand who it is

1 that you're talking about. The rule has never been
2 satisfactory to me in terms of being prescriptive
3 enough to where we're not going to end up in an
4 argument over who the RMEI is if we get down to having
5 to argue this in a licensing hearing. I think it's
6 important to maybe come back at some point and dwell
7 on that not necessarily in terms of guidance to an
8 answer for both DOE and the NRC staff, but in terms of
9 guidance to what the intricacy of that question really
10 is.
11 One other point that I thought was
12 interesting. I think, John, you mentioned that it was
13 important to look at uncertainties in two major areas,
14 one of the being the transport release area, the other
15 one being in the biosphere area. It is important to
16 do that but also the idea that you can separate them
17 is not entirely true because you get into this
18 question of the significance of the difference
19 depending on whether you're talking small amounts or
20 large amounts.
21 Just as an example if you look at some
22 factors like the difference between what was proposed
23 in Part 197 for the acre feet of water in which to
24 dilute the radionuclides, it was proposed if I recall
25 that 1460 or 1480 acre feet. It ended up in the final

1 rule at 3,000 for reasons that were not entirely
2 clear. But at the time, my judgement was "Well it's
3 only a factor of two" and that's pretty small compared
4 to the overall uncertainty in the system which is
5 true.
6 But a little later on, you do things like
7 look the one on and one off calculations. Look at
8 what the release of technetium would be if you had no
9 containers and convert that using the dose conversion
10 factor that DOE used, put all that technetium into
11 first availability. Then just use DOE's release
12 model. What you end up with is technetium alone
13 exceeding the groundwater standard and also exceeding
14 the individual standard by a relatively small amount.
15 But that's putting it all into 3,000 acre feet of
16 water.
17 If you take the 1460, well then you're
18 exceeding it by twice that amount. So when you're
19 dealing with looking for uncertainties in the two
20 areas of analysis, release and then converting that
21 release to dose, with this system and its
22 complications, you have to look at the two of them
23 together at points where they really are significant,
24 where they really do make a difference. Technetium
25 was one that became pretty obvious once you do a very

1 simple calculation.

2 VICE CHAIRMAN RYAN: Steve, that's a

3 little risky because you're mixing bounding

4 calculations and nominal calculations by making the

5 assumption that all the Technetium enters the system

6 directly instantaneously at the beginning. That's a

7 bounding analysis. So I'm cautious.

8 MR. FRISHMAN: No, I'm not dumping it all

9 in there. All I'm saying is --

10 VICE CHAIRMAN RYAN: That it all becomes

11 available.

12 MR. FRISHMAN: It all becomes available

13 because there are no containers.

14 VICE CHAIRMAN RYAN: Right.

15 MR. FRISHMAN: So it becomes available at

16 whatever rate it becomes available from its solubility

17 and so on.

18 VICE CHAIRMAN RYAN: I think it's risky

19 because that bounding case arbitrarily assumes

20 containers go away.

21 MR. FRISHMAN: I was hoping you would ask

22 because the answer to that is a real simple one.

23 That's that because of the half-life of technetium the

24 same thing will happen at 100,000 years out.

25 VICE CHAIRMAN RYAN: But it's a rate

1 process. So again I'm just very cautious to try and
2 take a bounding type assumption and then apply it to
3 a nominal calculation. That's a risky thing to do.
4 MR. FRISHMAN: It's not bounding because
5 we know the container's going away and the number they
6 used in the current model I think is like 13 percent.
7 VICE CHAIRMAN RYAN: At the rate of
8 release from becoming a container failure model is
9 really --
10 MR. FRISHMAN: You saw how steep that was.
11 Very, very steep and people remarked on how steep it
12 was. As soon as you start failing those containers,
13 the release becomes very steep. So I disagree. I
14 don't believe it's bounding. It's a statement of
15 reality. It's just a matter of when. I say you take
16 them all away at the beginning because of the half-
17 life of Technetium. It's really no different if you
18 take them all away later. The same thing happens.
19 VICE CHAIRMAN RYAN: -- results later.
20 MR. FRISHMAN: Why would you?
21 VICE CHAIRMAN RYAN: I don't.
22 MR. FRISHMAN: You do.
23 VICE CHAIRMAN RYAN: I guess I
24 misunderstood.
25 MR. FRISHMAN: Look at the release curves.

1 But my point is that there are ways of showing that
2 the site regardless of when you look at it. If you
3 took away the 10,000 years, there are ways of showing
4 that who the RMEI is and the way you mix the
5 uncertainties add up to numbers that in fact are make-
6 or-break numbers or sometimes really way beyond
7 accedence of a standard and something that no one
8 would ever propose as a standard in the first place
9 where you can run doses over a factor of two, higher
10 than the standard by putting together these
11 combinations of things that right now the performance
12 assessment shows happen but only show happen beyond
13 the loss of the waste container. So the separation is
14 an important one, but also putting them back together
15 and how you put them back together and who you impose
16 that on add up to numbers that are not in this realm
17 of worst case to worry about. They are numbers that
18 the performance assessment says are not unlikely.
19 It's just a matter of when they are going to happen.
20 CHAIRMAN GARRICK: Yes, but when you put
21 them back in the context of the period of compliance
22 it still looks like a bounding case to say that --
23 MR. FRISHMAN: Well, there's a period of
24 compliance but there is also the period when you have
25 to look hard to make some judgments about how this

1 site works and that goes out to the period of
2 stability.
3 CHAIRMAN GARRICK: Right.
4 MR. FRISHMAN: That's an error I believe
5 in the EPA's rule, but we won't go into that. If you
6 are going to make a reasonable expectation type
7 judgment the only reason to look at that period beyond
8 the period of compliance is to learn everything you
9 can and find out what's reasonable. If the site is
10 beyond the period of compliance is going to go vastly
11 out of compliance then that analysis is necessary and
12 tells you something. What it tells you in this case
13 is that the container is the compliance mechanism.
14 I think there were questions about why are
15 the median and the 95 percent so close together or
16 appear to be. They partly appear to be close together
17 because you're dealing in orders of magnitude and they
18 partly are close together because when you get
19 failures you get big failures. What that tells you
20 once again is that the failure mode is the container.
21 Because if you get a container failure, they're big.
22 You saw the dose curve for just one container.
23 Suppose there were ten. You could see it. You're
24 high enough on the curve. You could see it. If
25 there's 100, it's high on the curve so you could see

1 that. The failure mode that drives the appearance and
2 questions like "Why is the median and the 95 so close"
3 is because it's an phenomenon the container. It's
4 linear when it fails, linear in terms of if you fail
5 ten times more the dose is ten times more. That's
6 enough observations for now.
7 VICE CHAIRMAN RYAN: Okay. We're have a
8 couple more opportunities during the day. So we'll
9 hear from other members that might want to speak.
10 That's brings us to the close of our morning session.
11 We now have a one hour and six minute lunch break
12 scheduled. We'll reconvene at 1:00 p.m. Thank you
13 very much. Off the record.
14 (Whereupon, at 11:51 a.m., the above-
15 entitled matter recessed to reconvene at
16 1:02 p.m. the same day.)
17 VICE-CHAIRMAN RYAN: If we could get
18 everybody convened, please? We will start our
19 afternoon session. We have presentations. I think
20 first up is Mr. Pat LaPlante, senior scientist from
21 the Center for Nuclear Waste Regulatory Analyses.
22 MR. LaPLANTE: As he mentioned, my name is
23 Patrick McPlante. I work for the Center for Nuclear
24 Waste Regulatory Analyses. We are the technical
25 support contractor for NRC in the high-level waste

1 program. Today I am going to provide an overview of
2 biosphere pathway analyses supporting NRC's
3 pre-licensing activities.
4 Next slide, please. In general, I am just
5 going to provide an overview of the biosphere model.
6 Then I will discuss key radionuclides and exposure
7 pathways.
8 Before I start, I would like to emphasize
9 the NRC role with the biosphere modeling is to develop
10 review capabilities to review NRC's license
11 application. In this regard, the aim is to develop
12 flexible tools and to develop a basic understanding of
13 system behaviors.
14 Next slide. As you know, biosphere
15 modeling requires an understanding of site
16 characteristics. DOE already did a fairly good job at
17 outlining the characteristics of the Yucca Mountain
18 region.
19 I provide this chart. Yucca Mountain site
20 is here. And approximately 35 kilometers to the south
21 is the Armagosa Farms area, which is the nearest
22 populous center to the south along the flow path, as
23 we have seen it in previous presentations.
24 In general, this area could be
25 characterized as a rural residential farming

1 community. As we have seen in previous presentations,
2 there is livestock and farming activities as well as
3 gardening and so forth. The characteristics of the
4 area help us conceptualize potential exposure pathways
5 from postulated release scenarios.
6 Next slide, please. Once we have
7 conceptualized the potential exposure scenarios, we
8 have to implement those exposure pathways in a
9 biosphere model. This flowchart provides sort of the
10 basic outline of the processes that we are modeling in
11 our biosphere model. We can start with either
12 contaminated groundwater or contaminated soil.
13 This chart tends to emphasize the
14 groundwater, but we start with a soil concentration as
15 well as a groundwater concentration. The pathways are
16 fairly obvious. They are probably familiar to most.
17 We have direct drinking water ingestion,
18 irrigation of crops and livestock. To be complete,
19 there probably should be an arrow between crop
20 concentration and livestock. And we have resuspension
21 of soil leading to inhalation and external radiation
22 dose.
23 In the ingestion dose calculation, there
24 is much more detail that is shown there. We can
25 estimate intakes for a variety of food products,

1 including eggs, meat, milk, leafy vegetables, root
2 vegetables, fruits, grains, as well as soil ingestion.
3 Next slide, please. So we implement this
4 biosphere model. Most of the pathway models are based
5 on the GENII, Version 1.485 dose code. We're only
6 using the executable portion of that code that
7 calculates the intakes. And then we're doing the
8 conversion to dose using the federal guidance
9 dosimetry values within our TPA code.
10 We have also developed a separate mass
11 loading and inhalation model for the ground surface
12 igneous activity exposure scenario. We wanted to
13 refine the model a little bit more than what was in
14 the GENII code. And so we account for factors such as
15 ash blanket thickness, impact on mass loading. If you
16 have a very thin ash blanket, you will be resuspending
17 clean soil along with contaminated ash.
18 We also have a time dependence, a
19 time-dependent mass loading value. The literature
20 shows that over time as the fine resuspends, mass
21 loading will decay exponentially over time to somewhat
22 of a steady state.
23 We also account for loss routes from the
24 soil, including erosion, leeching, and decay
25 processes. And we have developed a human

1 activity-weighted soil disturbance and exposure model,
2 essentially different types of disturbances, high,
3 medium, low, and different levels of exposure, how
4 much time do you spend outdoors and indoors and so
5 forth?
6 Next slide. I already mentioned the
7 federal guidance values. Chris McKenney will be
8 discussing the dosimetry in much greater detail in his
9 following presentation this afternoon.
10 So in order to run the biosphere model,
11 obviously we need to come up with a number of input
12 parameters. In general, the objective is to enhance
13 realism by using site-specific parameter values where
14 possible and try to avoid implausible assumptions
15 within the context of the regulatory requirements and
16 the somewhat abstracted nature of the model.
17 To give you an idea of the magnitude of
18 the modeling effort, we have about on the order of 600
19 individual numbers that we have to come up with and
20 input into this model.
21 A number of these are radionuclide and
22 element-specific. And since we want a flexible model
23 where we have the ability to model doses from 43
24 radionuclides as well as which are comprised by 26
25 elements, it is worth noting that even though there is

1 a large number of input parameters, few of them are
2 highly significant to determining the dose. But we
3 need to come up with them anyway.
4 I am not going to go into the parameters
5 in detail, but I have provided this list of parameter
6 categories with parentheticals sort of paraphrasing
7 the general type of information sources that we are
8 using for those parameters. And if people have
9 additional questions, perhaps we can do that after I
10 finish.
11 VICE-CHAIRMAN RYAN: Will you take a
12 general question?
13 MR. LaPLANTE: Sure.
14 VICE-CHAIRMAN RYAN: It is interesting
15 that you looked at a variety of sources. And
16 obviously some thought has gone into perhaps different
17 sources and you pick one. When you develop, for
18 example, mass loading factors, do you actually get a
19 specific value or do you try and get a distribution?
20 MR. LaPLANTE: Oh, yes.
21 VICE-CHAIRMAN RYAN: A sampling
22 distribution?
23 MR. LaPLANTE: We are sampling a
24 distribution. And that is a parameter that, as I will
25 discuss a little later, is fairly important in the

1 calculation. And so we are continuously looking at
2 data and trying to get the best characterization for
3 that value.
4 If you look at the literature, obviously
5 it can range about eight orders of magnitude.
6 VICE-CHAIRMAN RYAN: Sure.
7 MR. LaPLANTE: So depending on the
8 situation, it becomes a little more complicated when
9 you are dealing with volcanic ash, which is a very
10 fine particulate.
11 There aren't a lot of people out there
12 collecting mass loading data on volcanic ash. So you
13 have to look for analogues and so forth.
14 VICE-CHAIRMAN RYAN: Is it fair to say
15 just again in general that all of these kinds of
16 categories, you are looking for not only the best
17 value but what is the nature of the distribution of
18 appointed values and circumstances?
19 MR. LaPLANTE: Oh, yes. From the very
20 beginning, we have been doing this biosphere modeling
21 since the early '90s.
22 VICE-CHAIRMAN RYAN: Right.
23 MR. LaPLANTE: And we started off with the
24 idea that we would try to characterize the uncertainty
25 and variability in the input parameters.

1 This slide provides some additional
2 aspects of our current approach. Most of these could
3 be called assumptions. It is important to qualify
4 that these shouldn't be interpreted as expectations on
5 how DOE should be doing the modeling. These are just
6 how we are presently doing the modeling to give you an
7 idea of basically how we are doing it.
8 I have listed the first bullet.
9 Inhalation dosimetry, as you know, assumes a mean
10 particle size of one micron. We are certainly aware
11 that the air transport at deposition and mass loading
12 models that we are using generally apply to larger
13 particles.
14 And so essentially we are putting more
15 mass into the air for inhalation, but we are assuming
16 that its finer particles when we run the inhalation
17 dosimetry. That is a conservative approach. We are
18 currently looking into getting better estimates on how
19 conservative that actually is, but that is how we are
20 doing it at present.
21 We are also assuming adult dosimetry. We
22 have gone through that before, earlier in the morning.
23 The third tic sounds very conservative, but it should
24 be put in the context of most of the key radionuclides
25 that are dominating our dose do not have choices for

1 chemical form as it impacts the dosimetry in the
2 federal guidance. So, for instance, americium-241 and
3 tritium-247, technetium-99, iodine-129, there is only
4 one value in the federal guidance. They don't provide
5 D, W, or Y solubilities.
6 And so this assumption doesn't apply to
7 those. Those just happen to be terminating the dose.
8 So it is conservative for some of the other
9 radionuclides that aren't dominating the dose, but,
10 then, if it is not dominating the dose, then it
11 doesn't really matter.
12 VICE-CHAIRMAN RYAN: Let's kind of boil
13 that question down because that is an example of an
14 important one, I think. Is the guidance based on W
15 class for americium and plutonium? Is that right?
16 MR. LaPLANTE: Let's see. I wrote down
17 some notes. I believe plutonium does have a choice,
18 and it is W or Y.
19 VICE-CHAIRMAN RYAN: Okay.
20 MR. LaPLANTE: But the difference between
21 W and Y for plutonium is about 35 percent at most.
22 VICE-CHAIRMAN RYAN: Right.
23 MR. LaPLANTE: So that is the only one
24 that has a choice. I can't remember what exact
25 solubilities there were. All I know is that there

1 were only single values.

2 DR. ECKERMAN: Strontium would be a

3 choice. Titanate, strontium titanate, is N-11 because

4 of its importance occupationally.

5 MR. LaPLANTE: Right.

6 DR. ECKERMAN: I don't remember which one

7 has been --

8 VICE-CHAIRMAN RYAN: I'm thinking

9 specifically about the ignitant. I am thinking that

10 if something comes out with that temperature, it is

11 probably going to end up as a Y class article. I

12 guess I am sensitive to the fact that if you were

13 constrained to use a W class conversion factor, you

14 could be off by a factor of 50.

15 MEMBER HORNBERGER: Did I just sleep

16 through that chemistry freshman class when they talked

17 about W and Y and N-11? What is that?

18 MR. LaPLANTE: These are solubility, body,

19 essentially body solubility, for materials going into

20 the bloodstream.

21 VICE-CHAIRMAN RYAN: If it would help, I

22 will let Dr. Eckerman answer. He is the authority.

23 MR. LaPLANTE: He would probably be the

24 best person to answer.

25 DR. ECKERMAN: This is a case where the

1 system has changed in time, too. D, W, and Y referred
2 to clearances, half-times from the deep lung. And so
3 an aerosol that was classified as a D class aerosol
4 would have a residence time in a deep lung on the
5 order of days and weeks and years.
6 It is a real gross classification. It
7 includes both the mechanical clearance as well as
8 absorption, the later lung models that were current
9 state-of-the-art, as we separate those and talk about
10 another classification that relates simply to the
11 absorption, to the chemistry. And you would have
12 probably had that lecture in today's systems.
13 That was it. So it is just a way of
14 classifying aerosols.
15 VICE-CHAIRMAN RYAN: But the new system is
16 kind of independent of what is done here because that
17 has not invoked the regulations.
18 DR. ECKERMAN: Yes, right.
19 VICE-CHAIRMAN RYAN: It is best practice,
20 but it is not what the guidance is based on if I
21 recall right.
22 MR. LaPLANTE: Yes. The practical aspect
23 from a modeler standpoint is if you have got three
24 choices based on different solubilities of the
25 material, you need to decide what is the chemical form

1 of the material that is inhaled and make that
2 consistent with the choices you have, D, W, or Y.
3 And what I was trying to point out was for
4 most of the radionuclides that are important, given a
5 choice, in those where we do have a choice, this
6 bullet is saying we are choosing the one that causes
7 the highest dose because there are so many
8 uncertainties in determining the chemical form of the
9 material more so, I think, for a groundwater pathway,
10 for the material.
11 You have an idea what it might be in the
12 groundwater in terms of chemical form, but when you
13 spray it into the air, it could react. It could react
14 with the soil. It could react with the plants. It
15 goes into the plants. It could be transformed.
16 There are all kinds of places for that
17 chemical transformation to occur. And so it becomes
18 a very uncertain process to determine, well, what is
19 chemical form once it goes into a food product that
20 somebody eats?
21 Rather than get into that level of complex
22 chemistry, a lot of modelers just assume the higher
23 values.
24 VICE-CHAIRMAN RYAN: That is risky, I
25 think. Let me tell you why. I think if you just pick

1 a single value and assume it because it is
2 conservative, that is inconsistent with what you have
3 done in all of the other categories, where you have
4 sampled some distribution.
5 Now, you can at least construct this in
6 your mind and whether it makes sense or not. You
7 would be the judge.
8 MR. LaPLANTE: Right.
9 VICE-CHAIRMAN RYAN: You take the soluble
10 and the insoluble numbers. And you sample between the
11 two.
12 MR. LaPLANTE: Yes.
13 VICE-CHAIRMAN RYAN: Why do we pick multi
14 single value dose conversion factors when we sample
15 every other parameter? Why do we pick one micron and
16 not sample across a whole range of particle sizes?
17 Particle size has a huge swing in dose conversion
18 factor, too.
19 MR. LaPLANTE: Right. Well, one of the
20 reasons we don't sample the dose conversion factors is
21 because the reports that provide them don't really
22 have much of the uncertainty information documented.
23 It is true that for D, W, and Y, you
24 understand there is a range there and you could do
25 some sort of sampling.

1 VICE-CHAIRMAN RYAN: The way to adjust
2 those is fairly well-established in current practice.
3 I just wonder why we single them out as single values
4 of the conservative.
5 By the way, if something is extremely
6 conservative, it is not conservative. It is wrong.
7 MR. LaPLANTE: Yes. But if it is
8 extremely conservative and the licensee demonstrates
9 compliance of that calculation, then is there a need
10 to spend money in research?
11 VICE-CHAIRMAN RYAN: Why do we do it two
12 ways? Again, I say that rhetorically to think about
13 it as we go through the two days. But it is an
14 example where we do something different without really
15 in my view justifying why that different approach is
16 okay.
17 MR. LaPLANTE: Right. It is definitely
18 not informative. If you fail the standard and you are
19 conservative, it doesn't tell you anything other than
20 you need to do more precise modeling to see if --
21 DR. ECKERMAN: Part of the differences
22 that are introduced here comes from the occupational
23 experience. In the occupational setting, you knew
24 what the compound was that the worker was dealing
25 with. So you could pick a chemical form and deal with

1 it.

2 The difficulty here in the environment

3 situation is that the radionuclide probably is a trace

4 component to the aerosol. And so the characteristic

5 that you have brought to the table from your

6 occupational experience really has nothing to do with

7 the problem.

8 VICE-CHAIRMAN RYAN: It is all the more

9 reason to sample.

10 DR. ECKERMAN: All the more reason to

11 sample, all the more reason to question the

12 applicability of that particular set of dose

13 coefficients that we have got.

14 DR. KOCHER: A similar issue for your

15 volcanic ash is all of these lung models assume that

16 your radionuclides are attached to the surface of

17 particles.

18 MR. LaPLANTE: That is true.

19 DR. ECKERMAN: No. It's

20 volume-distributed. They are all volume-distributed.

21 The radionuclide is sitting in the volume of the

22 particle, not on the surface.

23 Otherwise, that's the assumption when you

24 calculate the activity media distribution of

25 aerodynamic diameter, that the radionuclide is in the

1 volume of the particles that you measured with your
2 cycle.
3 VICE-CHAIRMAN RYAN: John?
4 DR. TILL: Well, this is a discussion that
5 I would like to have. The question is this, exactly
6 what is assumed to be uncertain in these calculations
7 and what is not? What is assumed to be a fixed value?
8 Okay?
9 I mean, that is something I would love to
10 see a list of. And I would like to see the
11 assumptions regarding whether it is uncertain or not
12 and the rationale for the decision.
13 Now, I personally believe that those
14 conversion factors themselves ought to be fixed. I
15 personally believe that all of the parameters
16 associated with the hypothetical scenario in the
17 future that you are assuming is fixed, like two liters
18 of water, is fixed and that all of the other values
19 that characterize that scenario should be fixed, not
20 the environmental coefficients but things like
21 breathing rates, ingestion rates.
22 And that also includes the dose conversion
23 factors because uncertainties come in differences in
24 human beings. And we have got hypothetically a single
25 person out there.

1 This is a key philosophical but scientific
2 question that I think we need to talk about, the
3 commission needs to consider, and all of the people
4 doing the calculations need to make it very clear. So
5 maybe we can come back to this.
6 VICE-CHAIRMAN RYAN: Yeah, I think we can.
7 And I agree with you. I would probably agree with
8 everything you said except just think about the fact
9 of what Keith said with regard to dose conversion
10 factors.
11 In the workplace, I feel very comfortable
12 saying they are fixed because that is a relatively
13 narrow range of environmental possibilities. It is
14 usually very dilute to us. It is usually very
15 specific.
16 We can kind of hone in on solubilities and
17 things like that, but when you take it into a chronic
18 outdoor environmental setting, I am not too sure that
19 sampling wouldn't be at least informative of potential
20 doses over things like ranges of solubility or ranges
21 of particle distributions into which the activity is
22 distributed.
23 DR. TILL: To me, that is different,
24 Michael.
25 VICE-CHAIRMAN RYAN: Okay.

1 DR. TILL: I mean, when you talk about
2 whether it is a soluble compound or an insoluble
3 compound, I agree. Okay? You deal with that
4 separately. Okay?
5 VICE-CHAIRMAN RYAN: Right.
6 DR. TILL: But now it's one or the other.
7 What dose conversion factor do you use? You use one
8 value is what I see.
9 VICE-CHAIRMAN RYAN: I am not sure we will
10 know that answer. It is one or the other.
11 DR. TILL: Yes, right. I see what you are
12 saying, but we need to discuss this.
13 VICE-CHAIRMAN RYAN: We may or may not.
14 I mean, that is a great question, and I am sure our
15 current speaker is going to give us a full and
16 complete answer.
17 MR. LaPLANTE: I am moving in the
18 direction of talking about uncertainties, but I am not
19 quite there yet.
20 CHAIRMAN GARRICK: There is one thing we
21 want to be very much on guard for. That is you don't
22 take away uncertainties by taking a variable that has
23 uncertainty with it and making it constant.
24 You see that all the time. You see people
25 writing about uncertainty. And then you see something

1 there that you wonder how come it doesn't enter into
2 the uncertainty. And you discover in many cases,
3 "Well, it was assumed to be a constant." Well, that
4 is masking the uncertainty. We don't want to do that
5 either.
6 DR. THORNE: If I could comment, I think
7 you don't have to mask it. What you can do is to move
8 it into another category.
9 CHAIRMAN GARRICK: Yes.
10 DR. THORNE: For some of these things, it
11 may be better to do a sensitivity analysis, where you
12 move from, say, class D to class W and do an
13 alternative calculation, rather than folding it into
14 a PDF distribution function, which you know even less
15 about than you know the fact that it could be either
16 D or W.
17 VICE-CHAIRMAN RYAN: And that is the
18 alternative, is it not, sensitivity study? Maybe it
19 is the blend of PRA-type approaches to insensitivity
20 studies to really get at things. So let's hold those
21 questions and press on.
22 MR. LaPLANTE: Yes. It does become more
23 of an issue with things perhaps like transportation
24 accidents, where you are just blowing out a lot of
25 radionuclides, immediately out into the exposure

1 realm; whereas, like for a groundwater transport
2 pathway for this program, we have relatively few
3 radionuclides actually making it to their receptor
4 locations.
5 VICE-CHAIRMAN RYAN: More importantly, it
6 is chronic versus acute.
7 MR. LaPLANTE: Right. Okay. To keep
8 going here, we don't explicitly in our model correlate
9 the soil leeching parameters with the plan update
10 parameters. It is obviously a good thing to do.
11 The data itself that we are using may have
12 some implicit correlation in there, but this could
13 lead to the situation where elements that absorb to
14 the soil could be more available for plant uptake
15 because they are in the root zone.
16 And, in reality, if they are absorbed to
17 the soil, they may be locked and wouldn't go into the
18 plant. So that is somewhat conservative there.
19 We haven't gone into the level of detail
20 necessary to resolve that just because the pathway in
21 the total system calculation is not particularly
22 important.
23 The radionuclides leech below the roots on
24 exit at the biosphere. That is just sort of a given
25 assumption. In our experience, first use, pathways

1 tend to create the highest doses. So we don't feel a
2 need to account for the material that is leeched out
3 of the root zone.
4 We have no washing of harvest or crops, no
5 filtering or treatment of water. And we assume 15
6 years of irrigation deposition before exposure. That
7 15 years could be compared with the DOE approach that
8 was discussed at length, where they take it to
9 equilibrium, I guess, as they called it.
10 They will irrigate. If it takes 1,000
11 years to reach equilibrium, they are irrigating for
12 1,000 years. We just made the assumption that 15
13 years of farming seemed reasonable and leave it at
14 that.
15 Okay. Next slide. As I mentioned before,
16 we do run the biosphere model stochastically. And we
17 do try to propagate as much uncertainty that we know
18 about in the input parameters. Essentially we run the
19 model iteratively with sampled input parameters to
20 create variable output.
21 As I said, we are sampling. Essentially
22 we have done sensitivity analyses in the past, trying
23 to propagate as much uncertainty as we can in the
24 input parameters. And then we identify the important
25 input parameters.

1 And the model that we currently have in
2 our TPA code, we are sampling essentially all of the
3 parameters we found to be important in those prior
4 sensitivity analyses except for those that are fixed
5 by regulation or are the dosimetry factors that we
6 just discussed.
7 This chart here gives you an idea of the
8 variability that is propagated only through the
9 biosphere calculations. And this is for iodine-129
10 dose calculations. This should be a little bit wider
11 than some of the other radionuclides but generally
12 representative of the amount of variation that we
13 propagate.
14 As you can see, this is less than an order
15 of magnitude. It is lower. It is low relative to
16 other abstractions in out total system performance,
17 system model.
18 This is essentially why the biosphere, at
19 least for the groundwater release pathway, doesn't
20 tend to be particularly important in the total system
21 calculation because this level of variation isn't
22 significant given all of the other variation going on
23 within all of the other abstractions in the total
24 system calculation.
25 Now, there would be more variability in

1 the igneous activity biosphere calculations with mass
2 loading and so forth, but this is for groundwater.
3 Now, the next three slides, I am just
4 going to run through an example analysis for how we
5 would determine key exposure pathways in the
6 biosphere. In this example, we start off with doing
7 just a base case stochastic total system performance
8 assessment calculation with our code. And then we
9 identify the key radionuclides that are driving the
10 dose calculation.
11 Here we see we have technetium is over
12 half of the dose and neptunium and iodine are the
13 remainder.
14 DR. MOELLER: Is that for the first, what,
15 10,000 years?
16 MR. LaPLANTE: Ten thousand-year
17 calculation expected dose, sort of a base case, fully
18 stochastic calculation.
19 VICE-CHAIRMAN RYAN: Dose in the 10,000th
20 year?
21 MR. LaPLANTE: Generally, yes, it is. It
22 tends to go up with time.
23 Once we have identified the key
24 radionuclides, then we can look at the biosphere dose
25 results stratified by radionuclide and exposure

1 pathway to get an idea for those important
2 radionuclides with exposure pathways for dominating.
3 In this case, we can see for
4 technetium-99, which is dominating our dose, the
5 pathways that contribute to that dose are
6 predominantly drinking water and crop ingestion. It
7 is about 50 percent from each.
8 You see similar behavior for
9 neptunium-237. And iodine is similar. Yet, there is
10 a little more animal product consumption-related dose
11 because iodine is more mobile in those systems.
12 So the conclusion from this is, well, for
13 these radionuclides to dominate the dose, the
14 important pathways are drinking water and crop
15 ingestion.
16 Now, DOE when they present these results,
17 you will notice they will be somewhat different
18 because they have recently changed their crop
19 ingestion input parameters to be lower. And so that
20 crop ingestion pathway becomes deemphasized. I think
21 inhalation tends to become more important, inhalation
22 and drinking water, in their calculations.
23 Next slide, please. If we do a similar
24 type of analysis for the igneous activity release
25 scenario, we see that the key radionuclides -- and

1 this would be for an early eruption, around 200 years
2 -- americium-241 tends to dominate the dose with the
3 remainder of the dose dominated by the 3 plutoniums.
4 Now, since americium has as shorter
5 half-life than plutonium, if you have later eruptions,
6 the plutonium will tend to dominate almost completely
7 after the americium has decayed away from the
8 inventory.
9 With this, the early eruptions tend to
10 drive the expected dose from igneous activity. So
11 this would be representative of the dose results.
12 Now, for these radionuclides in this
13 particular calculation, the pathways that dominate are
14 inhalation, basically. It is over 90 percent for each
15 radionuclide. So that is basically the insight there.
16 VICE-CHAIRMAN RYAN: If I understand, you
17 are allowing inhalation all the way up to 100 microns.
18 MR. LaPLANTE: Well, like I said before,
19 the mass loading model, I believe, is capturing
20 particles that could go up to 100 microns, yes. And
21 so we are inhaling more particles, essentially more
22 mass than the dosimetry model would.
23 VICE-CHAIRMAN RYAN: And, again, I defer
24 to Dr. Eckerman's knowledge, but there is a mechanism
25 to make that calculation. I guess at some point it

1 becomes an ingestion, not an inhalation.

2 MR. LaPLANTE: Right. Larger particles,

3 I think generally above 20 microns, get trapped in the

4 nasal pharynx. And then --

5 VICE-CHAIRMAN RYAN: You swallow.

6 MR. LaPLANTE: Swallow. An ingestion dose

7 is I think generally a couple of orders of magnitude

8 below inhalation. And so --

9 VICE-CHAIRMAN RYAN: Particularly if it's

10 insoluble.

11 MR. LaPLANTE: Within this calculation,

12 that becomes sort of a loss mechanism that would lower

13 the dose.

14 VICE-CHAIRMAN RYAN: But do you do that?

15 I mean, do you assume it's inhaled or do you --

16 MR. LaPLANTE: We are not explicitly

17 accounting for the ingestion portion. So, like I said

18 before, the inhalation calculation is conservative.

19 And we are currently looking at an alternative

20 dosimetry model, some of the later models that have

21 been developed by CRP, to try and get a better handle

22 on how much are we overestimating that if we use more

23 refined models to account for some of these processes,

24 like the nasal pharynx ingestion?

25 DR. MOELLER: Could you go back to number

1 10, the previous one?

2 MR. LaPLANTE: Sure.

3 DR. MOELLER: Do any of them have

4 inhalation or direct exposure? You know, it is a

5 little difficult.

6 MR. LaPLANTE: Oh, yes. Well, I guess the

7 thing about this that I didn't mention is those two

8 pathways, crop ingestion and drinking water, generally

9 dominate the dose so much that you don't even see the

10 direct exposure and the inhalation for the groundwater

11 pathway. It's there, but that is why it is on the

12 key. Those are the pathways we model.

13 VICE-CHAIRMAN RYAN: We have a question,

14 I think, from Chris McKenney.

15 MR. McKENNEY: No. This is Chris McKenney

16 for the staff.

17 It is more of a comment on the other side,

18 which was the other side, of course, for the mass

19 loading issue, there are two sides. We can have dose

20 conversion factors of different particle sizes.

21 But, in addition, we have to first be able

22 to differentiate the mass loading for different size

23 particles, too. And we are currently investigating

24 how much that can be done and what sort of level data

25 we can justify partitioning the mass loading into

1 different particle sizes because that is what is
2 really the heart of the matter.
3 You have to partition the mass loading
4 factor, first of all, so that you can come up with
5 what are you going to compare to the different dose
6 conversion factors.
7 I mean, both are theoretically possible,
8 but whether you can get more volcanic ash with a
9 justifiable partitioning of the mass loading term is
10 a real difficulty.
11 VICE-CHAIRMAN RYAN: Thank you.
12 MR. LaPLANTE: Okay.
13 DR. MOELLER: Again, one of the
14 evaporative coolers included in the groundwater is
15 inhalation.
16 MR. LaPLANTE: We don't have that model
17 directly in our TPA code, but we have done analyses
18 off-line. We actually in the past based on our
19 analyses, it didn't come up as really, really
20 important, but it was important enough to ask DOE to
21 consider that. And so now they are modeling it.
22 Next slide, please. In summary, the
23 important biosphere pathways include inhalation and
24 resuspended volcanic ash and consumption of
25 contaminated drinking water in local crops.

1 Obviously the biosphere pathway modeling
2 is an ongoing activity. We have been doing it for a
3 long time. It is a learning process. Risk insights
4 five years ago were cruder than they are now. And we
5 are continuing to develop some of these additional
6 insights for the inhalation pathway, for example.
7 In general, the biosphere modeling
8 supports our prelicensing review activities and
9 prepares the staff for the license application review.
10 We are emphasizing, of course, protection
11 of public safety as well as increasing realism,
12 flexibility, and efficiency of our code. If we put
13 all of the details in there, it will never stop
14 running, uncertainty reduction and eliminating
15 implausible assumptions.
16 The results, risk-inform our staff
17 activities. Early efforts in biosphere modeling
18 helped us develop the Yucca Mountain review plan,
19 which was discussed in the first talk today, and focus
20 our document reviews, which led to some of these
21 agreements that I am actually going to talk about in
22 tomorrow morning's presentation, risk insights and DOE
23 document reviews or our reviews of DOE documents.
24 In general, our risk insights focus our
25 technical work on the most significant and uncertain

1 areas. Some things can be very significant, but if
2 they have no uncertainty, there is no point in going
3 further with them.
4 VICE-CHAIRMAN RYAN: Ruth, did you have a
5 question?
6 MEMBER WEINER: Yes. Pat, could you
7 summarize briefly what the major differences between
8 your approach and DOE's approach are?
9 MR. LaPLANTE: Well, I guess if I would
10 have to give a general comment, I would say in
11 general, we are modeling pathways in the biosphere in
12 a fairly similar manner.
13 For years, they used the same code that we
14 did. They recently just changed their model by
15 inputting all of the mathematical models into GoldSim.
16 We just got that document. So we
17 obviously haven't had a chance to digest this big,
18 thick new biosphere model document. My understanding
19 is they didn't radically change the mathematics, they
20 just sort of implemented the models within GoldSim to
21 allow more stochastic flexibility and so forth.
22 MEMBER WEINER: Are there any major
23 differences in the assumptions that you make or, for
24 instance, that you can point out that would lead to
25 different results?

1 MR. LaPLANTE: I think if I look at the
2 magnitude of like their BDCFs versus our BDCFs, I
3 think they are generally pretty similar. In some
4 cases, they may make certain assumptions for certain
5 parameters that are quite a bit different than ours,
6 but some things go up, some things go down. And they
7 all kind of balance out. So I don't see any major
8 differences.
9 Again, we just got a bunch of new
10 documentation in. Much of the stuff we reviewed
11 recently has just been to deal with the past comments
12 that we had on the SR model. So we got the new
13 documentation in and reviewed.
14 We reviewed the portions of those
15 documents that related to our past comments. We did
16 not do a complete, comprehensive review of all seven
17 AMRs that recently were produced.
18 We are going to continue to monitor what
19 they are doing and look for differences. I don't see
20 any major differences. I did note the one thing.
21 They changed the way they were averaging their survey
22 data for consumption rates, for instance.
23 They used to choose a higher value based
24 on, I believe, averaging among the group of people
25 that is consuming the crops. Now they are averaging

1 among the entire population, I believe, whether they
2 consume crops or not.
3 There are a lot of zeros in there. So it
4 tends to lower the consumption rate. And that is what
5 dropped out that leafy vegetable consumption pathway.
6 But since that drinking water dose
7 calculation is largely fixed, 2 liters per day, it's
8 just concentration times intake, and that is 50
9 percent of the dose. We are very consistent on that
10 part of it. You don't have much to change in that
11 other 50 percent.
12 VICE-CHAIRMAN RYAN: Let's turn our
13 questions to the panel. Yes, please?
14 DR. DANIELS: I would like to ask, you may
15 have spoken about it, but I am not clear. Are you
16 using the internal capability of the GENII model to
17 calculate the dose conversion factors or are you
18 selecting them? Do you know a lot of the fed
19 guidance?
20 MR. LaPLANTE: We're using the values out
21 of the federal guidance. The GENII code basically has
22 three executables in that package. The first one does
23 input processing. The second one does the pathway
24 calculations, which outputs intakes, curies per year
25 for each crop type and all of that.

1 We are using that. And then we are
2 multiplying the federal guidance values to those
3 intakes to convert to dose within our TPA code.
4 The GENII code is a deterministic code.
5 And we have got it linked into the stochastic sampling
6 capabilities of our TPA code. So we include the GENII
7 parameters as input parameters for our TPA runs. We
8 can sample them, just like we can sample all of the
9 other TPA parameters.
10 And it writes the input file for each
11 realization for that GENII code, runs through the
12 pathway calculations, gets the intakes, and then grabs
13 the federal guidance values from a look-up table,
14 multiplies it out, and gets a dose for each
15 radionuclide and pathway. That is just for one
16 realization. Then it just iterates over and over
17 again.
18 So we are running the GENII code with unit
19 groundwater concentrations just for that execution to
20 get out of BDCF, but it is all pretty nicely
21 integrated into the calculations. So the dose
22 calculations are fully integrated into our TPA code.
23 VICE-CHAIRMAN RYAN: Any other questions?
24 CHAIRMAN GARRICK: I'm going to ask Ruth's
25 question just a little differently. You qualified

1 your model at the outset with the expression along the
2 lines that you were preparing yourself to review,
3 rather than necessarily to model the biosphere. What
4 did you do differently if you were not doing that?
5 MR. LaPLANTE: Well, I guess the point
6 there was if I were a licensee, I would be more
7 interested in developing my client's case. And, as
8 you know, many licensees out there are using very
9 simplistic and conservative models to make their
10 compliance demonstrations for NRC licensing actions.
11 And they can make wildly conservative
12 assumptions. And they don't have anything to do with
13 reality, but if they comply with the standards, that
14 could pass because it gives you confidence, gives NRC
15 confidence that they are not underestimating the
16 consequences.
17 Now, from our standpoint, we are preparing
18 to review. We want to do things as realistically as
19 we can to get a handle on what are the processes that
20 are important in the biosphere, what should we focus
21 on, what maybe do we not need to focus as much
22 attention on. And I think that is sort of the
23 distinction.
24 A licensee may not be that focused on
25 modeling reality to demonstrate compliance. They look

1 at the standards, see what they need to demonstrate,
2 and then do their modeling and make all kinds of
3 decisions on which baskets they want to put their eggs
4 in and where they want to spend their resources.
5 CHAIRMAN GARRICK: So your carbon-14
6 results would be different?
7 MR. LaPLANTE: Well, our carbon-14 results
8 were not incorporated in the model. We used to model
9 carbon-14, but we didn't see it as important for an
10 individual dose calculation for this particular site.
11 So that was one of those aspects that we
12 considered early on, and it didn't really make it into
13 the final model.
14 CHAIRMAN GARRICK: Just one other
15 question. You indicated that you considered 43
16 radionuclides and 26 elements. Was it the TPA that
17 was the basis for your choice?
18 MR. LaPLANTE: Are you asking the
19 radionuclides of the TPA code models to be consistent?
20 CHAIRMAN GARRICK: Yes.
21 MR. LaPLANTE: Yes.
22 CHAIRMAN GARRICK: Yes. Okay.
23 DR. DANIELS: Could I just ask one last
24 question? Did you run the conservative deterministic
25 case as well as a sensitivity?

1 MR. LaPLANTE: The conservative
2 deterministic case? Which case are you referring to?
3 DR. DANIELS: Well, you mentioned that if
4 you were a licensee, that you --
5 MR. LaPLANTE: Oh, okay. Did we pretend
6 in our due bounding analyses?
7 DR. DANIELS: Yes.
8 MR. LaPLANTE: I think our biosphere
9 modeling has evolved over the years. Like I said, we
10 started looking at this closely in the early '90s. At
11 the time, there were no regulations. I think what we
12 had to go on were the WIPP regulations that were
13 maximally exposed individual, I think.
14 So we started out with pretty conservative
15 assumptions. Over the years, we have refined and
16 backed away from unrealistic assumptions and so forth,
17 but we have done those calculations early on.
18 So I think we started out pretty
19 conservative. And as we go into more details, we are
20 able to back off on the conservatism.
21 VICE-CHAIRMAN RYAN: Ruth? Jim?
22 Questions? Thank you very much.
23 MR. LaPLANTE: Thank you.
24 VICE-CHAIRMAN RYAN: Next up, Maryla
25 Wasiolek. Maryla's title is environmental transport

1 and receptor exposure pathways for the biosphere
2 model.
3 7.1.2) PRESENTATION BY DOE REPRESENTATIVE(S)
4 DR. WASIOLEK: I am going to present
5 pathway and parameter importance analysis or results
6 of pathway and importance analysis for the DOE
7 biosphere model, the model Kurt explained.
8 Next slide. Thank you. I will start off
9 with presenting overall results of pathway analyses
10 just to sort of put the whole presentation into
11 perspective.
12 I will limit the discussion to the
13 groundwater release. I am not going to discuss the
14 volcanic case, just the groundwater case. The source
15 of radionuclides is the groundwater.
16 Then I will discuss important pathways and
17 important radionuclides for the important pathways and
18 parameters for radionuclides that are identified by
19 ACNW as a candidate for the discussion.
20 Our sensitivity and importance analysis
21 results, we told them preliminary, although the model
22 runs exist and they are documented. But we are
23 currently working on the document that summarizes the
24 results of sensitivity and pathway analysis.
25 Maybe as a brief answer to some comments

1 and sort of to put this discussion into perspective,
2 our model is a similar model to the model that we had
3 before.
4 We basically had explained it accurately.
5 We took the core of our previous model and put it in
6 the different shelling so we could make our model more
7 transparent, we could show exactly how various
8 pathways are modeled.
9 We have very thorough documentation of the
10 model, including all of its input parameters. So it
11 is really a lot of documentation, like just the
12 description of how we developed distributions for the
13 input parameters of almost 900 pages. And it is all
14 online, just the most critical way.
15 Because the model is so complex, I mean,
16 what we are going to discuss here will just barely
17 scratch the surface. Whenever it is necessary, we
18 will try to sort of pull the thread and try to get to
19 the bottom of why we have certain pathways and certain
20 mechanisms, transport mechanisms, that are more
21 important than others.
22 This slide shows this is an overview of
23 the pathway analysis results for the six radionuclides
24 that were selected by the ACNW. And these are
25 carbon-14, technetium-99, iodine-129, neptunium-237,

1 plutonium-239, and americium-241. They are in the
2 order of increasing mass numbers. This will help us
3 show trends that are in the behavior of the
4 radionuclides and in the pathway importance.
5 The first thing that we can notice is that
6 pathway ingestion, water ingestion pathway, is by far
7 the most important, regardless of radionuclide. It is
8 the one that is furthest to the left.
9 So the results are average percentage
10 pathway contribution. These are average results
11 because we run the model using 1,000 realizations.
12 Every bar is an average of 1,000 results.
13 VICE-CHAIRMAN RYAN: At what time are
14 these calculated? Closure? Because it is the
15 10,000th year?
16 DR. WASIOLEK: Oh, this is biosphere dose
17 conversion factors.
18 VICE-CHAIRMAN RYAN: Oh, these are the
19 factors?
20 DR. WASIOLEK: Yes.
21 VICE-CHAIRMAN RYAN: Oh, okay. All right.
22 DR. WASIOLEK: These are biosphere and
23 their contribution. So we take a biosphere dose
24 conversion factor for a radionuclide and dissect it
25 into water ingestion component, other food components,

1 inhalation, soluble ingestion. And these would show
2 percent pathway contributions for the BDCF.
3 MEMBER WEINER: How big is your
4 uncertainty band there? Those are averages.
5 DR. WASIOLEK: I will show uncertainties
6 for selected radionuclides later.
7 MEMBER WEINER: Thank you.
8 DR. MOELLER: In the first row, again, for
9 tap water, what is 60 percent?
10 DR. WASIOLEK: Sixty percent of the BDCF
11 for given radionuclides comes from the drinking water.
12 DR. MOELLER: Okay. I see what you mean.
13 All right.
14 DR. WASIOLEK: So, for example, for
15 technetium-99, 40-some, or 50 percent, -- it is a
16 prospective thing here -- is from the drinking water
17 and about 15 or 20 will be from leafy vegetables. So
18 this is how to --
19 DR. MOELLER: So class horizontal and
20 total --
21 DR. WASIOLEK: But it is in such a way of
22 showing the results because we can see patterns among
23 the radionuclides. We see the light radionuclides,
24 those that are modeled in the environment, tend to
25 have a relatively good appearance of ingestion across

1 the various food products that we consider in the
2 model.
3 And then as we move towards actinides,
4 ingestion practically disappears except for the
5 groundwater. But what appears is we have this island
6 here of inhalation, which is part of that. It is only
7 40 actinides. So there was a general pattern,
8 ingestion for radionuclides like technetium, iodine,
9 inhalation per actinides, and water for just about
10 everybody.
11 VICE-CHAIRMAN RYAN: Is it fair to say
12 that is driven by their relative environmental
13 insolubilities?
14 DR. WASIOLEK: Oh yes, absolutely.
15 Absolutely. That is exactly what this graph reflects,
16 how they behave in the environment.
17 Could I have the next slide, please? This
18 slide shows a very similar graph for the future
19 climate, for the upper bound of the glacial transition
20 climate.
21 What are the differences? Because we
22 reviewed it last, the field of the radionuclides in
23 the soil goes down. So everything that is related to
24 the soil is pretty much suppressed. Water becomes
25 more important became it is a factor that does not

1 vary.

2 So the relative contribution from the

3 water pathway goes up, and everything else pretty much

4 goes down: inhalation because it is driven by the

5 concentration in the soil, also food consumption. But

6 it is not a major difference.

7 DR. MOELLER: And, once again, the

8 inhalation is due to these evaporative coolers?

9 DR. WASIOLEK: No. Well, I will get to

10 the inhalation pathway later, but it depends on the

11 climate. Evaporative coolers are less important for

12 the future planet, but regardless of that, inhalation

13 is primarily driven by the inhalation of particulate

14 matter, not the evaporative coolers.

15 Exposure of the receptor is driven by the

16 concentration of radionuclides in the environmental

17 media the receptor comes into contact with. And also

18 it is driven by the parameters which describe receptor

19 exposure, such as assumption rates or how long the

20 receptors dispense at a given environment or the

21 nature of the contact of this individual with

22 confining media.

23 So in the next slides, we will try to

24 explore more into how important individual

25 environmental transport pathways are in the overall

1 picture. And, again, the graph shows the same or
2 suspect five radionuclides. Carbon-14 is not
3 included. I will get to this in just a while.
4 So what this graph shows, these are
5 fractions, average fractions, of radionuclide
6 concentration in crops. This is only for the crops
7 that result from a given environmental transport
8 pathway. And for radionuclide transport to crops, we
9 distinguish three environmental transport pathways,
10 which is uptake by the roots and deposition by
11 recessed particulates and deposition of irrigation
12 water on plants.
13 That is the orange. Orange cylinders are
14 doused. The next one, towards the background, is root
15 uptake. Irrigation are the tallest blue cylinders,
16 the bars in the back.
17 What we can see is that, by far,
18 radionuclide deposition on plant surfaces dominates
19 from the irrigation water. It is a dominant
20 environmental transport pathway.
21 This again got averaged over four
22 individual crop types that we consider crop types for
23 human consumption, which are leafy vegetables, other
24 vegetables, fruits, and grains.
25 VICE-CHAIRMAN RYAN: David, you had a

1 question?

2 DR. KOCHER: Yes. We are back to the

3 equilibrium concentration business again because that

4 is critical to this result. The irrigation water part

5 of this calculation comes to equilibrium very quickly

6 because -- I don't know -- mean residence time on a

7 plant surface is 10 days, 20 days, something like

8 that.

9 So the key here is what are you assuming

10 about how long it takes to reach equilibrium in the

11 soil because the longer it takes, the more buildup you

12 get and the more important root uptake gets.

13 The irrigation part of it just sort of

14 stays constant after a few days. Over time, the root

15 uptake increases. So it is really critical what you

16 are assuming for how long is this irrigation going on

17 as root uptake occurs.

18 DR. WASIOLEK: Well, this is the part of

19 our assignment that we tried to explain before the

20 break.

21 DR. KOCHER: I understand how you do it,

22 but what do you assume?

23 DR. WASIOLEK: How long it takes for the

24 --

25 DR. KOCHER: Yes. How long did it take?

1 DR. WASIOLEK: It depends on the
2 radionuclides.
3 DR. KOCHER: For example?
4 DR. WASIOLEK: Well, for technetium, it
5 takes I think 20. We have a table. I don't remember
6 the exact numbers, but these are like -- I don't know
7 -- 20-30 years for technetium and maybe 1,000 years
8 for plutonium.
9 DR. THORNE: If I could comment? I think
10 there is a key question here actually, about the
11 chemical form. I think when you do technetium,
12 because this is a sandy soil, you are effectively
13 assuming that it is the protectonate and, therefore,
14 it has a low retardation and, therefore, it comes to
15 equilibrium on the order of a few years.
16 DR. WASIOLEK: Yes,
17 DR. THORNE: Fundamental to both the
18 technetium and iodine questions to my mind is the
19 change in redux state as you move down the soil
20 profile and the degree of change absorption that may
21 occur as you move from technetium as protectant to
22 CTO_2 minus.
23 I've gotten what you said this morning.
24 You know, it is possible that availability decreases
25 as Kd increases.

1 DR. WASIOLEK: Yes. Technetium is very
2 sensitive to redux conditions. We assume the
3 technetium is TCO_4 protectonate. And we do so
4 consistently throughout the whole food chain. It also
5 comes up as a problem or potential problem in animal
6 uptake, whether it gets converted into TCO_2 or not,
7 which is insoluble, which increases the intake. And
8 if this question comes up later, I would be glad to
9 elaborate on that.
10 So yes, we do assume that we have TCO_4,
11 that we do not account for a possible reduction of
12 TCO_4 to TCO_2 as it travels through the profile.
13 VICE-CHAIRMAN RYAN: I'm sorry? You did
14 or did not account for that?
15 DR. WASIOLEK: Excuse me?
16 VICE-CHAIRMAN RYAN: You did or did not
17 account for that?
18 DR. WASIOLEK: We did not account for
19 that.
20 VICE-CHAIRMAN RYAN: Okay. Ruth?
21 MEMBER WEINER: Since your results are so
22 sensitive to the chemical nature of the solubility,
23 the equilibrium and so on, have you considered doing
24 a distribution or a sensitivity analysis? What if you
25 did use TCO_2? How would that make your results

1 different?

2 It seems to me this is a logical point for

3 some sort of sensitivity analysis or uncertainty

4 distribution because, really, you are making the

5 assumptions which appear to drive your results.

6 DR. WASIOLEK: Well, there is a graph

7 later on that shows how sensitive will the results be

8 to how quickly the technetium is removed from the root

9 zone. When I get to this point, I hope I will have

10 answered your question.

11 MEMBER WEINER: Okay. Thank you.

12 DR. WASIOLEK: There is a graph of it.

13 VICE-CHAIRMAN RYAN: Yes, please?

14 DR. THORNE: I think I would like to

15 comment on that before we get there because I think

16 there is a conceptual modeling problem.

17 It is not a question of whether it is TCO_4

18 minus throughout the system or TCO_2 minus throughout

19 the system. It is a question of whether within the

20 soil profile there are transformations between the two

21 and the storage compartment; that is, at the free

22 acting surface and below, is actually TCO_2 minus and

23 that is what retains it. But as the soil dries out

24 and it becomes oxygenated, there is a conversion to

25 TCO_2 minus. And plant uptake occurs from that phase.

1 It is the kinetics of that process that
2 seem to me to be the question and not simply a one or
3 the other.
4 VICE-CHAIRMAN RYAN: Other questions?
5 Comments? Yes, John?
6 DR. TILL: So just to make it clear,
7 plutonium-239, for example, is based on essentially
8 1,000 years of buildup in the soil --
9 DR. WASIOLEK: That's correct.
10 DR. TILL: -- through irrigation
11 practices, right?
12 DR. WASIOLEK: That's right.
13 DR. TILL: Okay. This will be important
14 later on in the calculation of the inhalation dose
15 because that would affect it significantly.
16 DR. WASIOLEK: Absolutely, absolutely.
17 DR. TILL: So I think I understand now
18 what they have done. I am not sure I agree.
19 VICE-CHAIRMAN RYAN: Well, let's ask
20 Maryla to continue. I think we will have some of our
21 questions as she goes along.
22 DR. WASIOLEK: So just to finish with this
23 graph, root uptake is, for example, important for
24 taking assume and not quite so for other
25 radionuclides. And the importance goes down as the

1 atomic number goes up.

2 The deposition from dust is a relatively

3 insignificant contributor. And it does increase as we

4 go towards actinides just because there is a stronger

5 accumulation in the soil for these guys.

6 Carbon-14 is not included on the graph

7 because it has different transport mechanisms. And in

8 the case of carbon-14 transfer to crops, almost 100

9 percent is from air, from the air. And very little of

10 it is through the roots.

11 VICE-CHAIRMAN RYAN: David?

12 DR. KOCHER: Are you aware that somebody

13 has actually measured root uptake of carbon-14?

14 DR. WASIOLEK: Well, we found a few

15 articles I think with Shepherd.

16 DR. KOCHER: Yes, quite illuminating.

17 CHAIRMAN GARRICK: How so?

18 DR. KOCHER: Well, BV is on the order of

19 .1 to 1. So, I mean, I think this assumption just

20 isn't right. Carbon is not magic. It works just like

21 everything else with a few exception. It buffers in

22 water. You know, not everything does that. Not

23 everything makes bubbles in champagne.

24 In terms of behavior in the environment,

25 it is very little different from other things. And it

1 gets absorbed through the roots just like everything
2 else.
3 DR. THORNE: I think the other thing,
4 though, is irrigation is quite an interesting question
5 because if it is also in the soils, though, and you
6 have capture under the canopy, when you put a canopy
7 in front of it, you have got your prior concentration.
8 DR. WASIOLEK: This is exactly what we do.
9 DR. THORNE: So there is a driving force
10 the other way for the enhanced folia uptake simply
11 because the concentrations are seen as enhanced in
12 that sub-canopy atmosphere. That is only at the stage
13 that you have got a mature aplomb with a fully fledged
14 canopy.
15 I think it is a difficult one to model.
16 DR. WASIOLEK: Yes. This is exactly what
17 we do. We allow carbon escape from the soil. We
18 assume a mixing cell in which we predict wind
19 velocities that are for the canopy. So they are much
20 lower.
21 Not much mixing occurs because we model it
22 as wind speed in the new surface environment. And we
23 let the plants absorb carbon from that mixing cell.
24 DR. THORNE: That is what I did. That is
25 what brought it up, the same thing.

1 DR. WASIOLEK: Right or wrong. Animals.
2 For the animals, I couldn't have lumped them all
3 together, the animal products, which is meat, milk,
4 poultry, and eggs. These are four animal products
5 considered in the model.
6 I couldn't have lumped them all together
7 like I did with the crops because there were just more
8 differences between them, pretty much between meat and
9 milk and poultry and eggs. That is why I divided them
10 into two graphs.
11 What we can see is that for meat and milk
12 contribution from animal, feed is the most important.
13 And the importance goes down with the atomic number of
14 radionuclides.
15 Consumption of soil goes up with the
16 atomic number, again, for the same reasons that we
17 pointed out before. And the water ingestion is not a
18 very significant pathway. By the way, soil ingestion
19 is a new pathway that we added to the model that we
20 did not have before in the JNES because JNES just did
21 not have the staff link. And it turns out that it is
22 quite important.
23 JNES only has feed and water. And, as you
24 can see, especially for poultry and eggs, I suppose
25 maybe because chickens go around and look for soil, it

1 is quite an important pathway.

2 DR. KOCHER: I am having a lot of trouble

3 with this. I am probably completely wrong, as always.

4 Go back to the last slide. On the top there, you are

5 telling me that most of the radioactivity that ends up

6 in animal products comes from their eating feed,

7 rather than drinking water from the source, that the

8 animals are consumed to be drinking this contaminated

9 water from the well, right?

10 DR. WASIOLEK: Do you mean for technetium?

11 It is more because we have --

12 DR. KOCHER: Well, the blue is high for

13 everything on the top.

14 DR. WASIOLEK: Yes.

15 DR. KOCHER: I find that really hard to

16 reconcile with the previous one, which for humans was

17 just the other way around. In fact, I don't think

18 this is possible.

19 Ask yourself the following question. I am

20 a cow out there, and I am drinking water and I am

21 eating grain. Which is the bigger source of water for

22 me? Do I get more water from drinking out of the tank

23 or do I get more water by eating alfalfa?

24 DR. WASIOLEK: Well, don't forget that for

25 human consumption, we have to remember that not all

1 fruit that is eaten comes from a contaminated source,
2 which throws this balance off completely.
3 For animals, every blade of grass that
4 they eat and every grain of corn that they pack on is
5 contaminated. For humans, just because we base their
6 consumption rates on local population, only a small
7 fraction of their food is contaminated, but all of the
8 drinking water is contaminated.
9 A cow will eat 100 kilograms or whatever
10 of contaminated feed. And a person will only eat two.
11 DR. KOCHER: I just don't believe that
12 most of the water in a cow comes from eating food. I
13 just don't believe it.
14 DR. ECKERMAN: It's the same deal here.
15 Most of the technetium is coming from the feed, cow,
16 right, because that is what this graph is saying, --
17 DR. WASIOLEK: Yes.
18 DR. ECKERMAN: -- which, of course, goes
19 back again to your question about the equilibrium
20 because you have forced the feed concentrations if we
21 had equilibrium, --
22 DR. WASIOLEK: That's right.
23 DR. ECKERMAN: -- whatever they took, from
24 the irrigation pathway, where it is drinking the
25 water. Now, the unit concentration, the other one,

1 has been amplified by the continued deposition.

2 DR. WASIOLEK: Yes.

3 DR. ECKERMAN: So I think it makes sense

4 when you figure out how it is all normalized back to

5 unit concentration of water.

6 DR. KOCHER: Root uptake of plutonium is

7 virtually zero.

8 DR. WASIOLEK: Yes. But this is the key.

9 This graph does not show mechanism for transport to

10 feed. So when you are looking at this graph, the fact

11 that they get a lot from feed does not mean that

12 plutonium in the feed came from root uptake. It

13 didn't. It came from the same mechanisms that were

14 shown in the previous graph, which is very similar for

15 the feed.

16 Most of it for plutonium because you were

17 asking about plutonium is from irrigation water and

18 dust deposition. Root uptake was very, very small,

19 almost nonexistent.

20 DR. KOCHER: The residence time, you

21 cannot accumulate plutonium on the surface of that

22 plant for longer than 60 days.

23 DR. WASIOLEK: It is deposition of

24 contaminated dust. It is a dynamic process that we

25 model, also because we consider growth time and

1 weathering factor. So we are continuously depositing
2 contaminating soil on the plant surface and
3 continuously removing it.
4 DR. KOCHER: It doesn't hold up.
5 DR. WASIOLEK: It comes to an equilibrium.
6 DR. KOCHER: No. She just told me that
7 that is not it.
8 DR. ECKERMAN: But I think she --
9 DR. WASIOLEK: I am explaining.
10 DR. ECKERMAN: I think you are mixing the
11 two. You have got to take out the part about the
12 water, the irrigation of plant, and then the
13 irrigation of the soil.
14 DR. WASIOLEK: Oh, yes. They are two
15 different things.
16 DR. ECKERMAN: Yes, right. And I think
17 you haven't explained both of those to us. That is
18 why there is some confusion.
19 DR. WASIOLEK: Okay. Irrigation of the
20 soil is a long-term process that leads to this
21 equilibrium concentration. Irrigation of the plant is
22 a dynamic process that reduces water with the current
23 concentration, which is unit concentration.
24 DR. ECKERMAN: So at the end of the day,
25 most of the activity that is on the plant has come

1 from first when its deposit was on the soil and then
2 resuspended.
3 DR. WASIOLEK: Some of it will be
4 deposited on the soil and resuspended. Some of it
5 will come from the irrigation water that --
6 VICE-CHAIRMAN RYAN: I'm going to make the
7 suggestion in the interest of time, we have to move
8 on. We could probably spend the rest of the day
9 working through these irrigation models, but I think
10 we really would maybe like to ask Maryla to move on
11 with one last question.
12 DR. TILL: Not a question.
13 VICE-CHAIRMAN RYAN: Observation.
14 DR. TILL: It's important to know that,
15 even in cattle feed, you have got 10 to 14 percent
16 moisture. Alfalfa usually runs eight percent, ten
17 percent moisture. Silage will run 14-15 percent
18 moisture.
19 So you do have a way to get moisture in
20 cattle feed. Plus, you are compounding it with this
21 buildup in soil, resuspension on the plant, and the
22 deposition through the water on top of the corps. So
23 it doesn't look logical, but I see how that could
24 happen.
25 VICE-CHAIRMAN RYAN: Okay. Well, let's

1 press on. We can talk about this in the discussion.

2 DR. WASIOLEK: Well, we are not really

3 renting these models. These are models that are

4 commonly used. It is the same model as in ten years,

5 for example.

6 Just a brief summary of receptor exposure

7 pathway. It is very similar to the bar graph that I

8 started my presentation with. Just the ingestion and

9 inhalation pathways are summarized. I mean, they are

10 all added up.

11 It shows that the water ingestion is an

12 important pathway. Ingestion of locally produced food

13 is also an important pathway, especially for light

14 model radionuclides. And then as we move to

15 inhalation, it becomes more important for actinides

16 because of the accumulation in the soil.

17 DR. THORNE: Could I just qualify that

18 one? The carbon-14, the ingestion is dominated by

19 fish, though, is it not, rather than the plant? There

20 is an interesting question there because I think you

21 use a specific activity model between carbon-14 and

22 water --

23 DR. WASIOLEK: That's right.

24 DR. THORNE: -- and carbon-14 in fish.

25 And hiding under that number is the whole question

1 about whether we should represent other sources of
2 carbon for fish because if we are talking about fish
3 farming, most of the carbon comes from external
4 sources and not from carbon-14 in water.
5 DR. WASIOLEK: Yes. We had a problem with
6 this because this is not a natural system. It is a
7 farm. And we interviewed people who used to run this
8 farm. This buy commercial pellets. They don't grow
9 fish food locally. And most of the carbon in fish
10 comes from the food and not from the water.
11 But we were limited by our sources of
12 bioaccumulation factors for carbon to whatever exists
13 in the literature. And we are sort of stuck with
14 this.
15 VICE-CHAIRMAN RYAN: Did you evaluate what
16 that meant in terms of either sensitivity or
17 uncertainty?
18 DR. WASIOLEK: Well, the uncertainty in
19 the distribution is included.
20 VICE-CHAIRMAN RYAN: Using fish pellets
21 versus contaminated feed?
22 DR. WASIOLEK: Well, fish pellets are not
23 contaminated. They come from the outside.
24 VICE-CHAIRMAN RYAN: That is my point.
25 DR. WASIOLEK: They are externally

1 produced. They are not contaminated at all.

2 VICE-CHAIRMAN RYAN: But this ingestion is

3 of what exactly?

4 DR. WASIOLEK: It is primarily --

5 VICE-CHAIRMAN RYAN: Contaminated fish.

6 Yes, please?

7 DR. SWIFT: This is Peter Swift. I just

8 wanted to reiterate something that came up earlier

9 this morning, that because of the repositories in the

10 unsaturated rock 18 kilometers from the exposure

11 point, we had a choice back there to make also as to

12 what to do with the carbon-14.

13 The choice there, the moment when it

14 leaves the waste package, was to put it all into the

15 water phase. So it reaches the receptor point with

16 all of the issue inventory of carbon-14, essentially

17 all of it because we don't retard it en route, is

18 still in the water.

19 So the water is pumped out on the fields.

20 It then goes through this pathway near the crops or on

21 the fish, contains all of the carbon-14 that was

22 available on the system. We have lost none to the

23 atmosphere until we get to the receptor point.

24 VICE-CHAIRMAN RYAN: We really have to

25 press on. We are getting low on time. So if you

1 would continue, Maryla, please?

2 DR. WASIOLEK: Okay. This graph is a

3 slice from the first graph that I showed, the

4 carbon-14 slice. I superimposed it with the

5 consumption rates just to show how the consumption

6 rates of locally produced food influences the

7 individual pathways for carbon-14.

8 The carbon model is based on relative

9 concentrations of carbon-14 and carbon in various

10 environmental media. The transport of carbon through

11 the food chain reflects these ratios. So basically

12 carbon-14 concentrations are related to carbon

13 concentration in a given environmental medium of food

14 or whatever it is.

15 So if you look at the pattern of

16 consumptions of locally produced food, it is pretty

17 much which led to the pattern of percentage of

18 contribution of this pathway to the BDCF for

19 carbon-14.

20 This is just a summary. Let's move on.

21 Let's skip this one. Fish, as we noted before, is an

22 important, consumption of locally produced fish is an

23 important, pathway. This is how we calculate activity

24 concentration in the fish.

25 If it is a product of activity

1 concentration in the water, what we call a modifying
2 factor, which accounts for evaporation and possibly
3 concentration of the radionuclide in the fish pond.
4 And the bioaccumulation factor in the case
5 of carbon, this concentration concentrates for a
6 factor, a modifying factor. It is equal to one. We
7 do not concentrate carbon.
8 Technetium pathways. In essence, it is
9 very similar to carbon in that for technetium, water
10 is more important than it was for carbon and fish is
11 not a player, but the consumption rates are pretty
12 much reflected in the relative contributions of
13 individual food consumption pathways.
14 External exposure, inhalation are not
15 important. Neither is the soil. So I suppose we can
16 move on. If there are questions, just for the sake of
17 keeping up, the following slide just showed the
18 summary of what was said about the contributions of
19 technetium pathways.
20 This slide shows where the uncertainties
21 are coming from. The BDCFs got broken into major
22 components. First, we have a total, but then we have
23 a drinking water, inhalation, ingestion. The symbols,
24 the most top one is the maximum. The lowest one is
25 the minimum of 1,000 values for that value of BDCF,

1 approximately BDCF. The symbols in between are the
2 95th percentile, and the green trend goes to meat.
3 So if we look at where the uncertainties
4 are in the technetium pathway distribution are coming
5 from, well, the uncertainty in the BDCF, for instance,
6 is almost entirely due to the uncertainty in the
7 non-water consumption pathway.
8 Water is fixed. So there is no
9 uncertainty here because it is prescribed by the
10 regulation. And the uncertainty, since inhalation is
11 external, the absolute values are so low, although
12 they are relatively uncertain, they don't contribute
13 to the total BDCF to any significant degree.
14 Now, let me read my numbers. The BDCF for
15 technetium varies by a factor of 16 between minimum
16 and maximum -- so this is the first group of symbols
17 -- and less than a factor of 4 between the 5th and
18 95th percentiles.
19 For the non-water ingestion, we have a
20 variability range of about 200 between the minimum and
21 maximum. So this is what contributes most to the
22 distribution for the final distribution of the BDCFs
23 for technetium.
24 Now, if we take a closer look at the root
25 uptake, which was an important environmental pathway

1 for technetium, we calculate activity in concentration
2 in plant by multiplying activity concentration in the
3 soil, soil-plant transfer factor, and dry-to-wet
4 ratio.
5 The values of transfer factors for
6 concentration ratios come from the literature, not
7 only for technetium but for most of our environmental
8 transport parameters. We do a literature search and
9 select the values. In this case, there were many
10 different values. So we have chosen a distribution
11 that pretty much encompasses the whole range of
12 values, which is marked on these graphs by this dashed
13 line. This would be the range of our distribution
14 around the value.
15 As far as we can, we are trying to recite
16 specifics. So, for example, dry-to-wet ratios were
17 developed on selection of representative crops for the
18 region.
19 If we start drilling deeper, how do we get
20 to specific quantities in the equation? A very
21 important equation is obviously the one that
22 determines activity concentration in the soil but has
23 been discussed numerous times already. And this is
24 the very equation that we used to calculate activity
25 concentration in the soil.

1 In the numerator, we have a product of
2 activity coefficient in the water, one, in this case
3 and irrigation rate. So this is our source.
4 The same terms are represented by an
5 effective loss factor, which is a sum of three removal
6 constants, representing removals by radioactive decay
7 leeching from the surface soil and soil erosion.
8 Among the three, leeching is the most important.
9 The second equation shows how we calculate
10 leeching removal constant.
11 DR. KOCHER: What is the value of $lambda_e$?
12 DR. WASIOLEK: That is the value of
13 $lambda_1$.
14 DR. KOCHER: What is the value of $lambda_e$
15 that you assume?
16 DR. WASIOLEK: $Lambda_e$? Soil erosion. I
17 don't remember what the value is. It is a
18 distribution again of some values. I am not the
19 person who developed this value. So I don't know what
20 is the exact number. But it is in the report that you
21 can look it up online within --
22 DR. RAUTENSTRAUCH: This is Kurt
23 Rautenstrauch. It is on page 39 of my presentation.
24 I have some distributions of some of our parameter
25 values in that.

1 DR. WASIOLEK: Okay. Luckily this one was
2 included.
3 VICE-CHAIRMAN RYAN: Maryla, I'm just
4 looking at the clock, and I want to be respectful to
5 our time for public comments. Maybe I could ask you
6 to move through the rest of your slides a little bit
7 and we can finish up.
8 DR. WASIOLEK: Okay.
9 VICE-CHAIRMAN RYAN: Thank you.
10 DR. WASIOLEK: Well, let's move on. This
11 graph shows dependance of BDCF of some over-watering
12 rate, which is an important parameter that controls
13 leeching removal concentration. It is a quite
14 interesting graph, too.
15 The next one is also interesting. It sort
16 of addresses the question that Ruth has asked before,
17 how the uncertainties in values of parameters that
18 will control removal of technetium in this case from
19 the soil affect BDCFs.
20 It actually is a very interesting graph.
21 We do have a correlation between Kd and transfer
22 coefficients, unlike the NCRP model. These two values
23 are correlated in our model.
24 One thing that we can see is that the
25 orders of magnitude variations in Kd values do not

1 cause a lot of variability in the BDCFs. It is very
2 small variability, actually.
3 There is a very interesting effect that we
4 see between BDCFs and Kd. What we have, low values of
5 Kd, plants just suck it up from the technetium from
6 the liquid phase because it is all practically there.
7 And then, as Kd increases, the less
8 technetium becomes available for root uptake. But
9 then, as we Kd increases, activity concentration in
10 the soil increases, then the BDCFs go up again. So it
11 is a pretty neat graph.
12 Iodine pathway is very similar to the
13 technetium pathway. So we can probably skim over
14 these. Consumption of animal products is more
15 important for iodine just because the transfer
16 coefficients are higher for iodine than they are for
17 technetium.
18 As was the case with technetium
19 variability in the iodine, pathway comes almost
20 entirely from the variability in the non-water
21 component, non-water food ingestion.
22 Because of the relatively large
23 contribution of drinking water, which is a fixed
24 component, there isn't much variability in the BDCF
25 for iodine.

1 For the transuranics, food consumption is
2 virtually nonexistent. What counts is the inhalation
3 and consumption of water. If we look at the
4 inhalation for these three radionuclides and split it
5 into particulate matter and evaporative cooler, which
6 answers Dave's question, what fraction comes from
7 which inhalation component, the majority is from the
8 inhalation of suspended particulate matter;
9 evaporative cooler, not very important. These values
10 are for the modern climate. So for the future
11 climate, evaporative coolers are going to be even less
12 important.
13 If we look closer at the inhalation
14 pathway, inhalation, if we spread the contribution to
15 the inhalation pathway, this is the inhalation of
16 particulates, suspended particulate matter. Almost
17 entire inhalation dose comes from people spending
18 their time in what we call an active outdoor
19 environment, which is the environment in which people
20 disturb soil, enhanced soil resuspension perfectly by
21 mechanical means.
22 The other environments, like inactive
23 outdoors, which is outdoor without taking dust pretty
24 much, or indoor do not contribute that much to the
25 inhalation dose. Again, if we start drilling and

1 looking at what individual parameters cause this high
2 inhalation dose in the active outdoor environment, we
3 will see that activity concentration in air is high in
4 active outdoor environment, much higher than in the
5 remaining environments.
6 If we look at the population-weighted time
7 spent in the environments, which is the graph that is
8 similar to the pie chart that Kurt showed in his
9 presentation, people don't spend all that much time in
10 the active outdoor environment, population-weighted
11 time, but the activity concentration is so much higher
12 in this environment.
13 The breathing rate is a little bit higher,
14 too, in this environment. We use ICRP-60 reference
15 values for the breathing rates. So this pretty much
16 is what drives inhalation dose.
17 This slide shows how individual parameters
18 were developed for the inhalation pathway. So we can
19 skip through this one.
20 The following slide shows inhalation
21 pathway for the evaporative coolers. There are two
22 parameters that are site-specific which control a
23 fraction of houses that have evaporative coolers,
24 which is a survey quantity. And evaporative cooler
25 use factor, which is driven by the climate, we make a

1 determination when for a given temperature people will
2 use evaporative coolers.
3 The important parameter is activity
4 concentration in the air. Activity concentration in
5 the air is calculated as a product of some specs for
6 an evaporative cooler, how quickly it moves and how
7 much of it.
8 What we call this FE stop, which is a
9 fraction of the radionuclides in water transfer in the
10 air, this is something that Mike mentioned in the
11 morning. It is the parameter that we could not find
12 any reference in the literature to.
13 So because this was a very new pathway
14 that did not exist in our previous model and we had
15 absolutely no sense of how important it will play in
16 the overall model, neither to just say, "I don't know
17 what is the value of it" -- so theoretically it can be
18 between zero and one. Let's see how it matters.
19 Let's move two slides. And this is how it matters.
20 For the modern climate, if we change the
21 fraction of radionuclides transfer to the indoor air,
22 I mean, the full swing from zero to one, we are
23 changing BDCF for neptunium, which had the highest
24 contribution from evaporative coolers by a factor of
25 1.35. And because modern climate is hardly used in

1 TSPA because it exists for such a short period of
2 time, the lower slide, the bottom graph will better
3 represent contributions from evaporative coolers.
4 So this full range of possible values of
5 the fractions of radionuclides transferred to indoor
6 air only changes the BDCF by a factor of 1.12. So it
7 has a negligible effect on the BDCF.
8 The summary, basically it is just the
9 summary of the pathway contributions, which we can see
10 that there is a limited number of pathways and
11 parameters that control the doses.
12 Again, because of the nature of our model
13 and the way it ties with the TSPA model, we do not
14 know what the concentration of radionuclides is.
15 These values or the pathway analysis
16 applies only to individual radionuclides. It does not
17 apply to the TSPA importance, pathway importance,
18 analysis because --
19 VICE-CHAIRMAN RYAN: These are all unit
20 concentrations, yes.
21 DR. WASIOLEK: All unit concentrations.
22 For example, for us, technetium, for example, which is
23 a very important player and comes at the top of every
24 TSPA analysis, BDCF for technetium is the lowest of
25 them all because there was a lot of technetium. It

1 comes out as an important player.

2 VICE-CHAIRMAN RYAN: Before we have

3 additional questions from the panel members or ACNW

4 members, are there any questions or comments from the

5 audience? Do members of the public or staff have

6 comments at this point?

7 (No response.)

8 VICE-CHAIRMAN RYAN: Okay. Hearing that,

9 more questions? I am sorry to cut you off, but I

10 wanted to make sure we had time for further questions

11 as well. John?

12 7.1.3) DISCUSSION

13 DR. TILL: Just a quick one. What is the

14 fraction of food generated locally versus imported in?

15 What is that, food produced locally versus brought in

16 from the outside? What is the --

17 DR. WASIOLEK: It varies. It is based on

18 the results of the survey.

19 DR. TILL: So what is it? Give me a

20 ballpark figure of what we are talking about.

21 DR. WASIOLEK: On the slide, you will see

22 the exact numbers on slide 9. It is in kilograms.

23 DR. TILL: Slide 9 of?

24 DR. WASIOLEK: Slide 9. Here we go, the

25 bottom, the lower graph. These are the actual

1 consumption rates in kilograms per year of locally
2 produced food consumed.
3 DR. TILL: That does not mean it is --
4 DR. WASIOLEK: It is not the percentage.
5 These are the actuals. The one thing that we need to
6 stress out is Pat made a comment that our consumption
7 rates went down, but the receptor has changed.
8 In the previous assessments, our receptor
9 was the average number of the critical group. Now our
10 receptor is an average number of the valid percent.
11 And this does include people who do not consume any
12 food from a given food type.
13 VICE-CHAIRMAN RYAN: Kurt, I think --
14 DR. RAUTENSTRAUCH: Kurt Rautenstrauch.
15 Yes. I can answer that in a simplistic way. For
16 fruit, it is less than 18 percent of average daily
17 intake would come from locally produced crops. For
18 other products, it is much less than that, certainly
19 less than ten percent, probably less than five. I
20 don't remember the numbers right off. Fruit is the
21 highest one, and it is less than 18 percent.
22 VICE-CHAIRMAN RYAN: That is what I
23 wanted. David, do you have any questions?
24 DR. KOCHER: It doesn't really matter in
25 the grand scheme of things, but the bioaccumulation

1 factor for carbon in fish is fishy.

2 DR. WASIOLEK: Well, it is fishy.

3 DR. KOCHER: It is fishy.

4 DR. WASIOLEK: I agree. It is way too

5 high.

6 DR. KOCHER: I am wondering. Specific egg

7 models are widely misused, but I am wondering if this

8 isn't a place where it really applies, that if you

9 know the specific activity of carbon in that water,

10 which you ought to because the water quality should be

11 known --

12 DR. WASIOLEK: Fifty micrograms per liter.

13 DR. KOCHER: Surely, the fishes are not

14 going to accumulate carbon-14 --

15 DR. WASIOLEK: No more than there is in

16 the water.

17 DR. KOCHER: -- and not accumulate

18 carbon-12.

19 DR. WASIOLEK: Yes, but I look at --

20 DR. KOCHER: There is only one exposure

21 medium for those critters.

22 DR. WASIOLEK: Basically, these

23 bioaccumulation factors reflect exactly what you are

24 saying except that the poor fish take all of the

25 carbon from the water.

1 DR. THORNE: Now, that concentration
2 factor, say if they go up to 50,000 or 100,000 were
3 derived on exactly that basis. They took the carbon
4 content of fish. They divided it by the stable carbon
5 concentration and divided by the stable content of
6 water. That is where that number comes from.
7 DR. WASIOLEK: Exactly.
8 DR. THORNE: And that is why it is orders
9 of magnitude out.
10 DR. WASIOLEK: Stable carbon in fish is
11 about 20 percent. Stable carbon in water is about 50
12 micrograms. There you have it, 4,500.
13 DR. ECKERMAN: But I think what David was
14 saying is that model isn't applicable to this
15 situation.
16 DR. WASIOLEK: Yes. And we agree because
17 the components of the fish environment are not in
18 equilibrium with carbon. But there was not a single
19 study that I know of that somebody would calculate
20 bioaccumulation factors for farmed fish, where their
21 food is not contaminated.
22 VICE-CHAIRMAN RYAN: To bring it back to
23 one of our central questions of uncertainty and/or
24 sensitivity and margin, this seems to be something
25 that is right for that sort of an evaluation, where it

1 sounds like -- and correct me if I am wrong -- you are
2 overestimating the dose from consumption of fish.
3 DR. WASIOLEK: We do. That is correct.
4 VICE-CHAIRMAN RYAN: And that could be an
5 upper limit or a bounding value.
6 DR. WASIOLEK: It is.
7 VICE-CHAIRMAN RYAN: Have you thought
8 about ways to sample that somehow or to create some
9 kind of an evaluation that is an upper limit? What
10 does it more properly look like?
11 MEMBER HORNBERGER: Remember your dictum?
12 DR. ECKERMAN: Yes, sir.
13 MEMBER HORNBERGER: If it is too
14 conservative --
15 DR. ECKERMAN: It is wrong.
16 MEMBER HORNBERGER: -- it is wrong. This
17 is wrong.
18 DR. ECKERMAN: Okay. Well, thank you. I
19 have a convert.
20 VICE-CHAIRMAN RYAN: Yes, sir.
21 DR. KOCHER: I did want to go back and
22 figure out what your loss rate constant for soil
23 erosion is because I don't get the answer from looking
24 on page 39 of the previous talk.
25 CHAIRMAN GARRICK: In fact, my question

1 was this was labeled kilograms per cubic meter. How
2 is that a rate?
3 DR. KOCHER: That is not a rate constant.
4 CHAIRMAN GARRICK: That is not a rate
5 constant. You noticed that, too. Not per year.
6 DR. WASIOLEK: I don't have the report
7 with me. So I don't want to make up numbers. I don't
8 know what it is.
9 CHAIRMAN GARRICK: I suppose we can get
10 that tomorrow.
11 DR. KOCHER: I suppose we could figure it
12 out. I am sure it will work. It's going to be not
13 hard.
14 CHAIRMAN GARRICK: Yes. Let's make it a
15 homework problem.
16 DR. WASIOLEK: It's a line. It is on the
17 open Web site.
18 VICE-CHAIRMAN RYAN: Yes? I'm sorry.
19 DR. THORNE: Could I? Just two points.
20 I would like to return to the point I was talking
21 about about are we talking about an individual or a
22 population, which is one I raised this morning?
23 I think that one on the inhalation of
24 neptunium, if we could possibly go back to that slide,
25 makes that point absolutely perfectly. It is the

1 inhalation of particulate matter slide. Can we go
2 back? Keep on going.
3 Now, if you look at that, what drives that
4 is time active outdoors. And the weighted time in the
5 environment for the average person in the survey is
6 about 0.3 hours per day. But the man who works on the
7 soil who is included in that is the guy who is going
8 to be out there eight hours a day.
9 So there is a factor of potentially 25
10 depending on whether you talk about an individual or
11 a population-weighted average value. I think we can't
12 do anything about it in terms of the definition of the
13 RMEI, but I think you have got to be aware of that
14 distinction between individuals in populations because
15 of those sorts of differences.
16 VICE-CHAIRMAN RYAN: That is interesting.
17 DR. WASIOLEK: Well, probably it would not
18 be quite as high multiplier because the person would
19 not stand eight hours every single day of conducting
20 work in highly dusty activities. They would spend a
21 fraction of their time. So even for a person who is
22 an agricultural worker, the multiplier would likely be
23 much lower than that.
24 VICE-CHAIRMAN RYAN: Dr. Weiner?
25 MEMBER WEINER: I have, really, two

1 questions. The first one refers to an evaporative,
2 your evaporative cooler question, because that is the
3 way I cool my house in the summertime.
4 The water circulates through a spongy pad,
5 normally wood fibers. Now, I can't believe that that
6 won't pick up any particulate matter because it
7 certainly would.
8 It seems to me also that given the large
9 number of evaporative coolers in existence, you could
10 measure. You could simply measure the particulate
11 uptake in the pads of a normal evaporative cooler and
12 get some kind of bound, some kind of distribution that
13 is not, as Dr. Ryan says, simply so conservative it is
14 wrong. I would suggest you do that.
15 DR. WASIOLEK: Well, to answer your
16 question, this concern, I said in the beginning this
17 is a new pathway. Before you embark into conducting
18 a wide survey and measure people's outputs, you are
19 trying to determine whether it is worth your effort or
20 not. And what we are trying to show here is that it
21 is not worth the effort because even this value, that
22 is why we let it swing from zero to one to see whether
23 it matters.
24 And the answer is no, it doesn't really
25 matter, even if it is overestimated So why would we

1 go and conduct a survey of a parameter that is not
2 very important?
3 MEMBER WEINER: That is a perfectly good
4 answer if it is not important.
5 My other question has to do with the
6 animal feed. Having visited the Armagosa Valley, as
7 we did, I am not convinced that all of the animal
8 feed, even all of the alfalfa, these animals in the
9 valley consume is grown locally, I don't think they
10 can grow enough. I wondered what kind of effect that
11 has on your --
12 DR. WASIOLEK: We did not conduct animal
13 consumption surveys in the valley, just human
14 consumption surveys. Our model does conservatively
15 assume that every kind of food that animals eat is
16 locally produced.
17 MEMBER WEINER: That is my point.
18 DR. WASIOLEK: It is a conservative
19 assumption. I agree.
20 VICE-CHAIRMAN RYAN: We have two former
21 farmers on this side of the table who want to talk to
22 you also about feed. John?
23 DR. TILL: Actually, Dr. Weiner's question
24 about the evaporative cooler, what you are losing here
25 is a chance to get credibility with people. All

1 right? I mean, if it is a simple thing to do, it is
2 something that is going to come up. And just saying,
3 "Well, it isn't important," okay. It isn't important.
4 But if you could get the data, get it.
5 One of the things I believe that worries
6 me the more I hear about this is that all of these
7 analyses being done by DOE are being based on other
8 people's work. And there is a lack of originality to
9 it. Okay?
10 Now, going back to the animal feed, that
11 is a huge question. And it is a very important
12 question. It is a credibility issue. It is very
13 simple to get the answer. You know that. Go to the
14 farmer and ask.
15 But also you can make a pretty quick
16 calculation. I can tell you you can't get enough
17 alfalfa for 5,000 cows out of 2,000 acres.
18 DR. WASIOLEK: There was a commercial
19 operation, this huge farm, which products milk that
20 goes elsewhere. Apart from the farm, not enough
21 alfalfa grown in the valley that can provide food for
22 those thousands of cows, we can have individual
23 farmers that may grow enough food for one or two cows.
24 DR. TILL: The question is, is there
25 enough food and can there be enough food grown if you

1 are basing it on current statistics? You have 2,000
2 irrigated acres out there, right? I believe that is
3 what I saw. You can't produce enough food on 2,000
4 acres to feed those 5,000 cows, no matter what.
5 DR. WASIOLEK: The milk out of these cows
6 is not consumed locally. It is a commercial
7 operation; whereas, individual farmers or individual
8 people have been farmers. They can have a couple of
9 animals, and they may indeed produce enough food.
10 DR. TILL: So you are saying this is for
11 the RMEI.
12 DR. WASIOLEK: Yes, for the RMEI.
13 DR. THORNE: I'm sorry. There is a
14 logical inconsistency there. We have just had the
15 RMEI has average consumption rates over the whole
16 population. And now we have got one or two farmers
17 drinking their own milk. One of those can be the RMEI
18 or the other one can. They can't both be the RMEI.
19 DR. ECKERMAN: And your equation for the
20 evaporators deals with the fraction of the population
21 that is using the coolers. So it is back to this
22 further confusion of the population or individual are
23 we addressing here because if it is an individual, the
24 cooler thing may look a whole lot different to you
25 when you change that fraction to one, rather than what

1 you have got.

2 DR. WASIOLEK: We have to be careful about

3 the parameters that apply to an individual and

4 parameters that apply to the environment. The

5 parameters that apply to individuals are average

6 value. It was the subject was brought up in the

7 morning.

8 DR. ECKERMAN: You also have to be not

9 only sensitive to the parameter values, but you have

10 to be sensitive to the formulation of the model

11 because the formulation you have for the evaporative

12 coolers is not the right formulation to be applied to

13 an individual.

14 So you have to keep your story. You have

15 got to stay consistent across the way. You have got

16 to use the right model formulation for the subject

17 that you are addressing. We have shown examples that

18 we have got problems with that right now.

19 DR. WASIOLEK: Parameters such as

20 behavioral and dietary characteristics are averaged

21 for the population. Parameters that are related to

22 environmental media, we allow them to vary. They are

23 not averages. We allow them to vary over whatever

24 ranges are tweakable.

25 So there will be a difference in the way

1 we develop, say, evaporative cooler usage factor
2 because it will be an average for the RMEI.
3 DR. ECKERMAN: You understand what I am
4 saying. If you look at slide 27, now, why is the
5 fraction of coolers there?
6 DR. WASIOLEK: It is the RMEI. It is the
7 RMEI value. It reflects behaviors of the RMEI. It is
8 the average value. The rule directs us to keep
9 dietary and lifestyle characteristics for the
10 individual for the RMEI of their mean values.
11 So we do take the entire population and
12 create this hypothetical individual that has average
13 characteristics for the entire population in Armagosa
14 Valley. This does the work like this for the
15 environmental.
16 VICE-CHAIRMAN RYAN: I think the
17 difficulty that we are having -- and I am glad you are
18 explaining it a bit -- is that there are certain
19 things -- and I think you said this -- that apply to
20 the RMEI as an average construct.
21 DR. WASIOLEK: That is right.
22 VICE-CHAIRMAN RYAN: We sometimes talk
23 about the RMEI as if it were an individual, --
24 DR. WASIOLEK: It's not.
25 VICE-CHAIRMAN RYAN: -- which it is not.

1 So I think it is as much a matter of semantics in
2 looking at each one of these parameters as it is -- we
3 have to be careful not to confuse ourselves or anybody
4 else that the RMEI is a reference individual like,
5 say, reference man calculations are for internal dose.
6 It is a construct of an average circumstance.
7 I think the second thing is to me -- and
8 I am summarizing a bit -- that we have to be careful
9 that if we have this construct of an average
10 individual, the RMEI to whom we are calculating a
11 dose, we have to check and make sure that various
12 parameters like alfalfa that is used on farms is that
13 average circumstance as well, do we not? I think that
14 is really the question that you heard in several
15 different forms here.
16 DR. SWIFT: This is Peter Swift.
17 Commenting on the alfalfa and the 5,000 cows, I think
18 that is a bit of a red herring or a red cow. The cow
19 in question here is not the cow that lives in the
20 valley. It is the cow that is eaten in the valley.
21 And if 5,000 cows are grown in the valley
22 but eaten in California, we don't really care where
23 their feed came from. It is the feed that was given
24 to the cows that were eaten in the valley that
25 matters. And there may very well be enough alfalfa to

1 feed those cows.

2 VICE-CHAIRMAN RYAN: We have time for one

3 or two more. Maryla, did you want to sum up in any

4 way?

5 DR. WASIOLEK: Well, I suppose --

6 DR. TILL: I still want to --

7 VICE-CHAIRMAN RYAN: Hang on. Let her go

8 ahead. Yes, please? Did you have any final comments

9 or, John, did you have a question?

10 DR. TILL: Well, I think we have really

11 hit on something that is key here. I am not sure I

12 fully understand what the regulation is, what you have

13 to do, as opposed to what you have chosen to do.

14 What you have said is because it is in the

15 regulation that you have to take all of those people

16 in the valley, 1,800 or so persons, and derive average

17 characteristics based on those 1,800 persons. You

18 have to do that? The regulation says that?

19 DR. McCARTIN: Yes, the regulation does

20 specify mean values. In relation just to continue the

21 discussion about the alfalfa, what would be allowed by

22 what is specified in the regulation?

23 If indeed the alfalfa farms in Armagosa

24 Valley currently use, let's say, 10 percent of the

25 feed grown in Armagosa Valley, 90 percent of the feed

1 that the cows use come from outside the valley, then
2 they could assume 10 percent of the feed was
3 contaminated and 90 percent was not because that is
4 the practice on average if that was the average for
5 it.
6 From a regulatory standpoint, assuming all
7 of it is contaminated, it would be conservative if
8 that was the practice.
9 DR. TILL: Well, what I'm trying to
10 clarify is what you have to do versus what you have
11 chosen to do. If I had 1,800 people in this valley,
12 the way I would do a risk assessment on those 1,800
13 people is to find what you know of as the critical
14 group of individuals, which is a smaller group of
15 people.
16 It is a group. It is not one person. It
17 is not an extreme. But it might be your farmers who
18 have those single cows, who have their evaporative
19 cooler and who drink the water from the well.
20 You might have 30 of these farmers. And
21 then that is the way I would select my parameters for
22 my individual for compliance.
23 DR. WASIOLEK: This was in the draft
24 regulations. And in the previous assessment, we used
25 an average number of the critical group. But, then,

1 the receptor that an average member of the critical
2 group got replaced with the RMEI.
3 This is when we had to change the way we
4 calculated dietary and lifestyle characteristics for
5 that receptor. We did use an average member of the
6 group in the previous calculations. This is when, as
7 Pat pointed out, our consumption rates were higher.
8 DR. TILL: I don't understand. There is
9 a big difference between the two approaches.
10 DR. WASIOLEK: There is.
11 DR. TILL: Why was the change made? And
12 who made the decision?
13 DR. McCARTIN: The language in the current
14 regulation is the language in the EPA standard that
15 NRC was required by law to adopt. So we have adopted
16 the language of the RMEI.
17 There was discussion both in the EPA
18 standard and NRC regulations that in general, we feel
19 the RMEI and the average member of the critical group
20 would be approximately the same. Would they be
21 exactly the same? No. But they are approximately the
22 same. But right now the RMEI is what is specified in
23 the standard, and that is in the regulation.
24 DR. THORNE: But I think when we show some
25 examples here where you can construct cases where the

1 critical group representative of the RMEI can diverge
2 substantially because we can have a farmer who
3 produces all of his own milk. That is a perfectly
4 good critical group-type member. The RMEI is defined.
5 DR. McCARTIN: It depends. If you want to
6 include speculation on what can happen, yes, you can,
7 but I would maintain the regulations were written to
8 preclude the kind of speculation in terms of what I
9 could have this person do this, this person do that.
10 I would still maintain if you look at
11 reasonable assumptions, the RMEI and the average
12 members of the critical group I don't believe diverge
13 that much. However, the ISRP construct of the average
14 member of the critical group was that there was an
15 order of magnitude range. And that would still be
16 considered an average member of the critical group.
17 So there is a fair amount of variation.
18 VICE-CHAIRMAN RYAN: And I think to me, it
19 comes back to the question of some of these key
20 parameters, some of which we have touched on through
21 the day, of thinking about sensitivity and uncertainty
22 analysis.
23 I am instructed by Maryla's observation
24 that certain ones are not important, whether they
25 range from zero to one. That is an interesting one to

1 focus on for a second. And if it is not important to
2 what is ultimately calculated for dose, then it is not
3 important.
4 I take George Hornberger's caution that if
5 it is a factor of 100; yet, it is at 10^{28} millirem per
6 year, then it doesn't matter if it is a factor of 100
7 or 1,000. It is only when it gets up to the
8 compliance case that we take note of that.
9 The other aspect of this to me -- and it
10 is one of the things that Professor Thorne said this
11 morning -- is that there is a compliance calculation.
12 I think have all sort of drifted off the
13 compliance case to "All right. If we are going to
14 model the true environment, what would we do?" And I
15 think those are two different things that we have to
16 also be mindful that they both have different
17 purposes. So I think that is helpful to think about.
18 We are at a point in our agenda where we
19 are due for about a 15-minute break. So why don't we
20 plan to come back right at 20 after 3:00? Thank you.
21 (Whereupon, the foregoing matter went off
22 the record at 3:05 p.m. and went back on
23 the record at 3:22 p.m.)
24 VICE CHAIRMAN RYAN: Our next session is
25 about metabolic models. The human response to

1 radionuclides is assessed. Participants will be asked
2 to describe metabolic roots and exposure duration for
3 each of the environmental pathways that we've talked
4 about and again, the discussions will be in the
5 context of the six key radionuclides of interest.
6 Our first speaker is Chris McKinney from
7 the Division of Waste Management and his title is
8 Dosimetry and Metabolic Models. Welcome.
9 MR. McKINNEY: Well, hopefully, I won't
10 have many questions. You guys went over this about
11 six or seven times so far today. So we'll try to get
12 through this fast. Wishful thinking.
13 I tried to break up also in the title the
14 fact that we got -- there's a synergy of two different
15 things in this part of the one value we have in the
16 dosimetry codes. We've got both the dosimetry or the
17 weighting factors, the various assumptions that ICRP
18 makes on those things and we got the metabolic models
19 which is like the lung model, the gastrointestinal
20 model.
21 I'm a systems performance analyst for the
22 Division of Waste Management so I'm going to try to go
23 through focusing more on what are the requirements for
24 dosimetry models and somewhat what we assume in ours.
25 So I'm going to go over these topics, the regulatory

1 requirements, the Federal Guidance, the new dosimetry
2 systems, some sources of uncertainty, examples using
3 that uncertainty and some conclusions.
4 Part 20 and Part 63 both use effective
5 dose equivalent, stay in dose limits. That's defined
6 by the dosimetry system is defined by ICRP 26, using
7 weighting factors to translate organ doses into
8 effective whole body dose that would have the
9 equivalent cancer risk.
10 Metabolic models were derived in ICRP 30
11 and later in 48 and 56 and so forth. We create new
12 and better models all the time on calculating organ
13 doses.
14 Federal Guidance on how to use -- for
15 dosimetry systems. Part 20 is consistent with 1987
16 Presidential Orders on occupational exposure. So Part
17 63 is build upon Part 20.
18 We have the current Federal Guidance on
19 dose convergent factors in Federal Guidance Report 11
20 which tabulates the internal dosimetry ones consistent
21 with ICRP 2630 and Federal Guidance 12 which tabulates
22 dose convergent factors external dosimetry which use
23 the weighting factors from 26.
24 And also there is a more modern risk
25 factor based Federal Guidance Report which is Federal

1 Guidance Report 13, however, that's not used get for
2 the Federal Government for dose factors, but it is
3 used for risk factors in programs like CRCLA.
4 ICRP recommendations put out new
5 recommendations in 1990 to calculate effective dose
6 which is slightly different terminology. It uses
7 different weighting factors, also newer advanced lung
8 models came out for the various organs and how various
9 new metabolic data on how things travel through the
10 body. And these are tabulated -- have tabulated dose
11 conversion factors in 68 and 72.
12 While we've not updated the part 20 to
13 meet or to use these dosimetry systems, we do allow
14 exemptions for definitions of weighting factors which
15 unfortunately was put in our regulations so that
16 licensees on a request basis can use the new dosimetry
17 models.
18 Uncertainties. Effective dose equivalent
19 is a radiation protection term. It is not a
20 measurable quantity in any stretch of the imagination.
21 It's taking organ doses which potentially could be
22 measured, but probably not, but in quantifying times
23 a weighting factor which is based off of organ
24 radiosensitivity.
25 VICE CHAIRMAN RYAN: Dose directly to a

1 body can never be measured.

2 MR. McKINNEY: Dose directly to a body?

3 VICE CHAIRMAN RYAN: Cannot be measured.

4 You can infer it, but you can measure it.

5 MR. McKINNEY: Okay. The metabolic models

6 are relatively simple, yet conservative models for

7 complex case. You know, there's various degrees of

8 understanding metabolism. I mean our iodine model

9 hasn't changed in 40 or 50 years, has pretty much

10 stayed similar. The lung model has gotten more and

11 more complex as we understand more. Plutonium models,

12 americium models have gotten more and more complex

13 over the years as more and more understanding of how

14 that -- how the body utilizes or doesn't utilize these

15 elements and issues such as the ICRP 2630 pretty much

16 ignores homeostatic controls. And of course, it's

17 divided up by chemical forms.

18 Weighting factors. For uncertainty

19 examples, in one study they did for external dose at

20 the weighting factors made less than about 10 percent

21 difference for most photon emitters. Obviously, for

22 internal dosimetry this is all over this place,

23 depending on what is the primary organ that is exposed

24 by that radionuclide.

25 For chemical form, the difference can be

1 a factor of 2 to 10 or so, between different chemical
2 forms for inhalation. If you go to the most extreme
3 for soluble to completely insoluble, you can get quite
4 a different for like uranium, but for like the
5 plutonium, you're using -- like Class W which is all
6 non-oxide forms of plutonium to Class Y, there's about
7 35 percent difference at one micron. At higher
8 microns, they tend to diverge even further.
9 VICE CHAIRMAN RYAN: Chris, could I just
10 ask a quick question here. This is an interesting
11 point to get to our focus. What's the range of
12 variation in the parameter like it does conversion
13 type? If I look at W Class plutonium 239, it's non-
14 oxide compounds, I'm assuming already valent state,
15 plutonium can exist in.
16 MR. McKINNEY: Right.
17 VICE CHAIRMAN RYAN: And yet we have a two
18 decimal place accuracy in the dose conversion factor.
19 MR. McKINNEY: Well --
20 VICE CHAIRMAN RYAN: Could you speak to
21 that? Would you? I mean that's fairly important --
22 (Laughter.)
23 VICE CHAIRMAN RYAN: On the one hand,
24 recognizing there's a wide range of values in this
25 parameter, yet we show -- and it's not just you, we

1 often show a lot more significance to that than we
2 deserve.
3 MR. McKINNEY: That's the tabulated
4 values. Whether I personally would agree that we
5 could ever go that far --
6 VICE CHAIRMAN RYAN: My point is is that
7 if there's no difference between either of those with
8 the precision with which we know --
9 MR. McKINNEY: That's true, the culture is
10 two decimal places.
11 VICE CHAIRMAN RYAN: And there is a
12 distribution. I'm not talking about -- I'm talking
13 about both values. They're really the same number
14 within the range of what we truly know about --
15 MR. McKINNEY: At that point.
16 DR. ECKERMAN: But do your rounding at the
17 appropriate place. You have to carry some extra
18 digits --
19 VICE CHAIRMAN RYAN: For the calculation.
20 DR. ECKERMAN: So the third digit is just
21 a guard digit because then you run into these things
22 where you can't convert units back and forth.
23 MR. McKINNEY: They're coming.
24 DR. ECKERMAN: You guys want to always
25 work in non-SI units so we have to give you an extra

1 place so that you can --

2 VICE CHAIRMAN RYAN: That's fair.

3 (Laughter.)

4 DR. ECKERMAN: The problem is at the end

5 of the calculation.

6 VICE CHAIRMAN RYAN: However, my point

7 still stands and if we look over the range of chemical

8 compounds at oxidation states, for all the things that

9 are classed in that W class and then look at oxides,

10 how do we differentiate the two numbers.

11 DR. ECKERMAN: I also would add one more

12 note of caution in your deliberations here. One of

13 the things is the effective dose and I use a newer

14 term, is a very robust quantity. If you look at lung

15 dose, you'll see a bigger difference here and you

16 think about health risk, the health risk is probably

17 dictated by the dose by lung cancer and not by

18 effective. You don't get cancer of the effective.

19 You get cancer at particular sites. And so you're

20 seeing part of this, the robustness of the effective

21 dose quantity.

22 MR. McKINNEY: Right, the uncertainties in

23 the weighting factors, unfortunately, can sometimes

24 again cover up some of the actual uncertainty in the

25 overall dose. I mean it's back to like the previous

1 presentation where we had a wide range in KDs, but we
2 don't have a wide range in the dose conversion factors
3 because there's not very much ingestion. If you don't
4 have very much of a weighting factor, then the
5 uncertainty is going to be tempered by that.
6 VICE CHAIRMAN RYAN: Well, I think the
7 other thing is these factors are not on the board are
8 actually applied to an intake and it's a risk that's
9 assigned 50 years of exposure, some intake. It's not
10 annualized or organ specific.
11 MR. McKINNEY: No, those are committed
12 over 50 years.
13 VICE CHAIRMAN RYAN: And my question about
14 robustness is is it's robust because of that 50 year
15 integration, more than anything else.
16 MR. McKINNEY: Okay, this one is just a
17 comparison between some of the newer models and ICRP
18 30. And I broke out the five of the six
19 radionuclides. Carbon 14 really doesn't become too
20 much of importance in our calculations and I broke
21 them out by where they tend to show up in our
22 assessments. So for inhalation we got americium 241
23 and plutonium 239. These are both at 1 AMAD. You
24 start getting into, depending on what AMAD you
25 classify and which chemical form becomes an issue

1 where Class W increase the micron size of the
2 particle. The dose factor doesn't drop off as very
3 fast while the Class Y, it drops off right away.
4 For the two factors, you have basically
5 the same plutonium 239 while for americium going to
6 the new dose conversion factors will give you a factor
7 of -- well, a factor of about three or so, maybe.
8 And meanwhile, over here for ingestion you
9 have similar dose factors or factor of 2 or 3 for
10 these where you have a factor of 10 for neptunium 237.
11 Just to show -- if you use the ICRP 72 being more
12 modern models and more data and everything else as
13 being potentially more realistic versus the
14 assumptions we are using in the code, to characterize
15 possibly as a surrogate to characterize level of
16 conservatism and level of uncertainty versus what real
17 dose are being used for these dose conversion factors,
18 I mean that's what this is to be used as.
19 DR. THORNE: Can I cut in, Chris? That's
20 the key. I think that neptunium one is all do to a
21 change in the gastrointestinal absorption.
22 DR. ECKERMAN: A good part of that is.
23 DR. THORNE: It's almost exactly an order
24 of magnitude.
25 DR. KOCHER: My reaction to this is these

1 comparisons have very little, if anything, to do with
2 uncertainty. That's just my reaction. You're
3 comparing point estimates while using different
4 models.
5 MR. McKINNEY: Modeling needs more than --
6 DR. KOCHER: You're comparing the effect
7 of changing a model and your second little tick up
8 there is important for plutonium because if you -- you
9 know, I haven't memorized these tables, but if you
10 keep the same chemical form and compare the ICRP
11 models, you're going to get a different one than for
12 the one for americium because they are almost the
13 same. So it's
14 -- be careful here.
15 DR. TILL: Dave's point is very important
16 and it gets back to this issue in my mind of what is
17 uncertain and what is not uncertain. And for me, for
18 a given radionuclide, for a given class of chemical
19 compound, for a member of the public exposed in the
20 future hypothetically, the uncertainty in the dose
21 conversion factor is zero. It is a number you pick
22 out of the book.
23 And if it isn't zero, then the question is
24 have you evaluated this thoroughly for all of the
25 radionuclides? Because I don't think you have and I

1 don't think we can. I think it would be very tough.
2 So is that right?
3 MR. McKINNEY: Yes, I mean that basic
4 assumption and that basic explanation is the basically
5 the working way we deal with why we don't propagate
6 uncertainty in the dose conversion factors.
7 DR. TILL: Okay.
8 MR. McKINNEY: Is that it's considered
9 just a part of the stylized calculation.
10 VICE CHAIRMAN RYAN: It is true that there
11 are a set of reference calculations of dose conversion
12 factors that are accepted as facts, but they are not.
13 There's uncertainty in them.
14 DR. TILL: Okay and listen -- for the
15 purposes of compliance, for a future calculation and
16 this may be a policy decision, all right? I say that
17 the uncertainty should be zero. That you ought to
18 pick a value from a book and go with it.
19 VICE CHAIRMAN RYAN: And I'm not arguing
20 about one point or the other. I think the key thing,
21 John, is that you've been given a construct. Yes,
22 it's a stylized calculation. Yes, it's a compliance
23 demonstration. But I think the focus is, to me, well,
24 you have to somehow be sure of where you stand on the
25 -- is a reality question. Is it very conservative?

1 Is it so conservative it's long? Is it not
2 conservative? Or where do you stand on that scale?
3 You somehow have to, I think, appreciate where you are
4 on that scale, even if it's in a qualitative way. I'm
5 not saying I don't accept your construct for the
6 purpose you've stated it, but I think you still need
7 to understand where that construct sits and why. From
8 a technical standpoint, I understand that fully.
9 CHAIRMAN GARRICK: From a technical
10 standpoint, I don't accept the construct. That's the
11 problem I have with compliance is that if it comes out
12 of a look up table that's offered by the regulator,
13 then from the point of view of complying, the risk is
14 zero, as you say or the uncertainty is.
15 DR. TILL: Uncertainty is zero.
16 CHAIRMAN GARRICK: But from a science
17 standpoint, it's a bad practice.
18 DR. TILL: I don't disagree with that, but
19 you know in this realm of what you're doing is trying
20 to demonstrate compliance for a facility and I think
21 this is a huge question and if you're going to deal
22 with uncertainty in dose coefficients you've got a lot
23 of work to do.
24 CHAIRMAN GARRICK: Oh yes.
25 DR. TILL: We all recognize it's there,

1 but that's why this kind of goes back to my suggestion
2 that you consider a hypothetical person, some person
3 that you create in the future to be the person you
4 demonstrate compliance, use to demonstrate compliance
5 that the characteristics of that individual are also
6 fixed.
7 And I know a lot of people don't agree
8 with me on this, but I have reasons for suggesting it
9 as a way to think. That means the breathing rate is
10 fixed. The ingestion rate is fixed. It's because you
11 assume that person exists. You assume that person
12 lives in a certain place at a certain time. That's --
13 there's no uncertainty in that. And therefore, you
14 assume that his heart weighs so much, his lung weighs
15 so much. That's all very exact and assumed to be well
16 known.
17 That's a little bit different way of
18 thinking, I know, that I'm suggesting here. And I
19 know everybody doesn't agree with it.
20 VICE CHAIRMAN RYAN: Sir?
21 DR. KOCHER: This is maybe a question more
22 for Keith than anybody else, but I found myself
23 reacting a big negatively to the assertion that the
24 metabolic models are conservative. My understanding
25 is that they weren't set out to be that way and I

1 guess I would like Keith to maybe weigh in on this
2 question.
3 DR. ECKERMAN: I was going to hit that one
4 a little later, but yes. That's a touch point with me
5 because ever since we started with particularly after
6 the Chernobyl period, that's kind of a marker when
7 things changed from being focused just on occupation
8 on the worker to dealing with the general public and
9 the intent has now been to be realistic because once
10 you produce that number with our many figures,
11 significant figures you show it with, it's going to be
12 used by people in different senses and so you can't --
13 you can't automatically decide whether the
14 conservatism is in the direction you think it is or
15 not or actually being nonconservative.
16 And so the whole focus in the ICRP system
17 which most of this is inherited has been now to be as
18 realistic as you can.
19 Now at the same time we're trying to be
20 constrained by having models that could be implemented
21 by people and so forth and do the job at the end of
22 the day and come up with a point value just as John --
23 the number of reasons that John was talking about.
24 But it isn't true that -- we do not construct models
25 to be conservative.

1 MR. McKINNEY: I wouldn't say that
2 especially with current models. I mean when you look
3 at how the weighting factors are created --
4 DR. ECKERMAN: That's another story.
5 MR. McKINNEY: That's part of the whole
6 thing.
7 DR. ECKERMAN: Right.
8 MR. McKINNEY: Altogether where you are
9 taking, based on which sex you're picking for each
10 organ --
11 DR. ECKERMAN: Unfortunately, I have a
12 comment on that one.
13 DR. THORNE: But even if we go back to
14 ICRP 30 they weren't conservative. We took a --
15 DR. ECKERMAN: Don't know.
16 DR. THORNE: A partitioning for plutonium,
17 for example, between liver and bowel, stick 45 percent
18 in each, but if you didn't know very much better, but
19 it wasn't conservative.
20 DR. ECKERMAN: It wasn't conservative,
21 that's right.
22 DR. MOELLER: Let me offer not to wear you
23 out, but offer a couple of comments.
24 CHAIRMAN GARRICK: He's not doing
25 anything. He's just standing there.

1 (Laughter.)

2 MR. McKINNEY: You're the ones who are

3 doing all the conversation. It's great.

4 DR. MOELLER: You say ICRP 30 is based

5 upon the risk of cancer, well so is ICRP 72, but

6 there's a major difference. The ICRP 30 is based on

7 the risk of fatal cancer. ICRP 72 is based upon the

8 risk of cancer morbidity as well as mortality as well

9 as years of life lost. That's a major difference.

10 One other comment, we're talking about

11 tissue weighting factors. Well, what do they do and

12 I don't disagree with what they've done, but they

13 took, they calculate the tissue weighting factors and

14 they create four hoppers, four or five, I forget, you

15 know. And you throw each one, it has to go in this

16 hopper. Some of them you throw in a higher weighting

17 factor hopper, some in a lower weighting factor

18 hopper. And you fix it up so the total is 1.0. So

19 that has to be taken into consideration.

20 And lastly, I wanted to say I'm with John

21 Till. I believe looking at it from a regulatory point

22 of view the fact they drink two liters water a day is

23 non-negotiable. I mean we're not -- we shouldn't even

24 be discussing it. That's in the regulations. The

25 fact there are RMEIs in adult, that's there. These

1 other factors that John pointed out, I agree with him.
2 Don't waste our time talking about them.
3 I mean I'm not talking to you.
4 (Laughter.)
5 DR. KOCHER: I'm glad you mentioned the
6 issue of whether a license applicant can use a newer
7 dosimetry system because my understanding was that
8 licensees could apply to do that.
9 MR. McKINNEY: Yes, they can.
10 DR. KOCHER: And that you intend as far as
11 you know now that the Commission will allow this in
12 this license application?
13 MR. McKINNEY: Their general policy has
14 been to accept exemptions from the weighting f actors.
15 DR. KOCHER: DOE, go for it. Don't fool
16 around. Just go for it. Do it.
17 MR. McKINNEY: It's up to them.
18 DR. KOCHER: That is the basic conclusion
19 on the end.
20 MR. McKINNEY: We use effective dose. We
21 have FGR 11 and 12 out there and that is the basic
22 guidance to show compliance with part 20 now.
23 However, just like any other licensee, a licensee can
24 come in and request to use the new stuff.
25 And that's always an option for them.

1 DR. MOELLER: Well, whose decision was it
2 to choose FGR 11? DOE's? Yours?
3 MR. McKINNEY: No, FGR -- it's all because
4 of just NRC has never upgraded. In 1992, 1991, 1994,
5 effective, but 1991, part 20 was changed to use FGR 11
6 and 12, basically in the dose conversion factors.
7 We have over the years considered whether
8 to go through the rule making factors to actually make
9 a change to all regulations upgrade. Now there's a
10 big cost benefit analysis has to be done about the
11 cost to all of our current licensees about how much it
12 would be to change over to the new system and that has
13 not yet been ever shown to be very effective. That's
14 why we allow on a licensee by licensee basis for them
15 to make the decision that it's beneficial for them.
16 There may be a policy called at some other
17 point that we're just going to say it's going to have
18 to be done, but we haven't done that yet.
19 DR. KOCHER: This is fairly important,
20 actually, for Yucca Mountain in the following sense.
21 This change in dosimetry system for several important
22 radionuclides will greatly change the importance of
23 the drinking water pathway in the all pathways dose
24 limit. Plutonium, especially.
25 MR. McKINNEY: Yes.

1 DR. KOCHER: And Plutonium 2. I mean it
2 makes a difference, but that also, it will make no
3 difference if the doses are as low as the projected
4 values we saw today.
5 MR. McKINNEY: Right.
6 DR. KOCHER: But it could in our
7 hypothetical world.
8 VICE CHAIRMAN RYAN: David, I think that
9 exemplifies the key point that in an absolute sense is
10 a difference, but in a context of a dose that's so low
11 that it's way below any kind of threshold of concern,
12 whether it's a compliance level or some other measure,
13 then I think you get into the judgment of is it worth
14 it or not.
15 DR. KOCHER: Except --
16 VICE CHAIRMAN RYAN: Do you agree to that?
17 DR. KOCHER: Ninety-nine percent I agree
18 with you, but what we've been told here is that the
19 biosphere modeling is basically decoupled from
20 everything else which I think is not a good idea, but
21 given that they've made that decision, they don't know
22 what the concentrations in water are and they
23 shouldn't if they have a decoupled system.
24 VICE CHAIRMAN RYAN: Well, that's right.
25 They're working in that per unit concentration basis

1 and that's something to think about.

2 But it also gets me back to the -- if you

3 accept some parameters as single point values, and you

4 could do that in the context of the compliance case

5 and I don't disagree with either Dave or John on that

6 point, but you lose the ability to inform yourself of

7 where you are if you can't talk about that as where is

8 it on the margin of certainty or uncertainty.

9 DR. THORNE: I'm not sure that I agree

10 with that. The fact that you do a particular

11 calculation for compliance purposes does not preclude

12 you doing other calculations to inform that value

13 through sensitivity --

14 VICE CHAIRMAN RYAN: If you allow me to do

15 that, i agree. I agree. If you guys accept that as

16 a friendly amendment, I'm okay.

17 MEMBER HORNBERGER: It strikes me if I'm

18 not mistaken too, Mike, even if the doses are very low

19 in the compliance period. They do have to do a

20 calculation beyond the compliance period. And if

21 there is a change, that is at least to me,

22 psychologically helpful.

23 VICE CHAIRMAN RYAN: Yes. Other questions

24 from Panel Members for Chris or HNW members?

25 DR. TILL: Along the same lines, I think

1 it's important what we're discussing and it is an idea
2 of do you use the best science or not? And if you're
3 going to use the best science, you it across the board
4 and that's why -- and it goes back to credibility
5 thing with DOE, which I think they ought to be using
6 the best science. Yes. I think they ought to be
7 using it consistently. Yes.
8 VICE CHAIRMAN RYAN: But that wasn't a
9 question for you, Chris. That's okay.
10 Let's see, any other questions?
11 MR. McKINNEY: Or comments?
12 VICE CHAIRMAN RYAN: Any other comments?
13 Thank you, sir, very much.
14 Again returning, Maryla Wasiolek. Welcome
15 back after a short breather.
16 DR. WASIOLEK: Well, actually I do not
17 have a whole lot to say about the biokinetic and
18 dosimetry models because we picked the number out of
19 the book.
20 (Laughter.)
21 This is exactly what we do.
22 VICE CHAIRMAN RYAN: You've got two --
23 DR. WASIOLEK: It is a stylized
24 hypothetical individual. It has all of the parameters
25 as far as those that are derived from biokinetic and

1 dosimetry models. They are out of the book. We do
2 not include any variabilities. We use -- we calculate
3 annual doses in terms of total effective dose
4 equivalent which is for our purposes, it is dose
5 effective equivalent and cumulative effective dose
6 equivalent which is different from the definition of
7 total effective dose equivalent from 10 CFR 20. That
8 is the document that allows us to use effective dose
9 equivalent in place of peak dose equivalent.
10 And we use dose coefficient for internal
11 exposure from Federal Guidance 411 and for external
12 from Federal Guidance 312.
13 There was a lot of discussion already how
14 these values came into being. We looked a little bit
15 -- we do use the most conservative values for values
16 of dose calculations which seems to be the common
17 practice.
18 As far as the choice of inhalation, dose
19 coefficients, it was brought up here that there is an
20 easy method for recalculation of dose coefficients for
21 inhalation for particulates with sizes different than
22 one micrometer ADAM. We looked at the distribution of
23 particle sizes in various environments and just one
24 short comment that I would like to offer is if you
25 recall the slides from my previous presentation, the

1 majority of the inhalation dose was coming from the
2 active outdoor environment which is the environment
3 that we say -- it is basically related to just
4 generating activities, mechanical disturbance of the
5 soil.
6 What happens in this environment is that
7 in terms of particle size distribution for this
8 environment, we have this transient component where
9 particle sizes are much higher than one micrometer
10 AMAD. It's a transient component if you look at the
11 long-term effect. However, this is exactly where our
12 receptor gets its dose. It's in this environment
13 where there was a lot of dust that was respirated just
14 temporarily.
15 So what we did was we looked at the dose
16 coefficients for different size particles --
17 CHAIRMAN GARRICK: Something bad is
18 happening to our recorder.
19 (Off the record.)
20 DR. WASIOLEK: So we are looking at dose
21 coefficients for large particles because the
22 distribution is basically by model. We have one mode
23 that is around like 2, 3, 5 micrometers AMAD, which is
24 there in the other environment and on top of this mode
25 we are adding this transient several tenths of

1 micrometer AMAD.

2 Since this is where our dose is coming

3 from, we compare the dose coefficients and of course

4 we had to use the ICRP 30 model and for most of the

5 transuranic, it doesn't matter by much, at least when

6 this model is used.

7 So like plutonium, there is a small

8 reduction compared to a micrometer, but not really a

9 lot. Uranium goes down dramatically, but uranium was

10 not a major player. But for most transuranics, if you

11 just looked at just your calculations without

12 reference to anything else, just plugging the numbers

13 and look at the relative values of dose coefficients,

14 we're doing pretty well just by using one micrometer,

15 especially considering what was already discussed here

16 overall uncertainties in the dose coefficients. But

17 we're not -- we are not addressing these. We just use

18 the values the way they are.

19 VICE CHAIRMAN RYAN: Keith, you may have

20 better insight having been involved in much of the

21 history, but I imagine that 1 AMAD was picked for a

22 reason, that probably being the one. It covered a

23 wide range of circumstances. Is that right?

24 DR. ECKERMAN: Well, that's true. The

25 early classification was based on the deep lung and

1 one micron you were getting most of the material into
2 the deep lungs. But I'd like to think more about what
3 you've just said because one of the things -- the old
4 lung model that you're using was based on deposition
5 studies on volunteers and they were all mouth
6 breathers. Because they put a mouthpiece in and they
7 breathe the aerosol in and out and so while the
8 population has modeled it more with the newer lung
9 model has a combination of mouth breathing and nose
10 breathing. And the deposition patterns will get
11 changed drastically.
12 Because you're really putting another
13 filter, if you will, up front. So of course the whole
14 structure of the lung with regard to dosimetry
15 changes. Right.
16 DR. WASIOLEK: It's for soluble
17 radionuclides, there isn't much --
18 DR. ECKERMAN: Oh, for soluble there won't
19 be. Right. For soluble there won't be much
20 difference.
21 This was an ICRP on the lung model, recent
22 commentary and even if you use the -- there is a huge
23 difference when you're in the submicron particle
24 ranges between particle sizes, but once you move
25 towards the particles that are basically, micrometer

1 and larger, AMAD.

2 DR. ECKERMAN: But you have to be a bit

3 careful on how you interpret these graphs because

4 what's on the X axis is the median of the

5 distribution.

6 DR. WASIOLEK: Oh yes.

7 DR. ECKERMAN: Not particle sizes

8 themselves.

9 DR. WASIOLEK: Absolutely.

10 DR. ECKERMAN: So you have to be careful

11 how you fold these things together.

12 DR. WASIOLEK: It's just a concept. We're

13 not using -- why didn't anybody tell me we could use

14 newer models.

15 DR. ECKERMAN: You didn't ask.

16 (Laughter.)

17 DR. ECKERMAN: It's in my slide because

18 I've been getting calls from people for a long time,

19 particularly the folks that knew of thorium. They've

20 asked us this question and it's been in the NRC and

21 DOE both have been giving people exemptions if they

22 ask and a lot of us asked.

23 DR. WASIOLEK: For us it was a very simple

24 concept. We have our standard that is expressed in

25 terms of total efficient dose equivalent and then

1 there's virtually one source of the dose coefficients
2 such that you are getting this quality. So this is
3 what we use.
4 DR. MOELLER: Did you say earlier on the
5 first slide something about you always adopted a
6 conservative approach or something?
7 DR. WASIOLEK: Well, if there was a choice
8 of dose coefficients, then it is a quite common
9 practice to -- when you cannot justify specific
10 chemical form to just pick the highest.
11 DR. MOELLER: A second question, the Panel
12 a few minutes ago said, you know, go for FGR 13. How
13 much would that set you back or is that a tremendous
14 -- assuming you, you know, DOE agrees, whoever makes
15 the decision to use FGR 13 dose coefficients?
16 DR. WASIOLEK: This is not my decision.
17 I'm just the lowly contractor.
18 DR. MOELLER: But how much work would that
19 entail? Is it an enormous effort or what? Can you
20 say?
21 DR. WASIOLEK: I really cannot comment on
22 that.
23 DR. MOELLER: You just copy down a new set
24 of numbers.
25 DR. WASIOLEK: Well, it's not just that.

1 It's very easy in academia. In our structure we have
2 a very -- the way we documents things, the way the
3 changes are propagated through the model. I mean it
4 would have to come from a DOE person.
5 DR. THORNE: It's one set of numbers, so
6 I would have seen it compared with other changes that
7 were made in the model. They're all cut loose with
8 the QA system. It has to be one of the smaller
9 changes rather than one of the bigger changes.
10 VICE CHAIRMAN RYAN: Questions? Comments?
11 DR. WASIOLEK: Well, the last slide was --
12 the second slide was the models that we used for the
13 groundwater standard and we pretty much used the same
14 model for consistency.
15 VICE CHAIRMAN RYAN: Anyone else? Dr.
16 Eckerman?
17 Now you're going to sort out all 17 systems of dose
18 calculations and constants, right?
19 Thank you, Maryla, we appreciate it.
20 DR. WASIOLEK: Thank you.
21 DR. ECKERMAN: Maybe I should start with
22 my last slide.
23 (Laughter.)
24 I wasn't exactly sure I was to present
25 here so I just threw a number of slides together under

1 this context of the Federal Guidance and if you could
2 change the next slide there.
3 Just remind you back what the Federal
4 Guidance says. Most of you know this better than I
5 do, but a set of guidelines developed by EPA for use
6 by the federal agencies in the protection of the
7 public from the harmful effects of radiation.
8 The next one -- there's actually two types
9 of guidance documents that come out. There's what's
10 called guidance documents which really define the
11 principles and policies of the radiation protection
12 that are to be applied in the U.S.
13 This is the kind of a document that gets
14 signed by the President. The President doesn't review
15 our technical reports, fortunately.
16 (Laughter.)
17 And so the technical reports provide
18 current scientific and technical information regarding
19 radiation dose and health effects. So all of these
20 federal documents, numbers that we've been kicking
21 around here are the technical reports.
22 So next slide -- well, this goes back to
23 the authority in the system, what used to be under the
24 Federal Radiation Council which was established in
25 1959, so maybe Handbook 69 has an origin back here.

1 In 1970, this was transferred to EPA under that
2 reorganization act.
3 Next slide. So the guidance documents are
4 signed by the President and issued by EPA and of
5 course that's the guidance that led in to 10 CFR 20
6 and the last one was signed by President Reagan.
7 Next slide. So then periodically or on
8 some schedule EPA issued some technical reports that
9 provide the details with respect to the protection
10 system and the next slide then lists these. So since
11 1984, we've been involved at Oak Ridge in generating
12 these documents. 10 was a short-lived, little special
13 purpose thing that got superseded by 11 which was the
14 one that you folks are currently using with which was
15 issued in 1988 and really is just the information that
16 was sitting in electronic files after Pergaman
17 published for ICRP 10 and we published further details
18 and including the dose coefficients because you won't
19 find it, a very detailed set in the ICRP publications.
20 12, which deals with -- gives you dose
21 coefficients for external exposure pathways,
22 radionuclides in the environmental media. That report
23 addressed the topic that actually ICRP really never
24 had touched at the time and hasn't touched yet. And
25 so that gave current state of the art calculations for

1 the external exposures.

2 Thirteen is the most recent and of course

3 that's the one we recognize as we're discussing here

4 as having the current -- representing the current

5 state of the art and the unusual thing of 13 which now

6 I have to go through the details here because Dave set

7 me up on all of this, is that 13 actually doesn't

8 present committed dose coefficients. It's a document

9 that goes straight to risk. And as a document it

10 gives you the risk associated with an intake of a

11 radionuclide. And it didn't -- we didn't put any

12 dosimetric information in because we weren't using the

13 committed dose coefficients and there was some concern

14 among the different federal agencies that if we put

15 dose coefficients in that document, it would confuse

16 a lot of people. Well, it confused a lot of people

17 anyway.

18 (Laughter.)

19 People think we're -- that these risks

20 were derived from the ICRP dose coefficients and they,

21 of course, were not.

22 Next slide I think amplifies this a little

23 bit. What we did was look at the risk, just focused

24 on the cancer risk. Now in the W sub Ts that we've

25 been talking about from ICRP, there is a genetic risk

1 as well, that has, of course, has changed over the
2 years in different context as ICRP has defined it.
3 But this document focuses strictly on cancer as a
4 risk. We consider the age structure of the U.S.
5 population. We used U.S. life tables, that is U.S.
6 natural mortality rates and background cancer rates in
7 the population. We had intake scenarios for the
8 radionuclides. We used the age-dependent dosimetry
9 models that were coming out and we didn't do the dose
10 coefficients.
11 So what -- there's two ways -- because of
12 the linear nature of the system, there's two ways you
13 can look at this. One way is that you can think of
14 this starting with a population of live born cohort
15 population and let them live their life out and have
16 use, breathe air, eat food in proportion to their age
17 criteria, their age demands, and live their life out
18 in an environment that has a uniform concentration of
19 the radionuclide.
20 Or the other way to look at it is to say
21 you've got a standing population and they have an
22 intake of the radionuclide. So there's age aspects
23 both in the importance of the dosimetry that's
24 considered there which can be as much as a factor of
25 10, in the dosimetry itself, but of course, it's

1 negated a little bit by the intake because an adult
2 consumes more food than a newborn and so forth. So
3 all of these are rolled together in these
4 calculations.
5 And it comes out with then strictly rick
6 per unit activity ingested or inhaled. Or exposure to
7 the environmental sources of the radionuclide. As a
8 backup to this, the agencies wanted us to put the dose
9 coefficients out on a CD so there is a CD that's
10 available. That's where you can find the age specific
11 dose coefficients. There's a whole lot of numerical
12 information that's actually archived on that CD that
13 a lot of people don't notice, but for example, the
14 dose rates as a function of age in each of the organs
15 is actually archived on those files and people can
16 take these apart and find all sorts of little
17 additional details.
18 This is -- so the end of the day here is
19 that there are -- under that disguise of the Federal
20 Guidance 13, there is age-dependent information on
21 exposures for members of the public. This was not
22 workers. This was entirely members of the public.
23 Next slide. I think we all know this, the
24 differences here between internal and external,
25 particularly the one that we have to keep in mind is

1 the protracted nature of the internal exposure.

2 Next slide. This is just a little detail

3 on Federal Guidance 12's calculations. We did a

4 detailed calculation of the radiation field above the

5 contaminated ground surface and so forth and then you

6 transport those radiations into the body and look at

7 the doses to the various organs and this is probably

8 one of the first times there's a real heavy duty

9 detail of calculation of the field was carried out.

10 Next slide, well, this is a suite of

11 anatomical bottles stylized as you can for different

12 age individuals.

13 Next slide. I don't know why some of

14 these were thrown in here because I just wasn't

15 exactly sure. I think we can skip this one. This is

16 just the details of our computational system.

17 I have got a few slides that deal with the

18 models they're involved in. I think they may be

19 worthwhile to run over these a bit.

20 This is -- when you're doing these kind of

21 calculations, of course the -- we typically deal with

22 just an intake by inhalation and ingestion, although

23 there are cases not in the environment, but workers'

24 situations where we worry about a wound kind of a

25 case, but anyway, in the inhalation there's, of

1 course, going to be a whole model details of the lung
2 and the respiratory system, the radionuclide, some of
3 it's going to be mechanically cleared and be ingested,
4 so even for an inhalation exposure you need a
5 gastrointestinal model.
6 There's a transfer to blood from the lung
7 as well as coming in from absorption there and it then
8 eventually excretes, one of the new things later on in
9 the later models is to deal with the doses along the
10 pathway of excretion which wasn't addressed in
11 publication 30, for example.
12 And of course, underneath all of this is
13 there is, of course, models that deal with the
14 conversion from the number of decays that are
15 occurring to what the energy deposition is in the
16 tissues.
17 Next slide. I think I switched over here
18 and spoke a bit more on the systemic behavior of the
19 material once it's reached blood and what we generally
20 have now are two types of models here. We have really
21 a retention kind of model which is actually sort of an
22 empirical fit to observations. And then we have
23 another set of models that are physiologically based
24 and the motivation was to deal with age as an issue
25 because we have lots, probably a lot more information

1 on the physiology of changes with change and
2 anatomical changes with age, than what we have on
3 nuclide specific information across the ages.
4 The data sources that you have to deal
5 with, of course, the information comes specific from
6 human studies, animal studies and then there's the
7 physiological processes probably going on their analog
8 information that you use.
9 One of the characterizations that we do on
10 certainty is to think about the characterizing the
11 quality of the information that you have to bring to
12 bear on the modeling process and rather than just the
13 usual parameter kind of uncertainty is actually to
14 characterize the quality of the information that you
15 had to work with because that really captures how well
16 you're able to do the modeling.
17 Next slide. Well, early on the
18 physiological model we had deal with - it's actually
19 shown here - was the iodine because that model really
20 included the fact that the material came in the body
21 - uptake in thyroid, some of it excreted -- but there
22 was a recycling of the iodine as the body reused the
23 iodine because of its importance for normal body
24 function.
25 A lot of the work that's been done dealing

1 with the age processes has focused on the bone
2 seekers, because that's the site of tenacious
3 retention of many of the radionuclides, so what was
4 taken in as a child may be with you for the rest of
5 your life or still be present. And, of course, we had
6 a great deal of information from the physiologist with
7 regard to the growth and development of the skeleton,
8 so that's why you see a lot of the newer models
9 hitting actually the actinides that are important to
10 considerations here.
11 Next slide. Well, let's skip on. I've
12 already talked about this.
13 What happens when you go into this process
14 is things become a little bit more complicated, and
15 this was a big step for a lot of people in this
16 business as we went from ICRP Publication 30 which
17 really dealt with pretty simple - characterized the
18 behavior in terms of a fraction going to an organ and
19 staying there for some half-time for the bulk of the
20 model. So here's the actinide model. The yellow
21 skeleton region is actually put together largely from
22 the physiological processes. When bone is formed and
23 the radionuclide - the actinides are deposited, that
24 action occurs along the surfaces of the bone. And in
25 Publication 30, we knew that that was happening and we

1 had a class that said these nuclides are surface-
2 seekers.
3 Well, what we did in 30 was they were laid
4 down on that surface and they never left that surface,
5 only by radioactive decay. There was no remodeling in
6 growth and development of the skeleton. And so what
7 happens, of course, is that as new bone is formed,
8 this deposit starts to move into -- begin to look like
9 it's volume-distributed. It gets away from some of
10 the sensitive target tissues that we're concerned
11 with. However, the body, in order to maintain
12 exquisite control on calcium content in blood, which
13 it has to maintain a tight tolerance on that, it calls
14 upon the skeleton for calcium. And so some of this
15 can return back into the blood. The other tissues of
16 importance here are competing for a plutonium ion
17 that's in blood or the liver processes and of course,
18 the kidney and the excretion.
19 The significance of much of the reduction
20 in dose that you see for the actinides for ingestion
21 is associated with this burial process. Of course,
22 over the time there have been some adjustments on what
23 the F1 value is that this fraction is coming -- that's
24 absorbed from blood.
25 I think the next slide is a alkaline

1 earth, which of course is calcium-strontium-radium.
2 So it hits some of the target, some of the high-end
3 radionuclides that we're concerned with. But, again,
4 the action in the skeleton is on the surface, but
5 things get buried, moved into the volume rather
6 quickly and although we've got arrows coming back to
7 the surfaces there, the dominant thing is to go into
8 this nonexchangeable area and you really have isolated
9 those -- that activity from some of the target tissues
10 that are of concern.
11 So the point in showing these to you is
12 that one, they become a lot more complicated to deal
13 with. Thinking about doing parameter uncertainty on
14 this kind of model and propagating uncertainty through
15 a -- into a dose coefficient is a major task.
16 Next slide, I think -- what we have of
17 course realized now and everybody has to keep in mind
18 is that what we're really dealing with here is today's
19 modern computing environment. When we put these
20 models together they're all displayed as first order
21 differential equations and we're solving on the order
22 of 160 differential equations at a time. But you can
23 do that on our desktops, so it's -- so the idea, the
24 stimulus for sort of isolating the dosimetry off in a
25 handbook kind of environment had always been it's too

1 complicated and let's do these calculations on the
2 side and everybody just go into the book and look them
3 up. There's no need for that any longer.
4 We've demonstrated in Federal Guidance 13
5 that you can couple the dosimetry and the risk
6 considerations and bring in the living habits of the
7 population and do that all -- you can couple it
8 together. You don't need to have -- restrict yourself
9 just to having dose coefficients to work with, if
10 you're looking at things outside the regulatory
11 environment. I'm talking here, taking you outside of
12 the regulatory environment.
13 Next slide. This is the one that -- this
14 is the flow chart that usually when I'm giving
15 classroom lectures I use to end things up because this
16 is the important box here is that you have to ask,
17 when you're doing regulatory focus. If you ask NRC or
18 DOE, they will grant you an exemption to use the new
19 dosimetry material.
20 And so this is -- first question is is it
21 a regulatory compliance question or not? If you're
22 not doing -- if the answer is yes, but if you've asked
23 for the exemption, you can use the later dose
24 coefficient. If you haven't asked for the exemption,
25 you're tied to 11 and 12 and at the end of the day, of

1 course, if you're really doing -- my point is if
2 you're -- and I think for transparent with the public,
3 there is an aspect that you need to address I think
4 that borders on consequence analysis or risk analysis
5 or whatever you want to cal lit, where you should
6 really be doing probably the best kind of calculation
7 that you can. No matter whether you've got to dismiss
8 it, that's that second kind of analysis that you need.
9 And eventually, you may want to call the
10 dosimeters and find out what the current state of the
11 art is at the time and clearly, folks doing
12 epidemiological studies can't use any of this stuff.
13 Now the only other caution that I wanted
14 to mention, I think you should be concerned about also
15 using the effective dose quantity. It's the sole
16 measure, not again -- I'm talking about outside of the
17 regulatory kind of analysis because you know, when we
18 changed the -- when we went to the weighting factors
19 of ICRP 60 from 26, the medical folks were up in arms
20 because that changed for iodine, that changed the
21 effective dose.
22 We only changed -- one of the hoppers the
23 thyroid weight went to was .05 and it had been .03, so
24 it wasn't a big change, but the difficult -- there was
25 no information that would suggest that we had any

1 newer information on the risk of thyroid cancer. That
2 changed because the other organs changed.
3 And I think you are going to see in the
4 next set of recommendations, I don't know the numbers
5 yet, but you're going to see probably another big
6 swing in some of the weighting factors because we
7 probably -- we've been overestimating the genetic
8 contributions, so that's going to change.
9 So you're going to -- you can have people
10 nailing you about the fact that you've under-estimated
11 this dose or over-estimated it strictly by looking at
12 what the changes in the tissue weighting factors are.
13 So somewhere you should have at least a backlog of
14 what the organ doses are because that's really the
15 fundamental quantity here. The other is a real
16 transient to deal with.
17 So effective dose is nice and robust, but
18 it's a little bit tricky. I think that's the last,
19 yes.
20 VICE CHAIRMAN RYAN: Keith, I'm reminded
21 on this slide, in particular, that this is a much
22 different case and maybe folks in the room who haven't
23 experienced that, they dealt with exposure in the
24 workplace where you have enough in a bioassay sample
25 to actually measure something. I think we're in a

1 real in these situations where individual exposures
2 would likely be so small as to be immeasurable in any
3 useful way.
4 DR. ECKERMAN: Right.
5 VICE CHAIRMAN RYAN: So this is strictly
6 a calculational construct.
7 DR. ECKERMAN: Correct, this is strictly
8 calculational.
9 VICE CHAIRMAN RYAN: So, you know, I'm
10 cautioned that any time there is a workplace exposure
11 where there's any measurable significance, we end up
12 doing an individual specific model, typically.
13 Could you talk about how that works out
14 for individual cases versus these reference models?
15 DR. ECKERMAN: I don't know what you want.
16 VICE CHAIRMAN RYAN: It might not be a
17 fair comparison.
18 DR. ECKERMAN: I'm having some
19 difficulties with some aspects of this because the
20 effective -- well, I guess this actually goes back to
21 the early question about are we dealing with a
22 population here or are we dealing with an individual?
23 The effective dose is a gender/age
24 population weighted quantity. So it isn't applicable
25 to an individual. Those weighted factors don't belong

1 to any one of us. They belong to us collectively and
2 so that's actually the rub of the thing. I think even
3 in the occupational setting, the -- in the past when
4 we used to -- we would talk about the dose with a
5 worker, you'd say we have calculated your dose based
6 -- we have calculated the dose based on the bioassay
7 samples that you gave us.
8 Had the referenced individual experienced
9 this intake, this is the dose he would have received.
10 And so it's -- I was kind of curious in getting the
11 sense here of what this individual really is or he's
12 a -- whether he's a real individual or is he part of
13 the population and I guess he's part of the
14 population.
15 That's probably an answer to a different
16 question, but that's --
17 VICE CHAIRMAN RYAN: That's okay. I'll
18 get back to my question. I guess what I'm trying to
19 focus on is when you look at whatever version of the
20 stylized calculations you want to hone in on, whether
21 it's FRG 11 and 12 or ICRP 2 or ICRP 72, they're all
22 stylized under some construct and I'm always mindful
23 of when you get a real exposure in the workplace which
24 is where most -- nuclear medicine, they're individual
25 models.

1 For example, in the clinical trials for
2 monoclonal antibody tagged iodine, they give a scaling
3 dose. They give some small amount of the
4 pharmaceutical to each patient to calibrate their
5 uptake bracket. That's disease-process specific, but
6 it's something for the patient because there's no
7 certainty in the reference model and there's some wide
8 swing and how any individual would measure up against
9 the reference model.
10 And I guess what I'm trying to probe is
11 your experience or your insights on that range of
12 certainty or uncertainty. It gets back to my decimal
13 point question.
14 DR. ECKERMAN: Even in the case of medical
15 exposures, we have difficulties. You can do it, just
16 as you say, give a trial dose and so forth, but you're
17 not sure of all the other health conditions and status
18 of the immune system of the individual, we see cases
19 where people are calculating the dose to the red
20 marrow which is the sensitive target in the body, but
21 the individual has already been subjected to a history
22 of chemotherapy and his red marrow is highly
23 compromised at that time.
24 So there we may be able to do the physics
25 of the calculation exquisitely, and put him in a PET*

1 (4:31:57) unit and get all sorts of time
2 distributions, but we're at a bit of a loss, even
3 there to explain what the significance, the biological
4 nature of the responses.
5 But there is a complete difference here,
6 as you pointed out between the kind of thing that we
7 deal with in the workplace setting versus what we have
8 to do with the members of the general public because
9 you can't make these assessments from bioassays
10 exposure data and so forth.
11 VICE CHAIRMAN RYAN: One other follow-up
12 question is you mentioned that metabolic modeling
13 tends to be at least try to be more realistic today
14 versus say ICRP 2 or earlier versions. Could you
15 expand on that and give us some more insight as to
16 where we're doing well and where we might not be as
17 well along and so forth?
18 I value your insight there. Pick our
19 radionuclides of interest. Which ones are good and
20 conservative or nominal or where are we on americium
21 and plutonium.
22 DR. ECKERMAN: Actually, well, let me just
23 say that the publication 2 kind of models where not
24 only were they responsive to the information they had
25 available at the time, but they were really focused in

1 on the long -- the sites of long-term retention in the
2 body that committed dose, although it didn't use
3 committed dose at that time, but the idea of where in
4 the long sense is the -- the long-lived radionuclide
5 is the dose coming from.
6 I think and so -- well, often now we have
7 maybe a little greater uncertainty on some of the
8 shorter lived radionuclides, but that's not in our
9 menu here. It's the long-lived ones.
10 I think the ones that you had up there
11 that we've been talking with, the plutonium is
12 probably one of the better biokinetic models that we
13 have available and there's plenty of studies that even
14 recent injection data with non-alpha emitting
15 plutonium isotopes that have been really shown --
16 helped that modeling process and convinced us of it.
17 I think plutonium is probably a good
18 model. The members of the alpha earth family --
19 strontium and radium that are here, uranium is
20 probably good. We saw that TM-126, I'm not sure our
21 TM model is very good at all.
22 DR. THORNE: I think there is a major
23 issue of speciation on TM.
24 DR. ECKERMAN: That's right. What else?
25 Technetium model probably isn't that good either and

1 there, of course, we get those stable analogs. There
2 are no other naturally occurring --
3 DR. THORNE: One thing I found with
4 Technetium which was surprising was the degree of
5 variability in gastrointestinal absorption even if you
6 restricted yourself to the * (4:35:39) and dietary
7 forms and that seemed -- that was surprising to me.
8 DR. KOCHER: And even for the same
9 individual.
10 DR. THORNE: Yes.
11 DR. KOCHER: And we still should use a
12 single value.
13 DR. ECKERMAN: Yes, 1.0. Right on the dot
14 or .9 what it is. And the F1 is probably -- of the
15 biokinetic parameters, the F1, the fraction absorbed
16 from the GI tract, this probably is our most
17 uncertainty. That's a difficult experiment to do,
18 especially when you get down to the actinides and when
19 the reabsorption is almost nil. It's hard to quantify
20 it.
21 So that's the -- actually, I think once
22 some of these materials get to blood, we handle them
23 pretty well.
24 The lung model, I think is or the new lung
25 model is much more realistic in its design and

1 incorporated a lot more of the physiological
2 information that was available with regard to the
3 respiratory systems, so it's -- and the ability to
4 actually consider nose breathing as well as mouth
5 breathers is an important --
6 VICE CHAIRMAN RYAN: You kind of quickly
7 reviewed a key point which I think needs a little
8 amplification, if I may, and that's intake and uptake.
9 Metabolic models deal mainly -- well, they can deal
10 with both, but I think the focus you've offered is
11 once it gets to blood, we're pretty good. Well,
12 that's the uptake.
13 DR. ECKERMAN: That's uptake.
14 VICE CHAIRMAN RYAN: So we can then take
15 something from the blood and distribute it in body in
16 a time-dependent way and pretty much figure out where
17 it's going to go and what organ doses in red, if
18 you'll met me, or gray are going to be. So that's one
19 part. But a part where we're doing the environmental
20 assessment or an assessment of a particular technology
21 or Yucca Mountain or anything else for that matter is
22 what's the intake. I think what we heard from our
23 speakers today was more about what is the intake.
24 DR. ECKERMAN: Yes, yes.
25 VICE CHAIRMAN RYAN: So I think that's a

1 very important distinction and I guess, in my mind,
2 that kind of factors in to what John and Dave talked
3 about. I have no problem with fixing the uptake and
4 making that very clear, but I think there's room to
5 assess the intakes and in a span of possibilities in
6 the world of intakes versus uptakes.
7 Maybe that's a breakpoint where we can see
8 the assessment that Michael talked about earlier to
9 say well, there's no reason you can't inform yourself
10 about those variations and it's the variations in the
11 intakes that I think are the key because that's what
12 the environmental parameters drive is the intake, not
13 the uptake, whereas on the backside of the metabolic
14 models that deal with, at least in my mind, you can
15 have a clean breakpoint at the uptake.
16 Would you agree with that?
17 DR. ECKERMAN: Yes.
18 DR. THORNE: I think there's an
19 implication that that as well is worth studying
20 explicitly. We saw in the calculations, I think, all
21 the pathways treated as if the relationship between
22 intake and uptake is the same. It didn't matter
23 whether the radionuclide came in in drinking water or
24 incorporated in food or on soil, but I think if you're
25 going to make that distinction then it makes a

1 considerable difference on bioavailability which of
2 those ways the radionuclide comes in on. And that
3 could change the sort of weighting that we saw between
4 pathway.
5 VICE CHAIRMAN RYAN: Sure. Thank you.
6 Other comments?
7 Questions?
8 MEMBER HORNBERGER: If I could just be
9 clear on this, this assembled group. Did I just hear
10 everyone agree that there was a subset of the
11 parameters in dose models that should be sampled in a
12 stochastic fashion?
13 VICE CHAIRMAN RYAN: I don't think you
14 heard that. It's a nice speech.
15 MEMBER HORNBERGER: I thought I just heard
16 you say that you were making a distinction between
17 intake and uptake and you wanted to fix intake, but
18 let uptake be --
19 VICE CHAIRMAN RYAN: It's the other way
20 around.
21 MEMBER HORNBERGER: Sorry, the other way
22 around, sorry.
23 VICE CHAIRMAN RYAN: But to me that's
24 where you can best inform your calculation of
25 potential uncertainty and sensitivity is to deal with

1 those things that change the intake.

2 MEMBER HORNBERGER: But if those

3 parameters are really uncertain, why shouldn't we

4 treat them as uncertain parameters? I'm still a

5 little lost.

6 VICE CHAIRMAN RYAN: I agree with you.

7 That's what I'm saying.

8 MEMBER HORNBERGER: But John Till didn't

9 disagree, that's what I'm worried about.

10 VICE CHAIRMAN RYAN: There's only two.

11 (Laughter.)

12 But the point is there is a breakpoint to

13 think about if you want to look at a risk insight,

14 it's kind of on the intake side where you have the

15 opportunity to actually do something about it. Once

16 you get into the metabolic, we're not going to excise

17 lungs and cut them into pieces and figure out what

18 went where. It just doesn't work that way. We have

19 to do inference from bioassay and all of that.

20 And again, I think Keith is kind of

21 representative of 50 years of that work sitting here

22 at the table and it's good to hear that some of these

23 key models for the long-lived radionuclides are pretty

24 good.

25 So if we maybe try to get away from

1 struggling with the dose conversion factors that focus
2 and focus on the intake part, what actually gets into
3 the body and in what form and so on, that might be an
4 instructive breakpoint.
5 I guess in trying to find summary points
6 for the day, I think that's maybe something we can
7 think about toward tomorrow is maybe that's something
8 we can focus on, if we looked at intakes.
9 Yes, Ruth.
10 MEMBER WEINER: Dr. Eckerman, I've always
11 had a problem with going from dose to risk in these
12 models because it seems to me you're introducing
13 another dimension of uncertainty which is very large
14 and I have a lot of problem with reporting this in a
15 document because everybody looks at it and says oh, my
16 goodness, you know, I'm going to get cancer from this.
17 I'd really like to have your comment on
18 the reporting of results of these models.
19 DR. ECKERMAN: Well, you're indeed right,
20 of course. That translation of a dose, no matter how
21 it's distributed in time over to a risk is -- has lots
22 of uncertainty and you'd have to deal with the -- most
23 of our information comes to bear to that question is
24 from the Hiroshima/Nagasaki studies. And the first
25 thing you wind up is worrying about how well can you

1 transfer that information from that population to the
2 population you're interested in and so on.
3 And so we talked about this in 13 and we
4 have another report that's going further in looking at
5 the uncertainties in the risk values themselves, the
6 whole thing put together, because it is difficult.
7 However, we're tending to be risk-based in
8 our decision making and so forth, so it seems that you
9 need at least somewhere along the line to look at the
10 -- not just stay with just a pure dose assessment, but
11 actually have to wrestle with the question of risk and
12 indeed look at these uncertainties.
13 In 13, we actually used a lot of the
14 information from the National Academy of Sciences, of
15 course, in doing that and they're poised to -- and
16 have a committee together to now reexamine the state
17 of the information. There were questions, that whole
18 exercise has been pushed back because of some
19 questions with regard to the dosimetry for the A-bomb
20 survivors.
21 Now that issue has been pretty well
22 brought to a resolution and so the Academy will now go
23 forward with that estimate, but it's fraught with
24 uncertainties along the way, yes.
25 MEMBER WEINER: I guess the problem is

1 isn't there a way and I'm asking this, isn't there a
2 way to express risk without just kind of linear
3 conversion to cancer? I mean that's the thing that
4 gives me a problem. I'm not at all concerned that we
5 express these doses as risks in some fashion. It's
6 the end product, the way we now express the end
7 product that I think hides the uncertainty, if you
8 will.
9 DR. ECKERMAN: There are parts of this --
10 the conversion is not -- is often done in an
11 inappropriate manner in that especially with regard to
12 the internal emitters because the committed dose is a
13 legislated quantity over which we average. That's why
14 Publication 13 couldn't use committed dose.
15 We only calculated doses to people who the
16 life table told us were alive at the time, so you had
17 to survive. One of the benefits of cancer is that, of
18 course, you have to survive to get it. Forget that.
19 But you have to have include that in a rigorous
20 calculation. So it's difficult to make the whole --
21 all of this quite transparent to everybody because
22 it's deeply involved in the mathematical models and
23 the linearity in these models and so forth, but the
24 information is there to do it and you can do it in a
25 process that overcomes some of the obvious criticisms

1 that people will put you to.

2 CHAIRMAN GARRICK: With all this expertise

3 here, I want to ask a question. How do the intake

4 models involving other toxic substances compare in

5 terms of comprehensiveness and completeness with the

6 intake model for radiation?

7 DR. ECKERMAN: I think we know a lot more

8 about radiation than probably any other pollutant that

9 man is subjected to.

10 MEMBER HORNBERGER: And part of the

11 problem there is the world thinks that the only way

12 you get cancer is radiation.

13 DR. ECKERMAN: Right.

14 MEMBER HORNBERGER: I read Dade Moeller's

15 book and it talks about a lot of other things that

16 threaten our health.

17 And again, the question is where are we

18 with respect to the comprehensiveness and technical

19 quality of those models and do they contribute

20 anything to what we're -- is there one of them that's

21 way ahead of the radiation intake community?

22 DR. KOCHER: In terms of the modeling

23 effort?

24 MEMBER HORNBERGER: Right.

25 DR. ECKERMAN: In terms of the modeling

1 effort, no.

2 DR. KOCHER: There are very few that could

3 be considered comparable like carbon tetrachloride.

4 MEMBER HORNBERGER: Right. There's all

5 kinds of toxic substances in the work place.

6 VICE CHAIRMAN RYAN: They have some

7 problems to deal with that we don't.

8 MEMBER HORNBERGER: Yes. Even something

9 that has as much notoriety as asbestos, do we have

10 comparable models for asbestos that we do for

11 radiation?

12 VICE CHAIRMAN RYAN: Well, even simple

13 things, I think, John, like dosimetry, how do you do

14 dosimetry for asbestos? Well, it's fiber accounting

15 and that sort, so it really, how would you even get

16 and I know some attempts have been made as an NCR peer

17 report that took a crack at talking about chemicals

18 and radiation on the same page, but I guess my view is

19 like Keith's that that's probably a beginning step

20 rather than a well matured step along the way of

21 figuring out the chemicals.

22 John, you've done a lot of work on both,

23 so maybe you can address that.

24 DR. TILL: I can't add any more to the

25 conversation. We know far, far less about the

1 chemicals.

2 This goes back to that whole question

3 about the uncertainty. It exists. It's huge. It is

4 unknown as far as conversion to risk is concerned and

5 that's why I recommend for compliance, don't go there.

6 That's the point.

7 DR. MOELLER: Well, and the history of

8 this is pretty -- I was going to say wild. That's not

9 the correct word, but Ruth is correct. The ICRP and

10 the NCRP estimated the risk from radiation in order to

11 calculate the tissue weighting factors. They say in

12 their reports everything we did is very conservative

13 and you should not use these numbers to estimate risk.

14 Well, they did it themselves when they did it for the

15 tissue weighting factors.

16 What I believe should be done is -- and

17 what NCRP and ICRP have done would be a good start.

18 Could not someone take all of their sequences of

19 calculations and estimating the risk for cancer in

20 each individual organ and you know sharpen up the

21 numbers or you know try to put some uncertainty and so

22 forth on them and come up with a whole lot better risk

23 estimate.

24 DR. ECKERMAN: Well, the Federal Guidance

25 13, organ specific risks were attempting to be right

1 on the A-bomb survivor data and they didn't have
2 hoppers. They didn't use hoppers.
3 That was our objective.
4 DR. MOELLER: Well, let me compliment.
5 I've read, looked at FTR 13 and that is an excellent
6 digest, but even so we were mentioning or Keith
7 mentioned that our basic epidemiological data, I mean
8 we have data on radium which showed conclusively that
9 there's a threshold for cancer, Robley Evans to his
10 dying said and his publications show it. But we use
11 predominantly the Japanese data. Well, as Keith
12 pointed out the Japanese normal rates of cancer and in
13 different organs are entirely different than ours.
14 The bomb was, as you know, a short-term high dose
15 exposure. It was external. They've even acknowledged
16 that there are missed diagnoses of the types of
17 cancer, people who have died got, you know. Or
18 whatever the word. "Got" is a very poor word,
19 whatever -- substitute in the record whatever is the
20 correct word. And the NCRP, bless them, so far as I
21 know is the only group, Warren Sinclair chaired the
22 group, that tried to take those Japanese data and move
23 them over to the U.S. and put in the uncertainties and
24 so forth. And they finally came up with a factor of
25 2. They said take the risk of cancer suffered by the

1 Japanese, divide by two and say that's okay for low
2 dose in a chronic situation.
3 But then he also plotted the distribution
4 in the 95th and 5 percentile and it's pretty wide,
5 pretty wide margin.
6 DR. KOCHER: I guess I disagree with that
7 last statement. For uniform, whole body irradiation,
8 their conclusion was that the risk of any cancer was
9 known to less than a factor within a factor of 3. The
10 difference between the median and an upper or lower
11 confidence limit was less than a factor of 3 and I
12 call that pretty tight.
13 DR. MOELLER: I agree.
14 DR. KOCHER: There are many complications
15 in all of this. If you really want to amuse yourself,
16 look at the basic data from which risk factors for
17 chemicals are derived. It's a hoot. It's absolutely
18 a hoot.
19 VICE CHAIRMAN RYAN: So we've got the easy
20 one.
21 DR. KOCHER: You know, whoever said we
22 know a heck of lot more about radiation risks than
23 anything else, that's true. Of course the organ
24 specific risk coefficients can vary widely and if you
25 want to get sort of the latest NCI thinking on that,

1 it's available.

2 To me, the issue of risk really boils down

3 to if you're going to compare radiation with anything

4 else, there is no other coin of the realm. You can't

5 compare grays with anything else out there for any

6 other insult, so you've got to bite the bullet and

7 talk about risk. There's no other measuring stick.

8 DR. MOELLER: Well, in Bill Bair's

9 Lauriston S. Taylor's lecture of 1997, you know is a

10 good place to start. It's not the only thing, but

11 it's certainly a good document to read to understand

12 the differences between external radiation and

13 internal radiation of the body.

14 VICE CHAIRMAN RYAN: I think we're at a

15 point where we can probably close this discussion

16 session. I wanted to offer any time for members of

17 the public that wanted to make public comments. I

18 think we have at least one and only one.

19 Would you introduce yourself to everybody,

20 please?

21 MS. TREICHEL: Judy Treichel, Nevada

22 Nuclear Waste Task Force. I think at the very

23 beginning of the day when Dave Moeller started out and

24 said we're going to be -- the public is going to ask

25 what dose am I getting, I don't think that's probably

1 the case. The question is going to be why am I being
2 dosed?
3 And that's an entirely different question, but in
4 listening to the whole conversation that's gone on
5 here today, and knowing that this isn't just
6 theoretical and it's not something that's just being
7 done on paper, I know the people in Amargosa Valley.
8 I know a lot about that area and it's very hard to sit
9 here and listen to the discussion about the receptor
10 when you know what it's name is.
11 And it seems to me that if this whole
12 thing works out and Yucca Mountain is licensed and
13 it's built and the rating standards are applied and so
14 forth, there should certainly be a disclaimer -- not
15 a disclaimer, there should certainly be an explanation
16 that goes out to those people letting them know who it
17 is that this regulation applies to, that it's an
18 adult. That's the big thing. Because children are
19 very, very different. They're more susceptible and at
20 the same time they're more exposed.
21 You talked about how these people eat that
22 they go off and commute to work. Well, an infant and
23 a child don't commute to work. They're right at home
24 and they play outside and they drink sometimes regular
25 milk, sometimes mother's milk and they put everything

1 in their mouth and they play in the dirt. So it's
2 very difficult and even knowing that, taking the
3 surveys that were used, as Steve said, partially they
4 were bad surveys. They only talked to people that had
5 telephones. I think, I remember, that they were only
6 done in English and there's a large Spanish-speaking
7 population out there that is difficult to even find
8 sometimes, but you can't find them by phone.
9 And a lot of the crops are changing and I
10 realize that this whole thing is being taken in a
11 snapshot in time where you take exactly what's going
12 on right now and you apply it thousands of years into
13 the future, but at this point, pistachios are becoming
14 a big deal and people are coming back from there with
15 commercial pistachios, things that you buy in the
16 store that are grown in Amargosa Valley and there's a
17 whole lot of them.
18 There's also honey that's coming out of
19 that area. I don't know if it's being sold or I got
20 it as a gift, so I'm not sure if it's commercial or
21 not. But that's another crop. And it may be that the
22 people there aren't eating a lot of these things. I'm
23 sure they don't eat the majority of their pistachios
24 because they're a very valuable commercial crop and
25 they're doing pretty well on them and it's going to

1 increase. It takes a long time for pistachios to
2 start producing. And they're going now and they're
3 going to keep going, but so you may not be killing
4 them with radiation. You might just kill them
5 economically because there's a huge and growing
6 organic farming situation going on out there where you
7 have organic milk. You've got organic vegetables.
8 All of those sorts of things. And that just dies if
9 you mention the word radiation.
10 So that's a factor that I suppose is not
11 relevant here, but it's extremely relevant to those
12 people and they aren't going to understand a
13 conversation about is conservatism caution and that if
14 you're overly conservative, you're wrong. Well, in
15 their minds, if you're overlay cautious, that's great.
16 And that's what they're looking for.
17 So a lot of the word games are really
18 problematic when you're actually talking about the
19 people and avoiding the worse case is not something
20 that should be done. Nevadans know what the worse
21 case is and we've got a real good one going right now,
22 very currently. And you can find out a lot more about
23 how other things, how other toxics work. If you take
24 a look at the people who have died already at Yucca
25 Mountain digging the tunnel.

1 There's the silicosis out there and that's
2 a lung thing and it was mentioned that we're still
3 just learning how lungs work. Well, there's a good
4 study. We've got people that have inhaled toxic dust
5 and have already been affected.
6 So it's just very difficult when you have
7 to understand that you're talking about real people
8 and perhaps it's a really bad thing to combine a
9 repository and a farming community. There are a lot
10 of people working on this project that have come from
11 WIPP that are very familiar with WIPP and WIPP did not
12 combine farming, heavy water use and a repository.
13 And I'm not sure you should ever do that. And
14 particularly, not when you can throw a volcano in just
15 as frosting on the cake.
16 So thank you.
17 VICE CHAIRMAN RYAN: Thank you for your
18 comments. It is at the hour of five o'clock and I
19 think what I'd like to do is -- yes, I'm sorry.
20 DR. WASIOLEK: Just for the record, the
21 Spanish and English was used in the survey. So there
22 were two sets of questions, one set was in Spanish and
23 the other set was in English.
24 VICE CHAIRMAN RYAN: Thank you for that
25 clarification. Anything else? Thank you.

1 I think what I'd ask is to challenge each
2 of the Panel Members to digest and think about what
3 you've heard through the day and then maybe we can
4 start with an introduction and kind of a review of the
5 key points and what you see as summary points that
6 you'd like us to take away from the first day's
7 activities leading into the second and then we'll hear
8 tomorrow and kind of finish up with a similar summary
9 toward the end of the day. So I won't try and press
10 into service for summary information today. It's
11 probably best to digest and think about it.
12 Are there any questions from ACNW members?
13 From the fact that the brief cases are coming up off
14 the floor -- that tells me it's time to bang the gavel
15 and I'll turn it back to the chairman for the gavel at
16 the end of the day. There we go.
17 Thank you very much. See you in the
18 morning.
19 (Whereupon, at 5:01 p.m., the meeting was
20 concluded.)
21
22
23
24
25

CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: Advisory Committee on Nuclear Waste 148th Meeting

Docket Number: n/a

Location: Rockville, MD

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

Rebecca Silberman

Rebecca Silberman
Official Reporter
Neal R. Gross & Co., Inc.

ACNW WORKING GROUP MEETING

Dade W. Moeller

Chair, Science & Technology Review Panel, Office of Civilian Radioactive Waste Management, U.S. Department of Energy

BIOSPHERE DOSE ASSESSMENTS

- Accompanying Assumptions
- Associated Uncertainties
- Degree to Which They Affect the Dose Estimates

QUESTIONS TO BE ADDRESSED

- What Are the Issues?
- What do We Know?
- What do We Not Know?
- What do We Need to Know to Adequately Address Them?

RELATED QUESTIONS

- Are We Analyzing the Right Things?
- Will the Results be Useful From a Scientific, Technological, and Regulatory Perspective?
- Again, Will They Be Adequate?

SUGGESTED GOAL – NRC CHAIRMAN DIAZ

REALISTIC CONSERVATISM

- Conservatism – Providing Adequate Margins of Safety
- Realism – Anchored in the Real World of Physics, Technology, and Experience

REALISTIC CONSERVATISM

- Avoiding the "Worst Case" Syndrome
- Recognizing That Unrealistic Conservatisms Can Skew the Results Significantly

REQUIREMENTS

- Uncertainties Should be Understood to the Maximum Practicable Extent
- They Should be Quantified so They Can Be Properly Addressed in the Decision-Making Process
- Otherwise, They Could Remain Hidden Under the Mantle of Conservatism

REALISTIC CONSERVATISM

- Properly Applied, Realistic Conservatism Goes Hand-in Hand With a Risk-Informed and Risk-Based Approach to Regulation
- Remember: The Risk Significance of an Issue Cannot be Determined Without a Realistic Understanding of it

SPECIAL SIGNIFICANCE OF DOSE ESTIMATES

- Annual Doses Represent a Subject That is Not Only Personal in Nature But It is Also One That Members of the Public Believe They Understand
- Therefore, This Represents a Primary Area In Which They Will Not Hesitate to Ask Questions

SPECIFIC MEETING SCOPE

- Beginning: Contaminated Water at the Well
- Continuing: Interactions of Water With Exposed Population
- Ending: Estimation of Doses

RELATED TOPICS

EPA STANDARDS &
US NRC REGULATIONS

- Although Complicated – They Exist
- Primary Attention Will Be Directed to Their Implications – Not on What May be Wrong With Them or How They Should be Changed

AGENDA – DAY #1

EXPOSURE PATHWAYS

- Direct Exposure Pathway: Consumption of Drinking Water
- Indirect Exposure Pathways: Irrigation of Crops and Their Consumption; Irrigation of Pasture Grass & Consumption of Milk and Meat

AGENDA – DAY #1

INTAKE AND DOSE

- Metabolism of Radionuclides in the Body – Associated Models & Input Parameters
- Dosimetry of Radionuclides – Associated Models & Input Parameters

PRESENTATIONS – DAY #1

- Biosphere Assessments – What Does the US NRC Expect?
- What is the DOE Response and/or Approach?
- What Can be Done to Achieve Closure?
- Opportunity for Public Comments

OBJECTIVES – INTERACTIVE SESSIONS

ENVIRONMENTAL PATHWAYS

- Where are We?
- What Needs to be Done?
- How Can We do It?

SPECIFIC QUESTIONS

- What Key Factors Govern Intake?
- What are Their Associated Conservatisms & Uncertainties?
- What Can be Done to Quantify the Conservatisms

SPECIFIC QUESTIONS

- What Can be Done to Reduce The Magnitudes of The Uncertainties?
- Can Realism be Achieved?
- Implications Regarding "Reasonable Expectation"?

MAGNITUDES OF THE UNCERTAINTIES

ARE THEY IMPORTANT?

- Factor of 2 – Interesting – May be Important but Within a Reasonable Range of Certainty
- Factor of 10 to 20 – Pay Attention
- Factor of 100 – Needs to be Addressed

OBJECTIVES – INTERACTIVE SESSIONS

METABOLISM & DOSIMETRY

- Where are We?
- What Needs to be Done?
- How Can We do It?

SPECIFIC QUESTIONS

- What are Key Factors That Govern Metabolism and Dosimetry?
- What are the Magnitudes of Their Associated Conservatisms & Uncertainties?
- What Can be Done to Reduce The Magnitudes of Their Associated Uncertainties?

INTERACTIVE PRESENTATIONS – DAY #2

- Identification and Ranking of Sources of Conservatism and Uncertainties – US NRC Risk Insights Initiative
- DOE Response to Initiative

INTERACTIVE PRESENTATIONS – DAY #2

CONTINUED

- Opportunity for Stakeholder Input
- Perspective of US NRC Office of Nuclear Regulatory Research

WORKING GROUP ROUND-TABLE PANEL DISCUSSION

- Panel Discussion
- Is There Research That Can Readily be Performed to Resolve Certain Issues?
- Opportunity for Public Comments

ACNW WORKING GROUP SESSION

THE END

OTHER CONSIDERATIONS

PUBLIC PERCEPTIONS AND DOE/US NRC CREDIBILITY

- Reasonably Maximally Exposed Individual is an Adult
- Ground Water Consumption is Set at 2 Liters per day
- Use of Best Science

INTERACTIVE SESSIONS

- Environmental Pathway Analysis
- Topics for Discussion:

  #1: Biosphere Avenues of Transport and Associated Models

  #2: Metabolism & Dosimetry and Associated Models

GOALS – REMINDER

- Identification of Significant Conservatisms & Uncertainties
- Their Relative Magnitudes
- Identification of Appropriate Studies to Address and Resolve Key Issues

QUESTIONS TO BE ANSWERED -- REMINDER

- What Questions Need to Be Addressed?
- How Can This Be Accomplished?
- What Types of Studies are Needed?

PRIMARY OBJECTIVES WORKING GROUP MEETING

COMPONENTS OF DISCUSSION

- Direct Exposure Pathway: Drinking the Water
- Indirect Exposure Pathways: Irrigation of Crops; Irrigation of Pasture Grass & Consumption of Milk

INTRODUCTION TO BIOSPHERE DOSE ASSESSMENT: FRAMEWORK AND PROCESS FOR NRC STAFF REVIEW OF A POTENTIAL YUCCA MOUNTAIN LICENSE APPLICATION

Keith Compton 301-415-5495 klc@nrc.gov
Division of Waste Management
U.S. Nuclear Regulatory Commission

Main Contributors: Patrick LaPlante (CNWRA)
Christepher McKenney, Timothy McCartin (NRC)

148th Meeting of
Advisory Committee on Nuclear Waste
February 24-27, 2004

OBJECTIVES

- Provide the regulatory framework for dose assessments carried out in support of the post-closure performance assessment
- Describe how the dose assessments in the post-closure performance assessment will be reviewed by NRC staff

OUTLINE

- Regulatory Concepts
- Post-Closure Performance Objectives
- Scope of Information
- Review Process
- Summary

REGULATORY CONCEPTS

Multi-step Process Anticipates New Information

Construction authorization based on site characterization results

↓

License to receive and possess informed by construction activity and performance confirmation program

↓

Amendment for permanent closure updated by performance confirmation program

REGULATORY CONCEPTS

Attributes of the Post-Closure Performance Assessment

- Identification of Barriers Important to Waste Isolation
- Quantitative Estimates of Performance

REGULATORY CONCEPTS

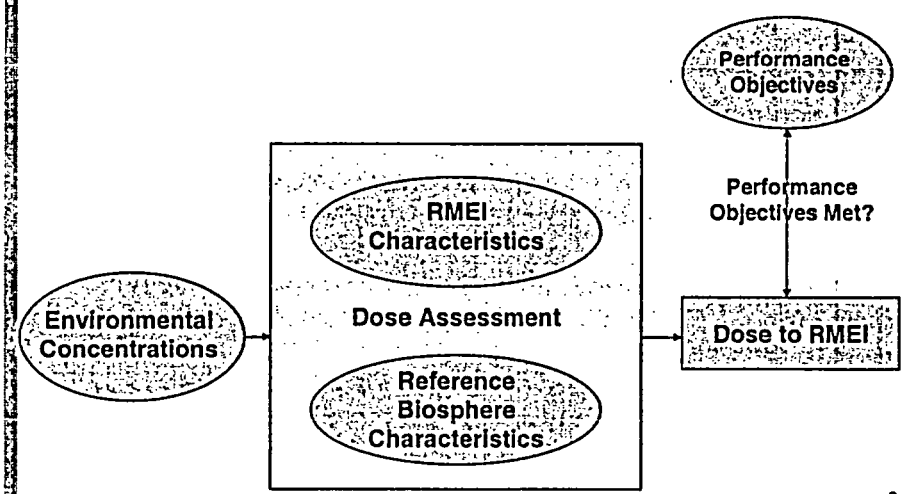
Reasonable Expectation

- "Requires less than absolute proof, because absolute proof is impossible to obtain..."
- "Accounts for the inherently greater uncertainties in making long-term projections..."
- "Does not exclude important parameters from assessments and analyses simply because they are difficult to precisely quantify..."
- "Focuses performance assessments and analyses on the full range of defensible and reasonable parameter distributions ..."

POST-CLOSURE PERFORMANCE OBJECTIVES

- §63.311: Individual protection standard after permanent closure
- §63.321: Human intrusion scenario
- §63.331: Separate standards for protection of ground water

DOSE ASSESSMENT SCOPE



DOSE ASSESSMENT SCOPE

Reasonably Maximally Exposed Individual (RMEI)

- §63.2 Defines the Reasonably Maximally Exposed Individual (RMEI) as "...A hypothetical person meeting the criteria specified in §63.312".
- §63.312 requires the applicant to assume that the RMEI:
  - Lives in the accessible environment above the location of highest radionuclide concentration in groundwater
  - Has a diet and lifestyle representative of the current population of Amargosa Valley, based on mean values from local surveys
  - Uses well water with average concentrations based on demand of 3000 acre-ft and drink 2 liters of groundwater per day
  - Is an adult

DOSE ASSESSMENT SCOPE

Reference Biosphere

- §63.2 Defines "Reference Biosphere" as the environment inhabited by the reasonably maximally exposed individual ...biotic and abiotic...including/not limited to climate, topography, soils, flora, fauna, and human activities
- §63.305 requires the applicant to:
  - Assume that factors related to the human environment (human behavior, society, knowledge, and biology) are constant and consistent with conditions at the time of license application
  - Vary factors related to the physical environment (geology, hydrology, and climate) based on cautious but reasonable assumptions consistent with present knowledge, consistent with arid or semi-arid conditions

DOSE ASSESSMENT SCOPE

Requirements for Biosphere Modeling

Biosphere modeling is part of the post-closure performance assessment. Therefore, the relevant requirements in §63.114 apply:

- Must include technical bases for inclusion/exclusion of FEPs and for models used in performance assessment (limited by biosphere requirements and likelihood of events)
- Must account for uncertainties in parameter values and provide technical bases (except when specified by regulation)
- Must consider the effects of alternative conceptual models (limited by biosphere requirements)

REVIEW PROCESS

Risk Insights

The Yucca Mountain Review Plan (YMRP) delineates the *subject matter* and *review process* for the staff review of a potential license application

Risk insights will be used to determine the *depth of review* of individual elements of the license application

- Focus review
- Assist determination of depth of information needed for NRC review
- Assist the development of requests for additional information

REVIEW PROCESS

Areas of Review in the YMRP

- System Description
- Model Integration
- Data and Model Justification
- Data and Model Uncertainty
- Model Support

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REVIEW PROCESS

Review Methods and Acceptance Criteria in the YMRP

- Are the parameters and models *consistent* with other models in the performance assessment and with regulatory requirements?
- Are parameters and models *justified*?
- Are technical bases and analyses *adequate* and *appropriate*?
- Is uncertainty *characterized* and *propagated*?
- Are the results *supported* by objective comparisons?

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SUMMARY

- Characteristics of the "Reasonably Maximally Exposed Individual" (RMEI) and "Reference Biosphere" used in the dose assessment are specified by regulation
- Yucca Mountain Review Plan and Risk Insights Will Guide NRC Review of DOE Biosphere Abstraction

REFERENCES

10 CFR Part 63, "Disposal of High-Level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada"

Ciocco, J.A. NUREG-1804, "Yucca Mountain Review Plan", Revision 2. Washington, DC: U.S. Nuclear Regulatory Commission. 2003.

BACKUP SLIDES

POST-CLOSURE PERFORMANCE OBJECTIVES

Individual Protection Standard (§63.311)

- DOE must demonstrate, using performance assessment, that there is a reasonable expectation that, for 10,000 years following disposal, the reasonably maximally exposed individual receives no more than an annual dose of 0.15 mSv (15 mrem) from releases from the undisturbed Yucca Mountain disposal system. DOE's analysis must include all potential pathways of radionuclide transport and exposure. (§63.311)

- To complement the results of §63.311, DOE must calculate the peak dose of the reasonably maximally exposed individual that would occur after 10,000 years following disposal but within the period of geologic stability. (§63.341)

POST-CLOSURE PERFORMANCE OBJECTIVES

Human Intrusion Standard (§63.321)

- DOE must determine the earliest time after disposal that the waste package would degraded sufficiently that a human intrusion could occur without recognition by the drillers... (§63.321)
- If complete waste package penetration is projected to occur at or before 10,000 years after disposal, ... (DOE must) demonstrate that there is a reasonable expectation that the reasonably maximally exposed individual receives no more than an annual dose of 0.15 mSv (15 mrem) as a result of a human intrusion, at or before 10,000 years after disposal... (§63.321b)
- If exposures to the reasonably maximally exposed individual occur more than 10,000 years after disposal, DOE must include the results of the analysis and its bases in the environmental impact statement for Yucca Mountain... (§63.321b)

POST-CLOSURE PERFORMANCE OBJECTIVES

Groundwater Protection Standard (§63.331)

DOE must demonstrate that there is a reasonable expectation that, for 10,000 years of undisturbed performance after disposal, releases of radionuclides from waste in the Yucca Mountain disposal system into the accessible environment will not cause the level of radioactivity in the representative volume of ground water to exceed the following limits:

Radionuclide or type of radiation emitted	Limit
Combined radium-226 and radium-228	5 pCi/L*
Gross alpha activity *(including radium-226 but excluding radon and uranium)*	15 pCi/L*
Combined beta and photon emitting radionuclides	0.04 mSv (4 mrem) per year to the whole body or any organ, based on drinking 2 liters of water per day from the representative volume.

**includes natural background*

U.S. Department of Energy
Office of Civilian Radioactive Waste Management

YUCCA MOUNTAIN PROJECT

Overview of the U.S. Department of Energy Total System Performance Assessment Model

Presented to:
Advisory Committee on Nuclear Waste

Presented by:
Peter Swift
Manager
Performance Assessment Strategy and Scope
Sandia National Laboratories
Bechtel SAIC Company, LLC

February 24, 2004
Rockville, Maryland

Outline

- Current Status of the Total System Performance Assessment
- Summary of Total System Performance Assessment methodology
- Role of the Biosphere Model and Biosphere Dose Conversion Factors in Total System Performance Assessment

Status of Total System Performance Assessment Analyses

- All DOE Total System Performance Assessment information used at this workshop is from existing Total System Performance Assessment analyses
  - December 2000: Total System Performance Assessment for the Site Recommendation
  - July 2001: FY01 Supplemental Science and Performance Analyses
  - September 2001: Revised Supplemental Total System Performance Assessment to support the Final Environmental Impact Statement and Site Suitability Evaluation
  - Additional analyses completed in 2002
    - "One-off" analyses to support risk-based prioritization
    - "One-on" analyses to provide insight into barrier performance
- Models and analyses that will support the License Application are currently under development

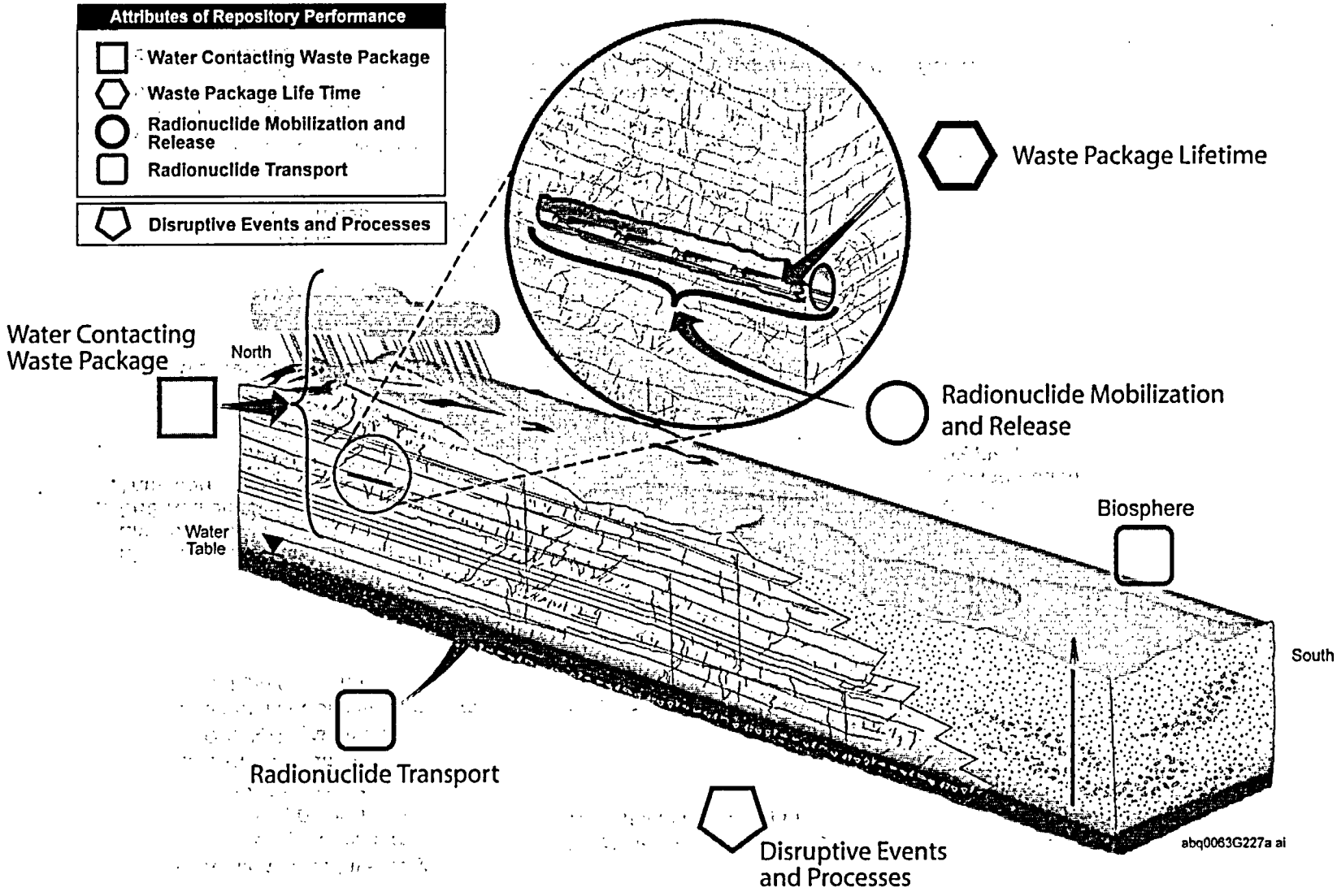
YUCCA MOUNTAIN PROJECT

Total System Performance Assessment Process

- Screen features, events and processes to determine those that must be retained in performance assessment
- Develop models, along with their scientific basis, for each process included in Total System Performance Assessment
- Identify uncertainty in models and parameters
- Construct integrated Total System Performance Assessment model using all retained processes
  - Nominal scenario class contains all features, events and processes likely to occur
  - Disruptive event scenario classes contain low-probability events (e.g., volcanism, seismic disruption)
  - Stylized human intrusion model, as specified by regulation
- Evaluate total-system performance (individual protection, groundwater protection, and human intrusion standards)
  - Evaluate uncertainty through Monte Carlo simulation
  - Weight consequences by scenario class probability

YUCCA MOUNTAIN PROJECT

Nominal Performance Scenario Class



Total System Performance Assessment Model Components

(Nominal Performance - Site Recommendation)

- Radionuclide Inventory
- In-Package Chemistry
- Cladding Degradation
- CSNF Degradation
- DSNF Degradation
- DHLW Degradation
- Solubility Concentration Limit
- Colloid Concentration

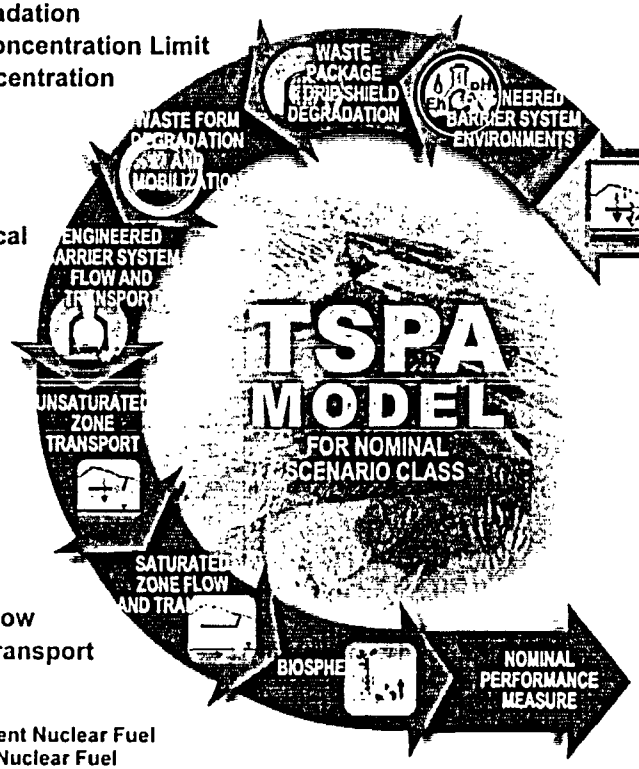
- Waste Package Degradation
- Drip Shield Degradation

- Chemical Environment
- Thermal Hydrologic Environment

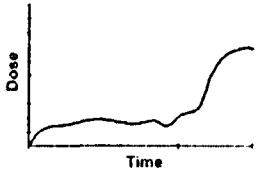
- EBS Physical Chemical Environment
- EBS Radionuclide Transport

- UZ Transport

- SZ Flow
- SZ Transport



- Climate
- Net Infiltration
- UZ Flow
- Seepage



00185DR_Figure 1 ai

- Biosphere Dose Conversion Factor
- Reasonably Maximally Exposed Individual Behavior

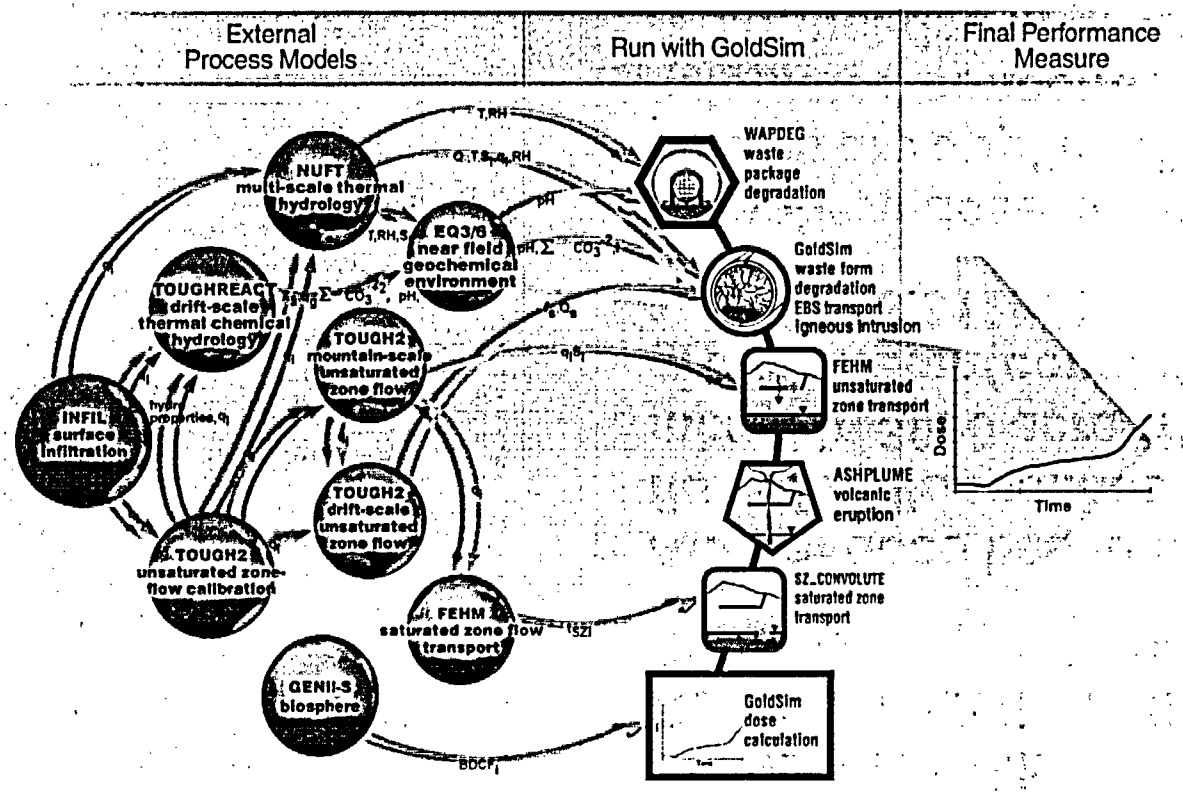
LEGEND

CSNF	Commercial Spent Nuclear Fuel
DSNF	Defense Spent Nuclear Fuel
DHLW	Defense High-Level Waste
EBS	Engineered Barrier System
SZ	Saturated Zone
UZ	Unsaturated Zone

YUCCA MOUNTAIN PROJECT

Overview of Model Linkage

(Total System Performance Assessment - Site Recommendation)



Output Parameters

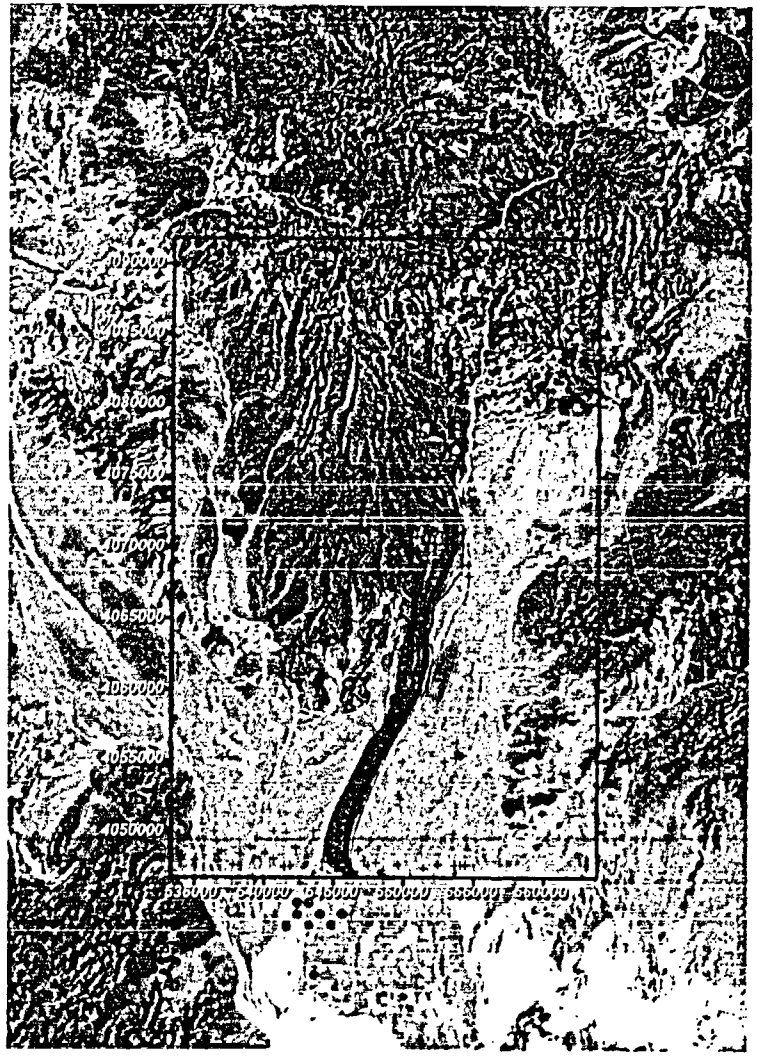
f_S	Fraction of WPs with Seeps	T	Temperature	I	Ionic Strength
EBS	Engineered Barrier System	RH	Relative Humidity	t_{SZi}	Saturated Zone Transport Time
Q_S	Seep Flow Rate	S_l	Liquid Saturation	$BDCF_i$	Biosphere Dose Conversion Factor
Q_e	Evaporation Rate	X_a	Air Mass Fraction	q_g	Gas Flux
pH	pH	q_l	Liquid Flux		
ΣCO_3^{-2}	Carbonate Concentration	q_i	Infiltration Flux		

Legend

- Response Surface Between Process Models
- Response Surface from Process Model to GoldSim

00185DR_Figure 2.ai

Total System Performance Assessment Analysis of the Groundwater Pathway



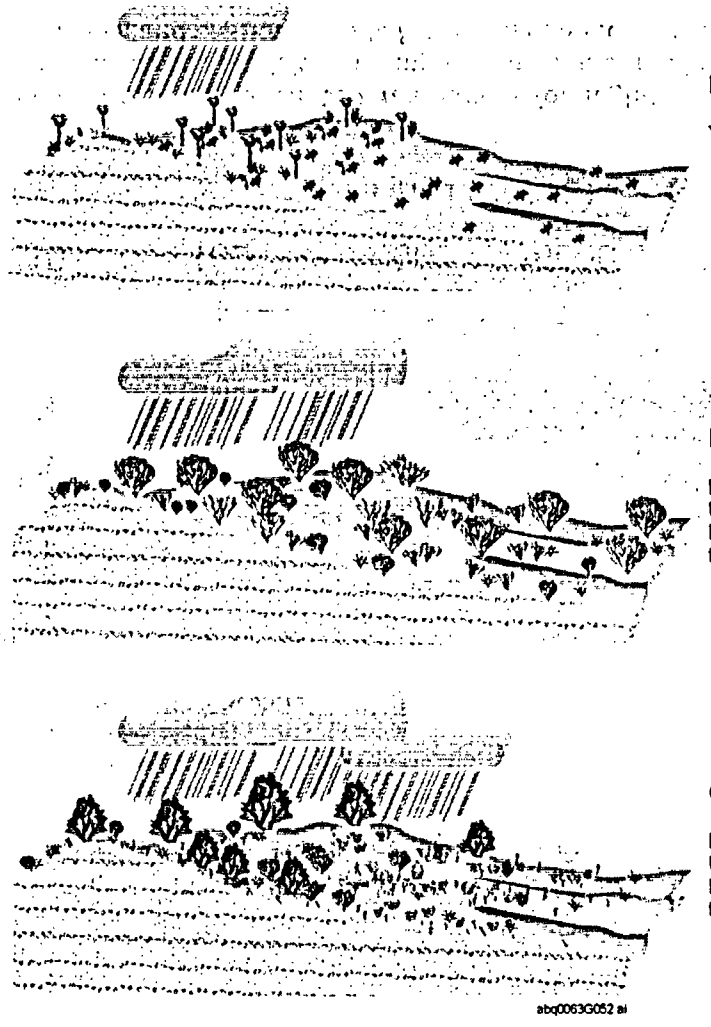
00185DR_Figure 3 a

- Flow paths shown for Total System Performance Assessment-Site Recommendation Site-Scale Saturated Zone Flow model
- Annual dose based on total mass flux of radionuclides at 18 km, mixed in 3000 acre-ft/yr of groundwater (consistent with 10 CFR 63.312(c))
- Biosphere dose conversion factors are applied directly to calculated concentrations of radionuclides in groundwater

YUCCA MOUNTAIN PROJECT

Future Climates in Total System Performance Assessment

- **Future climates based on paleoclimate data and modern analogs**
  - Present day: 0-600 yr
    - Mean annual precipitation: ~190 mm, mean annual temperature: ~19°C
  - Monsoon: 600-2000 yr
    - Mean annual precipitation: ~300 mm, mean annual temperature: ~17°C
  - Glacial Transition: 2000-10,000 yr
    - Mean annual precipitation: ~320 mm, mean annual temperature: ~10°C
- **Use in Total System Performance Assessment**
  - Biosphere model
    - Used to establish values for climate-dependent input parameters (e.g., growing seasons, irrigation rates)
  - Other models
    - Input to infiltration, unsaturated and saturated zone flow and transport



Present Day

Yucca Mountain

Monsoon

Lower-bound analog: Yucca Mountain
Upper-bound analog: Nogales, AZ
Higher precipitation and temperature than present-day

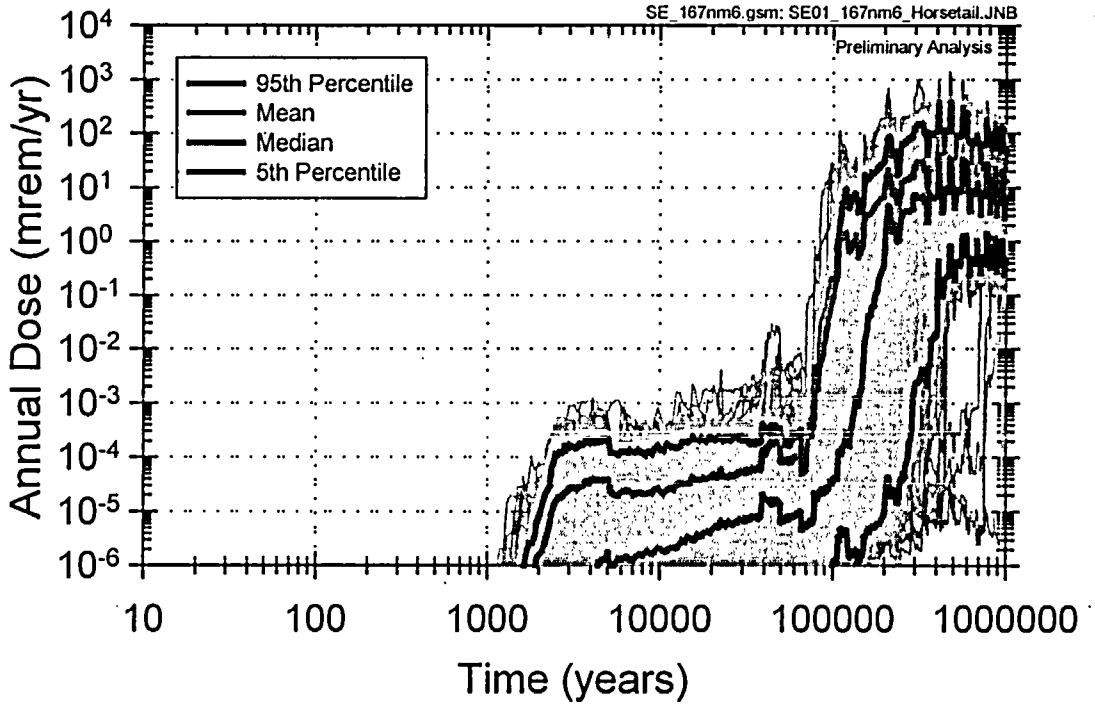
Glacial Transition

Lower-bound analog: Delta, UT
Upper-bound analog: Spokane, WA
Higher precipitation and lower temperature than present-day

YUCCA MOUNTAIN PROJECT

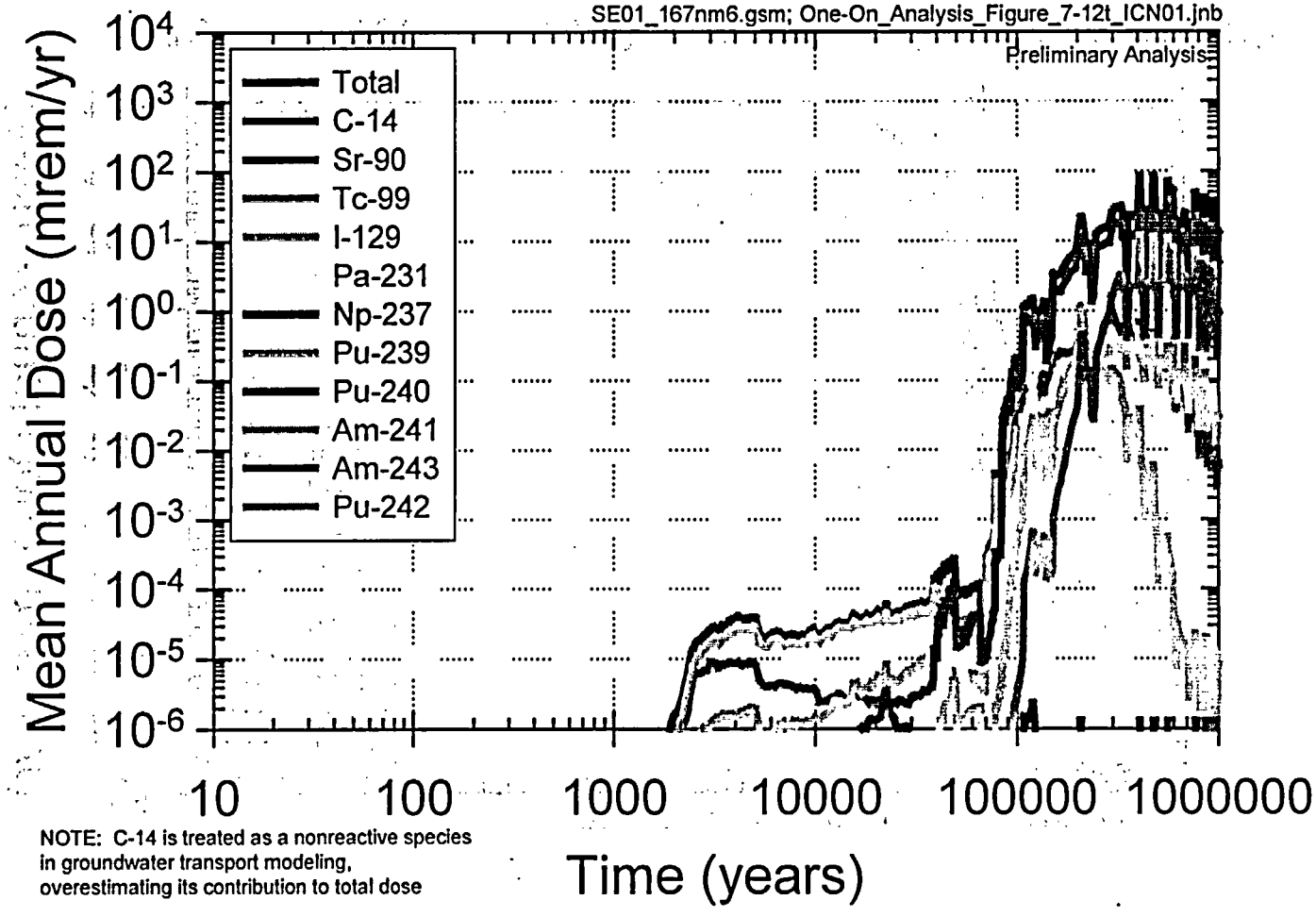
Overall Performance
Nominal Scenario Class (2002 Analyses)

- Total System Performance Assessment - Final Environmental Impact Statement model, modified to include strontium-90 and cesium-137 transport, updated long-term climate states, one early waste package failure per realization, and regulatory specification for 3,000 acre-ft annual groundwater usage
- Results from ANL-WIS-PA-000004 Rev. 00 ICN 00 ("one-on analysis" Case 12)



Mean annual dose based on 300 realizations of high-temperature operating mode nominal performance. Models and input values are preliminary. Results are for information only, and are not suitable for comparison to regulatory standards.

Contributors to Nominal Performance Dose 2002 Analyses (page 1 of 2)

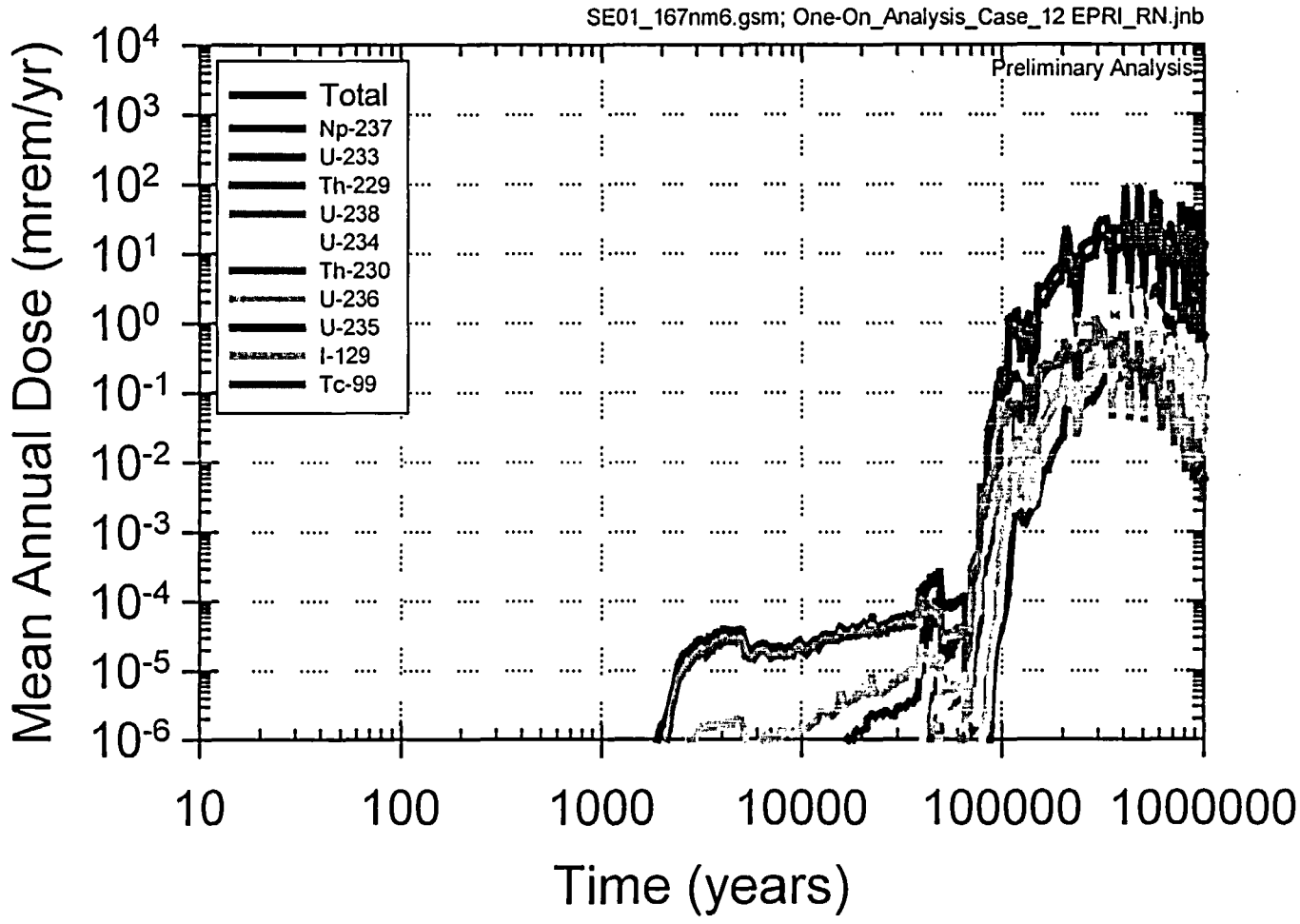


NOTE: C-14 is treated as a nonreactive species in groundwater transport modeling, overestimating its contribution to total dose

Results from ANL-WIS-PA-000004 Rev. 00 ICN 00 ("one-on analysis" Case 12)

YUCCA MOUNTAIN PROJECT

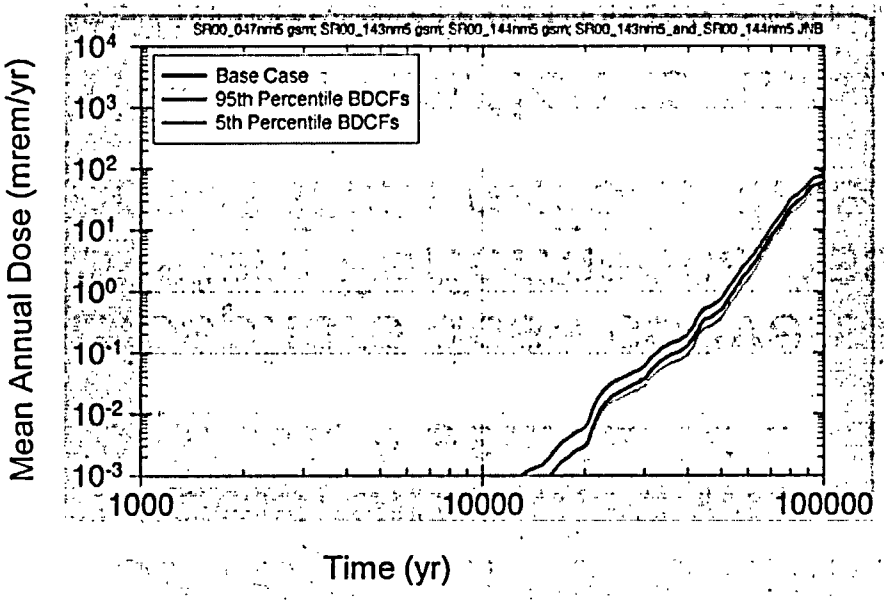
Contributors to Nominal Performance Dose 2002 Analyses (page 2 of 2)

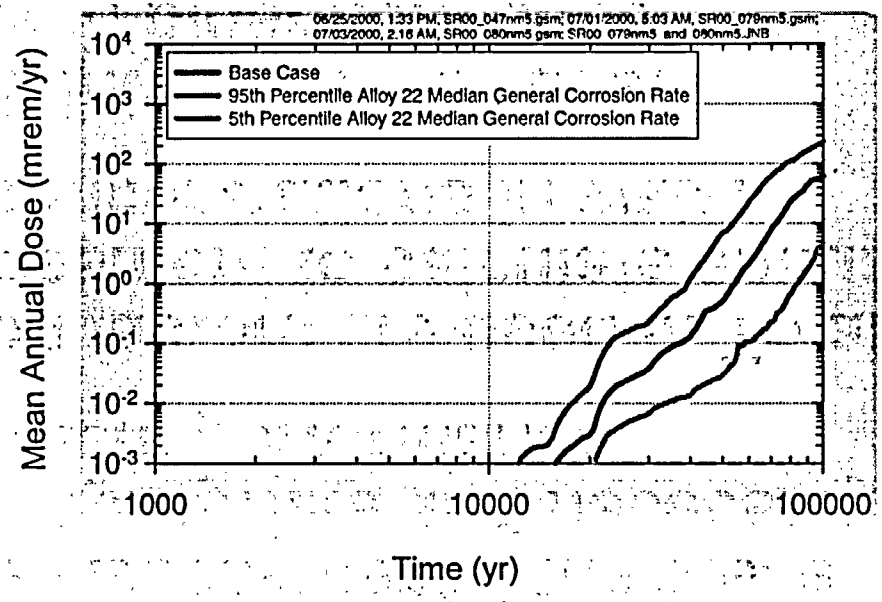


Results from ANL-WIS-PA-000004 Rev. 00 ICN 00 ("one-on analysis" Case 12)

YUCCA MOUNTAIN PROJECT

Sensitivity to Biosphere Dose Conversion Factor Uncertainty Examples from Total System Performance Assessment-Site Recommendation Nominal Performance





TSPA-SR Rev. 00 ICN 01 Figures 5.2-15 (left) and 5.2-9 (right)

Mean annual dose for 100,000 years, nominal performance, calculated with sampled values for all parameters ("Base Case"), and Biosphere Dose Conversion Factor values fixed at 95th and 5th percentiles (left) compared to results calculated with the Alloy 22 median general corrosion rate fixed at 95th and 5th percentile values (right). All other Total System Performance Assessment models and parameter values (both sampled and fixed) are the same in each case. Means are based on 100 realizations.

Summary

- Detailed models characterize water flow, radionuclide transport, and other important processes through the major components of the system
- Total System Performance Assessment links these models, simplified where appropriate and necessary, to provide estimates of system performance
- Biosphere dose conversion factors are used in Total System Performance Assessment to calculate annual doses from radionuclide concentrations in water
- The contribution to uncertainty in overall dose estimates from uncertainty in biosphere dose conversion factors is less than that from other model components (e.g., waste package performance, groundwater transport)

Backup

References

- "Total System Performance Assessment - Site Recommendation"
  - CRWMS M&O 2000. *Total System Performance Assessment for the Site Recommendation.* TDR-WIS-PA-000001 REV 00 ICN 01. Las Vegas, Nevada: CRWMS M&O. ACC: MOL.20001220.0045
- "Total System Performance Assessment - Supplemental Science and Performance Analysis"
  - BSC (Bechtel SAIC Company) 2001. *FY01 Supplemental Science and Performance Analyses, Volume 2: Performance Analyses.* TDR-MGR-PA-000001 REV 00. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20010724.0110
- "Total System Performance Assessment - Final Environmental Impact Statement"
  - Williams, N.H. 2001. "Contract No. DE-AC08-01RW12101 – Total System Performance Assessment – Analyses for Disposal of Commercial and DOE Waste Inventories at Yucca Mountain – Input to Final Environmental Impact Statement and Site Suitability Evaluation REV 00 ICN 02." Letter from N.H. Williams (BSC) to J.R. Summerson (DOE/YMSCO), December 11, 2001, RWA:cs-1204010670, with enclosure. ACC: MOL.20011213.0056 (SL986M3, Rev. 00)
- "One-Off Analyses"
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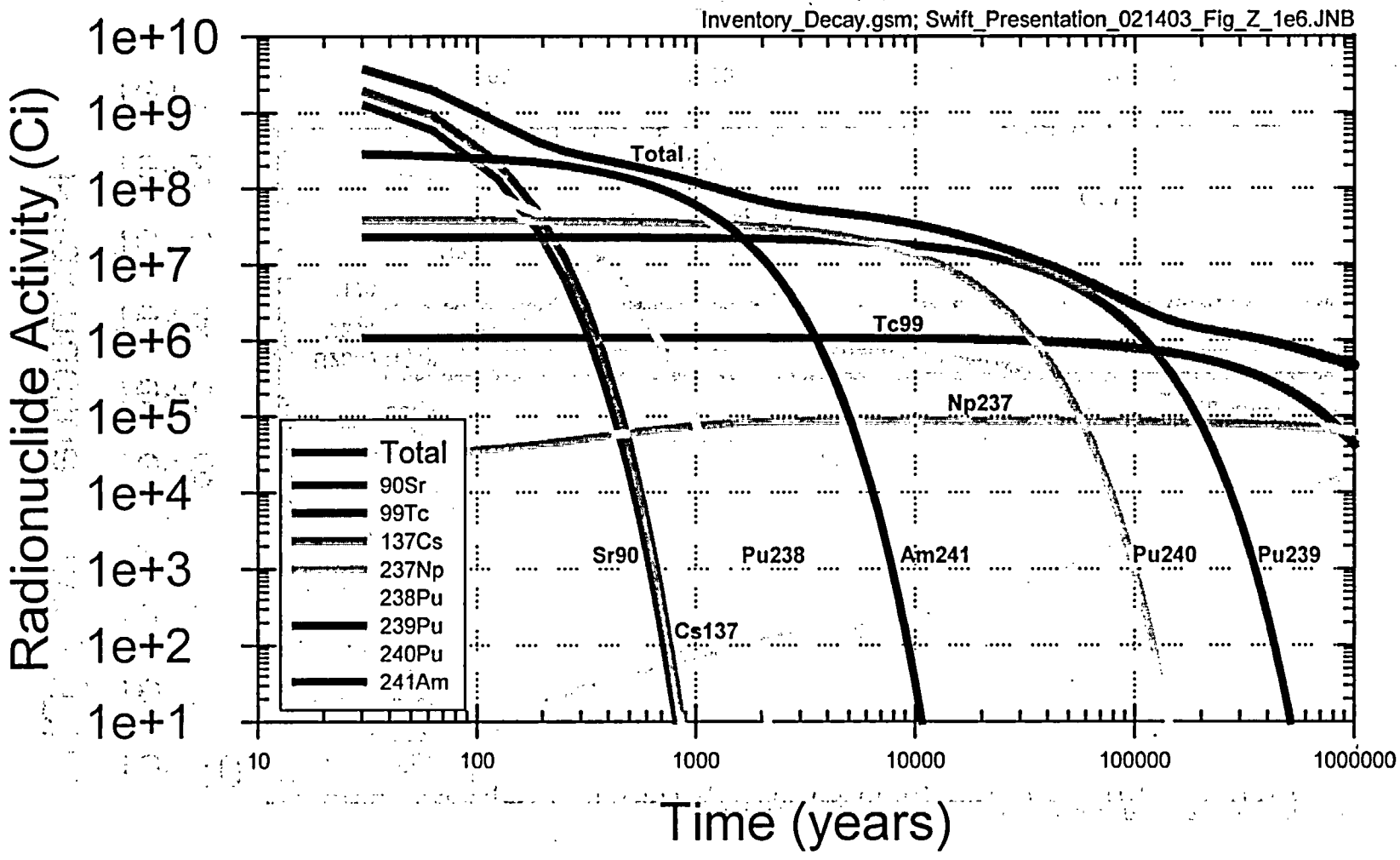
- "One-On Analysis"
  - Saulnier, G. J., 2002. *Use of One-on Analysis to Evaluate Total System Performance.* Las Vegas, NV: Bechtel SAIC Company. ANL-WIS-PA-000004 Rev. 00 ICN 00

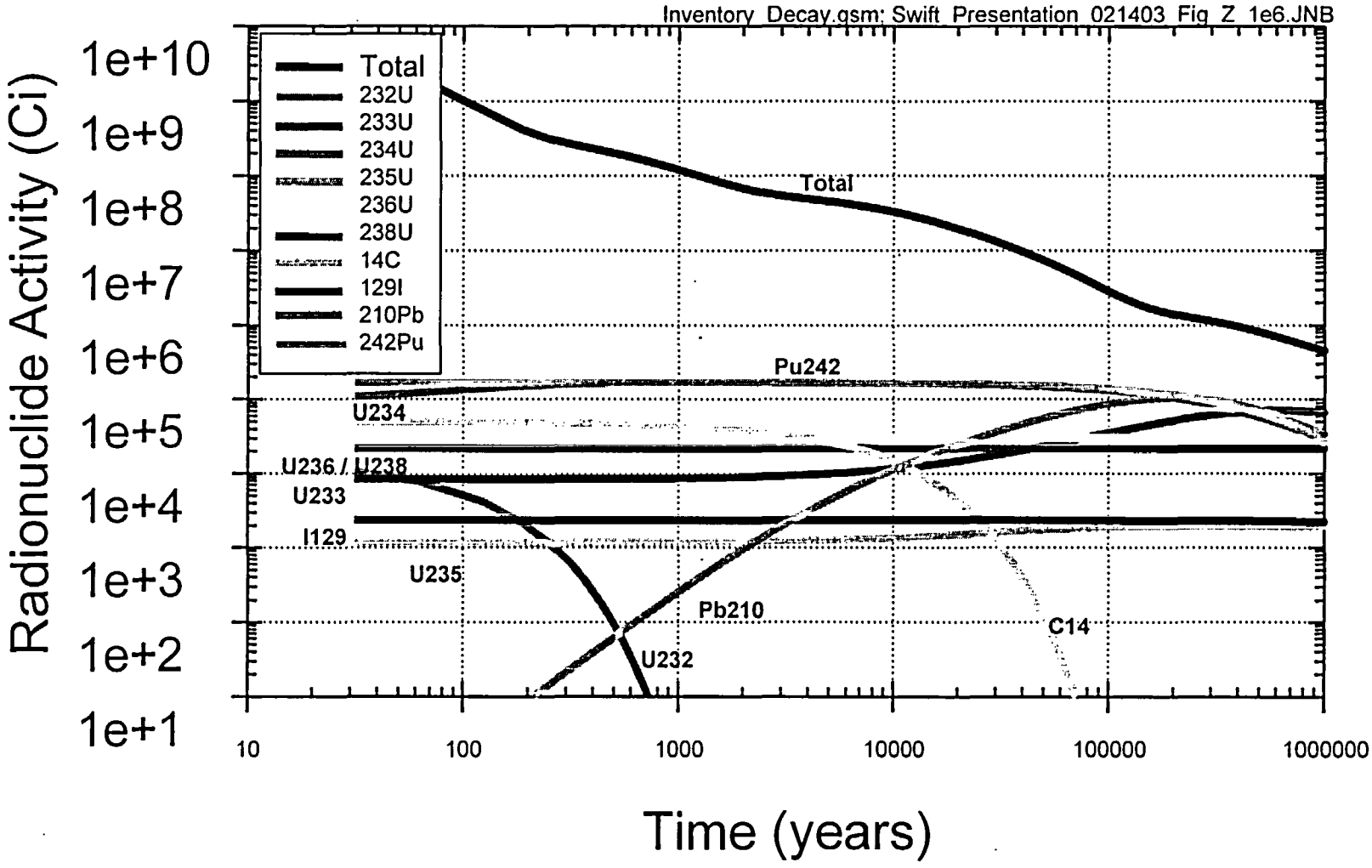
Yucca Mountain Radionuclide Inventory
(page 1 of 3)



Initial inventory from Total System Performance Assessment - Site Recommendation, adjusted for radioactive decay and ingrowth

YUCCA MOUNTAIN PROJECT

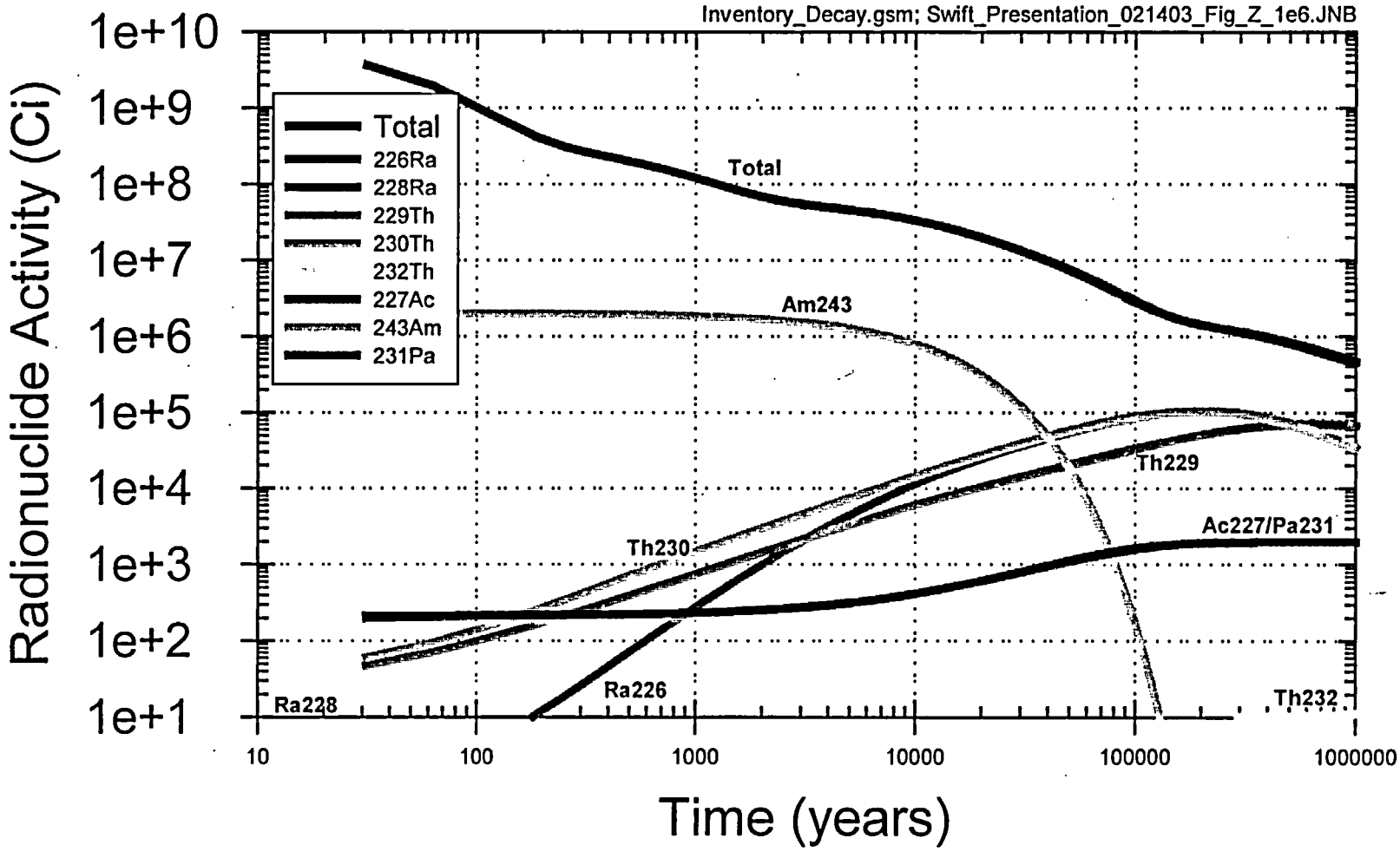
Yucca Mountain Radionuclide Inventory
(page 2 of 3)



Initial inventory from Total System Performance Assessment - Site Recommendation, adjusted for radioactive decay and ingrowth

YUCCA MOUNTAIN PROJECT

Yucca Mountain Radionuclide Inventory
(page 3 of 3)



Initial inventory from Total System Performance Assessment - Site Recommendation, adjusted for radioactive decay and ingrowth

YUCCA MOUNTAIN PROJECT

U.S. Department of Energy
Office of Civilian Radioactive Waste Management

YUCCA MOUNTAIN PROJECT

Yucca Mountain Biosphere Model for Postclosure Performance Assessment

Presented to:
Advisory Committee on Nuclear Waste

Presented by:
Kurt Rautenstrauch
Bechtel SAIC Company, LLC

February 24, 2004
Rockville, Maryland

Outline

- Describe basis for and development of the U.S. Department of Energy's biosphere conceptual model
- Describe the model structure and function
- Summarize uncertainty and results

Purpose of Biosphere Model

- Track the transport of radionuclides through the reference biosphere
- Calculate radionuclide concentrations in important environmental media
- Calculate annual exposure to a human receptor from radionuclides in environmental media

Environmental Radiation Model for Yucca Mountain, Nevada - ERMYN

- Developed in 2003 to support the Performance Assessment for the License Application
- Improvements:
  - Additional pathways (e.g., evaporative cooler)
  - Ability to define values for and stochastically sample all parameters
  - Transparency of the model
- Mathematical methods were selected from review of applicable environmental radiation models
- Input parameter distributions also revised for license application

Relation to Total System Performance Assessment Model

- Environmental Radiation Model for Yucca Mountain, Nevada is run independently of Performance Assessment
- Because radionuclide concentrations are not known when biosphere model is run, the output of the model is biosphere dose conversion factors
  - Annual total effective dose equivalent per unit concentration of a radionuclide in:
    - Groundwater
    - Volcanic ash
- Biosphere dose conversion factors are multiplied by predicted concentrations to estimate annual dose

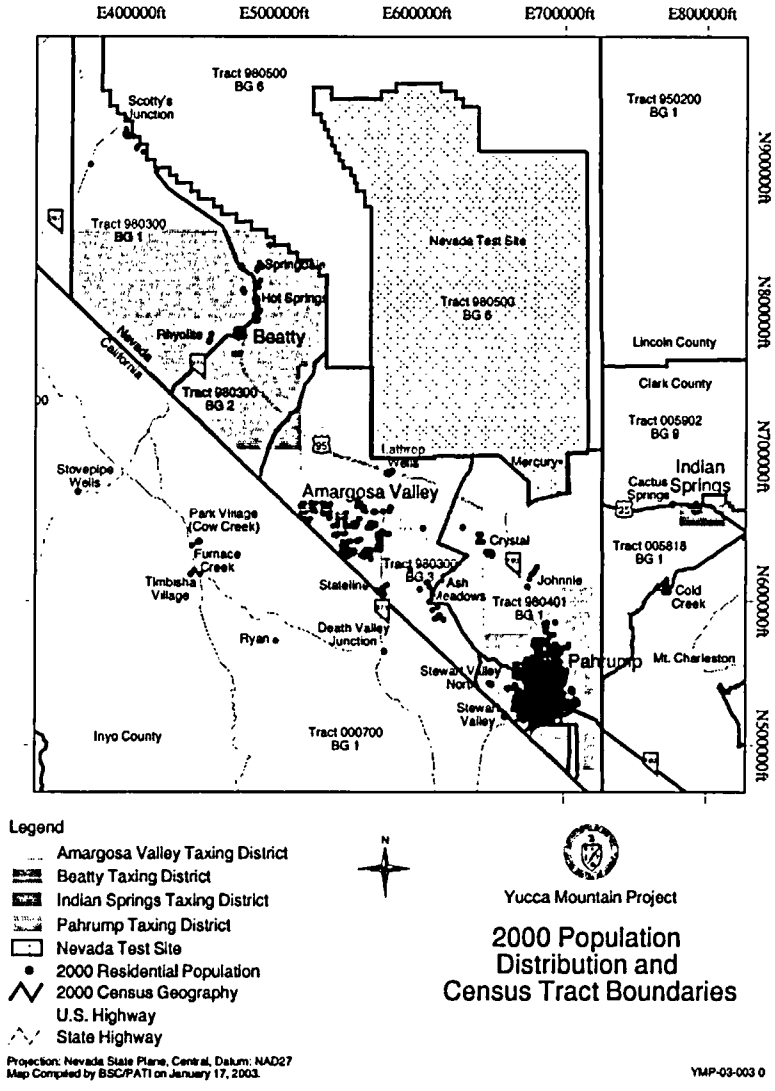
Biosphere Exposure Scenarios

- Environmental Radiation Model for Yucca Mountain, Nevada considers two exposure scenarios:
  - Groundwater - to be used for all Performance Assessment modeling cases that evaluate consequences of groundwater releases of radionuclides
  - Volcanic Ash - for the evaluation of the consequences of exposure to ash from a volcanic eruption
- Separate conceptual and mathematical models have been developed for each scenario
- Remainder of presentation focuses on the model for the groundwater scenario

Development of Conceptual Model

- Characterize reference biosphere and human receptor based on requirements in 10 CFR 63:
  - Consistent with present conditions of Yucca Mountain region
  - Changes in reference biosphere other than climate not considered
  - Pathways are consistent with arid to semi-arid conditions
  - Diet and living style representative of people of Amargosa Valley
  - Drinks 2 liters of well water per day
- Identify applicable features, events, and processes
- Develop a radionuclide transfer interaction matrix
- Develop submodels and important assumptions

Reference Biosphere Population and Infrastructure

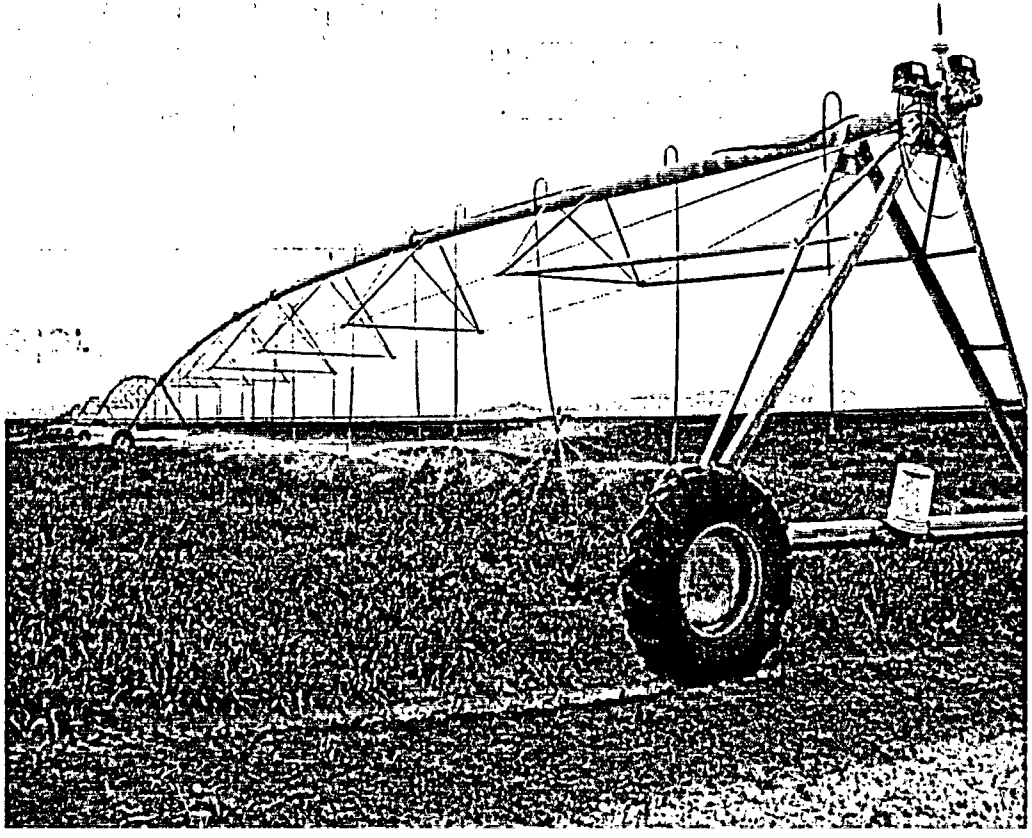


- Amargosa Valley has about 1,180 people in 430 households (2000 census)
- Limited shopping, recreational, and medical facilities
- Most employment centers more than 20 miles away
- Water comes from local groundwater wells and is not treated prior to use

YUCCA MOUNTAIN PROJECT

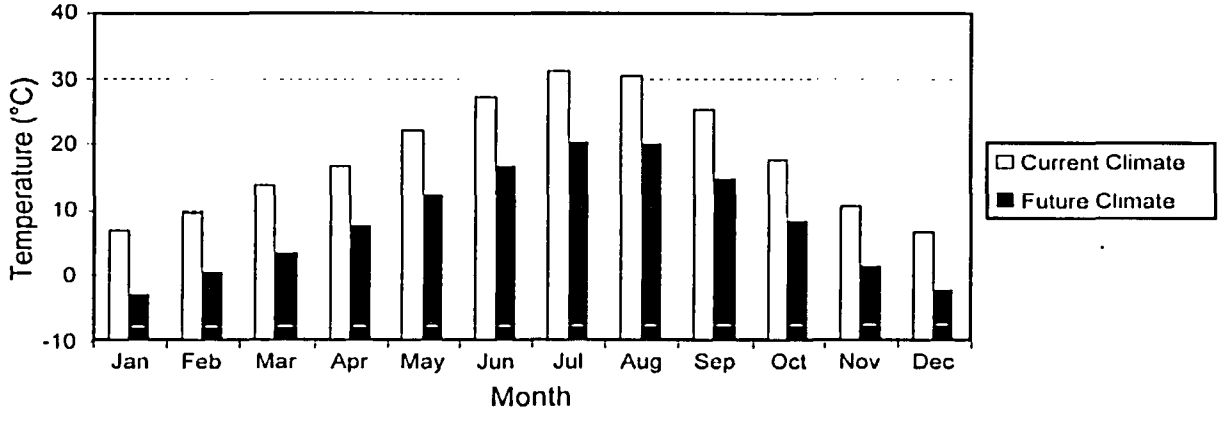
Reference Biosphere - Agriculture

- Amargosa Valley has a small agricultural industry
  - About 2,000 acres are commercially farmed
  - 90 percent is alfalfa and other hay
  - Dairy with more than 5,000 head
  - Fish farm operational in 1990s
  - All farmland is irrigated
- Soils are deep, well drained sands and sandy loams



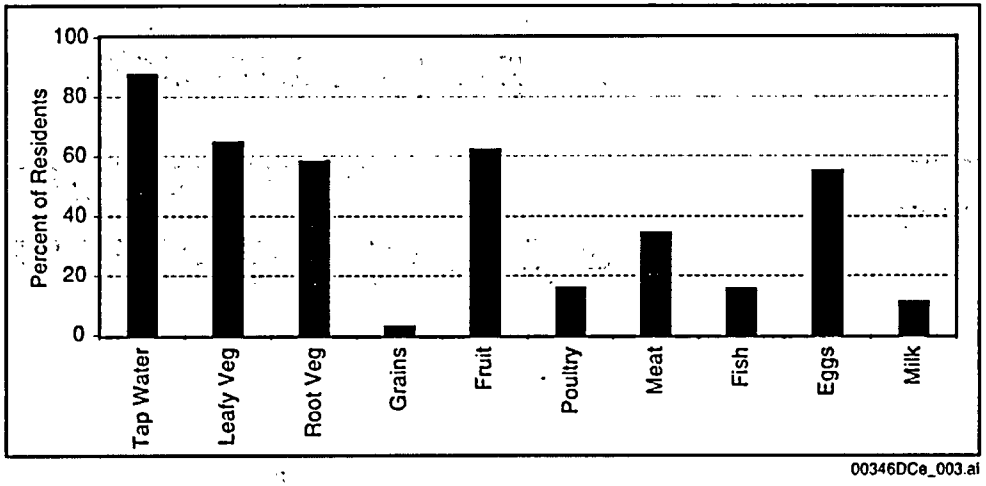
Reference Biosphere - Climate

- Current climate
  - 100 mm annual precipitation
  - Average monthly temperatures range from 6.9 to 31.0°C
- Dominant Future Climate
  - Upper bound analog is eastern Washington
  - 400 mm precipitation
  - Temperatures about 10°C cooler



Receptor Characteristics - Diet

- Information on frequency of consumption of locally produced food from 1997 survey of Amargosa Valley residents
- Locally produced foods comprise a small portion of total diet
- Consume about 1.9 liters of tap water per day

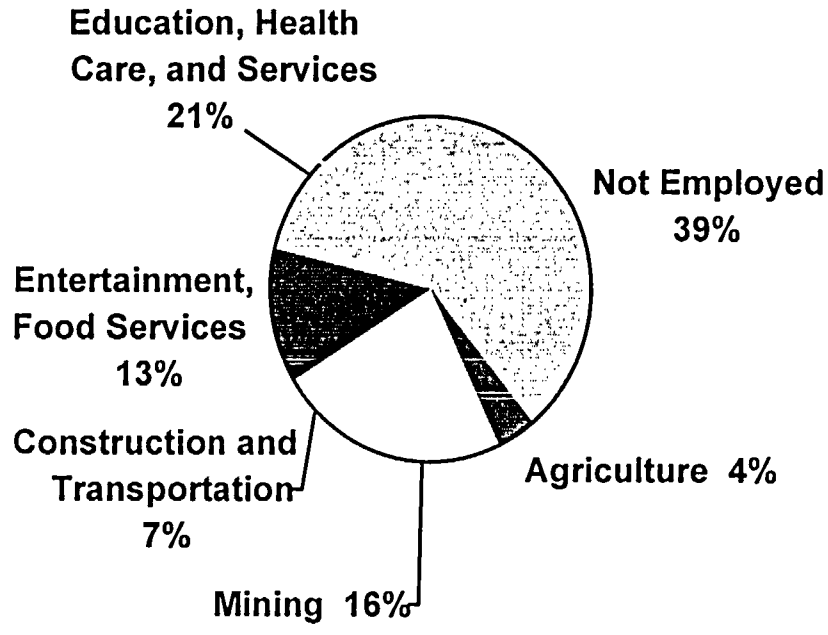


Percent of Amargosa Valley residents surveyed that consumed any tap water or locally produced foods

YUCCA MOUNTAIN PROJECT

Receptor Characteristics - Employment

- Information from the 2000 census
- 39 percent retired or otherwise unemployed
- Mining is largest industry of employment
- 4 percent of residents worked in agriculture
- Used to develop time budgets



Industry of Employment - Amargosa Valley Residents (2000 Census)

Receptor Characteristics

- 46 percent of households surveyed in 1997 had gardens
- 64 percent of employed residents commuted more than 10 minutes (one way) to work and 21 percent commuted more than 35 minutes
- 91 percent of the population of Amargosa Valley lived in mobile homes during 2000
- 73 percent of residents surveyed in 1997 used evaporative coolers and they used them for about 5 months per year

Features, Events, and Processes

- Of 48 biosphere-related features, events, and processes:
  - 13 were excluded because the process is inconsistent with 10 CFR 63 (e.g., human influence on climate, changes in agricultural practices)
  - 4 were excluded because of low probability or low consequence (e.g., glacial and ice sheet effect, animal burrowing)
  - The other 31 were implemented in the biosphere model

Environmental Media

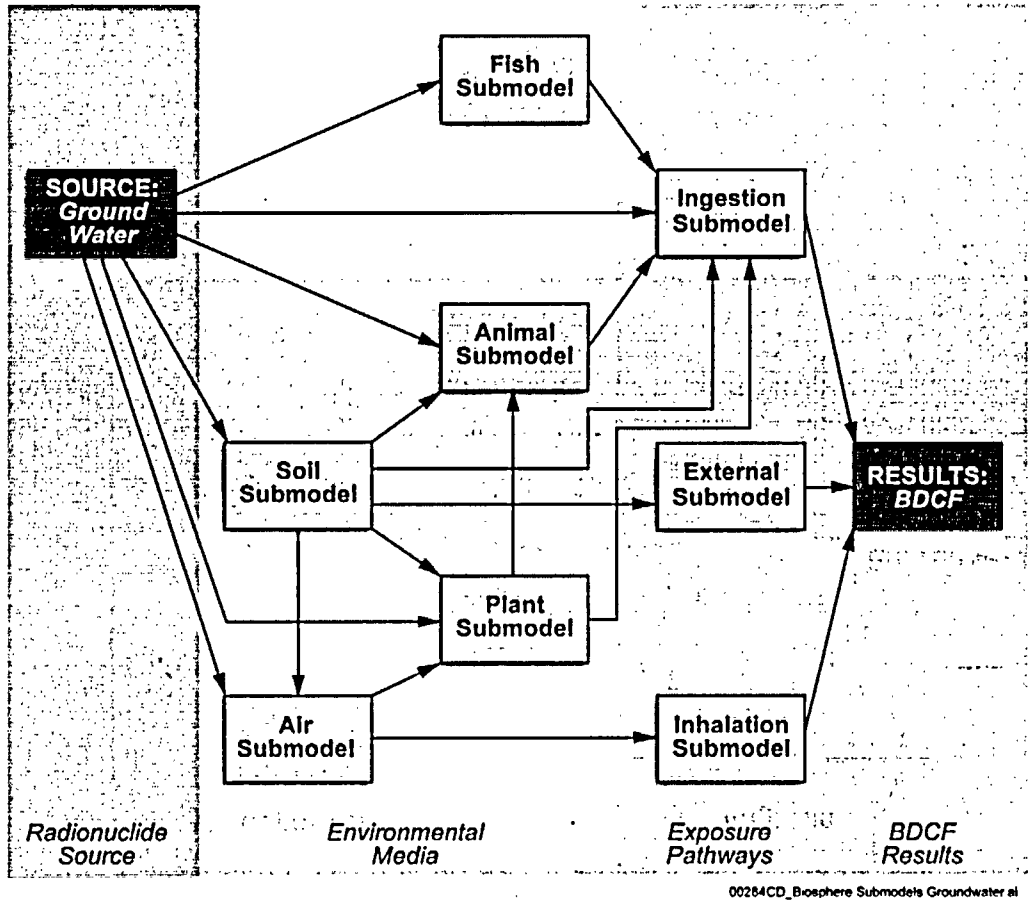
- Use of groundwater could result in radionuclide concentrations in 6 environmental media to which the receptor may be exposed
  - Groundwater
  - Irrigated soil
  - Indoor and outdoor air
  - Crops consumed by the receptor and by farm animals
  - Animal products consumed by the receptor
  - Fish raised at a fish farm and consumed by the receptor
- This could result in 3 exposure pathways
  - Ingestion exposure
  - Inhalation exposure
  - External exposure

Radiation Transfer Interaction Matrix
Groundwater Scenario

i,j	1	2	3	4	5	6	7
1	**SOURCE** (groundwater)	irrigation	evaporation	irrigation interception	ingestion of water	bio-accumulation (water use in fisheries)	drinking water ingestion
2	leaching	**SURFACE SOIL**	particle resuspension, gas release, soil erosion	root uptake	soil ingestion	-	soil ingestion, external exposure
3	-	dust deposit	**AIR**	dust deposition, photosynthesis	-	-	Inhalation of particulates, gases, and aerosols
4	-	weathering, harvest removal	-	**PLANTS** (crops)	ingestion of feed	-	crop ingestion
5	-	fertilization	-	-	**ANIMALS** (animal products)	-	animal product ingestion
6	-	-	-	-	-	**FISH**	fish ingestion
7	-	-	-	-	-	-	**HUMAN** (receptor)

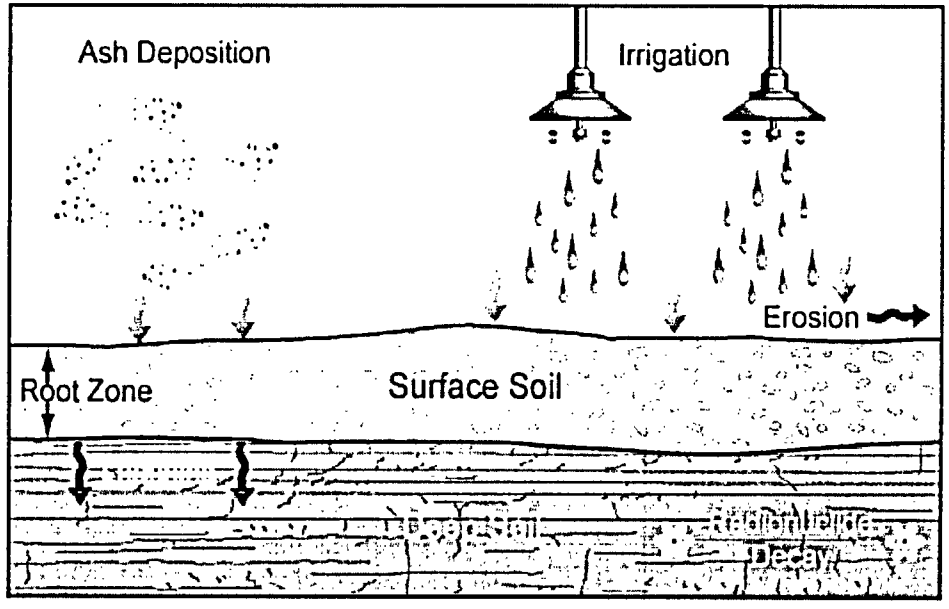
Model Structure

- Model organized based on
  - 5 submodels for environmental media
  - 3 submodels for exposure pathways
  - Special submodel for environmental transport of carbon-14
- Same methods used for all radionuclides



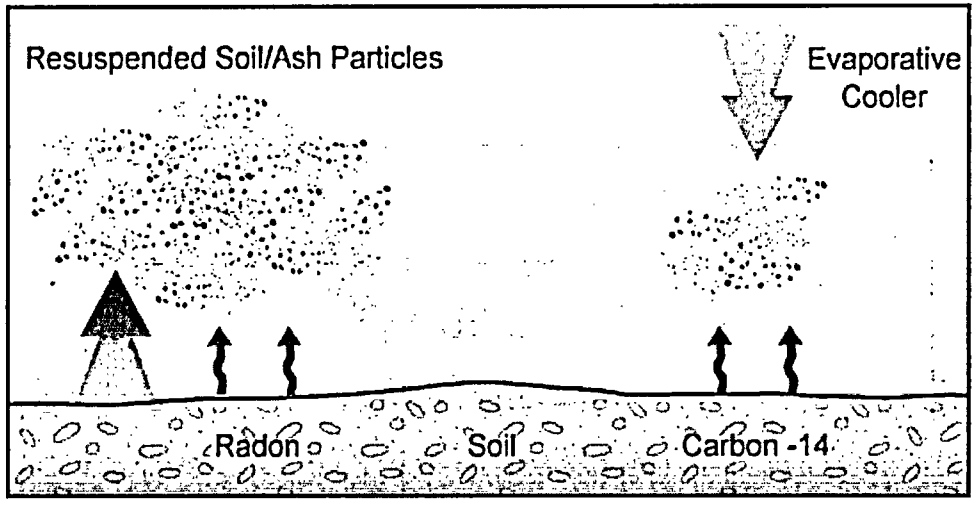
Soil Submodel

- Calculates concentrations in surface soil from addition of irrigation water
- Includes 3 loss pathways:
  - Erosion
  - Leaching
  - Radionuclide decay
- Important assumption:
  - Saturation concentrations
- Irrigation rate about 50 percent lower for upper bound of future climate
- Large uncertainty in leaching rates



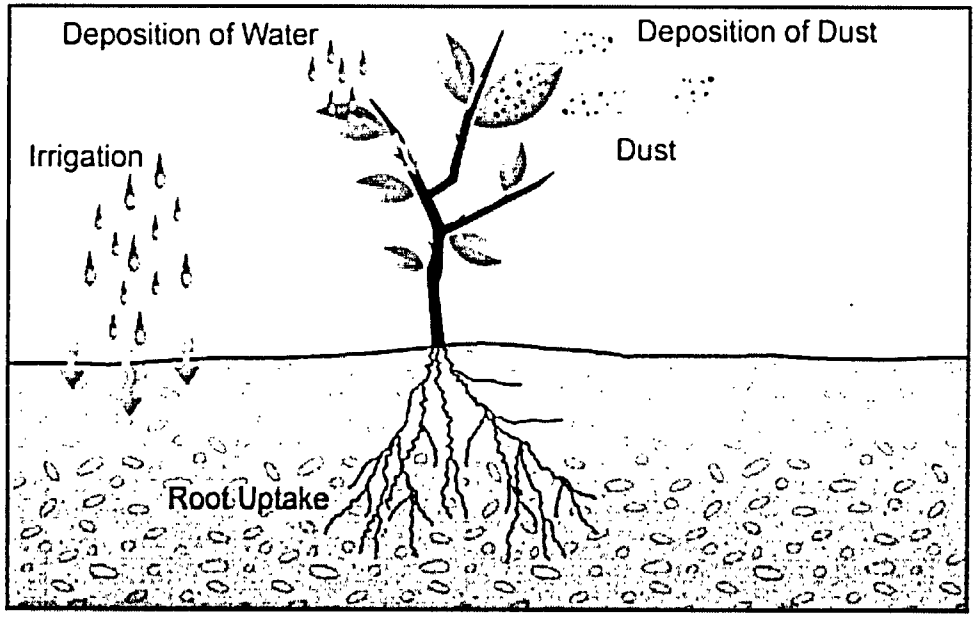
Air Submodel

- Calculates concentrations in air from:
  - Dust resuspension
  - Evaporative cooler
  - Radon-222
- 5 environments considered
  - Outdoor: active and inactive
  - Indoor: active and asleep
  - Around plants
- Large variation among environments in concentrations of resuspended soil (mass loading)
- Moderate to large uncertainty in resuspension enhancement factor and evaporative cooler transfer fraction



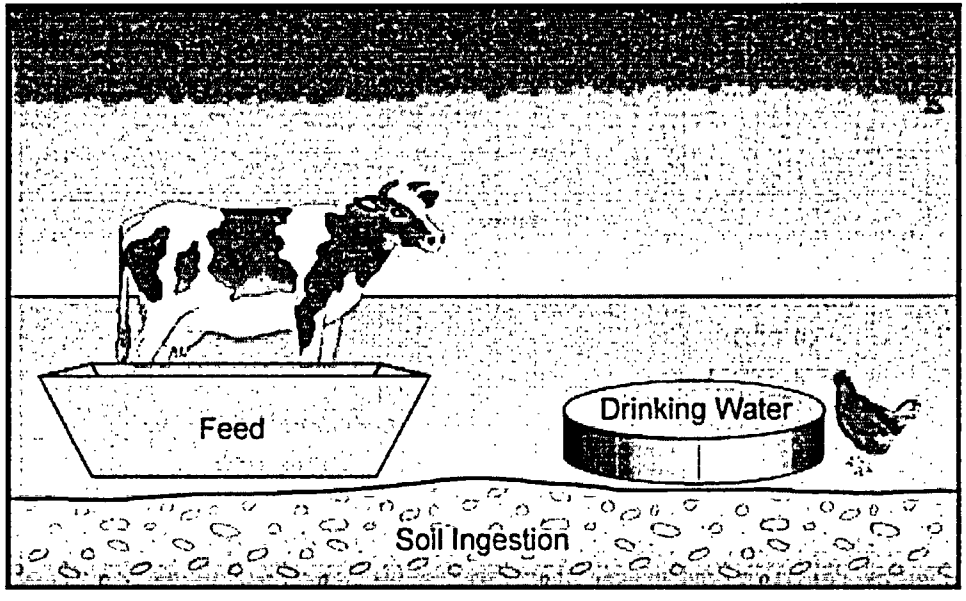
Plant Submodel

- Calculates concentrations in foodstuffs from:
  - Deposition of irrigation water
  - Deposition of dust
  - Root uptake
- Five crop types considered
  - Leafy vegetables
  - Other vegetables
  - Fruits
  - Grains
  - Cattle forage
- Large uncertainty in transfer factors



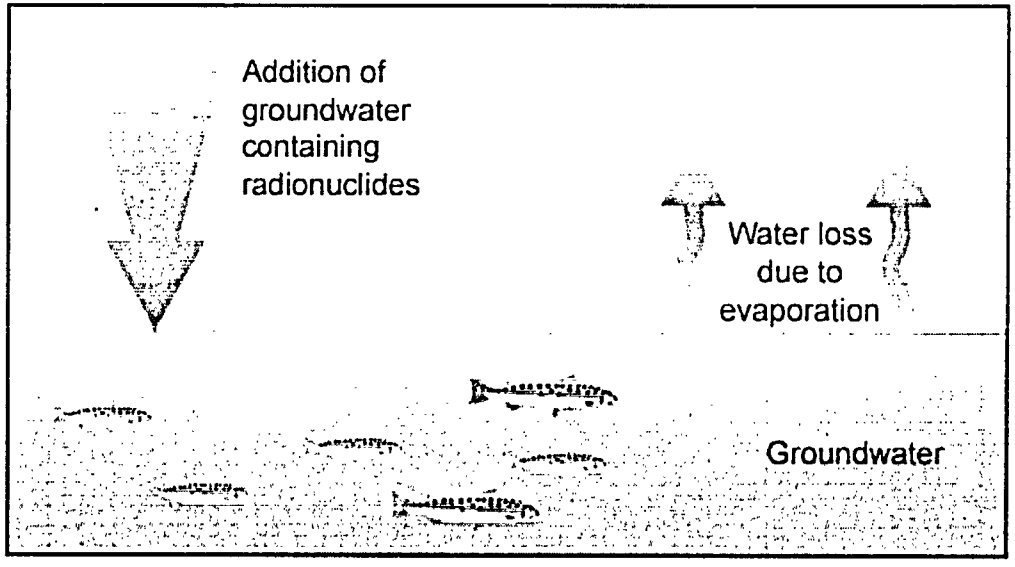
Animal Submodel

- Calculates concentrations in animal products from ingestion of feed, water, and soil
- 4 products considered:
  - Meat (beef, pork, game, etc.)
  - Poultry (chicken, duck, etc.)
  - Milk
  - Eggs
- Animals are assumed to consume only locally produced food
- Large uncertainty in transfer coefficients



Fish Submodel

- Included because of fish farm in Amargosa Valley
- Increase in concentrations due to evaporation and replacement of water included in calculation
  - 2 to 6 times increase for modern climate
  - 1.5 to 3 times increase for future climate
- Large uncertainty in bioaccumulation factor



Carbon-14 Special Submodel

- Calculates carbon-14 concentrations in surface soil, air, crops, and animal products
- Concentrations calculated based on proportion of carbon-14 to stable carbon in environmental media
- Applies only to environmental transport of carbon-14
- Annual exposure to carbon-14 is calculated using the same methods as other radionuclides

Exposure Calculations

- Calculated as
  - Exposure Rate × Media Concentration × Dose Conversion Factor
- Dose conversion factors from Federal Guidance Reports 11 and 12
- Dose contributions of short-lived decay products included in dose conversion factors
- Dose contribution of long-lived decay products calculated separately and added to dose of parent radionuclide

Ingestion Exposure

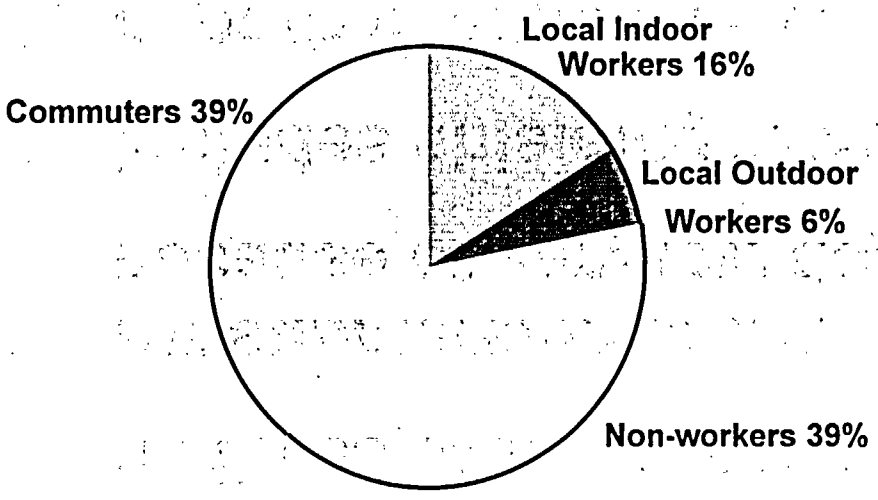
- Food consumption rate based on 1997 survey of Amargosa Valley residents
- Water consumption = 2 liters
- Includes inadvertent soil ingestion
- Most important pathway for some radionuclides (technetium-99, iodine-129)

Inhalation Exposure

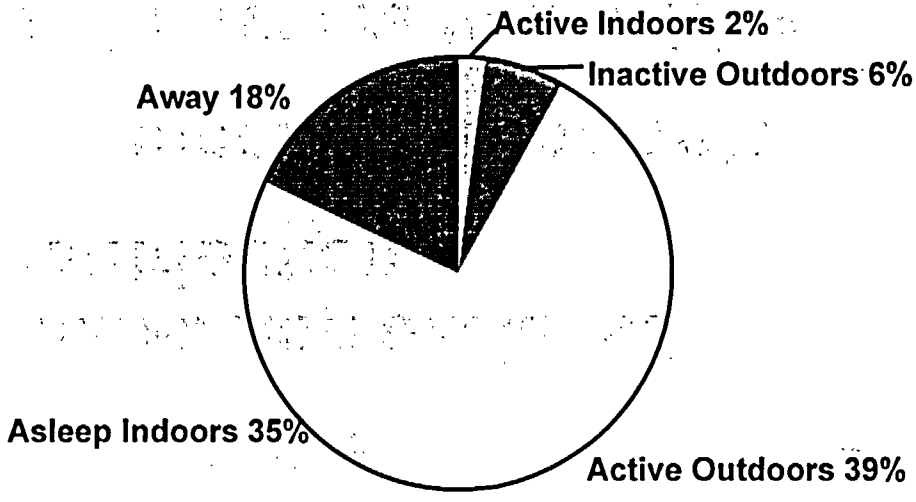
- Includes exposure to resuspended particles, aerosols from evaporative coolers, and gaseous emissions
- Evaporative cooler use averages 39 percent of year for modern climate and 9 percent for upper bound future climate
- Average exposure time calculated for 5 environments and is based on employment characteristics of Amargosa Valley residents
- Most important pathway for actinides (e.g., plutonium-129 and neptunium-237)

Population Proportions and Exposure Times

Population Proportions



Weighted Average Exposure Time



Proportion of commuters and time spent away is lower for the volcanic ash exposure scenario.

External Exposure

- Uses same exposure times as inhalation exposure
- Assumes receptor is exposed to contaminated soil at all times while in reference biosphere
- Air submersion and water immersion excluded because of very low dose contribution
- Includes shielding factor for indoor environments
- Important exposure pathway for two radionuclides (cesium-137 and tin-126)

Parameter Values

- Most parameters were stochastically sampled
- Receptor parameters were based on the distribution of mean values, and environmental parameters were based on entire range of variation [per 10 CFR 63.312(b)]
- Selected reasonable range of values based on site-specific information when possible
- Distribution bounds were selected to incorporate reasonable variation and uncertainty
- Conservative bounds were selected when there was great uncertainty (some radionuclide-specific parameters)

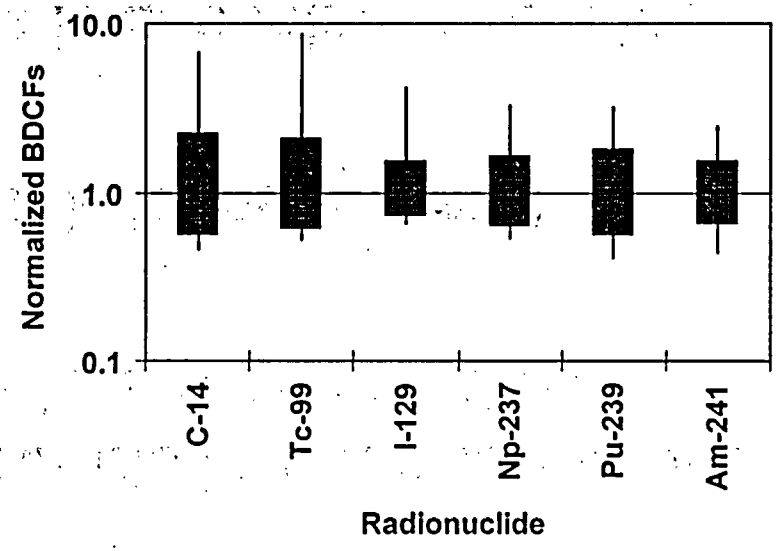
Model Uncertainty

- Conceptual Model Uncertainty
  - Low because all relevant transport and exposure pathways are included and assumptions are reasonable
- Mathematical Model Uncertainty
  - Model validated by comparison to 5 environmental radiation models
  - Few differences in mathematical methods identified
  - Few differences among mathematical methods
- Parameter Uncertainty
  - Low for most parameters that define receptor characteristics, environmental conditions, and agricultural practices
  - High for some radionuclide specific parameters

Results

- Biosphere dose conversion factors generally range by a factor of about 3 to 5 over 95 percent of range
- Total range in variation is about 1.2 orders of magnitude for carbon-14 and technetium-99 and about a factor of 5 to 8 for other radionuclides
- Biosphere dose conversion factors for dominant future climate are about 4 percent (carbon-14) to 20 percent (plutonium-239) lower than modern climate

95% (box) and 100% (line) of Range of BDCFs Normalized to Mean Values for Selected Radionuclides



Summary

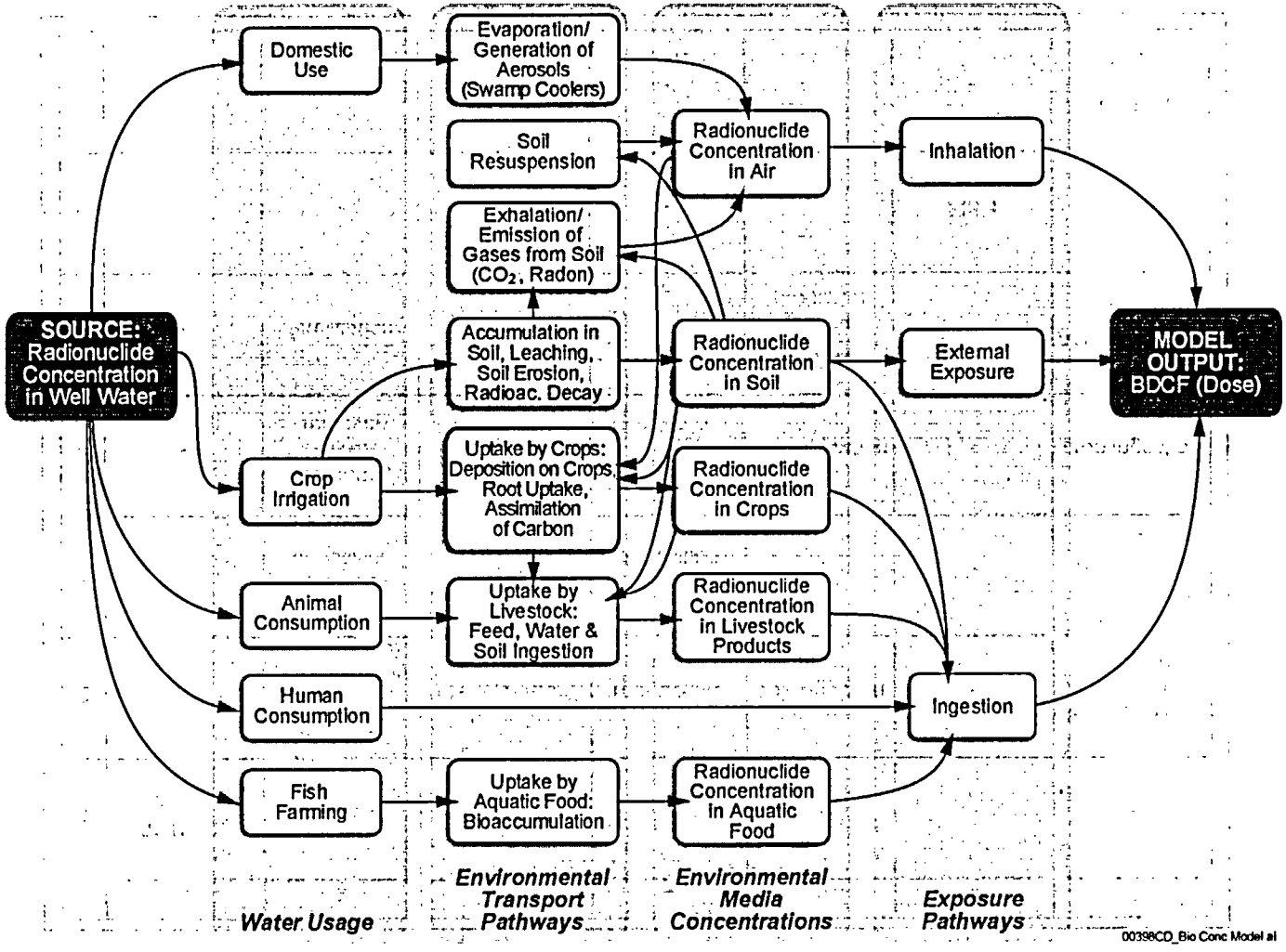
- A new biosphere model has been developed for the license application
- The model is based on site specific information about the Yucca Mountain region and Amargosa Valley population
- Includes all relevant radionuclide transport and exposure pathways
- Most uncertainty in the results is associated with input parameters

Backup

References

- **Model Description:**
  - *Biosphere Model Report.* MDL-MGR-MD-000001 REV 0
- **Input Parameters**
  - *Agricultural and Environmental Input Parameters for the Biosphere Model.* ANL-MGR-MD-000006 REV 1
  - *Characteristics of the Receptor for the Biosphere Model.* ANL-MGR-MD-000005 REV 2
  - *Environmental Transport Input Parameters for the Biosphere Model.* ANL-MGR-MD-000007 REV 1
  - *Inhalation Exposure Input Parameters for the Biosphere Model.* ANL-MGR-MD-000001 REV 2
  - *Soil-Related Input Parameters for the Biosphere Model.* ANL-NBS-MD-000009 REV 1
- **Model Results**
  - *Nominal Performance Biosphere Dose Conversion Factor Analysis.* ANL-MGR-MD-000009 REV 2
  - *Disruptive Event Biosphere Dose Conversion Factor Analysis.* ANL-MGR-MD-000003 REV 2
- **Features, Events, and Processes**
  - Evaluation of Features, Events, and Processes for the Biosphere Model. ANL-MGR-MD-000011 REV 3

Conceptual Representation of the Transport and Exposure Pathways for the Groundwater Exposure Scenario

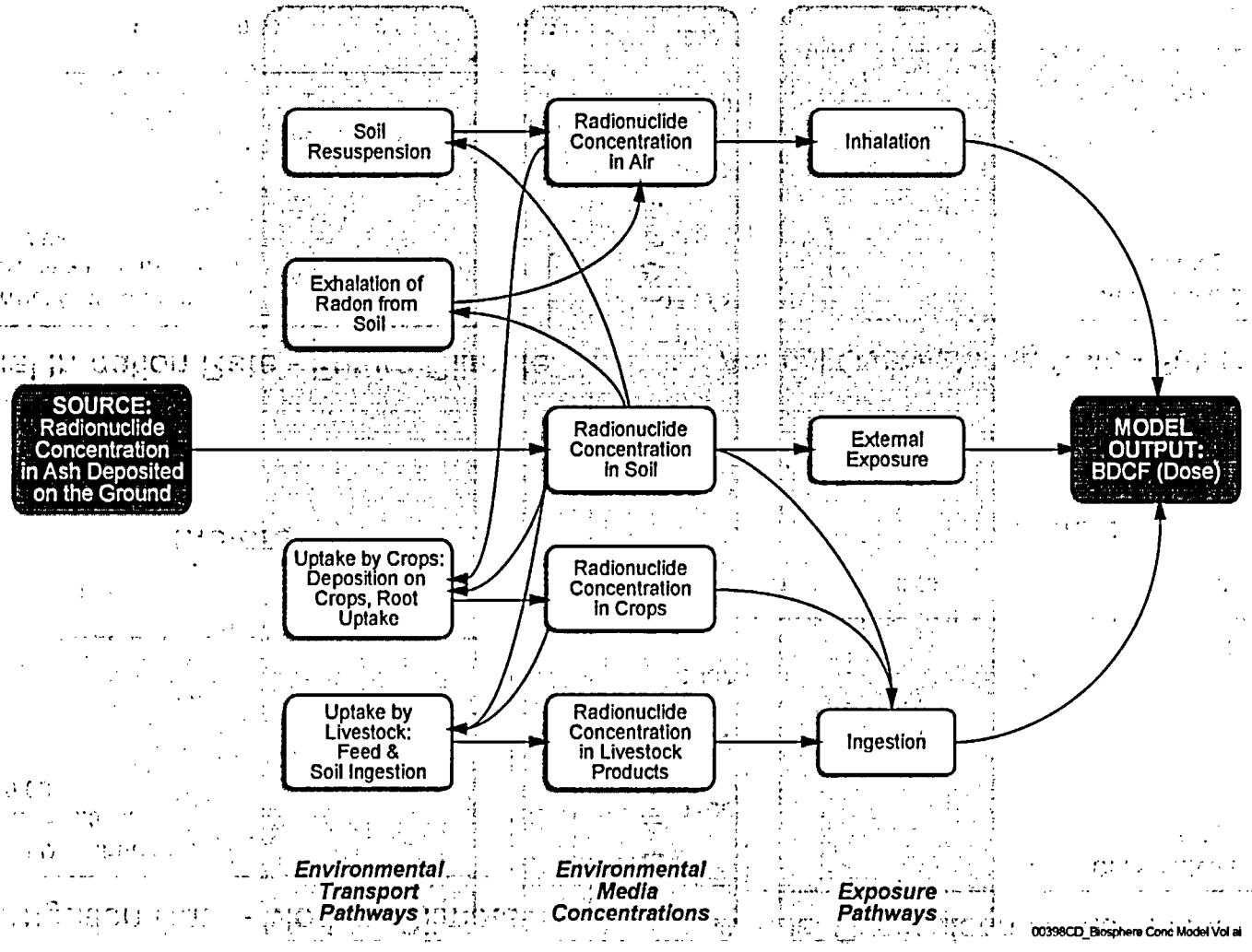


YUCCA MOUNTAIN PROJECT

Radiation Transfer Interaction Matrix
Volcanic Ash Exposure Scenario

(i, j)	1	2	3	4	5	6	7
1	**SOURCE** (volcanic ash)	ashfall	-	-	-	-	-
2	-	**SURFACE SOIL** (ash or ash-soil mixture)	particle resuspension, gas release	root uptake	soil ingestion	-	soil ingestion, ground exposure
3	-	particle deposition	**AIR**	particle deposition	-	-	inhalation of particulates and gas
4	-	weathering, harvest removal	-	**PLANTS** (crops)	feed ingestion	-	crop ingestion
5	-	fertilization	-	-	**ANIMALS** (animal products)	-	animal product ingestion
6	-	-	-	-	-	**FISH**	-
7	-	-	-	-	-	-	**HUMAN** (receptor)

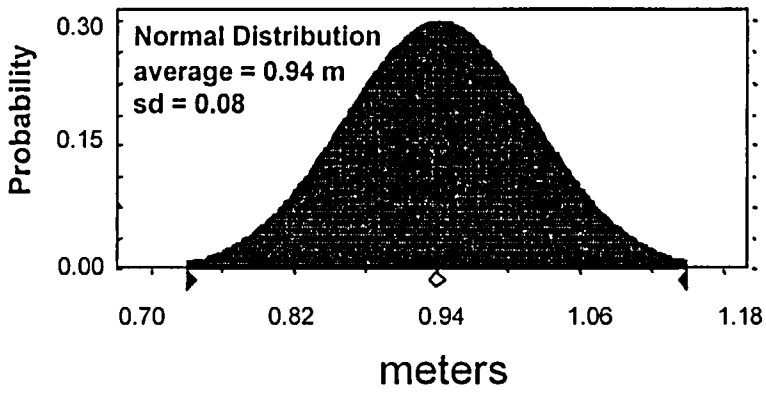
Conceptual Representation of the Transport and Exposure Pathways for the Groundwater Exposure Scenario



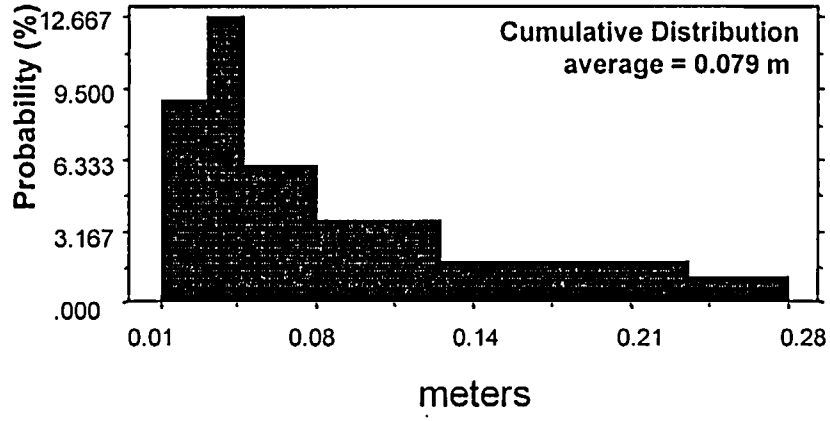
YUCCA MOUNTAIN PROJECT

Selected Parameter Distributions

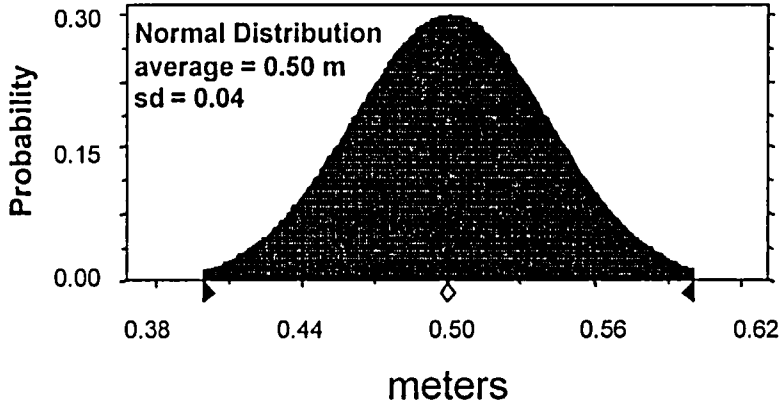
Annual Irrigation Rate - Modern Climate



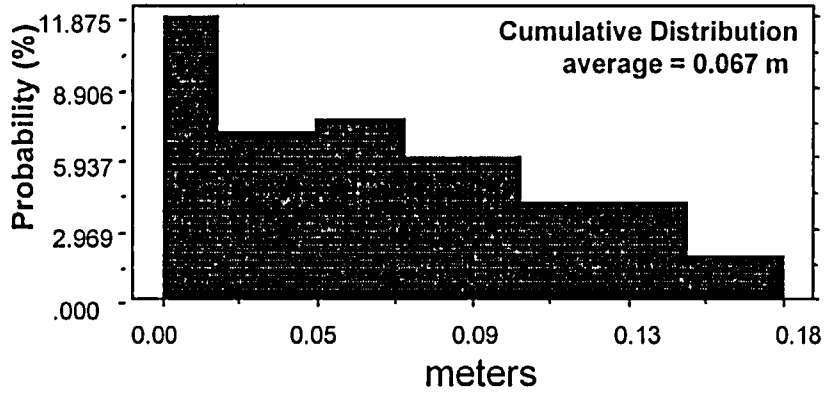
Annual Overwatering Rate - Modern Climate



Annual Irrigation Rate - Future Climate



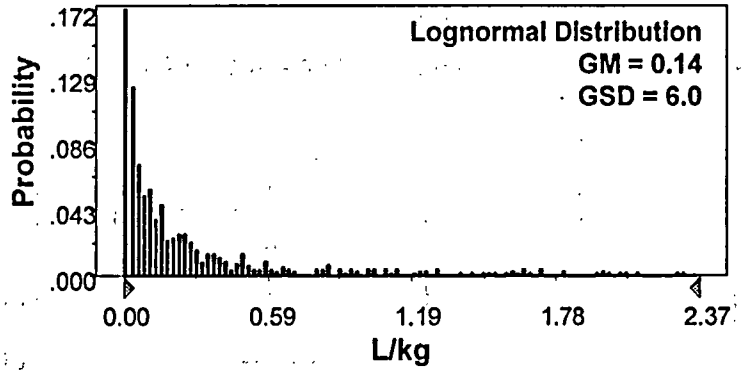
Annual Overwatering Rate - Future Climate



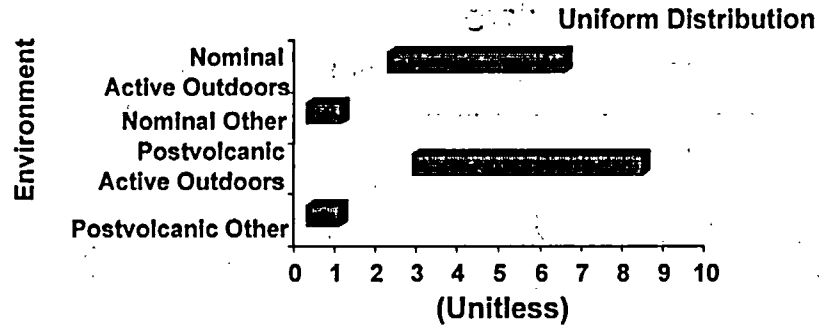
Selected Parameter Distributions

(Continued)

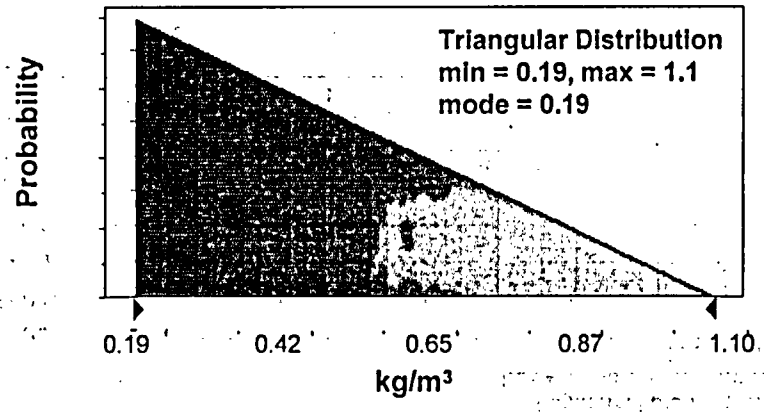
Partition Coefficient - Technetium-99



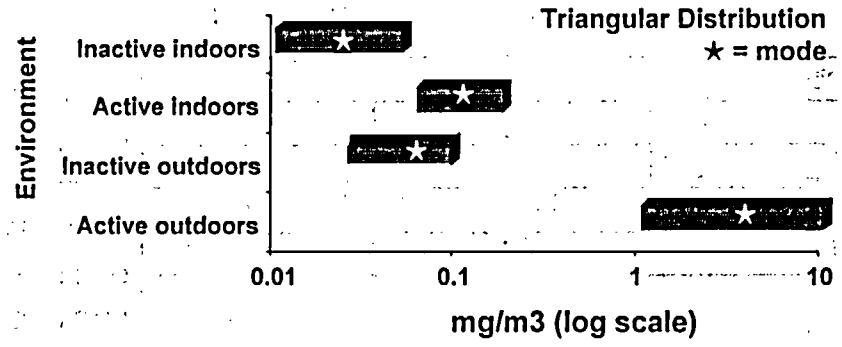
Dust Resuspension Enhancement Factor



Surface Soil Erosion Rate



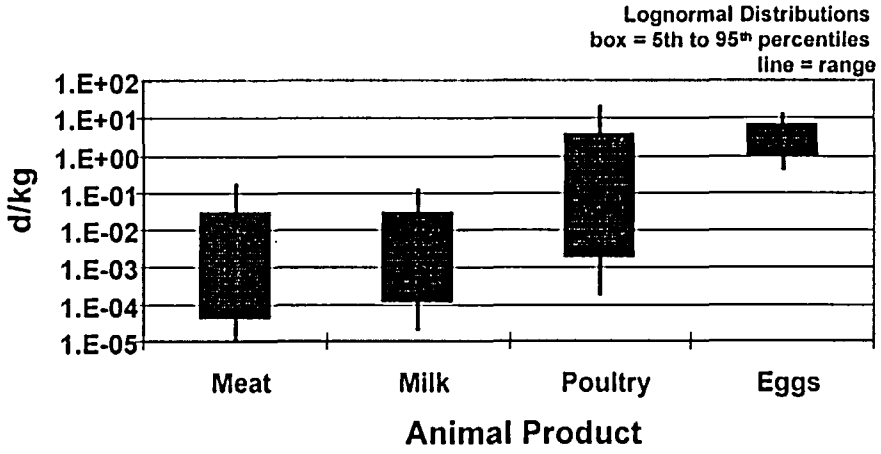
Mass Loading - Nominal



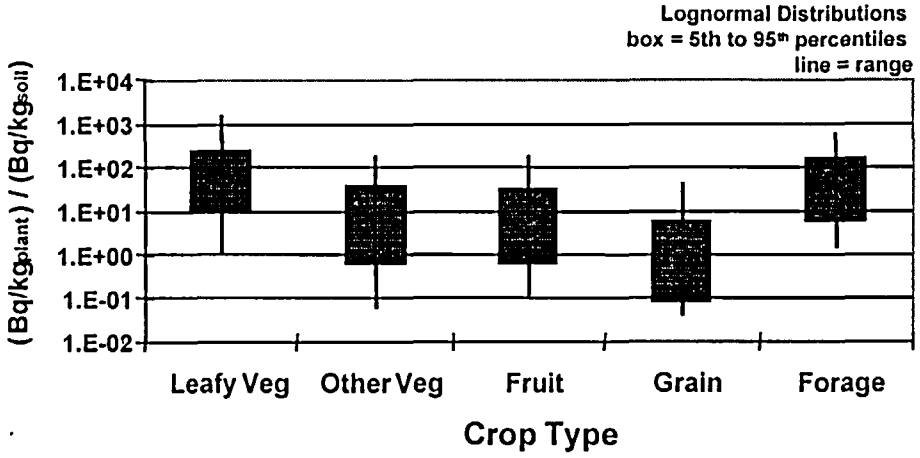
Selected Parameter Distributions

(Continued)

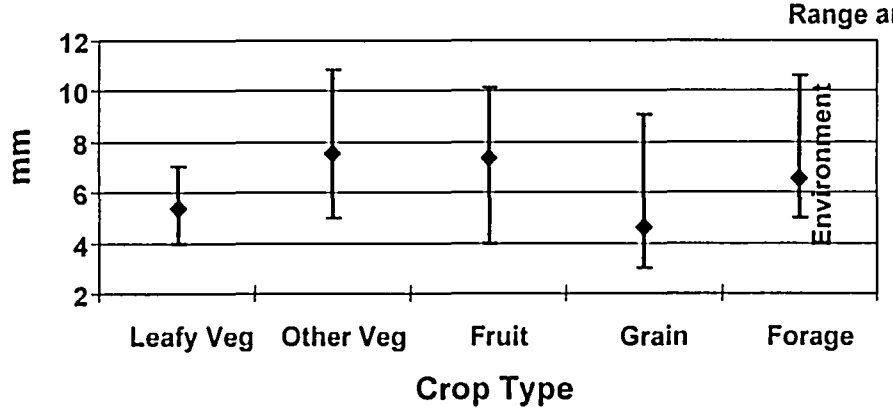
Animal Product Transfer Coefficients Technetium-99



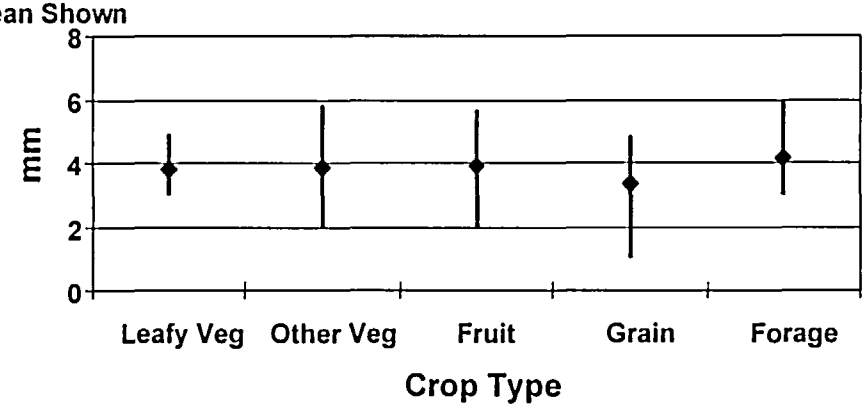
Soil-to-Plant Transfer Factor Technetium-99



Daily Irrigation Rate - Modern Climate



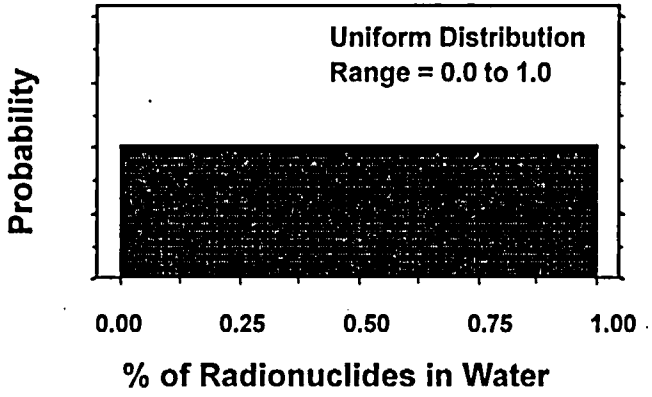
Daily Irrigation Rate - Future Climate



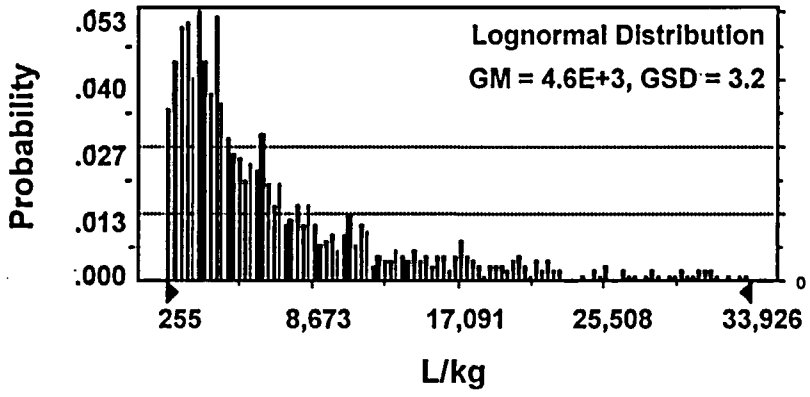
Selected Parameter Distributions

(Continued)

Evaporative Cooler Water Transfer Fraction



C-14 Bioaccumulation Factor



Overview of Biosphere Pathway Analyses Supporting NRC Pre-licensing Activities

Patrick LaPlante 301-881-0289 plaplante@swri.org
Center for Nuclear Waste Regulatory Analyses

148th Meeting of
Advisory Committee on Nuclear Waste
February 24-27, 2004

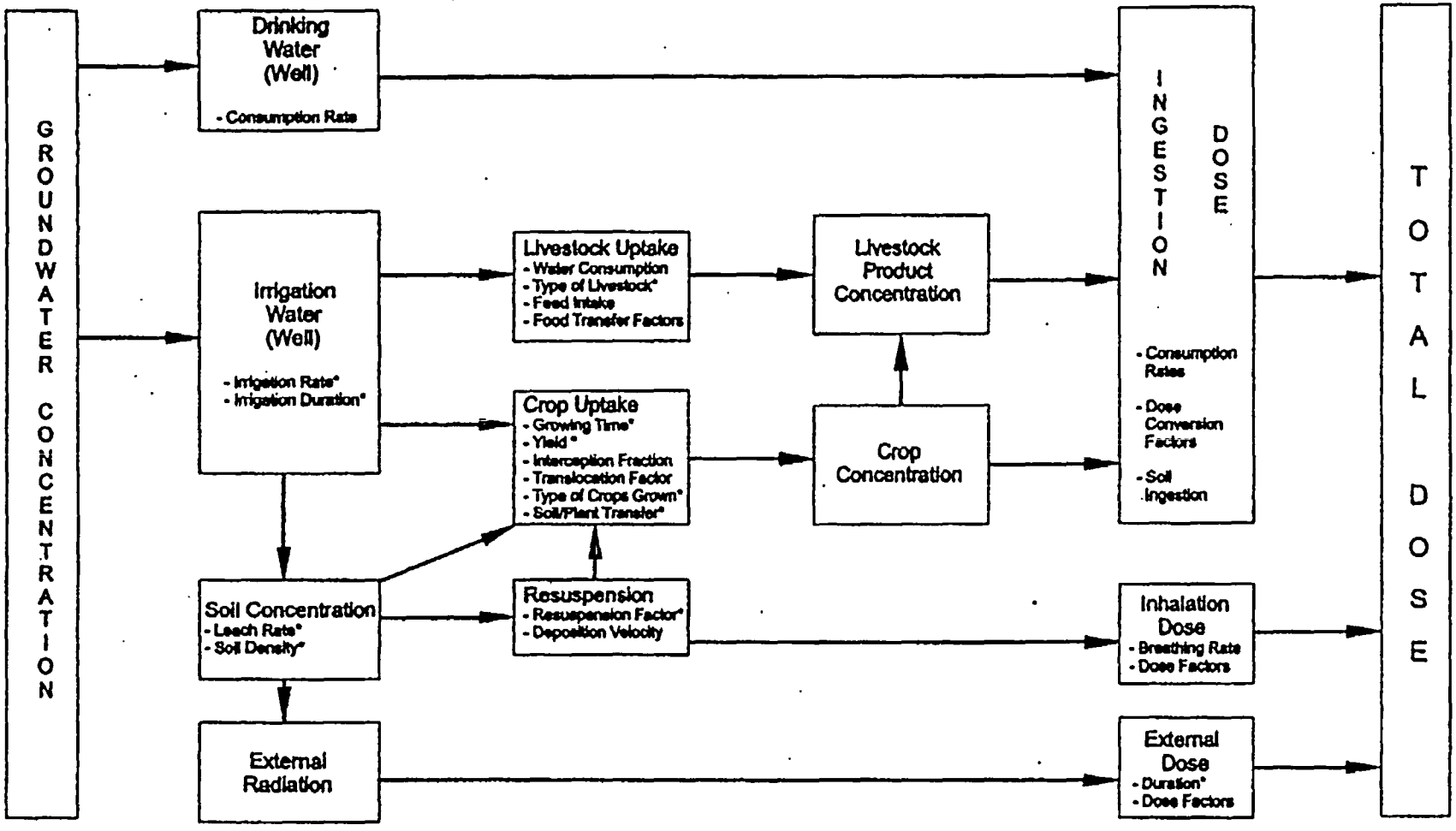
OBJECTIVES

- Provide an Overview of Biosphere Model
- Discuss Key Radionuclides and Exposure Pathways
- Emphasize NRC Role/Objective to Develop Review Capabilities

SATELLITE IMAGE OF YUCCA MOUNTAIN REGION

ACNW Meeting
2/24/04

BIOSPHERE MODEL



* Examples of Site-Specific Parameters

ACNW Meeting
2/24/04

MATHEMATICAL MODELS FOR TPA CODE BIOSPHERE CALCULATIONS

- Selected Pathway Models (Except Inhalation) Based on GENII 1.485
- Developed Mass Loading and Inhalation Pathway Model for Ground Surface
- Used Internal and External Dosimetry Models from Federal Guidance

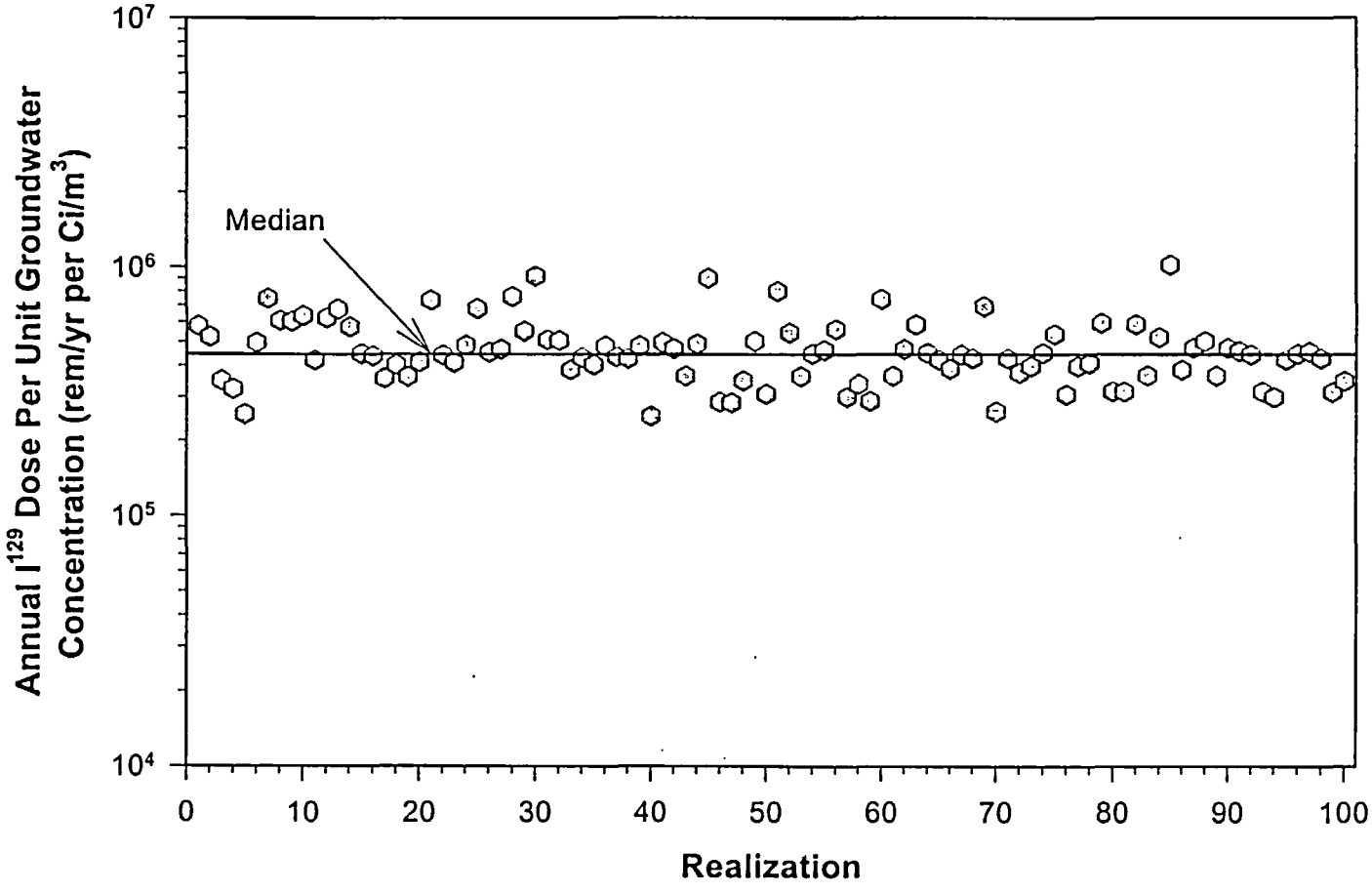
INPUT PARAMETERS AND INFORMATION SOURCES

- Objective: Enhance Realism and Avoid Implausible Assumptions
- Used about 600 Input Values, 43 Radionuclides, 26 Elements
- Used Available Information Sources:
  - Mass Loading Factors (Variety of Field Data)
  - Exposure Duration by Human Activity (NRC Guidance)
  - Drinking Water Consumption (Regulation)
  - Food Consumption Rates (DOE Local Survey)
  - Plant and Animal Uptake Factors (IAEA Compilation)
  - Soil Distribution Coefficients (Literature Summary)
  - Crop Interception Fraction (Arid Field and Laboratory Study Compilation)
  - Agricultural Parameters (Site-specific and General Sources)

CURRENT TPA CODE APPROACH

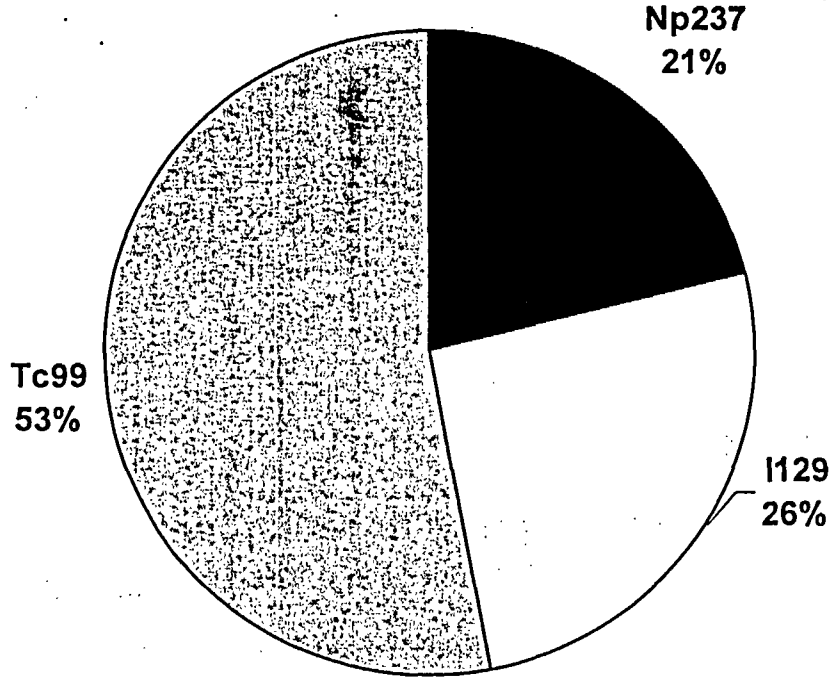
- Inhalation Dosimetry Assumes Mean Particle Size of 1 Micron
- Adult Dosimetry
- Conservative Dosimetry Assumptions Based on Uncertainty in Chemical Form of Ingested or Inhaled Material
- No Explicit Correlation Between Soil Leaching and Plant Uptake
- Radionuclides Leached Below Root Zone Exit the Biosphere
- No Washing of Harvested Crops
- No Filtering or Treatment of Municipal Water
- 15 Years of Irrigation Deposition Before Exposure

EXAMPLE OF BIOSPHERE MODEL OUTPUT VARIATION

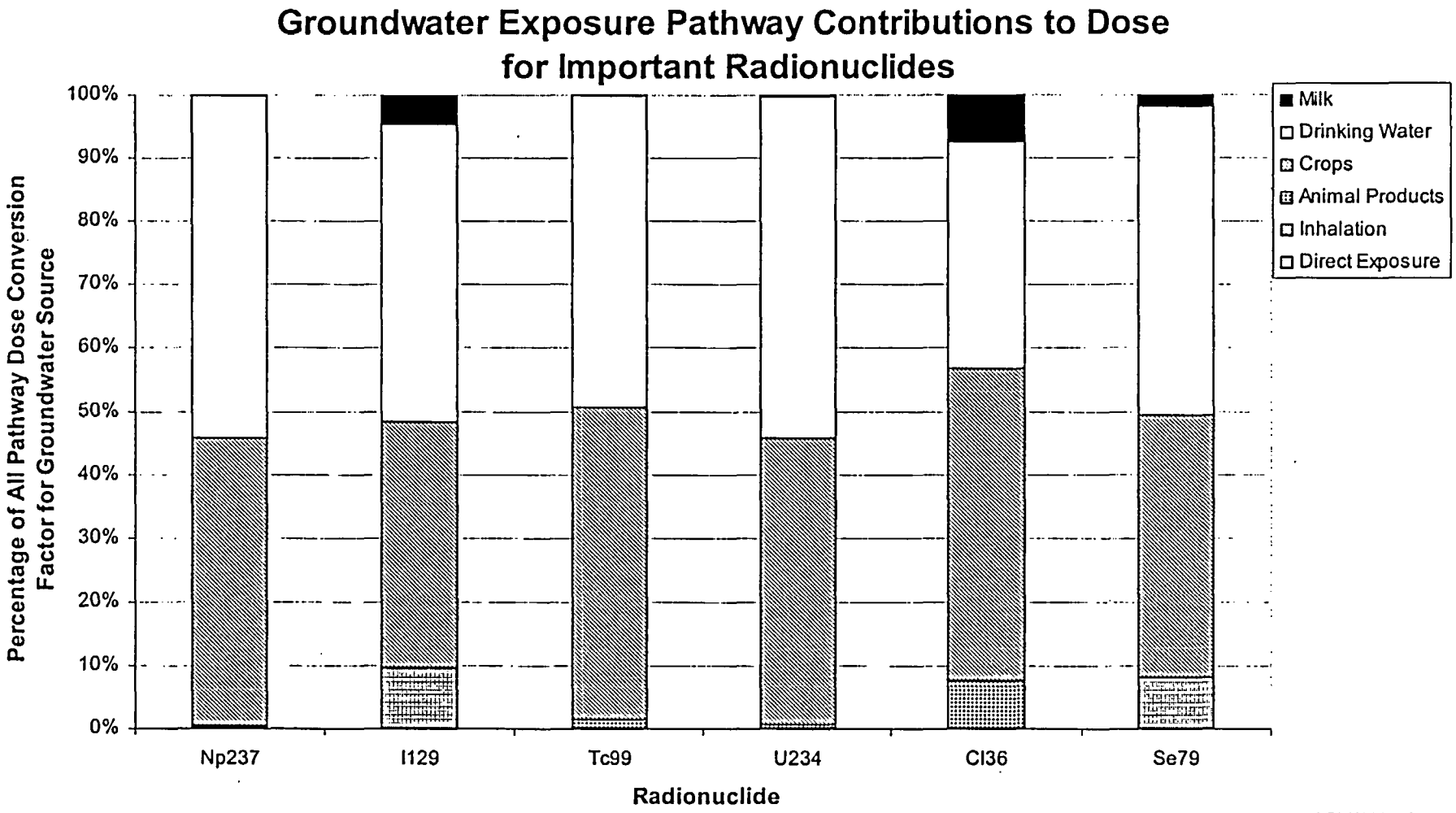


EXAMPLE PATHWAY ANALYSIS

Key Radionuclides for Groundwater Release Dose



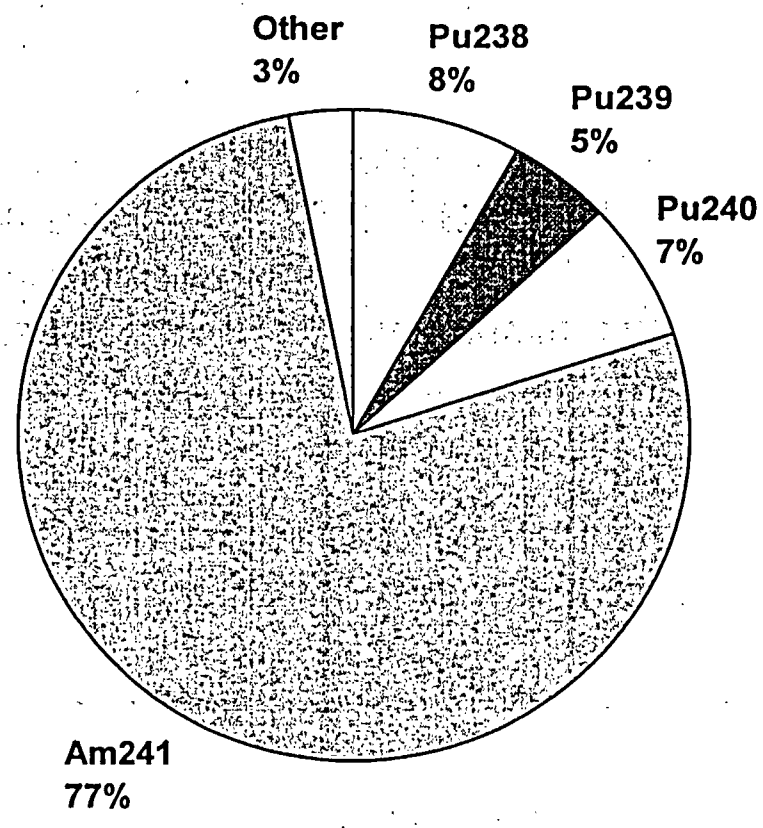
EXAMPLE PATHWAY ANALYSIS (Cont'd)



ACNW Meeting
2/24/04

EXAMPLE PATHWAY ANALYSIS (Cont'd)

Key Radionuclides for Igneous Activity Disruptive Event Dose



SUMMARY

- Important Biosphere Pathways Include Inhalation of Resuspended Volcanic Ash and Consumption of Contaminated Drinking Water and Local Crops
- Biosphere Pathway Modeling is an On-going Activity
  - Supports Pre-licensing Review Activities and Prepares Staff for License Application Review
  - Emphasizes: Safety; Increasing Realism; Flexibility and Efficiency; Uncertainty Reduction; Eliminating Implausible Assumptions
- Results Risk-Inform Staff Activities
  - Early Efforts Guided Development of Review Plans, and Focused Document Reviews
  - Biosphere Risk Insights Focus Technical Work on the Most Significant and Uncertain Areas

U.S. Department of Energy
Office of Civilian Radioactive Waste Management

YUCCA MOUNTAIN PROJECT

Environmental Transport and Receptor Exposure Pathways for the Biosphere Model

Presented to:
Advisory Committee on Nuclear Waste

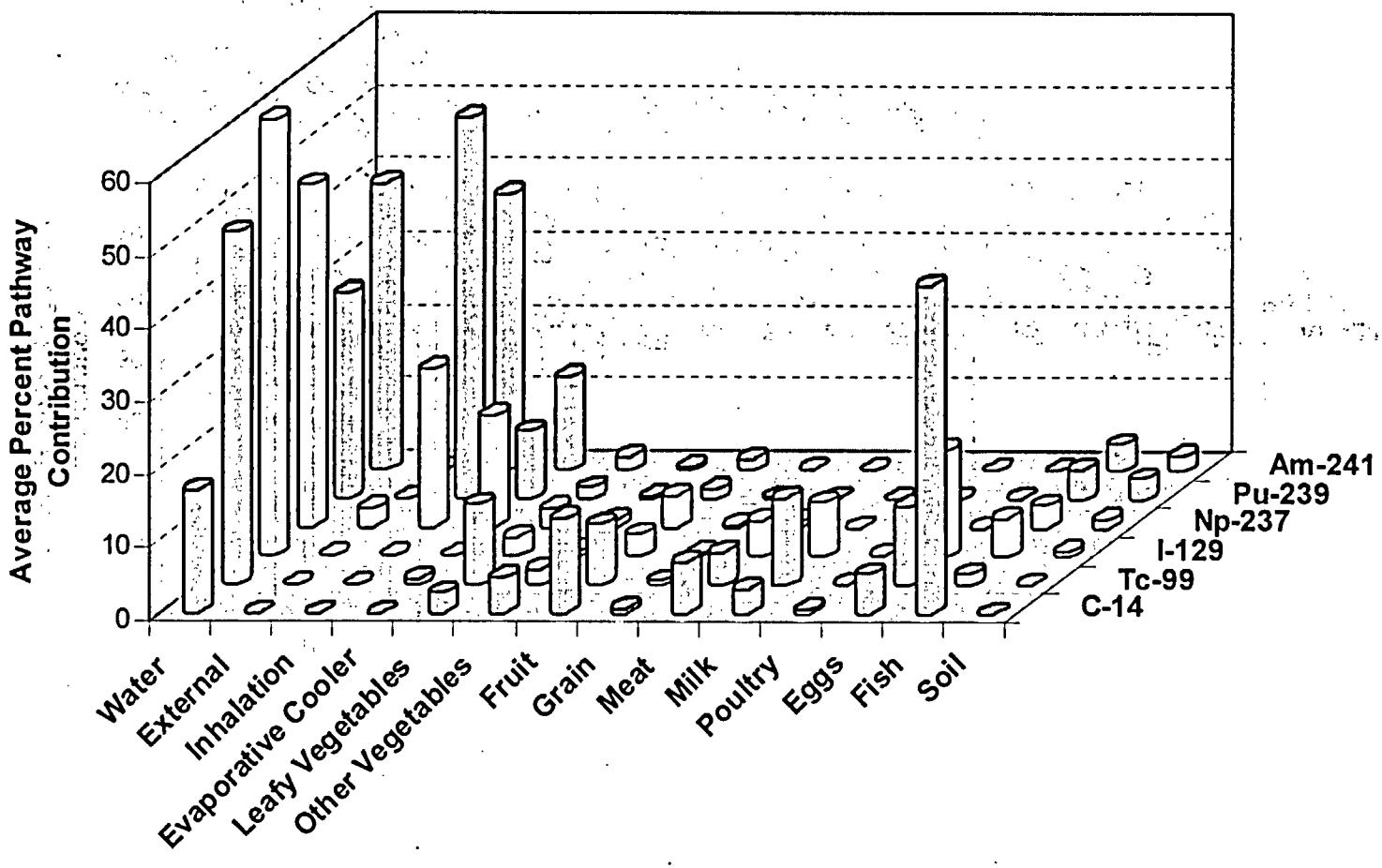
Presented by:
Maryla Wasiolek
Biosphere Department
Bechtel SAIC Company, LLC

February 24, 2004
Rockville, Maryland

Outline

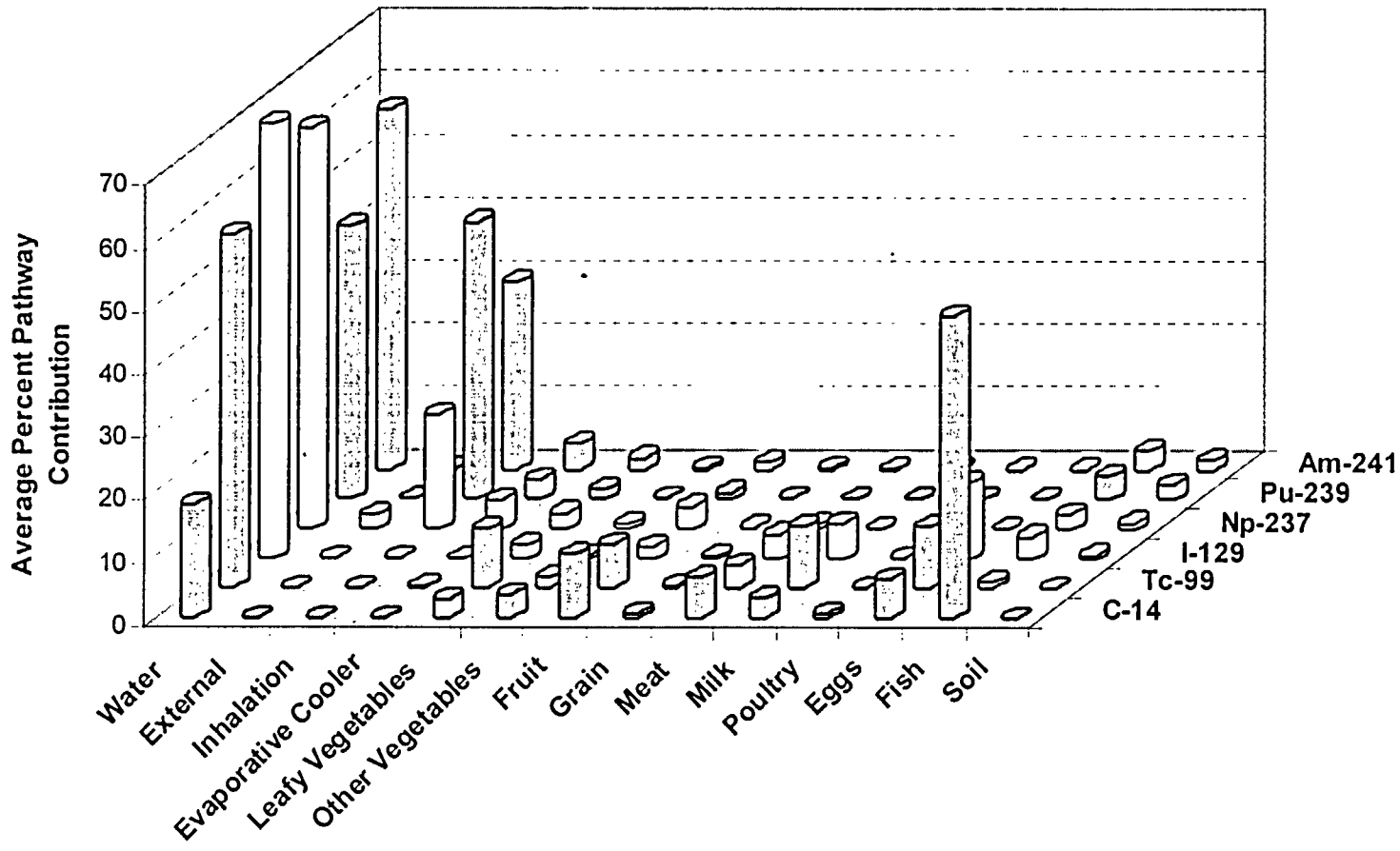
- Summary of pathway analysis for radionuclides identified by Advisory Committee on Nuclear Waste (carbon-14, technetium-99, iodine-129, neptunium-237, plutonium-239, and americium-241)
- Discussion of pathway contributions for groundwater release
- Discussion of important parameters for individual radionuclides for groundwater release
- Sensitivity/importance analysis results are preliminary (work in progress)

Pathway Contributions for Modern Climate



Work in Progress

Pathway Contributions for Upper Bound of Glacial Transition Climate



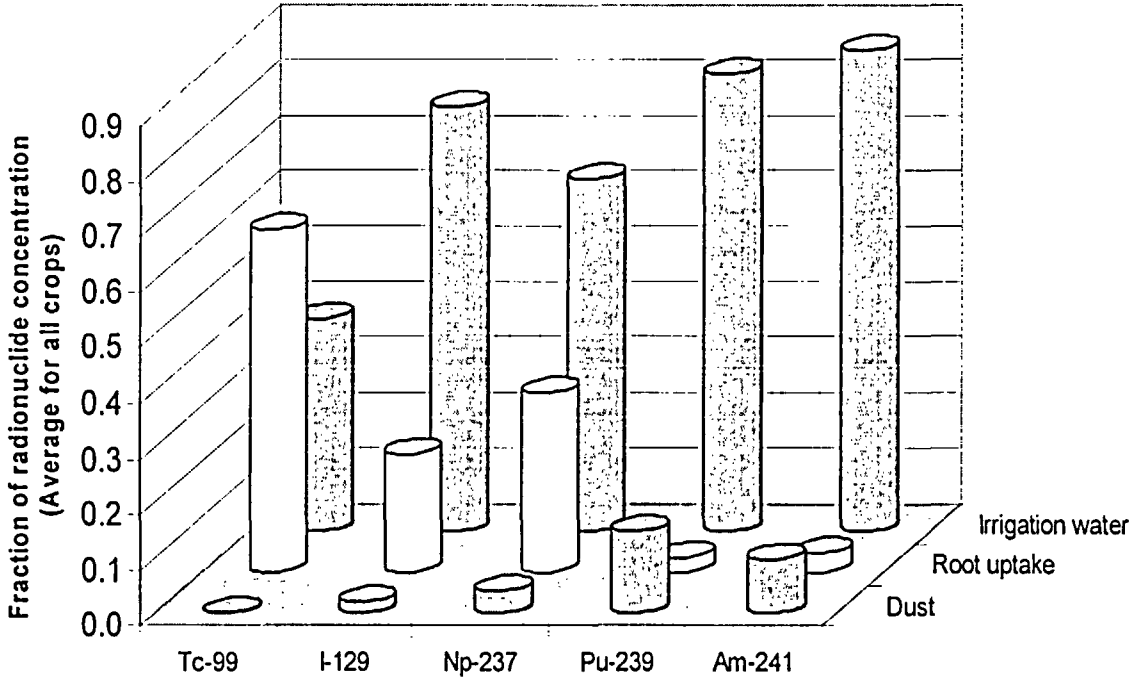
Work in Progress

Pathway Contributions

- Environmental transport pathways
- Receptor exposure pathways

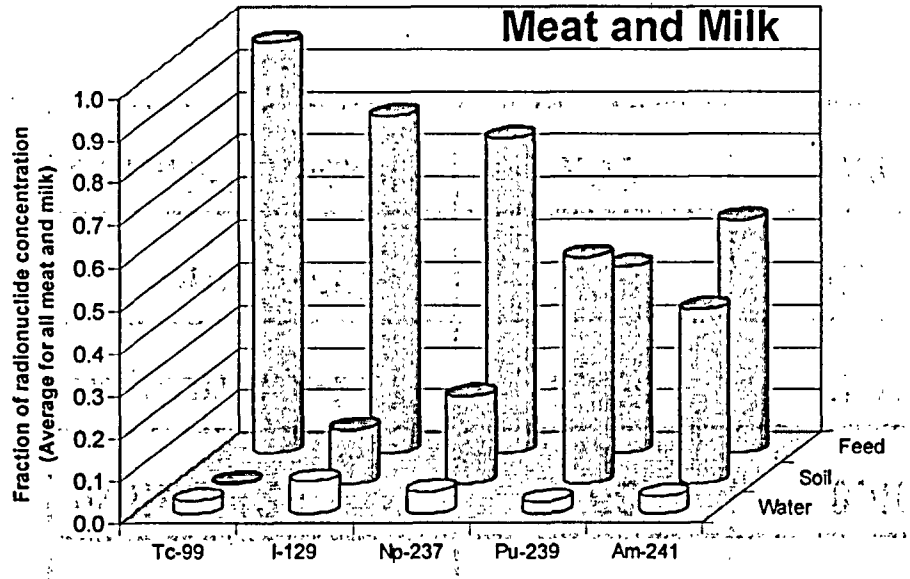
Environmental Transport Pathways for Crops

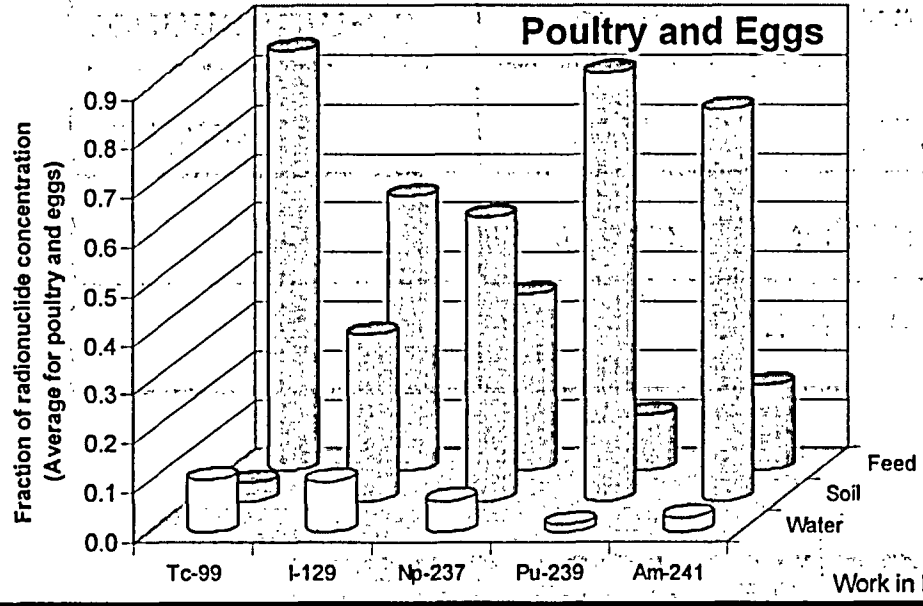
- Radionuclide deposition on plant surfaces from irrigation water is usually a dominant mechanism of activity transport to crops
- Root uptake is dominant for technetium-99 and a significant contributor for iodine-129 and neptunium-237
- Particulate deposition is relatively unimportant
- Almost 100 percent of carbon-14 in crops is from air



Work in Progress

Environmental Transport Pathways for Animal Products





- Contribution from animal feed is dominant for technetium-99, iodine-129, and neptunium-237 for meat and milk and for technetium-99 and iodine-129 for poultry and eggs
- Contribution from ingestion of soil increases for transuranics and especially dominates for neptunium-237, plutonium-239 and americium-241 for poultry and eggs
- Ingestion of water is relatively unimportant
- Fraction of carbon-14 intake from feed is 97-98 percent, from water, 2-3 percent, and negligible fraction from soil

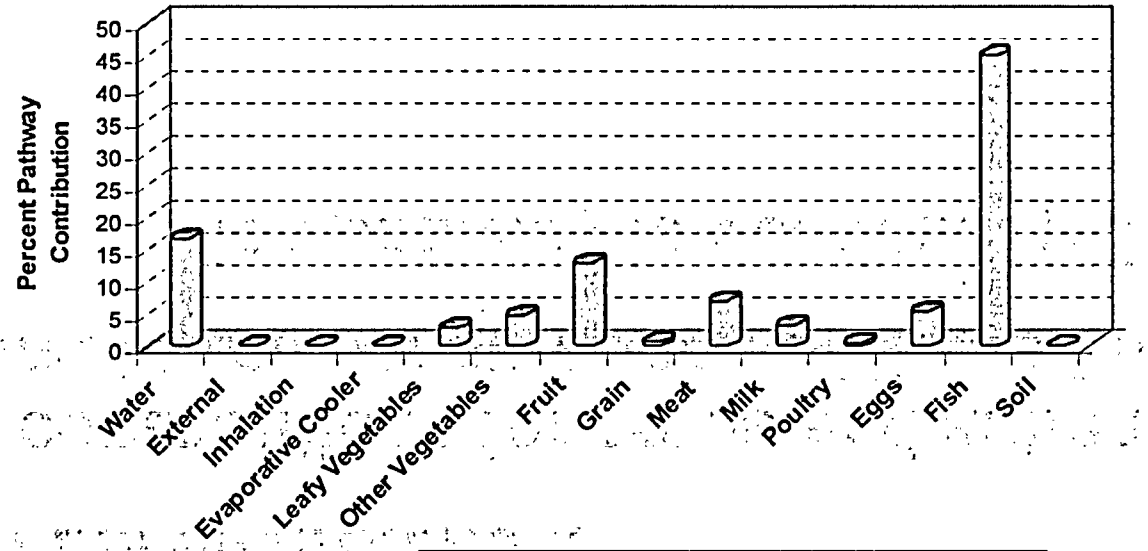
Work in Progress

Receptor Exposure Pathways

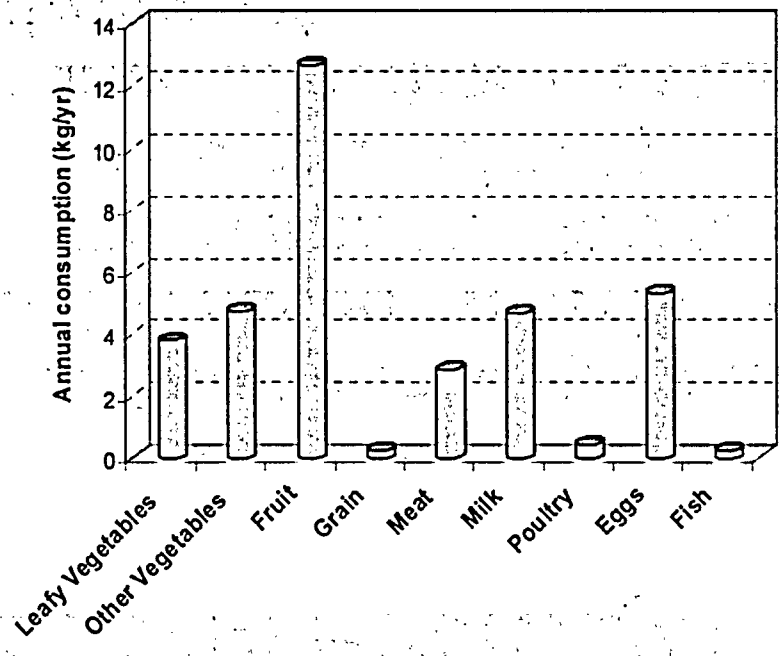
	Percent Pathway Contributions			
	Water	Ingestion	Inhalation	External
carbon-14	0.17	0.83	0.00	0.00
technetium-99	0.48	0.51	0.01	0.00
iodine-129	0.60	0.40	0.00	0.00
neptunium-237	0.47	0.13	0.37	0.03
plutonium-239	0.28	0.11	0.61	0.00
americium-241	0.39	0.10	0.51	0.00

Carbon-14 Pathways

Pathway Contributions



Consumption rates of locally produced food



Carbon-14 Pathways

- Concentration of carbon-14 in crops and animal products is calculated based on carbon-14 intake relative to stable carbon intake. Carbon-14 concentrations in crops and animal products reflect the relative abundance of carbon-14 and stable carbon in the environment
- Pathway contributions for crops and animal products correspond to the consumption of these foodstuffs
- Fish consumption pathway is dominant (45 percent)

Carbon-14 Pathways - Fish

$$Cf = Cw\,MF\,BF$$

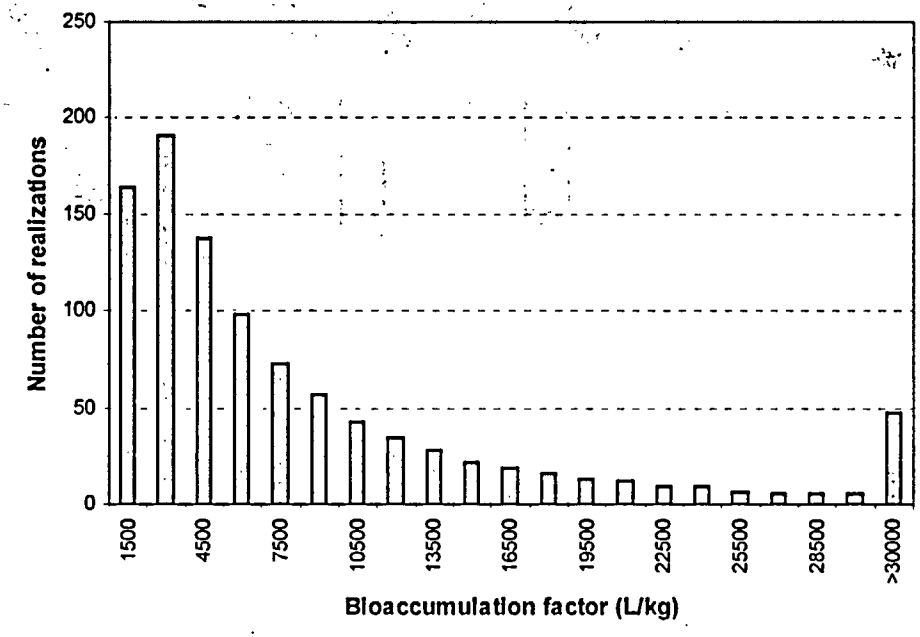
Cf = activity concentration in fish (Bq/kg $_{wet}$)

Cw = activity concentration in groundwater (Bq/L)

MF = water concentration modifying factor (dimensionless)

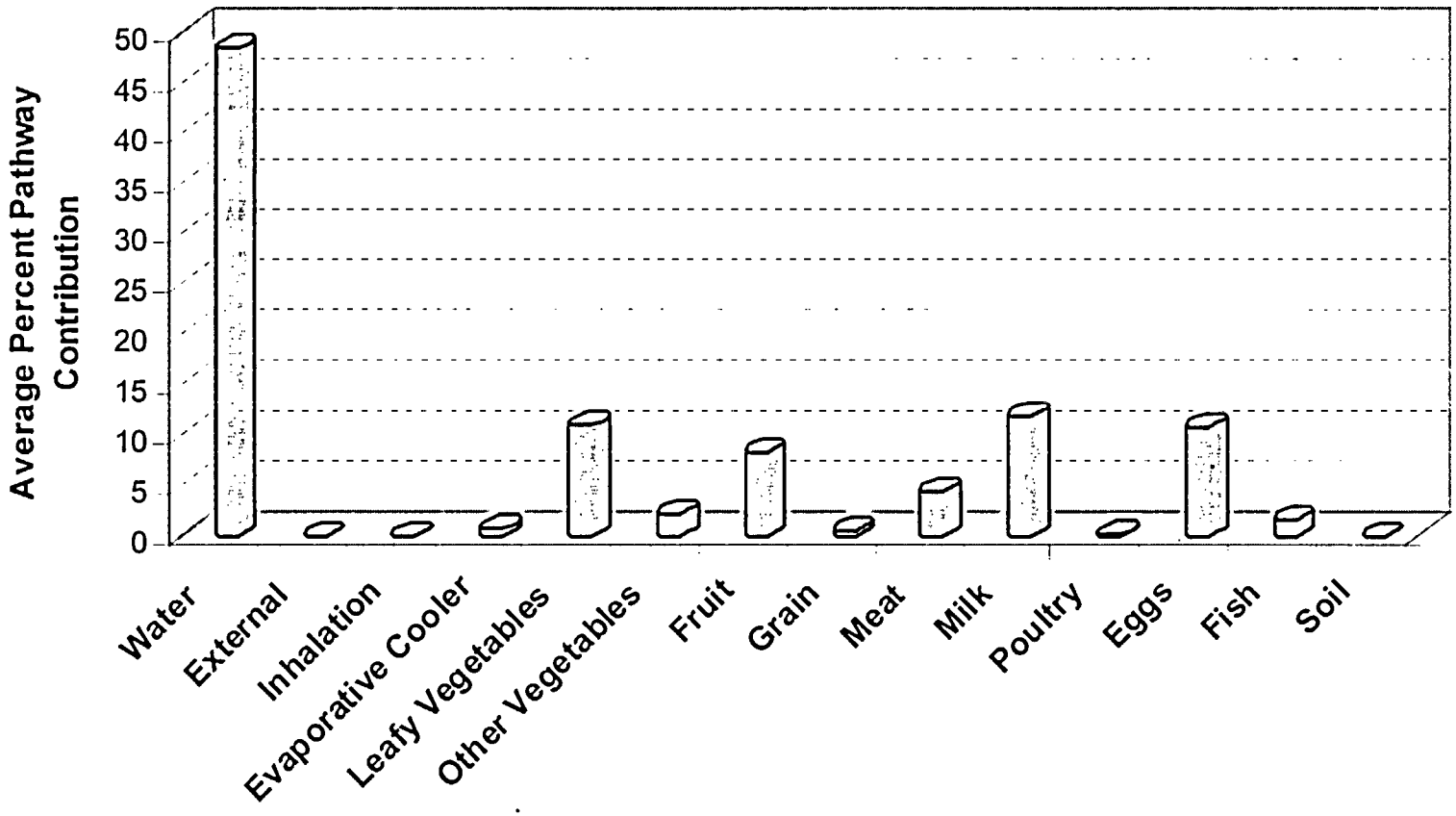
BF = bioaccumulation factor for freshwater fish (L/kg)

Bioaccumulation Factor



Work in Progress

Technetium-99 Pathways



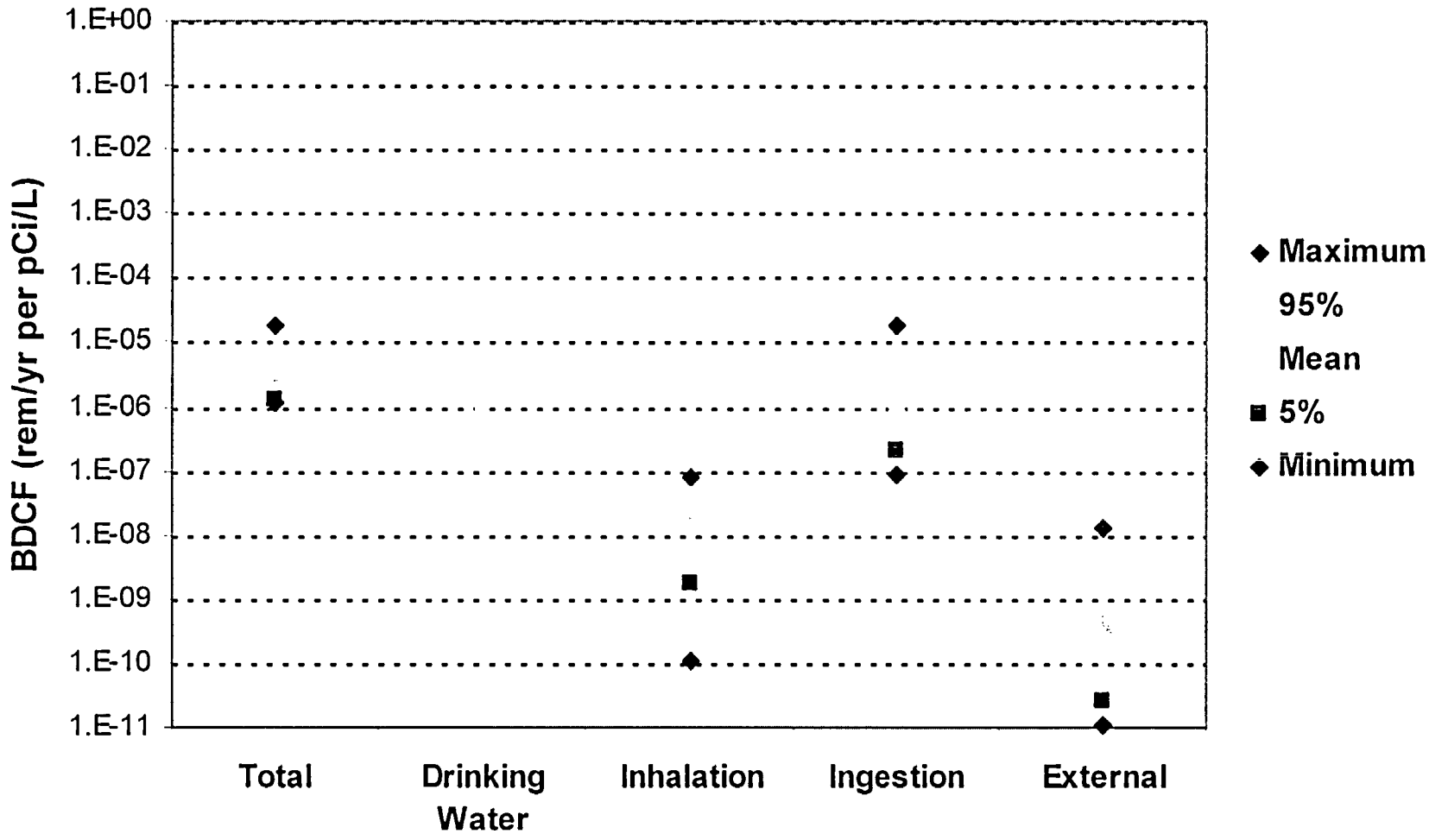
Work in Progress

Technetium-99 Pathways

(Continued)

- Consumption (ingestion) pathways are much more important than other pathways (inhalation or external exposure)
- Water consumption is the most important consumption pathway
- Contributions of individual food consumption pathways typically reflect the consumption rates for individual locally produced foods
- Contribution from consumption of leafy vegetables is more important than that from the consumption of fruit, although the consumption of fruit is higher, because the transfer factor for leafy vegetables is about an order of magnitude higher than the transfer factor for fruits
- Root uptake is a dominant environmental transport pathway

Technetium-99 Pathways - Distributions



BDCF = Biosphere Dose Conversion Factor

Work in Progress

Technetium-99 Pathways - Root Uptake

$$Cp_{root} = Cs_m F_{s \to p} DW$$

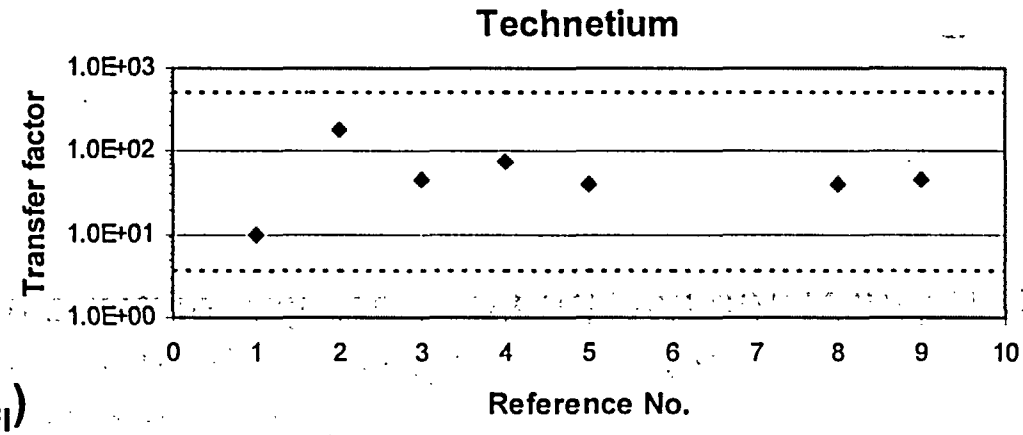
Cp_{root} = activity concentration in crop from plant root uptake (Bq/kg $_{wet}$)

Cs_m = activity concentration in surface soil (Bq/kg $_{dry\ soil}$)

$F_{s \to p}$ = soil-to-plant transfer factor (Bq/kg $_{dry\ plant}$ per Bq/kg $_{dry\ soil}$)

DW = dry-to-wet weight ratio for edible part of plant (kg $_{dry\text{-}\ plant}$ /kg $_{wet\text{-}\ plant}$)

Technetium transfer factor for leafy vegetables



Dry-to-wet weight ratios developed based on U.S. Department of Agriculture data for representative crops (crops currently grown in southern Nye County)

Work in Progress

Technetium-99 Pathways - Root Uptake

(Continued)

$$Cs = \frac{Cw\,IR}{\lambda_d + \lambda_l + \lambda_e}$$

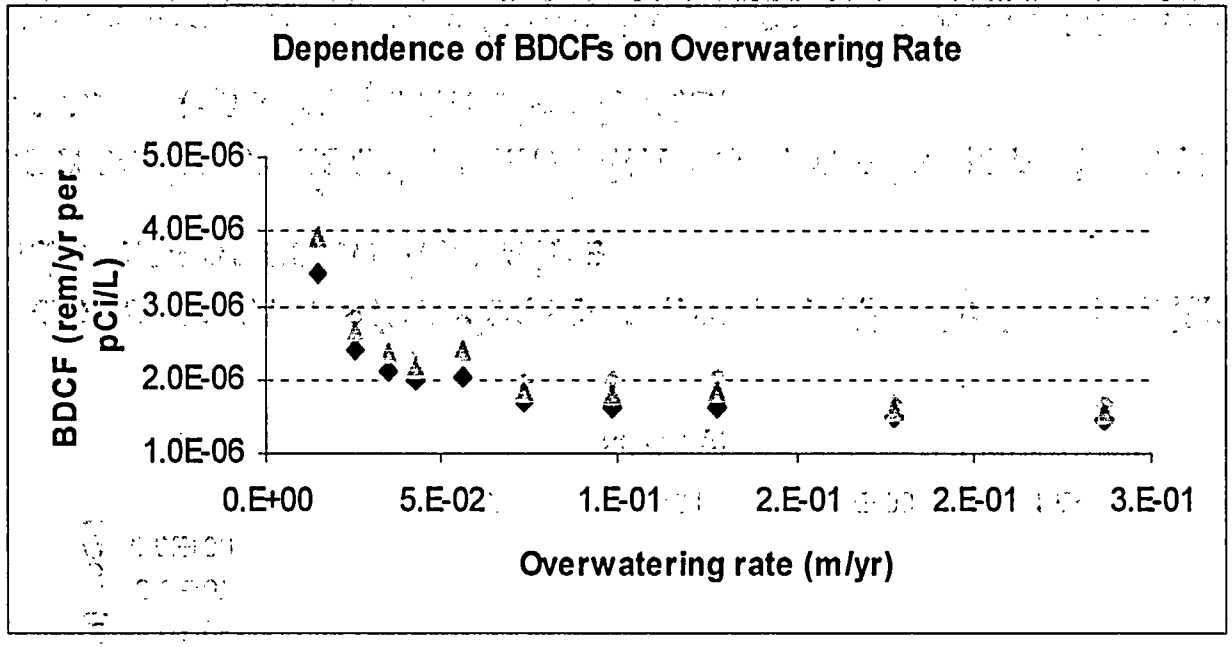
Cw = activity concentration in groundwater (Bq/m^3)
IR = annual average irrigation rate (m/yr)
λ_d = radioactive decay constant (yr^{-1})
λ_l = average annual leaching removal constant (yr^{-1})
λ_e = average annual surface soil erosion removal constant (yr^{-1})

$$\lambda_l = \frac{OW}{d \times \theta \left(1 + \frac{\rho}{\theta} K_d\right)}$$

OW = crop overwatering rate (m/yr)
θ = volumetric water content of soil (dimensionless)
K_d = element-specific solid- liquid partition coefficient in surface soil (Bq/kg $_{solid}$)/(Bq/m^3 $_{liquid}$) = (m^3 $_{liquid}$ /kg $_{solid}$)
ρ = bulk density of surface soil (kg/m^3)
d = depth of surface soil (m)

Technetium-99 Pathways - Root Uptake

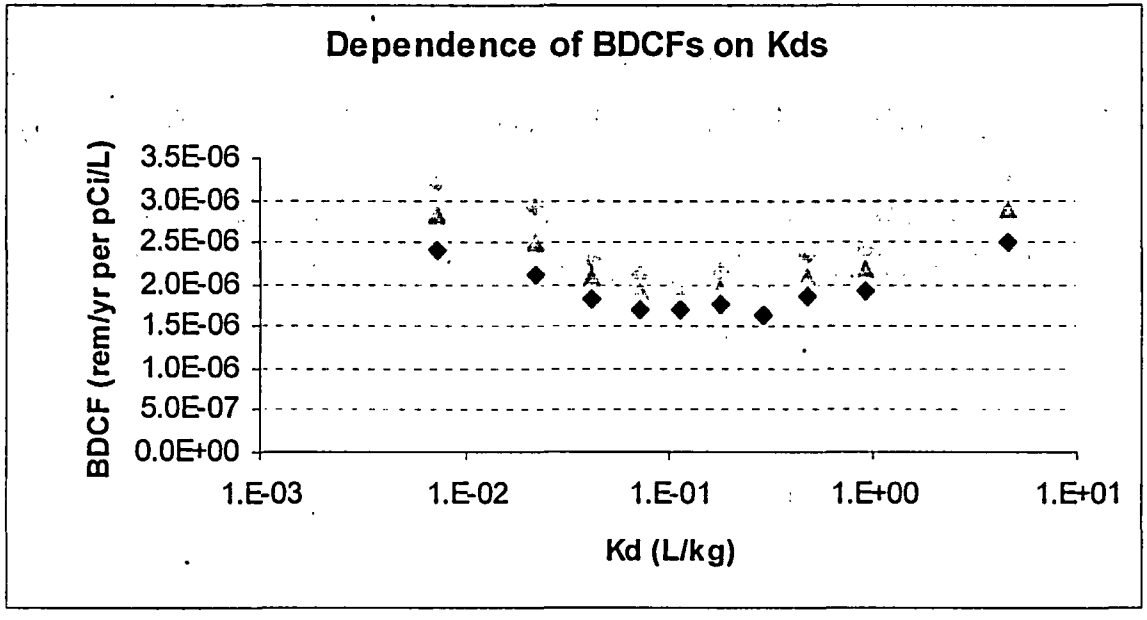
(Continued)



- Correlation coefficient for biosphere dose conversion factor and overwatering rate is the highest of all parameters
- Overwatering rate was developed for representative crops based on crop leaching fraction (amount of water applied in addition to crop water requirements to remove excess salts)

Technetium-99 Pathways - Root Uptake

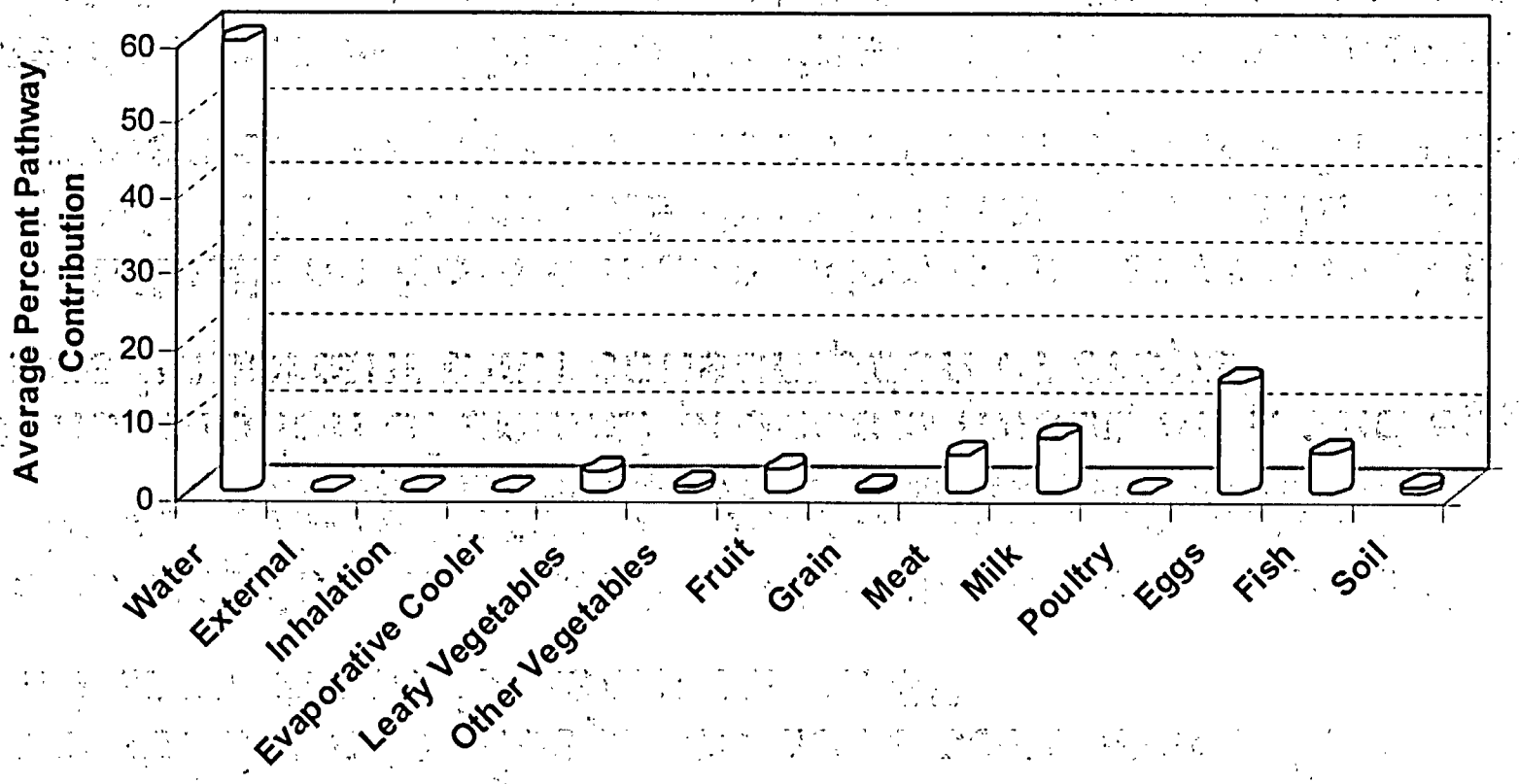
(Continued)



- Biosphere dose conversion factors are relatively insensitive to order-of-magnitude changes in K_d value
- Low K_ds lead to increased availability of an element in solution and thus higher root uptake (transfer factor)
- High K_d values lead to lower leaching rate and thus higher saturation concentration of radionuclide in soil

Work in Progress

Iodine-129 Pathways



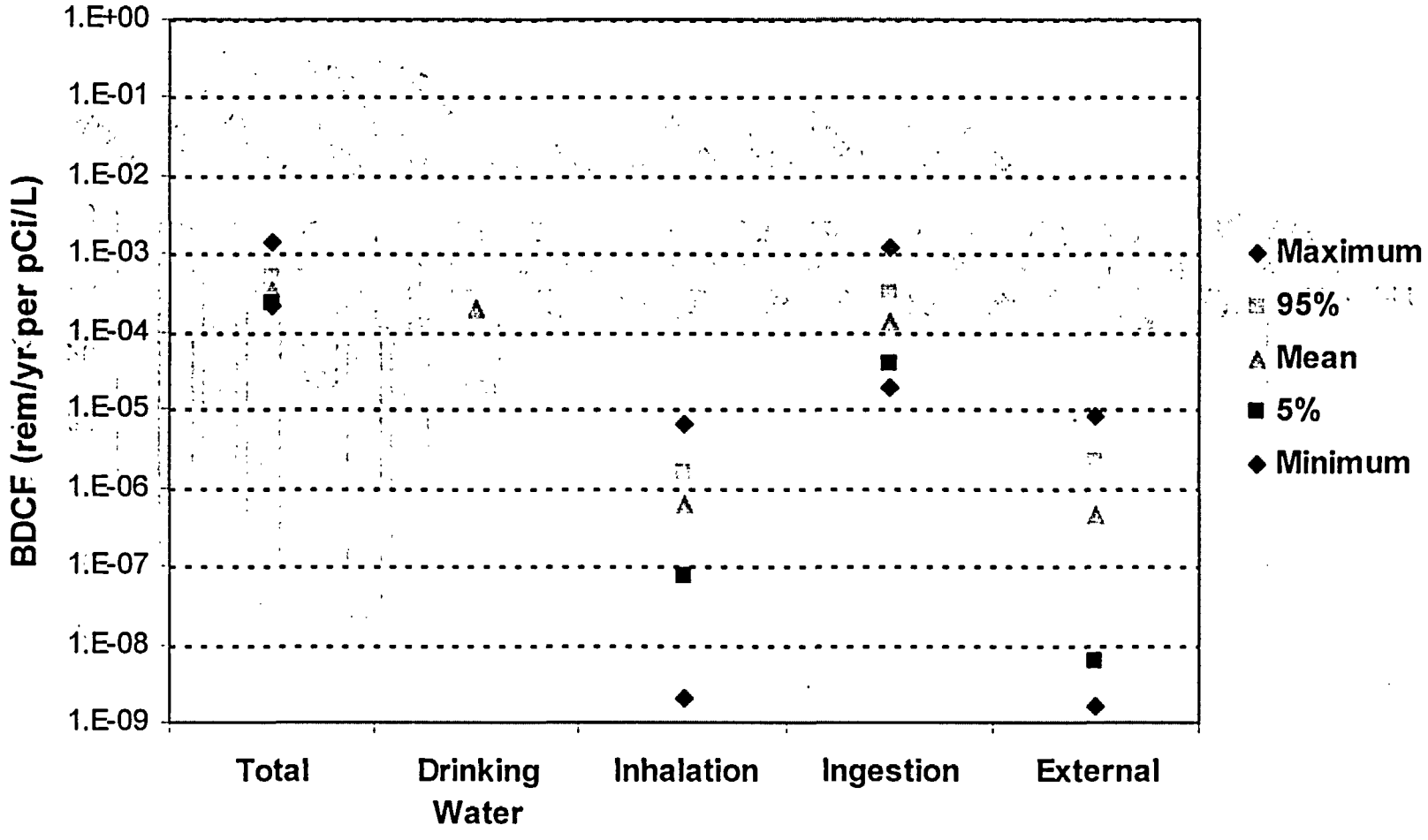
Work in Progress

Iodine-129 Pathways

(Continued)

- Pathway modeling for iodine-129 and pathway contributions to biosphere dose conversion factor are similar to those for technetium-99
- Consumption of water is by far the most important pathway (60-70 percent depending on the climate)
- Consumption of animal products (meat, milk and eggs) is more important than consumption of crops
- Contributions from consumption of meat and milk is more important for iodine-129 than that for technetium-99 because of the greater values of transfer coefficients
- Stable isotope of iodine (iodine-127) in the environment affects the dose from iodine-129. Estimates of biosphere dose conversion factors for iodine-129 are conservative

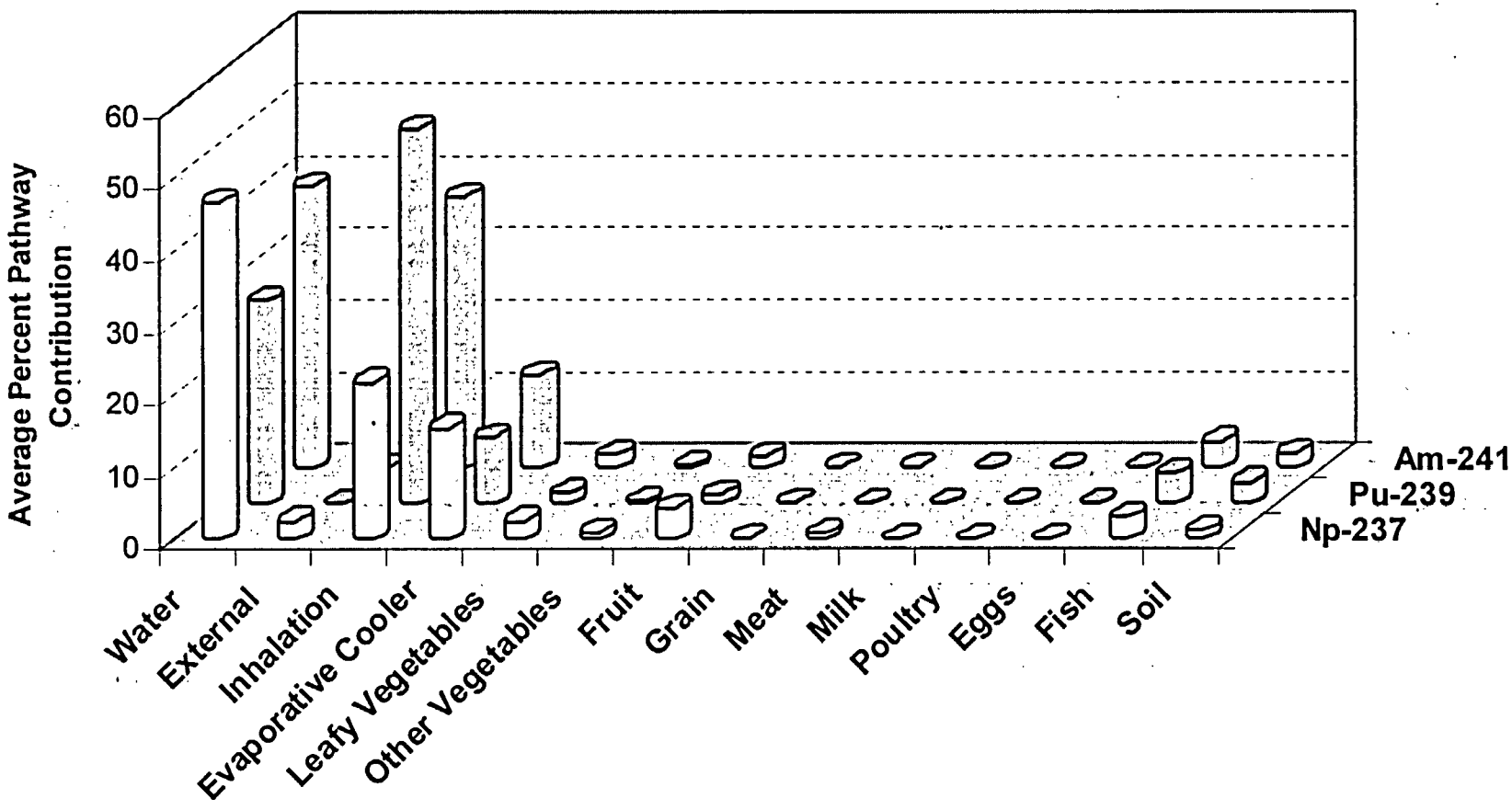
Iodine-129 Pathways - Distributions



BDCF = Biosphere Dose Conversion Factor

Work in Progress

Neptunium-237, Plutonium-239, and Americium-241 Pathways



Work in Progress

Neptunium-237, Plutonium-239, and Americium-241 Pathways Average Percent Contributions

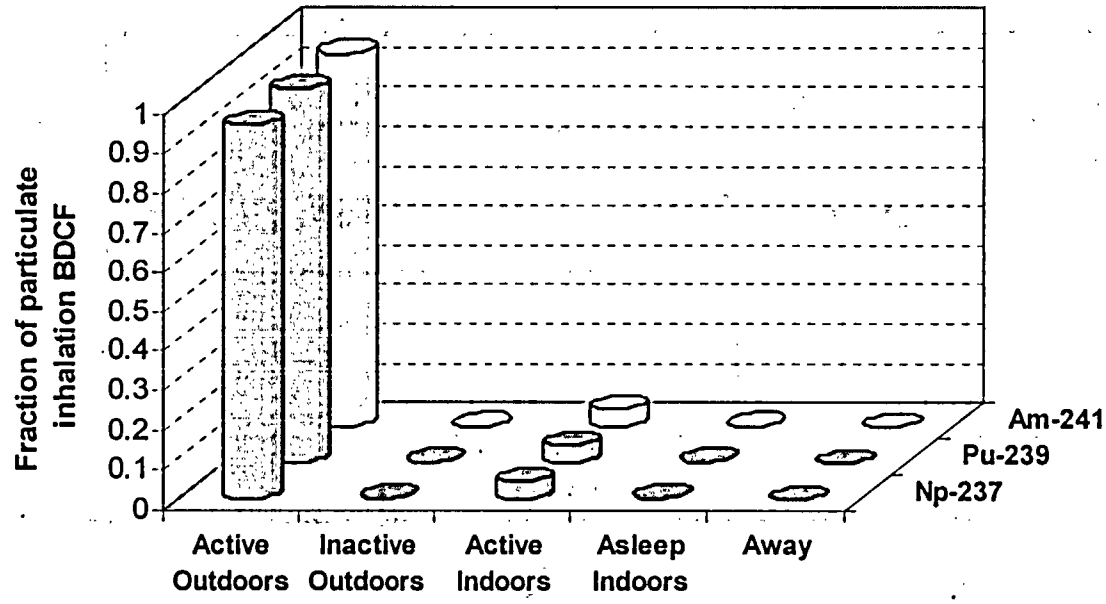
	Water	Ingestion	Inhalation	External
neptunium-237	0.47	0.13	0.37	0.03
plutonium-239	0.28	0.11	0.61	0.00
americium-241	0.39	0.10	0.51	0.00

	Total Inhalation	Particulate Matter	Evaporative Coolers
neptunium-237	0.37	0.22	0.15
plutonium-239	0.61	0.52	0.09
americium-241	0.51	0.38	0.13

Work in Progress

Inhalation of Particulate Matter

- **Microenvironments:**
  - Active outdoors - time spent outdoors conducting dust generating activities
  - Inactive outdoors - time spent outdoors conducting activities that do not resuspend soil
  - Active indoors - time spent awake indoors
  - Asleep - time spent sleeping
  - Away - time spent away from contaminated area



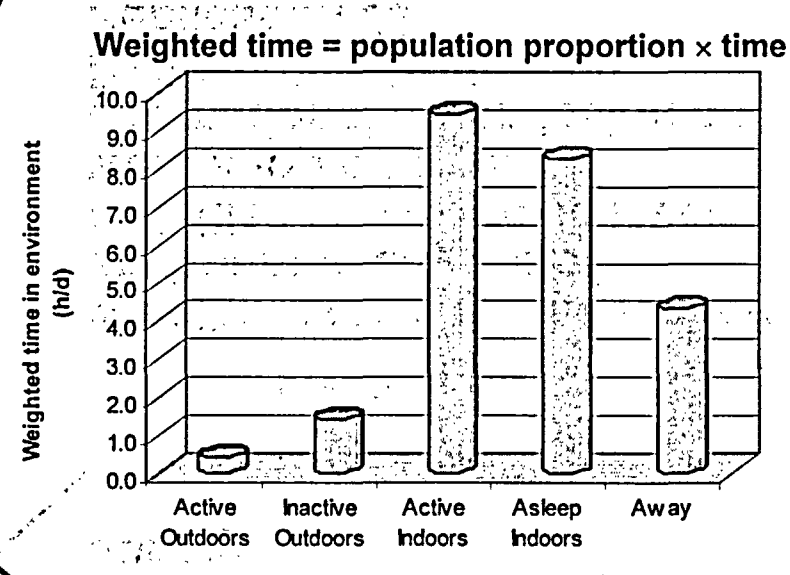
Note: Graph was constructed using average values

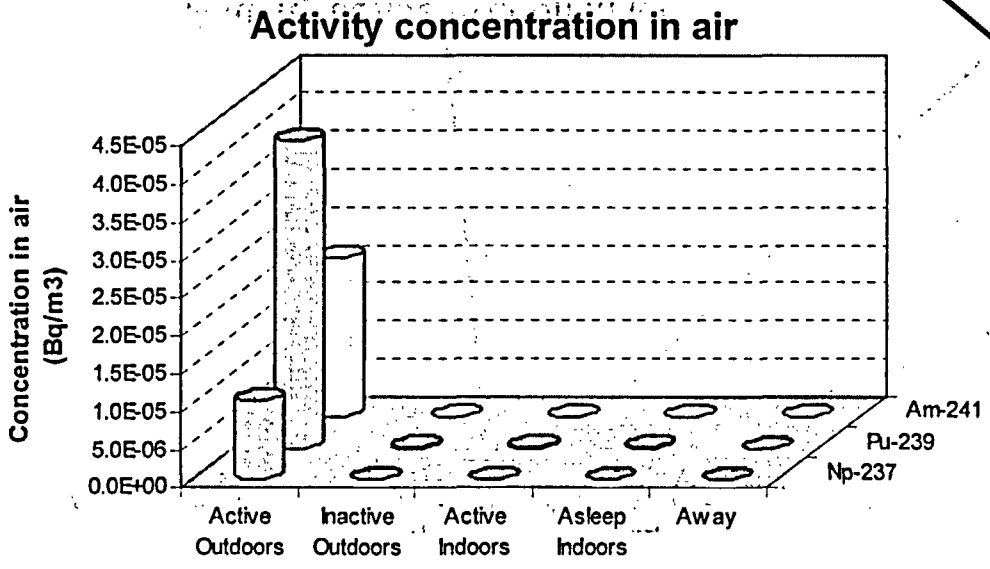
Work in Progress

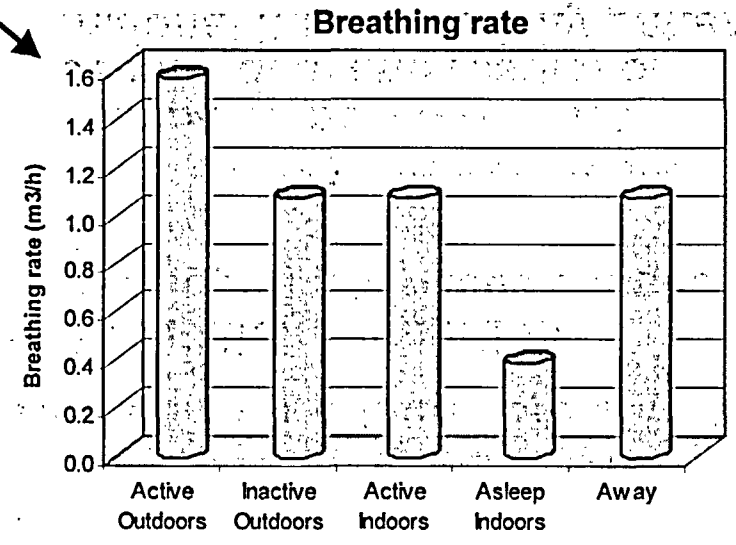
Inhalation of Particulate Matter

(Continued)

$$D_{inh,p} = DCF_{inh} \sum_{n} Ca_n \, BR_n \sum_{m} \left(PP_m \, t_{n,m} \right)$$







Note: Graphs were constructed using average values

Work in Progress

Inhalation of Particulate Matter

(Continued)

$$D_{inh,p} = DCF_{inh} \sum_{n} Ca_n \, BR_n \sum_{m} \left(PP_m \, t_{n,m} \right)$$

Weighted time = population proportion × time

- Population proportion developed from 2000 census data
- Time spent in environments calculated based on 2000 census data and results of national human activity pattern survey

Activity concentration in air

- Calculated as a product of air mass loading, activity concentration in surface soil, and enhancement factor
- Mass loading developed based on measurements in environments or conditions analogous to those considered in the biosphere model

Breathing rate

- Breathing rates for the receptor environments/types of activities and exercise levels were adopted from International Commission on Radiological Protection Publication 66

Inhalation of Aerosols Generated by Evaporative Coolers

$$D_{inh,e} = DCF_{inh}\, Ca_e\, f_{cooler}\, f_{use} \sum_{n(indoor\ env.)} BR_n \left(\sum_m PP_m\, t_{n,m} \right)$$

Ca_e = activity concentration of radionuclide i in indoor air attributable to the evaporative cooler operation (Bq/m^3) (calculated based on specifications and characteristics of evaporative coolers)

F_{cooler} = fraction of houses with evaporative coolers (dimensionless) (site-specific based on 1997 survey)

f_{use} = annual evaporative cooler use factor (dimensionless) (based on local temperature)

Inhalation of Aerosols Generated by Evaporative Coolers

(Continued)

$$Ca_e = f_{evap} \frac{M_{water}}{F_{air}} Cw$$

f_{evap} = fraction of radionuclides in water transferred to indoor air (dimensionless)

M_{water} = water evaporation rate (water use) for an evaporative cooler (m^3/h)

F_{air} = air flow rate for an evaporative cooler (m^3/h)

Inhalation of Aerosols Generated by Evaporative Coolers

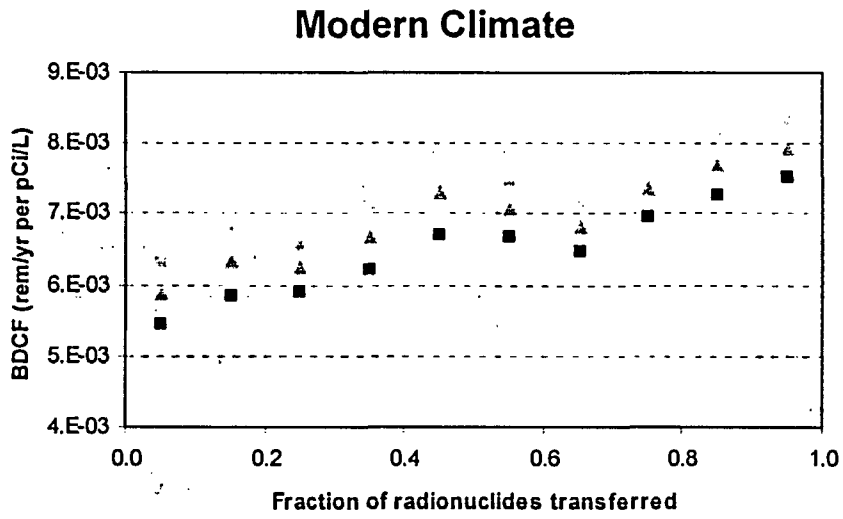
(Continued)

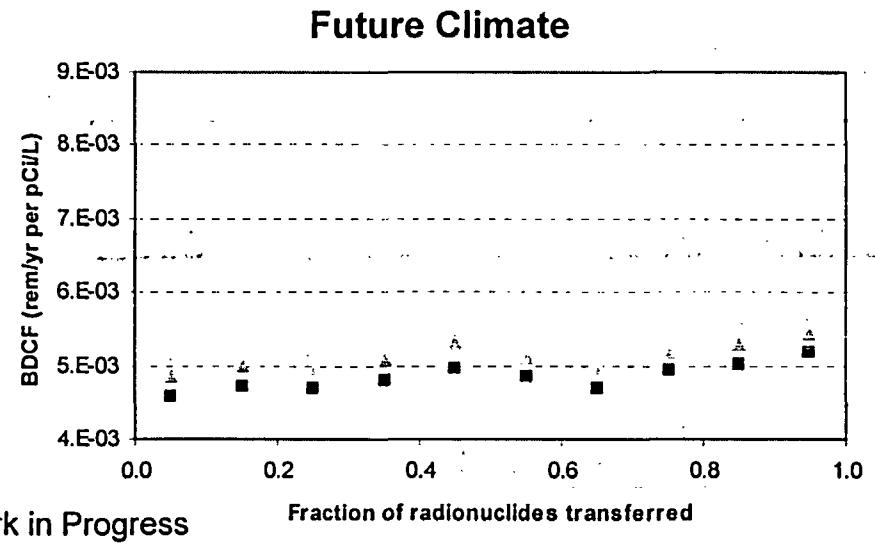
Percent Biosphere Dose Conversion Factor Contribution from Evaporative Coolers

	Modern Climate	Future Climate
neptunium-237	15.4	4.6
plutonium-239	9.2	3.1
americium-241	12.9	4.1

Inhalation of Aerosols Generated by Evaporative Coolers

(Continued)





Dependence of biosphere dose conversion factors for neptunium-237 on fraction of radionuclides in water transferred to indoor air

Work in Progress

Summary

- For carbon-14, technetium-99, and iodine-129, ingestion pathways are dominant
- Estimates of contribution from iodine-129 are conservative due to the stable iodine in the environment
- For actinides, inhalation is a dominant pathway with inhalation of particulate matter (resuspended contaminated soil) being the most important contributor. Inhalation of aerosols generated by evaporative coolers is less important, especially for the future climate

Backup

Correlations

Biosphere Dose Conversion Factor Correlations for Carbon-14

Parameter	Correlation Coefficient
Bioaccumulation factor	0.88
Consumption rate, fish	0.34
Annual average wind speed	-0.26
Consumption rate, eggs	0.11
Consumption rate, other vegetables	0.10
Daily irrigation rate, forage	0.10
Consumption rate, meat	0.09

Correlations

(Continued)

Biosphere Dose Conversion Factor Correlations for Technetium-99

Parameter	Correlation Coefficient
Overwatering rate	-0.63
Transfer coefficient, milk	0.24
Transfer coefficient, eggs	0.19
Weathering half-life	0.19
Translocation factor, other vegetables, fruit, and grain	0.16
Transfer factor, fruit	0.15
Irrigation intensity	-0.12

Work in Progress

Correlations

(Continued)

Biosphere Dose Conversion Factor Correlations for Neptunium-237

Parameter	Correlation Coefficient
K_d	0.51
Overwatering rate	-0.51
Transfer factor, grain	-0.41
Transfer factor, other vegetables	-0.41
Transfer factor, fruit	-0.37
Transfer factor, forage	-0.37
Transfer factor, leafy vegetables	-0.36

Work in Progress

Correlations

(Continued)

Biosphere Dose Conversion Factor Correlations for Plutonium-239

Parameter	Correlation Coefficient
Erosion rate	-0.56
Air mass loading, active outdoors	0.46
Enhancement factors, active outdoors	0.35
K_d	0.23
Transfer factor, grain	-0.21
Transfer factor, other vegetables	-0.21
Transfer factor, leafy vegetables	-0.20

Work in Progress

Correlations

(Continued)

Biosphere Dose Conversion Factor Correlations for Americium-241

Parameter	Correlation Coefficient
Air mass loading, active outdoors	0.42
Enhancement factors, active outdoors	0.36
K_d	0.35
Erosion rate	-0.30
Transfer factor, fruit	-0.30
Evaporative cooler water transfer fraction	-0.29
Transfer factor, forage	-0.29

Work in Progress

Dosimetry and Metabolic Models

Christepher McKenney 301-415-6663 cam1@nrc.gov
Division of Waste Management
U.S. Nuclear Regulatory Commission

148th Meeting of
Advisory Committee on Nuclear Waste
February 24-27, 2004

Overview

- Regulatory Requirements
- Federal Guidance
- Newer dosimetry systems and metabolic models
- General sources of uncertainty in dosimetry and metabolic models
- Examples of uncertainty
- Conclusions

Regulatory Requirements

- Part 20 and Part 63 use "effective dose equivalent" in stating dose limits
- Effective dose equivalent is defined by the International Commission on Radiological Protection Report No. 26
- Effective dose equivalent uses weighting factors to translate organ dose to the effective whole body dose that would have the equivalent cancer risk
- Metabolic models derived in ICRP Report No. 30 to calculate organ doses

Federal Guidance

- Part 20 is consistent with the 1987 Radiation Protection Guidance to Federal Agencies for Occupational Exposure
- Current Federal Guidance on Dose Conversion Factors
  - Federal Guidance Report No. 11 tabulates dose conversion factors for internal dosimetry consistent with ICRP 26/30
  - Federal Guidance Report No. 12 tabulates dose conversion factors for external dosimetry consistent with ICRP 26/30
- Current Federal Guidance on Risk Conversion Factors
  - Federal Guidance Report No. 13 calculates risk factors using updated metabolic models and risk information

Newer Dosimetry Models

- ICRP provided dosimetry recommendations in 1990 (ICRP Report No. 60) to calculate "effective dose"
- More advanced models (e.g., the ICRP 66 Lung Model) and metabolic data have become available to calculate organ doses
- Tabulated values of dose conversion factors for effective dose available in ICRP Reports No. 68 (worker) and 72 (public)
- To use newer dosimetry system, an exemption from the definition of weighting factors is required

Uncertainties

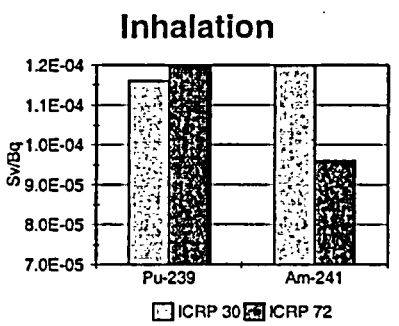
- Effective Dose Equivalent
  - Radiation Protection concept, not measurable quantity
  - Relies on organ weighting factors
- Metabolic models are relatively simple yet conservative models for complex case to account for uncertainties and variabilities. Examples include:
  - Understanding of metabolism
  - Individual variability
  - Age and gender issues
  - Elements under homeostatic control
  - Chemical Form

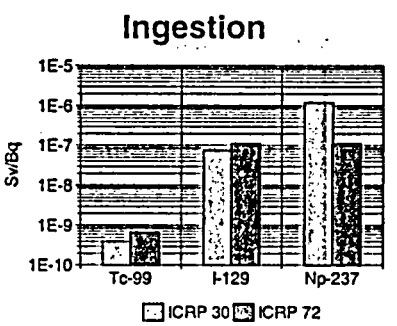
Model Uncertainty Examples

- Weighting Factors: For most photon emitters, external dose <10% difference
- Chemical Form: Approximately a factor of 2-10 difference between different chemical forms for inhalation
  - Not all radionuclides exhibit or have data to support different chemical forms
  - NRC's TPA code uses generally the most conservative choice for each radionuclide
  - Example: Pu-239 Class W (non-Oxides) 1.16e-4 Sv/Bq
  - Pu-239 Class Y (Oxides) 8.33e-5 Sv/Bq

Metabolic Model Uncertainty

- Comparison between ICRP 30 and ICRP 72
- Compares "worst-case" DCFs - not necessarily similar chemical forms
- 1 micron AMAD for inhalation





Conclusions

- Part 20 and Part 63 use "effective dose equivalent" in stating dose limits
- Acceptable approach for showing compliance is use of FGR 11 and FGR 12
- To use newer dosimetry system, an exemption from the definition of weighting factors is required

U.S. Department of Energy
Office of Civilian Radioactive Waste Management

YUCCA MOUNTAIN PROJECT

Metabolic Models

Presented to:
Advisory Committee on Nuclear Waste

Presented by:
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Biokinetic and Dosimetric Models Individual Protection Standard

- Dose limits expressed in terms of total effective dose equivalent
- Effective dose equivalent used in place of the deep dose equivalent
- Dose coefficients for internal exposure
  - Federal Guidance Report No. 11
- Dose coefficients for external exposure
  - Federal Guidance Report No. 12
- Biokinetic and dosimetric models used in Federal Guidance Report Nos. 11 and 12 based on International Commission on Radiological Protection Publications 26 and 30 methodology

Biokinetic and Dosimetric Models Groundwater Protection Standard

- The reasonably maximally exposed individual concept does not apply
- Dosimetric methods for organ and whole body dose consistent with International Commission on Radiological Protection Publications 26 and 30
- Organ doses expressed as committed dose equivalent
- Federal Guidance Report No. 11 used as a source of organ dose coefficients
- Methodology consistent with the methodology used for the individual protection standard

Backup

Exposure Pathways

Summary of receptor exposure conditions for the major exposure pathways (ingestion, inhalation, and external exposure)

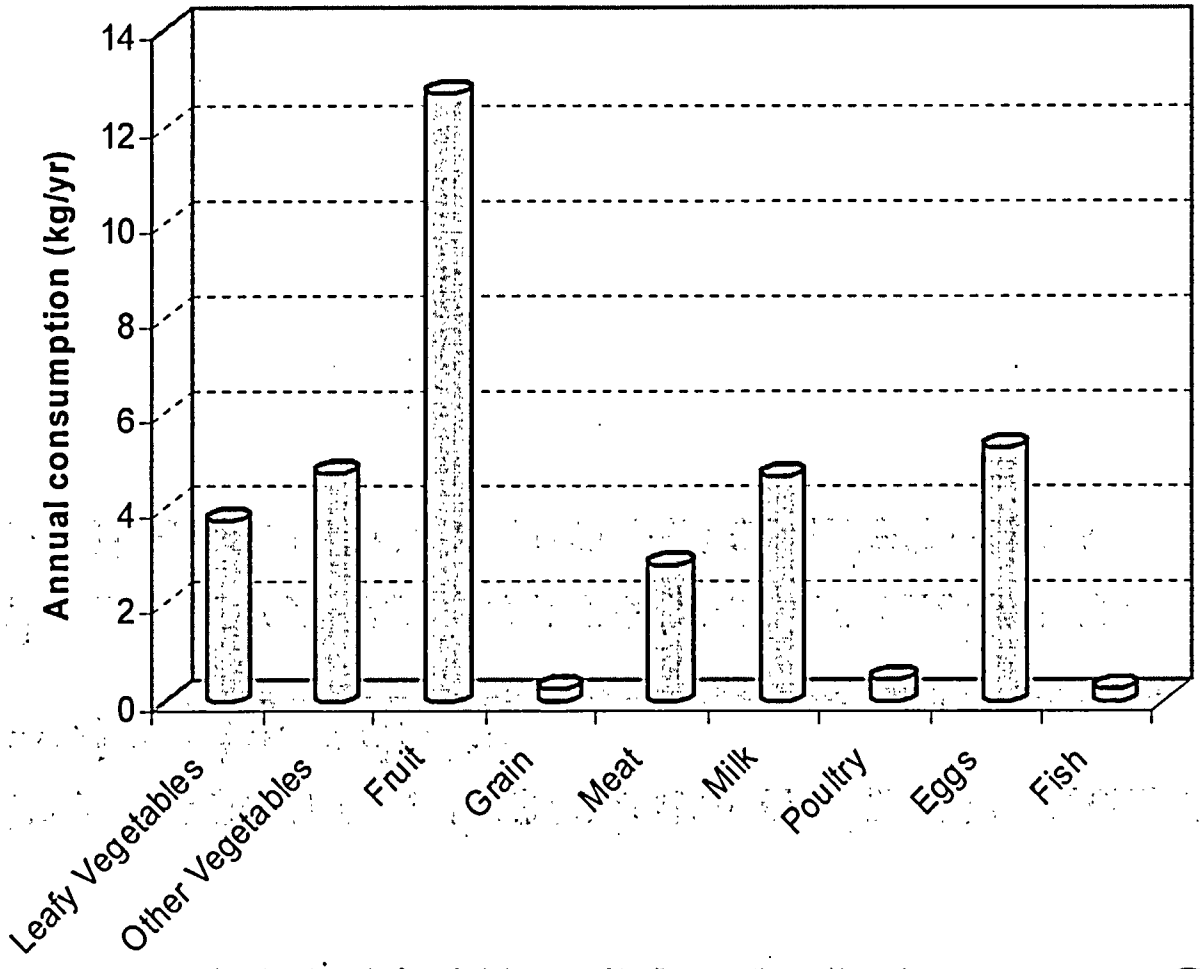
Ingestion Exposure Pathway

- Distributions of consumption rates for locally produced food were based on food consumption survey and U.S. Department of Agriculture data on daily intakes of food
- A large number of surveyed individuals indicated that they consumed little, if any, locally produced food
- Consideration of males and females in proportion determined by the 2000 census

Ingestion Exposure Pathway

(Continued)

Average Consumption Rates of Locally Produced Food



Ingestion Exposure Pathway

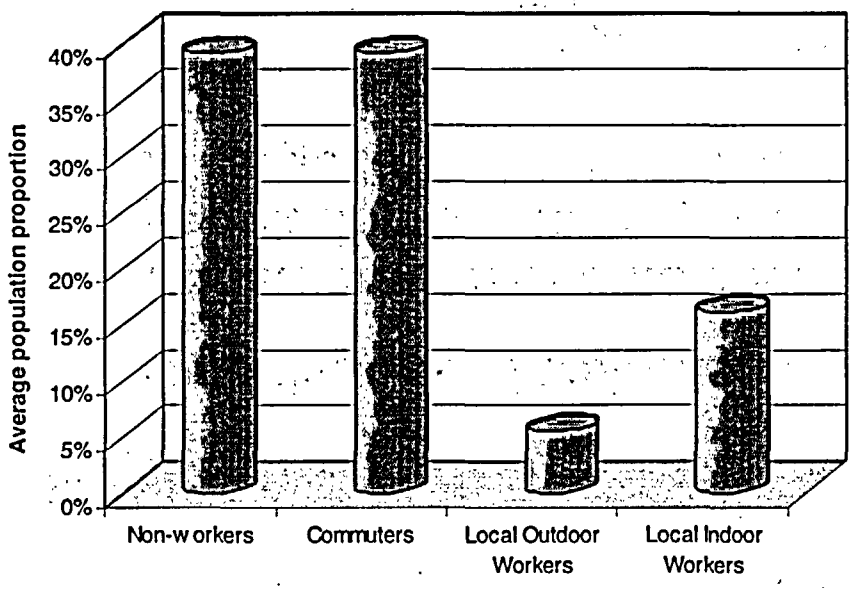
(Continued)

Inadvertent Soil Ingestion

- Calculated based on literature data on inadvertent soil ingestion by adults
- Selected range of values representative of agricultural scenarios and rural lifestyles

Inhalation and External Exposure

- Population groups
  - Non-workers
  - Commuters
  - Local outdoor workers
  - Local indoor workers

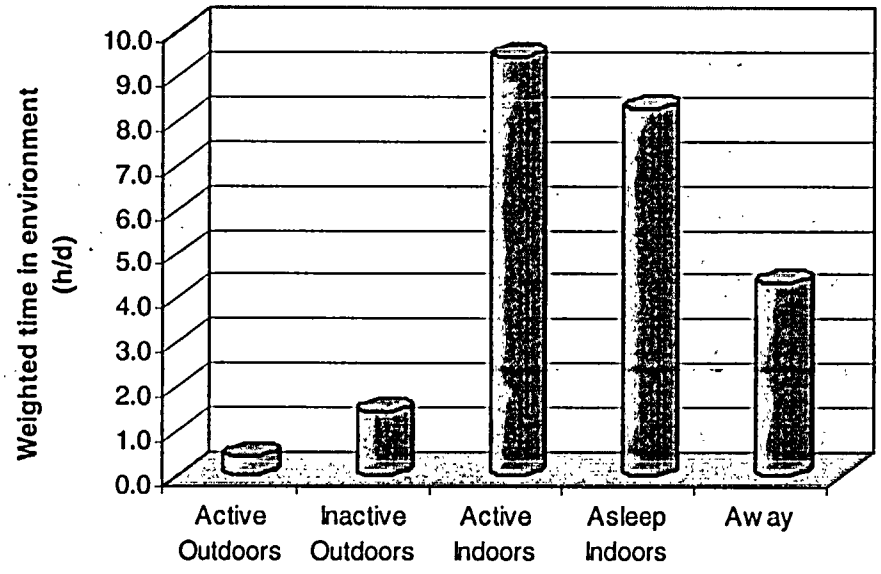


- Exposure environments
  - Away from contaminated area
  - Active outdoors (conducting activities that resuspend soil)
  - Inactive outdoors
  - Active indoors
  - Asleep indoors
- Values based on 2000 census and national habit survey

Inhalation and External Exposure

(Continued)

- **Exposure Times**
  - Calculations of weighted exposure time for the five environments
  - Consideration of time spent in each environment by each population group weighted by proportion of that group in Amargosa Valley population



Inhalation Exposure

- Environment-specific exposure times (previous slide)
- Environment-specific concentrations of airborne activity from particulates and from aerosols generated by evaporative coolers
- Environment-specific breathing rates

External Exposure

- Exposure outdoors
  - Outdoor exposure times
  - Soil contaminated to infinite depth
  - Indoor exposure times
  - Building shielding factors