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HIGH-LEVEL WASTE

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PUBLIC MEETING

Nuclear Regulatory Commission
One White Flint North
Rockville, Maryland

Wednesday, October 27, 1993

The Commission met in open session, pursuant to notice, at 10:00 a.m., Ivan Selin, Chairman, presiding.

COMMISSIONERS PRESENT:

IVAN SELIN, Chairman of the Commission
KENNETH C. ROGERS, Commissioner
FORREST J. REMICK, Commissioner
E. GAIL de PLANQUE, Commissioner

STAFF SEATED AT THE COMMISSION TABLE:

SAMUEL J. CHILK, Secretary

KAREN CYR, Office of the General Counsel

JAMES TAYLOR, Executive Director for Operations

ERIC BECKJORD, Director, Office of Research

ROBERT BERNERO, Director, NMSS

FRANK COSTANZI, Deputy Director, Division of Regulatory Applications, RES

MELVIN SILBERBERG, Chief, Waste Management Branch, RES

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

10:00 a.m.

CHAIRMAN SELIN: Good morning, ladies and gentlemen.

The Commission is meeting at this time to receive the latest in our series of briefings from the Research and Program offices on a major research area. Today's will be the high-level radioactive waste research program.

As I'm sure you know, the NRC has the responsibility of reviewing the Department of Energy's future application for a high-level waste repository. Although this is far in the future, there are a great number of things that have to be accomplished before we'll be in a position to do that and much of this activity is carried out under our high-level radioactive waste research program, which is designed to develop the licensing tools as well as the technical basis necessary to judge the adequacy of any license application to ensure sufficient independent understanding of the basic physical processes that would take place at a geological repository and, not incidentally, to maintain a limited but nevertheless robust independent confirmatory research capability under NRC's auspices.

Commissioners, would you have any remarks?

Mr. Taylor, would you -- I'm sorry.

There's one other thing, Mr. Bernero. I hope that during this discussion you're able to put some of the research programs into the context of timeliness and the appropriate level of effort that we should be putting into the preparation for this application given that its perspective date has slipped considerably in the future since we first started this program.

Mr. Taylor?

MR. TAYLOR: Good morning.

With me are members of the Office of Research and NMSS.

As you mentioned, Mr. Chairman, there are a number of technical issues in planning for the ultimately licensing of the DOE geologic repository. One of the unique things, of course, is the time span considered for the repository and its performance is unprecedented in our regulatory experience. So, I'm meeting this challenge.

The high-level waste research program involves a broad range of technical and scientific disciplines, from metallurgy to rock mechanics, from geochemistry to hydrology. As you're aware, most of

the research is being carried out through the Center for Nuclear Waste Regulatory Analyses and I believe some of the members from there are here -- from the senior staff are here today.

Frank Costanzi from the Office of Research will start the formal presentation.

MR. COSTANZI: Thank you, Mr. Taylor.

As you stated, Mr. Chairman, the objective of the high-level waste research program is to provide the tools and data to support the licensing assessment of DOE's demonstration of compliance against 10 CFR Part 60 and the EPA high-level waste standard.

(Slide) May I have page 2, please?

The activities that the research program is undertaking can be broadly categorized in three areas. One is to address what the staff has identified as the key technical uncertainties, to provide technical bases of support for future identification of uncertainties as DOE progresses in its development of the repository, and to further refine existing identified uncertainties, and of course to provide the tools, models, technical support and limited data for the development and use of performance assessment, in particular the iterative performance assessment process which is ongoing today.

(Slide) Next slide, please.

With regard to performance assessment, I wanted to mention particularly that that's kind of the glue that holds the program together, that all the programs, all the elements in this program are related in one fashion or another to performance assessment. Either they are developing models which will be used in performance assessment or models in which we'll do calculations to review DOE's demonstration of compliance. Or they're developing the technical support to choose among competing models for describing various processes which should be ongoing at the Yucca Mountain site, or they're developing limited data sets against which we can test and evaluate competing models.

COMMISSIONER ROGERS: Just before we leave that, I wonder if you would say a little bit about the iterative aspects of performance assessment.

MR. COSTANZI: The interactive performance assessment is an exercise which the staff, under the leadership of the licensing staff, is undertaking now. It's essentially running through actual performance assessment and to make sure that we have the capability of -- not only the capability of doing the performance assessment, but will we understand exactly

what the pinchpoints are in a performance assessment, what is going to be controlling in terms of the repository performance over time, what particular things we need to pay attention to in doing our license review assessment.

I think the licensing staff probably would be in a better position to answer any particular questions in the IPA itself and where they are and the like.

MR. BERNERO: Excuse me. If I could add to that, we're actually on the second stage of the performance, our second iteration, and we envision several in the course of it. It's really the ultimate licensing compliance assessment against what we expect to be the EPA standard at the time, which will be part of our regulations. What we learned from the iterations is, as Nick said, the pinchpoints, what are the key technical issues that have to be addressed and resolved, whether it be carbon-14 emissions or some geotechnical issue about solubility or rock retention or fracturing or something like that.

We thereby get the information needed to say more is needed here or there to focus site characterization or site investigation. It is our independent check of what DOE is doing. DOE now does

and must do iterative performance assessment themselves for the same reasons.

COMMISSIONER ROGERS: Well, I guess what I'm curious about is just how the research and the performance assessment are actually linked together, how those two are working exactly as you say you'd like to see them work. To what extent has the research program thus far, for example, if we are in the second iteration, in fact been influenced by the fact that we're in the second rather than the first go-around on that.

I'd like to see how that's working because that seems to me very, very important that we, in fact, have feedback from the performance assessment iterations into the research program rather than the research program somehow or other been initially defined as important things to look at and then it just runs on.

MR. BERNERO: Perhaps so.

MR. COSTANZI: Well, as Mr. Bernero mentioned, the IPA is a continuing process. The definition of the research program, the things that the research is looking at, has both been shaped as well as has helped to shape the identification of the issues. As we run through and do performance

assessments, it helps us further define what are the important things to look at in terms of our research program and where to focus our efforts.

There are certainly many more questions than one could possibly dream up to ask than we would have resources to focus on. So, the task of the IPA is to make sure that we've identified those issues which are critical to the performance and to those which require research for addressing, that the research program does indeed address it. It's an ongoing process. It's a continual review and a looking back of what we're doing and how we're doing it.

I can't point to a specific task in the program that says relate findings of IPA to research program because there is no such specific task. It's an ongoing effort. It's something that we can continually do.

It occurs in large part because many of the same people are doing both things among the research staff. They're managing the individual research projects. They're also participating in the IPA exercise. Researchers at the center are doing the same thing.

COMMISSIONER ROGERS: I have difficulty

envisioning a continuous process.

MR. BERNERO: Okay. Let me suggest that perhaps --

COMMISSIONER ROGERS: To me it's inherently discontinuous.

MR. BERNERO: -- what you need is an example. I believe in the second phase of performance assessment one of the technical examples of program guidance or program sensitivity that is coming out of it is our ability to discern calculation of individual risk on a limited pathway model. One of the characteristics of a dry site is that although it might be very good for overall release standards, that is total curies released to the accessible biosphere, it may have what few curies come out, coming out one little rivulet of water.

That is a major issue in the National Academy of Science consideration of should you have a health risk-based standard or a release standard. I believe there is an example where our own analysis is able to focus on the calculation of individual dose, what would be entailed and what would be the quantity in that little rivulet, that one small stream. That can be very significant to us now in the program. That's just an example of a thing that can come out.

The carbon-14 is another I mentioned earlier.

COMMISSIONER ROGERS: Well, why don't you just proceed? I think I'd like to just see how it seems to be shaping up.

MR. COSTANZI: All right.

(Slide) May I have the next slide, please?

The way I would like to proceed this morning with the presentation is first to identify the issues of regulatory significance which the research program is addressing and briefly describe what research is that's addressing the issue, what end products we anticipate from that research and how we anticipate that those products will be used.

CHAIRMAN SELIN: Before you start, Mr. Costanzi, you've got some engineering stuff at the end that I'm quite interested in and you have a very large number of issues and you have a fixed amount of time. So you might take all that into account as you --

MR. COSTANZI: Okay.

CHAIRMAN SELIN: -- allocate those --

MR. COSTANZI: (Slide) All right. Okay. The next slide.

I've divided this presentation into dealing with issues related to the site, issues

related to engineering. That's what's going to be done at the site and finally what I call the source term issues which really that's the mathematical characterization of the in place waste that's used to test the compliance against the Part 60 performance objectives and EPA high-level waste standard.

The first group of site issues can be described, I suppose, as reading the geologic record. How do you do that? And the uncertainties that we're focusing on there put in -- phrased as questions. The first one, what measurement techniques are appropriate for determining the geologic properties and parameter values? Secondly, what measurement techniques are appropriate in determining hydrologic properties and parameter values?

(Slide) Next slide, please.

With regard to that first question, the research that we've done and are doing, we've conducted previous experiments and investigated techniques such as down-hole tomography and core-logging, and present experiments are examining other methods of determining geologic properties and parameters.

I might mention here that the bulk of this work is being done at the center and, in fact, all the

work in this presentation would be considered as being done at the center unless it's explicitly noted otherwise.

(Slide) Next slide, please. Page 7.

What we anticipate in terms of products or evaluation of site characterization techniques that DOE would be using at Yucca Mountain and we would intend to use those, of course, in evaluating the appropriateness of DOE's site characterization program, whether they're using the right techniques to go after the right data to get the right story.

(Slide) Page 8, please.

The related issue on hydrology, what measurement techniques are appropriate for determining hydrologic properties, again we have done some previous field work that was done at Arizona to determine local hydrologic properties. Current research at Arizona is continuing measurements of hydrologic properties of a site very similar to Yucca Mountain. That's namely an unsaturated fractured tuff.

(Slide) The product is field data which has been developed using demonstrated techniques from a well-characterized site. So, we will have done some site characterization. We will understand what the

successes and failures are of site characterization and that will, of course, put us in a favorable position to review the hydrologic data that DOE develops at the Yucca Mountain site, techniques and also the way they analyze that data.

(Slide) On page 10 we begin the second part of the story. Now that we've read the geologic record we need to understand what it means. What is the nature of the processes, the tectonic processes operating in the central basin and range? That's the geological area in which the site is located. What are the characteristics affecting groundwater flow at Yucca Mountain? What are the characteristics affecting radionuclide transport at Yucca Mountain?

(Slide) With regard to the tectonic processes operating in the basin and range, we're performing geodetic observations, those are being done by Cal Tech, and analytical studies at the center using existing data of tectonics in the central basin and range. The outcome of this research will be models with appropriate supporting data of what the major tectonic processes and significant features are of the Yucca Mountain area, in particular the deformation rates which, of course, relate to the stability at the site.

CHAIRMAN SELIN: How is this different from the research that DOE itself must be doing because they have to answer the same questions?

MR. COSTANZI: Indeed, they are going to be answering the same questions and doing the same sort of research. This is part of the independent base for evaluation of what they're doing.

CHAIRMAN SELIN: Are we ahead of them in this or have they done much of this work and we're confirming it? What's the relative timing of the licensee's work?

MR. COSTANZI: That's my understanding, it's parallel efforts. They're doing the same thing now as we are doing. We have been trying to develop the understandings of what's going on so that we can interpret the results of their investigations.

CHAIRMAN SELIN: Is there a sharing of information as we go along or do we wait for a certain time and then disclose what we have found?

MR. COSTANZI: There are periodic meetings which the licensing staff conducts with DOE for exchanging of information. They're under the agreement that we have with the Department of Energy.

MR. BERNERO: But we don't have a coordinated plan.

MR. BIRCHARD: I can answer this question directly. The DOE is focused specifically --

CHAIRMAN SELIN: Would you identify yourself for the record?

MR. BIRCHARD: Hello. I'm George Birchard of the Office of Research.

The DOE is focused specifically on the Nevada test site and is conducting geodetic measurements on that test site. The Cal Tech program is coordinated with the geological survey. It was conducting those measurements for the test site, so there is communication at the investigator level. We are going from the test site across to the Sierra Nevada range to understand the broader context to be able to model the regional processes to make sure that the DOE has not in some way overlooked some important process.

CHAIRMAN SELIN: Okay. Thank you.

COMMISSIONER ROGERS: Could you just say what you mean by model here? Is this a computer model? Is this a conceptual model?

MR. COSTANZI: The first stage is conceptual.

COMMISSIONER ROGERS: What is a model?

MR. COSTANZI: Yes. Well, all of the

above. Initially it's a conceptual model, trying to identify and understand what processes are operating. To the point where we will actually assess the information rates it will be a mathematical model, be quantitative to allow us to do calculations.

COMMISSIONER de PLANQUE: I'd like to just follow-up on the Chairman's question too. If where you're headed is diverging or is different from where DOE is heading in terms of results, how do you know that? Do you know when you've reached a point where your data tell you something entirely different from what they're telling DOE?

MR. COSTANZI: Well, certainly we'd know that when the license application comes in.

COMMISSIONER de PLANQUE: Yes. That's way down the road.

MR. COSTANZI: Hopefully we'd know that before.

COMMISSIONER de PLANQUE: I mean are there any ways in which you find that out along the line?

MR. COSTANZI: The periodic exchanges, the periodic meetings that we have with DOE we do tell them what the results of our work is, and they also tell us what the results of their work is. So, there is a transfer of information back and forth and I

think -- was it the matrix fracture fluid is a good example of a case where we, through our research, assess that fracture flow is very significant in the type of rock that exists at Yucca Mountain. That information was related back to DOE and they have since focused their program more to examine fracture flow than they had to that point.

MR. SILBERBERG: In fact, when DOE issued its site characterization plan that the staff reviewed, that in effect laid out their process of what they were going to -- in effect their study program, how they were going to proceed. They also come out periodically with study plans which are more details for the staff to look at on how they're proceeding.

In the site characterization plan they immediately came out with -- in there showed the concepts they were using, except for models of the hydrology, and the staff noted that very early on, as Nick says from our own work, but the comments back to DOE were put on record that, in fact, alternative conceptual flow models would have to be looked at, that what they had was not sufficient.

COMMISSIONER de PLANQUE: Okay. So there's a good enough exchange that there shouldn't be

some big surprises when the applications come in.

MR. SILBERBERG: Certainly.

MR. COSTANZI: That's our hope, yes.

(Slide) The next site issue is what are the characteristics affecting the groundwater flow at Yucca Mountain on page 13. The research that we're doing there are analytical studies both at the University of Arizona and primarily at the center assessing the use of stochastic techniques to develop large-scale hydrologic models of unsaturated flow in fractured, porous tuff. What all that means really is we're trying to determine how one takes into account the tremendous variability in hydrologic properties from location to location within the Yucca Mountain region.

What the results of that research will be is identification of appropriate modeling techniques, which is essentially algorithms, computer algorithms for taking into account the variability of hydrologic characteristics. The use, of course, would be to evaluate DOE's description of the hydrology at the Yucca Mountain site and in particular how they treat the spatial and temporal variations in those hydrologic properties.

(Slide) On page 16 we ask a similar

question with regard to the characteristics of radionuclide transport. The field research, the research that we're doing includes field research at Peña Blanca Analogue and laboratory studies to determine the controlling mechanisms of radionuclide transport in tuffaceous rock. The result will be kinetic and thermodynamic models and data of radionuclide speciation and movement in the tuff and the use again is evaluation of DOE's geochemical model of the Yucca Mountain site. Of course, supporting data and also DOE's use of natural analogues that they intend to use as well to help support their evaluation of the site.

(Slide) We've read the geologic record and we think we've understood it. What does it tell us about what's going to happen there in the future? That's what the next four issues relate to. First is how will the heat from the high-level waste that's in place at the site affect the local hydrology and geochemistry? What is the credible range of future climates that may affect a repository? How likely are volcanos at the site and what effect may they have on the repository, the geology, the hydrology and, of course, the emplaced waste?

(Slide) And lastly, on page 19, what

effect does seismic activity in the region have on the hydrology of the Yucca Mountain site.

(Slide) With regard to the heat from the emplaced waste, the work we're doing in natural analogue studies, primarily the Oklo study and laboratory experiments in geochemistry and repository thermal hydraulics. The products would be identification of the key heat-driven mechanisms that affect hydrology and transport close in to the repository and a model of the effect of heating on local geochemistry and hydrology.

COMMISSIONER ROGERS: How do you do those studies without knowing what the expected design of emplacement will be? I mean you don't know what the heat sources are really going to be in that site until that's been decided and it hasn't been decided yet.

MR. COSTANZI: Well, that's right. What we are trying to do is right now understand how heat affects these various elements, the local hydrology and the geochemistry. The heat loading of the repository will affect both the time duration and the temperature that the repository will receive. So, the objective is to have the understanding of the physics of the situation so that when we know the parameters of the situation we'll simply be able to evaluate the

consequences using the same physical models.

Obviously the --

COMMISSIONER ROGERS: Well, my impression is that some of these models are very complex.

MR. COSTANZI: They are extremely complex. They also don't have -- many of them do not have extremely broad ranges of applicability. So, we are looking at a number of models to determine what their limits of the applicability are over the various ranges. Whatever the final internal parameters of the repository might be, we will be able to select appropriate models to again test what DOE's demonstration of compliance is.

MR. TAYLOR: Did you want to say something?

MR. BERNERO: Yes. I just wanted to add, Commissioner Rogers, I believe you have heard the briefing on the subject of the hot hole concept out at Livermore. That concept is very strongly entrenched in the DOE design right now. It focuses on the near-field effect of having calibrated heat content keeping the excavation right around the canister above the boiling point of water for a very long time. But the far-field or mid-field effect where the mountain could turn into a heat pipe by starting some rather

macroscopic flow condensation and capillary return, that's extremely important because that could be an issue that would have a very great impact on the entire design of the facility from the outset.

COMMISSIONER ROGERS: Right.

MR. BERNERO: Very, very important, this information. And frankly, from what I've seen so far, I'm not sure that DOE's program has enough focus on that.

MR. COSTANZI: The implications for the performance of the repository of obtaining those high temperatures the closer to the waste package are pretty profound. The regional or the hydrology at least on the scale of the repository itself could be altered quite dramatically to what the amount of water that was initially considered to be available for dissolution and transport may increase significantly owing to the fact that what we have observed appears to be a concentrating of water near the dry-out zone in some of our laboratory tests. If that's the case, the hot dry repository might actually attract water to it. Once the temperature starts to recede, then the amount of water available may actually be more than the current design anticipates.

But these are the sorts of questions which

we're trying to examine in our program.

COMMISSIONER REMICK: Frank, how pertinent is the Oklo study results to the local hydrology studies and so forth? Is CEA still doing research at Oklo?

MR. COSTANZI: Yes, CEA is still doing a good deal of research there. With regard to the hydrology, I don't know that we know an answer to that right yet. I do know with regard to the geochemistry, the transport, it's very clear. There is a -- close to one of the reactors there is an intrusive dike that occurred some time after -- I don't remember the exact number of thousands of years, but the alteration of the rock and the thermal effect is clearly visible there in terms of what effect it has had on the migration of the fission products and actonides from the reaction.

COMMISSIONER REMICK: I could see where maybe the geochemistry -- I wasn't quite clear how it would help in the local hydrology studies.

MR. SILBERBERG: But the presence of a dike is, in fact, one possible scenario that one might have under potential volcanic conditions at the site. So, looking at intrusion from a volcanic source is something that's looked at within performance

assessment.

MR. COSTANZI: One of the things, the real benefits of doing the IPA exercise is that when you take a piece of a model there, the piece that talks about geochemistry and the piece that talks about hydrology and the piece that talks about engineering and combine them altogether you start to get a limiting set of parameters. It starts to constrain the problem and you have to start looking for consistencies. We found that, in fact, in studying the natural analogues that the conglomerate deposit is a good example of how we were able to learn a lot about the hydrology from the geochemistry just by demanding consistency of the models and we would anticipate that that kind of thing will just continue as we keep doing these performance assessments. It will help constrain and give us a more realistic picture of what's going on because -- to avoid internal contradictions.

MR. SILBERBERG: I would just also note, Commissioner Remick, that the CEA is doing that in conjunction with the Commission on European Communities and along with us in the field of countries.

COMMISSIONER REMICK: Good.

COMMISSIONER de PLANQUE: There was some discussion of a natural analogue site in Mexico. Is that being used at all?

MR. COSTANZI: Peña Blanca?

COMMISSIONER de PLANQUE: Yes.

MR. COSTANZI: Yes. Oh, yes, very definitely.

COMMISSIONER de PLANQUE: Oh, I didn't remember the name of it.

MR. COSTANZI: I believe we'll talk a bit more about that later.

COMMISSIONER de PLANQUE: Okay.

MR. COSTANZI: (Slide) I'd like to turn to page 22 now. The next question we wish to address is what is the credible range of future climates. This largely has to do with precipitation, water infiltration, how much water could get into the repository. Methods to assess water infiltration field side have been examined and future work will focus on a possible range of climates at Yucca Mountain. We've done some work in that area already. We've, in fact, had an expert elicitation exercise that NMSS conducted with regard to the climates.

What we will be doing in terms of the product is that we will evaluate the methods of

treating infiltration that have been developed and looked at by the University of Arizona and this would be work be done at the center. We'll address the consequences of range of potential climates as well. If water balance increases by a factor of two or a factor of four, how does that -- given our current understanding of what the repository looks like, how will that affect the performance? And again, all this is to evaluate DOE's treatment of future climates.

The last or, I guess, an ultimate question in this set is how likely are volcanos at the site and what affect may they have on the repository, the geology, the hydrology and, of course, the emplaced wastes themselves.

We're doing analytical studies of using field observations, assessing volcanism in the basin and range. We're anticipating to developing a model which will give us an idea of the likelihood as well as the characteristics and the consequences of all that volcanic eruptions in the repository area.

Again, the use will be to develop interpretations of the regional data that DOE is now, of course, developing at the site and interpretations of the likelihood and the location and characteristics and consequences of volcanoes.

The last site issue that we'll address is what effect will the seismic activity in the region have on the hydrology of Yucca Mountain? The work we're doing to -- analysis and interpretations of existing historical and field data relating to changes in the regional hydrology to seismic activity. This is being done at the University of California in a site out in California where there is some large -- the seismic activity is fairly frequently and fairly large magnitude and work that has been done and is now in the final process of analysis at the center, field work at the Lucky Friday Mine.

We will be developing a model which relates regional hydrologic changes to the seismic events. In particular, the kinds of things that we have observed is that the local core pressures change and they change in odd ways as a result of seismic event. First of all, there are some cases where there are delays. The seismic event precedes the changing core pressure or pressure in a fracture by some time. In some fractures pressure goes up as a result, in some fractures pressure goes down. Sometimes some observations it's taking a long time before pressure goes back to its ambient state and sometimes it's taken a very, very long time. Sometimes it's rather

quick. We don't really understand all the mechanisms. Obviously it has to do with the opening and closing of fractures. But to relate that kind of information as to what will happen in a repository is what we're trying to do now.

Again the use of this will be to review DOE's treatment of potential perched water zones as well as some of the steep hydraulic gradients which appear to be near the Yucca Mountain site, will an earthquake essentially end up flooding the repository and delivering a lot of water into the waste emplacement area.

(Slide) Now I'd like to turn to the engineering questions. I have two sets of questions related to the repository engineering itself. One, will the waste emplacement drifts and boreholes at Yucca Mountain remain open during the retrieval period and will they be stable in the post-retrieval period? And secondly, how long will the shafts in the boreholes remain sealed at the site?

(Slide) With regard to the first question, the research that we're doing consists of field and laboratory experiments, as well as analytical studies evaluating the efficacy of rock mechanics models that are used for predicting tunnel

stability, actually reviewing the models and doing some laboratory experiments in testing the predictions of the models against what's observed.

(Slide) What we will end up with as a product are, of course, a review of several of the rock mechanics codes against field observations, both the University of California and the center work, and laboratory observations of rock joint behavior. This is being done at the center, as I mentioned.

(Slide) The use of this product will be the development of methods for the review of DOE's assessment of repository response to earthquakes, stability, the opening themselves and thermal mechanical stability of underground excavations. Of course when DOE places the wastes in the repository the heat is going to put thermal stresses on the rock itself and will change the -- the change in the stress fields will, of course, be reflected in the -- could be reflected in stability of changes in the stability of the excavations themselves.

(Slide) The next engineering issue is how long will the shafts and the boreholes remain sealed? We've had a laboratory program investigating the effectiveness of various techniques for sealing the shafts and boreholes. This was done at the University

of Arizona. The product is data on the effectiveness of various techniques and designs for sealing shafts and boreholes and unsaturated fractured tuff. We have a pretty good idea at this point of what the design parameters for a good seal are. Good in this case however is defined only to what makes the seal hold right now. The long-term performance is something which we really don't have a good handle on and that would be the subject of future research. The use, of course, of the work from this program is to assess the suitability of DOE's sealing program at the site.

(Slide) The next set of engineering questions focus on the waste package itself, in particular how long will the waste package contain the high-level waste, and the next question being how confidently can you extrapolate the short-term tests that are being conducted in the laboratory today to the long-term performance of the waste package. We have in the laboratory, at best, and opportunity for maybe a few decades of experiment. Certainly field observations of the behavior of various metals gives us maybe a century or so worth of data, but the waste package themselves don't maintain themselves from the order of tens of centuries. So, the question is how confidently can you extrapolate the short-term data to

the long-term performance?

(Slide) With regard to how long will the waste package contain waste, expect a performance in the waste package. We have an experimental program to identify the corrosion mechanisms of the various metals that DOE has been examining in the repository environment. The product has been correlation of dominant corrosion types and rates with environmental parameters. We've looked at pitting corrosion. We've just about finished our work on that. The question of internal corrosion, that's the interaction of the waste itself on the waste package or canister. We're now in the midst of looking at stress corrosion cracking of the waste materials, waste package materials.

(Slide) The use, of course, will be to assess whether DOE has identified the controlling waste package failure mechanisms, employed appropriately conservative models in assessing the waste package performance, and confirm the suitability of waste package material to meet the containment requirement.

(Slide) The next question of engineering issues is how confidently can a short-term laboratory test be used to predict long-term performance. The

research that we have underway is continuing laboratory program of testing waste package materials under a range of potential repository conditions. We had planned to supplement this with observation of buried metal objects at the Akrotiri site, which is an archeological site, and also long-term observation of waste package materials. We still have not yet formulated exactly what we're going to do on that, but we have been considering the possibility of burying the waste package materials in tuffaceous rock, heating it and just letting it sit and cook in the laboratory for a couple of decades.

COMMISSIONER ROGERS: How long have those metal objects been buried at Akrotiri.

MR. COSTANZI: Thirty-five hundred years.

COMMISSIONER ROGERS: Thirty-five hundred years.

MR. COSTANZI: (Slide) The product of this research will be an assessment of the mechanistic corrosion models for correlating the short-term laboratory tests, long-term in situ tests and field observations. The use, of course, will be to review DOE's demonstration of compliance with the containment requirement in 10 CFR Part 60.

(Slide) The last issue --

CHAIRMAN SELIN: Before you come off this, Mr. Costanzi --

MR. COSTANZI: Yes.

CHAIRMAN SELIN: The other topics really have to do with the site or some sort of major civil engineering around which there aren't a huge number of alternatives. But when you get to waste packages, the number of different kinds of materials that might be used seems quite large. Is this a continuing process? Are we going to be looking at ceramics as well as metals or some other --

MR. COSTANZI: Well, what we are doing generally -- well, what we have been doing is following DOE's lead. The metals that -- DOE has been investigating metals. They have looked at titanium, carbon steel, mild steel to a certain degree, copper to a certain degree, nickel alloys which seems to be -- right now they're their favorite candidate material and we've essentially been following them, looking at materials which they have been observing and trying to determine what are the degradation mechanisms characteristic of that material in repository environment and trying to understand how we could ascertain over the short-term what the long-term performance might be.

CHAIRMAN SELIN: The license application would assumably be amendable later on if they decided after the observation period to change the materials or is that fixed for once and for all? What's the --

MR. COSTANZI: I assume that it's amendable until they actually start putting the waste in and even then I suppose they could pull it out.

MR. BERNERO: One of the things that has a potentially very great impact on this is this concept of multipurpose canister that is now afoot where among other things DOE might be able to some degree to uncouple the waste package from the spent fuel package and just use the concept of an over pack, that you have a handling package that comes along, maybe an alloy steel or something, and then have a pure and simple waste package sleeve that goes over it and really have two packages in one and thereby uncouple and be able to handle a variety of things within it.

DOE also has other waste forms than just spent fuel and there are a variety of spent fuel forms and waste forms that they have to deal with. This might give them greater flexibility. But therein also lies a much more difficult problem for us. Many of the concepts like the multipurpose canister can and

may very well make the shaft bigger, the seals bigger and so we really need to have a good knowledge of how that would affect the reliability of the repository.

MR. SILBERBERG: And about five years ago DOE had a much larger candidate selection, a number of array of candidates which they have narrowed down in the last five years and I think they need to narrow it down within again the next few years, narrow it down further as well as select the design with regard to the thin canister or the more robust design, as Bob Bernero noted.

But nevertheless, the licensing process allows for what they call a license application design that they will have to come up with. I think it's like 96. They have a process that they're going over now, what they call the alternative conceptual designs. I think by 96, as I recall, they're supposed to fix on the license application design, as I understand it.

MR. BERNERO: Something of that order.

MR. SILBERBERG: Something like that.

MR. BERNERO: That's part of the issue I want to say a few words about, about the program progress and what happens when.

MR. COSTANZI: (Slide) The last issue

relates to the source term, simply at what rate will radionuclides enter the -- be released from the waste package and be available to enter the groundwater system. Here again our national analogues come into large play, those field observations of the actinide and fission product migration at Oklo and Peña Blanca where we're looking at the actual transport of material away from the ore bodies, the reactors at Oklo and the ore body at Peña Blanca.

The data which will be product in the models, spent fuel leaching and radionuclide speciation and transport in an actual geologic environment. That's what we're going to get out of these studies and their use, of course, will be to confront the results of laboratory experiments on radionuclide speciation and mobility.

I might mention that some of the things that we've already determined is that under an appropriate set of potential repository conditions iron makes a great getter for uranium. It likes to bind up with the uranium and that also we've identified under what conditions the leaching of radionuclides from a waste glass would be controlled by essentially silicon chemistry which makes the problem of demonstration compliance a bit more

tractable. It makes the geochemical modeling a bit simpler.

That concludes my prepared remarks.

CHAIRMAN SELIN: Thank you.

Should we go on to Mr. Bernero's remarks and then questions?

MR. BERNERO: Yes. Let me just say a few words about program approach and resources and what's going on in the program today.

I'm sure the Commission recalls that we have divided the work in the program for a long time into reactive and proactive work, reactive work being reacting to what they find in site characterization, that that rock is different than you expected or there's more water here than you expected or something like that, that also is reactive to design. I mention the multipurpose canister. That is an extremely important piece of reactive work that's now on the table because it can have such a profound effect on the entire repository approach, the hot hole, whether or not they can manage or control the thermal loading precisely and so forth.

The proactive work is something -- well, in fact, Nick Costanzi used a very good example of scientific proactive work, that fracture flow may be

far more important than people envisioned, you know, based on some research. Or proactive work can be quite specific in what does it take to make a licensing finding about containment or package lifetime, something like that.

We have had for quite some time a strategy for characterization and for regulation, licensing, that we would focus early on the most important issues whether reactive issues like carbon-14 release or proactive like what is substantially complete containment or what is a 1,000 year package when you're talking about 15,000 or 20,000 packages and each holding different materials.

Now when we look at what's going on in the program today, the DOE Yucca Mountain program, there is a lot of talk. They haven't announced yet, but there is a lot of talk that they'll do what they did in 1989 and move the date out, and we ought to look very carefully at what that date movement means. Is it simply rescheduling a previously well-known thing or is it recognizing that the critical path takes longer than you left time for?

The Nuclear Waste Technical Review Board has been criticizing the DOE program for some time now for not having within their planning horizon enough

time to complete or to conduct sufficient span of geologic testing. Certain testing aspects should take longer according to that.

I think what we will see in the three months or four months is, you know, perhaps a mission plan amendment that may indeed do what happened in 1989, a several year change in overall schedule, but I think it will be more in the character of what the Nuclear Waste Technical Review Board was saying, that you haven't recognized that the critical path will take longer than you now have in your books.

Nevertheless, a program like the High-Level Waste Program, all you have to do is listen to the regulatory utility commissioners or anyone else that watches the cash flow. If you have large resources going out year after year after year for decades, the numbers are mind boggling. You can just pile up billions of dollars and the only way you can deal with that is by careful planning. And remember what the focus is. If it's not a good site, find out early. Get the important issues on the table early.

Now DOE has a very great responsibility in their mission plans, in their site characterization plans, in their study plans, to iterate those, to do those again and again, to review those again and

again, and I presume they're doing that right now and that will be the basis of whatever reschedule they come out with.

At the same time, we have to do the same thing here. At the NRC we have an internal management plan for the High-Level Waste Program. We have a high-level waste research plan and we must look at those, in my view, every budget cycle, and certainly now when we're taking a fresh look at the five year plan. We've got to look at those to say, "Do we really need to do this now? Do we really need to have these resources now?" It's a difficult issue, but you have that tension and I think it's very important to understand. If in past years it slipped from 1989 to 1998 to 2001 and now the application may slip another several years, is that a simple rescheduling of a predictable thing or is it recognition that you couldn't get there from here?

I think the program has to focus on a responsible use of resources in doing what needs to be done this year, next year and the year after, so we are doing that and we will come to the Commission certainly in the five year planning process that we're going to be doing this winter, but our management plan has to reflect a very careful look at that issue.

CHAIRMAN SELIN: Well, that's a discussion with which one cannot differ. It's interesting, because at least for me a couple of things have fallen into place.

One is I'd like to congratulate you, Mr. Costanzi, and your team on putting together really a very nice bottom-up discussion of what you're doing and why you're doing it and in smaller sessions different Commissioners might want to follow-up on how you're doing it, but that's clearly a much greater level of detail, but some feeling for the lead times there and the fruitful interaction between the licensing people, the preapplication people and the research people to identify the topics.

So clearly you've put your finger on a number of long-term objects. On the other hand, we could get so far ahead in the licensing part that every time DOE changes the program a little bit we've wasted a fair number of resources and have to go back and do that and we clearly don't want to do that. I'm not thinking so much of research resources as program resources.

Commissioner Rogers?

COMMISSIONER ROGERS: Well, a couple of observations.

One is I didn't see in the briefing slides and, although you did say some words about it, I don't really see exactly how it is that you're making decisions on research topics that essentially duplicate an area that DOE is dealing with, just exactly how you manage that question of are you simply repeating something that somebody else has done, what do you expect to get out of it that is going to be of assistance in the future. I think that that really isn't clear from your presentation today. I think it's very important that be done.

You've said all the right words about the philosophy of your research and so on and so forth, but I guess what I'm uncomfortable about is how you're arriving at very difficult decisions as to essentially repeating a piece of research to get a kind of feeling about whether -- what the problems are and what the expertise is that one must have to make judgements on that particular subject as distinct from what are the difference -- you know, what can you really add to this, in a certain sense, that's helpful for us other than a general level of comfort in our ability to make decisions.

I wonder if you can go one more step beyond the sort of general arguments in favor of a

particular piece of research to more specifics with respect to what extent particular uncertainties are dealt with or questions are raised about the validity of a particular approach, something of that sort. I don't get any feeling about that from what I've seen so far and it seems to me that there is a question of resources. There is a question of how you make your research decisions and of course the extended time frame of this whole project makes those things very difficult decisions to make.

But I personally don't feel I've gotten much help in my concerns about how you do this from the presentation today or from what I've seen so far and it seems to me that these are absolutely fundamental to justification for anything that we do, in a certain sense. We can't just do something because it has some pretty good-- it gives us sort of a good feeling that we've done that and we have some comfort level.

Now I'm being a little bit superficial here in this, but I think you understand what I'm saying, that somehow you've got to go one more step beyond that as to the justification for particular pieces of work as to how far to go and when to stop. These are very tough questions. They're not easy

questions at all and they fly somewhat in the face of the natural inclination of researchers to pursue things because they do fit together in some way and they represent a considerable intellectual challenge, and so this is a very difficult area to deal with in managing applied research and I guess I haven't really gotten a feeling from what I've heard today of how you're doing that and what the level of resources are.

These are all interesting topics and yet, when I look here and what I've heard so far, I don't know how much you're getting a lot of resources and how much you're getting a little resources and how expensive and what the time frames are in which some of these things are being done, so I don't have any feeling about that.

In other words, I don't have a context, a framework on which to hang this program that gives me some feeling about relative importance and how priorities are being set with respect to the assignment of resources, financial and FTE type of resources. That wasn't part of today's briefing. Maybe it was by design not to be, because maybe you didn't think it was appropriate. But I think it is appropriate, so I'd like to get a better feeling about how this whole thing fits together from that point of

view.

MR. COSTANZI: Let me address your question by, one, giving an example with regard to what we look at. We have been aware for some time that DOE had been pursuing in the area of geochemical modeling the so-called "KD approach" or "partition coefficient approach," a very simple geochemical model. We undertook to examine the thermodynamic database for various mineral species and their action with actinides -- uranium, neptunium, for example -- to determine just how good an approach that would be, how robust it would be, where it would work and where it wouldn't work. We have to a large extent finished that geochemical program and we're just wrapping it up now and we do have a very good idea of under what conditions how complex a geochemical model really does need to be to give us adequate comfort in the geochemical description of the site that DOE may derive.

What we do in the future we're not sure yet. Clearly the temperature is still a large unknown and the possibility of the hot dry or the hot hole model would require us to do some additional thinking as to what kind of geochemical model is appropriate. The mechanism by which we do this really inputs from

several areas.

One, of course, is just knowing what the DOE program is and keeping track of that.

The other one is, in collaboration and consultation with the users, the licensing office as to what they view as being the critical things which they will be looking at from this vantage point in the licensing assessment, those have recently been articulated in the set of uncertainties called "key technical uncertainties" which we're now using, I would guess, as our most prominent assessment tool for assessing our program, and this is the identification of those things which must be resolved or addressed some time between now and the actual granting of the license or the license review. Some of those have been identified as requiring research, either to develop models or data or both, and that is what the licensing staff has indicated to us also in terms of their priorities and so we reflect, given our own judgement as part of that input, in our research program.

With regard to -- I can show you a cartoon which gives you kind of an idea of where everything kind of fits together.

(Slide) If I can have the 1-B backup,

please, this is kind of a complicated chart and I was kind of hesitant to put it up because a lot of lines at least confuse me.

But I think the essence of this --

COMMISSIONER ROGERS: Have you ever seen the severe accident closure program?

MR. COSTANZI: Yes, as a matter of fact, I have.

MR. BERNERO: There are no heads on the arrows.

MR. COSTANZI: I think the essence of this is that it is a complex process. It's an iterative process with a lot of feedback. It's a loop in which the staff is actively involved to try continually, as Mr. Bernero said, review our priorities and the direction of our program every budget cycle.

MR. BERNERO: I wonder if I could interject here. There is a rather simple and to me a significant example that Nick covered in the briefing on pages 24 and 25, volcanism.

I think you've all been on Yucca Mountain. You just look around and you see volcano cones. From a program point of view, I can't envision licensing a repository at Yucca Mountain without dealing with the question, can those volcanos effect it. But you get

into some very simple pragmatic issues. Is there something we can realistically do? Can we even get volcanology specialists? How much would it cost? What could we do?

And so really what we're looking for is a sufficient degree of independent judgement to be able to judge the bulk of the work which DOE has to do, and Research has a modest but I think realistic and sufficient program to develop that degree of independence. It's certainly not an example of research sufficient to support licensing of Yucca Mountain. It's not a replacement or a redundancy for the DOE program, but it's what we need because here's a program issue I can't walk away from. I can't ignore those cones.

COMMISSIONER ROGERS: Well, it seems to me you're touching on something I wanted to mention and didn't, and that was that it seems to me that what we need to be able to do is to be able to ask the right questions and we have to also be in a position to be able to evaluate whether the answers are reasonable or not, not to supply the answers but to know whether an answer is a reasonable answer or not. Now, you know, that's a fair level of sophistication.

One level is to be able to ask the right

questions. That's pretty high. But then there's a second level that's even deeper, to know whether those answers are reasonable answers or not without having done all the work ourselves. We can't do that. And so it's that kind of a judgement that has to be made as to where to stop, how far to go, to know that you can ask the right questions, what they are, what the right questions are to ask, and then what's the basis on which you can judge whether an answer you get to those questions is a reasonable answer or not from a technical point of view. And so it seems to me that's what has to drive our approach here. Once we feel that we can do that, then that may change, of course, because the questions may change because of the iterative nature of this business, but that's what I'd like to have some feeling about, how that works.

I don't want to pursue this too much further, but I would like to ask you if you could comment on the recent DOE decision to not emplace waste in WIPP because they didn't feel that this -- well, what I've read is they didn't feel that they would learn as much by doing this as they would from laboratory experiments. I don't know the WIPP situation that well, but, to me, I was a little bit surprised by that rationale because there's nothing

like hard data about a specific site and, you know, a laboratory experiment is not the same thing as working on a site with all of its dirty aspects.

I'm not familiar enough with the particulars of the WIPP project to be able to comment on it in any way, but, I wonder -- that question of laboratory studies versus on-site studies it seems to me is something that's important for our judgements here as well and, if you could, comment very briefly, or if you choose not to that's fine, on what was the basis for DOE deciding that actually doing studies on-site at WIPP with some waste emplaced as an experiment are not -- would not yield as much information as doing laboratory studies. And I understand that there was some question from advisory committees that this was a better way to go, and so--

MR. BERNERO: Well, Commissioner Rogers, the WIPP tests when they were originally postulated, the bin tests or you might call them "package tests," they became a subject of discussion about a year and a half or two years ago in the Yucca Mountain Program as, is there anything to, you know, test emplacement in the strategic planning sense and there was discussion at that time.

I think the essential question that the

technical commenters commented on and which led to the decision is the tests were really focused on bins and the waste reaction with the bin rather than the waste reaction with the salt and the repository WIPP was providing simply an environment to hold the bin and therefore you could do that under just as well a control in a laboratory, and I think that was the essential thing.

In all of our dialogue on the strategic planning, we did not see relevance of those tests. Remember, they have what is essentially unprocessed waste, unpackaged waste, and so it's a different issue they're looking at.

MR. TAYLOR: Commissioner, continuing in your line of questions, Nick has a slide here on the distribution of resources. It gives you a rough idea and we can give you actual numbers.

MR. COSTANZI: May I have the bar graph, please?

MR. TAYLOR: Not that one. The other one.

MR. COSTANZI: May I have the bar graph?

(Slide) This is a further breakdown of our program in terms of the various technical disciplines in which we're working.

Just to draw your attention to two things,

the bulk of the work that we're doing is in the area of hydrology, geochemistry and geology. Those, of course, are the things which deal directly now with site characterization, which is what DOE is doing.

We're doing a little bit of work on containment and engineered systems.

We're not doing anything on what we call controlled release, which is really the waste form studies. At this point DOE is -- well, one, has not selected a waste package material, so our containment study is kind of an overview sorts of studies right now. It's ongoing sorts of things. Just due to budgetary limitations we feel that it's more appropriate to put our resources in those areas in which DOE is now conducting activities, namely site characterizations. So, the site-related properties are the ones in which we're putting the bulk of our money.

COMMISSIONER REMICK: I'd just like to say that I share Commissioner Rogers' observation that it was not clear to me either how we make the research decisions and it came to mind to me in a specific example when you were talking about we're doing research on borehole sealing because my memory tells me that 12, 15 years ago a considerable amount of

effort was done by international experts on borehole sealing and a lot was published and so forth. The thought went through my mind, and I realize we use the term "research" very loosely. Are we doing independent research or are we evaluating a lot of that work that has been done and has been in journals and so forth, done for DOE admittedly and so forth? But are we doing independent borehole sealing or are we doing evaluation of research that has been done and reported in the literature and so forth?

MR. COSTANZI: The work that I discussed here is independent work and not been done before. The material is unsaturated fractured tuff. It's material which -- it's rock which usually doesn't host anything of resource value. So, there is not a whole lot of interest in looking at it, certainly not in sealing it. It's not a typical material in which you drill holes to -- through which you drill holes to obtain oil or water or other resources that then require sealing.

So, there was really no body of directly applicable literature on sealing fractured tuff and what work we had done was to determine what kinds of designs and what kinds of procedures that you can develop competent seals in this kind of material.

That just had not been done before.

MR. OTT: I'm Bill Ott, also from the Office of Research. One other aspect is that the regulations require us to seal according to the permeability of the rocks in place. A lot of traditional sealing work was just done to make certain that there was not gross leakage, but we had to seal those things to essentially very tight, very high permeability work. So, it really is state-of-the-art work which has not been traditionally done in the past.

COMMISSIONER REMICK: So you're saying the work that was done over a decade ago and so forth, quite extensive, had no applicability to the tuff?

MR. OTT: There may have been some work that was done, but there's a large body of knowledge of work on sealing in the industry and petroleum industry and places like that, which was not really applicable.

COMMISSIONER REMICK: No, I'm referring to work that was specifically done for Department of Energy.

MR. OTT: I'm not certain whether that was done to seal to the permeability. The individual that we have working or had working on the program, Jack

Daemen, is an internationally recognized expert and is thoroughly familiar with the field. We're confident that what he is doing did not essentially -- just looking at other work, it was new work that hadn't been done before. He had also done work in salt and in basalt before and his latest work was in the tuff area itself.

COMMISSIONER REMICK: Yes. I was referring to some of the work, I think, that Russ Roy did and I think work at University of Arizona and so forth in the past is quite extensive.

MR. OTT: Yes, Jack Daemen was at the University of Arizona and he was aware of Russ Roy's work as well.

COMMISSIONER REMICK: Okay. Good. Okay.

Those that are looking at the hot hole concept, are they also looking at what effect this might have on the waste form? Because I also remember a decade or so ago the findings that borosilicate glass at elevated temperatures and pressures fragments quite easily, increasing the surface area for leaching and therefore if a canister fails, why there's a concern. Are they looking at those aspects? Is there a coupling between those who are looking at the hydrology and so forth and those that are looking from

leaching from waste form and --

MR. COSTANZI: I don't know that there is. There may be. I'm not aware that there is any cross talk there. In fact, you point out something which is a very concern to us that it's not simply drying out-- the effect is not to simply dry out the area next to the waste package. The effects of high temperatures in the repository are far reaching. They change the local mineralogy, they change the local hydrology and, as you point out, they change the leaching characteristics of the waste form.

We are not addressing yet in an integrated fashion that question. We're still trying to attack this problem in terms of the pieces.

MR. SILBERBERG: The center has done some initial modeling actually starting with NMSS and something that we can use that we'll be looking at in the research program. Given the fact that there might be this dryout effect, there also can be locally a concentration of minerals and minerals which, in fact, being left behind could attack the waste package. So, the modeling in terms of how it might impact the waste package, we've started looking at that at the center.

COMMISSIONER REMICK: Good.

MR. BERNERO: I wonder if I could add to

it, Commissioner Remick. Our program in the research program is not spending any significant resources on waste form and there's a major regulatory reason why. Originally in the high-level waste program there was going to be a form specification because it was presumed all would be reprocessing waste and it would be vitrified to some specified process and to certain waste form performance criteria. What we have now instead is a need for DOE to characterize what the form of the waste is and the forms are many. Some is vitrified waste, some is ordinary power reactor spent fuel, some is N reactor spent fuel, some will -- you know, whatever it might be.

So, we're in the mode of expecting and telling DOE that they have to characterize it and they do have to consider that in order to understand what credit, if any, can be attributed to the waste form.

In our present licensing requirements, we have overall performance. The package should not leak for about a thousand years and then when it does leak it shall leak slowly, very slowly. So, that's when you would take into account the waste form. But I don't know of any specific work that DOE has right now.

COMMISSIONER REMICK: Yes. Okay.

One other observation. I agree with Chairman Selin when he said that the presentation was a good explanation of what you're doing and why you're doing it. The one area that I thought was missing would have been of interest and I hope sometime we hear and that is results. You must be getting some results and we have not talked about results of what we are doing, and that obviously is missing from the presentation and would be of interest, realizing some of this is ongoing research, but some of it's been going for some time. We must have some things that -- being an engineer, that always stimulates me rather than plans.

MR. SILBERBERG: In fact, annually in the Office of Research we collect for Mr. Beckjord a listing of, if you will, peer reviewed products, amongst others, that are done in the research programs. But we have actually compiled that this past year for the high-level waste program and with a large preponderance of the products coming from the center. I think it's a rather impressive list of products and that in itself will, I think, make another presentation. So, what have we learned so far?

COMMISSIONER REMICK: Okay. Thank you

very much.

CHAIRMAN SELIN: Commissioner de Planque?

COMMISSIONER de PLANQUE: Yes. I would agree with Commissioner Remick. Researchers also yearn for what's the bottom line, what do you know. But we realize the constraints on the timing for this briefing.

I have a couple general questions. Can you tell us if and how you're interacting with the National Academy of Sciences on their work right now? Are you going to these meetings? Are you plugged into what they're doing?

MR. BERNERO: We're actually -- we have an observer representative, Margaret --

COMMISSIONER de PLANQUE: For Research?

MR. BERNERO: No, no, no, from the NRC. Margaret Federline is actually, if you could say, an NRC representative or liaison with that activity and we have tracked that activity very closely. I expect to attend their December meeting which is here in Washington and speak to them at that meeting. But we are doing it collegially, as an agency, not separately as Research.

COMMISSIONER de PLANQUE: But Research is in the loop on what's going on?

MR. BERNERO: I believe so.

COMMISSIONER de PLANQUE: Okay. It's obvious that a lot of work is being done in the international community on waste and I didn't hear too much about that other in the analogue studies, the natural analogue studies. Could you just give us briefly some of the ways that the NRC staff is plugged into the international work? Not necessarily contractors, but the NRC staff, in research.

MR. COSTANZI: Okay. In anticipation of my answer, my colleague has put on the slide. This is a list of groups with whom we're involved in international research in the waste area. It spans everything from looking at hydrologic and transport models and methods to gain confidence in the appropriateness of those models, doing what they say they're supposed to do, looking at the thermal response and mechanical response of the host rock to the emplaced waste. That's the DECOVALEX, so-called THMC, thermal mechanical chemical, hydrologic couplings.

Of course the Oklo study itself, which I talked about earlier and the CEC-run organization, National Analogue Working Group, which looks at the suitability and opportunity to use natural analogues

throughout the world in again assessing processes and models describing processes operating in a repository.

We estimate that -- I think conservatively, that in our interactions in the international community looking at this problem probably in effect doubles our resources.

MR. SILBERBERG: I would just add that if you look at the lower set of bullets, if you look at each one of those multi-national programs, we have a staff member in the branch who is intimately involved in every one of those programs, either serving on the managing board or the advisory committee within the program and our staff are in attendance at all of those principle meetings. And in fact, I have an impact, important impact on the international programs, while also receiving peer review from them.

COMMISSIONER de PLANQUE: Okay.

MR. COSTANZI: I also might mention that the nature of the agreements run from cooperative research -- we give you our results, you give us your results -- to international exercises where we're sitting down and working problems and each member country has problems they work on and then we compare the answers that we get by employing various techniques that try and get some feels. Again, the

range of application of -- perfect range of application of various models that are out there that people are exploring to try and assess performance of a repository.

COMMISSIONER de PLANQUE: I don't know all the acronyms up there and you don't need to tell me, but any IAEA work that you're plugged into?

MR. BERNERO: Actually, the way it works out in high-level waste, the OECD has a radioactive waste management committee. I'm the NRC member of that committee and they have subcommittees such as the performance assessment advisory group and things like that. The IAEA has participated with that activity. Also, the IAEA has its own RAWS, radioactive waste standards, and we have some direct interaction with them on that. But that's not focused as much on high-level waste as it is more on low-level waste.

COMMISSIONER de PLANQUE: Yes, I know. Yes. Okay.

You talked about resources earlier and I think the budget calls for a reduction in FTEs in this area. How are you going to deal with that? What impact is that going to have?

MR. BERNERO: Which budget are you referring to?

COMMISSIONER de PLANQUE: Well, you've got something like seven in '93, four in '94 listed in this area.

MR. BERNERO: We have had the '95 budget is up now and then the future ones are the ones I was referring to where we're in that agonizing reappraisal as part of the management plans, the research plans and the five year plan.

CHAIRMAN SELIN: He's talking most about NMSS.

COMMISSIONER de PLANQUE: Yes.

MR. BERNERO: Yes. Well, if you look at the budgets, remember that the high-level waste budget, the nuclear waste fund origin budget includes OGC, LSS, Research, ourselves. It's a whole program. It has to be looked at integrated.

COMMISSIONER de PLANQUE: Okay.

MR. BERNERO: But I can't tell you right now how those cuts will be taken.

MR. TAYLOR: More to come on that.

COMMISSIONER de PLANQUE: Right. Okay.

I want to ask you a big picture question. It's obvious that a lot of the kinds of research that you're doing should yield results eventually, should yield answers eventually. But are there any key

issues where it looks difficult, if not impossible, to get the answers that you think you'll need? Are there any issues in that category?

MR. COSTANZI: I think that certainly some areas the answers are more difficult than others. I think in terms of modeling, for example, it's very difficult to deal successfully with the variability of the hydrologic parameters at a site. But to say that we don't think that we're going to get an answer, I don't think I can say that. I think we are pretty confident that the lines of research we're pursuing are going to pay off. We've had some successes. We are chipping away at some of these major uncertainties, but I can't say, "Yes, everything's in the bag." But on the other hand, I have no reason to be pessimistic.

COMMISSIONER de PLANQUE: There's nothing that you go to bed at night saying, how are we ever going to get this answer given the requirements that you're anticipating?

MR. COSTANZI: No. DOE may go to bed at night saying that since they ultimately do have to supply the answers and we, as Commissioner Rogers pointed out, have to make sure that the answer makes sense. But no, I don't see anything like that.

DOCTOR BECKJORD: Yes. I think that the predictions about performance far into the future get extremely difficult. The legislation calls for this kind of thing. I just don't feel myself that you can say that this is going to do this over the next 10,000 years with high confidence. The further out that people want to know the performance, the less the confidence will be and I think we have to face that.

COMMISSIONER de PLANQUE: Are we facing that?

DOCTOR BECKJORD: Well, a lot of it has to do with legislation, Commissioner.

COMMISSIONER de PLANQUE: I know.

DOCTOR BECKJORD: I think that the technical people are facing that. I think if you have a face to face discussion with the people who are working on the job, they recognize the problem.

MR. TAYLOR: Bob, do you want to --

MR. BERNERO: I think there's something that should be added here. It's not so much a question of can you get an answer, but can you get the right answer or an acceptable --

COMMISSIONER de PLANQUE: Or the acceptable uncertainty.

MR. BERNERO: An acceptable answer and

perhaps carbon-14 is the most dramatic current example of that. There has been a lot of work on modeling and analysis of carbon-14 released from Yucca Mountain and on its face it appears that it constitutes a release in excess of the EPA standard. So, yes, we can get an answer, but what do we do with that answer and that is one of the crucial issues the National Academy is looking at, a release standard where there is no individual risk ever with the high confidence to say that and yet it's an exceedance on its face. It appears to be an exceedance of the standard. So, one can have many cases perhaps where the answer is obtainable, but then the question is what do we do with it.

COMMISSIONER de PLANQUE: Doesn't match with the requirements.

MR. BERNERO: Yes.

COMMISSIONER de PLANQUE: Yes. Okay. Thank you. Excellent briefing.

MR. TAYLOR: That concludes it. Thank you.

(Whereupon, at 11:31 a.m., the above-entitled matter was concluded.)

CERTIFICATE OF TRANSCRIBER

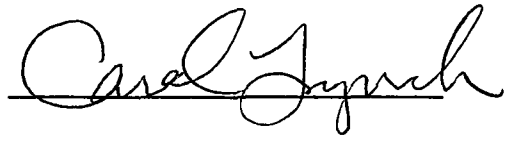
This is to certify that the attached events of a meeting of the United States Nuclear Regulatory Commission entitled:

TITLE OF MEETING: BRIEFING ON NRC RESEARCH PROGRAMS ON HIGH-LEVEL WASTE

PLACE OF MEETING: ROCKVILLE, MARYLAND

DATE OF MEETING: OCTOBER 27, 1993

were transcribed by me. I further certify that said transcription is accurate and complete, to the best of my ability, and that the transcript is a true and accurate record of the foregoing events.



Reporter's name: Peter Lynch

STAFF BRIEFING ON THE HIGH LEVEL RADIOACTIVE WASTE RESEARCH PROGRAM

OCTOBER 27, 1993

FRANK A. COSTANZI

Contact: Frank A. Costanzi
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HIGH LEVEL WASTE RESEARCH PROGRAM

OBJECTIVE

PROVIDE TOOLS AND DATA TO SUPPORT LICENSING ASSESSMENT OF DOE COMPLIANCE WITH 10CFR PART 60 AND EPA HLW STANDARD

HIGH LEVEL WASTE RESEARCH PROGRAM

ACTIVITIES

ADDRESS KEY TECHNICAL UNCERTAINTIES

PROVIDE TECHNICAL SUPPORT FOR FURTHER IDENTIFICATION/REFINEMENT OF KEY TECHNICAL UNCERTAINTIES

PROVIDE MODELS, TECHNICAL SUPPORT, AND LIMITED DATA FOR DEVELOPMENT AND USE OF ITERATIVE PERFORMANCE ASSESSMENT

HIGH LEVEL WASTE RESEARCH PROGRAM

PERFORMANCE ASSESSMENT
IS THE INTEGRATING ELEMENT OF
THE NRC'S HLW PROGRAM

EACH ELEMENT OF THE HLW RESEARCH PROGRAM IS TIED TO PERFORMANCE ASSESSMENT THROUGH THE DEVELOPMENT OF: MODELS, TECHNICAL BASIS FOR THE SELECTION OF MODELS, OR LIMITED DATA TO TEST AND EXERCISE MODELS

OUTLINE OF PRESENTATION

- TECHNICAL ISSUES OF REGULATORY SIGNIFICANCE
- RESEARCH ADDRESSING ISSUES
- ANTICIPATED PRODUCTS
- ANTICIPATED USE

SITE

KEY TECHNICAL UNCERTAINTIES RELATED TO SITE CHARACTERIZATION METHODS

- WHAT MEASUREMENT TECHNIQUES ARE APPROPRIATE FOR DETERMINING GEOLOGIC PROPERTIES AND PARAMETER VALUES?

- WHAT MEASUREMENT TECHNIQUES ARE APPROPRIATE FOR DETERMINING HYDROLOGIC PROPERTIES AND PARAMETER VALUES?

SITE ISSUE--WHAT MEASUREMENT TECHNIQUES ARE APPROPRIATE FOR DETERMINING GEOLOGIC PROPERTIES AND PARAMETER VALUES?

- **RESEARCH** PREVIOUS EXPERIMENTS INVESTIGATED TECHNIQUES SUCH AS DOWN-HOLE TOMOGRAPHY AND CORE-LOGGING (U OF AZ, ETC.)

  PRESENT EXPERIMENTS ARE EXAMINING OTHER METHODS OF DETERMINING GEOLOGIC PROPERTIES AND PARAMETERS, SUCH AS AGE DATING FAULT OFFSETS

SITE ISSUE--WHAT MEASUREMENT TECHNIQUES ARE APPROPRIATE FOR DETERMINING GEOLOGIC PROPERTIES AND PARAMETER VALUES? (CONTINUED)

- **PRODUCT** — EVALUATION OF SITE CHARACTERIZATION TECHNIQUES BEING USED BY DOE AT YUCCA MOUNTAIN (CY 96)
- **USE** — ASSESS DOE'S GEOPHYSICAL SITE CHARACTERIZATION PROGRAM

SITE ISSUES--WHAT MEASUREMENT TECHNIQUES ARE APPROPRIATE FOR DETERMINING HYDROLOGIC PROPERTIES AND PARAMETER VALUES?

- **RESEARCH** PREVIOUS WORK FIELD TESTED METHODS TO DETERMINE LOCAL HYDROLOGIC PROPERTIES (U OF AZ)

  CURRENT RESEARCH (U OF AZ) IS CONTINUING MEASUREMENTS OF HYDROLOGIC PROPERTIES OF A SITE VERY SIMILAR TO YUCCA MOUNTAIN--UNSATURATED FRACTURED TUFF

SITE ISSUES--WHAT MEASUREMENT TECHNIQUES ARE APPROPRIATE FOR DETERMINING HYDROLOGIC PROPERTIES AND PARAMETER VALUES? (CONTINUED)

- **PRODUCT** HYDROLOGIC FIELD DATA DEVELOPED USING DEMONSTRATED TECHNIQUES FROM A WELL-CHARACTERIZED SITE (U OF AZ, FY 94)

- **USE** EVALUATE METHODS DOE EMPLOYS TO INTERPRET REPOSITORY-SCALE HYDROLOGIC PROPERTIES FROM LOCAL MEASUREMENTS

SITE

KEY TECHNICAL UNCERTAINTIES RELATED TO QUALITATIVE AND QUANTITATIVE DESCRIPTION OF THE YUCCA MOUNTAIN SITE

- WHAT IS THE NATURE OF THE TECTONIC PROCESSES OPERATING IN THE CENTRAL BASIN AND RANGE?
- WHAT ARE THE CHARACTERISTICS AFFECTING GROUND WATER FLOW AT YUCCA MOUNTAIN?
- WHAT ARE THE CHARACTERISTICS AFFECTING RADIONUCLIDE TRANSPORT AT YUCCA MOUNTAIN?

SITE ISSUES--WHAT IS THE NATURE OF THE TECTONIC PROCESSES OPERATING IN THE CENTRAL BASIN AND RANGE?

- **RESEARCH** GEODETIC OBSERVATIONS (CAL TECH), AND ANALYTICAL STUDIES USING EXISTING DATA, OF THE TECTONICS OF THE CENTRAL BASIN AND RANGE

- **PRODUCT** MODELS WITH SUPPORTING DATA OF: MAJOR TECTONIC PROCESSES, SIGNIFICANT FEATURES, AND DEFORMATION RATES OF THE YUCCA MOUNTAIN AREA (CY 96)

SITE ISSUES--WHAT IS THE NATURE OF THE TECTONIC PROCESSES OPERATING IN THE CENTRAL BASIN AND RANGE? (CONTINUED)

- **USE** — EVALUATION OF DOE'S ASSESSMENT OF TECTONIC PROCESSES AND RELATED VOLCANISM AT THE YUCCA MOUNTAIN SITE

SITE ISSUES--WHAT ARE THE CHARACTERISTICS AFFECTING GROUND WATER FLOW AT YUCCA MOUNTAIN?

- **RESEARCH** ANALYTICAL STUDIES (U OF AZ AND CNWRA) ASSESSING THE USE OF STOCHASTIC TECHNIQUES TO DEVELOP LARGE-SCALE HYDROLOGIC MODELS OF UNSATURATED FLOW IN FRACTURED, POROUS TUFF

SITE ISSUES--WHAT ARE THE CHARACTERISTICS AFFECTING GROUND WATER FLOW AT YUCCA MOUNTAIN? (CONTINUED)

- **PRODUCT** — IDENTIFICATION OF APPROPRIATE TECHNIQUES FOR MODELING GROUND WATER FLOW AT THE YUCCA MOUNTAIN SITE (CY 95) AND DEFINING THE RANGE OF HYDROLOGIC MODELS THAT WOULD BE CONSISTENT WITH THE MEASUREMENTS TAKEN AT THE SITE (CY 97)

SITE ISSUES--WHAT ARE THE CHARACTERISTICS AFFECTING GROUND WATER FLOW AT YUCCA MOUNTAIN? (CONTINUED)

- **USE** — REVIEW OF DOE'S QUANTITATIVE DESCRIPTION OF YUCCA MOUNTAIN HYDROLOGY, DOE'S TREATMENT OF SPATIAL VARIATIONS OF THE HYDROLOGIC PROPERTIES OF THE SITE, AND DOE'S ASSESSMENT OF THE EVOLUTION OF YUCCA MOUNTAIN HYDROLOGY OVER TIME

SITE ISSUES--WHAT ARE THE CHARACTERISTICS AFFECTING RADIONUCLIDE TRANSPORT AT YUCCA MOUNTAIN?

- **RESEARCH** FIELD (PEÑA BLANCA NATURAL ANALOGUE) AND LABORATORY STUDIES TO DETERMINE THE CONTROLLING MECHANISMS OF RADIONUCLIDE TRANSPORT IN TUFF

- **PRODUCT** KINETIC AND THERMODYNAMIC MODELS AND DATA OF RADIONUCLIDE SPECIATION AND MOVEMENT IN TUFF (CY 95)

SITE ISSUES--WHAT ARE THE CHARACTERISTICS AFFECTING RADIONUCLIDE TRANSPORT AT YUCCA MOUNTAIN? (CONTINUED)

- **USE** — EVALUATE DOE'S GEOCHEMICAL MODEL OF THE YUCCA MOUNTAIN SITE, SUPPORTING GEOCHEMICAL DATA, AND DOE'S USE OF NATURAL ANALOGUES IN DEVELOPING ITS GEOCHEMICAL MODEL

SITE

KEY TECHNICAL UNCERTAINTIES RELATED TO FUTURE STATE OF YUCCA MOUNTAIN SITE

- HOW WILL THE HEAT FROM THE HLW AFFECT THE LOCAL HYDROLOGY AND GEOCHEMISTRY?
- WHAT IS THE CREDIBLE RANGE OF FUTURE CLIMATES AT YUCCA MOUNTAIN (PRECIPITATION AND WATER INFILTRATION)?
- HOW LIKELY ARE VOLCANOS AT THE SITE AND WHAT EFFECT MAY THEY HAVE ON THE REPOSITORY (GEOLOGY, HYDROLOGY, AND EMPLACED WASTES)?

SITE

KEY TECHNICAL UNCERTAINTIES RELATED TO FUTURE STATE OF YUCCA MOUNTAIN SITE (CONTINUED)

- WHAT EFFECT WILL SEISMIC ACTIVITY IN THE REGION HAVE ON THE HYDROLOGY OF YUCCA MOUNTAIN?

SITE ISSUES--HOW WILL THE HEAT FROM THE HLW AFFECT THE LOCAL HYDROLOGY AND GEOCHEMISTRY?

- **RESEARCH** NATURAL ANALOGUE STUDIES (OKLO--CEA) AND LABORATORY EXPERIMENTS IN GEOCHEMISTRY AND REPOSITORY THERMOHYDRAULICS

- **PRODUCT** IDENTIFICATION OF THE KEY HEAT-DRIVEN MECHANISMS THAT AFFECT HYDROLOGY AND TRANSPORT CLOSE TO THE REPOSITORY, AND A MODEL OF THE EFFECT OF HEATING ON LOCAL GEOCHEMISTRY (CY 96) AND HYDROLOGY (CY 94)

SITE ISSUES--HOW WILL THE HEAT FROM THE HLW AFFECT THE LOCAL HYDROLOGY AND GEOCHEMISTRY? (CONTINUED)

- **USE** DATA AND MODELS TO TEST DOE'S ASSESSMENT OF THE ANTICIPATED WASTE PACKAGE ENVIRONMENT OVER TIME

SITE ISSUES--WHAT IS THE CREDIBLE RANGE OF FUTURE CLIMATES AT YUCCA MOUNTAIN (PRECIPITATION AND WATER INFILTRATION)?

- **RESEARCH** METHODS TO ASSESS WATER INFILTRATION HAVE BEEN EXAMINED (U OF AZ)
  - FUTURE WORK WILL ADDRESS EFFECT OF CHANGING CLIMATE ON YUCCA MOUNTAIN REGION

SITE ISSUES--WHAT IS THE CREDIBLE RANGE OF FUTURE CLIMATES AT YUCCA MOUNTAIN (PRECIPITATION AND WATER INFILTRATION)? (CONTINUED)

- **PRODUCT** — METHODS OF TREATING INFILTRATION AT YUCCA MOUNTAIN HAVE BEEN IDENTIFIED--THESE WILL BE EVALUATED ON REGIONAL AND SUB-REGIONAL SCALES--MODELS ADDRESSING THE CONSEQUENCES OF A RANGE OF POTENTIAL CLIMATES WILL BE DEVELOPED (CY 96)

- **USE** — EVALUATION OF DOE'S ASSESSMENT OF THE EFFECTS OF FUTURE CLIMATES AT YUCCA MOUNTAIN

SITE ISSUES--HOW LIKELY ARE VOLCANOS AT THE SITE AND WHAT EFFECT MAY THEY HAVE ON THE REPOSITORY (GEOLOGY, HYDROLOGY, AND EMPLACED WASTES)?

- **RESEARCH** ANALYTICAL STUDIES USING FIELD OBSERVATIONS ASSESSING VOLCANISM IN THE BASIN AND RANGE

- **PRODUCT** MODELS OF THE LIKELIHOOD, CHARACTERISTICS, AND CONSEQUENCES OF VOLCANIC ERUPTIONS IN THE CENTRAL BASIN AND RANGE (CY 96)

SITE ISSUES--HOW LIKELY ARE VOLCANOS AT THE SITE AND WHAT EFFECT MAY THEY HAVE ON THE REPOSITORY (GEOLOGY, HYDROLOGY, AND EMPLACED WASTES)?

- **USE** DEVELOP ALTERNATIVE INTERPRETATIONS OF REGIONAL DATA, AS TO THE LIKELIHOOD, LOCATION, CHARACTERISTICS, AND CONSEQUENCES OF VOLCANOS IN THE YUCCA MOUNTAIN REGION, TO EVALUATE DOE'S ASSESSMENT OF THE POTENTIAL FOR AND EFFECTS OF VOLCANISM AT YUCCA MOUNTAIN

SITE ISSUES--WHAT EFFECT WILL SEISMIC ACTIVITY IN THE REGION HAVE ON THE HYDROLOGY OF YUCCA MOUNTAIN?

- **RESEARCH** ANALYSES AND INTERPRETATIONS OF EXISTING HISTORICAL AND NEW FIELD DATA RELATING CHANGES IN REGIONAL HYDROLOGY TO SEISMIC ACTIVITY (U OF C AND CNWRA)

- **PRODUCT** MODEL RELATING REGIONAL HYDROLOGIC CHANGES TO SEISMIC EVENTS (CY 95)

SITE ISSUES--WHAT EFFECT WILL SEISMIC ACTIVITY IN THE REGION HAVE ON THE HYDROLOGY OF YUCCA MOUNTAIN? (CONTINUED)

- **USE** — REVIEW DOE'S TREATMENT OF POTENTIAL PERCHED WATER ZONES AND STEEP HYDRAULIC GRADIENTS NEAR THE YUCCA MOUNTAIN SITE

ENGINEERING

KEY TECHNICAL UNCERTAINTIES RELATED TO REPOSITORY ENGINEERING

- WILL THE WASTE EMPLACEMENT DRIFTS AND BOREHOLES AT YUCCA MOUNTAIN REMAIN OPEN DURING THE RETRIEVAL PERIOD, AND WILL THEY BE STABLE POST RETRIEVAL PERIOD?

- HOW LONG WILL THE SHAFTS AND BOREHOLES REMAIN SEALED?

ENGINEERING ISSUES--WILL THE WASTE EMPLACEMENT DRIFTS AND BOREHOLES AT YUCCA MOUNTAIN REMAIN OPEN DURING THE RETRIEVAL PERIOD, AND WILL THEY BE STABLE POST RETRIEVAL PERIOD?

- **RESEARCH** FIELD AND LABORATORY EXPERIMENTS AND ANALYTICAL STUDIES EVALUATING EFFICACY OF ROCK MECHANICS MODELS USED FOR PREDICTING TUNNEL STABILITY AND RESPONSE TO EMPLACED WASTES AND TO EARTHQUAKES

ENGINEERING ISSUES--WILL THE WASTE EMPLACEMENT DRIFTS AND BOREHOLES AT YUCCA MOUNTAIN REMAIN OPEN DURING THE RETRIEVAL PERIOD, AND WILL THEY BE STABLE POST RETRIEVAL PERIOD? (CONTINUED)

- **PRODUCT** — REVIEW OF SEVERAL ROCK MECHANICS CODES AGAINST FIELD (U OF C CY 96, CNWRA CY 94) AND LABORATORY OBSERVATIONS OF ROCK JOINT BEHAVIOR (CNWRA CY 94)

ENGINEERING ISSUES--WILL THE WASTE EMPLACEMENT DRIFTS AND BOREHOLES AT YUCCA MOUNTAIN REMAIN OPEN DURING THE RETRIEVAL PERIOD, AND WILL THEY BE STABLE POST RETRIEVAL PERIOD? (CONTINUED)

- **USE** — DEVELOPMENT OF METHODS FOR REVIEW OF DOE'S ASSESSMENT OF REPOSITORY RESPONSE TO EARTHQUAKES, AND THERMOMECHANICAL STABILITY OF UNDERGROUND EXCAVATIONS

ENGINEERING ISSUES--HOW LONG WILL THE SHAFTS AND BOREHOLES REMAIN SEALED?

- **RESEARCH** LABORATORY PROGRAM INVESTIGATING EFFECTIVENESS OF VARIOUS TECHNIQUES FOR SEALING SHAFTS AND BOREHOLES (U OF AZ)
- **PRODUCT** DATA ON THE EFFECTIVENESS OF VARIOUS TECHNIQUES AND DESIGNS FOR SEALING SHAFTS AND BOREHOLES IN UNSATURATED FRACTURED TUFF (CY 94)
- **USE** REVIEW OF DOE'S SHAFT AND BOREHOLE SEALING PROGRAM

ENGINEERING

KEY TECHNICAL UNCERTAINTIES RELATED TO CONTAINMENT PERFORMANCE OF WASTE PACKAGE

- HOW LONG WILL THE WASTE PACKAGE CONTAIN THE HLW?
- HOW CONFIDENTLY CAN SHORT TERM LABORATORY TESTS BE USED TO PREDICT LONG TERM PERFORMANCE?

ENGINEERING ISSUES--HOW LONG WILL THE WASTE PACKAGE CONTAIN THE HLW?

- **RESEARCH** EXPERIMENTAL PROGRAM TO IDENTIFY WASTE PACKAGE CORROSION MECHANISMS THAT CAN BE EXPECTED IN REPOSITORY ENVIRONMENT

- **PRODUCT** CORRELATION OF DOMINANT CORROSION TYPES AND RATES WITH ENVIRONMENTAL PARAMETERS (PITTING CORROSION-CY 93, INTERNAL CORROSION-CY 95, AND STRESS CORROSION-CY 95)

ENGINEERING ISSUES--HOW LONG WILL THE WASTE PACKAGE CONTAIN THE HLW? (CONTINUED)

- **USE** — ASSESS WHETHER DOE HAS IDENTIFIED CONTROLLING WASTE PACKAGE FAILURE MECHANISMS, EMPLOYED APPROPRIATELY CONSERVATIVE MODELS IN ASSESSING WASTE PACKAGE PERFORMANCE, AND CONFIRM SUITABILITY OF WASTE PACKAGE MATERIAL TO MEET CONTAINMENT REQUIREMENT

ENGINEERING ISSUES--HOW CONFIDENTLY CAN SHORT TERM LABORATORY TESTS BE USED TO PREDICT LONG TERM PERFORMANCE?

- **RESEARCH** CONTINUING LABORATORY PROGRAM OF TESTING WASTE PACKAGE MATERIALS UNDER A RANGE OF POTENTIAL REPOSITORY CONDITIONS WILL BE SUPPLEMENTED WITH OBSERVATION OF BURIED METAL OBJECTS AT AKROTIRI NATURAL ANALOGUE SITE, AND LONG TERM (YEARS) OBSERVATION OF WASTE PACKAGE MATERIALS

ENGINEERING ISSUES--HOW CONFIDENTLY CAN SHORT TERM LABORATORY TESTS BE USED TO PREDICT LONG TERM PERFORMANCE?

- **PRODUCT** — ASSESSMENT OF MECHANISTIC CORROSION MODELS FOR CORRELATING SHORT TERM LABORATORY TESTS, LONG TERM IN SITU TESTS, AND FIELD OBSERVATIONS
- **USE** — REVIEW DOE DEMONSTRATION OF COMPLIANCE WITH CONTAINMENT REQUIREMENT

SOURCE TERM

KEY TECHNICAL UNCERTAINTIES RELATED TO RELEASE OF WASTES FROM WASTE PACKAGES

- AT WHAT RATE WILL RADIONUCLIDES ENTER THE GROUND WATER SYSTEM?

SOURCE TERM ISSUES--AT WHAT RATE WILL RADONUCLIDES ENTER THE GROUND WATER SYSTEM?

- **RESEARCH** FIELD OBSERVATION OF ACTINIDE AND FISSION PRODUCT MIGRATION (OKLO AND PEÑA BLANCA NATURAL ANALOGUE STUDIES)

- **PRODUCT** DATA ON AND MODEL OF SPENT FUEL LEACHING, AND RADIONUCLIDE SPECIATION AND TRANSPORT IN A GEOLOGIC ENVIRONMENT (CY 95)

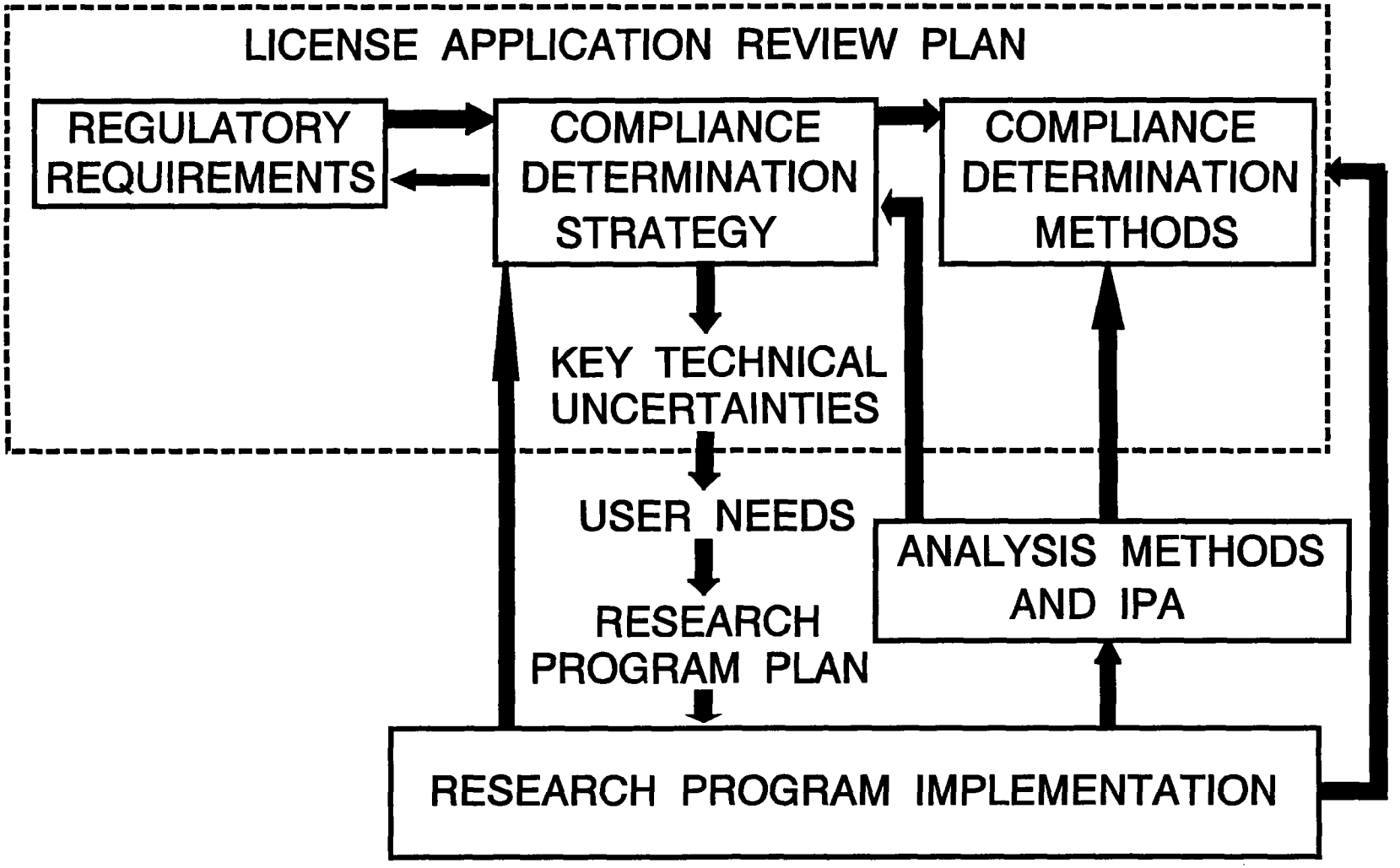
- **USE** CONFIRM RESULTS OF LABORATORY EXPERIMENTS ON RADIONUCLIDE SPECIATION AND MOBILITY

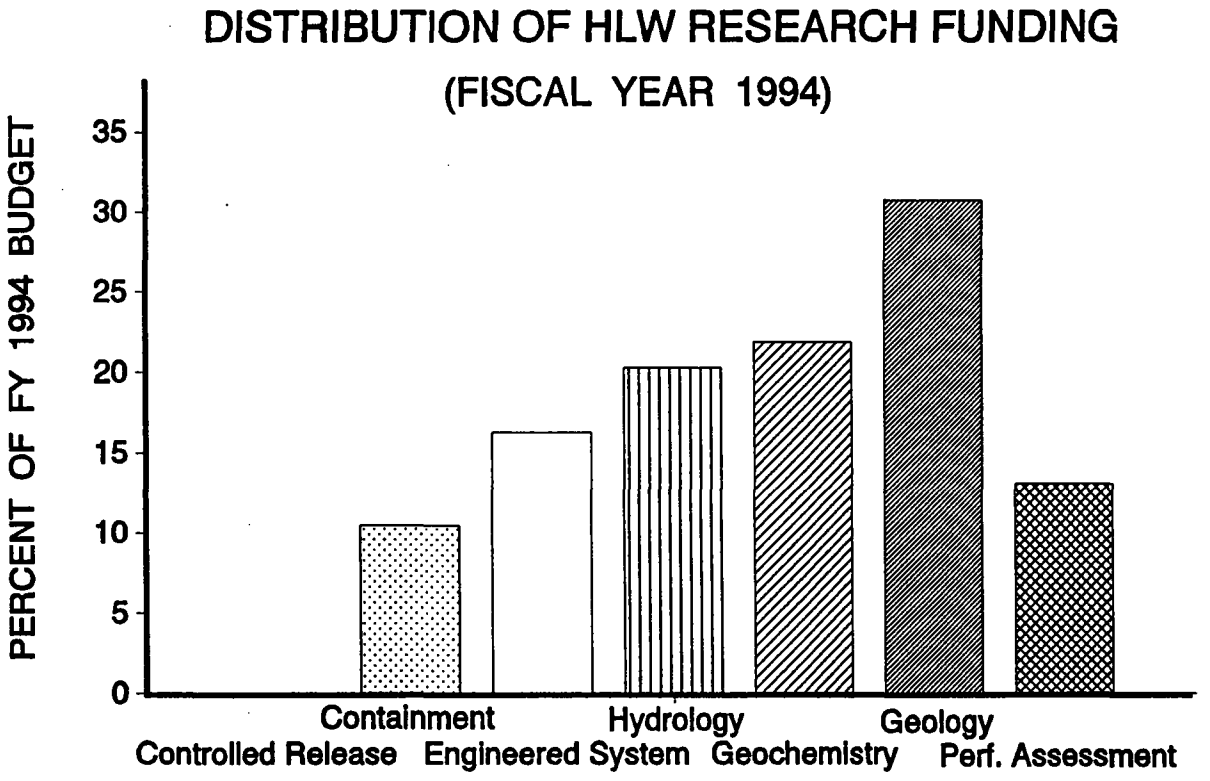
NRC HLW RESEARCH INTERNATIONAL INTERFACES

- **Bilateral Agreements**
  - Switzerland (NAGRA)
  - France (CEA)
  - Sweden (SKI)
  - Japan (JAERI)

- **Multi-National Programs**
  - INTRAVAL
  - ARAP/ASARR
  - DECOVALEX
  - Oklo (CEC/CEA)
  - NAWG (CEC)

RELATIONSHIP OF NRC HLW RESEARCH TO LICENSING PROGRAM





PLANNED DISTRIBUTION OF FY94 FUNDS