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ANN RILEY & ASSOCIATES, LTD.
1025 Connecticut Avenue, NW, Suite 1014
Washington, D.C. 20036
(202) 842-0034

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

OFFICE OF THE SECRETARY

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ADVISORY COMMITTEE ON NUCLEAR WASTE

MEETING WITH THE U.S. NUCLEAR REGULATORY COMMISSION

Commissioner's Conference Room
White Flint Building 1
11555 Rockville Pike
Rockville, Maryland

Wednesday, December 15, 1999

COMMISSIONERS PRESENT:

RICHARD A. MESERVE, Chairman
GRETA J. DICUS, Commissioner
NILS J. DIAZ, Commissioner
EDWARD McGAFFIGAN, Commissioner
JEFFREY S. MERRIFIELD, Commissioner

STAFF AND PRESENTERS SEATED AT THE COMMISSION TABLE:

KAREN D. CYR, General Counsel

ANNETTE L. VIETTI-COOK, Secretary

DR. B. JOHN GARRICK, ACNW Chairman

DR. GEORGE M. HORNBERGER, ACNW Vice-Chairman

DR. RAYMOND G. WYMER, ACNW Member

MR. MILTON LEVENSON, ACNW Consultant

DR. JOHN T. LARKINS, Executive Director - ACRS/ACNW

P R O C E E D I N G S

[9:36 a.m.]

CHAIRMAN MESERVE: Let me turn now to the way we are going to spend the rest of our morning, which is to -- a meeting with the Advisory Committee on Nuclear Waste.

I am particularly pleased to do this, in part because I am -- across the table from me are two individuals with whom I have spent a lot of time over the past several years on waste-related matters, and I'm very pleased to have the opportunity to deal with both John Garrick and George Hornberger in this context as well as the others in which we have worked over the years.

I'm also looking forward to getting to know other members of the advisory committee.

I understand that the committee did brief the Commission in March on issues relating to its work, that since that time it has had a -- meetings with regard to the DOE's examination of Yucca Mountain and had meetings in Las Vegas and met with a variety of stakeholders, and we welcome the opportunity to hear from you about that and the other work that you have underway.

Mr. Chairman, before I turn the matter over to you, why don't I inquire as to whether my fellow Commissioners would like to make a opening statement?

If not, why don't we proceed?

DR. GARRICK: Thanks, Chairman Meserve. It's a pleasure to be here. The committee is anxious to get back on a more frequent schedule of interacting with the Commission, because the feedback is always extremely valuable in inspiring us to be on target on some of the issues.

Today we're going to cover five items, one on the business of risk communication. We're going to discuss a white paper that a committee -- a former committee member prepared on the repository design. We're going to talk about Part 63, a special category of decommissioning called rubblization, and then we're going to end the meeting with some discussion about our planning process and how we conduct that.

So, our first item is something called risk communication.

As is generally known, the field of risk has kind of matured into three major components -- risk assessment, risk communication, and risk management -- whereby, in risk assessment, we try to quantify what the risk is, and by risk communication, we try to improve the processes and the methods by which we communicate the results of risk assessments, and then risk management is basically the issue of taking action and implementation.

So, let me start with my first exhibit on page 2,

with an overview.

The committee identified risk communication as a first-tier priority in its 1999 action plan, and I'll come back to that in a little while as to why.

In the course of dealing with this subject, we have met with a lot of organizations, agencies, and institutions, including the Nuclear Energy Institute, the Environmental Protection Agency, and the NRC.

In order to be in a better position to appreciate the discipline of risk communication, we also subjected ourselves to a little training by a professional risk communicator, and then, perhaps the highlight of the year with respect to risk communication was our one-day roundtable meeting and evening meeting with stakeholders and the public in Las Vegas, and I need to point out that we are in the process of developing our observations and recommendations, so this is basically a work-in-progress report.

View-graph number three -- as to why we identified risk communication as a first-tier priority -- and I should point out that we do this every year.

So, what we're talking about here is basically the calendar year 1999, but we make a strong tie between risk communication and public involvement and participation in the regulatory process, and so, in a sense, we have tried to

let the NRC strategic plan be one of the guidelines for establishing priorities, and NRC states in its strategic plan that building and maintaining public confidence is critical for achieving its mission and vision and that fundamental to that process, of course, is the involvement of the stakeholders.

As far as the international experience is concerned, the committee spent some time in Germany in 1998 learning about the German program, the Swiss program, the French program, and the program in Sweden, and while the approaches taken by the different nations have differences, there was one thing in common with all of them and that is the issue of public participation and involvement in the process and that if you were to ask any of them what was the major obstacle, most of them would probably answer it was winning public confidence in what we're doing.

Also a highlight in 1998 as far as this issue was concerned -- and maybe the meeting that really captured our interest and imagination about it -- was a meeting we had at Yucca Mountain with stakeholders in Amargosa Valley, and one of the things that we attempted to do in this meeting was to try to, after we listened to the public, feed back to them what we thought we heard, and there seemed to be a great deal of appreciation for that, that we (a) took the time to do that and (b) that apparently our feedback was pretty much

on target with what they had identified as their principle concerns, and then, of course, the committee has always tried to be active in outside meetings such as the Technical Review Board and the academies on this topic, as especially the academies have done a tremendous amount of work in trying to define and give body and substance to the issue of risk, including risk communication.

Now, on slide four, let me turn to one of the highlights of our addressing of this issue this year.

We had a roundtable meeting on safety assessment and a public meeting with the stakeholders.

The daytime meeting was kind of set up to get into some of the issues of how the safety assessment process works. The public was involved. And then the evening meeting to allow those who perhaps could not make the daytime meeting to attend was devoted essentially exclusively to public discussion.

Our objectives were to enhance our ability to communicate technical issues.

If risk communication is fundamental in winning public confidence, then it's kind of important, it seemed to us, for the technical community to understand what it meant and whether there were some lessons to be learned in a more formal way about how to communicate the subject of risk, develop ideas about how to improve public participation in

NRC's regulatory process, and third, to clarify the roles of the ACNW and NRC, which we will come to a little later in a little more detail.

The participants, we were pleased to see, represented diverse points of view. They included representatives from the State of Nevada, the counties that are involved, and then a number of government institutions, as well as the American Indians, the Nevada Nuclear Waste Task Force, and the Yucca Mountain Study Committee, and of course members of the public that were not necessarily affiliated with a particular group.

We are preparing a letter. We are hopeful of getting that letter out in the course of this meeting today and tomorrow, and we'll detail some of these things that we're sharing with you now.

But to give you a little heads-up on some of the observations -- and our attempt here was to be as direct as possible in communicating to you what we heard, and here are some of the observations.

When we talk about risk communication, what we're talking about principally is the matter of exchanging information about risk with the public, and that process is very much dependent on listening to them and creating opportunities for their participation, and they have great interest, of course, in the NRC decision-making process, how

it works and how they might contribute.

It was obvious that some members of the public and some stakeholders perceive risk communication as disingenuous because of a lack of real opportunity to influence NRC's options and decisions.

Now, as I say, what we're doing here is providing you with observations, not necessarily the committee's opinions.

Some members of the public, on slide seven, and some stakeholders perceive transportation, for example -- this is just picking out a very specific issue -- as an afterthought rather than a well-understood component of overall safety assessment, and there is obvious a great deal of concern about transportation of high-level waste to Yucca Mountain over the operational period of the mountain, which is now talked about in kind of 24-year periods.

Most members of the public and some stakeholders have little or no experience with the NRC and its method of doing business.

They do have experience with nuclear activities but not with activities that have involved interacting with the Nuclear Regulatory Commission, and they are anxious to have a better understanding of how it works, and there appears to us to be a great opportunity.

Some additional and selected perceptions of some

stakeholders and members of the public are delineated on slides eight and nine.

NRC, they're fearful, will not be tough on the DOE. This came especially from the State and counties representatives.

NRC is perceived by some as having relaxed the high-level waste regulations to ensure that Yucca Mountain will comply.

Also, NRC has not justified its position against groundwater protection and that conflict between the Nuclear Regulatory Commission and the Environmental Protection Agency undermines public interest in the agency.

And then there was a lot of discussion about the decision-making process, how the reasonable assurance finding evolves, and I don't think that most of them were particularly satisfied by just referring to the regulations and generally compliance with the regulations.

They seemed to be looking for a clear indicator of what constitutes the conditions under which a decision is made, and that came not only from the public but from representatives of the press at the meeting.

We're still architecting the recommendations, but to give you a little insight on what we probably will be recommending, we have summarized some of those on page 10.

First, to evaluate the feasibility of involving

stakeholders and interested members of the public in conducting some of the more specific activities associated with the licensing process, such as performance assessment.

The often-heard comment made is that the public are not just interested in reviewing and seeing what you've done and sort of passing on it, but we think that the real effective avenue of participation is to be able to be involved in scoping, setting up the conditions, and perhaps some of the assumptions underlying the analyses, such as the performance assessment.

Another recommendation is to establish transparency in the NRC decision-making process to facilitate public involvement, and of course, here, we need to provide some assistance in tying in the concept of risk communication and how it's used in that transparency process, and this is a logical extension of the whole concept of risk-informed, performance-based regulation.

That is to say, if we are transitioning to a new era of decision-making based on the risk-informed processes, we need to work especially hard to manifest what that mechanism is, and the opportunity exists, given that we are making changes and we are writing new regulations, especially in the case of Yucca Mountain -- we have an opportunity to demonstrate what that process is.

NRC should take the lead in clarifying the role of

various agencies involved in transportation of high-level waste.

This keeps coming up because there are so many agencies involved -- Transportation, the DOE, the NRC, the EPA -- that the public is a bit confused on who really is in charge here when it comes to convincing them what the transportation risk is.

Transportation seemed to be something that they really latched onto, because it was almost a personal thing in the sense that many of the local people feel they are directly involved in that, given that so much of the transportation will be through their neighborhoods.

So, that's we have to say at the moment on risk communication. It will come up in the context of some of the other presentations, but if there are any questions before we move to the next --

CHAIRMAN MESERVE: Thank you very much, Dr. Garrick.

This is -- risk communication is obviously an enormously important subject for us, as it cuts across the entirety of our activities, and it's an area which I'm sure we need to work on, and we very much weigh your considered recommendations.

I appreciate that you've tried to give us a glimpse of what's coming.

I would be interested in knowing whether you have some specific points that you would like to make with us as to how we could be more transparent in our decision-making.

Obviously we try to do things in the public and with Federal Register notices and using processes that are really quite standard in the Federal Government, and I recognize that they may not be understood in other areas, and exactly how one might participate and how the decisions are made may not be understood.

Do you have any suggestions as to things we might do different that are more concrete?

DR. GARRICK: Well, some thoughts on it.

One of the things that -- when you start getting questions on decision-making and you try to reduce it to fundamentals, most people that are the point of a decision like to have alternatives.

They like to be able to be presented with different alternatives to address a specific problem, and they also like to understand what the measures are for each of the -- for these alternatives and that those measures should be a consistent set, and usually there is some variation on the three fundamental attributes of risk, cost, and benefits, and so, I think that, when I talk to people, what they're looking for is, well, what alternatives do we have and what attributes did they assign as a basis for

decision-making and what was the form of the results for each of those attributes?

Now, you're caught in a position here of being quite far downstream in the decision-making process, and so, you have to accommodate that, but I think that they have questions about, well, is risk assessment a decision analysis and, if so, how was it performed, and of course, our general observations to them on this is that a risk assessment is an important component of a decision analysis but usually a decision analysis involves other issues having to do with such things as costs and benefits.

On the other hand, even there, the principles of risk assessment have elevated the quality of the decision analysis considerably, especially in the area of how you address such things as uncertainty, and there is uncertainty in costs and there is uncertainty in benefits and what have you.

So, the whole notion of performance assessment, as it's called in the waste field -- the whole notion of risk assessment and what it can contribute to the decision-making process is rather substantial, but we do try to draw a distinction between a decision analysis and a risk assessment, and I think those are some of the things that could put it on a more definitive basis, and we realize that the regulations bound what can be done, but we also realize

that the NRC is in a position to bring into the decision-making process things like cost-benefit and issues beyond what one might normally associate with the results of a performance assessment.

CHAIRMAN MESERVE: Thank you.

Let me turn to my fellow Commissioners and see if they have any questions.

COMMISSIONER DICUS: Thank you.

I'd like to bring up one thing.

The findings that you had from some of your public meetings with stakeholders -- now, are these from meetings you had in '98 or '99?

DR. GARRICK: Oh, I should have made that a little clearer. Actually, it's both, but most of this is from the '99.

COMMISSIONER DICUS: Okay. When did you meet in '99?

DR. GARRICK: Was it October? Yes, it was in October of this year.

COMMISSIONER DICUS: I'm curious about that, and what I'm going to bring into this is this risk communication but, more importantly, how we communicate with the public and how the public sees the NRC.

I had the opportunity in April -- I spent a day -- I went out to Yucca Mountain, toured it. I spent a day and

made it aware I'd meet with anyone who wanted to meet with me, and we spent a day. We started about 8:30 in the morning to about 5:30 in the meeting.

DR. GARRICK: By the way, we heard about that.

COMMISSIONER DICUS: It was a good meeting. I meet with State and local officials. I met with public interest groups. I met with Native American tribes, anyone. I met with the press, which is unusual. I usually don't do that.

And I learned the same things you learned. I learned some things beyond that.

I learned that the public didn't quite know how to deal -- how could they be part of the process. They didn't know who we were. We weren't communicating who we were. We weren't telling people -- we were not DOE. Some felt we were actually part of DOE.

And so, I came back and I met with the staff, and I've told them what I had learned. I had a lot of people of the staff with our Yucca Mountain group with me, so they heard the same things I Heard.

And we talked about it, and changes were made in how we're going to communicate with the public and some of the things that we were doing that maybe were not as effective as they should have been, and we had a series of meetings with the public in the summer, and my feedback was

things had changed, we were communicating better.

So, that's why I bring up the question. If you met in October and you had these findings, where are we in getting this change-around, because I think we're doing a better job of communicating.

DR. GARRICK: Well I think you're absolutely correct, and I think that, in talking to the staff and in their public meetings, they had similarly positive experiences, and I think the number one issue here is the public would like to see a much stronger presence of the NRC, because they really don't know the agency.

COMMISSIONER DICUS: And I think that's what we're trying to do.

DR. GARRICK: Right. And I think that, in '99, we probably made our first real attempts to expose them to the agency and its advisory process,and I don't see anything but positives that have come out of that, and I think that your meeting, the staff's meetings, coming before our meeting, and ours from last year, were all building blocks, and they just want -- some of these observations, they just want to make sure that they got out and that they weren't forgotten, because they were extremely appreciative that we didn't forget them.

Most of the people that were in our meeting were also in our 1998 meeting, and they thought, I'm sure, that

we might just forget about it, but the fact that we came back and the fact that we tried to respond and show continuity between the two meetings seemed to be very appreciated, and we plan to go back.

COMMISSIONER DICUS: I think that's extremely important and we keep this message going forward, because it's clear that -- the point is not to try to, quote/unquote, "win people over." The point is be sure they understand the role, understand who we are, and understand they do have a part in the process and know how to participate in that process.

Mr. Chairman, if I could just ask one more quick question -- I have two or three, but let me stop at this, and we can come back if there's additional time.

You say the NRC should take lead in clarifying the role of various agencies involved in transportation of high-level waste, but clearly the lead agency is DOT. So, how are you dealing with DOT on this?

DR. GARRICK: Well, this is a continuing subject of some confusion.

It's true that the NRC's role is principally with respect to the shipping cask and the certification of those casks and that DOT's role is principally with the transportation issues, but our understanding is that, as far as the -- taking over the waste at the reactor site, once

it's taken over, that DOE becomes responsible as far as safe delivery of that waste, and so, I think the fact that we have had to discuss this issue of who's in charge -- and it seems to be different for WIPP, for example, in New Mexico than what we're hearing it is for Yucca Mountain, and I think this is still kind of an open question, but our discussions of late on this have led us to believe that, as far as safety of the process of moving the fuel, that's a DOE responsibility in terms of making sure that the DOT, the NRC, and all other requirements are met.

But as far as the safety of the process, we have been recently led to believe that it's principally in the hands of the Department of Energy

So, I think just the very fact that there's some question about that is another opportunity for us to provide clarification on just exactly --

COMMISSIONER DICUS: So, do we have a pathway to go forward on that?

DR. GARRICK: Yes.

COMMISSIONER DICUS: I mean the transportation, I think we might all agree, is not really necessarily a public health and safety issue, but it is a public policy issue, and we do need to address it.

DR. GARRICK: Yes. And the public does not seem to be aware of the extensive amount of work that's been done

on such things as the testing of fuel casks and the Sandia experiments of years ago, when they crashed these things into walls and 70-mile-an-hour trains and what have you.

So, there seems to be a real gap here of understanding the difference between death that might come from an accident, a truck or automobile accident, and deaths that might come or injuries that might come from radiological effects, and I think we really need to do some work there.

CHAIRMAN MESERVE: Commissioner Diaz, do you have any questions?

COMMISSIONER DIAZ: Yes.

I have been very pleased seeing that you are casting risk a tripod of assessment, communication, and management, because I think that's a very important issue, and you have spent now one year in an effort of trying to communicate risk? Is that correct?

DR. GARRICK: Well, I've spent a lot more than one year.

COMMISSIONER DIAZ: I know you have. I think that is a fascinating issue, and I was wondering if you could define for us, when you are trying to portray how you would be able to accept a risk, how do you define risk?

DR. GARRICK: Well, it's interesting you'd ask. I was delighted to see the Commission white paper of a couple

of years ago adopt what we refer to in the business as the triplet definition of risk.

When you ask the question, what is the risk, you're really asking three questions in the judgement of those who have accepted the triplet, and that is what can go wrong, how likely is it, and what are the consequences, and we've been very encouraged by the results of adopting that point of view of what we mean by risk, because we answer the question of what can go wrong in the context of a structured set of scenarios, and of course, the consequences question is something this agency has a lot of experience with, what are the end states of these scenarios, and usually what happens there is you decide on what those are and then you look for scenarios that can get you to those end states.

In the reactor field, an end state might be core melt or it might be a release fraction of a certain mix of fission products, or it might be dose, or it might even be health effects, but the point being is that it's not -- it's important to define what the end state is or what the risk measure is and then deal with the question of how can you get there, and then, of course, you have to look at whatever supporting evidence that's available to you to deal with the question of likelihood, and the important thing to recognize in that part of the question is that there's uncertainty, and you've got two choices with uncertainty.

One is you can ignore it, which unfortunately is often done, or you can embrace it as best you can and recognize that the uncertainties have to be supported by whatever evidence you can develop, but if you don't have much evidence, then your uncertainty curves are very broad, but that communicates a very important aspect of risk, because in the minds of many, the uncertainty is the risk.

COMMISSIONER DIAZ: That brings up -- you know, the immediate point is that, when you're trying to communicate risk -- at least my own experience is, when you start talking about probabilities, consequences, and uncertainties, you immediately get glazy eyes.

People want something that is more precise and more specific, and you know, once you start, you know, going in what we will call a very complete scientific analysis or definition, the immediate question is what does it mean to me, and my question is have we made progress to answer that question, what does it mean to me?

DR. GARRICK: I think it will take time. I suspect, when pressure parameters involving pounds per square inch first came out, that it was an abstract concept for many, or miles per hour, or any of these parameters, and I think, with usage, that the notion of expressing things in terms of probabilities will become more comfortable.

I think it's a convenient issue to pick on by

people who do not support the quantification movement, but I just have confidence that, with time -- and it will take time -- it will be increasingly accepted.

I don't think there's anything that will do it except experience with it.

DR. HORNBERGER: The Weather Channel is going to help us, because people are understanding, when they say a 10-percent chance of rain, as to whether they really want to carry their umbrella or not.

COMMISSIONER DIAZ: All right. Thank you.

CHAIRMAN MESERVE: Commissioner McGaffigan.

COMMISSIONER McGAFFIGAN: You referred to the WIPP experience, and from one of your draft observations, NRC lacks a clear bottom line and basis for decision-making, would the public in New Mexico have said the same thing about EPA when it was dealing with whether it would certify WIPP?

DR. GARRICK: Well, early in the time of the WIPP performance assessment work, they were clearly saying the same thing, and I think that the performance assessment was relatively unscrutable or inscrutable during its early drafts, and I think that there was a lot of confusion.

The technical community was a bit unhappy with the 40 CFR 191 and the released table -- released fraction tables associated with that regulation, partly because it

was not so much a real measure of risk, or putting it another way, the risk measure was based on release fractions, not on health effect or dose or something more directly translatable.

So, I think they went through the same process.

COMMISSIONER McGAFFIGAN: Did they ever succeed? How important was this Environmental Evaluation Group that New Mexico had?

DR. GARRICK: I think it was very important.

I think that they -- and it's regrettable, in my opinion, that there's no real effective counterpart to that in connection with Yucca Mountain, because these people, while they were extremely critical and raised very difficult issues, they were also scientists and engineers that attempted to understand the technical merits of the issue, and I think it was a tremendous bridge-gapper between the regulator and the licensee in this case in terms of gaining understanding of what was taking place, and they had an enormous impact.

COMMISSIONER McGAFFIGAN: For my fellow Commissioners, the Environmental Evaluation Group, my recollection, was created in '81 or '82, very, very early in the process, as part of a settlement between the State, I think then-Attorney General Bingaman was part of, and the DOE, and it was there for that entire 17-year period between

'81 and '98 while DOE worked on things, it's been, particularly for the last seven years, when EPA had a clearly established role as the party, and it does strike me, oftentimes, as we deal with Nevada, that the equivalent to the Environmental Evaluation Group, you know, isn't there.

It was funded by DOE. It was based at a university initially, at New Mexico Institute of Mining Technology, and had competent scientists there who spoke the same language, and they, in turn, struggled at risk communication with the broader public. So, they almost had a shared issue.

DR. GARRICK: Exactly.

COMMISSIONER McGAFFIGAN: So, I think that would help if Nevada would consider that.

But in terms of bottom line, in some sense, our Part 63 is an expression of our bottom line. Is this observation that they don't like our Part 63 which comes across in others, the 25 millirems, all pathway, 10,000 year -- over the first 10,000 years of the repository's existence, or is it something else?

DR. GARRICK: Well, I don't know that you could say they don't like 63. Sixty-three has some changes in it that are really fundamental as far as the regulatory process is concerned. Maybe most notably is the elimination of the

sub-system requirements.

And I think inherent in human nature is that, when you make changes of such a fundamental nature, you know, there is some concern that you're possibly removing some protection, but I also see in the public comments the other view, that it's very much a move in the right direction, that it's less dependent on surrogate measures of risk, it's more focused on bottom-line issues having to do with safety and risk.

COMMISSIONER McGAFFIGAN: The Nevada public may not be giving us a lot of comments.

DR. GARRICK: Right.

COMMISSIONER McGAFFIGAN: There's one other issue -- in terms of how we're going to communicate and how the Commission performs -- and we may well look at it -- we've said we're going to look at it, but when the license application comes in, if it comes in, in 2002, we get into a very different mode of communicating with the public, just as Calvert Cliffs -- I have met with the Calvert Cliffs licensee for a long time, because there's a pending proceeding or whatever.

If there is a pending proceeding and there are parties and people have standing and all that, then we, the five of us, get quite removed.

The staff can continue to have public meetings.

With PFS in Utah at the moment, the staff has a large number of public meetings, but Commissioners -- I think SECY has a standard letter, you know, the Commissioners appreciate your views, I've shared it with all of them, it's in the file, but you can understand why they aren't going to respond, because this is a matter pending before the Commission.

So, we get quite distant at that point, and that may be an impediment to communication at a critical time. I don't know what the answer is.

You will be able to communicate, the staff will still be able to communicate, but we're going to have to be, with our judicial robes on, more sphinx-like during a fairly critical time period.

DR. GARRICK: Maybe that's an additional opportunity for the advisory committees.

COMMISSIONER McGAFFIGAN: It wasn't the case with WIPP, because EPA doesn't have a formal adjudicatory hearing process.

DR. GARRICK: Right.

COMMISSIONER McGAFFIGAN: They had numerous public meetings, including some that very high-level officials attended in New Mexico, but they weren't hearings, and so, there's a question in my mind as to whether you get more public confidence through something less formal than you do

through something as formal as we've chosen to do over the years.

CHAIRMAN MESERVE: Commissioner Merrifield?

COMMISSIONER MERRIFIELD: Thank you.

Former Chairman Dicus, Commissioner Dicus, had raised an issue relative to transportation casks and some of the information currently out there on that, and there has been a lot of rhetoric thrown around about mobile Chernobyls and the dangers associated with those casks.

When one talks about public communication -- you mentioned some of the films that are out there, some of the research that's been done -- I've seen some of those films -- and our ability to communicate our thoughts about those casks and their safety, it raises an issue and a tension that we've had in the 25 years since we became the Nuclear Regulatory Commission, and that is the tension between our providing information to the public and being promotional, and I think there has been some reservation on the part of staff and previous commissions to provide a greater level of information about some of these issues for fear that we would be cast in the light of being promotional, and so, as it relates to an example such as this, how can we -- have you thought -- how can we better serve the public by providing more information, whether it's the films, whether it's detail, whether it's our response to how safe those

casks are, without compromising the need for ourselves not to be promotional?

How do we get that balance and provide greater information and, to some degree, comfort to people who have fears about the use of these casks or other issues associated with Yucca Mountain.

DR. GARRICK: Well, I'm not sure I have an answer, but if I were sitting in the position of being the regulator, I guess the way I would attempt to address it would be to, during the licensing process, be darn sure that the case for transportation was visible and an important part of that application.

I think, if there's one issue we ought to be able to do a very thorough and comprehensive analysis of, it's transportation risk, and I think the burden for doing that ought to be on the applicant.

So, at least one approach here would be to make darn sure that the applicant does that.

Now, I don't think this is the kind of thing that's going to require long periods of time and extensive research and analysis.

I think it's more a matter of taking what we know, the experience we have -- we're much more advanced now in the analytical process on characterizing the risk of systems than we've ever been before, and bringing it together in the

context of a risk analysis that's compatible with the way in which they're doing their performance assessment.

So, I think, from NRC's perspective -- I'm not a regulatory expert, but it's more a matter of being satisfied that the license has done the job that the NRC thinks is required to enhance public confidence and understanding.

It just strikes me that this an issue that is out of control and absolutely unnecessary, because this not one where we don't have technologies, we don't have information. We have a tremendous amount of information, but we've just not put the story together in a way that allows the public to distinguish between routine transportation accidents and fatalities and the shipment of fuel and the associated radiological risk associated with it.

COMMISSIONER MERRIFIELD: You sort of go both ways on that.

In part, you're saying we ought to require that the applicant provide sufficient information to demonstrate all these things, but at the same time, you seem to be saying but there's still a need out there -- we have a lot of information that's available, we need to make that more readily available.

Is there a mechanism or a way in which we can say, okay, this is what we know about cask designs, this is how we would evaluate the cask, this is what we know about

transportation issues, this is how we would evaluate them?

Is there a better way for us to articulate the thought processes -- you talk about transparency -- the thought processes that we're going to through in evaluating that and making sure that they're safe?

DR. GARRICK: Well, I think there surely must be.

I happen to be a believer in the white paper concept. I think it would not be inappropriate for the Commission to say to its advisory committees give us some thought about this subject and perhaps it could be a candidate for preparing something like has been prepared by this committee in the past on selective topics, and the ACRS, as well.

So, I think that there's probably some things that could be done by the NRC that would better prepare them for addressing it in the license application that would begin to pull these pieces and parts together.

That's partly why, if we get to it, that's partly why we poked our nose into the design arena and wrote a white paper by our former member on the matter of repository design, because we think that it's very important, in order to ask the right questions, to stretch our limits of understanding of what's going on way beyond what we expect will probably be in the application.

CHAIRMAN MESERVE: We do need to move on to

another subject. Commissioner Diaz has assured me he has a very short question, and I'll hold him to that.

DR. GARRICK: It's a question of whether I have a short answer.

CHAIRMAN MESERVE: And I'll hold you to one.

COMMISSIONER DIAZ: Same issue. You know, we realize that this is a multi-layer system from the scientific issues to the technical issues and how you communicate risk, and we're all very aware of the disclaimers that are put every time something is finished, like you know, this is our conclusions, however additional work is needed to narrow down the uncertainties, and when you put that disclaimer in, you know, you throw the whole ball of wax.

My question is have you been able to gauge the importance of credible and accountable convergence and simplification of scientific and technical facts prior to the time that you disclose that you actually, you know, do your risk communication?

How important is a credible and accountable process of simplifying convergence so you will not have that many disclaimers, you will not have that many issues, which essentially reopen the issue?

DR. GARRICK: Well, I will try to give a short response to that.

I think part of what you're asking, Commissioner Diaz, is -- has to do with how you present the evidence that supports your analysis, and I think there is a lot more creative opportunities there than sometimes we employ in how we present the supporting information for our analysis, and this is why I really like uncertainty analysis, because if you admit to the uncertainty and present your state of knowledge in your parameter measurements, then you have a basis to say, okay, here is my supporting evidence and this is why those curves have the shape that they have, and I think there's got to be a better connection between the results we present and the supporting evidence, and that we just have to keep working on.

COMMISSIONER DIAZ: Okay. Thank you.

COMMISSIONER McGAFFIGAN: Just very briefly, this follows up Commissioner Merrifield and Commissioner Dicus.

Yesterday you got briefed by DOE, or the day before, on their DEIS, and one of the issues is, of course, transportation, and they present an analysis for the mostly truck case, the mostly rail case, with statistics that would lead one to believe this is not a big issue.

It's not dissimilar from the Part 51 rule-making we did earlier this year, where NRR, for the purposes of license renewal, had to look at transportation in the vicinity of Yucca Mountain and it had very, very

conservative analysis, really piling conservative assumption on conservative assumption, not the sort of thing you generally like, but it still found very low numbers in terms of latent cancer fatalities for any member of the public.

Is there something wrong with the way both we and DOE, when we're doing our EIS's, are presenting this? What are you looking for in the way of improved risk communication?

In some sense, DOE is trying to justify the transportation case right now in its draft EIS, and I'd be interested in whether you had any comments on how they could make that -- what they need to do to improve that case, what comments we maybe should make to them as to how they should improve that case.

DR. GARRICK: I think there's a couple of questions here.

One is the believability of the results by the public, and again, I say the answer to that is the same one I gave to Commissioner Diaz, and that is that I think part of our problem in getting the public to believe our results is the abstractness of our analyses.

They're very esoteric, they're very difficult to comprehend, and where we can improve things is to tighten the connection between the results we have and the supporting information.

Now, yesterday, when we heard all of this, it prompted a lot of the kind of questions you're asking, and we haven't had a chance to look in the details nearly as much as we'd like, questions about, well, how did you factor into your analysis the details of the integrity of the cask and what kind of basis did you use to decide what the impact forces were and so on and so forth, and it's going to require a little more digging than we've had an opportunity for us to establish a connection between what they, in fact, did, and what can be supported by the information base.

I really believe that the answer is in the evidence package, how you put the story together to support your analyses, and that's difficult to do, but where it's been done, it's been very effective.

COMMISSIONER McGAFFIGAN: My only comment is I know that the people of New Mexico, dealing with the WIPP containers and the WIPP transportation routes, you know, to this day continue to raise issues, because it tends to be bumper-sticker sort of stuff.

I mean I think that the EPA and the DOE and most of the folks don't believe there's a big issue there anymore and a lot of money is going to flow to improve local fire departments and that sort of thing, but -- so, partly, again, going back to the WIPP example, this is still not a fully resolved issue in the case of WIPP.

DR. GARRICK: That's right.

COMMISSIONER McGAFFIGAN: Yet, most people don't -- including the Environmental Evaluation Group, I think -- don't think there's a big transportation issue here.

DR. GARRICK: That's why it's all the more important to deal with it in a convincing and reasonably coped fashion, because the evidence is pretty strong that it's not a big issue, and yet, in the minds of the public, it's perhaps the biggest issue, especially during the operating phase.

CHAIRMAN MESERVE: I think that the extent of the questions reflected both the importance of the general subject and the interest, in particular, in its application to Yucca Mountain. Why don't we proceed?

DR. GARRICK: Okay.

One thing I did want to say -- as you know, the committee is only 75-percent complete right now, and so, what we've done to help us is bring in a consultant to work with us in a few meetings, and in order to make the consultant feel very comfortable -- and he's not on next -- we've given him one of the toughest subjects to talk about, Part 63, and he'll have a chance to do that in a little while, but first George.

DR. HORNBERGER: Thanks.

My topic, as you know, is to discuss with you a

little bit the white paper and the cover letter that the ACNW sent.

The white paper was prepared by our former member, Charles Fairhurst, and I guess, of our presentations, this is the only on that you already have in hand. Everything else is a work in progress.

Just as a little background, we have had an interest -- and this was enhanced when Charles joined the ACNW -- we have had an interest in engineering aspects of the repository.

It's our perception, was our perception starting even several years ago, that it's a geological repository. There was an awful lot of emphasis put on natural processes, geological aspects, site characterization, but in moving forward, it was pretty clear that DOE was focusing evermore on design aspects of the repository, and we thought that it was incumbent on NRC staff and on us to really keep up to date on what was going on, and Charles, in particular, had a very strong interest in the engineering aspects, and therefore, we thought that it would be a good opportunity for him to prepare a white paper that would certainly educate us and raise the level of our discussion on engineering aspects and provide some useful information to NRC staff, as well as others outside the NRC.

The point of the white paper, looking at page 12,

that slide, is that -- the whole issue is that there might be innovative engineering designs that would lead to two things: first of all, enhanced safety and, second of all, reduced costs.

This is the best applications of engineering analysis, and the intent of Charles' white paper wasn't to promote a specific design but, rather, to just stimulate thinking.

The next slide, on page 13 -- this is the piece de resistance of my presentation.

My colleague, Ray Wymer, told me this was a terrible slide and that it was a typical engineering slide with no title, with little dots, it was obscure, and I was warned that I would get bogged down for 10 minutes trying to explain this.

Nevertheless, pushing right on, this is just an illustration of one of the analyses that Charles undertook, just as an example.

Again, I stress it's just an example, and the issue is that, in looking at the performance assessments that are done for Yucca Mountain, it is clear that water contacting the waste is really important, and anything that can be done to avoid water contacting the waste package could lead to very significant improvements, and so, Charles was thinking, well, isn't there some way that we could use

aspects of the natural system to our advantage, and so, one of the things that this show is a three-level repository -- that's what those little dots are.

They're drifts, and you see that one -- there are three in a line, one above the other, and at the very top, he shows a slot with what's referred to as a Richards barrier to deflect water from the general direction, and then he goes through a fairly simple analysis that shows that, particularly for the lower two drifts, the water entering the drifts is very much reduced, it essentially goes to zero, so that with -- perhaps -- I underline perhaps -- with some very modest design changes, one could reap pretty large, significant benefits in terms of safety without much at all.

So, on page 14, the -- to tie this together, then, in terms of the white paper, I just wanted to recall that, in the past, we have recommended to NRC staff that, because of the increasing emphasis on engineering aspects of the Yucca Mountain design, we encourage the development and enhancement, if you will, of expertise and engineering aspects of repository design and really a systems engineering approach.

By that, we really mean an overall, a holistic view of the Yucca Mountain as a system, and we have recommended that in several letters over the past two years,

I think, and we did visit the center this past -- I think it was June, and we held a meeting down there, and we have seen that, in fact, there is a movement to really improve on the expertise available in engineering aspects.

The next slide -- as you will recall in the letter that we sent, we recommended that the NRC staff actually explore innovative designs for the repository, and our idea is that these could allow furtherance of the NRC mission of enabling safe and efficient use of nuclear materials, as well as to enhance the engineering capabilities of the staff in preparation for a design, and the enabling language -- I suppose, in large part, we are somewhat frustrated, as technical people tend to be when we deal with the Department of Energy and see what they're doing and say, well, we would like to advise them on what they should doing, even though that's not our job at all, and I think that, to the extent that the NRC staff, the NRC, could somehow encourage DOE to look at more innovative designs -- and of course, if NRC staff took it on themselves to do that -- that this actually might move the whole field forward, and that was the thrust of it.

Page 16, having said that, we fully recognized when we sent the letter forward that the most likely response would be, well, it's not NRC's job to design the repository, and we recognize that. That's straight up. We

know that it's not NRC's job to design the repository, and again, I think that our whole intent was to stimulate thinking, and it's our belief that, by looking at new ideas and looking for new ideas, that one will automatically be put in a better position to evaluate whatever does come forward.

Milt Levenson mentioned today that the idea can be expressed as, if you like, confirmatory engineering, in much the same way that NRC does confirmatory research, they don't do primary research for looking -- defining new things for Yucca Mountain, but they do confirmatory research, and at any rate, that's the idea that we came forward with.

Okay.

Finally, in terms of repository monitoring, we know that repository monitoring is included in Part 63, both pre-closure and post-closure, and the thrust of our recommendation here in terms of considering guidance that NRC may give to DOE on monitoring was really seconding, if you will, a USGS position that you may have seen that the ideas for monitoring have not really been expressed very clearly by DOE, they have not expended much energy on that, and we think that it is an important issue and that it's timely, that this really should be done, that the department needs to think about what both the pre-closure and the post-closure monitoring schemes will look like so that

evaluation can begin.

CHAIRMAN MESERVE: Thank you, Dr. Hornberger.

Has the ACNW forwarded the white paper to DOE, and have you had any reaction or response from them on that?

DR. HORNBERGER: I don't know that we officially forwarded it, but we do know that it has been seen and read, and one of the ways that we know this is that you see that Charles Fairhurst is no longer with us. He has been tempted by DOE to actually look at innovative designs. So, of course, he had to resign.

Has it been officially forwarded, John?

DR. LARKINS: No.

DR. HORNBERGER: No, but it's been picked up.

COMMISSIONER DICUS: I wonder if they've responded to it.

I have a couple of things, but I'm watching the time here, so let me get in the first one. If time allows, I'll get into the second one.

This has to do with the issue of the NRC being involved in whatever extent we do in design activities for the facility.

We're walking on, as you mentioned, thin ice, egg shells, however you want to place it, and I go back to the issue of public perception and how the public perceives us and DOE, and we're nudging over the line, in my view, on

this.

Now, I understand what you're saying. I understand that, well, we need to deal a little bit in this, in trying to put it in terms of confirmatory research, but the public will not understand that, and I'm really concerned that we're sending a dual message here, and I guess my question -- you know, we're obviously not funded to do this, it won't make a cost-effectiveness question -- is there another way for us to ensure that, should we get a license application -- and I think this is another message we need to be very clear on, because we talk so often in terms as though the decision has already been made, we will have a license application.

There is no decision. We don't know that we will. Let's be clear in our communications. That's another thing the public comes to us at. You talk about what you're going to do when you get the license application. We don't know that we will get one.

But is there another way for us to demonstrate that we do have the engineering expertise, if we get a license application, to deal with this without nudging into this field of facility design?

I'm worried. I think we're a little more into it than we should be.

I know what you're trying to do, and I appreciate

that, but I am concerned. Is there another avenue to success here?

DR. HORNBERGER: I'm not sure that the ACNW really thinks that the NRC should undertake -- the NRC staff should undertake a new program to really figure out what the optimal design should be.

I think that it was more being prepared to evaluate what might come forward as innovative designs, and in doing that, I think that the idea is that, by just thinking creatively about what such designs might look like and then being prepared to do the analysis, it's not really bringing new designs forward. I think that we're sensitive to that.

Part 60, of course, required alternate designs, and I think that, in draft 63, that's still carried over. Whether or not it will be in the final, I don't know, but the whole idea there, I think, is that, again, in terms of public confidence, one wants to see alternative designs, and if, in fact, there's a low-cost option that somehow adds a lot of safety, we want to make sure that the department would look at that.

I recognize it's a very dicey situation.

DR. GARRICK: Let me give another spin on this.

I think that one of the things we want to be very sure of, putting my public hat on, is that the NRC is

qualified to do the job they're asked to do.

We want as good a design capability, good analysis capability, as good a research capability on the things we're trying to license as we possibly can have, and a direct experience with the ACNW members is the experience we have when we come onto an issue and we make the decision that we need to burrow in on that issue more, and the way we do that is with a workshop, our working group session, and we had a working group session about the time when it was clear that it looked as though that Yucca Mountain was going to have to depend much more than anybody had envisioned on engineered systems, and so, we have a workshop on that, on multiple barriers, on engineered systems, and these workshops are the most satisfying, in many respects, activity that the advisory committee does, and it really is kind of the exciting part of our business, because it nurtures our own ability to do a better job of this, and it somewhat offers us a chance to be unbounded in our inquiries and our investigations, and it equips us, in our judgement, as George has already said, much more effectively to do our job, and that's exactly what happened here.

When we had the workshop, Charles Fairhurst really got stimulated about some of the design issues, and how can we make the repository less dependent upon engineered systems and take greater advantage of the natural system?

So, it sort of had -- and part of it's probably my fault, because I pushed Fairhurst to do a dump on us, on the committee, on matters of design, so that it could be used in this regard, but we recognize exactly what you're saying and the absolute importance of us not to send out the wrong message here, but I did want to make the point that it's these kinds of pursuits that makes, I think, the advisory committees more effective and allows us to attract the best possible people.

COMMISSIONER DICUS: Thank you.

COMMISSIONER DIAZ: My question has been answered.

COMMISSIONER McGAFFIGAN: It's sort of in the same ball park, but it strikes me that it isn't as clear-cut in some respects.

We just happened to affirm AP-600 earlier today. There's a famous issue on which the Commission was not unanimous with regard to the additional spray system that your fellow advisory committee, ACRS, ultimately advised us to go along with the staff and add.

Is that adding a safety feature -- it was added for severe management issues. It was the strongly-held view of the staff. As I said, ACRS, because of uncertainty, on balance, said, you know, let's do it. It was not very high-cost.

But we added a design feature to the AP-600 as a

result of the review process.

So, the question is really, you know, if we get an application -- and I don't know what a Richards barrier is -- I saw the chart, but -- and say it isn't in there and the staff asks DOE a question, you know, would safety been enhanced by having a Richards barrier and DOE hems and haws and the staff, over time, convinces itself it really would be better and we put in a license condition that says you do -- ultimately the staff proposes and we ratify through the adjudicatory process -- this is all hypothetical -- then we've changed the design by adding an additional safety feature, but it is not without precedent, and I'm sure Commissioner Diaz would say unhappy precedent.

COMMISSIONER DIAZ: In case you don't know, I am totally opposed to adding a system that is not safety-related to fulfill a safety function on the passive system.

COMMISSIONER McGAFFIGAN: Okay.

I'm not sure it's as cut and dried, because in reviewing an application and asking questions and thinking about -- clearly, in reactor space, we have said we'll approve it subject to the following conditions, and those conditions involve a design change.

So, I'm not sure -- we shouldn't be designing the repository, but we should be in a position, as I think you

all are saying, our staff should be asked hard questions about the design and asked questions, you know, would there be a benefit to a delta here and put the applicant through -- if there is an application -- through their paces as to whether that additional safety feature, that additional use of the mountain would provide a substantial increase in safety or not.

I think it's a path we have to walk, but it's maybe not quite as clear-cut, because we do get involved in the design issues in the license space.

CHAIRMAN MESERVE: Commissioner Merrifield.

COMMISSIONER MERRIFIELD: Two quick questions.

How do we -- given the presentation on the Richards barrier and these issues, you raise the notion that we need to keep considering some alternative theories out there.

How do you reconcile that with the need to try to get DOE to finalize a design so that we can move forward with the work that we need to do? I mean those seem to be two very different criteria.

DR. HORNBERGER: Yes. To a certain extent, they are, and I think our advice would, in fact -- we're always leery of the idea of finalizing a design and casting it in concrete and saying it shall evermore be thus.

At the same time, we recognize that the staff

faces this huge problem of analyzing the design du jour, and you have to get away from that.

I don't know how you resolve that, but I do think that maintaining flexibility is extraordinarily important, because it's clear, I think, to everyone that what we know 10 years from now is going to be different from what we know today, and we simply have to be prepared to accept changes as one goes.

COMMISSIONER McGAFFIGAN: That's fair enough.

My associated question is this: We rely quite heavily on the Center for Nuclear Waste Regulatory Analysis to do a lot of that work for us. I had an opportunity to visit there earlier this year, and I've said very complimentary things about what I refer to as our NRC extended family down there.

Are we looking at the right things there? Are we committing the right level of resources to that facility to do the kind of work that you're talking about?

DR. GARRICK: Good question.

DR. HORNBERGER: Oh. Well, you answer it.

CHAIRMAN MESERVE: You may want to consider that before answering.

DR. HORNBERGER: It's certainly something that we have considered over the years.

As I said, we held a meeting down at the center.

We have looked pretty carefully at their whole program, and we have expressed our ideas on how they might set their priorities by looking at the performance assessments and doing things that way.

I would say that -- my personal opinion from our latest visit and from other visits down there is that we are all quite impressed with the quality of work being done, that the people are not only doing good work but that they are approaching the work that they're doing in a structured way and that they really are doing the important things.

The question of level of resources needs some more consideration, I think.

COMMISSIONER MERRIFIELD: You've answered the most significant part of the question I wanted, so we can leave it at that.

CHAIRMAN MESERVE: Why don't we proceed?

DR. GARRICK: Okay.

Mr. Levenson.

MR. LEVENSON: Thank you, John, including the introduction that told me why you asked me to speak here, so you could avoid the tough questions.

I am not a member of the committee. I have read the ACNW letters on the topics I will cover, but I did not participate in the discussions leading up to those letters, and as a result, some of my comments and responses to

questions really should be considered as my opinions, not necessarily those of the ACNW.

The two areas I've been asked to address is the EPA high-level waste standard issue and the technical issues regarding 10 CFR Part 63.

My perception is that Part 63 is not just an update on the regulations. I think it's very special in that it represents a transition from prescriptive regulation to risk-informed, performance-based regulation, and therefore, it needs to be viewed a little differently than just another regulation.

On slide 20, from reading the letters, I observed that the ACNW concurs with the staff's comments on Part 197 and in the past has supported the 25-MR all-pathways standard, and I personally concur with that, too.

The next bullet is a little different matter. The overly restrictive standards, if accepted, become the norm, and I think that's very important, and the wording of that bullet is very specific to the second point I want to make.

I have not said overly conservative standards. I've said overly restrictive, because it's my personal opinion that overly restrictive standards are almost never conservative.

If you are overly restrictive and you can't do that consistently, you distort what are the real risks.

Something that is of relatively low risk gets distorted into high risk. You divert resources to address that, and something that isn't nearly so important rises up and catches the attention. I think it's extremely important to recognize that overly restrictive is very seldom conservative.

Once accepted -- I can give a specific example. For instance, like John, I've been involved with WIPP. An over-restrictive estimate of how much hydrogen there might be in a barrel in order to conform to the NRC license requirements is leading DOE to dump about 15,000 barrels of true waste into glove boxes -- this is heterogenous waste, broken glass, tools -- paw over it with gloves in glove boxes and sort it so they can repackage it into 150,000 barrels, 10 times as much increase.

So, because their computer model over-predicts the hydrogen generation, there is this very large program of expenditure to people and 150,000 additional barrels will have to be shipped across the country to WIPP.

The basis of saying their estimate is overly restrictive is when they randomly sampled 150-some barrels, none of them came within an order of magnitude of what the model predicted, but the model is what's in the license.

Standards, once accepted, tend to receive widespread application, and like the WIPP case, they lead

to, in fact, near-term exposure and cost very large amounts of money.

One of the things which impresses me is, unlike the financial community -- I, for one, seldom point to things they do as being the right things, but they have learned to cope with addressing the difference between an expenditure today and an expenditure in the future by discount.

We haven't done that with risks or public health. So, what we may be doing here is doing something that exposes people this year, and clearly, if you ship 150,000 barrels, the accident rate is going to kill some people for possible saving two or three lives 10,000 years from now, and that's something we don't know how to cope with, but we aren't going to.

The conflict between EPA and NRC must be resolved, and I realize that, by putting that down, I'm setting myself up for a question of how.

CHAIRMAN MESERVE: You can just answer it now.

MR. LEVENSON: Well, I should say that, obviously, it's not a technical question, but I will make a side comment, which is very strictly my own personal opinion, and that is that the agency and the commissions have a continuing battle on credibility not only with the public but with licensees and with the technical community, and you

may be legally obligated to accept a standard that has no basis in health and safety, and you may have to do that, but I, for one, think your credibility would be aided if it was possible for the Commission to say, from everything that's been done and our analysis in health and safety, our previous standard was -- did protect the health and safety of the public, for legal reasons we have to impose this, and retain the basis that what you're doing is because you have to.

A question came up about what did people mean by transparency in decision-making, and there was some discussion about standards and so forth.

I think the part of the decision-making which is not very transparent to the public, even more so than reading specs, standards, is the fact that the ultimate decision is not tied entirely to the technical language of the standards.

There is legal aspects, there's administrative aspects, there's safety aspects, and there's political aspects, and I know, when we -- I accompanied the committee, the ACNW, to Nevada for their meeting with the public, and that was one of the things the public didn't really understand, that there are a number of things that go into decision-making, and that, I think, is one of the things that can be addressed and separated.

The next slide, 21, multiple barriers and defense-in-depth -- in the letters I've written, it's clear that the ACNW has endorsed the staff's approach to Part 63, and that's still the case, but I think we need to be careful that it's not intended that it be a prescriptive set of quantifications in the new case.

In its previous letters, the ACNW has made recommendations on viability assessment, including the PA requirements. I think primarily those recommendations include urging more transparency and clear supporting evidence for the decisions that are made and that the licensing steps, the outline that is a series of things that go all the way from the initial safety review to the final closure.

Slide 22, the committee supports the staff thinking as it approaches multiple barriers, and again, I was to reiterate that the thinking is that prescriptive sub-system requirements are not consistent with the move toward performance-based evaluation.

In Part 60, prescriptive sub-system requirements for sub-systems served well, but they might not always have been optimum for safety, because they were independent of system effects, and that's fairly important.

The sub-system requirements do need to be spelled out. We don't want to generate another rock syndrome, but

we think that they should be spelled out in guidance with the acceptance based on the performance in the performance assessment.

Now, this will work only if the PA is transparent, but that should be a requirement in any case.

I should hasten to add, the staff is moving in these directions.

On Figure 23, the top bullet is just reiterating that we think the staff is moving in that way.

The last bullet, which actually has five items on it, two on this slide and three on the next slide, is to just identify things that the committee is working on and will be taken up in the next few meetings.

On slide 24, the design basis event probably requires a significant amount of rethinking. Most of the thinking within the agency on design basis events is related to reactors and dynamic-type accidents and things that are not exactly directly relevant to a repository. But there are some things, like human intrusion, that probably will require the design basis event as opposed to some other evaluation of how to go about it.

The issue of transportation continually comes up on everybody's slide, because it comes up with everybody you talk to.

I should say that the general public who live

right around WIPP may be comfortable with the transportation, but an awful lot of people, including representatives of the Conference of Governors and so forth, are not, and we've heard a fair amount of that, not in the ACNW hearings but in some National Academy hearings in which I've participated.

The WIPP -- it's our understanding that the Yucca Mountain and the WIPP thing are different in the following respect:

In Yucca Mountain, it appears that DOE has total responsibility, that they take legal custody for the fuel at the reactor site, or if it's high-level waste from Savannah River or somewhere, it's clearly theirs already, and it will move in licensed containers to a licensed facility, and DOE has responsibility for everything along the way.

That's not exactly the case with WIPP. It isn't very clear who's responsible for what. DOE is responsible -- as they are for Yucca Mountain, DOE is responsible for funding the training of people and providing equipment, but apparently the responsibility for emergency responses, for monitoring, for escorting is not a DOE responsibility.

That's a state's right issue and it resides with the states, and when you talk to the people at the state level -- this was a real issue with WIPP, even more so with Yucca Mountain -- states haven't done anything because it

isn't going to be shipped until X years from now, why should we be doing something about it now, but the local public, all they see is nothing is being done, they can't get answers to their questions, and so, it remains a troublesome issue at the local level, even though any assessment you want to do, the risks -- the radiological risks are very close to nil.

If you're shipping tens of thousands of trucks through your community, the accident rate is not nil, and the committee needs to still cope with what is appropriate role for the Commission and for the committee, but we recognize that it seems to be one of the most sensitive issues.

For one thing, at some level up here, members of the public are concerned about their descendants 10,000 years from now, but at a much more gut level, they're worried about a truck smashing through a neighbor's car next month, and so, it's an issue for future considerations.

CHAIRMAN MESERVE: Thank you very much.

I have no questions, but let me just observe that this rule-making will come to the Commission, I think, the end of March, so that you ought to be planning your activities, as I'm sure you are, to make sure you have whatever input and advice you can give us as we're confronting that issue.

Let me turn to Commissioner Dicus.

COMMISSIONER DICUS: Thank you.

Two quick questions, one of which you may want to defer and answer and think about a little bit, which is the topic you were just on, and whether or not -- and being a former state person, I appreciate the fact that state people have mixed emotions on the transportation issue, and I dealt with that on the Southern States Energy Board, but the question you may want to consider and get back to us at a later time -- do you think that DOE is on board and recognizes that transportation is a political, legal, public, policy, interest question, even though it may not be a health and safety question, and they're really prepared to deal with it?

Like I said, you may want to think about that.

The other thing, the other question, then, is are you pretty comfortable or do you have any concerns about the staff's approach on the defense-in-depth issue dealing with the repository?

MR. LEVENSON: Well, the defense-in-depth issue is an ongoing thing. In fact, there's a meeting in January to explore the staff's position on that. I'm, at the moment, not aware, but I will be attending that meeting. I think the important thing is a recognition that it's an issue that needs definition.

My own personal feeling is that, in the end, we ought to end up with two definitions, because I have trouble visualizing a detailed definition for defense-in-depth for a dynamic, high-pressure, potentially catastrophic thing like a reactor and as it applies to something that is very passive and slow-moving and slow-acting.

So, there's some over-arching requirements that will be general, but the meeting next month is a joint meeting between ACRS and ACNW, and I don't know what the committee members say. I can speak freely and say that I think it would make more sense to evolve two standards.

DR. HORNBERGER: Let me make just a quick comment.

I believe that your question relates to Part 63 in particular, draft part 63.

We have, of course, been in contact with staff, and we're aware of some of the things that they are looking into. We've discussed with them things like importance measures and a whole range of things.

So, we're aware of some of the developments that are going on, and in general terms, we are highly supportive of the directions the staff is taking.

COMMISSIONER DIAZ: I really wouldn't dream of trying to complete your statement, but when you were talking about EPA and overly-restrictive standards, were you implying that the superimposition of a ground-water standard

was an overly-restrictive standard?

MR. LEVENSON: Yes.

COMMISSIONER McGAFFIGAN: I think that makes it unanimous. We dearly hope that EPA will resolve this by reading the technical comments from all the technical bodies, including the Academy of Sciences, on that matter.

On our rule, you have human intrusion listed here, and you have others. Were these issues that were brought to you by the staff's attention or from you reading the comments that came in from others on Part 63 and saying we may need to make an additional comment here?

For instance, on human intrusion, you have EPA, DOE, NEI, almost universally, saying that our human intrusion -- and I think we probably overdid it, too -- that our human intrusion scenario is overly conservative and questioning whether we're following the academy and its advice that what we should do in building a standard is look at a stylized human intrusion scenario and see if there's significant degradation, not even under intrusion, 25 millirems to an average member of the critical group.

So, I just wonder, partly, was this a list that was brought to you by the staff or was this a list that you generated from your own review of the comments?

DR. GARRICK: I think it's our list, and we did observe the staff to make the comment in one of the

briefings that made to us that went along the lines, if there's a lightning rod in the Part 63, it might be human intrusion.

So, we know that the staff is very aware that this could turn out to be a significant issue.

CHAIRMAN MESERVE: Commissioner Merrifield?

COMMISSIONER MERRIFIELD: Getting back to this issue of our ongoing professional disagreement of opinion with the EPA in terms of the appropriate health and safety standards, one of the concerns -- and it gets to the issue we talked about earlier about risk communication -- is you have two standards -- ours, which is a 25-millirem, and the EPA's, which is 15-millirem with a separate 4-millirem ground water standard -- and from the point of view of scientists or others sitting around the table, we can come up with an analysis of why ours is better than theirs, and presumably they can, as well, but the public -- I'm trying to give them the benefit of the doubt.

I've been accused of being too hard on our sister agency. I'm trying to be more kind.

From the standpoint of the general public, it's two numbers. The lower has got to be better. You don't get any greater issue of risk communication than that. How do we get beyond that? If you want to respond later on, you can do that.

MR. LEVENSON: Obviously, it's not easy to do or it would have been done long ago, but it's why I think the committee used the term "systems analysis" in referring to part 63, and part of the dialogue with the public and some of the dialogue in connection with WIPP, for instance, when we pointed out that if, in fact, you reduce -- you're overly restrictive and the result leads to the requirement to ship 150,000 additional barrels, picking a lower number is not necessarily better or safer, because it leads to other consequences, and you know, there will be a similar thing here.

You can drive a repository, wherever it may be, to doing a tremendous amount of fuel handling in the pre-closure operation and in the packaging that exposes a lot of people, a lot of radiation exposure which is real, for mythical things in the future.

I don't know how you get the public to realize that a number out of context is not a measure of safety.

DR. GARRICK: Let me comment on that, because I think here is an opportunity for us to draw a major distinction between reactor safety and nuclear waste management safety.

In nuclear waste management safety, probably the principle risk issue is the handling of the waste. This is not a case where we have a lot of stored energy somewhere

and if something goes wrong we're going to blow up things. It's not a dynamic system, as George has already indicated.

When you start looking at it on a scenario basis and a total system basis, one of the things that begins to jump out at you is that you really ought to be adopting a strategy that minimizes the handling of the waste.

So, clearly, you could say I want to get it down to a certain number and, in the process of doing that, increase the risk considerably, and I think this is especially obvious in the waste business that may not be in other systems and plants where you worry about that instantaneous, if you wish, catastrophe or accident.

The whole idea of geologic isolation as it was professed in 1957 by the National Academy of Sciences was to minimize the handling of the waste as a result of taking advantage of the natural setting, and now we find ourselves kind of backing off of that and talking more and more about treatments and handling and losing, if you wish, some of the appeal and advantage that we were putting forth in the late '50s as the advantage of geologic isolation.

So, lower numbers are not necessarily better if you take a total risk perspective.

COMMISSIONER McGAFFIGAN: Just very briefly, one of the commenters -- and I forget which -- has made the point with regard to the ground water standard, which is

really two-tenths of a millirem, I think it is, for iodine-129 -- that's what the de facto standard for this repository is under the EPA rule -- that that will lead DOE to make design choices, I think the point you've just been making, that will actually increase handling but it will also increase output, because of the radon and other -- it won't be any big amount, but by focusing so heavily on that pathway and having a de facto two-tenths of a millirem standard, you're going to end up generating more through the air pathway and other pathways because -- you're just not optimizing as a system.

DR. GARRICK: Yes. And I don't want to do it here, but if we have time in the corridor someday, I'd like to give you a half-a-dozen examples in the reactor field where the over-focusing on a single criterion contributed to risk quite considerably.

CHAIRMAN MESERVE: Thank you very much.

Why don't we move on?

DR. GARRICK: Yes.

Dr. Wymer.

DR. WYMER: My topic is facility decommissioning. We think that it's a very important topic and one that's growing in importance almost daily. So, we're paying close attention to it and will continue to pay close attention to it.

My presentation has got two parts, really. One is I'm going to very quickly review our earlier recommendations in the letter of just about a year ago.

Last January, we wrote a letter on this topic, and so, I'm going to review the recommendations we made in that letter and give you some insight into what we think has been accomplished with respect to our recommendations very quickly, and then the second part of my presentation is a subset of decommissioning, which is rubblization, which is a relatively new concept, and I'll discuss a little bit about that.

Going to the first part, our previous committee recommendations are listed on this slide. I don't want to say that these recommendations are ours solely and that the staff hadn't thought of any of these things and therefore anything that's been accomplished is as a result of our recommendations.

For the most part, they were already on path to do all of these things. We pretty much endorsed their position, but they had not accomplished a lot of them at the time that we wrote our letter a year ago, and so, maybe a little updating is in order here.

With respect to continuing to develop review criteria for decommissioning, certainly that has been going along a pace and will be finished sometime in the spring.

The relatively new D&D screening code for screening radioactivity levels and thereby providing a path to license termination -- we suggested that they try that at a variety of sites. The code was relatively new at the time.

Since then, they have done that, and they have planned to test the D&D code. It's my understanding they've used it at six different sites up to this point, relatively simple sites.

We did suggest that they use the code and screen a complex site just to see how versatile the D&D code was. They have not yet really done that at what we would consider to be a truly complex site, but that's in the plans.

We thought that they should provide straightforward -- and this is another way of saying transparent -- guidance on selection, the screening and site-specific codes, and that has been done. A document has been prepared that lays out quite clearly, much better in its second iteration than it was in the first iteration, what codes apply to what situations and how to select among the several codes that are available.

We indicated that they should continue a program of licensee and stakeholder involvement. That's been done in spades. They've done a lot of that in the past year.

Shifting gears a little bit, we've concurred with

the staff that the clearance criteria should be a priority goal, establishing clearance criteria. This is the establishment of some sort of regulation or some sort of standard that allows you to release materials for unrestricted use.

We recognize that's a difficult issue.

We know that the staff is differentiating between clearance criteria now and below regulatory concern earlier in a sense that below regulatory concern was a policy position by the NRC, whereas the establishment of clearance criteria relates to specific situations and specific cases and it's not stated as a policy position, and that's very difficult.

We do know that the international arena says that maybe a millirem per year is an adequate limit below which something should be considered to be free for release.

Of course nothing has been adopted in this country yet, and it's only a working standard internationally, as I understand it.

We do believe that, if this could be done, it would save a lot of money and it would cycle a lot of useful and valuable materials back into commerce.

We recognize that there is a decommissioning management board which meets every other week, and we think that's a valuable integration tool that allows people in the

various parts of the Commission, of the staff to integrate and coordinate their activities one with another and sort of stimulate each other with respect to what to do next and what's important in a broad sense, and we support that.

That's my sort of quick resume of what we suggested in the past and what has been done since then, and a lot's been accomplished.

I want to move on to rubblization.

The best way to start talking about rubblization, I think, is to give you an example of what rubblization is, as its presently considered, and that would be in the area of reactor decommissioning and license termination, because that's the area that's mostly likely, almost certain to come up first with respect to consideration of this concept, and there will be other kinds of examples, we think, that might come up later that are not related, necessarily, to reactor decommissioning and license termination.

We do think that it is a precedent-setting concept, and by that, I mean it's a different approach to the handling of low-level -- probably, in this case, very low-level waste.

In the past, there have been regulations -- Britain -- with respect to low-level waste repositories and the conditions that have to be met.

In the case of rubblization, these are more or

less bypassed and the broader basis for granting a license termination, either restricted or unrestricted, is the use of the 25-millirem-per-year standard, as opposed to some of these other standards that have been written into the regulations, which are, for example, having survey markers around the low-level waste repository and having buffer zones and having clearance monitor stations.

These are not necessarily specifically included in the rubblization concept.

It would be acceptable if the ALARA and the 25-millirem-per-year standard were met on the site, after rubblization and after the site is left.

So, it is precedent-setting, and it very likely will -- clever people in industry who are trying to do things in the most economical way and still meet their licensing termination requirements will extrapolate, extend this concept to other things than reactor decommissioning.

For this reason, we think that very careful attention has to be paid to this concept as decisions are made with respect to how it is handled. There are as yet, I think, unforeseen consequences.

We think that clearly we are certainly led to believe that there is a potential for significant cost savings with respect to the use of the rubblization concept, and basically rubblization says you take everything outside

-- in the case of a reactor, take everything outside of a reactor, all of the equipment, furniture, everything that's in there, and you're left with nothing but the structure, you've taken out the core and all these things, and there is some residual contamination.

So, that part of the structure which is above grade, above surface, you do some amount, a yet unspecified amount of cleaning up of that surface by scabbling or some sort of decontamination process to some level which is not specified but could be, for example, as much as 10 times as high residual activity left after the cleanup -- could be maybe as high as 10 times what you would permit under some of the screening criteria if the building were to be left standing and to be available for occupancy.

So, there is residual activity, and it does not necessarily meet the screening criteria that have been established, and then you take these buildings, you convert them to rubble, anywhere from granular, small granular size to large chunks, no specification with respect to the degree of comminution of the concrete, and that would be handled on a case-by-case basis with respect to what the license termination application contains, and in addition to the cost savings, which are clear, we think that you need to understand better than we do what the cost-benefit ratio is with respect to doing this and what the risk implications

are, and the risk is not necessarily a negative thing.

The risk could go down by this approach because of -- in some ways it might be done, there would be less handling of the waste, as opposed to packaging it and shipping it and putting it in a low-level waste repository.

So, the risk could either go up or down, depending on how it's handled.

There is a significant problem, this same old bugaboo comes up here, with respect to conflicting radiation standards.

We not only have the Federal regulations and the conflicts there, but we have learned from -- in the case of the Maine Yankee, where the people gave us a little discussion, that the state may impose such stringent requirements that it would make it impractical for them to go ahead and use the rubblization concept, and they're waiting for a resolution of these conflicting standards.

I don't think there's a whole lot that the NRC can do about state standards, but nonetheless, this is a central issue.

We're looking for Maine Yankee to come in, we expect, in the not terribly distant future, that we heard from those people at our recent presentation last month, and this will be a test case, and we think a test case for rubblization is extremely important, because it's here that

the real issues will emerge, and the issues relate primarily to how do you demonstrate to the satisfaction of the Nuclear Regulatory Commission that you will, in fact, meet both the 25-millirem-per-year dose limit and ALARA standards and how do you measure the amount of radioactivity in rubblized waste where some of that radioactivity may be internal and not on the surface, you can't just run a probe over it and get a measure of it, and so, how do you get the volumetric measures?

Now, we should say that the staff at the NRC in the research branch have two study projects underway. They have contracts out to study how do you measure volumetric contamination, internal contamination, and we think that's important.

We don't really believe that there will be a lot of radioactivity there, and we think it's reasonably likely that, when you scabble the surfaces of these concrete structures, that you will remove the bulk of the radioactivity and they'll be relatively safe, but you've got to show it.

It has to be demonstrated. The models have to be produced.

Data have to be input, reliable data input to those models, both with respect to internal contamination and with respect to leaching of the contamination in

subsequent times, because this stuff, this concrete is pushed into the -- that part of -- in the case of reactors, that part of the reactor containment which is below grade, and it's covered over with dirt, and the real goal of rubblization is to get to unrestricted license termination.

That's what the desired goal is, and in order to accomplish this, models and the input have to demonstrate that.

So, sort of a bottom line here, it's our view that restricted and unrestricted license termination, which it's going to be at a site where rubblization has occurred, that distinction is fuzzy, and the staff will have to be very careful in walking their way through this, since there will be residual activity left on the site.

It's not like normal, where you think about green field, where somebody comes in and they raze a building, tear it down, and everything is hauled away to Envirocare or somewhere and it's clean and there's nothing left that was formerly there.

This is not the same. There's something left. The question is can it be made unrestricted with respect to the termination?

As a general position, our position, I think, is that we've favorably disposed toward rubblization. We think it's a good idea. We'd like to see it practiced, if it can

be.

We think that there are a lot of difficult issues to be addressed, and they will best be addressed, probably, by actually looking at rubblization proposals.

I'm through.

CHAIRMAN MESERVE: Thank you very much.

In order to allow time -- we've really run through a lot of time, but in order to allow time for Dr. Garrick to give an abbreviated presentation on self-assessment, I'm going to defer asking any questions and turn to my colleagues and see if I can get similar restraint.

COMMISSIONER DICUS: We will follow suit. I may put a question in writing later.

DR. GARRICK: All right.

I've got some good news. This last presentation, as I indicated at the outset, is more on process than technical issues, and I think we can shorten it quite considerably, and it's been put together such that it's fairly self-explanatory, and let me just say that the committee has been singing a variety of tunes in our advice about what the staff should do and look for in the applications, and one of those tunes has had to do with the application of a systems approach, systems thinking.

So, we decided a couple or three years ago that maybe we ought to practice what we preach in terms of

applying a systems approach to helping us better organize, plan, and prioritize the issues that we should address, and we were partly also inspired to do by the strategic planning process that the NRC went through, and these next exhibits primarily address some elements of that process that are all well-documented.

Exhibit 33 just simply delineates the by-lines of our first-tier priorities.

Exhibit 34 identifies our second-tier priorities, by which we mean, if the opportunity allows us to go beyond our priorities, these are the leading candidates for the committee's consideration, and then the -- an adjunct to the planning process was the process of self-assessment, and we tried to systematize the self-assessment process.

We put a lot of energy into trying to come up with simplifying exhibits that would do this.

One of the exhibits that we're kind of pleased with is the development of a self-assessment matrix that lines up our evidence and our metrics in such a way that you can get a quick snapshot of what we consider ourselves as doing and the effectiveness with which we're doing it.

As far as looking for evidence that our advice was useful, we have emphasized, as indicated on slide 35, direct evidence, including licensee response, customer feedback, staff requirement memos, EDO responses, and any indirect

evidence that we can see as a result of NRC actions, and as I see and as noted on 36, we created a matrix to track that, and we repeat this process every year.

We have currently scheduled time to do that next year in the month of February, and we'll go through the same two steps, the action planning and the self-assessment.

As far as what we've learned from this process, we've learned a great deal.

We have learned that the effectiveness of the committee is greatly stimulated when we kind of reach out and become creative on what the issues are and also when we are very sensitive to the Commission's interests, as a result of meetings like this, and follow up on those.

We do try to use the action plan as a basis for our operating plan and provide our executive director with information that will perhaps assist him in establishing budgets and so forth for the conduct of the advisory committee's business.

Let me end by just saying and highlighting what is coming.

Most of what we've been talking about will be documented in the form of letters and will be forthcoming, and that includes a letter on risk communication and the safety assessment process as it was evaluated in the working session, workshop, and the public meeting in Las Vegas in

October.

We will be addressing the draft environmental impact statement and some particular issues there.

As was already noted in several of the presentations, the ACRS and ACNW are planning a joint meeting on January 12th -- or 13th and 14th -- on the matter of defense-in-depth, and we're looking forward to that.

We are optimistic that there's probably some fundamental aspects of defense-in-depth that are basic enough that would apply to both reactors and waste, but beyond that, we should not be bounded in the implementation or application phase of one over the other and that the implementation will -- should take full advantage of the peculiarities and properties of the two activities.

We are writing a letter on decommissioning, rubblization in particular, and also on the research activities.

The next page, page 39, we will be passing on some additional views on Part 63, and of course, when we complete our February planning and self-assessment exercise, we will be forwarding to you the new plan, together with a summary and interpretation of both.

CHAIRMAN MESERVE: Let me speak for myself and say that I very much appreciate your efforts to undertake this self-assessment process. It's a very healthy thing to be

doing.

I have no questions about this presentation. It may well be that there will be some as to all of these that we'll submit to you later.

DR. GARRICK: Yes.

CHAIRMAN MESERVE: Let me turn to my colleagues and see if they have any questions that they'd like to ask at this time.

COMMISSIONER MERRIFIELD: I don't have a question. I have a comment I'd like to make.

COMMISSIONER DIAZ: I have a quick comment.

It would be worthwhile to the Commission to get your views on how can the staff differentiate between restricted and unrestricted release.

COMMISSIONER McGAFFIGAN: i do want to compliment the committee for all of its work. I think you do very good work, and going back to Dr. Wymer's presentation, I think, on the D&D code and decommissioning issues, we're all searching for overly conservative assumptions, bias analyses, and I think you've been very useful in all of that.

I'm glad to see you are going to address the DOE DEIS. We were getting some indication you weren't. I think what is a technical issue and what isn't isn't always clear. For the transportation issues and risk communication in

transportation, I think is a technical issue. Somebody might argue it's not, but I look forward to seeing those comments.

But they do need to get in fairly quickly, because our overall comments have to be formulated and to DOE by the 9th of February.

DR. GARRICK: We're aware of that, yes.

COMMISSIONER MERRIFIELD: In deference to the Chairman, I didn't ask any questions relative to decommissioning. However, I did have an opportunity last month -- actually, it was earlier this month -- to visit the Haddam Neck site up in Massachusetts, where they are very actively engaged in that process, and like Commissioner Dicus, I did take the opportunity to meet with a variety of stakeholders there and members of the community who are concerned about that.

I think, overall, there is a concern -- and I don't think they were as sensitive to some of the rubblization issues as perhaps individuals surrounding Maine Yankee, since that seems to more close to where they are in the process at this point.

I think there was an underlying concern that even if we -- even if that were to be allowed and if it were to allow unrestricted use, would that mean that the site could be utilized for future purposes for the community, and I

think that was one of things that underlies their concern.

It might be clean, or at least clean enough for us to release it, but is it something that can be utilized for an industrial purpose or some other community-based land use, and I think that's something that we need to be mindful of.

The second thing is, in your analyses, I hope you not only will be thinking about some of the radiological concerns associated with those materials but also the non-radiological impacts and leaching that might result from the rubblization activities.

Further, I would hope that there are some specific questions that you will be able to come up with to assist the staff in asking the hard questions about rubblization.

I know, obviously, you indicated that you are predisposed toward recommending rubblization, but I still think, in order to be fair to people who live around those sites, we do need to ask the hard questions and make sure that we are fully satisfied, all of us, in that regard.

CHAIRMAN MESERVE: Thank you.

If there are no further questions, I'm going to bring this meeting to a close.

I'd like to express my appreciation to the advisory committee and to Mr. Levenson for your participation today.

You've touched on many issues which are really central to our activities and very important to us, and we very much appreciate your thoughtful assistance, and with that, we're adjourned.

[Whereupon, at 11:42 a.m., the meeting was concluded.]

CERTIFICATE

This is to certify that the attached description of a meeting of the U.S. Nuclear Regulatory Commission entitled:

TITLE OF MEETING: ADVISORY COMMITTEE ON NUCLEAR WASTE MEETING WITH THE U.S. NUCLEAR REGULATORY COMMISSION

PLACE OF MEETING: Rockville, Maryland

DATE OF MEETING: Wednesday, December 15, 1999

was held as herein appears, is a true and accurate record of the meeting, and that this is the original transcript thereof taken stenographically by me, thereafter reduced to typewriting by me or under the direction of the court reporting company

Transcriber: Tamara Shipp

Reporter: Mark Mahoney

UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON NUCLEAR WASTE
WASHINGTON, D.C. 20555-0001

December 8, 1999

MEMORANDUM TO: Annette L. Vietti-Cook
Secretary of the Commission

FROM: John T. Larkins, Executive Director
Advisory Committee on Nuclear Waste

SUBJECT: ADVISORY COMMITTEE ON NUCLEAR WASTE MEETING WITH THE U.S. NUCLEAR REGULATORY COMMISSION, DECEMBER 15, 1999 – SCHEDULE AND BACKGROUND INFORMATION

The ACNW is scheduled to meet with the NRC Commissioners between 9:30 - 11:30 a.m. on Wednesday, December 15, 1999 to discuss the items listed below. Background materials related to these items are attached.

INTRODUCTION - NRC Chairman, Dr. Richard A. Meserve — 5 minutes

PRESENTATIONS - Advisory Committee on Nuclear Waste

1. Risk Communications
   Dr. B. John Garrick, Chairman, ACNW — 20 minutes

2. Repository Design White Paper
   Dr. George M. Hornberger, Vice Chairman, ACNW — 20 minutes

3. Part 63 and the Environmental Protection Agency High-Level Waste Standard
   Mr. Milton Levenson, ACNW Consultant — 20 minutes

4. Decommissioning
   Dr. Raymond G. Wymer, ACNW Member — 20 minutes

5. ACNW Action Plan and Self-Assessment
   Dr. B. John Garrick, Chairman, ACNW — 20 minutes

Closing Remarks — 5 minutes

Attachments: As stated

cc: ACNW Members
ACNW Staff

United States
Nuclear Regulatory Commission

RISK COMMUNICATION

DECEMBER 15, 1999

Dr. B. John Garrick, Chairman
Advisory Committee on Nuclear Waste

OVERVIEW

- ACNW identified risk communication as a first tier priority in its 1999 Action Plan.
- Met with NEI, EPA, and NRC.
- Risk Communication Training.
- Held one-day round table meeting and evening meeting with stakeholders and public.
- In process of developing observations and recommendations.

BASIS FOR IDENTIFYING RISK COMMUNICATION AS FIRST TIER PRIORITY

- NRC Strategic Plan.
- International experience (Germany, Switzerland, France, Sweden).
- 1998 meeting with Yucca Mountain stakeholders in Amargosa Valley.
- Participation in outside meetings (i.e., NWTRB, the academies).

ROUND TABLE MEETING ON SAFETY ASSESSMENT AND PUBLIC MEETING WITH STAKEHOLDERS

- **Purpose to initiate dialogue with and among Yucca Mountain stakeholders and hear and convey public concerns.**

- **Objectives were to: (1) enhance ACNW's capability to communicate technical issues, (2) develop ideas about how to improve public participation in NRC's regulatory process, and (3) clarify roles of the ACNW and the NRC.**

ROUND TABLE MEETING ON SAFETY ASSESSMENT AND PUBLIC MEETING WITH STAKEHOLDERS (Continued)

- **Round table participants represented diverse points of view and included State of Nevada, affected counties, EPA, DOE, Sandia National Labs, National Congress of American Indians, Nevada Nuclear Waste Task Force, Yucca Mountain Study Committee, and public.**

- **Draft letter in progress that summarizes public comments and our observations and recommendations based on stakeholder feedback.**

DRAFT OBSERVATIONS

- Risk communication involves exchanging information about risk with the public. It includes listening to stakeholder views and creating opportunities for the public to participate in NRC's decision-making process.

- Some members of the public and some stakeholders perceive risk communication as disingenuous because of lack of real opportunity to influence NRC's options and decisions.

DRAFT OBSERVATIONS (Continued)

- **Some members of the public and some stakeholders perceive transportation to be an "after thought" rather than a well-understood component of overall safety assessment -- has led to deep concern about transportation of HLW to Yucca Mountain.**

- **Most members of the public and some stakeholders have little or no experience with the NRC and its method of doing business.**

DRAFT OBSERVATIONS (Continued)

- **Additional perceptions of some stakeholders and members of the public include:**
  - **NRC will not be tough on DOE (State, Counties).**
  - **NRC relaxed the HLW regulations to ensure that Yucca Mountain will comply (State, Counties).**
  - **NRC has not justified its position against groundwater protection and that conflict between NRC and EPA undermines public trust in NRC (all).**

DRAFT OBSERVATIONS (Continued)

- **NRC lacks a clear bottom line and basis for decision-making (public, press).**

DRAFT RECOMMENDATIONS

- Evaluate feasibility of involving stakeholders and interested members of the public in conducting performance assessment.
- Establish transparency in NRC decision-making to facilitate public involvement.
- NRC should take lead in clarifying role of various agencies involved in transportation of HLW.

WHITE PAPER ON REPOSITORY DESIGN

December 15, 1999

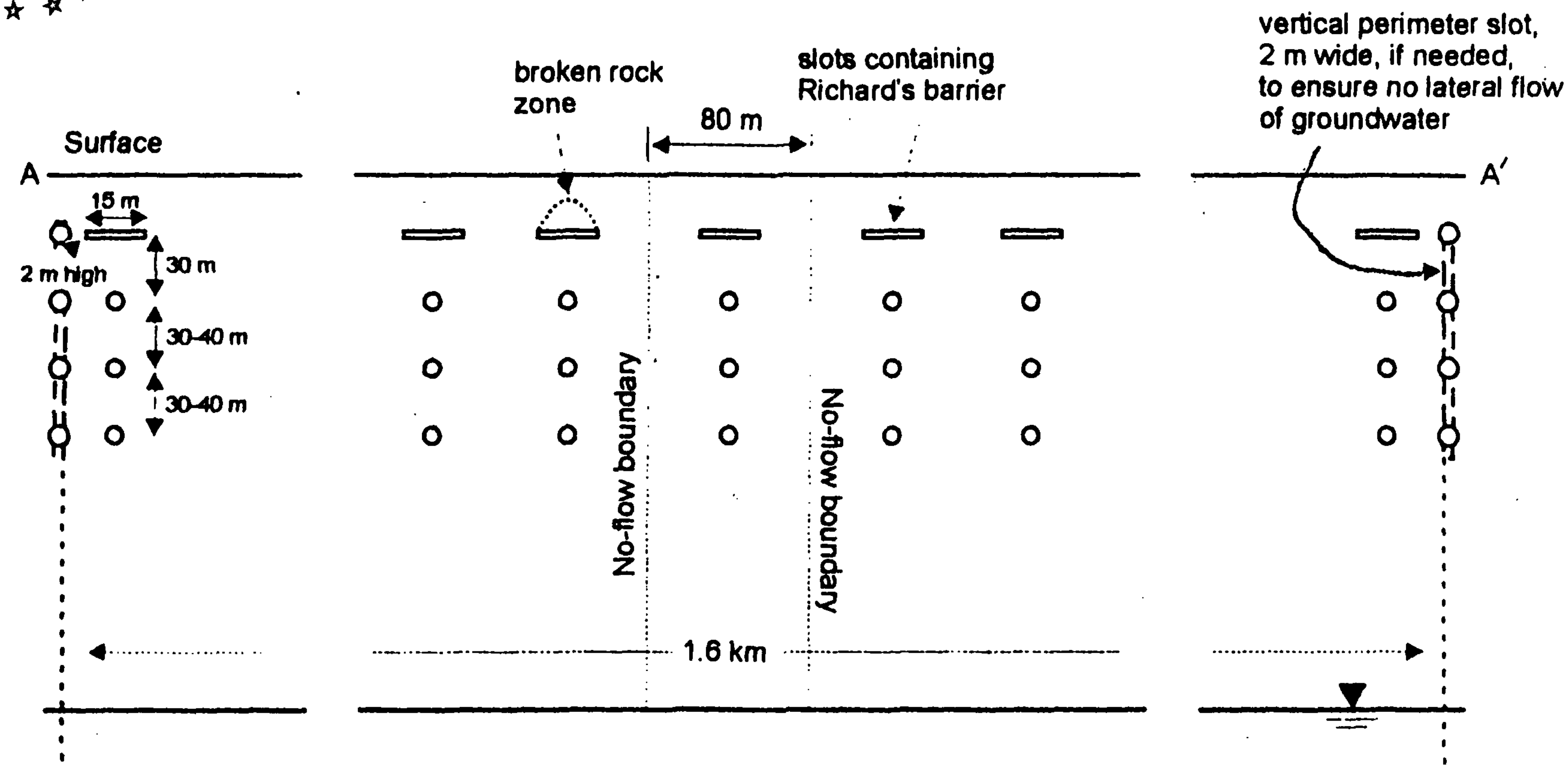
Dr. George M. Hornberger

WHITE PAPER ON ENGINEERED BARRIERS BY CHARLES FAIRHURST

- There may be innovative designs that could (a) have significant benefits with respect to safety assurance and (b) reduce costs.

- The intent of the paper is to stimulate thinking about design options; the intent is not to present a preferred design. As one example, the issue of a hot versus cold repository is cited as needing more study before a final decision.

United States
Nuclear Regulatory Commission



Cross section normal to long axes of drifts
(20x 3 tier columns)

PAST ACTIONS

- ACNW in the past has recommended that NRC staff must strengthen its expertise in the engineering aspects of repository design.
- In particular, ACNW has encouraged the development of a "systems" approach.
- In a visit to the CNWRA in June, ACNW was assured that engineering would receive greater emphasis.

REPOSITORY DESIGN ISSUES

- Regarding repository design issues, ACNW recommends that NRC staff explore innovative designs for the repository:

  in furtherance of NRC mission of "enabling the safe and efficient use of nuclear materials;"

  to enhance NRC's engineering capabilities in preparation for a critical review of an LA.

REPOSITORY DESIGN ISSUES
(Continued)

- **ACNW appreciates that the role of NRC is to regulate, not design facilities. Our recommendation about NRC involvement in innovative design relates to demonstrating that engineering expertise.**

REPOSITORY MONITORING

- Plans for monitoring of the repository have not been advanced. Evaluation of any proposed monitoring strategy will be an important part of NRC's evaluation of a repository license application.

- ACNW encourages NRC staff to consider long-term monitoring needs and strategies for how DOE may factor performance confirmation monitoring into its final design. The issue of what guidance (in respect to Part 63) should be provided regarding performance confirmation monitoring must be addressed.

ACNW COMMITTEE REPORT
(Dated August 9, 1999)

UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON NUCLEAR WASTE
WASHINGTON, D.C. 20555-0001

August 9, 1999

The Honorable Greta Joy Dicus
Chairman
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Dear Chairman Dicus:

SUBJECT: COMMENTS ON DOE'S LICENSE APPLICATION DESIGN SELECTION PROCESS (LADS) AND RECOMMENDED REPOSITORY DESIGN

This letter conveys our observations and recommendations regarding the Department of Energy's (DOE's) License Application Design Selection (LADS) process and the Management and Operations Contractor (M&Os) recommended repository design for the site recommendation (SR) and license application (LA). The letter also transmits the attached "white paper" by Charles Fairhurst titled, "Engineered Barriers at Yucca Mountain -- Some Impressions and Suggestions." In his white paper, Dr. Fairhurst examines some geotechnical aspects of the repository design in the setting of Yucca Mountain with particular attention to two issues - (i) reduction of water inflow to the waste emplacement drifts and (ii) pre- and post-closure stability of the drifts. A concept of an innovative repository design not presently being considered by the DOE is described, together with some impressions of the currently favored repository design. We hope that the paper will help the NRC as it prepares to conduct a thorough and critical safety review of the final repository design and the projected overall performance of the Yucca Mountain high level waste (HLW) disposal facility.

The observations and recommendations we make here are based on briefings we heard on July 20, 1999 on DOE's license application design selection, during the 111th ACNW meeting in Rockville, Maryland. The basis for the attached white paper is derived from a variety of sources, including the DOE's viability assessment, and interactions with the NRC and DOE staffs, the Center for Nuclear Waste Regulatory Analyses (CNWRA), the M&O, the ACNW, and others.

White Paper on Engineered Barriers at Yucca Mountain

In the attached paper, Dr. Fairhurst examines a repository shield concept that appears to have the potential to greatly reduce water infiltration into repository drifts. The shield acts like an umbrella above the repository to divert water around drifts by taking advantage of the vertical fractures and predominantly vertical flow system in the vicinity of the repository horizon. The shield system may also help reduce near-field flow uncertainties in designs such as the Enhanced Design Alternative-II (EDA-II) currently recommended by the M&O to the DOE. The shield concept is shown to be most effective when used in conjunction with a multi-layered repository to minimize the surface area contacted by infiltration. Dr. Fairhurst suggests that if the shield can be demonstrated to be effective with high confidence, it may be possible to avoid the need for the very costly ($4.6 billion) titanium drip shield used in the EDA-II.

The purpose of the paper is not to promote or endorse a specific design. Rather, the paper is intended to demonstrate that there may be innovative ways to engineer the natural setting such that the overall performance of the repository is improved. Current DOE designs appear to concentrate exclusively on engineering options within the drift itself. We believe that exploration of such ideas supports the NRC in its mission and in its vision of "enabling the safe and efficient use of nuclear materials." Consideration of the repository shield and a multiple level repository and other design concepts can provide insights into approaches for reducing critical uncertainties and for modifying the degree of reliance placed on natural versus engineered barriers. Exploration of alternative design concepts may also provide insights to help the NRC avoid placing constraints on DOE's repository design that might inadvertently limit possible future beneficial design changes and innovations, that would lead to greater confidence in the safe disposal of HLW at Yucca Mountain.

In its July 9, 1999, letter to Lake Barrett (DOE)[1], the Nuclear Waste Technical Review Board (NWTRB) expresses concern about the uncertainties associated with the above-boiling-temperature EDA-II design recommended by the M&O, and the lack of transparency in the process and rationale used to select this design. The EDA-II design is a "high temperature" design having a peak drift-wall temperature (160°C) above the local boiling point of water (96°C), with the space between drifts below boiling. To reduce uncertainties, the NWTRB urges DOE to consider modifying the EDA-II design to achieve below- boiling temperatures everywhere in the rock by increasing the rate or duration, or both, of ventilation before repository closure.

The ACNW believes that further analyses must be done before a determination can be made on a choice between a "totally below boiling" temperature repository and one in which some boiling takes place. Dr. Fairhurst points out that the recommended EDA-II design has some merits but also some disadvantages. Although a cooler repository design may simplify modeling of water redistribution, the potential for a higher temperature repository design to reduce the quantity of water reaching the drifts should not be abandoned without further assessment. It is possible that the existing EDA-II design, possibly modified to include multi-layered emplacement drifts, in conjunction with the infiltration shield concept, can be shown to reduce the uncertainties of water refluxing associated with a hot repository while maintaining the advantage of the hot repository to drive moisture away from the canisters.

We hope that you find Dr. Fairhurst's white paper to be of interest.

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[1]July 9, 1999 letter from Jared L. Cohen, Chairman, Nuclear Waste Technical Review Board, to Lake H. Barrett, Acting Director, Office of Civilian Radioactive Waste Management, U.S. Department of Energy.

Observations and Recommendations Regarding the DOE's Design Selection Process and the Recommended Repository Design

Observation 1

Over the past 10 months, the M&O contractor has been conducting a study of alternative repository designs for the proposed Yucca Mountain repository. As noted earlier, the M&O recently recommended that DOE select the EDA-II. The DOE has not yet made a decision about adopting the M&O's recommendation. The recommended EDA-II design differs significantly from the repository design presented in the DOE's viability assessment. As noted above, the NWTRB has expressed its dissatisfaction with the design selection process as well as with the recommended EDA-II design. Such recent and rapid changes suggest that the fundamental design and the many design-related details are likely to continue to change until such time as DOE submits its LA to the NRC. DOE's repository design must be regarded as a work in progress.

Recommendation 1A:

The NRC should plan for continued change in the repository design up until the time the LA is submitted. It follows that the NRC staff should adopt realistic expectations about the turnaround time that may be required to conduct a thorough review of the SR or LA design. The NRC should also develop a license review strategy that allows the DOE maximum flexibility to implement beneficial design changes and other innovations before its submittal of the LA as well as times throughout the preclosure period of the repository.

Recommendation 1B

As noted in the attached white paper, the preclosure period of the repository could last as long as 300 years, and, because of this, the NRC staff must be careful to avoid placing constraints on the design that might preclude future beneficial design changes or innovation. The NRC staff must ensure that it is prepared to recognize such innovation during its review of the LA. Further, as part of a strategy to develop review capability and insights into repository systems, the NRC and the CNWRA staffs should conduct independent evaluations of alternative, cost-effective designs. In evaluating such innovative designs as part of its preparation to review the LA, the NRC staff would gain insights into the relative importance of various design features, alternative strategies to reduce critical uncertainties, and alternative strategies for demonstrating defense in depth. The insights gained through the evaluation of alternative design concepts will enhance the NRC staff's capability to assess repository safety.

Observation 2

NRC's proposed rule governing HLW disposal (10 CFR Part 63) requires monitoring of repository performance. The 50- to 300-year repository preclosure period presents a major opportunity to establish the validity of design assumptions. Monitoring will require "performance

confirmation drifts"[2]. Such drifts, appropriately located, could also serve as part of the flow diversion system proposed in the white paper.

Recommendation 2

The ACNW endorses the sentiment expressed recently by the U.S. Geological Survey (USGS), "that a careful description of the proposed monitoring strategy, as well as a detailed and complete list of what is to be monitored—and why, where, how, and for how long—should be developed expeditiously." [3] We encourage the NRC staff to consider long-term monitoring needs and strategies for how DOE may factor performance confirmation monitoring into its final design.

Observation 3

As noted above, in its July 9, 1999, letter to L. Barrett, the NWTRB expresses concern over the lack of transparency in the assumptions and value judgments made in the design selection process as well as the recommended design. Implicit in the NWTRB's letter is that the Board is uncomfortable with the M&O's selection of the EDA-II repository design because of the current uncertainties associated with high repository temperatures. It is not clear to the ACNW how the uncertainty associated with the various design concepts and features has been quantified and factored into the M&O's process for selecting a preferred design. The M&O's identified evaluation criteria do not include uncertainty as a criterion for making a selection. The conceptual model and assumptions for the various design concepts and features will drive the results of the evaluation and comparison of alternatives.

Recommendation 3

The ACNW believes that the M&O's approach used to evaluate and compare quantitatively the various EDAs has not been made transparent. We encourage the NRC to ensure that the rationale, approach, and assumptions used in the evaluations and in comparisons of alternatives are appropriate. In addition, as noted in recommendation 1B, the NRC and CNWRA staffs should conduct their own independent evaluations of alternative, cost-effective designs, similar to the evaluation of the innovative design described in the attached white paper.

Sincerely,

B. John Garrick
Chairman

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[2]Viability Assessment of a Repository at Yucca Mountain, Preliminary Design Concept for the Repository and Waste Package, USDOE, Volume 2, 1998, p. 4-111

[3]USGS Circular 1184, 1999, "Yucca Mountain as a Radioactive Waste Repository."

Summary

Yucca Mountain was initially recommended as a potentially suitable site for a high-level waste repository because it was anticipated that it would be dry. The repository would be situated in the unsaturated zone at a depth of 300 m below the surface and approximately 300 m above the current water table. It was also proposed as a "hot repository," in which rock temperatures would rise above 200 °C and would remain above the boiling point of water for several thousands of years. The intent was to prevent any liquid water from reaching the waste packages during that period.

Recent studies suggest that infiltration rates in the unsaturated zone may be higher than originally anticipated, and may increase substantially 20,000 years or so into the future. This information has prompted a redesign of the repository placing greater emphasis on engineered barriers within the waste emplacement drifts, e.g., a drip diversion (Richards) barrier; corrosion-resistant waste package; titanium drip shield (cost $4.6 billion); active ventilation during the 100- to 300-year preclosure period; and lower repository temperatures.

The viability assessment (VA) published by the U.S. Department of Energy (DOE) in December 1998 indicates that these engineering measures should suffice to meet the 10 CFR Part 63 requirements of the U.S. Nuclear Regulatory Commission (NRC) over the 10,000-year regulatory period, although doses are predicted to rise considerably beyond 10,000 years.

These notes, prepared after review of the VA, focus on geotechnical aspects of the repository design. The author has profited from discussions with colleagues of the Advisory Committee for Nuclear Waste (ACNW) and NRC, as well as from participation in numerous meetings and discussions with staff of DOE and its Management and Operating (M&O) contractors. The notes emphasize (1) a repository shield concept and (2) prediction of drift stability during both the (100 yr ~ 300 yr) preclosure and postclosure periods.

This paper does not promote or endorse any specific repository design. Rather, its purpose is to stimulate the NRC's thinking as it prepares to conduct a thorough and critical review of the repository design used in DOE's license application. The paper attempts to demonstrate that consideration of such innovative ideas as the repository shield concept and triple-layer repository can redefine the problem by reducing or eliminating critical uncertainties, or altering the degree of reliance placed on natural versus engineered barriers.

Given that decisions regarding final closure will not be made until the end of the operational period of the repository, the NRC must be careful to avoid placing constraints on the project now that would inadvertently limit possible future advantageous design changes and innovation. It is incumbent on the NRC to have the capability and be prepared to recognize the possibilities for such innovation during its evaluation of the license application.

The repository shield acts as an *umbrella* above the repository, taking advantage of the (dominantly vertical) fracture and flow system of the site to divert water away from the

repository drifts. The shield uses natural material (rock) only, augments an existing design, can be developed at any time during the preclosure period, and can serve to house a remote-monitoring network for the repository.

For a repository shield to be most cost effective, the repository should be a multi-level (three-tier or two-tier) design. (Figure 2 shows a three-tier design.) The shield appears to have the potential of greatly reducing water infiltration to the repository drifts —with attendant reduction of doses and simplification of performance assessment calculations. Construction of a flow diversion barrier in the (radiation-free) slot excavations above the drifts would be simpler than remote placement around the unshielded waste packages in the repository drifts —as currently proposed by DOE. If water infiltration is reduced to the extent predicted by analysis to date (see Appendix I), the expensive titanium drip shield (see Figure 4) may not be required. The presence of the drainage slots directly above the emplacement drifts may also simplify near-field fluid-flow and reflux processes during the thermal cycle. The concept deserves serious examination by DOE and its contractors.

With respect to drift stability, the repository environment is unique in that substantial thermo-mechanical stresses may be generated in both the reinforcement support and the rock. From information available on the mechanical properties of the Topopah Springs formations, it appears that stable excavations can be designed in both the lithophysal and the non-lithophysal units. It is believed that rock reinforcement using fully grouted bolts, mesh, and (if possible) shotcrete is preferable to the use of concrete or steel set supports for the repository drifts. Attention will need to be given to pH control of the cement used, but this problem does not appear to be an insuperable problem.

For the postclosure period, it must be assumed that any rock reinforcement or support system will no longer be effective. Recent developments in the numerical modeling of long-term progressive degradation of the mechanical properties of rock masses can provide more realistic assessment and prediction of the behavior of rock around excavations that are not back-filled than were possible in the past. Progressive disintegration and collapse of the rock may, in fact, result in a "natural back-filling" process that could be as effective, eventually, as standard back-fill. Of course, this does not preclude the use of a "chemically tailored" back-fill in the drift section below the waste packages, which could provide significant radionuclide "capture" benefits.

Introduction

The goal of geological isolation of highly radioactive waste is fundamentally simple — to place the waste at depth in the subsurface such that the radioactive elements or *radionuclides* in the waste will never return to the biosphere in concentrations sufficient to pose a significant health risk to humans.

Given the very long half-life of some radionuclides, the times for which isolation is required may be on the order of several hundreds of thousands of years.[1]

The primary vehicle for transport of the radionuclides from the initial underground location or repository is moving water that comes into contact with the waste. Radionuclides become entrained in the water (by dissolution or by colloidal suspension) and move to the biosphere, either directly or in water that is pumped from the aquifer and used for drinking and/or irrigation.

Thus, one of the main criteria in repository siting is to minimize the probability of radionuclide uptake by water and transport to the biosphere. Some radionuclides have very low solubility in the groundwater, others may be very soluble. The physical and chemical characteristics of the rock may also greatly retard the overall rate of movement of particular radionuclides in relation to the rate of groundwater movement. The concentration may also be reduced by dilution (e.g., in water or air) so that release to the biosphere via large bodies of water (i.e., seas or oceans) can also provide an added measure of safety.

The first formal report on the feasibility of geological disposal was published by the U.S. National Academy of Sciences/National Research Council in 1957 (NAS/NRC, 1957). The report noted that:

> *Wastes may be disposed of safely at many sites in the United States, but, conversely there are many large areas in which it is unlikely that disposal sites can be found, for example, the Atlantic Seaboard. The research to ascertain feasibility of disposal has for the most part not yet been done . . . .*

The report concludes with the following two *General Recommendations on Corollary Problems:*

> 1. *The movement of gross quantities of fluids through porous media is reasonably well understood by hydrologists and geologists, but whether this is accomplished by forward movement of the whole fluid mass at low velocity or whether the transfer is accomplished by rapid flow in "ribbons" is not known. In deep disposal of waste in porous media it will in many cases be*

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[1] The "half-life" of plutonium 239, for example, is 24,000 years, i.e., the specific radioactivity will decline to $(\frac{1}{2})^{10}$ (i.e., 0.001 or 0.1%) of its initial activity in $24{,}000 \times 10 = 240{,}000$ years, and to (0.001)(0.001) or 0.0001% in 480,000 years. Other very long-lived radionuclides that contribute to the potential dose at various (long) times at Yucca Mountain are technetium 99 (half-life of 212,000 years), uranium 234 (245,000 years), neptunium 237 (2.14 million years), and iodine 129 (17 million years).

essential to know which of these conditions exists. This will be a difficult problem to solve.

2. *The education of a considerable number of geologists and hydrologists in the characteristics of radioactive wastes and its disposal problems is going to be necessary.*

Today, more than 40 years later, there are many hydrologists and colleagues in related disciplines worldwide who have studied groundwater flow in considerable detail. Significant advances have been made, but characterization of water flow still involves large uncertainties, especially in fractured rock masses. It remains "a difficult problem to solve."

Geological repository siting and evaluation programs are currently underway in approximately 30 countries. Of these, all but the Yucca Mountain project in the USA are sites below the groundwater table. For these, the host rock is usually of low intrinsic permeability with a low regional hydraulic gradient (i.e., the overall rate of water movement from the repository is expected to be very low). A number of countries are considering repositories in crystalline rock. Characterizing groundwater flow in fractures is frequently a serious issue for these sites.

In addition to understanding the natural system at Yucca Mountain, i.e., groundwater flow and radionuclide transport, NRC's proposed high level waste (HLW) disposal regulation, 10 CFR Part 63, indicates that *an engineered barrier system (EBS) consisting of one or more distinct barriers is required in addition to natural barriers.* The proposed rule states that *the Commission continues to beleive that multiple barriers, as required in the Nuclear Waste Policy Act of 1982 (NWPA), must each make a definite contribution to isolation of waste at Yucca Mountain.* Thus, DOE must design and demonstrate quantitatively that the total repository system relies upon and balances the contributions of both natural and engineered barriers to isolate waste.

The preclosure period of the proposed Yucca Mountain repository is expected to range from 50 to 300 years. Given that final repository closure will not occur until the end of the preclosure period, the NRC must be careful to avoid placing constraints on the project now that would inadvertently limit possible future beneficial design changes and innovations. It is incumbent on the NRC to have the capability (and be prepared) to recognize the possibilities for such innovation during its evaluation of the license application. One way to develop such capability is for the NRC to conduct an independent evaluation of viable, cost-effective designs. To conduct such evaluations, the NRC needs to have competent scientific and engineering expertise available over the broad spectrum of disciplines involved in repository design and long-term performance assessment. With the much larger complement of technical staff available to DOE and the recent and rapid changes in repository designs proposed by the DOE, the NRC faces a formidable challenge.

This report focuses on geotechnical aspects of the proposed Yucca Mountain repository. A design concept consisting of a repository shield used in conjunction with a multi-tiered repository is outlined. Particular attention is given to two issues: (1) diversion of groundwater before it reaches the waste-filled drifts and (2) drift stability. The paper then considers prediction of drift stability during the preclosure and postclosure repository periods. The paper compares the respository shield concept to the DOE's current, preferred repository design, which has

changed significantly from the design presented in the DOE VA. The purpose of the paper is to stimulate the NRC's thinking as it prepares to conduct a thorough and critical review of the repository design used in DOE's license application. The ACNW may also use the ideas in the paper in preparing its specific comments on the DOE site recommendation and license application. The paper attempts to demonstrate that consideration of alternative, innovative design concepts, such as the repository shield/multiple-layer repository, may take better advantage of the geological characteristics of the proposed repository site at Yucca Mountain. Critical, persistent uncertainties may possibly be reduced substantially and the degree of reliance placed on natural and engineered barriers can be varied. The proposed "shield drifts" can also serve the role of performance-confirmation monitoring drifts (see VA, Vol. 2, p. 4-111).

Groundwater Flow at Yucca Mountain

At Yucca Mountain, the proposed repository horizon is in the unsaturated zone, approximately 250—300 m below the surface of the Amargosa Desert and 300 m above the water table. Tectonically, the region is currently undergoing extension (i.e., the rock mass is tending to extend horizontally). This implies that, at least near the surface (i.e., within the region of concern with respect to the repository), the lateral stresses in the rock are less (~3 MPa) than the vertical (gravitational or *overburden)* stresses (~7 MPa at a depth of 300 m). This situation has given rise to high-angle (i.e., almost vertical) fracturing (see VA, Vol. 2, Figure 2-9, p. 2-17). As a result of this situation, the fractures tend to be highly transmissive, so that rainfall and surface waters drain rapidly through the fractured mass into the groundwater. However, these fractures are generally not single, continuous planar features. Individual fractures are of limited extent, so that connected pathways, allowing flow through the fracture network, will be considerably less frequent than the individual fractures.

In initial planning for the repository (Roseboom, 1983), it was felt that the annual percolation flux (i.e., precipitation less the amount of surface evapo-transpiration) was very small (on the order of 1 mm/yr) and that little or no moisture would drain into the repository (i.e., the repository would be "dry"). In addition, it was decided to adopt a "hot repository" design (i.e., such a disposal layout that the rock temperature in the vicinity of the repository would remain well above 96 °C, the local boiling point of water, for hundreds or thousands of years, so that no liquid water could reach the waste canisters[2]).

More recent studies indicate that the total infiltration may be higher, and that a considerable portion of this may flow through the interconnected fracture pathways. As noted in the VA:

> *Estimates of average percolation flux from these various studies range from about 0.1—18 mm (0.004—0.7 in) per year. Because of Paintbrush attenuation most of the flux probably requires hundreds to thousands of years to reach the repository horizon. However, isotopic (chlorine-36) data suggest that at least a fraction of the flux reaches the repository level in ten years or less. Thus, while some of the*

[2] The high-temperature design is feasible in an unsaturated high permeability zone, such as exists at Yucca Mountain, where the pressurized water vapor in the rock in the vicinity of the excavations can "leakoff" readily toward the surface.

> *water moves downward quickly, much of it travels more slowly.* (VA, Vol. 1, p. 2-38).

Studies of long-term climate change in the Yucca Mountain region over the past 500,000 years (see Figure 1) indicate that the climate in the region will very likely become colder *within the next few hundreds or thousands of years* (VA , Vol. 1, p. 2-30). Annual precipitation and infiltration are then likely to increase considerably. DOE performance assessment calculations consider a mix of dry and wetter climates extending up to several hundreds of thousands of years into the future (VA, Vol. 3, Sect 3.1.2.1, p. 3-15). These periods include dry climate conditions, as now, with an assumed base infiltration rate of 8 mm/yr, a long-term average period with a base infiltration rate of 42 mm/yr; and *superpluvial* periods with a base infiltration rate of 110 mm/yr (VA, Vol. 3, Table 3-5, p. 3-15). Increased infiltration rates will increase the proportion of total flow through fractures.

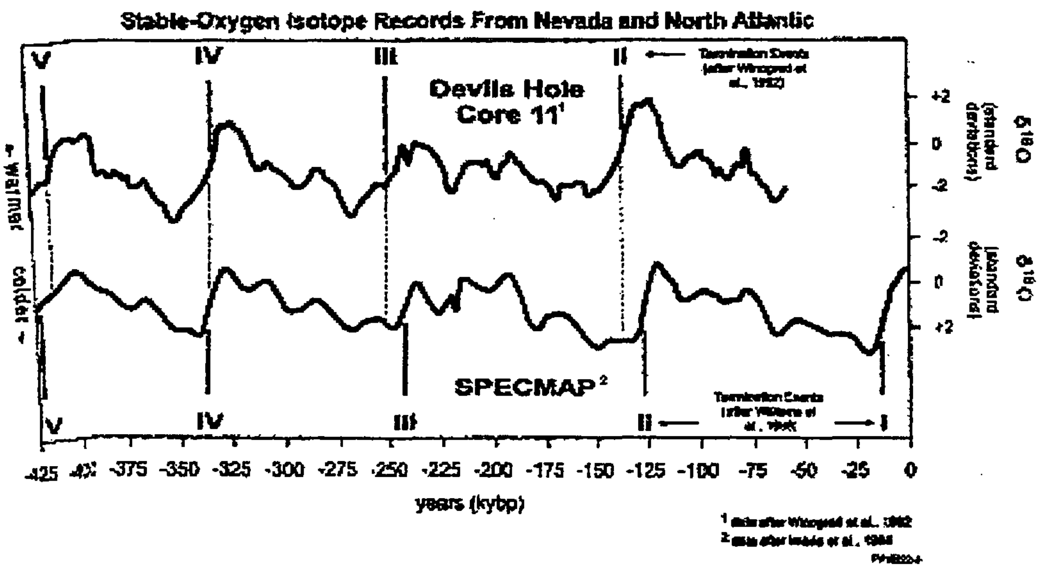

***Figure 1** Stable-Oxygen Isotope Records from Nevada and North Atlantic as Indicators of Past Climate Variation in the Vicinity of Yucca Mountain*

The overall conclusion with respect to repository design at Yucca Mountain is that a significant fraction of the total infiltration through the unsaturated zone will be by flow through interconnected fracture pathways. The precise location of these pathways cannot be predicted, and the amount of flow may vary considerably from place to place in the repository. The rates of flow in these fracture pathways can be high, on the order of tens of meters per year.

A fraction of the flux arriving at the drift horizon is assumed to drip onto the waste packages, causing corrosion of the package and, eventually, contact with and dissolution of some of the waste. Details of the calculation procedure are outlined in the viability assessment (VA, Vol. 3, Sec. 4.1.3, p. 4-4 et seq.).

Repository Design and Yucca Mountain

Waste isolation poses unique problems for both geoengineering and geoscience. These problems center around the time frames involved, with at least semi-quantitative answers needed over times on the order of 10^4 or 10^6 years — far longer than the 10^1 or 10^2 years for which engineers are accustomed to provide quantitative solutions. The geoscience issues have received more attention to date, so there is a good awareness of the uncertainties associated with predictions presented with respect to waste isolation over such times. With engineering design now receiving more attention, it is important not to overlook the time element. Repository design considerations place severe constraints on the use of "engineering experience" and require an unprecedented reliance on predictive (often numerical) analysis.

Development of a convincing prediction of the performance of a waste package alloy thousands of years into the future, when that material may have been known for less than 100 years or so, is an example of the challenges involved.

Time Frames of Concern in Repository Design

The following three periods of interest can be distinguished in the design and assessment of long-term performance of a repository at Yucca Mountain:

> **Preclosure**[3] — Between 100 and 300 years (i.e., the period from the start of repository excavation until the decision is made to "close" the filled repository). Although it would not be impossible to retrieve waste from the closed repository, retrievability at Yucca Mountain is currently envisaged to be accomplished only during the preclosure period. The drift support system should be designed for the preclosure period.
>
> **10,000 years beyond closure** — This is the regulatory period specified in 10 CFR Part 63. If the total system performance assessment (TSPA) computations presented in the license application submitted by DOE are deemed by NRC to provide reasonable assurance that individual doses to a reference *critical group* located 20 km from the

[3] The 300-year upper limit was apparently chosen because it corresponds to ten half-lives of radioactive decay for cesium 137 and strontium 90.

repository do not exceed allowable limits at the end of 10,000 years after closure, the repository can be licensed.

Beyond 10,000 years — Although this period is strictly not part of 10 CFR Part 63, DOE acknowledges in the VA that doses will continue to increase significantly beyond 10,000 years, approaching the order of natural background radiation (Fig. 4.12 in VA, Vol. 3 shows a peak dose of 0.2 rem, at 200,000~300,000 years), almost an order of magnitude greater than the 25-mrem maxmimum dose allowed during the 10,000-year NRC regulatory period.

The U.S. National Academy of Sciences/National Research Council 1995 report, *Technical Bases for a Yucca Mountain Standard* (TYMS, 1995), recommended that the regulatory period be sufficient to cover the period of peak dose. As noted above, this period extends well beyond 100,000 years.

Some estimates indicate much higher doses than those given in the VA, as is illustrated in the following extract from a recent article by Carter and Pigford (1998)[4]:

Calculations by the project show that in 10,000 years the annual dose from drinking contaminated water from the repository will be about 0.02 rem per year. When the dose from eating food contaminated by irrigation water from these same wells is added, the total dose will be about 0.13 rem. This is 13 times the annual dose limit established by the U.S. Nuclear Regulatory Commission (NRC) two decades ago for persons living near a nuclear power plant. It is five times the

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[4] Pigford, T. H., and E. D. Zwahlen, " Maximum Individual Dose and Vicinity-Average Dose for a Geologic Repository, "Scientific Basis for Nuclear Waste Management XX, W. J. Gray and J. R. Triay, Eds, Materials Research Society, Pittsburgh, PA, 1996, Vol. 465, pp. 1099-1108 .

Professor Pigford also recently provided the writer with the following details concerning the doses mentioned in the quotation:

For the dose calculations, we relied first on the dose calculations in TSPA-95 (Akins, J. E., J. H. Lee, S. Lingineni , S. Mishra, J. A. McNeish, D. C. Sassani, S. D. Secoughian, "Total System Performance Assessment — 1995: An Evaluation of the Potential Yucca Mountain Repository," TRW, November 1995.) These doses were calculated only for drinking contaminated well water. Additional doses from food chains were not included in TSPA-95. We utilized the graphs showing the cumulative complementary distribution functions for 1,000,000 years and for 10,000 years. We selected the drinking-water doses at a CCDF of 0.05, corresponding to a 95% confidence level. The 95% confidence level is commonly used in engineering practice, it has been recommended by Britain's NRPB, it was recommended in my dissent appearing in the National Research Council's TYMS (1995) report, and it was incorporated in draft legislation proposed by Congress for Yucca Mountain.

From other graphs in TSPA-95 we identified which radionuclides were the principal contributors to these doses. From EPRI data (Smith, G.M., B. M. Watkins, R. H. Little, H. M. Jones, A. M. Mortimerk, "Biosphere Modeling and Dose Assessment for Yucca Mountain," EPRI Report TR-107190, 1996) we derived the ratio of total individual dose to drinking-water dose for each of the principal radionuclide contributors. Multiplying the drinking-water doses derived from TSPA-95 by the appropriate ratios yielded the doses reported in our article in the Bulletin of Atomic Scientists.

> *two decades ago for persons living near a nuclear power plant. It is five times the annual dose the NRC allows for persons making unrestricted use of a nuclear facility whose license has terminated. (The dose calculations allow a 5 percent probability of doses higher than those cited here.)*
>
> *After 10,000 years, the calculated annual dose at a well three miles distant rises rapidly. Indeed, after 30,000 years, the annual dose from iodine 129 and technetium 99 will have increased about 80-fold, to 10 rems. Then the longer-term annual dose from neptunium 237 appears and rises to about 50 rem by about 100,000 years, amounting in less than a decade to an exceedingly high, life-shortening cumulative dose.*
>
> *The energy department recognizes that these doses exceed reasonable standards for public health protection — hence the pressing need for deeper analysis and a search for a more promising strategy.*

It is likely that a license application showing a dose that is in compliance over a 10,000-year regulatory period, but that indicates significantly increasing doses beyond that time, will be subject to legal challenge even if considered acceptable by NRC. A repository design that could avoid this difficulty, if such a design is feasible, should be given serious consideration.

Engineering design considerations will differ depending on the period of concern. The pre-closure period, although considerable, is comparable to the usual time for which engineered structures (e.g., bridges, tunnels) are designed to perform. Primary concern will likely be occupational exposure of workers involved in construction and maintenance of the open repository and its contents.

As noted earlier, the much longer postclosure period (to 10,000 years and beyond) requires a less traditional engineering design approach. However, it is worth recalling that the decision to use underground *(geological)* settings for waste repositories was made, at least in part, because rock is a natural material that is known to have existed in stable form for *many millions* of years. Prediction of performance for a small fraction of this time into the future involves much less uncertainty than is the case for fabricated materials that have been available on the order of 100 years only. (The Swedish [SKB] decision to select copper as their waste-package material was based in large part on the fact that native copper deposits are known to have survived for millions of years in groundwater environments similar to those proposed for their waste repository.)

Primary Attributes of a Yucca Mountain Repository Design

DOE's viability assessment (VA) lists the following four main attributes of a repository at Yucca Mountain that can influence the release of radionuclides to the biosphere:

- water contacting the waste package;
- waste-package lifetime;
- mobilization rate of radionuclides; and
- concentration of radionuclides in water.

These attributes serve as primary guides for DOE in establishing its repository safety strategy (RSS). *Each attribute has been further subdivided into principal factors of the so-called reference design.* Alternative design features have also been defined as possible contributors to an enhanced design (i.e., to improve the overall safety of the repository). The inter-relationships among these elements are all contributors to the RSS (see VA, Vol. 2, Table 8-3, p. 8-5).

Clearly, if water percolation into the waste-filled drifts could be avoided (i.e., if no water contacted any waste package), then the remaining three attributes become of little or no significance. All are dependent, in large measure, on contact of the groundwater with the waste package.

As noted by Shoesmith and Kolar (1998) in summarizing their study of the corrosion resistance of metallic alloys and the possibility of long-lived waste packages:

> *If the contact of seepage drips with the waste package is avoided, then extremely long lifetimes, in excess of 10^6 years, are predicted. This would suggest that the adoption of any engineering option to avoid contact between drips and waste packages would be a good idea.*

Given the potential benefits of elimination of water contact with the waste package, it is surprising that little consideration has been given in the VA to:

(1) diversion of inflowing water *before* it reaches the repository horizon, and

(2) use of a multi-level design (i.e., to reduce the repository plan area, or *footprint*, in order to minimize the potential for dripping into the drifts.

If, as appears to be the case at Yucca Mountain, flow through the unsaturated zone is predominantly vertical, at least in the southern portion of the proposed repository location, then elimination, or at least major reduction, of infiltration to the drifts seems technically feasible.

If net infiltration could be eliminated, major TSPA uncertainties would be removed, and doses would be reduced dramatically, especially beyond 10,000 years.

Elimination of Water Infiltration

The following two engineering options are within current technology and offer the possibility of eliminating water inflow to the repository:

(1) Surface modification (i.e., engineered fill), and

(2) Underground repository infiltration shield.

Surface modification is mentioned briefly in DOE's viability assessment (VA, Vol. 2, Sec. 8.2.2, p. 8-7). The repository shield concept is not considered.

Surface Modification

> *Net infiltration into the mountain could be significantly decreased if the surface of the mountain were modified . . . . Likewise, facilities for drainage of water to enhance runoff could be designed. Because* ***these effects could potentially eliminate net infiltration*** *at the site, the potential importance to performance could be high* (VA, Vol. 2, p. 8-7, emphasis added).

Standard procedures of surface mining and site rehabilitation could be used to cover the repository site with an impermeable cap and drainage. As noted in the viability assessment:

> *Surface modifications and near-field rock treatment can be independently evaluated* [i.e., without affecting other features of the design] *so this alternative concept was not retained for further consideration as an alternative design concept. However, the merits of these features will be evaluated in a separate study (VA, Vol.2, Sec 8.2.4.2, p. 8-12).*

Surface modification treatments (e.g., several meters of thickness of an impermeable barrier, such as clay, overlain by a drainage layer of large river gravel covered by, say, 10—15 m of alluvium) are well within current surface mining technology. However, the surface topography above the proposed repository is variable, so that this surface treatment could be costly and environmentally objectionable.

One of the potential shortcomings of surface modifications alluded to in the viability assessment (VA, Vol. 2, Table 8.5, p. 8-30), is the questionable longevity of such a barrier, due to erosion. However, erosion rates at Yucca Mountain are estimated (VA, Vol. 1, p. 2-26) to be less than 1.1 cm per 1000 years, or 11 m in 1 million years. DOE has given preliminary consideration to a more limited treatment of the surface, including a cover of alluvium over the existing surface (E. L. Hardin, personal communication, 1999), but this has not been pursued to date. Lack of permanence of the cover was one of the concerns cited.

Underground Repository Infiltration Shield, with Multi-Level Repository

An underground infiltration shield is particularly well suited to a repository in the unsaturated zone in fractured rock. where groundwater flow is predominantly vertical and the rock mass is anisotropic, both hydrologically and mechanically. At Yucca Mountain, fracturing (subvertical) is such that the vertical hydraulic conductivity is significantly larger than the horizontal conductivity. Similarly, the modulus of deformation of the rock mass is larger in the vertical direction than in the horizontal direction.

The infiltration shield concept is illustrated in Figure 2. In the example shown, the repository is laid out as a three-level system.[5] This alone, by reducing the plan area *(footprint)* of the

[5]Note that this would also reduce the probability of penetration of a vertical igneous dike intrusion by a similar factor, e.g., from a probability of 1×10^{-7}/yr as currently estimated by NRC scientists to 3.3×10^{-8}/yr.

repository to one-third of a single-level design, reduces the exposure of the drifts to vertical infiltration by a factor of three. Although the shield principle can be applied to a single-level repository design, it is obviously more cost effective to use a multi-level design.

A numerical analysis of the effect of placing a fourth row of drifts (left open, for example, as ventilated observation and performance confirmation drifts (see VA, Vol. 2, p. 4-45) above the three repository levels was carried out by Professor Pierre Perrochet, University of Neuchatel, Switzerland, using the numerical (hydrological) code FEFLOW. The analysis, with assumptions and results, is outlined in Appendix I to this paper.

A single typical column of drifts was analyzed. This corresponded to the central column shown in the upper diagram in Figure 2, but with the upper slot replaced by a circular drift (see diagram in Appendix I). The flow conditions and rock mass properties were considered to be representative of those in the unsaturated zone at Yucca Mountain. It was assumed that the rock mass could be considered to behave as an anisotropic continuum (i.e., discrete fractures were not considered). A uniform vertical infiltration of 50 mm/yr (1096 x 10^{-5} m^3/d over the 80 m^2 potential capture area (per meter of drift) was assumed to occur 30 m above the top row of drifts. A wide range of hydraulic anisotropy was examined. For all anisotropies considered, at least 94% of the top infiltration bypasses the lower three (rows of) drifts. The fluid pressure head above the lower drifts is reduced because of the proximity of the overlying drift, thus enhancing the potential for diversion of water around the lower drifts.

This calculation can be criticized in that it assumes the drifts to be circular and smooth, thus enhancing flow deviation around the drifts — as indicated in Figure 3 (after Philip et al., 1989; Philip, 1990). The presence of discrete fractures in the roof would increase the potential for water to drip into the drifts compared to the case analyzed — viz. that of a smooth opening in a continuum.

This criticism can be circumvented if the upper drift is replaced by a slot, say, 2 m high and ~10 m—20 m wide. Each such slot could be inclined slightly, as shown in Figure 2, and backfilled so as to establish a *flow diversion barrier*, to ensure that any infiltration from above the slot would drain into the rock mass outside the perimeter of the repository. Excavation of the 15 m—20 m slot would serve a dual purpose. A zone of enhanced fracturing would tend to develop above the slot (this would be further enhanced during the thermal cycle after the repository is filled with waste.) Any water infiltrating into the zone would drain into the slot; any remaining flow would be directed into the rock mass away from the drifts. Thus, both mechanisms (capillary diversion around and fracture flow into the slot) act to prevent flow into the drifts.

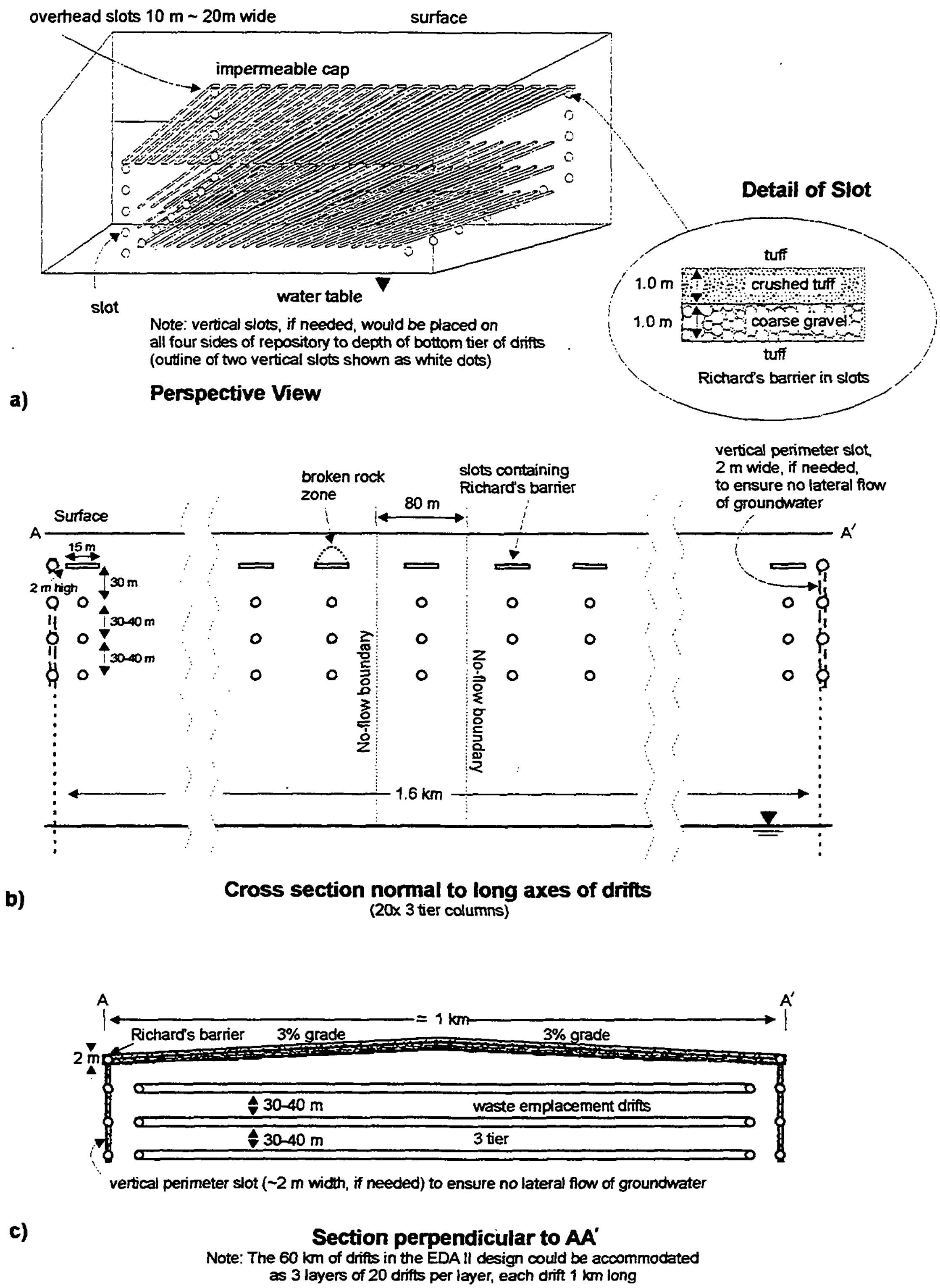


Figure 2. Underground Repository Infiltration Shield

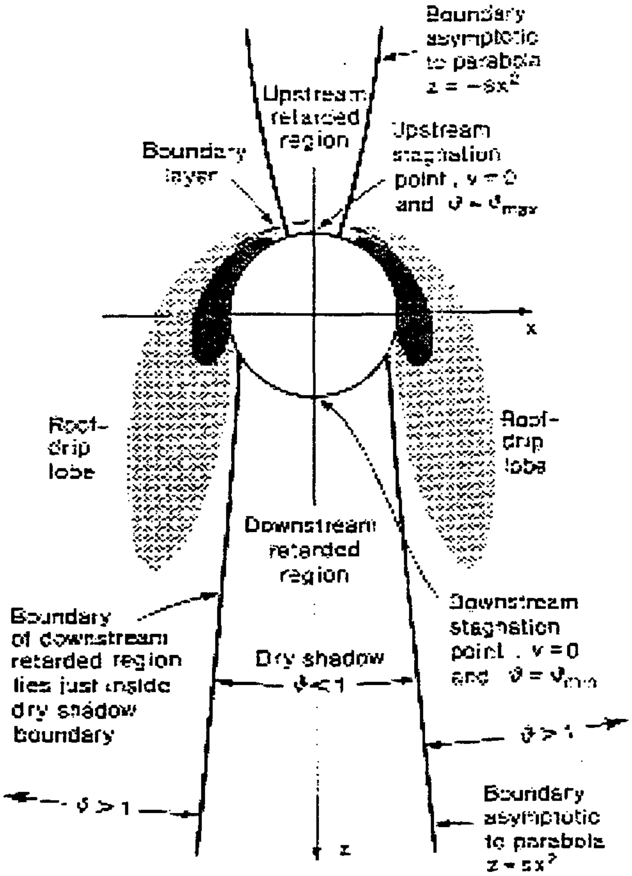


Figure 3. Seepage around cylindrical cavities (schematic diagram illustrating critical points and regions of the flow field)

Richards Barrier

This flow-diversion system incorporates two layers of material with contrasting hydraulic conductivities — a fine-grained porous layer overlying a coarser-grained layer, also porous (see EPRI (1996), pp. 1—2 et seq. for details). The capillary pressure established within the pore space in the upper layer material at the interface with the lower layer acts to prevent flow into the lower layer and promote flow laterally in the upper layer. Currently, the DOE is engaged in considerable study of the Richards barrier. The intention is to cover the waste packages with a "tailored backfill" possibly designed as a Richards barrier to divert water drips from the roof of the drift away from the packages (see Figure 4)[6]. Figure 2 shows a similar two-layer arrangement of backfill for the slots in the proposed repository shield.

[6]It may be that the behavior of a Richards barrier over very long times (i.e., 10,000 years and longer) could be considered doubtful. It is believed that a simple drain, consisting of graded, more or lessuniformly sized granite boulder (river gravel) would suffice to establish free draining of the slots.

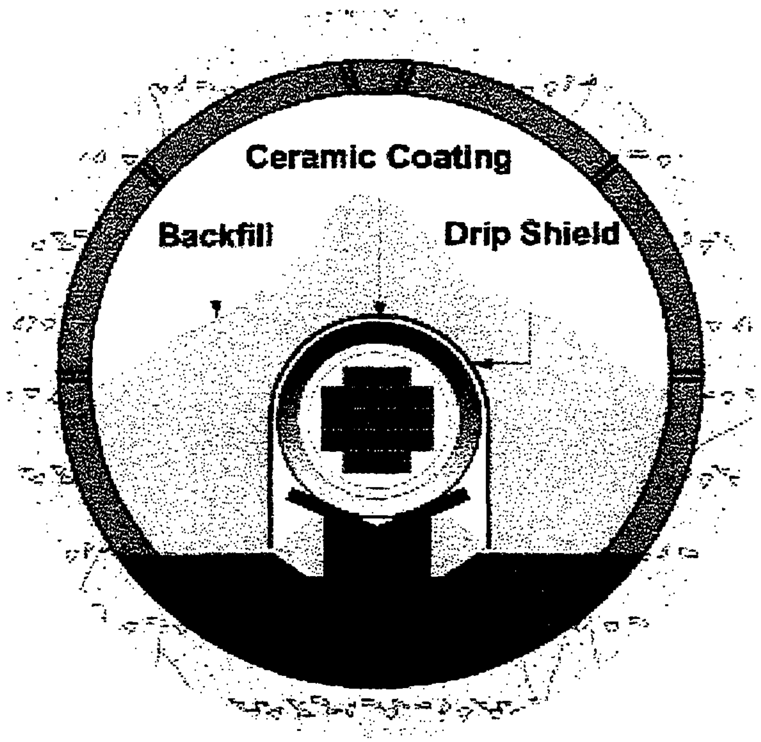


Figure 4. ***Near-Field Engineering Measures to Prevent Dripping on to Waste Packages (It is planned to place the backfill in two layers as a Richards Barrier, with fine-grained rock material overlying a coarser-grained rock material.)***

Potential for Lateral Flow at the Repository Horizon

The repository shield design described above is designed to be effective against vertical infiltration. It will fail if there is significant lateral flow across the repository. Lateral flow is possible, and is known to occur both above and below the proposed repository horizon. Within the proposed horizon (particularly, the southern region), flow appears to be dominantly vertical. As noted in the DOE viability assessment (VA, Vol. 1, p. 2-38),

> *... evidence indicates that surface infiltration generally moves downward rapidly in fractures through the Tiva Canyon tuff until it encounters the non-welded Paintbrush tuff. Flow in the non-welded unit appears to be predominantly in the rock matrix although fast flow paths along faults, fractures and other high permeability zones are present locally. In general, it appears that the Paintbrush non-welded unit attenuates (slows) and distributes flow downward, perhaps for periods of up to thousands of years. After migrating through the Paintbrush tuff, water moves into the welded Topopah Spring tuff* [Note: The proposed repository horizon is in the Topopah Springs formations] *where flow again appears to be dominantly in the fractures. The distribution of flow is heterogeneous; in some areas characterized by widely dispersed or poorly connected fracture systems, percolation fluxes may be very low. In areas with highly transmissive features*

such as faults or dense fracture networks, significant volumes of water may move downward rapidly.

This discussion suggests that lateral flow across the repository is likely to be minimal, so that (horizontal) slots above the waste-filled drifts will eliminate most, if not all, of the potential infiltration into the repository. It is entirely feasible technically, if deemed advisable to further reduce uncertainty, to construct a vertical perimeter shield around the entire repository, as shown in Figure 2. This would require a single vertical column of four 5-m-diameter drifts, located on the same level as the repository drifts and slots, along each side of the repository periphery. A narrow vertical zone of enhanced permeability could then established by blasting, using the VCR (vertical crater retreat) method (or a similar stopping procedure). Blasting would be conducted in vertical holes drilled downward from each overlying drift. The blasted rock would fill the underlying drift such that little, if any, of the broken rock would need to be removed. The aim is to establish a highly transmissive vertical flow pathway around the periphery of the repository; it is not necessary or desirable to create a vertical excavation. Alternate, less expensive techniques (e.g., creation and propping of hydraulic fractures from vertical holes along the drifts) could also be considered.

The horizontal slots and perimeter drifts could be used for monitoring (e.g., by microseismic and other geophysical techniques) repository performance during the preclosure period and beyond, if necessary. Since these openings would be ventilated during this period, any infiltration would be carried out as vapor in the air stream.

Additional Excavation Required for the Repository Shield

Horizontal Slots Only — The total excavation to develop 20 m-wide x 2 m-high slots would be the equivalent of 40 km of 5 m-diameter drifts. The EDA II repository design envisages a total of 60 km of waste-filled drifts. Thus, addition of the 20 m excavation slots would result in a total excavated volume less than the 110 km of drift excavation contemplated in the VA repository design.

"Full" Shield — The four drifts along the entire repository perimeter, if needed, would add a further 21 km of excavation (i.e., 4 x 2(1.6 + 1.0) km). It may be possible, in view of the reduced concern over reflux pathways between the (columns of) drifts, to reduce the spacing between drifts (currently 81 m). This would reduce the extent of the repository footprint plus the cost of generating the high-permeability vertical fracture zone between the drifts.

However, it is considered unlikely that construction of these vertical high-permability zones will be needed provided the repository horizon is selected appropriately, i.e., where the two sub-vertical joint sets are both well developed. They are orthogonal to each other, thus forming an effective barrier to lateral flow across the repository.

The preceding discussion suggests that it is technically feasible to ensure that essentially no infiltration into the repository ever occurs, for a cost that would not significantly exceed that of the VA repository design. This does not consider the added cost of a three -level repository compared to the VA single-level repository. DOE has considered a two-tier or split-level repository option, but did not examine the potential for water diversion. An increased cost of construction of 19% compared to the VA reference design was indicated (CWRMS/M&O Report

Design Feature Evaluation #25, Repository Horizon Elevation, April 2, 1999). It is also worth noting that the repository shield requires no reliance on the long-term performance of manmade materials. It should be relatively easy to establish the very long-time reliability of the repository shield.

The distinct possibility that the repository shield concept could reduce drift infiltration sufficiently to make the titanium drip shield (Figure 4) unnecessary — for a cost saving of $4.6 billion — strongly suggests that the repository shield concept deserves detailed study by DOE. Such a study should examine the implications of the multi-level arrangement (with overlying slots) on the optimum repository design.

Location of a Multi-level Repository at Yucca Mountain

A three-tier repository, as shown in Figure 2, would occupy a vertical interval of approximately 60 m~80 m in the Topopah Springs formation. Since the horizon proposed currently for the single-level repository is approximately at elevation 1080 m it appears that a three-tier interval from 1,040 m to 1,120 m in the central third of the current repository (see VA, Vol. 2, Fig. 4.21, p. 4-40) will remain well within the "groundwater surface plus 100 m" lower limit and within the "200 m cover" upper limit. The slot horizon would be some 30 m or so above the upper row of drifts, but this too will have almost 200 m of rock cover. Since the slot would contain no waste, a cover slightly less than 200 m is considered adequate.

Optimum Repository Layout

The VA reference design was a "hot repository" in which rock temperatures in excess of 200 °C were envisaged. A main intent was to prevent access of liquid water to the waste packages, at least for much of the regulatory period. Concern over the uncertainties associated with two-phase fluid flow behavior in the near-field of the repository and associated complexity of coupled (thermo-hydrological-mechanical-chemical) effects, especially in the near-field around the drifts, led to calls to revise the design to one in which the rock temperature was lower, preferably below the boiling point of water for much of the duration of the thermal cycle. The EDA II "lower temperature" design responds to these concerns.

The two designs are compared in Table 1 (from the presentation "Current Status of Repository Design," by Daniel G. McKenzie III, to the Drift Stability Panel, April 13, 1999).

The EDA II design has some merits, but also some disadvantages. Although the lower temperature system may be simpler *(perhaps!)* for purposes of analysis of near-field fluid (liquid water and water vapor) movement, the possibility that the high-temperature design may inhibit access of liquid water to the drifts is a feature that should not be abandoned lightly. Center for Nuclear Waste Regulatory Anslysis (CNWRA) staff (R. Green, personal communications, 1999) suggests that some counter-current flow may occur, -whereby water vapor may ascend within a fracture while liquid water may descend into the drift via the same fracture. The importance of this possibility in the context of a repository shield design would need to be assessed.) Also, as noted in the EPRI report (EPRI, 1996, p. 1-2):

The proposed DOE schemes for lower thermal loadings would not eliminate completely any of the coupled thermal effects causing concern at Yucca Mountain, although the proposed schemes would reduce the magnitude of at least some of these effects. For example, lowering peak temperatures below the boiling point does not eliminate the potential for evaporation of liquid water from the rock followed by buoyant convection and subsequent condensation farther afield. In order to reduce dramatically thermal effects in the very near field around the containers, the amount of spent fuel contained in an individual container would have to be dramatically reduced or the decay time of the spent fuel would have to be significantly extended (well beyond 100 years). Neither of these approaches seems so practical since both would dramatically increase disposal costs.

Table 1. Comparison Between the EDA II and VA Repository Design Options

EDA II Design	**DOE VA Design**
60 MTU/acre	**85 MTU/acre**
1,050 acre-layout	**741 acre-layout**
60,000 m of emplacement drifting for statutory waste capacity	**117,000 m of emplacement drifting for statutory waste capacity**
2-5 m^3 /s/drift airflow	**0.1 m^3/s/drift airflow**
81 m drift spacing	**28 m drift spacing**
Line load	**Point load (3 m between packages)**

It is instructive, in this regard, to consider the performance of a multi-level EDA II design, as illustrated in Figure 2. The switch to a "line load" of waste packages (i.e., with the packages placed essentially adjacent to each other along the drift) compared to a "point load" (packages separated by several meters along the drift) and a much increased spacing between drifts (81 m for EDA II; 28 m for the VA Reference Design), together with some (low) velocity ventilation of the EDA II drifts, was intended to simplify the convective flow paths with reflux via the cool region in the center of each pillar.

With the multi-level design, the rock temperatures are likely to be increased, principally along the vertical axis between the drifts. The region between the pillars will be less affected, although raised somewhat. Convection cells of heated water and water vapor would form, driving the fluids upward into the slots, where it would tend to condense on the coarser rock in the lower portion of the Richards barrier, flowing along the inclined drifts to drain outside the repository. Continued heating would eventually dry out the rock between each column of drifts. This

pathway provided by the slots would tend to eliminate the need for a pathway for the condensed reflux between the pillars, although concentration of the overburden stress through the pillars would induce a small tension tangential to the central vertical axis of the pillar, thereby tending to open the reflux pathway. In this regard, it should be noted that the intensity of the vertical stress concentrations in the pillars will persist to a greater depth than in the case of isotropic and unjointed rock (i.e., the "aperture opening" effect may be more significant in the jointed rock (see Goodman, 1989, Figs. 9.10 and 9.11 pp. 352—361). Shears induced at the corners of the slots could also cause fracture dilation, especially during thermal cycles.

It should be possible to reduce the 80-m drift spacing of EDA II somewhat (say, to 50 m). This would increase the temperature along the center-pillar axis, but the stress concentration in the now narrower pillar between the slots would increase, which may increase shear and dilation of fractures. The reduced pillar size would reduce the plan area of the repository, thereby either reducing the extent of any vertical perimeter shield or increasing the capacity of the repository. Chemical dissolution of minerals species (e.g., silicates) in the rock by the hotter fluids in the near field, with condensation upon reaching the slots would tend to develop a low-permeability "skin" along the slot floor during the thermal period. This would be beneficial to drainage of condensate along the drift.

Obviously, more detailed analysis and optimization studies are needed to establish the merits of the multi-level design with the repository shield in order to establish the merits of this concept vis-à-vis the proposed single-level designs.

Control of Repository Temperature

Reference has already been made to the perceived benefits of reduced repository temperatures in order to simplify the near-field fluid flow regime. Low temperatures are also desirable to reduce corrosion of the waste packages. The EDA II waste package involves a 2-cm-thick outer cylinder of C-22 alloy steel, with a 5-cm-thick inner cylinder of stainless steel (316NG).

Shoesmith and Kolar (1998) argue that pitting and crevice corrosion of C-22 are unlikely to occur at temperatures below 150 °C and 102 °C, respectively. The authors present detailed discussion of the corrosion processes, but conclude that a conservative design limit is to take 80 °C as the temperature below which crevice corrosion of C-22 can not occur (Shoesmith and Kolar, 1998, p. 5-8, para. 1). Also, it is noted that water must be present for significant waste package corrosion to occur. A relative humidity less than 70% and a temperature below 80 °C are sufficient to reduce the possibilities of corrosion of the C-22 alloy to insignificant values, i.e., yielding estimates of waste-package lifetimes considerably longer than the 10,000 years of the regulatory period.

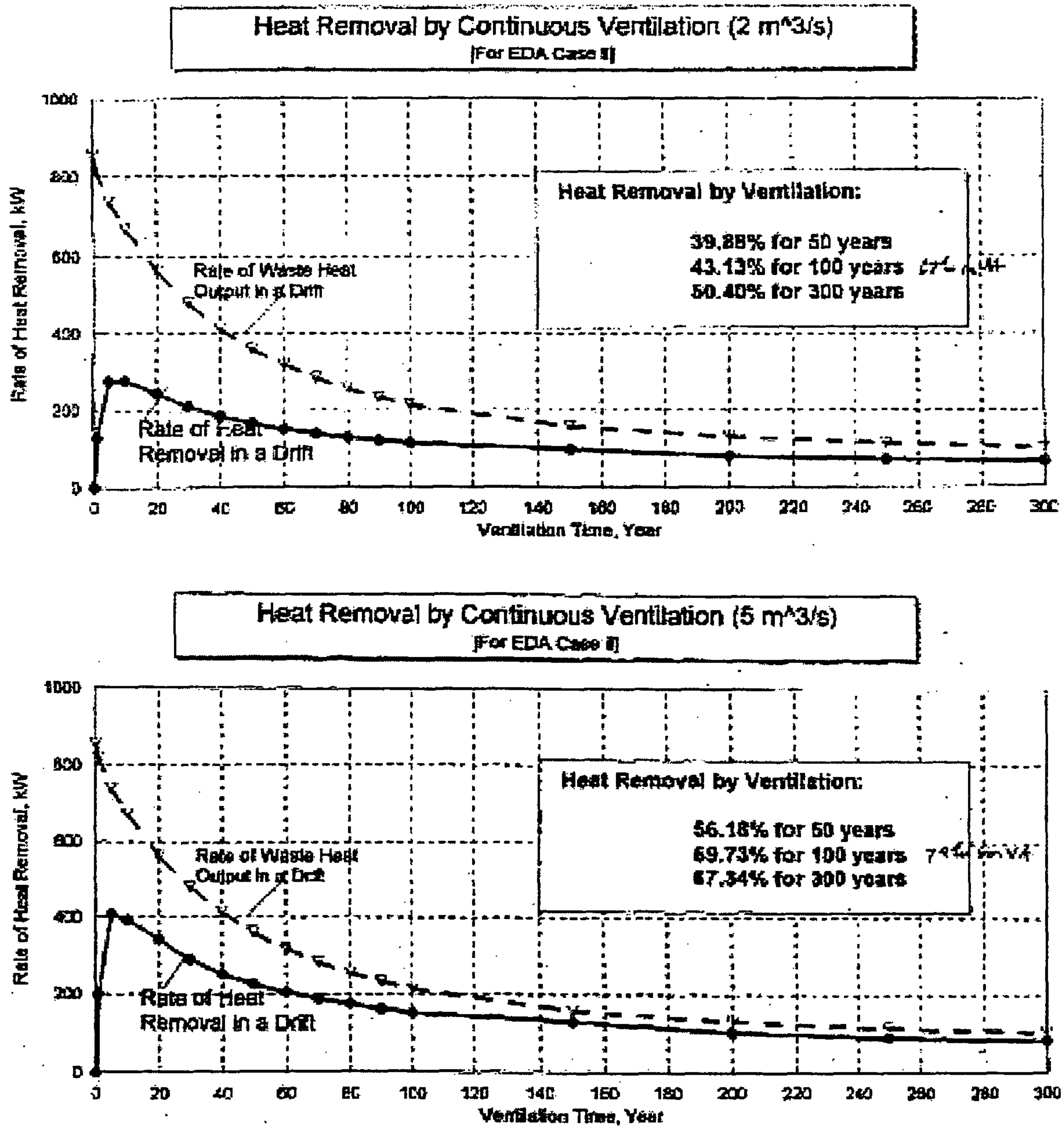


Figure 5. Heat removed by continuous ventilation of waste-filled drifts during the pre-closure period (2m^3/s air flow in a 5-m diameter drift corresponds to an air velocity of 20 ft/min, or 0.23 mph)

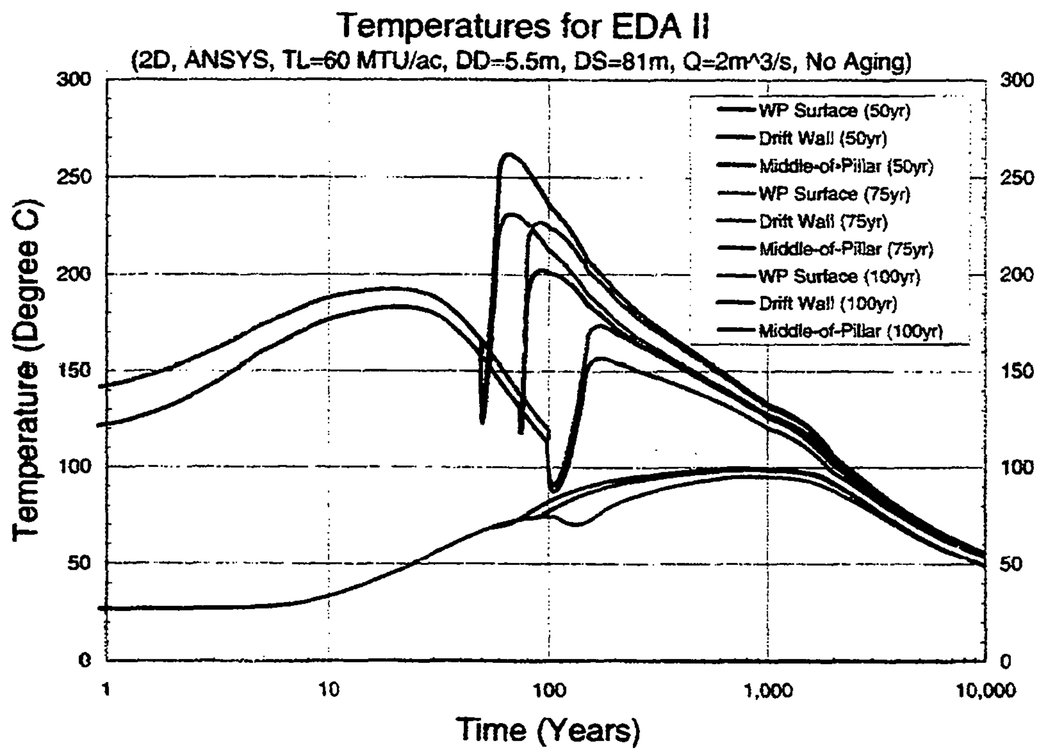


Figure 6. Effect of backfill on the evolution of temperature in the repository drifts (EDA II design)

Figure 5 (kindly provided by the DOE, courtesy of R. Craun, 1999) indicates that drift ventilation can remove significant quantities of heat from the waste packages, especially during the first 50~100 years, when heat generation is most intense. Figure 6 (courtesy of D.G. McKenzie, April 1999) indicates that, with the EDA II design, drift ventilation of 2 m^3/s, and no aging of the waste:

(1) The waste package surface and the drift wall both exceed 150 °C for several years after installation, and

(2) Active ventilation of the drifts, either natural or forced, can also reduce the humidity. Stellavato and Montazer (1996, pp. 25—26) have used the atmospheric/hydrologic code ATOUGH to model heat removal from a ventilated repository.

They advocate design of the repository to allow air to flow continuously and indefinitely through the waste-filled drifts driven by natural ventilation. In their report, the authors conclude that:

> *By considering a naturally ventilated repository (after construction) and taking advantage of the thermal drive of the waste package, the repository may be kept dry during at least the first 10,000 years if not longer. The amount of moisture removed from the rocks during this time will create a thick low-saturation skin*

around the drifts that will require thousands of years to re-saturate. Ventilation can also remove large amounts of heat generated by the waste canisters.

The authors' analysis indicates that the rock temperature never exceeds 25 °C during the ventilation period. The topography and surface layout of the proposed repository at Yucca Mountain is favorable to natural ventilation (and ventilation produced by waste heat generation), but it seems likely that the drifts will collapse over time, increasing the resistance to ventilation. Partial filling of the drifts with "moderately large" boulders to ensure some air access to the packages could be considered, but the resultant overall resistance to flow would be considerable.

Clearly, there is merit in preclosure ventilation of the repository with respect to limiting temperatures. Ventilation also tends to develop a "dryout" zone in the rock. Measurements over the past several years suggest that a region of approximately 100-mm radial thickness is dried out annually. Although the radial extent may not increase linearly with time, it appears that a region not greater than 10 m from the drift excavation will be "dried" over 100 years. With interruption of ventilation, this region will resaturate, probably at a comparable rate, so that the drift will be resaturated (i.e., partially) after the order of 200 years from installation of the waste. Thus, for almost all of the 10,000 years of the regulatory period, the waste packages (and backfill?) would be subject to a humid environment. With the C-22 alloy outer cover of the packages, and a package temperature not significantly above 100 °C, the alloy will corrode very slowly, if at all. This resaturation rate would be slowed considerably if the repository shield concept was used.

The preceding calculations suggest that, if one would hold the temperature of the C-22 waste package below 80 °C , some combination of waste form "blending" in the drifts, aging of the waste in surface facilities before emplacement in the repository, and active *vigorous* ventilation of the packages for at least 50—100 years may be necessary in open drifts. An *open drift* implies that the waste package will not be covered. —i.e., the waste package surfaces should be accessible to the ventilation. Tailored or "getter" backfill in the drift invert below the waste package could still be used.

Design considerations such as those outlined above suggest that it is entirely possible to engineer the natural setting of the unsaturated zone at Yucca Mountain to ensure that a high-level waste repository will be demonstrably safe for an indefinite period into the future. The *umbrella principle* of the repository shield is simple and can be comprehended easily by the general public.

Drift Stability

It is planned to locate the repository in the Topopah Springs tuff formations. For purposes of drift support/reinforcement and stability analyses, the formations can be divided into two general categories:

(1) *Non-lithophysal tuff.* - These formations contain three relatively well-developed joint sets. (Two are subvertical: joint set No. 1 has a dip of 77° and a dip direction of 40° ; joint set No. 2 has a dip of 80° and a dip direction of 130°. One is sub-horizontal: joint set No. 3 has a dip of 25° and a dip direction of 300°); and

(2) ***Lithophysal tuff.*** -These formations contain three-dimensional voids — approximating spheres or ellipsoids in most cases — or *lithophysae* generated as gas pockets during the

period of deposition of the volcanic tuff. Some of the lithophysae can approach 0.5 m in diameter, although most are smaller (predominantly 7—15 cm in diameter). Also, fractures in the lithophysal rock are shorter and less persistent than in the other units, and often terminate (or originate?) at the lithophysae.

> It seems likely that the lithopyhsal zones will be stronger and stiffer (i.e., higher rock mass modulus) than the non-lithophysal zones because of the lesser influence of through-going joints. The higher modulus would result in higher thermally induced stresses for a given temperature, so that the extent of *damage* during the thermal cycle could be comparable for both lithophysal and non-lithophysal tuffs.

It seems to the writer that excavations with rock reinforcement should be stable in both formations. The following discussion will examine the likely mechanical response of the two types of formation to loads generated in a repository. The stability of the repository drifts is of particular importance for the preclosure period, and can have consequences for the long-term performance of the repository, especially if the drifts are not backfilled.

Preclosure Stability

Although there is a wealth of experience in designing and constructing tunnels of the general dimensions of the repository drifts, and there are examples of tunnels that have remained stable for much longer than 100—300 years, design of a repository is unique in that a major thermal cycle is involved. For the case of a hot repository, this heating imposes substantial additional stresses on the rock and any rock lining. The likelihood that a concrete lining would be seriously and adversely affected by the high temperatures is — in part, at least — the reason why an Expert Panel on Drift Stability has recently recommended the use of rock bolts and wire mesh as being a more suitable support system than a concrete liner.

Postclosure Stability

DOE lists the following information needed with respect to performance assessment (PA) for ground support/drift stability (R. Howard, Yucca Mountain Drift Stability Panel, April 13, 1999):

Ground Support/Drift Stability Information Needs for PA (FEPs)[7]

- masses and spatial distribution of ground support materials
- nature and rates of continuous degradation processes
- nature and probability of disruption by rock fall
- nature and probability of disruption by seismic motion

Of these, the first can be answered as soon as a support system is selected. The remaining three require an understanding of the long-term, time-dependent behavior of the rock mass ***only if the drifts are not backfilled***. If the drifts are backfilled, then these issues are no longer of concern.

[7] FEPs are features, events, and processes that are considered to influence repository performance.

No firm decision has yet been made concerning whether to backfill the drifts after waste emplacement.

Numerical (discrete element) models currently in use to assess drift stability at Yucca Mountain have a significant limitation in that the rock blocks in these models, although deformable, are assumed to have infinite strength (i.e., they cannot break). This results in significant over-estimation of the consequences of rock falls on to waste packages. Considerable improvement in prediction of both (1) the consequences of heating on spalling of the drift walls and (2) the behavior of falling blocks can be obtained using a code such as the micro-mechanics numerical code PFC (Potyondy and Cundall, 1999) that allows the blocks to break under applied loading. Some indication of the difference that may be expected is demonstrated by the simple example of a rock block falling 2 m from the roof of the drift onto a waste package, as shown in Figure 7. The resultant force-versus-time history during the impact is shown in Figures 7(b) and 7(c) for the two cases in which (b) the block has infinite strength, and (c) a similar block has the (finite) strength of Yucca Mountain tuff. Fragmentation of the block (Figure 7(c)) traps a substantial proportion of the kinetic energy and momentum of the block with the result that, in this case, the peak force on the waste package is reduced to approximately one-third of the value indicated with the infinitely strong block.

Thermal loading and seismic effects can be considered in the PFC code. The rate of degradation over a long time can also be estimated, but this would require laboratory data on the strength of tuff (and joints in tuff) as a function of applied loading conditions (and possibly thermal conditions). Such data may not be available. The *pattern* of collapse with time can be examined for various *assumed* strength-degradation models. If this indicates that the pattern is relatively independent of rate of degradation, knowledge of the degradation pattern may suffice for PA purposes. Another approximate approach is to assume that the joint cohesion declines progressively in time toward zero. Frictional properties may decline somewhat, but are likely to remain significant.

It is anticipated that an analysis using PFC would indicate progressive spalling of the drift wall and collapse of *relatively small* rock blocks on to the packages. This would further reduce the severity of any rockfalls on to the waste packages.

Time-dependent deterioration of rock strength (and possible collapse) can occur whenever rock is loaded in compression beyond 40% to 50% of its ultimate compression strength. Stresses significantly above this level could be generated in the rock during the thermal pulse period of repository operation. (In the case of Yucca Mountain, the stress induced in the rock by temperature increase is approximately 0.5MPa/°C for an assumed modulus of deformation of the rock mass of E = 6 GPa.)

Recognition of the limited value of classical geotechnical engineering design approaches in prediction of rock mass behavior for repository design has stimulated studies to obtain a more fundamental understanding of the physical principles that control time-dependent failure in rock. The report by Potyondy and Cundall (1999), describing studies being conducted for the Canadian nuclear-waste isolation program (and including the influence of heat in degrading rock strength with time) outlines valuable developments on this topic.

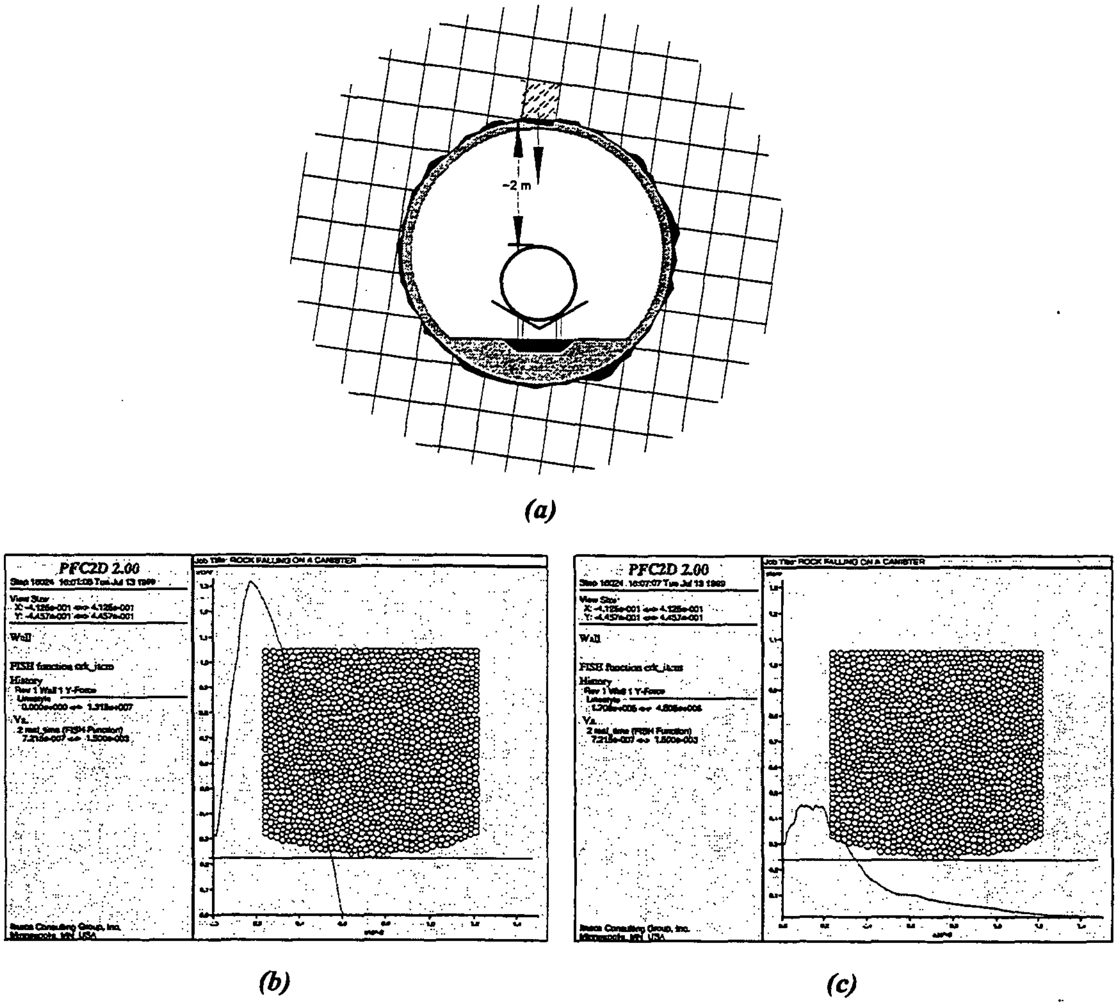


Figure 7. Effect of finite rock strength on the impulse generated by free fall of a rock block onto a waste package (PFC model) (The block in Fig. 6(c) has the same deformability as the (infinite strength) block of Fig. 6(b), but a strength corresponding to that of Yucca Mountain tuff)

Effect of Heating on Drift Stability

Figure 8 illustrates the change in stresses produced in the periphery of an unsupported drift as the result of heating, in this case to 145 °C, assuming that the rock mass has properties almost equal to those of intact tuff (i.e., RMQ 5). The initial insitu stresses were assumed to be approximately 10 MPa vertical. (This is equivalent to a depth approaching 400 m and 3 MPa horizontally). Under these stress conditions, the tangential stresses around the drift preceding heating would reach a maximum compression of approximately 26 MPa acting vertically across the central horizontal axis. Assuming a rock mass modulus of 32 GPa (i.e., RMQ5 rock properties), the effect of heating to 145 °C is to add compression on the order of 120 MPa more or less uniformly around the tunnel wall if the rock retains the RMQ5 properties and remains elastic.

If the rock properties are *degraded* to those of rock of RMQ1 quality, the stresses shown by the solid lines in Figure 8 are developed. The effect of a total of 50 years of heating, after which high temperatures (and stresses) have penetrated further into the rock, is shown by the dotted stress distribution. This results in a zone of inelastic deformation such as indicated in Figures 8 and 9. It is seen that the stress distribution and extent of inelastic deformation depend heavily on the rock properties. Recent results of insitu modulus measurements in the heated drift experiment indicate that the rock mass modulus (of deformation) increases from the order of 6~7 GPa at ambient temperature to higher values at higher temperatures. This is due, very likely, to expansion of the rock and consequent closure of the rock joints with increase in rock temperature. It is unlikely that the rock mass modulus in the jointed rock will reach the laboratory value for intact rock (32 GPa). In the lithophysal tuff, however, the modulus can be expected to be higher than in the non-lithophysal jointed tuff.

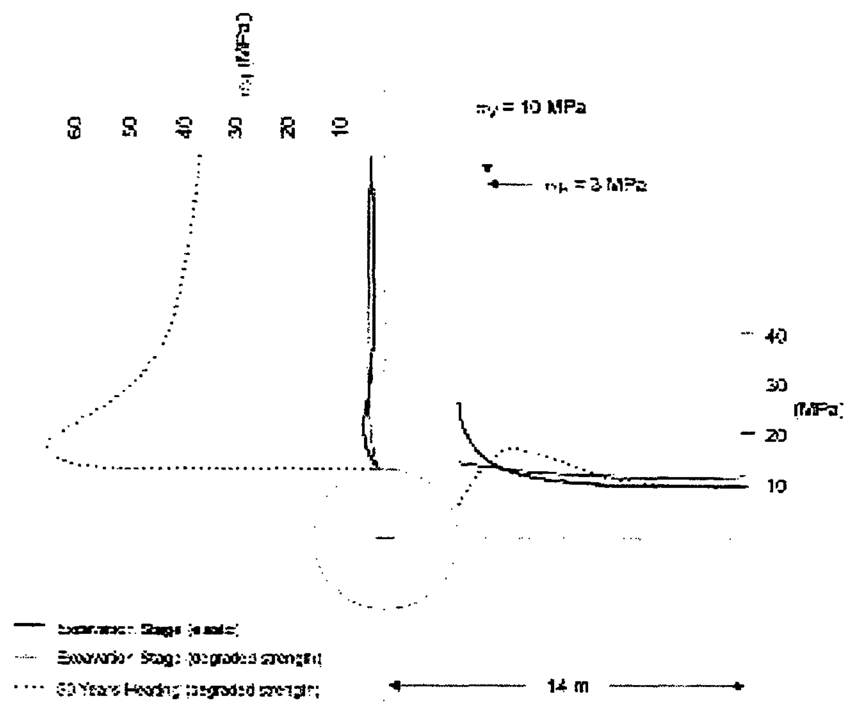


Figure 8. Effect of Heating on Stresses Around One of a Series of Excavations

Figure 9 shows the extent of joint slip that occurs before (Figure 9(a)) and after (Figure 9(b)) heating when a PMQ5-quality jointed rock mass is subject to heating as described for Figure 8.

Figures 9(c) and 9(d) show the results of numerical modeling in which a 5-m-diameter unsupported open drift is subjected to two identical seismic events, one that occurs before heating (Figure 8(c)); the other (Figure 8(d)) that occurs after 50 years of heating of the rock to a maximum temperature of 145 °C at the tunnel wall. The regions of joint slip are shown in Figures 9(a) and 9(b), and the rockfall due to the two seismic events in Figures 9(c)and 9(d). It is seen that the rock fall is considerably reduced for the heated rock. This is because the increased temperature superimposes a high compression all around the tunnel, tending to "clamp" the rock blocks together, and preventing fallout.

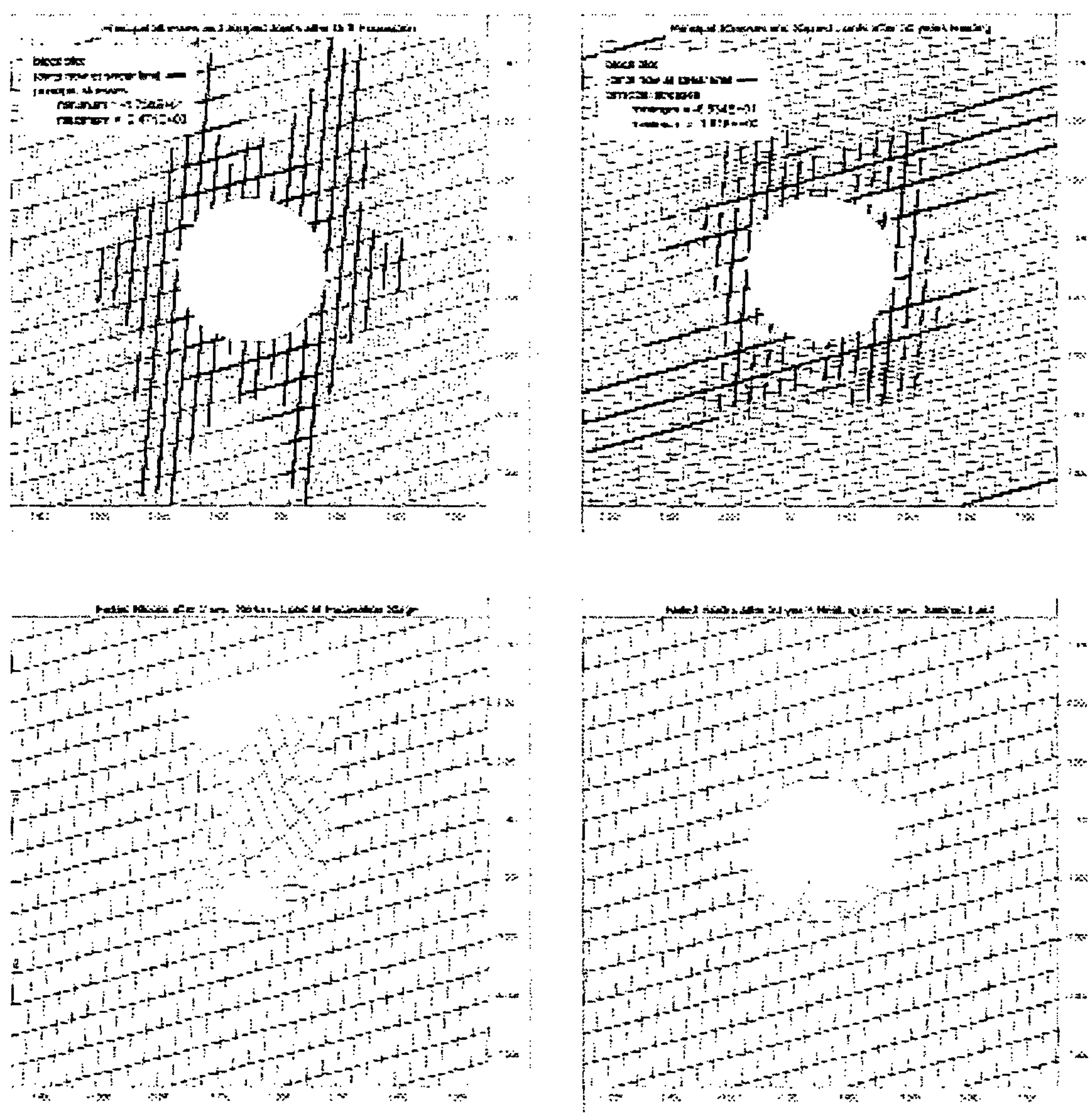


Figure 9. Effect of Heating (a,c) on Drift Stability and Seismic Event Before (b) and During (d) Heating

Thus, the consequences of a seismic event will depend very much on when the event occurs with respect to the thermal loading produced by the waste package. Upon cooling, the induced thermal stresses will disappear, and some additional collapse could occur. It was found, during the study of seismic effects mentioned above, that the second seismic event in each case caused little additional rockfall. However, the effect of time-dependent weakening of the rock mass was not considered. It seems probable that additional collapse would occur if this factor were added.

Figures 10(a)—10(d) show the results of numerical modeling to simulate various support options and assumed rock conditions.

The rock joints are assumed to have an initial (high) friction angle of 56° and a cohesion of 0.07 MPa. Other properties are those for RMQ5 rock (as defined by the M&O contractor). The reinforcement [grouted bolts (c)],or support [concrete (d)] is then installed, or the drift is left unsupported [(a), (b)] depending on the case considered. The rock is then heated to 100 °C. Joint slip and rock failure occur. Then, in order to simulate time-dependent degradation of the rock joints, the joint friction angle is reduced to 35°. Except for case (b), the joints are all assumed to be continuous. In case (c), the joints are *non-persistent*, consisting of alternate 1-m-long segments of intact rock and joint, for which the friction angle is degraded to 35°.

Results indicate that the extent of the damage zone depends primarily on the frictional properties of the joints. Non-persistent joints (case (b)) behave essentially as intact rock, so that the extent of the damage zone is significantly reduced compared to that produced with continuous joints (case (a)); see the discussion of the lithophysal rock zone, below. Grouted rock bolts (case (c)) reduce considerably both the slippage on joints and the extent of the damaged region. Case (d) indicates that the elastic liner installed with a gap between the crown of the drift and the top of the liner to simulate a noncontinuous liner/rock contact does little to reduce the extent of damage compared to the case in which there is no support (case (a)), although the liner does, of course, prevent the rock fallout that would be very likely to occur in case (a).[8]

Lower Lithophysal Rock Zone

A brief analysis of the mechanical properties of lithophysal tuff (see Figure 11 and related discussion) suggests that the overall mechanical response to stresses (including thermal stresses) in these zones may be less influenced by joints and joint slip than is the case in the non-lithophysal zones. Thus, the rock mass strength in the lithophysal tuff may be somewhat higher, but the modulus of deformation will also be higher. Because the induced thermal stresses are directly related to this modulus, the *ratio* of stress:strength will change less. It seems, therefore, that from the mechanical stability perspective, drifts (e.g., for a multi-level repository) may be located in either or both lithophysal and non-lithophysal regions.

Both the Nuclear Waste Technical Review Board (NWTRB) and the NRC have criticized DOE for its failure to determine the insitu mechanical properties of the lower lithophysal rock, in which approximately 70% of the repository will be located. (Most of the rock properties have been determined for other, non-lithophysal units.)

An analysis was conducted to assess the influence of the lithophysae (assumed to be spheres) on the strength of the rock mass. Since, as noted in the discussion of Figure 10 case (b), non-persistent joints tend to exhibit the same strength as the intact rock in which they are found, the analysis assumed that the rock around the lithhophysae had the same properties as those defined by RMQ5. As stresses are increased (in this case, due to heating) on the rock, the lithophysae behave essentially as interior (spherical) excavations, i.e., stress concentrations occur around the

[8] These analyses were made available, courtesy of Dr. R. Hart of Itasca Consulting Group Inc. Dr. Hart is a member of the Drift Stability Panel, for which the analyses were conducted.

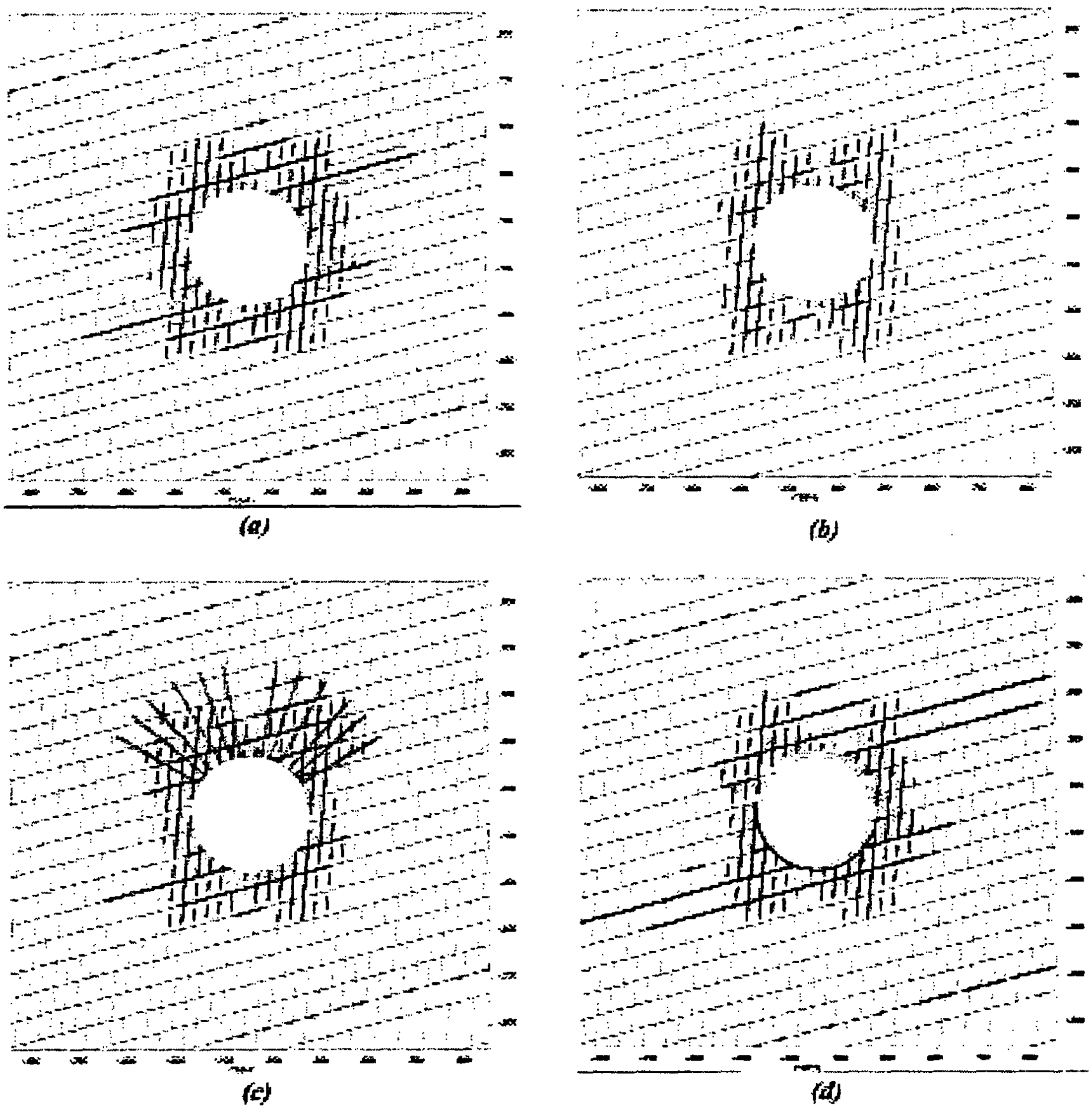
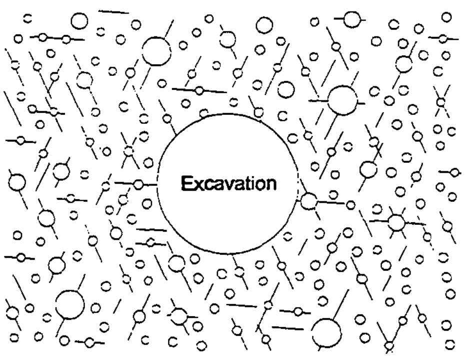
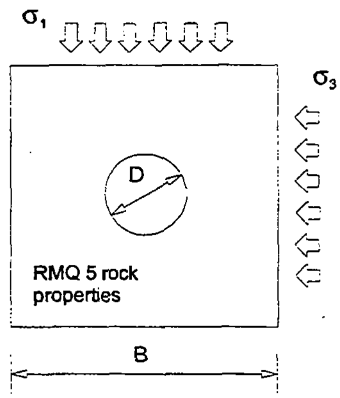


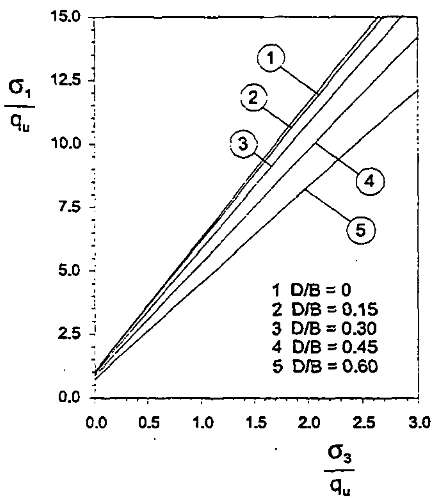
Figure 10. ***Effect of Long-term Degradation of Rock Joints Properties on Extension of Inelastic* Failed *Rock Zone for (a) Unsupported, Regularly Jointed Rock; (b) Unsupported, Non-persistent Jointing; (c) Reinforced by Jointed Rock Bolts; and (d) Supported by Elastic Concrete Support***



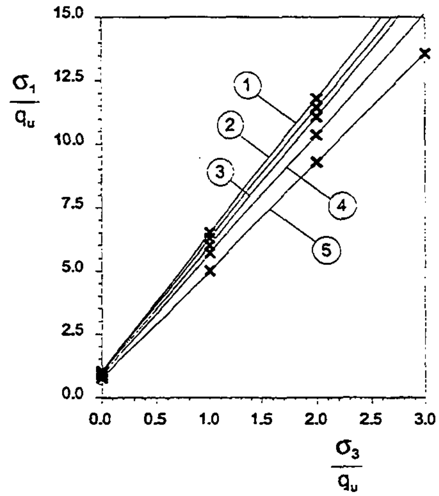
(a) Idealized representation of excavation in Lithophysae Tuff.



(b) Model analyzed in calculations.



(c) 'Tributary area' yield envelopes..



(d) FLAC^{3D} yield envelopes.

Note. Tributary area strength in (c) is calculated from the expressions,

$$\frac{\sigma_1}{q_u} = \left[1 - \frac{\pi}{4}\left(\frac{D}{B}\right)^2\right] K_p \frac{\sigma_3}{q_u} + \left[1 - \frac{\pi}{4}\left(\frac{D}{B}\right)^2\right] \qquad K_p = \frac{1 + \sin o}{1 - \sin \phi}$$

where q_u is the unconfined compressive strength and ϕ is the friction angle [with these intact rock properties, the yield envelope is given by line 1 in (c) and (d)].

The FLAC3D analysis also yielded the following results for the influence of the lithophysae on the overall modulus of deformation (E) of the lithophysae rock compared to the modulus of the rock without the lithopysae (E').

D/B	0.0	0.3	0.45	0.6
E/E'	1.0	0.96	0.89	0.78

Note E' in the FLAC3D analysis was 7.76GPa.

Figure 11. ***Predicted Rock Mass Strength (Mohr-Coulomb) Envelopes and Modulii of Deformation for Lithophysal Tuff (Intact rock between lithophysae is assumed to have RGM 5 mechanical properties.)***

lithophysae and, eventually, the rock around the spherical periphery will begin to "collapse" into the lithophysal cavity.

The model analyzed is shown in Figure 11(b). B is assumed to be the width of a cubical region containing one cavity, diameter D. Various ratios of B:D were considered. The reduction in strength of the cube of rock containing the cavity, compared to the strength of a cube without a cavity (B/D = 0) is shown in Figures 11(c) and11 (d).

Two approaches are taken. In the so-called *tributary area* method (frequently used for room and pillar design in mines), it is assumed simply that the strength is reduced in proportion to the reduction in cross-sectional area of the center section of the cube containing the spherical cavity. In the second approach, a three-dimensional numerical analysis (FLAC3D) was carried out. The strength limit was assumed to be reached when inelastic deformation started at the wall of the sphere. Results are shown in Figures 11(c) and 11(d). Although the FLAC3D results indicate slightly higher strengths for a given cavity size, the difference between the two approaches is small (maximum about 18% for D/B = 0.6), and the tributary area approach is conservative (i.e., it underestimates the strength of the rock). Thus, it seems sufficient to use the tributary area method in calculations involving the rock-mass strength of the lithophysal zone.

The FLAC3D analysis also yielded results for the influence of the lithophysae on the overall modulus of deformation (E) of the lithophysal rock compared to the modulus of the rock without the lithophysae (E*). Results (tabulated in Figure 11) indicate that the reduction in E is also small, and follows a similar trend to that of the strength reduction.

It is recommended that laboratory tests be carried out on intact samples (taken between lithophysae) to establish the envelope corresponding to D/B = 0, and then to estimate an average value of D/B from exposures in drift walls. This information can then be used, with Figure 10(c), to establish an envelope for the rock mass strength.

Actual lithophysal voids tend to be ellipsoidal rather than perfectly spherical. Although it is feasible to generate ellipsoidal cavities and analyze them numerically, the effect of such cavities will depend on their distribution in size and orientation with respect to each other and to the applied stress field. As a first approach, over-conservative but simple approximation, the voids could be assumed to be "replaced" by spheres of diameters equal to the major axis of the ellipsoid. (A less conservative option would be to assume spheres of diameter equal to the mean of the major and minor axes of the ellipsoids.) The approximate expressions presented in Figure 11 could then be used.

Use of Concrete for Excavation Support

Concern has been expressed that the use of concrete, as is popular, in concrete and "shotcrete" linings and in the cement grouting of rock bolts[9] would result in a high pH of water entering the drift. This could have numerous adverse consequences (for example, on the radionuclide retardation capability of materials that may be placed below the waste packages, or

[9] Note that resin grouts are not favored, as they are organic compounds.

that exist below the repository, e.g., zeolites) in order to retard the movement of radionuclides e.g., neptunium.

Discussions with concrete technologists reveal that it is possible to avoid high-pH water (e.g., by carbonating the cement, using carbon dioxide). The carbonation reaction has been studied extensively (it occurs naturally in concrete due to the effects of carbon dioxide in the atmosphere), and it appears possible to engineer a solution to avoid high-pH water. Also, the strength (and ductility) of concrete can be increased considerably compared to standard concretes traditionally used in construction. Although care should be taken to ensure that adverse effects are avoided, it is recommended that drift support designers not be prevented from taking advantage of the merits of shotcrete and grouted bolts, both of which could play a valuable role in drift support at Yucca Mountain.

Most of the designs showing precast concrete lining or steel sets in the (circular) drifts (admittedly idealized) indicate that the linings/sets are in intimate uniform contact with the drift wall. In reality, of course, there will be irregularities in the wall profile. Normally, these would be filled with cement grout to ensure that the lining is uniformly loaded. Sand *backpacking* can be substituted, but it is important that analysis of the lining support include consideration of the influence of such irregularities and fill methods on the bending stresses generated in the support during the thermal cycle.

The writer believes that a well-designed system of grouted rock bolts, mesh, and shotcrete will be sufficient to ensure stable openings during the preclosure period. Precast concrete linings or steel set supports, which would be very expensive, will not be needed.

Upper-Bound to Collapse Region

A simple estimate of the maximum extent of collapse around an unsupported tunnel can be made as follows.

Consider a circular tunnel, of radius a, surrounded by a circular zone of damaged rock, radius V. When rock is damaged, slip along joints and dilation occur, rock may collapse into the tunnel, etc. (i.e., the damaged rock will occupy a greater volume than when it was intact and undisturbed; it is said to undergo "bulking"). Let us assume that the rock is damaged to a radius b $(b > a)$. If we assume that the broken rock has a bulking factor (i.e., unit volume of unbroken rock occupies a volume $(1+k)$ in the broken state), we may determine the volume of unbroken rock in the annulus $(b - a)$ that, upon breaking, will fill the excavation. Thus, we have

$$\pi (b^2 - a^2)(1 + k) = \pi b^2$$

from which we obtain

$$\frac{b}{a} = \left(\frac{1+k}{k} \right)^{0.5}$$

For a value of $k = 10\%$ (10% to 25% is considered to cover most mining collapse situations), we find $b/a = 3.3$. For $k = 25\%$, $b = 2.2$.

Thus, the maximum possible extent of the damage zone around a repository tunnel will be of the order of three tunnel radii. Beyond this region, the rock will contain joints and fractures similar to those in the virgin rock mass. Hence, for calculation of post-thermal cycle water influx to the tunnel, such a model should suffice.

Heated drift experiments and niche tests are unlikely to resolve several important post-thermal cycle inflow issues. The effect of the thermal cycle on the mechanical properties of the rock mass, information that would have been very useful in drift stability analysis, appears to be a secondary consideration in these experiments compared to the hydrological issues. There has been no modeling of the effect of discrete jointing on rock mass behavior, for example. (Appendix II shows a preliminary study to illustrate what is possible.) Acoustic emission (micro-seismic) studies have only recently been added, and an opportunity to observe the rock-mass response from the onset of loading has been missed. Some microseismic equipment has now been installed, and data are being collected. Collection of such data can be very valuable in establishing which joints are slipping, and this information can be used to calibrate numerical models that contain such discrete features. (Figure 12 illustrates the microseismic network set up for the mine-by experiment at the Underground Research Laboratory in Canada, together with the locations of the microfracturing (detected by acoustic emission) induced by excavation. The network was installed before the mine-by excavation was started.)

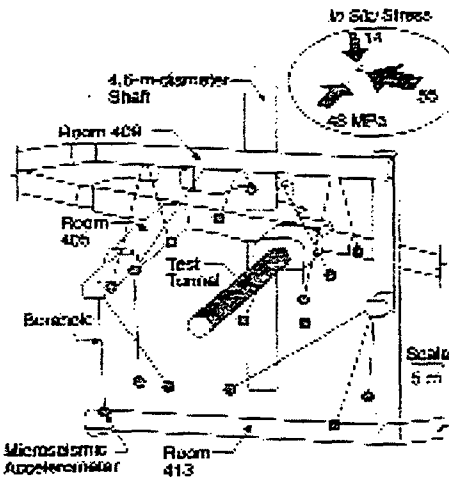


Figure [illegible]: Layout of the 420 Level showing the location of the Mine-by test tunnel, the microseismic monitoring system and Room 405, the location of the borehole breakout study.

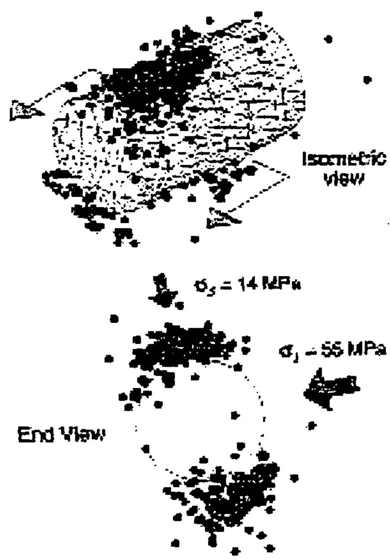


Figure 13: Location of microseismic events recorded after the excavation of a 1-m-long round in the test tunnel.

Figure 12. ***Mine-by Experiment, Underground Research Laboratory, Pinawa (Read and Martin, 1996)***

References

Carter, Luther J., and Thomas H. Pigford 1998. "Getting YUCCA MOUNTAIN RIGHT," *Bull. Atomic Scientists*, 56—61 (March—April).

Electric Power Research Institute (EPRI) 1996. ***Analysis and Confirmation of the Robust Performance of the Barrier System within the Yucca Mountain Site***. Flow Division, Report TR107189 (3294-17), December.

Goodman, R. E. 1989. ***Introduction to Rock Mechanics***, 2nd ed. New York: Wiley.

Philip, J. R. 1990. "The Watertightness to Unsaturated Seepage of Underground Cavities and Tunnels," in ***GEOVAL-90 (Proceedings of the Symposium on Validation of Geosphere Flow and Transport Models, Stockholm, May 1990)***, pp. 301—308. Stockholm: SKI.

Philip, J. R., J. H. Knight, and R. T. Waechter. 1989. "Unsaturated Seepage and Subterranean Holes: Conspectus, and Exclusion Problem for Circular Cylindrical Cavities," *Water Resources Research*, *25*, 16—28.

Potyondy, D., and P. Cundall. 1999. "Modeling of Notch Formation in the URL Mine-by Tunnel: Phase IV — Enhancements to the PFC Model of Rock," ICG, Report to Underground Research Laboratory. City: Atomic Energy of Canada Limited, March.

Read, R. S., and C. D. Martin. 1996. ***Technical Summary of AECL's Mine-by Experiment, Phase 1: Excavation Response***, AECL-11311, COG95-171. City: Atomic Energy of Canada Limited, February.

Roseboom, E. H. 1983. " Disposal of High-Level Nuclear Waste Above the Water Table in Arid Regions," Circular 903 City: U.S. Geological Survey.

Shoesmith, D. W., and M. Kolar. 1998 "Waste Package Performance," in ***Alternative Approaches to Assessing the Performance and Suitability of Yucca Mountain for Spent-Fuel Disposal***, Ch. 5, pp. 5-1 — 5-67, Report TR108732, City: Electric Power Research Institute (EPRI), November.

Stellavato, N., and P. Montazer. 1996. ***Nye County NVirRP Office Annual Report 1995/96***.

U.S. National Academy of Sciences/National Research Council (NAS/NRC). 1957. "The Disposal of Radioactive Waste on Land," Publication No. 519. Washington, D.C.

U.S. National Academy of Sciences/National Research Council (NAS/NRC). 1995. ***Technical Bases for a Yucca Mountain Standard***, TYMS. Washington, D.C.

U.S. Nuclear Regulatory Commission, Disposal of High-Level Radioactive Wastes in a Proposed Geological Repository at Yucca Mountain, Nevada, Proposed Rule, Federal Register Notice, February 22, 1999.

U.S. Department of Energy (U.S. DOE). 1998. VA reference design (CWRMS/M&O Report Design Feature Evaluation #25, Repository Horizon Elevation, April 2, 1999).

Appendix I

Steady Vertical Unsaturated Infiltration Through an Array of Horizontal Drifts

Assumptions

Validity of Richard's equation with equivalent unsaturated properties. Isothermal medium.

$$\nabla\cdot(\mathbf{K}K_r(\psi)\nabla(\psi+z)) = 0$$

ψ : relative pressure head ($\psi < 0$ unsaturated zone, $\psi > 0$ saturated zone) [m]
z : vertical coordinate [m]
$\mathbf{K}$: hydraulic conductivity tensor [m/s]
$K_r(\psi)$: relative hydraulic conductivity ($K_r < 1$ unsaturated zone, $K_r = 1$ saturated zone) [-]

Parametric model for unsaturated conductivity

van Genuchten : $$K_r(\psi) = \frac{1}{(1+|\alpha\psi|^n)^{m/2}}\left(1-\left(1-\frac{1}{1+|\alpha\psi|^n}\right)^m\right)^2 \quad , \quad m = 1-\frac{1}{n}$$

Exponential : $$K_r(\psi) = e^{\alpha\psi}$$

Assumed material properties

Matrix porosity : 0.1
Matrix permeability : $4\cdot10^{-18}$ m^2
Fracture frequency : 4.5 1/m
Fracture aperture : 54 μm

Matrix hydraulic conductivity (isotropic) K_{min} : $4\cdot10^{-11}$ m/s
Fracture hydraulic conductivity (cubic law) K_{max} : $5.85\cdot10^{-7}$ m/s
Homogeneous saturated and residual moisture θ_s, θ_r : 0.1, 0.01
van Genuchten model parameters α, n : 4 1/m, 2
Exponential model parameter α : 10 1/m

2D vertical equivalent hydraulic conductivity tensor (assuming vertical fractures)

$$\mathbf{K} = \begin{bmatrix} \beta K_{max} & 0 \\ 0 & K_{max} \end{bmatrix}$$

Anisotropy ratio β varied from 1 to K_{min}/K_{max}

Geometry

Drifts; diameter - 5 m ;spacing - 80 m (horizontal), 30 m (vertical)
Potential capture zone (per unit width) for a column of drifts : 80 m^2

Boundary conditions

Unsaturating infiltration rate at the surface (i): 50 mm/y ($1.37\cdot10^{-4}$ m/d , $1.59\cdot10^{-9}$ m/s)
Atmospheric seepage at the drifts
Static watertable level at – 200 m

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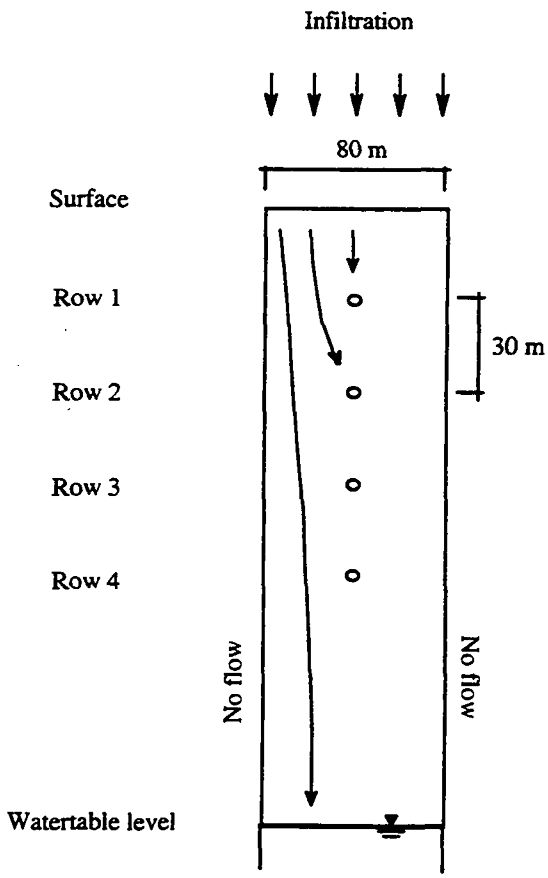
* i.e. 1096 x 10^{-5} m^3/d over the 80 m^2 potential capture area.

Sketch of the flow towards drifts in columns (with symetry conditions)



Discharge rates under steady state unsaturated conditions [10^{-5} m^3/d]

	Case 0 : $\beta = 1$ (isotropic)	Case 1 : $\beta = 10^{-1}$	Case 2 : $\beta = 10^{-2}$
Top infiltration	1096.0	1096.0	1096.0
Drifts at – 30 m	– 0.0	– 0.0	– 35.6
Drifts at – 60 m	– 0.0	– 0.0	– 0.0
Drifts at – 90 m	– 0.0	– 0.0	– 0.0
Drifts at – 120 m	– 0.0	– 0.0	– 0.0
Bottom drainage	– 1096.0	– 1096.0	– 1060.4

	Case 3 : $\beta = 10^{-3}$	Case 4 : $\beta = 10^{-4}$ ($\approx K_{min}/K_{max}$)	Case 5 : $\beta = 0$
Top infiltration	1096.0	1096.0	1096.0
Drifts at – 30 m	– 58.0	– 60.3	– 68.5
Drifts at – 60 m	– 6.1	– 7.0	– 0.0

Drifts at – 90 m	– 3.2	– 2.4	– 0.0
Drifts at – 120 m	– 2.9	– 2.0	– 0.0
Bottom drainage	– 1025.8	– 1024.3	– 1027.5

Remarks

Under unsaturating vertical infiltration, buried cavities may behave as obstacles to the flow and so increase water relative pressure head at parts of the cavity surface. Gravity dripping into the cavity occurs only at those points where the pressure head reaches the pressure inside the cavity (e.g., atmospheric pressure). Under uniform infiltration the first point reaching this pressure is the highest point of the cavity roof.

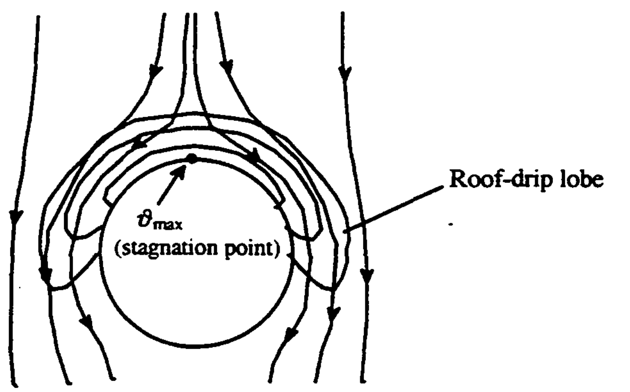
An analytical solution exists for horizontal cylindrical cavities in an isotropic medium (Philip and Knight, 1989, *Water Resources Research*, **25**, 16-28). Assuming an infinite vertical medium submitted to constant, uniform unsaturated seepage, the question as to whether or not water drips into a circular section centered at the origin is answered in a straightforward manner with the following simple rule

$$\text{if} \quad i < \frac{K_{sat}}{\vartheta_{max}(s)} \qquad \text{no dripping in the cavity, dripping otherwise}$$

In this (exact) formula i [m/s] is the specified uniform infiltration rate, K_{sat} [m/s] is the saturated isotropic hydraulic conductivity and ϑ_{max} is a normalized Kirchoff potential. Its value is maximum at the top of the circular section and can be approximated with excellent practical accuracy by

$$\vartheta_{max}(s) \approx \left| \begin{array}{ll} 2s+1 & \text{, for small values of } s \\ 2(s+1) & \text{, for large values of } s \end{array} \right. \quad , \quad s = \frac{\alpha D}{2}$$

where s is a dimensionless quantity defined by the decay parameter (α) of the Exponential model for the relative conductivity, and by the cavity diameter (D). Small s indicate capillarity dominated seepage, tending to divert water around the cavity, whereas gravity is dominant for larger values. Moreover, the larger the cavity the more vulnerable it is to water entry.



Iso- ϑ around the cavity and seepage flow lines

In the present situation (s = 10·5/2) no dripping occurs into the cavity since the above inequality is satisfied ($1.59 \cdot 10^{-9} < 5.58 \cdot 10^{-9}/52$). The infiltration rate could actually be increased by, roughly, a factor 10 before droplets form at the

top of the cavity. Alternatively, the isotropic saturated hydraulic conductivity could be reduced, or the cavity diameter increased by the same factor, to produce dripping into the cavity.

These theoretical considerations explain why the drifts remain dry in Case 0 and to a certain extend in cases with mild anisotropy (i.e., Case 1). As anisotropy becomes larger, horizontal capillary flow becomes less significant and water cannot be diverted around the cavity surface with the same magnitude any more.

As a result, saturation increases and dripping starts in the first drift (Case 2), while the drifts below remain dry because the roof-drip lobes coming from above are too diffuse (capillarity is still active) to generate saturation conditions there.

At larger anisotropy ratios (Case 3 and Case 4) the lower drifts become gradually active, but in a manner that is not straightforward to understand. There are obviously highly non-linear effects (the decay coefficient α is rather large) combined to the anisotropy ratio. Numerical effects due, for instance, to mesh orientation and refinement around the drifts may also be present. However, several grid size were enforced (the finer with node spacing of the order of 0.2 m around the drifts) yielding the same type of results. More investigations (including analytical ones) are needed to understand the flow processes (e.g. use of finer meshes and various solution schemes, columns with more drifts, etc), particularly at high anisotropy ratios.

With zero horizontal conductivity (Case 5) the first drift theoretically captures the quantity of water given by *iD* (i.e., $68.5 \cdot 10^{-5}$ m^3/d in the present case) and by-passes the drifts vertically below.

Appendix II

Numerical Simulation of the Effects of Heating on the Permeability of a Jointed Rock Mass

B. Damjanac, C. Fairhurst and T. Brandshaug

Itasca Consulting Group, Inc.
708 South Third Street
Suite 310
Minneapolis, Minnesota 55415

To be presented at the 9th ISRM Conference (Paris, August 1999)

Numerical simulation of the effects of heating on the permeability of a jointed rock mass

Simulation numérique des effets d'une augmentation de température sur la perméabilité d'une masse rocheuse fissurée

Numerische Simulation der Hitzeeinwirkung auf geklüftetes Gebirge

B.DAMJANAC, C.FAIRHURST & T.BRANDSHAUG, Itasca Consulting Group, Inc., Minneapolis, Minnesota, USA

ABSTRACT: One of the objectives of the Drift Scale Test (DST), currently underway at Yucca Mountain, USA, is to assess the effect of large-scale heating on the permeability of the rock mass. The DST is simulated using continuum and discontinuum models to predict the change in permeability in the rock mass surrounding the heated drift. The simulations show that heating will cause both reduction in permeability (in regions of increasing mean stress) and increase in permeability (in regions of non-linear shear deformation—slip). Although the elasto-plastic (ubiquitous joint) continuum model and the distinct element model (DEM) indicate similar regions of joint slip in the rock mass, the resulting change in permeability can be calculated much more easily from the DEM.

RÉSUMÉ: Un des objectifs de l'essai DST (Drift Scale Test), en cours au site de Yucca Mountain, Etats Unis, est l'évaluation de l'effet d'une variation thermique sur la perméabilité de la masse rocheuse, à l'échelle de la galerie. L'essai DST est simulé numériquement à l'aide de modèles continu et discontinu afin de prédire le changement de perméabilité de la masse rocheuse entourant la galerie lorsqu'elle est soumise à une augmentation de température. Les simulations numériques montrent que l'échauffement cause à la fois une réduction (dans les régions d'augmentation de la contrainte moyenne) et une augmentation de perméabilité (dans les régions de déformation non-linéaire en scisaillement-glissement). Bien que les modèles continu élastoplastique (ubiquitous joint) d'une part et d'élements distincts (DEM) d'autre part prédisent des zones similaires de glissement de joint dans la masse rocheuse, la méthode DEM se prête plus aisément au calcul des changements de perméabilité.

ZUSAMMENFASSUNG: Eine der Aufgabenstellungen des "Drift Scale Tests - DST", der gegenwärtig im Yucca Mountain Projekt in den USA durchgeführt wird, ist es, den Effekt von großräumiger Erhitzung auf die Permeabilität des Gebirges zu untersuchen. Der DST wurde durch Kontinuums- und Diskontinuumsmodelle simuliert, um die Änderungen der Permeabilität im Gebirge um den erhitzten Teil zu prognostizieren. Die Simulationen zeigen, daß die Erhitzung sowohl eine Reduzierung der Permeabilität (in Regionen erhöhter mittlerer Spannungen) als auch eine Erhöhung der Permeabilität (in Regionen nicht-linearer Scherdeformationen - "slip") bewirkt. Obwohl das elasto-plastische (verschmierte Klüfte) kontinuumsmechanische Modell und das Distinkt-Element-Modell (DEM) ähnliche Bereiche von Scherbewegungen auf Klüften ausweisen, kann die resultierende Änderung der Permeabilität über die DEM wesentlich einfacher bestimmt werden.

1 INTRODUCTION

A main objective of the ongoing Drift Scale Test (DST) at Yucca Mountain, Nevada, USA, is to assess the effect of large-scale heating (intended to simulate the heating produced by stored high level nuclear waste) on the permeability of the rock mass. The DST is conducted in fractured, densely welded, ash-flow tuff at the proposed repository horizon in Yucca Mountain. The permeability of this rock mass is controlled primarily by natural fractures in the rock; the matrix permeability is very small.

This paper discusses the results of numerical analyses carried out to examine the effect of heating around the DST on the change of permeability in the surrounding rock. Continuum models of a fractured medium (e.g. the ubiquitous joint model) provide reasonable approximation of the rock mass when: (1) the joint spacing is small relative to the characteristic dimensions of the problem, and (2) the joint properties are uniform (i.e. there are no joints in the set that have an aperture and transmissivity substantially greater than that of other joints). Determination of the constitutive relations needed to allow accurate prediction of the change in permeability of such a rock mass when deformed is especially difficult with continuum models. The relationship between deformation and permeability can be represented much more directly in models (such as the distinct element method), that simulate explicitly the effect of joints on deformation and fluid transport.

Given the actual geometry of the excavations and joints, rigorous interpretation of the effect of heating on joint aperture and permeability changes and flow in the drift experiment requires a three dimensional model. *3DEC* (Itasca Consulting Group, Inc. 1998a) was used to consider this influence. However, since a coupled thermo-mechanical-hydrological analysis of a fractured rock mass is computationally intensive, the main part of the analysis in this study has been carried out using the two-dimensional Universal Distinct Element Code, *UDEC* (Itasca Consulting Group, Inc. 1996). The continuum code *FLAC* (Itasca Consulting Group, Inc. 1998b) was also used to estimate the regions of non-linear deformation (i.e. the regions where the rock permeability changes) induced in the rock mass by heating. Comparison of results obtained using different models and codes (continuum; discontinuum, two-dimensional; three-dimensional) has proven to be very valuable in verifying the assumptions used in development of the analyses and may guide the use of particular models in further analysis.

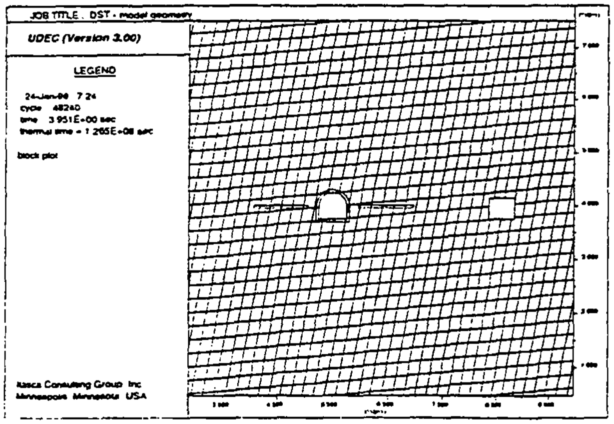


Figure 1. Geometry of the two-dimensional discontinuum model

2 DESCRIPTION OF THE MODELS

The heated drift is a 5 m × 5 m excavation of "horse-shoe" cross-section (see Fig. 1). The observation drift is rectangular, 5 m × 4 m in cross-section. A three-dimensional model of the DST was generated using *3DEC*. Figure 2 shows the lower half of this model (i.e. from the drift horizon downward). Three joint sets are represented. Joint set 1 has a dip of 77° and dip direction of 40°; set 2 has a dip of 80° and dip direction of 130°; set 3 has a dip of 25° and dip direction of 300° (Wagner 1996a). The joint spacing in each set is 10 m. The vertical cross-section, perpendicular to the axes of the drifts (from the *3DEC* model), coincides with the plane of the two-dimensional models used for simulation of the DST.

Figure 1 shows the joint sets 1 and 3 in the two-dimensional *UDEC* model. The joints in the two-dimensional model are spaced 2 m apart—i.e. much closer than the 10-m spacing in the three-dimensional model. (The coarser spacing in the *3DEC* model is dictated by the heavy computational demands of three-dimensional analysis.)

The rock was considered to be linearly elastic and isotropic, and to have the properties (Birkholzer & Tsang 1996) shown in Table 1. The response of the joints to deformation normal to the joint plane is assumed to be linearly elastic for compressive stresses (Joints can not sustain tension.); the response to shear deformation is assumed to be linearly elastic-perfectly plastic according to the Mohr-Coulomb slip condition. Slip of the joints is associated with dilation—i.e. joint opening.

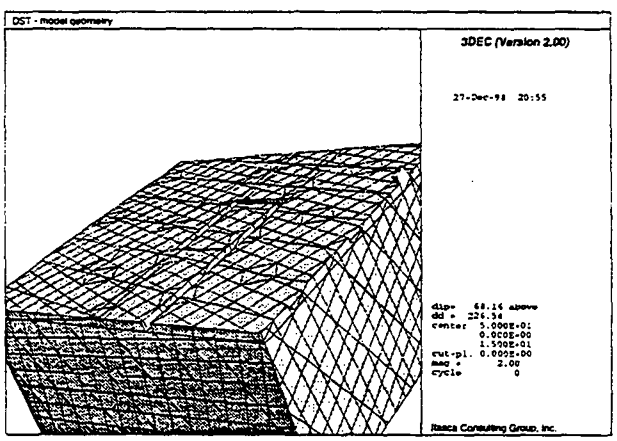


Figure 2. View of three-dimensional model (blocks above the drifts are hidden)

Table 1. Properties of the rock

Density, ρ	2540	kg/m^3
Young's modulus, E	32.4	GPa
Poisson's ratio, ν	0.17	
Thermal conductivity, k_t	1.67	W/m°K
Specific heat, c_t	928	J/kg°K
Coefficient of thermal expansion, α	10^{-5}	

"Fast paths", joints or fracture zones with much higher initial permeability (i.e. initial hydraulic aperture) than the other joints, are known to occur at Yucca Mountain. It is also expected that fast paths will be more compliant and weaker than the other joints. Two cases were considered in the discontinuum models: (1) all joints have the same properties, and (2) "fast-paths" are assumed to exist at several different locations relative to the heated drift. The properties of "typical" rock joints (Olsson & Brown 1997) used in the analysis are shown in Table 2.

Table 2. Properties of the rock joints

Normal stiffness, k_n	200	MPa/mm
Shear stiffness, k_s	150	MPa/mm
Cohesion, c	0.23	MPa
Friction angle, ϕ	42°	

For this analysis, the mechanical properties of the fast paths (shown in Tab. 3) are simulated by reducing the properties of "typical" joints—as can be seen by a comparison of Tables 3 and 2.

Table 3. Properties of fast paths

Normal stiffness, k_n	50	MPa/mm
Shear stiffness, k_s	50	MPa/mm
Cohesion, c	0.05	MPa
Friction angle, ϕ	25°	

The initial state of stress in the rock mass was assumed to be $\sigma_h = -5$ MPa, $\sigma_v = -10$ MPa at the drift level. The initial stresses vary as a function of elevation due to gravity, with a constant ratio maintained between the horizontal and vertical normal stresses. The initial temperature in the rock mass was taken to be constant, at 25°C throughout the model.

Thermal analysis of conductive heat transport was carried out for 4 years. An 800-W/m heat source, provided by heaters located in the square block at the floor of the heated drift, was simulated as a heat flux uniformly distributed along the boundary of the heated drift. The wing heaters are located symmetrically relative to the axis of the heated drift: a planar source of 125 W/m^2 is distributed between 4 m and 9 m from the drift axis, and a planar source of 175 W/m^2 is distributed between 9 m and 14 m distance from the drift axis (Wagner 1996b).

3 JOINT DILATANCY

Joint (normal and shear) stiffness and strength (cohesion and friction angle) are properties that affect the dependency of the permeability (of the joints and rock mass) on the imposed mechanical loading. However, the joint dilation angle ψ has the most profound

effect on the dependence of the permeability to shear deformation of a rock joint.

The joint dilation angle, the measure of joint opening as a result of joint slip, is a function of:

1. shear deformation (Dilation is usually large during the initial slip deformation, decreasing with slip accumulation.); and
2. stress normal to the joint plane (confinement). (Dilation is a consequence of joint roughness. The relative movement of rock blocks cannot be strictly parallel to the plane of the joint between them, since joint roughness enforces some displacement normal to the joint plane. At very high normal stresses, the joint asperities can be sheared-off, resulting in a reduced or zero dilation angle.)

Olsson & Brown (1997) reported joint dilation angles measured on samples taken from the TSw2 geological unit at Yucca Mountain for different confinements. (TSw2 is the repository unit.) The measured dilation angles show large dispersion, varying between 1.11° and 33.4°. As a result, the relationship between confinement and dilation angle is unclear. Therefore, the first-order analyses were conducted using an upper value, $\psi = 30°$, and an average value, $\psi = 14°$, for the dilation angle. It was further assumed in these analyses that the dilation angle was constant, independent of the shear deformation or normal stress. The dilation angle for the fast paths was assumed to be equal to the dilation angle of "typical" joints.

3.1 *Numerical Experiment*

In order to establish a clearer understanding of the dependence of dilation to shear deformation and confinement for the range of values expected to occur in the model, numerical experiments were conducted to simulate shearing of a rough joint using a shear box—in a manner similar to that described by Cundall (1999). The results from the numerical experiments (i.e. the relationship between peak dilation angle, joint shear displacement, and normal stress) for TSw2 rock and joint conditions were then used in the *UDEC* simulation of the DST.

The micro-mechanical model of the shear box experiment using the Particle Flow Code—PFC^{2D} (Itasca Consulting Group, Inc. 1999), is shown in Figure 3. The bonded assembly of particles (Particles are bonded at contact points.) can be envisioned as a synthetic rock. By adjusting the contact stiffness (shear and normal) and strength (shear and tensile), this "rock" was made mechanically similar to the TSw2 rock. The length of the specimen in Figure 3 is 0.10 m, and the height is 0.04 m. The joint trace is indicated by the continuous black lines transecting the specimen from left to right. The particles at or adjacent to this line are left unbonded. The black particles along the boundary of the specimen are designated as the shear box. The shear box particles below the joint trace are fixed, while those above the trace are assigned a constant horizontal velocity. The joint trace was produced using the following decreasing power law power spectrum (Brown 1995):

$$G(k) = Ck^{\alpha} \qquad (1)$$

where C is a constant; $k = 2\pi/\lambda$;λ is the wavelength; $\alpha = 5 + 2D$; and D is the fractal dimension of joint surface. Joint topography data provided by Olsson & Brown (1997) for specimen YM30 taken from the repository unit TSw2 were used. Numerical

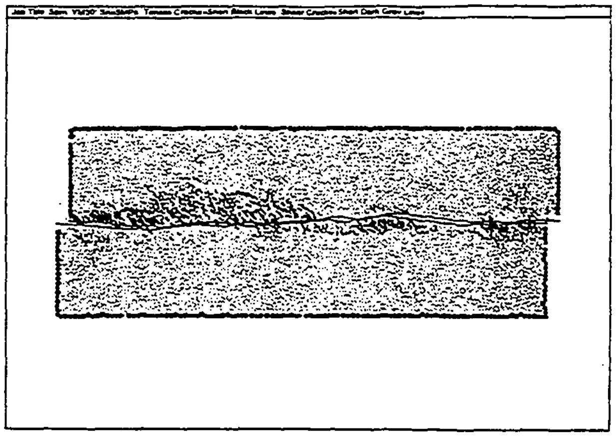


Figure 3. PFC model of a shear box test

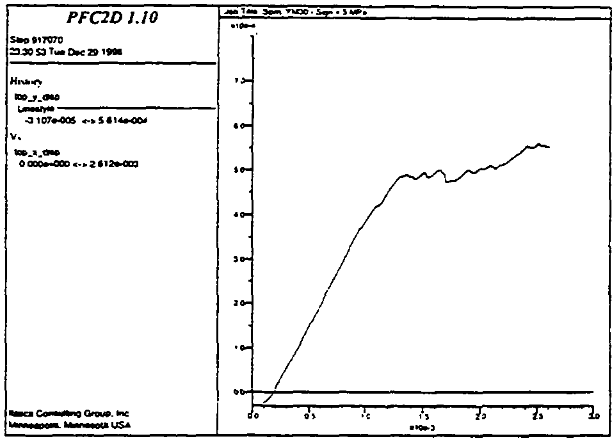


Figure 4. Vertical (m) versus shear displacements (m)

tests were conducted for normal stresses of 2.5, 5, 10, 15, 20, and 25 MPa. Figure 3 shows the specimen after a significant amount of shear for a normal stress of 5 MPa. The short black lines indicate locations of tensile cracks in the specimen, while the dark gray lines indicate shear cracks. Note that a significant amount of damage can be attributed to tensile cracking (i.e. particle contacts failing in tension). The test in Figure 3 predicted a peak shear strength of 6 MPa after 0.2 mm of shear displacement. Figure 4 shows normal displacement (m) (i.e. dilation) versus shear displacement (m) for the test in Figure 3. (Figure 4 suggests a peak dilation angle of 28°.)

The results from the numerical experiments were simplified as a bi-linear relationship between dilation and joint shear displacement. (This relationship is defined by a constant dilation angle and a shear displacement at which dilation becomes zero.) The dependence of the dilation angle and the zero dilation shear displacement on the confinement, as obtained from the numerical experiments (shown in Table 4), was implemented in the *UDEC* model of DST to provide a better approximation of the dilation behavior of the joints.

Table 4. Approximate relationship between joint dilation, zero dilation shear displacement, and normal stress for YM30

Normal stress (MPa)	2.5	5.0	2.5	10.0	15.0	25.0
Dilation angle (°)	42	28	16	15.5	13.0	12.0
Displacement (mm)	1.0	1.5	2.5	2.5	2.5	2.5

4 MODELING RESULTS

4.1 *Temperature fields*

It was assumed in all simulations (*FLAC*, *UDEC* and *3DEC*) that conduction is the only mode of heat transfer in the rock mass. In fact, boiling of pore water is likely to occur in the rock around the heated drift because of the high temperatures. This effect has been analyzed in models of heat and fluid transport by Buscheck (1998).

The temperature distributions due to heat conduction are almost identical for the continuum and discontinuum models. The contours (°C) after 4 years of heating are shown in Figure 5.

4.2 *Deformation in the two-dimensional continuum models*

The ubiquitous joint model is a continuum, elasto-plastic model in which an anisotropic strength of the rock mass is taken into account—i.e. there are predefined planes of weakness. The strength in the planes of weakness was assumed to be equal to the joint strength as given in Table 2. The markers shown in Figure 6 indicate slipping along the planes of weakness corresponding to sub-vertical joint set from Figure 1.

The ubiquitous joint model predicts the deformation and the region of joint slip in the rock mass. To assess the change in permeability produced by this deformation and slip, it is necessary to establish a constitutive relation between deformation (volumetric and shear) and the change in permeability. In the case of the distinct element method, the joint deformation is calculated, and it is usually assumed that the change in the joint hydraulic aperture is equal to joint normal displacement (i.e. closing and opening).

4.3 *Deformation in the two-dimensional discontinuum models*

The discontinuous model of the rock mass in which the joint properties are taken to be uniform shows a complex response to the perturbation induced by heating (Fig. 7). In general, it is possible to identify two regions exhibiting significantly different responses. In the immediate vicinity of the drift, the joints tend to close as a consequence of an increase in the compressive stress normal to the joint planes. Both the maximum closure and the region over which the joints close increase with the duration of heating. Joints from both sets (sub-vertical and sub-horizontal) tend to close, but the sub-vertical joints close more. Above and below the region of joint closure, the sub-vertical joint set dilates (opens) as a result of shear slip. Both the extent of the region where joints are opening and the value of the maximum opening increase as a function of the duration of heating. The maximum opening is more than twice as large as the maximum closure. The effect of dilation angle is significant. The maximum opening in the model with a 30° constant dilation angle (1.5 mm) is two to three times larger than in the model with a 14° dilation angle (0.6 mm). The maximum opening in Figure 7, which shows results for variable dilation angle calculated from the *PFC* model, is 1.2 mm. The regions of slip along joint set 1, as calculated in *UDEC*, agree remarkably well with the regions of plastic deformation indicated by the *FLAC* ubiquitous joint model.

The actual position of possible fast paths relative to the heated drift is unknown. However, the effect of the fast path was assessed by performing a series of simulations for three different assumed locations of the fast paths:

Case 1. The fast path passes through the heated drift.

Case 2. The fast path is offset approximately 15 m to the left of the axis of the heated drift.

Case 3. The fast path is offset approximately 15 m to the right of the axis of the heated drift.

The analysis shows that the effect of the fast path in case 1 is insignificant. The effects of the fast paths in cases 2 and 3 are dramatic. The joint opening and closure for case 3, after four years of heating, is shown in Figure 8. The maximum joint opening caused by slip in cases 2 and 3 is about 6 mm, compared to 1.5 mm in the model with uniform joint properties.

4.4 *Deformation in the three-dimensional discontinuum model*

The results of the three-dimensional model show that the two-dimensional model is an acceptable approximation of the deformation in the middle of the heated drift. However, deformation of joint set 2, which is neglected in the two-dimensional model, becomes important in the region close to the drift ends, where the temperature field is also three-dimensional.

5 CONCLUSIONS

Comparison of the results of different computational models used to predict the thermo-mechanical response of a jointed rock mass

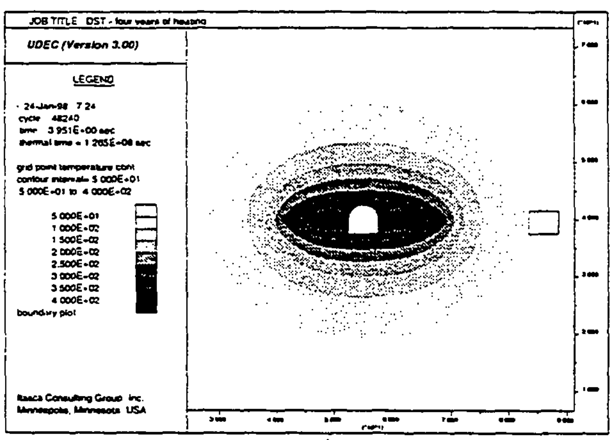


Figure 5. Temperature contours (°C) after 4 years of heating

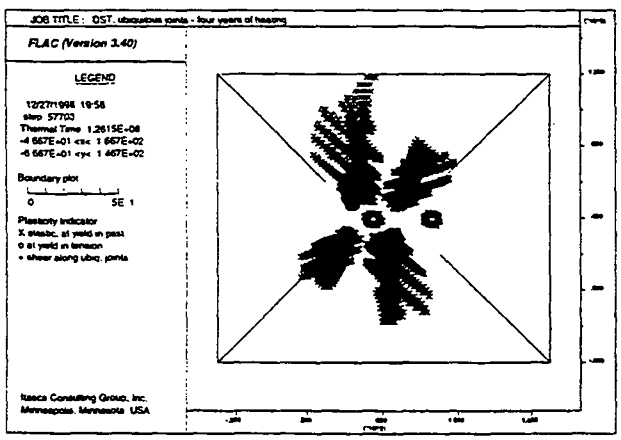


Figure 6. Indicators of slip in the ubiquitous joint model after 4 years of heating

in the vicinity of the DST, indicate the following.

1. Continuum. elasto-plastic ubiquitous joint models give a good prediction of the regions in the rock mass over which the joints slip. However. to calculate permeability change as a result of calculated deformation, a constitutive model that relates both volumetric and shear (elastic and plastic) strains to permeability change is required.
2. Discontinuum models are the most effective way to simulate the effects of heating (or any mechanical deformation) on change in permeability of a jointed rock mass. Constitutive relations are also required, but they are more straightforward than in the case of the equivalent continuum. Joint dilation angle and its dependence on accumulated slip and normal stress are important parameters that define the change in permeability produced by joint slip.
3. The two-dimensional model is an acceptable approximation of the deformation in the middle of the drift, even for the case in which orientation of the joints relative to the drifts' axes is slightly oblique.
4. Three-dimensional effects (particularly the deformation of the joint set neglected in the two-dimensional model) become important close to the end of the drift.

The various analyses described above have been used to illustrate the effects of large-scale heating on the hydrological conditions in the rock mass around the drifts in the DST. Increase in temperature produces different effects on the deformation of the rock joints (i.e. both closure and separation) in different regions of the rock mass. In general, shear stresses cause slip on the sub-vertical joints away from the drift, while increase in confinement causes closure of the joints (The sub-vertical joints close more.) in the vicinity of the heated drift. Both regions of opening and closure, and the maximum values of opening and closure in these regions are functions of several parameters, including: (1) intensity of thermal loading, and (2) properties of the rock mass and rock joints (e.g. stiffness, strength, dilation angle, orientation and spacing of joints). The effect of the deformation on the permeability of the rock mass is even stronger in the case when a fast path crosses the regions of large shear stresses induced by heating. The shear deformation and slip localize along the fast path. If a constant (independent of the magnitude of slip and the confinement)

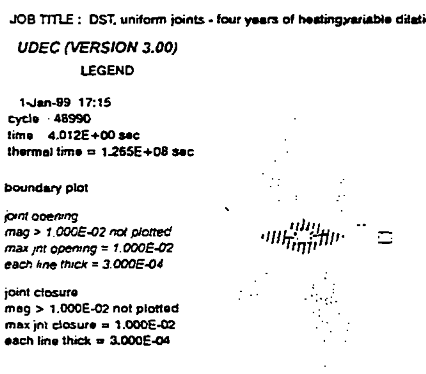


Figure 7. Uniform joint properties, variable dilation angle – opening and closure (m) of joints after 4 years of heating

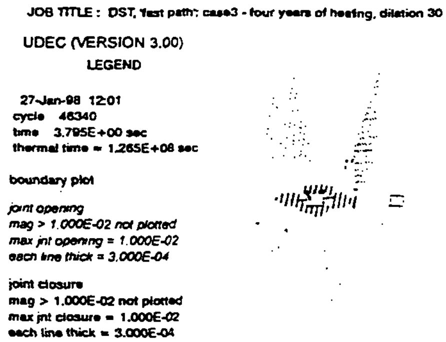


Figure 8. Fast path, case 3, dilation angle 30° – opening and closure (m) of joints after 4 years of heating

dilation angle of 30° is assumed, the opening of the fast path is of the order of six millimeters.

ACKNOWLEDGEMENT

The advice and interest of Professor P.A.Witherspoon, who suggested these studies, is gratefully acknowledged.

REFERENCES

Birkholzer, J. T. & Tsang, Y. W. 1996. Forecast of thermal-hydrological conditions and air injection test results of the single heater test. Technical report. Earth Sciences Division. Lawrence Berkeley National Laboratory.

Brown, S. R. 1995. Simple mathematical model of a rough fracture. *J. Geophys. Res. 100*, 5941–5952.

Buscheck, T. A. 1998. Private communications.

Cundall, P. A. 1999. Numerical experiments on rough joints in shear using a bonded particle model. In *Lecture Notes for Earth Sciences*. Springer. To be published.

Itasca Consulting Group, Inc. 1996. *UDEC (Universal Distinct Element Code) Version 3.0*. Minneapolis.

Itasca Consulting Group, Inc. 1998a. *3DEC (3-dimensional Distinct Element Code) Version 2.0*. Minneapolis.

Itasca Consulting Group, Inc. 1998b. *FLAC (Fast Lagrangian Analysis of Continua) Version 3.4*. Minneapolis.

Itasca Consulting Group, Inc. 1999. *PFC^{2D} Particle Flow Code in 2 Dimensions Version 2.0*. Minneapolis.

Olsson, W. A. & Brown, S. R. 1997. Mechanical properties of fractures from drillholes UE25-NRG-4, USW-NRG-6, USW-NRG-7, USW-SD-9 at Yucca Mountain, Nevada. Technical Report SAND95-1736, Geomechanics Department, Sandia National Laboratories.

Wagner, R. A. 1996a. Characterization of the ESF thermal test area. Technical Report B00000000-01717-5705-00047 REV01, TRW Environmental Safety Systems, Inc.

Wagner, R. A. 1996b. Test design, plans and layout. Report for the ESF thermal test. Technical Report BAB000000-01717-4600-00025 REV01 prepared for DOE, TRW Environmental Safety Systems, Inc.

EDO RESPONSE

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

September 30, 1999

Dr. B. John Garrick, Chairman
Advisory Committee on Nuclear Waste
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

SUBJECT: COMMENTS ON THE U.S. DEPARTMENT OF ENERGY'S LICENSE APPLICATION DESIGN SELECTION PROCESS AND RECOMMENDED REPOSITORY DESIGN

Dear Dr. Garrick:

I am responding to your August 9, 1999, letter to Chairman Dicus conveying your observations and recommendations on the U.S. Department of Energy's (DOE's) License Application Design Selection (LADS) process, and the Management and Operating Contractor's recommended repository design for the site recommendation and license application. I would like to thank you for sharing your observations on the LADS process, and for providing the recommendations in Dr. Fairhurst's white paper, "Engineered Barriers at Yucca Mountain - Some Impressions and Suggestions," presenting an innovative design concept for the repository and suggestions on geotechnical aspects of the design.

Our responses to the Advisory Committee on Nuclear Waste's (ACNW's) observations and recommendations are presented in Enclosure 1. As discussed in Enclosure 1, the Commission has set forth the regulatory responsibilities of the U.S. Nuclear Regulatory Commission (NRC) with respect to the consideration of alternative sites or designs (see Enclosure 2). Consistent with this Commission position, the staff did not review the white paper in detail. Instead, consistent with the NRC's independent regulatory role, the staff proposes to evaluate the design the DOE will propose as part of its license application.

Because the DOE is currently considering what design it will ultimately select for the repository, the ACNW may want to consider providing the white paper directly to the DOE. I trust this letter responds to your concerns.

Sincerely,

Frank J. Miraglia

for William D. Travers
Executive Director
for Operations

Enclosures:
1. NRC Staff Response to ACNW Observations and Recommendations
2. Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions and Related Conforming Amendments 49 FR 9352, March 12, 1984

cc: Chairman Dicus
Commissioner Diaz
Commissioner McGaffigan
Commissioner Merrifield
Office of the Secretary

U.S. NUCLEAR REGULATORY COMMISSION STAFF
RESPONSE TO THE ADVISORY COMMITTEE ON NUCLEAR WASTE
OBSERVATIONS AND RECOMMENDATIONS

Observation 1: The License Application Design Selection (LADS) process is not transparent enough to support selection of the EDA-II design.

Response: The U.S. Nuclear Regulatory Commission (NRC) staff agrees that the basis for the Management and Operating Contractor's (M&O's) recommendation of the EDA-II design is not totally transparent. We are aware that the M&O recommended the EDA-II design for the site recommendation (SR) and license application (LA), and that the U.S. Department of Energy (DOE) has not yet made a decision on accepting the M&O's recommended design. The NRC staff has attended the DOE's briefings on the LADS, and is aware of the Advisory Committee on Nuclear Waste's (ACNW's) and the Nuclear Waste Technical Review Board's (NWTRB's) concerns about the process used in selecting the recommended design (EDA-II) among the five alternate designs considered in the LADS. Because the DOE has not yet accepted the M&O's recommendation, it is possible that the DOE may address the NWTRB's and the ACNW's concerns in the LADS report that will be submitted to the NRC. We will know that when the DOE determines how it will address the M&O's recommendation, and submits a design to the NRC as part of the SR or in the LA.

Independent of the DOE's efforts on the design, the staff is currently developing the Yucca Mountain Review Plan (YMRP). In the YMRP, the staff will include criteria it will use to determine if DOE has acceptably demonstrated compliance with the applicable regulatory requirements. The development of the YMRP will be essential in allowing the staff to conduct an efficient and sound review of any design that the DOE ultimately selects. Thus, regardless of what process the DOE undergoes today to select a design, the staff, by having the YMRP ready, will be in a position to judge the acceptability of that design.

Recommendation 1A: The NRC should expect the repository design to change until the LA and, if needed, in the Preclosure period. The NRC should develop a license review strategy that allows the DOE maximum flexibility to implement beneficial design changes during the preclosure period.

Response: The staff clearly recognizes that the repository design may evolve until the LA. As part of the pre-licensing consultation process, the NRC reviews and comments on design documents that the DOE submits. However, as noted above, independent of any DOE activities, the staff is developing the YMRP which will contain the guidance staff will use to determine the acceptability of the DOE design. Because of this guidance, the DOE will have available to it a level of information the Department can use for a final design as the repository evolves. This process of having the YMRP available allows the staff to conduct pre-licensing consultation with the DOE with a focus on what ultimately will be acceptable in a final LA design for the repository. Thus, the NRC staff's initiative

of developing the YMRP today for use in both pre-licensing consultation, and during the LA review, will provide the flexibility the ACNW recommends. The YMRP could be changed by the staff as it also gains experience from DOE repository operations.

During the pre-closure phase of the repository, the staff fully expects that the DOE will propose design changes as it gains operational experience. This is not inconsistent with what happens at all types of facilities that the NRC regulates such as reactors and fuel-cycle facilities. The process requires the licensee for the facility to determine whether it needs to file an application for an amendment to its license in order to make the change. As part of the amendment process, the staff would evaluate the proposed design change, and if the change were found acceptable, modify the license accordingly.

Recommendation 1B: The NRC should not constrain the DOE from proposing revisions to the approved design during the pre-closure period of the repository, and the NRC should conduct independent evaluations of alternate, cost-effective, and innovative designs.

Response: The NRC staff agrees with the first part of the recommendation that it should not constrain the DOE from proposing revisions to any repository design found acceptable. As discussed in the response to Recommendation 1A, there is a process in place that allows the DOE to propose changes to the repository during pre-closure activities, both construction and operation. If the DOE finds that repository-horizon conditions or operational experience justify changes, the Department has the flexibility to propose such changes. For those changes requiring an NRC review, the NRC staff will evaluate the merits of the changes, and determine if they are acceptable. The options available to the staff in conducting such reviews, or for the entire LA, are discussed later.

It is important to note, however, that the NRC will not advocate nor work with the DOE to develop any design changes. Rather, as reflected in the "Statement of Considerations" (SOC) for revisions for 10 CFR Part 51, the Commission has stated that as an independent regulatory agency, the NRC does not select designs nor participate with an applicant in selecting proposed designs. Relevant portions of the SOC are provided in an Appendix for the convenience of the Advisory Committee on Nuclear Waste (ACNW). Consistent with this Commission policy, the staff would not recommend any design changes that the DOE could make. Rather, the staff would review those design changes proposed by the DOE to determine if they meet the applicable regulatory requirements.

The options available to the NRC in conducting reviews of the DOE LA or any proposed changes once the site is licensed are to either: (1) accept the proposal; (2) accept the proposal with conditions; or (3) deny the proposal. These options were identified by the Commission in the SOC for the Part 51 revisions. Given this Commission direction, the NRC staff cannot develop any independent design or propose any solutions to applicants/licensees as that

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would compromise the Agency's ability to perform its independent regulatory mission. To this end, the NRC and the Center for Nuclear Waste Regulatory Analyses (CNWRA) staffs are developing the review capabilities in the YMRP needed to independently evaluate the DOE application. However, the NRC staff, working within the framework established by the Commission for all NRC, cannot conduct independent evaluations of alternative, cost-effective, and innovative designs for the repository. It is the DOE's responsibility to propose a design in the LA. The NRC can only evaluate the proposal made by the DOE, and determine if it complies with the applicable regulations, and adequately protects public health and safety.

Observation 2: The preclosure period is likely to be 50 to 300 years, and it presents an opportunity to establish the validity of the design assumptions via performance confirmation (PC) monitoring. In the design option suggested in the white paper, it is suggested that the PC monitoring drifts may be used for diverting infiltration in the post-closure phase.

Response: The NRC staff is aware of the possibility that the preclosure period may extend 50 to 300 years, and agrees that it presents an opportunity to collect data to confirm the design assumptions made by the DOE in the LA. The PC monitoring during preclosure was seen as an important way for verifying design parameters and design assumptions, and for comparing the monitored performance with the assessed performance of the design. The current regulations as well as those in the proposed 10 CFR Part 63 include requirements for a PC program. This requirement was intended to ensure that the data available from the operating repository would be collected, and used to confirm the LA design. In the YMRP, the staff is developing criteria to review a DOE license application which will include the DOE's PC program. These criteria will allow the NRC staff to determine if the DOE's PC monitoring will obtain the data needed to verify the design assumptions, and thus comply with the applicable regulations.

With respect to the second part of the recommendation, the NRC is not in a position to propose the design concepts recommended in the white paper; namely that the design option suggested in the white paper would use PC monitoring drifts for diverting infiltration in the post-closure phase. As noted in the response to Recommendation 1B, the Commission's view of the NRC's role is that of an independent regulatory Agency that is not involved in the selection or development of designs. Rather, if the DOE LA design or subsequent design change contained a design incorporating the white paper recommendation, the NRC staff would evaluate that design, to determine its acceptability, using the YMRP.

Recommendation 2: The ACNW endorses the U.S. Geological Survey's (USGS's) view that monitoring program details should be carefully developed, and suggests that the NRC staff consider how long-term monitoring may be factored into the design.

Response: The NRC staff agrees with the USGS views on PC monitoring. As mentioned above, the NRC staff is currently developing a review plan for reviewing the LA, including the PC program. In developing the review plan for the DOE's PC program, the staff will consider the USGS's views and will prepare a plan that ensures an adequate review of DOE's PC program. The NRC will also enforce any PC commitments that are in the license as individual conditions.

Observation 3: Reiterate the NWTRB's comments on the DOE's LADS process.

Response: The NRC staff is aware of, and agrees with, the NWTRB's and the ACNW's concerns about the lack of quantitative evaluation of the several alternate designs considered in the LADS process. The NRC staff will review the LADS report when the DOE submits it to NRC. In conducting its review of the LADS report, the staff will use to the extent practical, those portions of the YMRP that are avaiable.

Recommendation 3: Encourage the NRC to make sure that the rationale, approach, and assumptions used in the evaluations and in comparisons of alternatives are appropriate. It recommends that the NRC and the CNWRA conduct their own independent evaluations of alternative, cost-effective designs similar to the innovative design described in the white paper.

Response: The staff will consider the ACNW's concerns during review of the LADS report as well as other DOE design documents up to and including the LA. The development of the YMRP is an essential component in establishing the criteria the NRC staff will use to judge the acceptability of the DOE's analysis of alternatives. With respect to the NRC and the CNWRA staff conducting independent evaluations of alternative designs, the Commission has stated that the NRC, as an independent regulatory Agency, does not become involved in the selection or development of designs. As such, the NRC staff's role would be to evaluate whether the DOE has proposed an acceptable design. However, the NRC does not undertake the development nor evaluation of innovative, cost-effective designs similar to the one presented in the white paper.

be considered in operating license proceedings for nuclear power plants and need not be addressed by operating license applicants in environmental reports submitted to the NRC nor by the staff in environmental impact statements (EIS's), at the operating license stage. An exception to or waiver of the rule will be permitted in particular cases if special circumstances are shown in accordance with 10 CFR 2.758 of the Commission's regulations, "Consideration of Commission rules and regulations in adjudicatory proceedings." The rule will be applied to ongoing licensing proceedings then pending on its effective date and to issues or contentions therein.

Pursuant to the Atomic Energy Act of 1954, as amended, the National Environmental Policy Act, of 1969, as amended, the Energy Reorganization Act of 1974, as amended, and section 553 of Title 5 of the United States Code, notice is hereby given of the adoption of the following amendments to 10 CFR Part 51.

47 FR 57446
Published 12/27/82
Effective dates:
10 CFR 20.311 of Part 20 effective date is 12/27/83; 10 CFR Part 61 and all other changes effective 1/26/83.

Licensing Requirements for Land Disposal of Radioactive Waste

See Part 61 Statements of Consideration

49 FR 8352
Published 3/12/84
Effective: Upon approval of the information collection requirements by the OMB or 6/7/84.

10 CFR Parts 2, 30, 40, 50, 51, 61, 70, 72, and 110

Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions and Related Conforming Amendments

AGENCY: Nuclear Regulatory Commission.

ACTION: Final rule.

SUMMARY: The Nuclear Regulatory Commission is revising Part 51 of its regulations to implement section 102(2) of the National Environmental Policy Act of 1969, as amended (NEPA) in a manner which is consistent with the NRC's domestic licensing and related regulatory authority. Related conforming amendments are being made to Parts 2, 30, 40, 50, 61, 70, and 110. This rule reflects the Commission's policy to develop regulations to take account of the regulations of the Council on Environmental Quality (CEQ) implementing the procedural provisions of NEPA voluntarily, subject to certain conditions.

EFFECTIVE DATE: Upon approval of the information collection requirements by the Office of Management and Budget or June 7, 1984, whichever is later. NRC will announce the date of approval of information collection requirements by OMB in a future document.

FOR FURTHER INFORMATION CONTACT: Jane R. Mapes, Senior Regulations Attorney, Regulations Division, Office of the Executive Legal Director, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Telephone: (301) 492–8695.

SUPPLEMENTARY INFORMATION: On March 3, 1980, the Nuclear Regulatory Commission published in the Federal Register (45 FR 13739–13766) a proposed revision of 10 CFR Part 51 and related conforming amendments to 10 CFR Parts 2, 30, 40, 50, 61, 70, and 110 of its regulations. Interested persons were invited to submit written comments and suggestions on the proposed amendments during the sixty day comment period which expired May 2, 1980. Comments were also solicited on several provisions of the CEQ regulations which the Commission had identified as requiring further study before implementing regulations could be prepared.

In addition to the preliminary views of the Council on Environmental Quality as set out in CEQ's letters of September 26, 1979 and October 29, 1979 which were published in Appendix B to the proposed rule, the Commission received twenty-one letters of comment, expressing the views of interested Federal agencies, state and local governments, industry, including electric utilities, vendors and architect-engineers, professional organizations and individual members of the public. The letters contained more than 100 individual comments and in some instances represented the views of several commenters. Comments were also received from interested members of the NRC staff.

As requested in the Commission's notice of proposed rulemaking, several commenters expressed views on the following sections of the CEQ regulations: 40 CFR 1502.14(b), 1502.22 (a) and (b) and 1508.18. A brief description of each of these provisions, accompained by a summary of the relevant comments and a statement of the Commission's present views on the issues raised, is set out below. The views of the commenters are fully set out in the individual letters of comment and in a subject matter compendium which has been placed with the letters in the Commission's Public Document Room at 1717 H Street, N.W., Washington, D.C. where they are available for inspection and copying. Since the topics addressed by §§ 1502.14(b) and 1502.22(a) of CEQ's regulations are interrelated, these sections will be discussed together.

By way of preface, the Commission restates its view that, as a matter of law, the NRC as an independent regulatory agency can be bound by CEQ's NEPA regulations only insofar as those regulations are procedural or ministerial in nature. NRC is not bound by those portions of CEQ's NEPA regulations which have a substantive impact on the way in which the Commission performs its regulatory functions.

Consideration of Alternatives

1. *40 CFR 1502.14(b).* This section provides that the environmental impact statement "[d]evote substantial treatment to each alternative considered in detail including the proposed action so that reviewers may evaluate their comparative merits."

In addition to the Council on Environmental Quality, eleven commenters responded to the Commission's request for views on this provision of the CEQ regulations. Of these eleven commenters, four provided brief statements expressing general support for 40 CFR 1502.14(b). Seven commenters voiced the opinion that § 1502.14(b) does not accurately reflect the statutory mandate of NEPA with respect to the consideration of alternatives. Relying on judicial decisions handed down since the enactment of NEPA, these commenters stated that consideration of alternatives in an environmental impact statement is subject to a rule of reason, that neither the number of alternatives considered nor the amount of information furnished concerning each alternative need be exhaustive. According to the commenters, consideration need only be given to *reasonable alternatives* to the proposed federal action; the detail and amount of information furnished concerning the environmental consequences of each of those alternatives, including the proposed action, need only be sufficient to permit the decisionmaking agency to make a reasoned choice among those alternatives so far as environmental consequences are concerned. The commenters noted that the courts have recognized that Federal agencies have a

Enclosure 2

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responsibility to reach meaningful decisions respecting environmental consequences if the objectives of NEPA are to be achieved. The commenters pointed out, however, that although the courts have taken a close look at the adequacy of the information on which those decisions are based, the courts have not required agencies, under the rule of reason, to supply or obtain more detailed information when the information needed for a meaningful decision is adequate.

2. *40 CFR 1502.22(c)*. This section provides that "[i]f the information relevant to adverse impacts is essential to a reasoned choice among alternatives and is not known and the overall costs of obtaining it are not exorbitant, the agency shall include the information in the environmental impact statement."

Seven commenters, including the Council on Environmental Quality, submitted views on 40 CFR 1502.22(a). Two commenters expressed general agreement with the CEQ position that the standard set forth in 40 CFR 1502.22(a) merely restates existing NEPA law, is subject to a rule of reason, and therefore should be adopted by the Commission. One of these commenters also expressed concern that failure to obtain the requisite information as mandated by 40 CFR 1502.22(a) would preclude the Commission from carrying out its NEPA responsibilities to make a rigorous comparison of the proposed action with available alternatives.

Several commenters expressed the view that the standard imposed by 40 CFR 1502.22(a) should not be automatically applied in every case because it would place "a burden on the NRC in preparing an EIS that is not required by NEPA." These commenters noted that "NEPA cannot be read as a requirement that complete information concerning the environmental impact of a project must be obtained before action may be taken," and that this CEQ provision could have the practical effect of "requir[ing] that the EIS not be used as a decision-making document, *i.e.*, does not satisfy the mandate of NEPA, until all 'relevant' information is available so long as the costs of obtaining such information are not 'exhorbitant'."

One commenter emphasized the importance of care and restraint in determining when costly information is essential to a reasoned choice among alternatives. The commenter suggested that requests for data involving large costs should "be justified on the basis that the magnitude of the benefits to be derived from the information clearly exceed the costs associated with obtaining and analyzing this information * * *" and that requirements for data involving large costs "should be limited to matters that speak to the basic license ability [*sic* licensability] of the perferred site/plant combination."

Several commenters stated that NEPA does not require that all relevant information regarding the adverse impact of alternatives, including information which is not readily available because it is expensive or otherwise difficult to obtain, be known before a decision is reached. According to these commenters, NEPA merely requires that the decisionmaker be informed of any uncertain or unknown environmental effects. In each case, responsibility for evaluating the sufficiency of the information rests with the decisionmaker who must determine first, whether it is possible to make a reasoned decision on the basis of the information provided, and second, whether in the absence of adequate information, more information should be obtained or a decision should be made not to proceed with the proposed action. In the opinion of the commenters, strict application of the standard in 40 CFR 1502.22(a) would not only eliminate this element of flexibility in agency decisionmaking, it would also lengthen the time needed to complete NRC environmental reviews. The commenters expressed the view that application of the rule is unlikely to result in better decisionmaking and could have a severe and detrimental effect on the ability of the NRC, as an independent regulatory agency, to carry out its substantive licensing and related regulatory functions in a responsible and objective manner.

The primary mission of the Nuclear Regulatory Commission is to regulate civilian nuclear energy activities to ensure that they are conducted in a manner which will protect the public from the standpoint of radiological health and safety, maintain national security, comply with the antitrust laws and, since the passage of the National Environmental Policy Act of 1969, protect the environment. Charged with carrying out the licensing and related regulatory functions of the former Atomic Energy Commission,[1] the NRC has no authority to encourage and promote the development of atomic energy for peaceful purposes. Nor does it bear any responsibility for the development or regulation of other energy sources.

Within this framework, the possible actions which the Commission itself may take are limited. Their scope is determined in the first instance by the nature of the application or petition presented to the Commission for action. So far as Commission action is concerned, the available alternatives are to grant the application, grant the application subject to certain conditions, or deny the application, either with or without prejudice. Although the Commission has an obligation to determine the accuracy and relevance of the safety-related and environmental information presented and to perform the requisite safety and environmental analyses, the Commission has no power to compel an applicant to come forward or to require an applicant, once having come forward, to prepare and submit a totally different proposal, for example to construct and build a different type of nuclear power reactor pursuant to detailed specifications furnished by the Commission on a site identified by the Commission but not chosen by the applicant. As an independent regulatory agency, the NRC does not select sites or designs or participate with the applicant in selecting proposed sites or designs.

In preparing this revision of 10 CFR Part 51 in final form, the Commission has reviewed its regulatory experience under NEPA, both from the standpoint of the kinds of alternatives which are considered in making evironmentally sound regulatory decisions and the kinds and amounts of information needed to evaluate the comparative merits of those alternatives. In the usual case, these alternatives include the alternative of no action (denial of the application) and reasonable alternatives outside the jurisdiction of the NRC.

The types of alternative actions which the Commission itself is able to take reflect the Commission's functional role—the role of an independent regulatory agency authorized to perform quasi-judicial and quasi-legislative functions. The decisions which the Commission is required to make in carrying out its responsibilities as an independent regulatory agency play an equally important role in determining whether, from the standpoint of NEPA, all reasonable alternatives have received substantial treatment and whether the information submitted with respect to each alternative is sufficiently detailed. In developing these regulations, the Commission has tried to ensure that, at the respective points of decision, sufficient information will be available for meaningful consideration and comparison of a reasonable spectrum of alternatives, leading, in turn, to a reasoned decision. The Commission believes that the provisions of subpart A of Part 51 are consistent with the standard in 40 CFR 1502.14(b), that alternatives selected for detailed consideration be accorded substantial treatment. The Commission is also of the opinion that the way in which the NRC conducts its evironmental reviews implements this standard in a responsible and meaningful manner. This includes the practice of handling generic matters (for example, those

[1] The Atomic Energy Act of 1954, as amended, Pub. L. 83-703, as amended, 42 U.S.C. 2011 et seq.; the Energy Reorganization Act of 1974, as amended, Pub. L. 93-438, as amended, 88 Stat. 1233-1254, see especially 42 U.S.C. 5841 et seq.

which are common to all power reactor licensing proceedings and which may relate to environmental as well as safety issues) in generic rulemaking proceedings and generic environmental impact statements. Generic environmental issues which have received this kind of analysis and review need not be accorded the same kind of detailed consideration as that given to issues arising solely in the context of a specific licensing proceeding.

The Commission intends to follow the standard in 40 CFR 1502.22(a), though it notes that implementation of § 1502.22(a) may present substantive issues, specifically whether information which is not known is (a) relevant to adverse impacts, (b) essential to a reasoned choice among alternatives, and (c) obtainable at a cost which is not exorbitant. Based upon its past experience, the Commission believes that it will seldom, if ever, be called upon to determine whether the cost of obtaining unknown information deemed relevant to adverse impacts and essential to a reasoned choice among alternatives is or is not exorbitant. In the unlikely event that the issue is presented, the Commission reserves the right to resolve the matter in a manner which is consistent with the Commission's reponsibilities as an independent regulatory agency.

As illustrated in the following description of the manner in which NRC considers alternatives in connection with its environmental review of license applications for nuclear power plants, the amount of detailed information needed to make a reasoned decision on each of the many issues presented varies substantially among issues but is in each case commensurate with the nature of the issue addressed. With respect to most issues, with the possible exception of those relating to radiological matters, information need not be presented in the same degree of detail as that furnished in support of the applicant's proposal. In the review of alternative sites, for example, the Commission has found that reconnaissance-level information is adequate to assure that these alternatives are accorded substantial treatment.

Consideration of Alternatives in NRC Environmental Review and Analysis of License Applications for Nuclear Power Plants

In the customary NRC environmental review, detailed descriptions are prepared of the proposed plant, of the site on which the plant is proposed to be located, of the need for the plant, and of the environmental impacts likely to result from construction of the plant and from station operation. The following alternatives to the project are then addressed:

1. *Alternative energy sources and systems*, including alternatives which do not require new generating capacity and alternatives which do require new generating capacity. The former include such alternatives as power purchases, reactivation of retired plants, extension of the service life of existing plants and conservation measures. The latter include other alternative energy sources uniquely available to the applicant. In each case, consideration is given to the following types of energy sources: solar and wind, geothermal, petroleum liquids, natural gas, hydrodynamic, advanced nuclear, municipal solid wastes, biomass and coal. After the available alternative energy sources have been identified, they are categorized as competitive or non-competitive.

The amount and type of information needed to make a determination that a particular energy source is not available, or that a particular energy source, although available, is not competitive, is less extensive than that required to evaluate the comparative advantages and disadvantages from the standpoint of the environment between the proposed plant which is the subject of the license application and an alternative energy source which is both available and competitive. Once it is readily apparent that an alternative is non-competitive, either because of its technological status or lack of availability, the only data and information required with respect to that alternative is that needed to explain why the alternative is no longer being considered. Similarly, it is possible to reach a meaningful decision on the issues presented at subsequent levels of review (for example, classification of alternatives as environmentally preferable, environmentally equivalent, or environmentally inferior to the applicant's proposed plant, and comparison of the applicant's proposed plant with environmentally preferable or environmentally equivalent alternatives) without insisting that the amount and type of information presented respecting the alternative energy source be as extensive and detailed as that provided concerning the facility sought to be licensed.

2. *Alternative sites*. The Commission uses a two-stage decision standard to assure that adequate consideration has been given to alternative locations for constructing power generation facilities to meet the demonstrated need. The first part of this standard requires that the applicant submit a slate of alternative sites which are "among the best that could reasonably be found" inside a region in which it is reasonable to construct a plant to meet the projected need for power. The second part of the standard requires that the proposed site be approved only if no obviously superior alternative site has been identified.

The reason for considering alternative sites is that many environmental impacts can be avoided or significantly reduced through proper selection of the location for a new generating facility. These significant impacts which can be avoided or reduced are also readily detected at the planning stage of a power plant. For this reason alternative site reviews are encouraged as early as possible in the process of licensing a power plant and the use of reconnaissance-level information for making the comparative analyses is urged. The use of reconnaissance-level information to identify potentially significant environmental impacts has been extensively used and while it may not be possible to optimize design or make detailed impact predictions based on such information it is still sufficient to make decisions at the pre-design stage to determine which site should be chosen. It is highly unlikely that detailed examination of the site selected would reveal a significant environmental impact that had escaped the reconnaissance-level investigations. Based on its past experience, the Commission has found reconnaissance-level information adequate for informed environmental decisionmaking on alternative sites.

3. *Alternative plant systems*. These systems include alternative heat dissipation systems, alternative circulating water systems and alternative non-radioactive waste-treatment systems.

Several levels of review, each requiring differing amounts and types of information, are used in evaluating alternatives to the heat dissipation systems and circulating water systems of the proposed plant. An initial screening is performed to eliminate alternative systems or system components which are obviously unsuitable for use at the proposed site, or are obviously incompatible with the types of systems expected to be used in the proposed plant. The remaining alternatives are screened again for the purpose of identifying those which are environmentally preferable, environmentally equivalent or environmentally inferior to the systems which the applicant is proposing to use in the proposed plant. The baseline systems against which the alternative systems are compared are those proposed by the applicant with any verified mitigation schemes to limit adverse impacts. The information needed to make this determination varies among alternatives and from case to case according to the type and

United States
Nuclear Regulatory Commission

Environmental Protection Agency High-Level Waste Standard and 10 CFR Part 63

December 15, 1999

Mr. Milton Levenson
ACNW Consultant

INTRODUCTION

- **EPA HLW Standard Issues**
- **Technical Issues Regarding 10 CFR Part 63**

EPA HLW STANDARD ISSUES

- ACNW concurs with NRC's comments on EPA's 40 CFR Part 197 and in past advice has supported 25 mrem all-pathways standard.
- Overly restrictive standards if accepted become the norm.
- Once accepted they tend to receive widespread application, possibly leading to increased near-term exposure and cost large amounts of money.
- Conflict between EPA and NRC must be resolved.

TECHNICAL ISSUES REGARDING 10 CFR Part 63

- **Multiple Barriers and Defense-in-Depth.**

  - In previous advice ACNW endorsed staff's' approach to implement multiple barriers in draft 10 CFR Part 63 and recommended quantification of individual barrier contributions.

  - ACNW made additional recommendations in its letter on Viability Assessment concerning other aspects of 10 CFR Part 63, including PA requirements and the need to outline steps in the licensing process.

TECHNICAL ISSUES REGARDING 10 CFR Part 63 (CONTINUED)

- **ACNW generally supports staff's current thinking for clarifying its approach to multiple barriers in 10 CFR Part 63. Approach is flexible and performance based.**

- **ACNW is still evaluating details of staff's approach for multiple barriers and is planning a joint working group meeting with ACRS on defense-in-depth in January.**

TECHNICAL ISSUES REGARDING 10 CFR Part 63 (CONTINUED)

- ACNW supports staff's approach on a 10,000-year time of compliance, 25 mrem all-pathways standard, and the characteristics of a critical group. ACNW has commented in past letters on each of these topics.

- ACNW may comment on additional issues including:
  - Human intrusion
  - Emergency preparedness

TECHNICAL ISSUES REGARDING 10 CFR Part 63 (CONTINUED)

- Design basis event.
- Performance confirmation.
- Transportation.

United States
Nuclear Regulatory Commission

FACILITY DECOMMISSIONING

December 15, 1999

Dr. Raymond G. Wymer
Advisory Committee on Nuclear Waste

PREVIOUS COMMITTEE RECOMMENDATIONS:

- **Continue to develop review criteria.**
- **Test DandD code at a variety of sites.**
- **Provide straightforward guidance on selection of screening and site-specific codes.**
- **Continue program of licensee/stakeholder involvement.**

PREVIOUS COMMITTEE RECOMMENDATIONS: (Continued)

- **Concur with staff that establishment and use of clearance criteria should be priority goal.**
- **An efficient license termination process, coupled with clearance criteria, could go far toward ensuring safe disposal of LLW and limiting decommissioning cost.**
- **Continue Decommissioning Management Board - valuable integration tool.**

RUBBLIZATION

- Precedent setting - broad implications for decommissioning.
- Potential for significant cost savings - need to understand cost/benefit and risk implications.
- Resolution of conflicting radiation standards required.
- Evaluation of bulk (volumetric) contamination is nontrivial - important to develop techniques for proper volumetric measurement of material - NRC Research has two studies underway.

RUBBLIZATION (Continued)

- **Restricted and unrestricted license termination - distinction fuzzy.**

COMMITTEE FUTURE ACTIVITIES

- **Participate in resolution of rubblization issues.**
- **Responding to Commission and staff request to review proposed clearance rule.**
- **Review progress in finalizing SRP module (modeling and rubblization); participate in workshop.**

COMMITTEE FUTURE ACTIVITIES
(Continued)

- **Review in-field use of proposed final License Termination Rule.**

- **Review agency integrated decommissioning requirements efforts.**

ACNW COMMITTEE REPORT
(Dated January 11, 1999)

UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON NUCLEAR WASTE
WASHINGTON, D.C. 20555-0001

January 11, 1999

The Honorable Shirley Ann Jackson
Chairman
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: DEVELOPMENT OF A STANDARD REVIEW PLAN FOR DECOMMISSIONING

Dear Chairman Jackson:

During its 102nd meeting on July 20–22, 1998, the Advisory Committee on Nuclear Waste (ACNW) heard a presentation from the NMSS staff on its plans to develop a Standard Review Plan (SRP) for use in reviewing and evaluating submittals by licensees to support the decommissioning of nuclear facilities. At its 103rd meeting on August 27–28, 1998, the Committee heard additional information on the selection of parameters for the DandD screening code and an update on the associated default parameter table. At its 105th meeting on December 15–17, 1998, the Committee received an overview of the staff's decommissioning plans for fiscal year 1999.

We found the staff's plans to date to be well thought-out. We applaud the increased interaction among the NRR, RES, and NMSS staffs. We view the institution of the Decommissioning Management Board as a welcomed step in ensuring agency consistency in the development of license termination requirements applicable to all facilities.

The Committee has the following observations on decommissioning that it believes are useful and timely to the development of the SRP.

1. We recommend that the staff continue to develop review criteria to provide a proper and consistent level of protection of public health and safety across a variety of sites.

2. We support the staff's plans to test the DandD code together with more site-specific alternative codes at a variety of sites. Results of these tests will add much to the understanding of the advantages of DandD as a screening tool. ACNW looks forward to hearing about the results.

3. We believe that it will be important to provide guidance to potential users on the appropriate selection of screening and site-specific codes for decommissioning.

4. The staff has instituted an effective program of licensee/stakeholder involvement. We support continuation of this effort.

5. We recognize that an efficient license termination process, coupled with a properly established standard for release of materials, could go far toward ensuring safe disposal of low-level waste and limiting decommissioning costs. We concur with the staff's position that the establishment and subsequent use of clearance criteria for decontamination and decommissioning activities should be a priority goal.

In closing, we have observed considerable progress in the development of the staff's plans and the necessary associated acceptance criteria. We recognize the magnitude and importance of the effort to develop the SRP and other relevant documents and analytical tools. The Committee intends to maintain an active awareness and participation in this activity as it evolves.

Sincerely,

B. John Garrick
Chairman

EDO RESPONSE

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

February 23, 1999

Dr. B. John Garrick, Chairman
Advisory Committee on Nuclear Waste
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: DEVELOPMENT OF A STANDARD REVIEW PLAN FOR DECOMMISSIONING

Dear Dr. Garrick:

I am responding to your letter to Chairman Jackson, dated January 11, 1999, regarding staff efforts to develop a Standard Review Plan (SRP) for decommissioning. The SRP is being developed to enable staff to evaluate information, submitted by licensees, in a timely, efficient, and consistent manner to determine if the decommissioning will be conducted such that the public health and safety are protected and the facility can be released in accordance with the Nuclear Regulatory Commission's requirements.

In your letter, you stated that the Advisory Committee on Nuclear Waste (ACNW) supports the staff's plans and activities to develop the SRP, including involving stakeholders in the development of the SRP. In addition, you stated that the ACNW supports staff's efforts to develop clearance criteria for materials generated during decommissioning and believes that the development of clearance criteria should be a priority goal for staff. Staff has initiated actions to develop clearance criteria and will keep the ACNW informed of the progress on this project.

You also stated that the ACNW supports the staff's plans to test the DandD dose modeling code, and other site-specific codes, at a variety of sites, and to provide guidance on when screening or site-specific dose modeling is appropriate. The staff is currently working with the ACNW staff to schedule a briefing for the ACNW on the issues that will be addressed during the development of the SRP and will include an update on this effort during this briefing. Your comments on these issues will be appreciated.

The staff has found the ACNW's comments and recommendations useful and constructive, and looks forward to continued interactions with the ACNW in the future.

If you have any questions concerning the SRP or clearance criteria, please contact John Greeves, Director, Division of Waste Management, Office of Nuclear Material Safety and Safeguards, at (301) 415-7437.

Sincerely,

William Travers

William D. Travers
Executive Director
for Operations

cc: Chairman Jackson
Commissioner Dicus
Commissioner Diaz
Commissioner McGaffigan
Commissioner Merrifield
SECY

United States
Nuclear Regulatory Commission

Advisory Committee on Nuclear Waste 1999 Action Plan and Self-Assessment

December 15, 1999

Dr. B. John Garrick
Chairman, ACNW

ACNW FIRST-TIER PRIORITIES

- Viability Assessment, Draft Environmental Impact Statement, and Site Suitability.
- Risk Communication.
- Repository Design, Thermal Effects, Coupled Processes.
- Decommissioning.
- Radiation Risk Levels for Low-Level Ionizing Radiation.

ACNW SECOND-TIER PRIORITIES

- **Risk-Informed, Performance-Based Regulatory Framework.**
- **LLW and Agreement States Programs.**
- **Research.**
- **Risk Harmonization.**
- **Interim Storage Facilities for Spent Fuel.**
- **Transportation.**

SELF-ASSESSMENT PROCESS

- Assessed performance using the following metrics: timeliness, effectiveness, efficiency, quality, and use of RIPB.

- Looked for evidence that advice was useful:
  - Direct evidence including licensee response
  - Customer feedback (SRMs, EDO responses)
  - Indirect evidence (observed modifications) in NRC programs or approaches.

SELF-ASSESSMENT PROCESS
(Continued)

- **Created a matrix to track advice and outcomes.**
- **Will repeat the process in February 2000**
  - **- New Action Plan/Priorities**
  - **- Self-Assessment**

LESSONS LEARNED FROM SELF-ASSESSMENT

- **Most effective when ACNW initiated review or Commission requested our advice.**
- **Areas in which advice not heard by staff became follow-up targets (CNWRA meeting).**
- **Focus on a limited number of issues that are aligned with agency priorities.**
- **The Action Plan provides the basis for the operating plan and budget request.**

ADVICE CURRENTLY BEING FORMULATED

- Risk Communications.
- Technical Issues associated with DOE's Draft Environmental Impact Statement.
- Defense In-Depth philosophy (with ACRS).
- Decommissioning/Rubblization.
- NRC Waste Related Research.

ADVICE CURRENTLY BEING FORMULATED
(Continued)

- **Additional views on 10 CFR Part 63.**
- **Year 2000 Action Plan/Self-Assessment.**

ACNW COMMITTEE REPORTS

UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON NUCLEAR WASTE
WASHINGTON, D.C. 20555-0001

January 22, 1999

The Honorable Shirley Ann Jackson
Chairman
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Dear Chairman Jackson:

SUBJECT: ADVISORY COMMITTEE ON NUCLEAR WASTE 1999 ACTION PLAN AND PRIORITY ISSUES

The Advisory Committee on Nuclear Waste (ACNW) has modified its 1998 strategic plan to update the priority issues it will consider in 1999. As part of this update, we refer to the plan as an "action plan" rather than as a "strategic plan" to distinguish it from strategic plans required by the Government Performance and Results Act. A copy of the action plan is enclosed for your consideration.

The action plan is anchored to the 1997-2002 NRC's revised strategic plan and supports NRC's mission, vision, and relevant goals, strategies, and substrategies identified by the agency. The plan is consistent with ACNW's revised charter and the ACNW's 1999 operating plan, which is being updated to reflect the priority issues identified herein.

One purpose of the ACNW action plan is to guide the Committee in carrying out its mission over the next year. The Committee identifies first-tier priority issues it will address this year, and second-tier issues it will address if time and resources permit, unless directed otherwise by the Commission. In addition to the priority issues, the ACNW identifies process and product improvements that we will initiate this year to improve its efficiency and effectiveness.

Two of the second-tier issues in the 1998 plan have been moved up to the first tier, including Radiation Risk Levels for Low-Level Ionizing Radiation (linear no-threshold [LNT] issue), and Yucca Mountain Repository Design. The LNT issue has been given a higher priority because of its importance from a risk-informed context and its potential to cause unnecessary costs to society. Further, it is timely because of the availability of new studies and scientific information. Yucca Mountain Repository Design was moved to the first-tier list to replace the Engineered Barrier System priority in response to the evolution of the high-level waste program. The Viability Assessment and Decontamination and Decommissioning (D&D) priorities have been expanded and remain as first-tier priorities. A priority entitled "Risk Communication" has been added to the first tier because of the mounting evidence world-wide that lack of public confidence may be the biggest impediment to radioactive waste disposal. Priorities on Risk Informed Performance Based (RIPB) and Research have been moved from the first tier to the second-tier priority list. Although the Committee will address RIPB issues such as the proposed 10 CFR Part 63, "Disposal of HLW in a Proposed Geological Repository at Yucca Mountain,

Nevada," Issue Resolution Status Reports, and Total System Performance Assessment, it does not anticipate the need to perform in-depth study this year on these topics. The Research priority has been dropped to the second tier because of the elimination of the requirement for the Advisory Committee on Reactor Safeguards to report to Congress on NRC research. The ACNW will still report to the Commission on ongoing research and technical assistance in its areas of competence. Low-level Waste (LLW) and Interim Storage remain on the second-tier list. LLW is of concern because the ACNW believes that resolution of the LLW disposal problem is required to allow society to continue to benefit from nuclear materials. Transportation has been added to the second-tier list because of strong stakeholder interest and recognizing that the issue will need to be addressed in the near term. Risk Harmonization has also been added to the second-tier list. Finally, several second-tier issues have been dropped, including Department of Energy Oversight and Orphan Sources.

We would appreciate your comments or suggestions on the enclosed plan.

Sincerely,

B. John Garrick
Chairman

Enclosure: As stated

ACNW 1999 ACTION PLAN AND PRIORITY ISSUES AND ACTIVITIES

This plan provides strategic direction to the ACNW in 1999 and beyond for focusing on issues most important to the NRC in carrying out its mission of protecting public health and safety, promoting the common defense and security, and protecting the environment. It also conveys ACNW's mission, vision, goals, and priority activities and indicates how these goals support the NRC's strategic plan.

SCOPE OF ACNW ACTIVITIES

The Committee reports to and advises the Commission on nuclear waste management. The bases of ACNW reviews include 10 CFR Parts 60, 61, and other applicable regulations and legislative mandates. The ACNW will undertake studies and activities related to transportation, the storage and disposal of high- and low-level radioactive waste (HLW and LLW, respectively), including the interim storage of spent nuclear fuel, materials safety, decommissioning, application of risk-informed, performance-based regulations, and evaluation of licensing documents, rules, regulatory guidance, and other issues as requested by the Commission. The Committee will interact with representatives of the public, NRC, ACRS, other Federal agencies, State and local agencies, Indian Tribes, and private, international, and other organizations as appropriate to fulfill its responsibilities.

OVERARCHING PHILOSOPHY

In conducting its self-assessment, the Committee realized that it has been the most effective in the areas where it either initiated review of an issue or the Commission requested ACNW's advice on an issue. Examples include letters on the defense-in-depth and multiple barrier concept relative to 10 CFR Part 63; NRC's risk-informed performance-based white paper; the guidance to implement the final rule on radiological criteria; the ACNW's 1998 strategic plan; probabilistic risk assessment methods applied to HLW performance assessment, and HLW performance assessment capability. As a result, the Committee has crafted its 1999 action plan to reflect greater emphasis on self-initiated and Commission-requested topics.

The Committee will strive to take a top-down approach in its review of issues, focusing on the interconnection between issues and their cross-cutting relationships, as opposed to reviewing issues in isolation.

The Committee also believes that it will best serve the Commission by taking a risk-informed, performance-based view in all of its activities. By this statement the Committee means that it will strive to ascertain the inherent risk associated with various issues, to encourage transparency in risk assessments, and to encourage consistency in the approach to risk assessments. The Committee will accomplish these goals by encouraging development of an overall flexible RIPB framework for materials and waste-related regulations. The ACNW believes that adoption of a RIPB framework

could advance efforts toward risk harmonization and could alleviate conflicts associated with dual regulatory authority by providing a systematic and quantitative framework for assessing and comparing risk assessment approaches across and within agencies. Differences in approach now debated at the policy level may prove to lack risk significance, once quantified. An RIPB framework will allow for greater flexibility and transparency and will thus lead to greater confidence in regulatory decisions. In this way, the NRC can develop defensible regulations that have an obvious link to safety and can achieve a greater understanding of relative risks.

Finally, as part of its philosophy, the Committee aspires to factor in international experience whenever possible in examining issues. The ACNW also strives to consider creative ways to involve the public to a greater extent.

ACNW MISSION

The ACNW's mission is to provide independent and timely technical advice on nuclear waste management issues to support the NRC in conducting an efficient regulatory program that enables the Nation to use nuclear materials in a safe manner for civilian purposes.

ACNW VISION, DESIRED OUTCOMES, AND COMMITMENTS

In addition to a clear mission statement describing the ACNW's purpose, the Committee has identified a vision statement and desired outcomes to convey the Committee's direction, as well as commitments that guide the Committee towards these outcomes.

Vision

The ACNW strives to provide advice and recommend solutions that are forward-looking, are based upon best-available science and technology, can be implemented, and reflect the need to balance risk, benefit, and cost to society to enable the safe use of nuclear materials.

Desired Outcomes

The Committee aspires to achieve the following ultimate outcomes:

1. Advice is provided in adequate time to influence Commission decisions,

2. Advice is "forward-looking" in that it alerts the Commission to potential problems that may be averted by taking interim action, or forewarns the Commission of emerging issues that may require action at a later time,

3. Advice reflects state-of-the-art science and technology, yet is sufficiently practicable to allow for incorporation into NRC technical approaches, regulations, and guidance,

4. Advice for the intended audience is clear and concise,

5 Advice reflects an understanding of inherent risk and reflects consideration of the need to balance risk, cost and benefit in all of NRC's decisions,

6. ACNW assists the Commission in making more transparent the regulatory decisionmaking process by operating in a spirit of openness and focusing on risk,

7. Advice identifies the interplay between HLW, LLW, and D&D programs wherever possible, as well as cross-cutting relationships of issues to the Environmental Protection Agency (EPA) and Department of Energy (DOE) programs,

8. ACNW is respected by the Commission, the NRC staff, EPA, DOE, and the public and perceived as adding value,

9. ACNW is trusted by the public for providing frank, open advice and for offering a forum for public participation in the regulatory process,

10. ACNW assists in resolving conflicts between NRC and DOE, EPA, and other stakeholders by encouraging communication and providing a neutral forum for interaction.

Commitments

The Committee will carry out the following commitments in accomplishing its mission and in pursuing its desired outcomes:

1. Be responsive to the Commission's needs,

2. Challenge the status quo, as appropriate, thereby becoming an "engine for change",

3. Remain flexible, be responsive to change, and consider various options and contingencies,

4. Identify in advance those issues that could have an impact on NRC's ability to achieve its mission,

5. Focus on risk by asking "what is the risk, what are the contributors to risk, and what are the uncertainties?",

6. Be mindful of and begin to identify issues that cut across NRC waste and materials programs, as well as across EPA and DOE waste-related programs,

7. Foster an atmosphere of mutual problem-solving with the NRC staff,

8. Keep abreast of international trends and developments that could influence NRC policies or approaches, and factor international experience into Committee advice,

9. Consider the public as its ultimate customer and seek improved approaches to obtain public involvement,

10. Maintain technical excellence and independence,

11. Abide by the Committee's action plan to ensure efficiency and effectiveness of Committee activities and products.

GOALS AND OBJECTIVES

The ACNW has developed general goals and objectives consistent with its mission and vision. The following five goals serve to provide strategic direction for the ACNW this year and support selected goals identified in NRC's strategic plan. For each goal, we identify objectives to help us better focus on our priority issues.

Goal 1: **Assist the NRC in positioning itself to respond to external change and uncertainty in the management of nuclear waste. [This goal supports the NRC mission, vision, and selected strategies and substrategies under NRC Goals 2-7.]**

Objective 1: Advise the Commission in a timely fashion on issues of a technical nature that may require changes in the regulations.

Objective 2: Inform the Commission about issues that could cause problems for the NRC or society if not given adequate attention, and recommend solutions.

Goal 2: **Strive to ensure that NRC is employing the best science in resolving key safety issues. [This goal supports the NRC mission, vision, and selected strategies and substrategies under NRC Goals 2-7.]**

Objective 1: *Keep abreast of cutting-edge methods and technologies being developed and utilized world-wide that are applicable for assessing and managing risks associated with cleanup, disposal, and storage of nuclear waste.*

Objective 2: *Advise the Commission on projected or perceived technical shortcomings in NRC staff capabilities that could adversely impact the agency's ability to address safety issues.*

Goal 3: **Advise the NRC on how to increase its reliance on risk as a basis for decisionmaking, including using risk assessment methods for waste management, that (1) implement a risk-informed approach, (2) quantify and reveal uncertainties, and (3) are consistent across programs where possible. [This goal supports the NRC mission, vision, and selected strategies and substrategies under NRC Goals 2-7.]**

Objective 1: *Encourage the NRC staff and propose approaches to gain a better understanding of the inherent risks of licensed activities regarding nuclear waste disposal, cleanup, and materials, as well as the relationship between regulations, cost, and safety.*

Objective 2: *Encourage the NRC staff to develop an overall flexible RIPB framework for management of nuclear waste disposal, cleanup, and materials that will allow for greater transparency of the underlying assumptions and associated uncertainties of risk assessments, greater consistency across programs, and development of more defensible regulations that are linked to safety.*

Goal 4: **Support the NRC in improving public involvement in its waste programs and gaining increased public confidence and respect. [This goal supports the NRC mission, vision, and selected strategies and substrategies under NRC Goal 6.]**

Objective 1: *Provide opportunities through the Federal Advisory Committee Act process for more meaningful public involvement in the regulatory process.*

Objective 2: *Recommend ways for the NRC to gain more meaningful public involvement in the regulatory process, taking into consideration international experience.*

Objective 3: *Assist the NRC in making more transparent the agency's decisionmaking process and ensuring agency documentation is thorough, clear, and readily understandable.*

Goal 5: **Improve the effectiveness and efficiency of ACNW operations. [This goal supports the NRC mission, vision, and strategies and substrategies under NRC Goal 7.]**

Objective 1: *Increase the perceived value of ACNW advice to the Commission and staff.*

Objective 2: *Improve and modify existing operational procedures to accomplish "more with less."*

PRIORITY ISSUES AND PROCESS IMPROVEMENTS

In support of its first four goals, the ACNW has identified its highest priority issues for this year, along with other important issues it plans to address this year or next, time and resources permitting. Also identified are the criteria the Committee uses to select its priority issues. In support of its fifth goal, the ACNW has identified process improvements it plans to implement this year to improve its effectiveness.

The highest priority issues of 1999 are identified as first-tier priorities, and other important issues are identified as second-tier priorities. Many of the first-tier priorities are topics for which the Committee will initiate a review and investigation. The Committee plans to conduct in-depth information gathering on most of the first-tier topics, that is, conduct a working group meeting on each topic, whereas it does not plan to carry out a concentrated effort this year on the second-tier issues, unless directed by the Commission or in response to changes in nuclear waste legislation. The Committee may move several of these topics to the first tier in its 2000 action plan. Each priority issue supports one or more of ACNW's goals, as indicated.

For each priority issue addressed, the Committee plans to prepare a task action plan that identifies the nature and scope of the issue and a strategy for addressing it, including planned products and schedule, and performance measures and targets that will enable the Committee to determine whether it has achieved its goals.

CRITERIA FOR SELECTING PRIORITY ISSUES

The following criteria are used to select priority issues:

- issues that are requested by the Commission or the Commissioners for ACNW review,
- the protection of public health, workers, and the environment from adverse effects of the management of nuclear waste, especially in regard to disposal facilities, that is, the risk significance of an issue,
- issues for which the ACNW's review is "self-initiated" rather than "reactive,"
- timeliness based on when an issue is scheduled to come before the Commission and when the advice would be of greatest benefit to influence the Commission's regulatory decisions,
- the relationship of an issue to the NRC's Strategic Plan, including trends and directions in regulatory practice, such as the adoption of a risk-informed, performance-based method of regulation and decisionmaking,
- issues that arise from strategies and activities of licensees and applicants,
- the potential for or likelihood of an issue to pose undue risk or costs to society, and
- issues that arise that are based on the scientific and technical information supporting the safety and performance assessments of nuclear waste disposal facilities, including the quality and level of expertise involved.

FIRST-TIER PRIORITY ISSUES

Viability Assessment, Draft Environmental Impact Statement, and Site Suitability - The DOE submitted its viability assessment (VA) in late December 1998. The NRC staff plans to submit a Commission paper on its review of the final VA in March 1999 and to brief the ACNW in February 1999. In addition, the staff has completed its Revision 1 series of its IRSRs that documents the status of and acceptance criteria for each key technical issue to support its review of the VA and eventual License Application (LA). The staff plans to begin developing a Yucca Mountain Review Plan based on the IRSRs in FY 1999. The staff's review of the VA will be a preliminary review of the eventual LA and is expected to provide valuable insights. The ACNW plans to review DOE's conclusions and the NRC staff's review of the VA, as well as monitor the

progress of the IRSRs and the Yucca Mountain Review Plan.

The DOE is also required to submit a draft Environmental Impact Statement (DEIS) in late FY 99. The NRC staff has 90 days to review and comment on the DEIS. The ACNW intends to track DOE's development of the DEIS and comment on NRC staff's review of the document. The DOE is also required to make a site suitability determination in 2001, and the NRC staff must make comments on the sufficiency of DOE's determination. The ACNW will begin to monitor the progress of activities leading toward the site suitability determination. Finally, the ACNW anticipates tracking the DOE's site characterization program and repository safety strategy. This issue supports ACNW Goals 1 through 3.

Risk Communication - The Committee believes that risk communication may be the most essential, yet most neglected, aspect of risk-informed, performance-based regulation. Mounting evidence suggests that public involvement and public confidence are the biggest impediments to solving the issue of radioactive waste management world-wide. Until the scientific community accepts and embraces the public as the ultimate decisionmaker in waste management, final solutions for radioactive waste management are likely to remain out of reach. Another critical element of public participation and risk communication is bringing RIPB to the forefront and addressing the risks of nuclear waste disposal in a broader context. The ACNW will focus on how NRC can improve its relationship with the public. ACNW will first explore ways to improve its own involvement and relationship with the public by holding a working group meeting in partnership with the public to address their questions and hear their views directly. The working group meeting may also focus on lessons learned from other countries and other waste programs in the U.S. to learn ways to involve the public more meaningfully in NRC regulatory programs. One option may be to encourage the public to participate formally in the performance assessment process. This issue supports ACNW Goals 1, 3, and 4.

Repository Design, Thermal Effects, Coupled Processes - On the basis of the results of its June 1998 working group on the engineered barrier system, two factors appear critical to the longevity of the waste package: thermal effects and the amount of water contacting the waste package. The Committee will begin to focus on the HLW repository design, emphasizing the results of thermal testing and modeling and how moisture contacts and affects the waste package. As part of its effort, the Committee may examine the significance of coupled effects on the performance of the proposed repository and the aspects of waste retrievability, repository ventilation, rock fall, and water dripping into drifts. Also of potential interest is the exploration of what additional design features may be necessary if a 300-year operational period is decided upon. The Committee may also explore the issue of which data must be collected before the LA is submitted, which data may be collected during the performance confirmation period, and the basis for these decisions. In lieu of a Working Group meeting on this

topic this year, one of the Committee members plans to develop a white paper on this topic. This issue supports ACNW Goals 1 through 3.

Decommissioning - The ACNW continues to have a strong interest in waste disposal issues related to decommissioning. Last year, the ACNW reviewed the supporting guidance for implementing the final Rule on Radiological Criteria for License Termination, including guidance on dose assessment modeling and parameter selection criteria for decommissioning assessments. In recent years, the ACNW has advised the Commission on aspects of the proposed and final rule on license termination and on streamlining the Site Decommissioning Management Program (SDMP), including encouraging the staff to apply the LLW Performance Assessment Methodology to SDMP sites. This year, the ACNW plans to review the Standard Review Plan (SRP) on conducting D&D assessments, to follow progress of the guidance on the final rule as it undergoes testing, and to review the status of the multi-agency-sponsored decision support system (DSS) to support decommissioning decisions. An issue also related to this first-tier priority is review of the forthcoming rulemaking on clearance levels. Other activities may include implications of the final license termination rule and implementing guidance for reactor decommissioning, tracking staff efforts to assess inherent risks of decommissioning and activities to simplify the decommissioning process, and assisting the Commission in contingency planning for a possible rapid increase in nuclear power plant decommissioning as a result of deregulation. This issue supports ACNW Goals 1 through 3.

Radiation Risk Levels for Low-Level Ionizing Radiation - The ACNW will revisit the issue of radiation risk levels for low levels of ionizing radiation. The ACNW may consider the question of what research, if any, the NRC should sponsor regarding the linear no-threshold (LNT) hypothesis and the appropriate regulatory approach, given the uncertainty about the LNT hypothesis. The ACNW will provide an update on the status of LNT research and will advise the Commission on a range of options for addressing the LNT issue. The NRC indicates in its strategic plan that it will incrementally move toward an RIPB regulatory framework for nuclear materials and waste. A major element of RIPB regulation is making transparent the assumptions and uncertainties associated with risk estimates, particularly those uncertainties that are most significant to risk results. The LNT hypothesis may be one of the most pervasive and significant assumptions used in NRC dose and risk assessments. For this reason, testing the validity of the LNT hypothesis is critical to ensure the reliability of risk estimates and the defensibility of NRC regulatory requirements. The agency has come under scrutiny regarding its understanding of the relationship between regulations, cost, and safety. The clear message is that the NRC is accountable not only for protecting public health and safety but for doing it in a manner that is cost-effective and not unnecessarily burdensome to society. This issue supports ACNW Goals 1 through 3.

SECOND-TIER PRIORITIES

Risk-Informed, Performance-Based Regulatory Framework - The ACNW will continue to support the agency's effort to implement a risk-informed and incrementally performance-based regulatory framework. The Committee anticipates continuing to encourage the NRC to adopt regulatory approaches that are transparent, to enhance public understanding of the key safety issues, and to encourage the NRC to use risk as a basis for setting priorities. In particular, the Committee will continue to stress the need for RIPB risk assessments to quantify the contributions of individual barriers for waste isolation and for staff to develop guidance that clarifies what is intended regarding quantification of barriers. Issues to be addressed may include the RIPB interoffice task force report, public comments on draft 10 CFR Part 63, NRC's comments on the proposed EPA HLW standard (40 CFR Part 197), and peer review of NRC's TPA code and sensitivity analysis. The Committee's major focus this year under RIPB will be on risk communication, which is listed as a first-tier priority. This issue supports ACNW Goals 1 through 4.

LLW and Agreement States Program - The ACNW believes that, from a risk perspective, the national LLW program is of growing concern because of the failure of the Low Level Waste Policy and Amendments Act (LLWPAA) of 1986 process to bring about new LLW sites. The ACNW will consider the role of the NRC in LLW disposal from the perspective that lack of progress of the national LLW program could interfere with society's benefitting from the use of nuclear material, hence NRC's ability to carrying out its mission. The ACNW will advise the NRC on alternatives to the current national LLW disposal program. The ACNW also may examine interactions between NRC and Agreement and non-Agreement States, and whether communications can be improved. Other topics under this priority may include review of the final LLW Branch Technical Position (BTP) on PA, and issues associated with the Envirocare LLW site. This issue supports ACNW Goals 1 through 3.

Research - The ACNW will examine again this year the waste-related research and technical assistance programs in the NRC. In 1998, the Committee provided input to an ACRS report to Congress and a report to the Commission. This year, the ACRS is not required to provide a research report to Congress as a result of the Reports Elimination Act but will provide a report to the Commission. The ACNW has moved this priority to the second tier because it plans to invest a lower level of effort to conducting its review of the waste-related research program. However, the ACNW will continue to monitor the NRC's research program to ensure that it is changing in response to the agency's shifting emphasis to risk-informed, performance-based regulation. This effort will include ensuring that research is focused on helping to assess the relationship between regulations and safety and on understanding the inherent risks of licensed activities. This issue supports ACNW Goals 1 through 3.

Risk Harmonization - The current perception is that all progress on addressing problems associated with dual regulation between NRC and EPA has been brought to a standstill over the debate of a 4-mrem groundwater pathway standard versus a 25-mrem all pathways standard. Little is being done on risk harmonization efforts between the agencies. The Committee shares the concern of the Nuclear Energy Institute (NEI) that dual regulation between NRC and EPA could undermine the NRC's efforts to move toward an RIPB framework, especially in the D&D program, in that EPA can undermine the finality of NRC's RIPB decisions. However, the ACNW believes that adoption of an RIPB framework could advance efforts on risk harmonization and could alleviate conflicts associated with dual regulatory authority by providing a systematic and quantitative framework for assessing and comparing risk assessment approaches across and within agencies.

In this regard, the Committee is especially interested in reviewing the status of the EPA/NRC-sponsored DSS funded by the Office of Nuclear Regulatory Research (see decommissioning priority). The DSS is intended to support greater consistency and transparency in risk-based decisionmaking in the D&D and LLW programs, as well as EPA hazardous waste-management and cleanup programs. The Committee is aware that EPA is considering no longer funding the project because of the policy disagreement between the two agencies related to groundwater protection. It is unclear whether NRC can continue to fund the project alone. The tool would be valuable for conducting and comparing risk assessment approaches within and across NRC programs, as well as across agencies. It is possible that different approaches and assumptions used in interagency risk assessments lead to variances that far outweigh the difference between 4 mrem and 25 mrem. Quantification of risk using a tool such as DSS could possibly provide important insights that could open new discussions on risk harmonization. The Committee plans to consider the issue of risk harmonization as time permits this year, including the Interagency Steering Committee on Radiation Standards efforts and intends to pay it greater attention in the year 2000. This issue supports ACNW Goals 1 through 4.

Interim Storage Facilities for Spent Fuel - The ACNW will begin to identify issues that the NRC may need to consider and prepare for in the event that proposed legislation is enacted to create a central, interim HLW storage facility. This issue supports ACNW Goals 1 through 3.

Transportation - To date, the Committee has not focused much attention on the issue of transportation of HLW and spent fuel. This topic is likely to become more significant as the Yucca Mountain project moves closer to the suitability and licensing stage, or if central interim storage is mandated. The DOE's Yucca Mountain DEIS will also focus on alternative modes of transportation and associated impacts. The ACNW will address this issue in its review of the DEIS, and will begin positioning itself to address this issue in more detail in 2000, if not sooner. This issue supports ACNW Goals 1 through 3.

PRIORITY OPERATIONAL ACTIVITIES

Operational processes or activities that the ACNW plans to implement this year in support of ACNW Goal 5, "Enhance the effectiveness and efficiency of ACNW operations," follow.

Strategic Planning - On an annual basis, the ACNW will conduct top-down planning to identify primary goals and priority issues and activities for the coming year, followed later in the year by a self-assessment of the Committee's performance against these goals. The ACNW has established performance goals and indicators to measure effectiveness and will use customer surveys to solicit feedback from the public on the Committee's effectiveness.

Changes in Operational Procedures - To improve its efficiency and effectiveness, the ACNW will try to modify some of its processes and products, including the letter-writing process, the depth and consistency of advice, the scope and duration of meetings, interactions with Commissioners, communication between members and ACNW staff, and use of ACNW consultants. The Committee plans to implement the following:

- Hold more informal meetings on technical topics between individual ACNW members and members of the NRC staff,
- Allocate more time for Committee discussion of the content of letters before preparing a first draft. Circulate draft letters before the next Committee meeting so as to increase letter-writing efficiency with the bounds of the FACA,
- Acquire software to allow for easier circulation of draft letters electronically,
- Develop shorter letters and provide greater detail in an attachment. This format is especially suitable for letters that are based on working group meetings,
- Limit letters to three or four pages, place recommendations up front, and indicate which of the recommendations the ACNW would like a formal response from the NRC staff. If possible, the ACNW will suggest the time frame within which the staff should carry out the recommendation,
- For each priority topic, the Committee will identify whether a consultant is needed and develop a list of possible consultants,
- Spend the same amount of time on Committee deliberation as is spent on the technical briefings,

- Consider reserving a full day of every meeting for letter-writing, EDO response review, and discussing the Committee's future agenda,
- Conduct more meetings one-on-one with individual Commissioners and have more public interactions with the Commission.

UPDATING THIS PLAN

The ACNW will conduct a planning meeting at least once a year to update this action plan as necessary. Revisions to the plan may be based on input from the Commission, changes to the NRC strategic plan or performance plan, results from customer surveys and self-assessments, external events and factors, and available resources.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON NUCLEAR WASTE
WASHINGTON, D.C. 20555

April 29, 1999

The Honorable Shirley Ann Jackson
Chairman
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Dear Chairman Jackson:

SUBJECT: ADVISORY COMMITTEE ON NUCLEAR WASTE METRICS AND SELF-ASSESSMENT EVALUATION FOR FISCAL YEAR 1998

Executive Summary

The Advisory Committee on Nuclear Waste (ACNW) has developed a three-tiered system to measure its performance against its desired outcomes, goals, and process improvements described previously in its 1998 Strategic Plan. Although several areas for improvement remain, the Committee has concluded that significant progress has been made in achieving the desired effectiveness and timeliness of its activities. Appendix A provides a detailed examination of the relation between the Committee's reports and the various metrics of overall performance.

Introduction

In 1998, the ACNW developed a Strategic Plan (subsequently renamed an Action Plan in 1999) as a guide for providing independent and timely technical advice to the NRC on nuclear waste disposal and nuclear waste management issues (NUREG/BR-0050). The plan was anchored to the NRC's Strategic Plan for Fiscal Year (FY) 1997-2002. This report gives the results of an assessment of the performance of the ACNW in FY 1998.

The goals of the ACNW identified in its Strategic Plan were to assist the NRC in (1) positioning itself to respond to challenges and uncertainties as it enters the 21st century, (2) bringing to bear the best science and technology in resolving key issues, (3) bringing a risk-informed approach to the forefront of decisionmaking, (4) improving public involvement, and (5) improving the effectiveness and efficiency of ACNW's operational processes.

The ACNW used a three-tiered system to measure its performance relative to the mission, vision, desired outcomes, commitments, objectives, and planned process improvements identified in its Strategic Plan.

Tier-One Metrics, which are aimed at measuring overall outcomes from individual Committee reports, include timeliness, effectiveness, efficiency, quality, and use of a risk-informed, performance-based regulatory (RIPBR) approach. The definitions of the five metrics are derived from the vision, desired outcomes, and commitments sections in the Strategic Plan. Tier-Two Metrics are designed to measure the extent to which the Committee achieved its first four goals by tracking recurring themes from Committee reports. Tier-Three Metrics are aimed at tracking the specific process improvements identified in the plan under Goal 5, which focuses on improving Committee efficiency and effectiveness. Thus, the three-tier system provides a means for evaluating the Committee's performance relative to all aspects of its Strategic Plan.

Basis for Evaluation

In conducting its evaluation, the ACNW compared its FY 1998 reports and activities to the performance metrics. In evaluating its performance, the Committee relied on (1) direct evidence of whether the advice was accepted or adopted by the NRC staff; (2) customer feedback, based on formal surveys, staff requirements memoranda (SRMs), response from the Executive Director for Operations (EDO) and other correspondence; and (3) indirect evidence based on verbal feedback from the NRC staff, the Commission, the Department of Energy (DOE), the nuclear industry, and the public, or observed modifications in NRC's, DOE's, or industry's programs or approaches.

To facilitate conducting the self-assessment, the Committee developed a tracking system for each of its letters to document the major recommendations, the essence of the EDO's response, any solicited or unsolicited feedback (verbal comments, correspondence, SRMs, etc.), and an evaluation of each letter's timeliness, effectiveness, efficiency, quality, and risk significance. Table 1 of Appendix A summarizes the results of the tracking system. The detailed self-assessment is provided in Appendix A; an overview is presented herein.

General Observations and Conclusions

With respect to the Tier-One Metrics (timeliness, effectiveness, efficiency, quality, and use of an RIPBR approach), a letter that best exemplifies the Committee's overall effectiveness is letter 7[1], which commented on the agency's RIPBR white paper. The ACNW recommended in this letter that NRC adopt an RIPBR framework and the triplet definition of risk[2] throughout the agency's programs. The recommendations were incorporated into the white paper during its revision. Other exemplary letters in terms of overall effectiveness include letter 3, concerning defense in depth, and letter 6, concerning multiple barriers, both of which included recommendations to show the effectiveness of individual barriers and to drop the subsystem requirements. The staff adopted these recommendations in its proposed draft high-level waste rule, 10 CFR Part 63.

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[1]Letters are numbered in Table 1 of appendix A.

[2]The triplet definition of risk considers what can go wrong, what is the likelihood, and what are the consequences.

Regarding its Tier-Two Metrics (Table 2 of Appendix A), the Committee met all of its first four goals by making recommendations related to Goals 1-4 throughout the majority of its letters. Many of these recommendations appear in more than one letter and are referred to as key themes in Table 2.

With respect to Goal 4, improving public involvement, the Committee took only passive approaches to encouraging greater stakeholder participation in developing NRC regulations and programs. The ACNW plans to be more active in this area in 1999, as indicated in its January 22, 1999 Action Plan.

In several instances, the advice offered by the ACNW did not result in any action by the staff. For example, the Committee recommended that performance assessment be used to reprioritize key technical issues (Goal 3); that a systems engineering approach be taken and a systems engineering analysis be developed for the high-level program (Goal 3); that the NRC Research and Technical Assistance programs adopt an RIPBR approach; that a more formal and transparent process of identifying the most important areas for research and technical assistance be implemented (Goal 3); and that the NRC staff involve outside senior, recognized experts in its work to avoid problems at the time of licensing (Goals 1 and 2). The ACNW plans to pursue further discussions with the staff in these areas in 1999.

Finally, with respect to the Tier-Three Metrics related to Goal 5, improving the effectiveness and efficiency of ACNW's operational processes, the Committee did a good job of meeting its first metric of gaining earlier access to predecisional material, thereby providing more timely advice (see Tier-Three Metrics in Appendix A). The Committee sees opportunities for improvements in some of the remaining process-oriented metrics, including spending more time during Committee meetings on strategic planning and future agenda planning; spending more time meeting with individual Commissioners to follow up on letters; ensuring that letters are clear and concise; and increasing the number of interactions with program office directors during Committee meetings. In part, these processes were not improved because of the heavy workload and time constraints on the Committee. The Committee has since reevaluated the need for these selected process improvements and has decided to select other targets in its 1999 Action Plan.

Sincerely,

B. J. Garrick
Chairman

Attachments:

1. Appendix A: The Three-Tier Self-Assessment Measurement System, including Tables 1 "ACNW Summary Matrix of FY 98 Letters and Outcomes," and Table 2 " Key Themes of FY 98 ACNW Letters."
2. Appendix B: ACNW Goals and Objectives From NUREG/BR-0050.

Appendix A

The Three-Tier Self-Assessment Measurement System

Tier-One Outcome Metrics

1. Timeliness — Timeliness is based on whether the ACNW's advice is provided to the Commission before a Commission decision or before the NRC staff develops a final Commission paper or position. Timeliness also includes advice that alerts the Commission in advance to issues that could interfere with NRC's mission or that may require action or attention.

The ACNW developed several letters that it considers timely because they were provided before the Commission voted on whether to approve the issue, or before the staff developed a position paper on the topic. An excellent example of timeliness is letter 3 concerning defense in depth (DID) (October 31, 1997). The ACNW engaged the NMSS staff in discussions on DID approximately 1 1/2 years before it issued the proposed draft high-level waste (HLW) rule, 10 CFR Part 63, and the ACNW advice was provided in ample time to influence development of the rule. In its DID letter, the ACNW recommended adopting a risk-informed, performance-based regulation (RIPBR) approach that relies on the use of performance assessment (PA) to quantify the contribution of individual barriers. Similarly, in letter 6, concerning support for the multiple barrier approach (March 6, 1998), the ACNW provided advice when the staff's proposed strategy for draft 10 CFR 63 was still a predecisional document and before the Commission voted to approve a proposed strategy.

The ACNW considers several letters timely because they were provided to meet a stringent deadline established by the Commission. Examples include letter 7, concerning comments on the RIPBR white paper (March 98), and letter 8, concerning comments on the decontamination and decommissioning (D&D) interim guidance (April 29, 1998), on which the Commission requested the ACNW's advice before voting to approve the guidance for a 2-year trial period.

Finally, several letters were timely because they alerted the Commission to forthcoming issues, including letter 1, concerning comments on PA capability in the HLW program; letter 9, concerning the NRC staff's plans to review viability assessment (VA) (June 19, 1998); letter 10, concerning total systems sensitivity (July 29, 1998); and letter 13, concerning the engineered barrier system (EBS) (September 9, 1998). In each of these letters, the ACNW advised the Commission of the increasing emphasis on EBSs in the Department of Energy's (DOE's) approach to complying with the HLW standard, and letters 1, 10, and 13 warned the Commission of the need to increase staff capability in engineering analysis. We also alerted the Commission in NUREG-1635 to the need for more involvement of outside experts in NRC's HLW program before licensing.

2. <u>Effectiveness</u> — Effectiveness is based on whether the advice is incorporated into NRC policies, approaches, and regulations; whether the advice is forward-looking, proactive, or challenges the status quo; and whether the advice is responsive to the Commission's needs or requests, or triggers Commission action.

The ACNW considers one of its most effective letters to have been letter 3, concerning DID (October 1997), because its advice was incorporated into the draft 10 CFR Part 63 approved by the Commission for public comment. In addition, the advice was cited in the Commission paper transmitting the proposed strategy to develop the draft HLW rule and was quoted in the Statements of Consideration (SOC) of the draft rule. Another important letter in this regard was letter 6, support for multiple barrier approach (March 98). The advice was effective in that the draft rule does not contain subsystem requirements but does require demonstration of multiple barriers and quantification of uncertainty, as recommended by the ACNW. Also, the staff indicated in the SOC of the rule that implementing guidance would contain requirements for quantification of individual barriers. The ACNW intends to follow the development of the Yucca Mountain review plan guidance to ensure that its advice is implemented.

Other examples that demonstrate the effectiveness of ACNW letters are letters 7 and 8. In letter 7, concerning the (RIPBR) white paper (March 98), the ACNW's recommendations on risk assessment for radioactive waste management were substantially adopted by the Commission and incorporated directly into the agency white paper. Similarly, the Committee's recommendations in letter 8 concerning interim guidance for the final radiological criteria rule (April 98) were factored directly into the Commission's staff requirements memorandum (SRM) for staff action. The Committee recognizes that incorporation of its recommendations into the SRM is not direct evidence that the advice will be incorporated into the D&D guidance.

Finally, other letters that the ACNW considers effective include letters 1 and 2. In letter 1, concerning PA capability (October 97), the ACNW recommended the need for verifying the total system performance assessment (TPA) 3 code and exposing it to extensive peer review and the need to acquire more engineering capability to evaluate the EBS design options. These recommendations resulted in the staff's setting up of a peer review of the code at the Center for Nuclear Waste Regulatory Analysis (CNWRA) beginning in early 1999, as well as the staff's acquiring additional engineering expertise. In letter 2, concerning probabilistic risk assessment (PRA) and PA (October 97), the Committee recommended development of a post-processor to rank order contributors to risk. This recommendation resulted in ACNW's providing a small amount of funding to NMSS for the CNWRA to conduct a feasibility study for development of a post-processing tool. The NRC and CNWRA staffs have met with an ACNW member and consultants to discuss the details of the project.

3. **Efficiency — Efficiency is a measure of whether the advice was produced in a cost-effective manner, based on the efficiency of Committee processes and effective use of resources. Examples include focusing the Committee's efforts through development and use of strategic planning, measuring outcomes, carrying out specific process improvements, and collaborating with the ACRS or others. Another aspect of this metric is whether the advice, if implemented, will result in greater efficiency in NRC's regulatory program.**

The most significant example for this metric is letter 4, concerning the ACNW 1998 Strategic Plan (December 97), which, when followed, enabled the ACNW to nearly double its output from the previous year. In addition, the plan enabled the Committee to address all five of its Tier-One priorities and two of its Tier-Two priorities, which included responding to four requests from the Commission. The Committee's tracking system, self-assessment, and other tools (see Table 1)

have contributed to greater efficiency, as have increased use of videoconferences between ACNW, the NRC staff, the CNWRA, and the DOE. The Committee also made recommendations in letters 2, 6, and 12 that, if implemented, should lead to greater efficiency. In these letters, the Committee recommended the use of techniques for making PAs more transparent and useful, such as a post-processor to rank order contributors. In addition, in letters 7, 8, and 10, the Committee conveyed the need for the agency to adopt a flexible framework for risk-informed decisionmaking in the waste and materials arena, which should lead to greatly improved efficiency and consistency in carrying out its regulatory responsibilities.

4. <u>Quality</u> — Quality is based on whether the advice is technically sound, is clear and concise, and reflects the Committee's independence; whether advice incorporates state-of-the-art science and technology and can be readily incorporated into regulatory practices; whether the advice reflects international trends or developments; and whether the advice is perceived by the Commission or the staff as adding value.

The Committee believes that all of its Fiscal Year (FY) 1998 letters met the first criterion and also reflected the ACNW's independence. Several of the letters also met this metric because the Committee recommended use of state-of-the-art PRA risk assessment techniques for waste disposal. These letters include 1, PA capability; 2, PRA/PA; 3, DID; 7, RIPBR; and 10, total sensitivity studies. Letter 13, on the HLW EBS, exemplifies the quality metric because it reflected international perspectives, and letters 5, Issue Resolution Status Reports (IRSRs), and 9, NRC proposed review of viability assessment VA, exemplify the quality metric because the format used was particularly clear and concise.

5. <u>Use of a Risk-Informed, Performance-Based Regulation (RIPBR) Approach</u> — This measure of performance is based on whether the advice reflects consideration of the risk significance of an issue and is aimed at understanding the risk, the contributors to risk, and the uncertainties. The measure may also be based on whether the advice, if implemented, reflects a balance between risk, benefit, and costs to society, or whether the advice reflects a bottom-line rather than a prescriptive approach.

The Committee considers that all of its letters met the RIPB metric because each letter actively reflected the Committee's fundamental approach that risk should be used as the basis for decisionmaking.

Tier-One Observations

One letter met all five of the Tier-One Metrics: letter 7, on the RIPBR white paper. Letters meeting four of the five Tier-One Metrics include 2, PRA/PA; 3, DID; and 6, multiple barriers. Letters meeting at least three metrics include 1, PA Capability; 8, D&D; and #10, total sensitivity analysis. All letters met at least one of the Tier-One Metrics.

Tier-Two Metrics for Measuring Progress Toward Meeting ACNW's Goals 1-4

The approach used to evaluate compliance with the Tier-Two Metrics involved first identifying recurring themes throughout the letters and then determining which of ACNW's first four goals and associated objectives were supported by each of the themes. Goal 5 is evaluated

separately under the three-tier metrics. The themes and the number of the corresponding goals and objectives are incorporated in Table 2. Finally, the disposition or outcome of each of the recurring themes is documented in Table 2. Appendix B contains a complete list of the ACNW goals and objectives from its 1998 Strategic Plan. The ACNW believes that this comparison of goals, themes, and outcomes is a useful method for demonstrating how it achieved its 1998 goals.

Tier-Two Observations

The Committee addressed each of its goals on the basis of recurring themes from the FY 1998 letters. The goal most often addressed in the Committee's letters related to risk (Goal 3), followed by Goals 2, 1, and 4, in decreasing order of mention. The most effective themes were related to Goals 2 and 3, that is, verify the TPA code and expose it to extensive peer review (related to Goal 2) and use PA to show the effectiveness of individual barriers in 10 CFR Part 63 and drop the subsystem requirements (related to Goal 3).

Some of the themes are considered to have been less effective because they did not result in any action by the staff. These themes recommended use of PA to reprioritize key technical issues (KTIs) (Goal 3), take a systems engineering approach and develop systems engineering analysis (Goal 3), adopt an RIPBR approach for the NRC RES and Technical Assistant (TA) programs and a more formal and transparent process for identifying the most important areas for research (Goal 3), and finally, involve outside senior, recognized experts in NRC staff work to avoid problems at the time of licensing (Goals 1 and 2).

Tier-Three Metrics for Improving Operational Procedures - Goal 5

Tier-Three Metrics are designed to measure whether ACNW improved its efficiency and effectiveness, including modifying specified procedures.

In its Strategic Plan, the ACNW addressed improvement in its current processes for the following activities: letter writing, scope and duration of meetings, interactions with the Commissioners and the program offices, and use of ACNW staff and consultants. The following specific actions were measured

Metric 1: **Consider options for gaining early access to predecisional material to assist the Committee in providing more timely advice.**

Action: The Committee raised the issue with OGC, the Deputy Executive Director for Regulatory Programs, Commissioner McGaffigan, and other Commissioners and their technical assistants and initiated a routine database search for newly issued SECY documents. Some letters (e.g., 3, DID; 7, RIPBR White Paper; 6, Multiple Barriers; 8, D&D Guidance; and 12, draft 10 CFR Part 63) were prepared on the basis of early receipt of predecisional material. In all five examples, the advice was provided before a Commission vote was cast.

Metric 2: **Spend more time during Committee meetings on strategic planning and future agenda planning.**

Action: The Committee spent no more time this year on strategic planning or future agenda planning than it did in the previous year.

Metric 3: **Spend more Committee time meeting one-on-one with Commissioners to followup on letters and works in progress, alert Commissioners to potential problem issues, and discuss topics of interest to Commissioners.**

Action: Individual Committee members met at least once with every Commissioner but the Committee did not increase this effort in comparison to the previous year.

Metric 4: **Ensure all letters are clear, concise, and consistent.**

Action: The letter that best met this criterion was letter 5, IRSR process, principally because it explicitly identified an observation and a recommendation for every major point. The Committee will strive to use this format in future letters.

Metric 5: **Increase the number of interactions with program office directors during Committee meetings.**

Action: The intention of the Committee was to establish a closer relationship with the Directors of the offices the ACNW interacts with most often, including RES, Spent Fuel, and NMSS. During FY 1998, the Committee met once with Carl Paperiello, Director of NMSS, and once with Hugh Thompson, Deputy EDO. It is not clear whether there was improvement over the previous year.

Tier-Three Observations

The ACNW was most effective in implementing Metric 1, related to increasing the number of reviews on predecisional issues. There was less measurable activity in the other metrics. The Committee has revised most of its process improvements in its 1999 Action Plan.

Overall Conclusions: Accomplishments and Areas for Improvement

The Committee's most effective letter was letter 7 on the agency's RIPB white paper, which met all five of the Tier-One Metrics. The NRC Chairman incorporated most of the Committee's letter directly into the revised white paper. In addition, other letters meeting most of the Tier-One Metrics included letters 3 and 6, which recommended the need to show the effectiveness of individual barriers (letter 6) and to drop the subsystem requirements in the proposed draft HLW rule, 10 CFR Part 63 (letter 3). Both of these recommendations relate to Goal 3. The staff incorporated this idea into its draft rule and is working on supporting guidance to better describe how the transparency of individual barriers might be achieved. The Committee will continue to follow and guide the development of the regulation and regulatory guidance.

The Committee plans to increase its efforts in encouraging greater stakeholder participation in NRC regulations and programs, which is related to Goal 4. Examples in which the Committee's advice resulted in no action by the staff include recommendations to use PA to reprioritize KTIs (relates to Goal 3); to take a systems engineering approach and develop systems engineering analysis (relates to Goal 3); to adopt an RIPBR approach for the NRC RES program for developing a more formal and transparent process of identifying the most important areas for research (relates to Goal 3); and to involve outside senior, recognized experts in the NRC staff's work to avoid problems at the time of licensing (relates to Goals 1 and 2). When appropriate, the ACNW plans to pursue further discussion with the staff in these areas in 1999 (see the Action Plan January 22, 1999).

Finally, with respect to Goal 5, the Committee was effective in reviewing more predecisional material before a Commission vote, thereby contributing its advice to the outcomes. The Committee sees opportunities for improvements in other targeted process areas including spending more time during Committee meetings on strategic planning and future agenda planning, spending more Committee time meeting one-on-one with Commissioners to followup on letters, ensuring that all letters are clear and concise, and increasing the number of interactions with program office directors during Committee meetings. The Committee has since reevaluated the need for these selected process improvements and has selected new targets in its 1999 Action Plan that it believes will bring about greater efficiency and effectiveness.

ACNW SUMMARY MATRIX OF FY98 LETTERS AND OUTCOMES

TABLE 1

ACNW Letter	Main Message of Letter	EDO Response	Timely	Effectiveness/Outcome	Recommended Follow-up
#1: Comments on Performance Assessment Capability in HLW Program Oct. 8, 1997	Improve PA capability in analyzing EBS, including expanding expertise in engineering analysis, material science and chemistry; use greater realism in PA models; verify TPA 3 code and expose it to extensive peer review	Staff generally agrees with advice; DWM hiring new staff with noted capabilities; have reevaluated KTIs based on sensitivity studies and restored funding to radionuclide transport at CNWRA; plan to initiate an independent review of TPA code in FY99	Advice was provided prior to NRC's VA review and prior to NRC's development of working version of the TPA code	Staff agrees with and plans to or already has implemented 5 of 7 recommendations	Follow-up on staff's enhancement of expertise in systems engineering and modeling; follow staff's use of realism vs. conservatism in PA models; follow-up on model verification
#2 Application of Probabilistic Risk Assessment Methods to Performance Assessment in the NRC HLW Program, Oct. 31, 1997	Incorporate PRA methods into PA modeling; use greater realism in PA modeling; risk-informed analysis involves use of post-processor to make transparent the contributors to performance	Staff believes it is implementing these recommendations; staff will reevaluate models and parameter values in TPA code; staff only uses conservative values when other data is not available; staff will develop importance measures	Advice was provided prior to staff's VA review; advice was provided in adequate time for staff to develop PA capability and prioritize KTIs prior to VA/LA reviews	Advice raised NRC consciousness of need to avoid undue conservatism; advice led to ACNW providing small grant to CNWRA to develop post-processing modeling output	Follow closely development of post-processor and staff's use of top-down, event tree approach to rank order contributors to performance

ACNW SUMMARY MATRIX OF FY98 LETTERS AND OUTCOMES

TABLE 1

ACNW Letter	Main Message of Letter	EDO Response	Timely	Effectiveness/Outcome	Recommended Follow-up
#3 Recommendations Regarding the Implementation of the Defense-In-Depth Concept in the revised 10 CFR 60, October 31, 1997	ACNW endorses DID and multiple barriers; does not endorse use of rule-based subsystem requirements. PA should reveal the effectiveness of individual barriers	Staff agrees with use of both natural and engineered barriers; believe must evaluate individual barrier performance, contribution to performance, and quantification of uncertainty	ACNW engaged staff in discussion a year and a half prior to its development of draft rule; advice provided in ample time to influence development of rule*	ACNW advice was incorporated into draft 10 CFR 63; advice was cited in Commission paper transmitting proposed strategy to develop draft rule and is quoted in SOC of draft rule*	Follow evolution of 10 CFR 63 until finalized; follow closely development of IRSRs and YM review plan to ensure guidance requires transparency in PA analysis; follow development of tools to enable staff to rank-order contributors to performance
#4 1998 Strategic Plan and Priority Issues for the ACNW, December 23, 1997	Develop top-down framework to guide ACNW in providing advice while remaining flexible and focused; Plan identifies near- and far-term priorities.	Commission Response: Commends ACNW; modify plan to reflect ACNW charter; include a timeliness goal in metrics; call plan "performance criterion" vs. "Strategic Plan"; revisit 2nd tier priorities	Advice was proactive, and was synchronized with finalization of NRC's strategic plan	Advice enabled ACNW to address all five of its first-tier priorities, two of its second tier priorities, and address four requests from the Commission.	Continue top-down planning annually

ACNW SUMMARY MATRIX OF FY98 LETTERS AND OUTCOMES

TABLE 1

ACNW Letter	Main Message of Letter	EDO Response	Timely	Effectiveness/Outcome	Recommended Follow-up
#5 NRC HLW Issue-Resolution Process (IRSR) and IRSR Reports, March 6, 1998	ACNW supports IRSR approach, but cannot determine yet whether staff has capability to integrate and abstract complex and coupled information to "resolve issues"; staff should use PA to reevaluate KTIs and subissues; Staff should encourage greater stakeholder participation	Staff believes PA sensitivity analysis already includes relative ranking or reevaluation of KTIs; staff does not agree with need for greater stakeholder involvement	Advice alerts Commission to a potential problem that needs to be watched, i.e., whether staff can deal with the complexity involved in successful issue resolution*	TBD - based on EDO response, advice not effective	ACNW to follow development of IRSRs, and how issue resolution proceeds for complex issues such as coupled effects
#6 ACNW's Support for NRC Staff's Approach to Assessing the Performance of Multiple Barriers, March 6, 1998.	Abolish SSRs in YM specific regulation and require quantification of individual barriers; use PPA with realistic assumptions and parameter values in PA; explore use of post-processor to rank-order contributors	Staff agrees use of RI analysis to quantify contribution of individual barriers is strongly preferred to using SSRs in revised 10 CFR 63; Staff does not agree to use PPA with realistic assumptions and values instead of bounding assumptions, as the latter is easier to defend and requires less resources.	Advice was provided while strategy was a predecisional document and before Commission voted on proposed strategy*	Advice was effective in that the draft rule does not contain SSRs, but does require demonstration of multiple barriers and quantification of uncertainty.* Staff indicates in SOC of rule that implementing guidance will contain requirements for quantification of individual barriers	Follow guidance development closely, follow development of post-processor and importance analysis, follow use of realistic assumptions in PA analysis

ACNW SUMMARY MATRIX OF FY98 LETTERS AND OUTCOMES

TABLE 1

ACNW Letter	Main Message of Letter	EDO Response	Timely	Effectiveness/Outcome	Recommended Follow-up
# 7 Risk-Informed, Performance-Based Regulation in Nuclear Waste Management, March 26, 1998	White paper should use terminology for RIPBR approach applicable to both reactors and materials; need flexible framework for RI decision-making; adopt triplet definition of risk; RI approach requires quantification of all elements of defense, and implies decisions to be made based on risk with other information	Commission response was provided in form of revised white paper -see effectiveness criterion	Letter was provided to Chairman on time despite the very short turnaround time on the request*	ACNW recommendations substantially adopted by Commission and incorporated directly into Agency white paper*	None
#8 Comments and Recommendations on Interim Guidance in Support of the Final Rule on Radiological Criteria for License termination, April 29, 1998	Support release of decision tool to public; consider approach RIPB; ALARA requirement may lead to unnecessary conservatism; test code on a complex site; need commitment and adequate resources; RIPB approach could help alleviate conflicts in dual regulation	EDO response in general agreement with advice; indicates staff is developing an SRP that covers simple to complex sites, however staff did not commit to test code on complex site.	Commission awaited ACNW's advice before voting on guidance; ACNW made great effort and succeeded in meeting Commission's tight deadline*	Advice was factored into Commission SRP and staff directed to follow-up on all items in ACNW letter *	Follow development of SRP closely, attend weekly D&D Board meetings, become more familiar with D&D code assumptions, potential conservatisms, and decision framework

ACNW SUMMARY MATRIX OF FY98 LETTERS AND OUTCOMES

TABLE 1

ACNW Letter	Main Message of Letter	EDO Response	Timely	Effectiveness/Outcome	Recommended Follow-up
#9 ACNW's Comments on NRC's Review of the DOE Viability Assessment, June 19, 1998	Staff should use VA to focus on issues important to licensing and develop adequate licensing criteria in SRP; take systems approach to review; focus on preclosure issues due to longevity of operational period; adapt to increasing importance in EBS performance	Staff believes it is already doing 3 of the recommendations, but does not explain how it is doing them. Staff disagrees with need to look at preclosure issues, except those that affect post-closure performance	Advice was provided before staff's VA review	Not clear whether advice had or will have any impact, based on EDO response	Reemphasize importance of taking a systems approach to its VA/LA review; follow-TSPA IRSR closely; possibly discuss with staff concern about preclosure issues including that DOE should not license its own operators
#10 Comments on NRC's Total Sensitivity Studies for The proposed HLW Repository at Yucca Mountain, July 29, 1998	Strengthen capability to do engineering analysis due its increased emphasis; begin integrating IRSRs into YM Review Plan and reevaluate KTIs based on current knowledge; a flexible tool is needed to evaluate contributions of individual components.	Will continue to use sensitivity studies to upgrade knowledge base; will use TSPA-IRSR to initiate top-down RIPB YM review plan	Advice can be used by staff in its preparation of its VA review	Staff is planning or has implemented 4 or 5 recommendations. Staff does not address need for flexible tool; however, this is being implemented by a feasibility study through an ongoing ACNW project with DWM/CNWRA.	Follow project with DWM/CNWRA; follow TSPA sensitivity studies and implementation of results; continue to evaluate whether staff's approach to TSPA IRSRS is adequate for top down systems review

TABLE 1

ACNW SUMMARY MATRIX OF FY98 LETTERS AND OUTCOMES

ACNW Letter	Main Message of Letter	EDO Response	Timely	Effectiveness/Outcome	Recommended Follow-up
#11 NRC Staff Research on Generic Post-Disposal Criticality at Low-Level Radioactive Waste Facilities, July 30, 1998	Likelihood of a criticality in a licensed LLW disposal facility is remote, consequences are minimal; significant research not warranted; possibly perform site-specific risk-assessment	Agree likelihood is low and consequences minimal; will consider ACNW's comments in report to Commission; disagree with need for peer review	Advice provided before Commission vote	TBD -too early to judge effectiveness	If criticality research project goes forward, ACNW may request to study scope and analysis
#12 ACNW's Comments on NRC's Draft 10 CFR 63 and Revision 0 of TSPA IRSR, September 3, 1998	Commends staff's progress toward developing RIPB rule; rule is consistent with previous ACNW advice; continue to develop techniques to ensure modeling transparency, and ensure that guidance conveys clearly what is expected in model transparency	Staff believes it has incorporated ACNW's advice on Part 63; Staff is revising the IRSRs to be consistent with Part 63 and is examining a variety of analysis methods and techniques to ensure transparency of the compliance demonstration with the overall performance objective and multiple barriers. The staff will seek Committee input as it progresses.	ACNW was able to provide advice prior to staff providing draft rule to the Commission*	TBD -Follow closely the evolution of the TSPA IRSR and development of techniques to evaluate contributions of individual components	Follow closely the evolution of the TSPA IRSR and development of techniques to evaluate contributions of individual components

TABLE 1

ACNW SUMMARY MATRIX OF FY98 LETTERS AND OUTCOMES

ACNW Letter	Main Message of Letter	EDO Response	Timely	Effectiveness/Outcome	Recommended Follow-up
#13 Issues and recommendations Concerning the Near-Field Environment and the Performance of Engineered Barriers at Yucca Mountain	As move from VA to LA, augment engineering review capability; reexamine KTIs and subissues as needed; develop systems engineering analysis capability; and identify most important EBS components in terms of capabilities to limit doses.	NRC is augmenting the staff in appropriate engineering areas; system engineering principles are deeply ingrained in NRC's program, no need for additional expertise; request ACNW to suggest areas that can be reduced to compensate for its suggestion to augment engineering areas.	Advice provided before VA and LA reviews	Letter is partially effective in that staff is hiring engineering capability. Staff still does not comprehend what ACNW means by systems analysis or systems approach	Meet with NMSS to discuss issue of what is meant by systems engineering
ACNW contribution to ACRS' Report to the Commission on NRC Safety Research, April 30, 1998	Use an RIPB regulatory framework for NRC's Research Program; develop a more formal and transparent process for setting priorities; Involve outside senior, recognized experts in NRC staff's work to avoid problems at the time of licensing.	Formal response received 3/8/99. Staff did not address whether it agrees with or how it plans to implement a more formal and transparent process for identifying the most important areas for research.	Information provided to the ACRS in time for them to present integrated report to Chairman.	As of this writing, have not seen significant changes in the way research/TA priorities are established or work performed. Not clear yet whether advice was effective. Staff verbally conveyed that it already has outside experts involved through the CNWRA.	ACNW has prepared a letter report to the Commission which will be submitted in April.

TABLE 1

ACNW SUMMARY MATRIX OF FY98 LETTERS AND OUTCOMES

ACNW Letter	Main Message of Letter	EDO Response	Timely	Effectiveness/Outcome	Recommended Follow-up
ACNW contribution to the ACRS' Letter Report to Congress (12/26/97)	RIPB approach should be used. NRC research and TA must be focused and current especially with respect to the risk and uncertainty associated with the long time periods associated with waste disposal; Additional reductions to the research program could critically affect the NRC's effectiveness.	None. EDO response not required on letters to Congress.	Information provided to the ACRS in a timely manner.	No obvious measure. Congress does not respond. (However, funding for NRC's Yucca Mountain activities was increased slightly for FY99)	None. Report no longer required.

Definition of Acronyms

RIPBR = risk-informed, performance-based regulation
RIPB = risk-informed, performance-based
RI = risks-informed
DID = defense-in-depth
SSR = subsystem requirement
SOC = statement of considerations
PA = performance assessment
PPA = probabilistic performance assessment
YM = Yucca Mountain
DWM = Division of Waste Management
EBS = engineered barrier system
KTI = key technical issue
VA = viability assessment
TSPA = total system performance assessment

*implies excellent example of timeliness and effectiveness

TABLE 2

KEY THEMES OF FY 98 ACNW LETTERS

THEMES	LETTER NUMBERS	GOALS/ OBJECTIVES	DISPOSITION
Use PA to show effectiveness of individual barriers	3, 6, 7, 13	Goals 2, 3 and 4	Advice was incorporated into draft 10 CFR 63; IRSR guidance to provide additional detail to DOE; recommendation was incorporated into agency RIPB white paper; staff and CNWRA developing techniques to show barrier contribution.
Improve capability to analyze EBS	1,10, 13	Goal 1, Objective 2; Goal 2, Objective 2	Staff continues to hire needed engineering capability.
Increase emphasis on EBS	9,10, 13	Goal 1, Objective 2; Goal 2, Objective 2,	Staff continues to hire needed engineering capability.
Develop and use techniques such as post-processor to rank order contributors of individual barriers	2, 6, 12	Goal 2, Objective 2; Goal 3	Staff is examining a variety of analysis methods and techniques to ensure transparency of compliance demonstration with multiple barriers and overall performance objectives, including conducting a feasibility study for developing post-processing modeling capability.
Drop SSRs	3, 6, 12	Goal 1, Objective 1	Advice incorporated into draft 10 CFR 63.
Use PPA methods in PA modeling and use greater realism	1, 2, 6	Goal 2, Objective 2	Advice raised consciousness of need to avoid undue conservatism, although staff maintains that regulatory role should be appropriately conservative.
Use PA to reprioritize KTIs, reexamine KTIs and subissues as needed	5,10, 13	Goal 3, Objectives 1 and 2	Staff believes that its sensitivity analysis already includes relative ranking or reevaluation of KTIs , thus no obvious impact.

TABLE 2

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THEMES	LETTER NUMBERS	GOALS/ OBJECTIVES	DISPOSITION
Develop robust acceptance criteria in IRSRs/ YM, review plan to ensure transparency of individual barriers, continue to develop techniques to ensure modeling transparency	5, 9, 12	Goal 3, Objective 2; Goal 4	Staff is examining a variety of analysis methods and techniques to ensure transparency of compliance demonstration with multiple barriers and overall performance objectives, including conducting a feasibility study for developing post-processing modeling capability.
Adopt flexible framework for risk-informed decision making for agency	7, 10, 8	Goal 3, Objective 2, Goal 4	Recommendation was incorporated into NRC RIPB white paper.
Take systems approach to review of VA/LA, develop systems engineering analysis capability	9, 13	Goal 3	Staff considers it already has adequate systems engineering capability and systems engineering approach.
Adopt triplet definition for risk in HLW program	7	Goal 3	Advice incorporated into white paper.
Verify TPA code and expose to extensive peer review	1	Goal 2	Staff conducting extensive peer review of TPA code in early FY99.
Encourage greater stakeholder participation	5	Goal 4, Objective 2	Although EDO response did not agree with ACNW's recommendation, staff began developing a public outreach plan in FY99.
Use an RIPB regulatory framework for NRC's Research Program	RES Letter	Goal 3	Staff did not address whether it agrees with or how it plans to implement an RIPB framework.

TABLE 2

KEY THEMES OF FY 98 ACNW LETTERS

THEMES	LETTER NUMBERS	GOALS/ OBJECTIVES	DISPOSITION
Develop a more formal and transparent process for identifying the most important areas for research	RES Letter	Goals 3 and 4	Staff agrees that an objective planning mechanism to identify the priority research is needed. Insights from PA and other mechanisms will be evaluated. Will keep ACNW advised.
Involve outside senior, recognized experts in NRC staff's work to avoid problems at the time of licensing	RES Letter	Goal 1, Objective 2 Goal 2, Objective 1	Staff believes many NRC and CNWRA staff members are recognized experts. In addition, CNWRA staff has utilized overseas experts many times.

Appendix B

ACNW Goals and Objectives From NUREG/BR-0050

Goal 1: **Assist the NRC in positioning itself to respond to external change and uncertainty in the management of nuclear waste. This goal supports the NRC mission, vision, and selected strategies or substrategies under NRC Goals 2 through 7.**

Objective 1: Advise the Commission in a timely fashion on issues of a technical nature that may require changes in the regulations.

Objective 2: Inform the Commission about issues that could cause problems for the NRC or society if not given adequate attention and recommend solutions.

Goal 2: **Strive to ensure that NRC is employing the best science in resolving key safety issues. This goal supports the NRC mission, vision, and select strategies or substrategies under NRC Goals 2 through 7.**

Objective 1: Keep abreast of cutting-edge methods and technologies being developed and utilized worldwide that are applicable for assessing and managing risks associated with cleanup, disposal, and storage of nuclear waste.

Objective 2: Advise the Commission on projected or perceived technical shortcomings in NRC staff capabilities that could adversely impact the agency's ability to address safety issues.

Goal 3: **Advise the NRC on how to increase its reliance on risk as a basis for decisionmaking, including using risk assessment methods for waste management that (1) implement a risk-informed approach; (2) are consistent across programs, where possible; and (3) quantify and reveal uncertainties. This goal supports the NRC mission, vision, and select strategies and substrategies under NRC Goals 2 through 7.**

Objective 1: Propose approaches and encourage the staff to gain a better understanding of the inherent risks of licensed activities in nuclear waste and materials, and the relationship between regulations, cost, and safety.

Objective 2: Examine risk assessment approaches being utilized within the NRC's waste and materials programs and recommend improvements for making more transparent the underlying assumptions and associated uncertainties, incorporating greater realism where appropriate, and identifying apparent inconsistencies in approach.

Goal 4: **Support the NRC in improving public involvement in its waste programs and gaining increased public confidence and respect. This goal supports the NRC mission, vision, and select strategies or substrategies under NRC Goal 6.**

Objective 1: *Provide opportunities through the Federal Advisory Committee Act process for more public involvement in the regulatory process.*

Objective 2: *Recommend ways for the NRC to gain more meaningful public involvement in the regulatory process.*

Objective 3: *Assist the NRC in making more transparent the agency's decisionmaking process and ensuring that agency documentation is thorough, clear, and readily understandable.*

Goal 5: **Improve the effectiveness and efficiency of ACNW operations. This goal supports the NRC mission, vision, and select strategies or substrategies under NRC Goal 7.**

Objective 1: *Increase the value of ACNW advice to the Commission and staff.*

Objective 2: *Improve and modify existing operational procedures to accomplish "more with less."*

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Objective 2: *Improve and modify existing operational procedures to accomplish "more with less."*

CHAIRMAN'S RESPONSES

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

CHAIRMAN

June 18, 1999

Dr. B. John Garrick, Chairman
Advisory Committee on Nuclear Waste
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

SUBJECT: ADVISORY COMMITTEE ON NUCLEAR WASTE 1999 ACTION PLAN AND PRIORITY ISSUES

Dear Dr. Garrick:

This letter responds to the 1999 action plan submitted by the Advisory Committee on Nuclear Waste (hereafter the Committee) on January 22, 1999. I am providing general comments to guide the Committee in carrying out its work during the remainder of fiscal year (FY) 1999 and in preparing its FY 2000 action plan.

The 1999 action plan clearly describes the Committee priorities for 1999, consistent with its mission and goals, and should contribute both to the efficient use of Committee resources and to the enhancement of coordination with the staff. On April 20, 1999, senior managers of the Office of Nuclear Material Safety and Safeguards (NMSS) discussed with you and the Committee staff how the action plan and priorities support the Agency's operating plan for the waste programs under the Committee Charter. This dialogue should continue so that Committee resources can support the Agency's operating plans for the waste programs in the most beneficial manner.

In general, the priorities of the Committee are consistent with the priorities in the staff operating plans. However, some of the Committee's new initiatives have broadened the topics to be addressed and potentially could diminish the attention to some high priority program activities. For example, the goal to support the Nuclear Regulatory Commission in enhancing public confidence (Goal 4) is an appropriate, but broad goal that needs to be focused on those aspects in which the Committee has unique expertise. Risk communication (already included in the action plan) and suggestions for building the confidence of the scientific community are specific areas where the Committee could provide valuable advice to the Commission. However, such initiatives should not reduce Committee attention to key technical issues in the high-level waste (HLW) repository program or new issues emerging in the decommissioning program. For example, the Committee may have to pay greater attention to the clearance rulemaking and mixed waste rulemaking, where work is beginning in FY 1999 and will continue into FY 2000. Similarly, both the staff and the Committee will need to pay increased attention to issues related to Part 63 that are likely to receive a wide range of public comment, as well as any HLW standards proposed by the Environmental Protection Agency. Also, the Committee should place a higher priority on risk-informed, performance-based regulation, as discussed in SECY-99-100, dated March 31, 1999.

I further note that the Committee has identified the linear-no-threshold (LNT) issue as a first-tier priority. As you are aware, this matter is receiving much national and international attention. The Office of Nuclear Regulatory Research (RES) has funded proposals for the on-going work with the National Council on Radiation Protection and Measurements (NCRP), and the upcoming work with the National Research Council Biological Effects of Ionizing Radiation (BEIR VII) Committee on this issue. The Committee work and recommendations in this area should be coordinated with RES, and should consider the results of these research studies.

In addition, I would like to bring to your attention a recent Commission initiative that should be important to future Committee planning. The staff recently has completed an evaluation of its HLW repository program using the Planning, Budgeting, and Performance Management process, and will use this process for evaluating its other waste programs. The results of this planning will be provided to the Committee so it is aware of how the HLW repository program has been refocused on a set of new common Agency goals and associated measures. Understanding these new goals and measures is important for the Committee's future planning and updating of its action plan to support these goals.

Finally, I support the changes to the operating procedures described in the Committee action plan. In particular, I am pleased to learn that recent examples of informal meetings to understand staff activities in various technical areas have benefited both the Committee and the staff. I encourage such initiatives for improving coordination and communication, so as to enhance the Committee advice to the Commission and staff.

Sincerely,

Shirley Ann Jackson

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

CHAIRMAN

August 16, 1999

Dr. B. John Garrick, Chairman
Advisory Committee on Nuclear Waste
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Dr. Garrick:

On April 29, 1999, the Advisory Committee on Nuclear Waste submitted its self-assessment evaluation for fiscal year (FY) 1998, including identification of its metrics and evaluation of its performance using these metrics. The Commission supports the Committee's continued preparation of annual self-assessments and provides the following observations that should be addressed in future self-assessments. In addition, please note that Commission direction provided in the enclosed SRM on COMSECY-99-018 allows the Committee to combine its self-assessment report with its Operating Plan to be submitted to the Commission for review on an annual basis.

We appreciate the initiative the Committee has taken to evaluate and report on its performance relative to its FY 1998 strategic plan (currently referred to as the action plan). In particular, its emphasis on measuring outcomes relative to its goals is consistent with the new approach that has been piloted for some agency programs, using the Arthur Andersen assessment process. We agree with the Committee's general conclusion that significant progress has been made in achieving the desired effectiveness and timeliness of its activities. This improvement has been achieved, in part, as a result of the Committee's enhanced planning, including use of tools such as the strategic plan and this self-assessment. In addition, the tracking system the Committee developed to track its recommendations and the staff's responses provides a basis for evaluations of performance.

Our first observation is related to how the Committee has defined its effectiveness metric (Appendix A on page A-1). One measure of effectiveness identified is based on whether the Committee's advice is incorporated into the Nuclear Regulatory Commission policies, approaches, and regulations. Another measure is whether the advice triggers Commission action. There needs to be a recognition in this metric that full implementation of some of the Committee's advice might be limited by budget constraints. It should also be recognized that in addition to the existing measure of triggering Commission action, Committee advice would be effective if it resulted in changes to staff plans or positions or even if the advice agreed with existing staff plans or positions, thereby adding independent technical support.

We also have an observation regarding the Committee's conclusion regarding the effectiveness metric. On page 3 of the letter, the Committee summarizes examples where Committee advice did not result in any action by the staff. It is our understanding that while the staff has addressed

each of these areas, additional discussions appear to be necessary and hopefully will be useful in reaching an agreeable resolution or a mutual understanding. The Committee has noted that it plans to pursue further discussions with the staff in these areas in 1999. We understand that the staff had informal discussions with the Committee in many of these areas in preparation for the Committee meeting in June 1999 at the Center for Nuclear Waste Regulatory Analyses. We encourage both the Committee and staff to continue addressing these areas appropriately.

Sincerely,

Greta Joy Dicus

Greta Joy Dicus

Enclosure: SRM on COMSECY-99-018

SECRETARY

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

August 6, 1999

MEMORANDUM TO: John T. Larkins, Executive Director
Advisory Committee on Reactor Safeguards
Advisory Committee on Nuclear Waste

FROM: Annette L. Vietti-Cook, Secretary

SUBJECT: STAFF REQUIREMENTS - COMSECY-99-018 - SELF ASSESSMENT OF ACRS AND ACNW PERFORMANCE

The Commission has agreed that the periodic self-assessment report and the ACRS and ACNW Operating Plan can be combined into one annual report to the Commission that should include self-assessment summary matrices.

in future reports, ACRS and ACNW should continue to specifically highlight, where appropriate, areas identified for improvement and planned actions and should highlight the degree of improvement observed in areas identified in previous self assessments.

cc: Chairman Dicus
Commissioner Diaz
Commissioner McGaffigan
Commissioner Merrifield
EDO
OGC
CIO
CFO
OCA
OIG
PDR
DCS