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

May 17, 1991

The Honorable Kenneth M. Carr
Chairman
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Chairman Carr:

SUBJECT: SUMMARY REPORT - THIRTIETH MEETING OF THE ADVISORY COMMITTEE ON NUCLEAR WASTE, APRIL 23-24, 1991

During its 30th meeting, April 23-24, 1991, the Advisory Committee on Nuclear Waste completed the activities noted below and the following reports and memoranda.

REPORTS AND MEMORANDA

- Individual and Collective Dose Limits and Radionuclide Release Limits (Memorandum to Mr. Robert M. Bernero, Director, Office of Nuclear Material Safety and Safeguards, dated April 29, 1991. See Enclosure 1.)

- Consideration of Human Intrusion in the Licensing of a High-Level Waste Repository (Report to Chairman Carr, dated April 29, 1991.)

- Program Plan for the Advisory Committee on Nuclear Waste (Report to Chairman Carr, dated April 29, 1991.)

- Draft Staff Technical Position on Underground Facility Design -- Thermal Loads (Memorandum to Mr. B. J. Youngblood, Director, Division of High-Level Waste Management, from Mr. Raymond Fraley, dated April 29, 1991. See Enclosure 2.)

HIGHLIGHTS OF MATTERS CONSIDERED BY THE COMMITTEE

- Staff Technical Position on the High-Level Waste Repository Design for Thermal Loads

  The Committee reviewed and commented on a draft NRC Staff Technical Position (STP) on the High-Level Waste Repository Design for Thermal Loads. The STP is intended as a generic document to provide an acceptable approach for demonstrating compliance with 10 CFR Part 60.133(i).

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- Decommissioning Activities

  The Committee was briefed on decommissioning activities at the West Valley Demonstration Project and two Chemetron sites located in Newburgh Heights near Cleveland, Ohio. This briefing was for information only. No Committee action was taken.

- Individual vs. Collective Doses

  In response to your suggestion during our April meeting that the Committee provide comments to the NRC staff, the Committee discussed the advantages and disadvantages of using collective dose criteria versus individual dose criteria and individual radionuclide release limits when determining risk posed to the public health and safety from a potential release from an HLW repository. The remanded EPA HLW standards stipulate compliance in terms of total releases of radionuclides. The Committee approved sending a memoranda to Mr. Robert Bernero, NMSS, as background to a paper that NMSS is preparing at the Commission's request.

- Uncertainties in Implementing the EPA's HLW Radiation Protection Standard

  The Committee was briefed on the revised draft paper on the "Staff's Approach for Dealing with Uncertainties in Implementing the EPA HLW Standards," 40 CFR Part 191. The Committee and NRC staff favor different alternative probabilistic formats for the containment requirements in EPA's high-level waste standards.

  In addition to going through the staff's draft item by item, the Committee agreed to work to issue a report on this subject during its May 22-23, 1991 meeting.

- Consideration of Human Intrusion in the Licensing of an HLW Repository

  The Committee discussed and approved the final draft report prepared by Mr. Steven Mays, ACRS/ACNW Senior Fellow, entitled, "Comparison of Techniques for Assessing Nuclear Power Plant Protection Against Sabotage and High-Level Waste Repository Protection Against Human Intrusion." A copy of this report has been provided to you for transmittal to EPA.

- Leaching Resistance of Low-Level Waste Forms

  The Committee continued its discussion with the NRC staff on a response to a recent Staff Requirements Memorandum (SRM) concerning a proposed revision of Part 61 with regard to

leaching resistance of the low-level waste form. The NRC staff responded to member's questions and discussed further issues that will need to be addressed during the May 22-23, 1991 meeting.

- ACNW Four-Month Plan

The Committee prepared and forwarded to the Commission its four-month plan for the period May-August 1991.

ACNW Future Activities

- The Committee discussed its planned visit to the Center for Nuclear Waste Regulatory Analyses (CNWRA) in San Antonio, Texas, scheduled for June 26-28, 1991. The Committee will be briefed on the status of the Systematic Regulatory Analysis program and will receive an update on other activities of the Center, such as PRA computer codes and tectonic modeling.

- The Committee agreed to establish a Working Group on residual contamination clean-up criteria. Dr. Moeller will be the Chairman.

- The Committee agreed to establish a Working Group on post-closure monitoring of an HLW repository and other related issues. The ACNW staff will invite representatives from EPA and NRC to brief the Committee on various aspects associated with post-closure monitoring. The date for this meeting is to be determined. Dr. Moeller has been tentatively selected to be the Chairman.

- The Committee agreed to have a Working Group on an alternative probabilistic format for the containment requirements in EPA's high-level waste standards. The NRC staff proposes that processes and events potentially affecting a repository be divided into three categories (likely conditions, unlikely conditions, and very unlikely conditions). Dr. Steindler will be the Chairman.

- The Committee agreed not to schedule briefings on the decommissioning of the Hanford Production Reactors and in-place vitrification. The Committee also stated that further review of the LLW Uniform Shipping Manifest by the Committee was not necessary.

- The American Society of Mechanical Engineers has invited the Committee to make a presentation during the plenary session of its mixed wastes meeting to be held in

Baltimore, Maryland, on August 26-29, 1991. The Committee agreed to accept the invitation. Dr. Moeller will summarize Committee recommendations on mixed wastes (ACNW report dated February 28, 1991).

Appendix A summarizes the proposed items for future meetings of the Committee and related Working Groups. This list includes items proposed by the Commissioners and NRC staff as well as ACNW members.

Sincerely,

Dade W. Moeller

Dade W. Moeller
Chairman

Enclosures:
As stated

APPENDIX A. FUTURE AGENDA

31st ACNW Committee Meeting May 22-23, 1991 (Tentative Agenda)

EPA HLW Repository Standards (Working Draft #3) - The Committee will be briefed on Working Draft #3 of the Environmental Protection Agency's 40 CFR Part 191, High-Level Waste Repository Standards, if available.

Leaching Resistance of LLW Waste Form - The Committee will continue its discussion on a response to a recent Staff Requirements Memorandum (SRM) concerning a proposed revision of Part 61 with regard to leaching resistance of the low-level waste form and groundwater protection requirements.

Uncertainties in Implementing the EPA's HLW Radiation Protection Standard - The Committee will continue discussions which address dealing with uncertainties associated with implementing the EPA HLW repository standards.

Working Group Report on Integration of Geophysics into Site Characterization of a High-Level Waste Repository - The Working Group Chairman will report on the importance and advantage of, and potential results from, geophysical testing methods as those methods apply to the identification of possible adverse conditions at an HLW site.

State of South Carolina - The Committee will be briefed by representatives of the State of South Carolina on the implementation of its Agreement State Program.

Trip Reports - The Committee will hear from members who attended the Second Annual International High-Level Radioactive Waste Management Conference and members who participated in the field trip to Lunar Crater.

Digital Data Set - The Committee will be briefed on a digital data set prepared for the Yucca Mountain Site.

Committee Activities - The Committee will discuss anticipated and proposed Committee activities, future meeting agenda, and organizational matters, as appropriate. The members will also discuss matters and specific issues that were not completed during previous meetings as time and availability of information permit.

Working Group Meetings

Expert Judgment in Performance Assessment of a Geologic Repository June 18-19, 1991, 7920 Norfolk Avenue, Bethesda, MD, 8:30 a.m., Room P-110 - The Working Group will continue the examination of methods for eliciting expert judgment. The meeting will focus on the actual mechanics of elicitation. This includes questions on who will identify and select the experts, as well as how the selected experts are trained and how their opinions are aggregated. Human intrusion will serve as the reference example in relating the elicitation process to a real and useful application. Participants will include normative experts, as well as NRC and DOE staff and consultants involved with Yucca Mountain and WIPP.

Geologic Dating (Date to be determined) - The Working Group will review and discuss the problems and limitations associated with the various quaternary dating methods to be used in site characterization of an HLW repository.

Residual Contamination Clean-up Criteria (Date to be determined) - The Working Group will review, discuss and make recommendations regarding the clean-up criteria and clean-up levels for unrestricted use at contaminated sites that are or have been under NRC license.

Post-closure Monitoring (Date to be determined) - The Working Group will discuss post-closure monitoring of an HLW repository and other related issues. The ACNW staff will invite representatives from EPA and NRC to brief the Committee on various aspects associated with post-closure monitoring.

Alternative Probabilistic Format for the Containment Requirements in EPA's HLW Standards (Date to be determined) - The Working Group will discuss the division of the processes and events (likely conditions, unlikely conditions, and very unlikely conditions) that potentially affect a repository.

Enclosure 1

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

April 29, 1991

Mr. Robert M. Bernero, Director
Office of Nuclear Material Safety
and Safeguards
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Mr. Bernero:

SUBJECT: INDIVIDUAL AND COLLECTIVE DOSE LIMITS AND RADIONUCLIDE RELEASE LIMITS

The Advisory Committee on Nuclear Waste has been developing comments, thoughts, and suggestions relative to individual and collective dose limits and radionuclide release limits. Since we understand that your staff is reviewing these same topics, we wanted to share our thoughts with you. In formulating these comments, we have had discussions with a number of people, including members of the NRC staff and Committee consultants. The Committee also had the benefit of the documents listed.

Basic Definitions

As a basic philosophy, individual dose limits are used to place restrictions on the risk to individual members of the public due to operations at a nuclear facility. If the limits have been properly established and compliance is observed, a regulatory agency can be confident that the associated risk to individual members of the public is acceptable. Because the determination of the dose to individual members of the public is difficult, the International Commission on Radiological Protection (ICRP) has developed the concept of the "critical group" and recommends that it be used in assessing doses resulting from environmental releases. As defined by the ICRP, a critical group is a relatively homogeneous group of people whose location and living habits are such that they receive the highest doses as a result of radionuclide releases. The group may be real (in which case their actual habits may be known or predicted) or hypothetical (in which case their habits may be assumed, based on observations of similar groups).

The dose to individuals within the critical group is assumed to be that received by a typical member of the group. The purpose of this approach is to ensure that members of the public do not receive unacceptable exposures while, at the same time, ensuring that decisions on the acceptability of a practice are not prejudiced by a very small number of individuals with unusual habits.

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If the number of people being exposed is large, the question often arises as to how to quantify the societal impact of the individual exposures. The collective dose concept was developed for expressing that impact in a quantitative manner and, as such, it is a numerical expression of the summed doses to a given population.

In many respects, placing limits on total radionuclide releases from a nuclear facility is comparable to placing a limit on its total societal impact. In other words, placing a limit on the quantity of a given radionuclide that can be released is equivalent to placing a limit on the total societal impact that the facility can exert. This was the basis used by the U.S. Environmental Protection Agency (EPA) in setting release limits for a high-level radioactive waste repository, and it relates directly to EPA's basic criterion that the number of health effects should not exceed 1,000 during the first 10,000 years.

Underlying Assumptions

Although it is generally accepted that the dose received by an individual is a reasonable expression of the associated risk, it is questionable whether the collective dose is a true measure of the societal impact of the aggregate of exposures to individual members of a population. Implicit in the concept of collective dose is the assumption that the linear hypothesis is correct, that is, that there is a linear (non-threshold) relationship between the total dose to a population group and the associated health impacts.

In many ways, application of the collective dose concept leads to a paradox. At high doses and high dose rates where the risk coefficients are best known, the concept of collective dose cannot be applied since the dose-response curve is nonlinear; at low doses and low dose rates where linearity between dose and the associated health effects is assumed to apply, the risk coefficients are far less certain. This leads to additional restrictions in the application of the collective dose concept, as follows:

- The exposed population must be well known with respect to size and possibly age, sex, and temporal distributions.
- The exposure pathways must be characterized for the population at risk.
- Individual contributions to the collective dose must consist only of doses to the whole body, or to specific organs or tissues for which stochastic risk coefficients are known.

In short, application of the collective dose concept requires detailed knowledge of the exposed population and the radiation doses to its members. The collective dose concept is valid for representing the collective risk only if both of these factors can

be described and quantified, and it should be used for risk assessments only if the associated uncertainties are sufficiently small that the calculated collective dose itself is within an acceptable range of uncertainty. In addition, it is important to note that a high individual risk to a small number of people is not necessarily the same as a low individual risk to a large number of people, even though the collective dose may be the same. For this reason, expressions of societal risk in terms of collective dose should always include detailed data not only on the number of people exposed, but also on the number of people receiving exposures within each dose range. Although collective dose can be used as a surrogate for societal risk, its interpretation requires care.

Truncation of Collective Dose Calculations

On a theoretical basis, there is no justification for excluding the application of the linear hypothesis to the evaluation and interpretation of the societal impact of low doses and low dose rates on population groups. This hypothesis, in fact, has been generally accepted by the scientific community, including organizations such as the National Council on Radiation Protection and Measurements (NCRP) and the ICRP, as a valid basis for estimating the stochastic risks associated with low doses of ionizing radiation. If one accepts this observation, calculations of collective doses should include the doses to all individuals within the population group, regardless of how small the associated doses and/or dose rates may be. At the same time, however, it is important to recognize that there may be cogent reasons for not including within collective dose calculations extremely low doses to individual members of a population group. Several approaches that have been proposed and/or applied to justify such omissions are discussed below.

Following the concept that certain risks to individual members of the population are negligible, the NCRP has recommended (under what it defines as the concept of a "Negligible Individual Risk Limit") that annual doses to individual members of the population that are less than 0.01 mSv (1 mrem) be excluded from collective dose calculations. In interpreting this recommendation, however, it is important to understand the underlying principle on which it was based. Informal discussions with representatives of the NCRP revealed that truncation in this case was considered to be acceptable from the standpoint of societal impact, because the burden on society represented by any additional cancers among people receiving exposures in this dose rate range would not necessitate any additional medical facilities. Another approach for truncation that has been informally suggested by representatives of the NCRP is that it might be permissible to discard a collective dose (calculated on the basis of extremely low dose rates to members of an exposed population) provided that the

associated collective dose would not be estimated to result in one additional cancer.

Variations in the dose rates from natural background radiation sources have been proposed as another basis on which to truncate collective dose calculations. The contribution to collective dose from natural sources is large relative to that from many artificial sources. Consequently, it is often difficult to measure in a meaningfully quantitative manner very low dose rates to individual members of the population that arise from artificial sources. Thus, although there may be no biological basis for excluding very low dose rates from collective dose calculations, there is justification for excluding them on a statistical basis because of the uncertainties in the associated calculations.

Determinations of Compliance With Standards

From the previous discussion, it follows that the establishment of limits on the concentration of individual radionuclides in various environmental media (e.g., air and water) is comparable to the establishment of dose limits for individual members of the population. Likewise, the placement of limits on total radionuclide releases from a nuclear facility is comparable to the establishment of limits on the associated permissible collective doses to the affected population. In terms of the determination of compliance with a set of standards, it is readily possible to measure the concentrations of individual radionuclides in various environmental media, and it is similarly possible to estimate the associated doses to individual members of the population. In contrast, estimates of the total releases of radionuclides from a nuclear facility would require not only knowledge of the concentrations of individual radionuclides in all environmental media, but also the determination of the rate of movement (transport) of each radionuclide (including the evaluation of site-specific pathways) within all such media from the facility to the accessible environment. Similar uncertainties would accompany estimates of the associated collective doses.

Summary

In summary, the Committee offers the following statements on the benefits of the application of various limits for determining the public health risks associated with nuclear operations.

1. Individual dose limits can be used to limit the risks to individual members of a population group.

2. Collective dose limits can be used to limit the societal impacts of doses to a large number of individuals. The accuracy of collective dose as a measure of societal risk, however, depends on the validity of the linear (non-threshold)

hypothesis in assessing the stochastic effects of ionizing radiation.

3. Collective dose calculations are representative of societal risk only if certain conditions are satisfied; namely, the exposed population is defined and characterized with respect to size, age, and sex; the distribution of doses to individual members of the population is within a limited range; the exposure pathways have been characterized for the population at risk; and individual contributions to the collective dose consist only of doses to the whole body, or to specific organs or tissues for which stochastic risk coefficients have been adopted.

4. Techniques for measuring the concentrations of individual radionuclides in various environmental media, and for estimating the associated dose rates to individual members of the population, are readily available, and compliance with such limits can be determined. In contrast, the measurements that would be required to determine the total releases of individual radionuclides from a nuclear facility and estimations of the associated collective dose to all offsite population groups would be difficult.

5. Given the general acceptance of the linear hypothesis, there is no biological basis on which to truncate calculations of collective doses. Nonetheless, regulators must recognize that estimates of dose rates from artificial radiation sources, that represent only a few percent of those from natural radiation sources, carry with them large uncertainties and relatively little aggregate risk. Such uncertainties may well serve as a basis for truncating collective dose calculations at very low dose rates without adverse impacts on estimates of the associated risks.

We trust that these comments will be helpful. We plan to review and comment on your report regarding this subject when it becomes available, consistent with the SRM dated April 18, 1991.

Sincerely,

Dade W. Moeller

Dade W. Moeller
Chairman

References:

1. International Commission on Radiological Protection, "1990 Recommendations of the International Commission on Radiological Protection," Publication 60, Annals of the ICRP (1991).
2. National Council on Radiation Protection and Measurements, "Recommendations on Limits for Exposure to Ionizing Radiation," Report No. 91 (1987).
3. National Radiological Protection Board, "Radiological Protection Objectives for the Land-based Disposal of Solid Radioactive Wastes." Consultative Document. NRPB-M279, March 1991.
4. "Possibilities and Limits of the Application of the collective Dose." A Recommendation of the Radiological Protection Commission (SSK). Bundesanzciger, No. 126a, July 1985.

Enclosure 2

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

April 29, 1991

MEMORANDUM FOR: B. J. Youngblood, Director
Division of High-Level Waste Management

FROM: R. F. Fraley, Executive Director
Advisory Committee on Nuclear Waste

SUBJECT: DRAFT STAFF TECHNICAL POSITION ON UNDERGROUND FACILITY DESIGN -- THERMAL LOADS

During the 30th meeting of the Advisory Committee on Nuclear Waste, April 23-24, 1991, the Committee discussed the Draft Staff Technical Position on Underground Facility Design -- Thermal Loads. The Committee decided that it has no objection to the staff's proposal to issue this technical position for public comment subject to due consideration to those comments made by the Committee during this discussion.

The Committee wishes to review the proposed final version of this technical position after public comments have been received and resolved.

References:
Memorandum from B. J. Youngblood, Division of High-Level Waste Management to R. F. Fraley, Advisory Committee on Nuclear Waste, transmitting the draft Staff Technical Position on Underground Facility Design -- Thermal Loads. U. S. Nuclear Regulatory Commission, March 22, 1991.

cc: H. Thompson, EDO
J. Blaha, EDO
R. Bernero, NMSS
J. Linehan, NMSS
J. Bunting, NMSS
J. Holonich, NMSS
A. Eiss, NMSS

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

April 29, 1991

The Honorable Kenneth M. Carr
Chairman
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Chairman Carr:

SUBJECT: CONSIDERATION OF HUMAN INTRUSION IN THE LICENSING OF A HIGH-LEVEL WASTE REPOSITORY

In its report to you dated May 1, 1990, the Committee recommended that the U.S. Environmental Protection Agency (EPA) standards for the disposal of high-level radioactive waste be revised to permit the application of a separate approach for evaluating the potential impacts of human intrusion. Mr. Floyd L. Galpin, Chief, Waste Management Standards Branch, Office of Radiation Programs, EPA, has requested that the Committee provide additional comments and elaboration regarding this subject. This letter is in response to that request.

One approach for evaluating human intrusion in the case of the geologic repository would be to apply techniques similar to those used by the NRC staff in assessing the threat of sabotage at nuclear power plants. In evaluating this threat, the NRC uses a deterministic rather than a quantitative probabilistic approach. The NRC approach recognizes the inherent uncertainties associated with the application of quantitative probabilistic techniques in assessing an issue of this nature.

The enclosed paper summarizes the NRC approach in the treatment and evaluation of the sabotage threat at nuclear power plants, and it addresses the issue of human intrusion as treated in the EPA standards. The paper was prepared by Mr. Steven E. Mays (ACRS/ACNW Fellow) at the request of the Committee. It has been discussed with members of the NRC staff, and it is being provided to you for possible forwarding to Mr. Galpin.

Sincerely,

Dade W. Moeller

Dade W. Moeller
Chairman

Enclosure:
As stated

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COMPARISON OF TECHNIQUES FOR ASSESSING NUCLEAR POWER PLANT PROTECTION AGAINST SABOTAGE AND HIGH LEVEL WASTE (HLW) REPOSITORY PROTECTION AGAINST HUMAN INTRUSION

Steven E. Mays
ACRS/ACNW Fellow

April 1991

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ABSTRACT

Human actions have the potential to bypass the protective features that minimize the likelihood of release of radioactive material to the environment from nuclear power plants or a geologic high level waste (HLW) repository. Sabotage of nuclear power plants and human intrusion into a geologic repository are examples of acts of commission that the NRC and EPA respectively have concluded require specific regulations. This paper compares the use of probabilistic techniques by the two agencies in dealing with these acts of commission. The NRC chose a deterministic approach for assessing the impact of sabotage on power plants and limited the use of probabilistic techniques to qualitative assessments of the adequacy of licensee security plans. EPA chose to require treatment of human intrusion quantitatively as an explicit part of the performance assessment required for licensing a geologic HLW repository.

COMPARISON OF TECHNIQUES FOR ASSESSING NUCLEAR POWER PLANT PROTECTION AGAINST SABOTAGE AND HIGH LEVEL WASTE (HLW) REPOSITORY PROTECTION AGAINST HUMAN INTRUSION

INTRODUCTION

Nuclear power plants have engineered features and proposed HLW repositories have engineered and geologic features that serve to limit the likelihood of release of radioactive material to the environment. In the case of nuclear power plants, several engineered barriers exist including the fuel cladding, the reactor coolant system boundary, and the containment. For spent fuel at a nuclear plant, the barriers include the fuel cladding and the spent fuel pool (or dry cask storage at some locations). For a HLW repository the proposed barriers include the fuel cladding, the containers for the spent fuel, and the geological formation (analogous to the reactor containment).

Human actions such as sabotage or human intrusion have the potential to bypass the features that limit the likelihood of release of radioactive material to the environment. While the intent of the participants and the nature of these two actions are different, such events are difficult to analyze by probabilistic techniques and at least sabotage is not so treated. This paper examines the extent that the two agencies use probabilistic techniques to regulate protection from these acts of commission. It is not intended to equate the physical acts themselves nor to state that the approach suggested here is the final word on the subject.

The NRC and EPA have regulations[1,2] requiring licensees to demonstrate their ability to maintain the integrity of the features against certain acts of commission. In the case of nuclear power plants, physical security requirements for protection against sabotage are contained in 10 CFR 73.55. For a HLW repository, the EPA requirements for human intrusion (HI) are contained in an appendix to 40 CFR 191.

While both agencies recognize the potential for human actions to bypass these protective features, the use of probabilistic techniques in the licensing and regulatory process is vastly different. Briefly stated, the EPA regulations require a quantitative probabilistic analysis (called a performance assessment) of the performance of the protective features of a repository over a 10,000 year period. This assessment must include human intrusion scenarios explicitly. The NRC approach with respect to sabotage at nuclear power plants, on the other hand, eschews quantitative probabilistic criteria in favor of a deterministic evaluation supported by qualitative use of probabilistic analyses.

The purpose of this paper is to compare the methods used by the NRC and EPA to regulate protection from sabotage at reactors and inadvertent human intrusion at a potential HLW repository. The paper specifically addresses the use of (or the lack of) probabilistic techniques in their regulations and applications. While there may be concerns regarding the similarity of the events themselves (and therefore the applicability of comparing the types of regulation) and

whether either agency has come upon the ultimate methodology for regulating them, this paper compares the regulations and applications as they currently exist. It is for the reader to determine the applicability of these techniques to the regulation of protection against sabotage at reactors and human intrusion at a HLW repository.

PROBABILISTIC TECHNIQUES

In any discussion of probabilistic analysis, definitions are important. Since the terms used by the two agencies differ somewhat, it is necessary to define the terms in this paper with respect to the two agency's terms.

The EPA regulations require, as a licensing condition for a HLW repository, a "performance assessment" of any potential site. The EPA has set release limits for various radionuclides and constructed a probabilistic criteria that the performance assessment needs to satisfy. Specifically, the assessment must analyze a variety of scenarios that could result in release of radioactive material to the environment and calculate a complementary cumulative distribution function (CCDF) that shows the likelihood of releases to be below the EPA's probabilistic limits. In nuclear power plant probabilistic risk assessment language, this is known as a "risk curve". This paper will use the terms CCDF and risk curve synonymously.

For nuclear power plants, risk curves are a quantitative part of the process known as probabilistic risk assessment (PRA) or probabilistic safety assessment (PSA). Thus, the performance assessment of the EPA requirements is analogous to a PRA for a nuclear plant. The elements of a PRA needed to generate a risk curve are a set of initiating events, a model of the plant response to these events (event trees and fault trees), and a model of the consequences of the various sequences derived from the models. Figure 1 shows the three major elements of a PRA along with its equivalent element from a performance assessment required by the EPA. The PRA risk curve is generated by propagating data distributions for the initiating events, plant response models, and consequence models to arrive at a distribution for each of the undesired sequences in the models. A distribution is derived for the sum of the sequence distributions and the risk curve (CCDF) for the result is produced. The equivalent elements of an EPA performance assessment are scenario development, HLW containment behavior models, and transport models. Distributions are propagated through these mathematical models in a manner similar to the PRA methods (although the mathematical models for containment and transport are much different from the event/fault tree models of PRA). The combination of the resulting distributions is used to produce the CCDF for comparison to the EPA requirements.

SABOTAGE VERSUS HUMAN INTRUSION

As noted before, both the NRC and the EPA recognized the potential for human actions to adversely impact the protective features of a nuclear power plant or potential HLW repository. The method for dealing with these two similar issues is vastly different.

Human actions that adversely impact the performance of protective features are

generally characterized by the PRA community as either acts of omission or acts of commission[3,4]. Acts of omission are cases where a required action does not occur. Acts of commission are cases where actions occur that adversely impact the protective features in spite of the fact that the action is neither required nor desired.

This paper characterizes sabotage and human intrusion as examples of acts of commission. While the intent of the participants in both cases is drastically different as is the physical nature of the actions, probabilistic analysis of acts of commission is the same. Current PRA practice excludes acts of commission from the quantitative process due to the inability to calculate either the frequency of such acts or their effects on the protective features. This paper compares the NRC use of probabilistic analysis techniques for regulating protection from sabotage to the EPA requirements for probabilistic analysis of human intrusion for a geological repository. It is not intended to equate the actions themselves.

NRC Approach to Sabotage

The NRC chose a deterministic, rather than a quantitative probabilistic approach, for dealing with sabotage. In fact, even with the current maturity of PRA (as compared with the emerging performance assessment techniques), the NRC has not used a risk curve as a licensing criteria for any plant, much less for the subset of events that would include sabotage.

The NRC approach recognized the inherent uncertainties and lack of data for quantifying the nature of or the probability of a sabotage event. It also recognized the difficulty in assessing the damage a potential sabotage event would have on the operation of the engineered features for limiting the release of radioactive material. In other words, quantifying sabotage initiating events and their effects on plant systems was impractical.

The NRC conducted studies to assess the threat level that plants would be required to address in their security plans. Their rules[1,5,6] recognized that a graded approach to sabotage protection at nuclear power plants (in comparison with nuclear weapons facilities or weapons grade material facilities) was appropriate. After determining the threat level that security plans must address, the NRC regulations specify the types of plant equipment that require protection and the level of protection required. For nuclear power plants, 10CFR73.55 specifies general performance objectives and requirements for the plant's physical security organization, physical barriers, access, detection, and communications.

This approach is similar to other NRC actions, such as regulations dealing with the spectrum of loss of coolant accidents (LOCAs) that emergency core cooling systems must be capable of mitigating. None of the sabotage regulations require quantitative analyses such as risk curves as a basis for acceptance. However, probabilistic techniques have played an important role in the NRC reviews of licensee security programs.

The NRC has used fault tree models as one tool for assessing the effectiveness of security programs. Fault tree models for almost every plant in the United

States have been prepared by the NRC. The models differ from typical PRA models by virtue of the fact that the vital equipment locations are included in the models. In a PRA, the fault tree models are reduced by computer algorithms to produce minimal cut sets. This qualitative analysis is necessary before data distributions can be propagated to produce a distribution for the system failure probability that eventually is part of the input to the risk curve (CCDF). For evaluating security programs, the location information included in the models is used to produce minimal cut sets containing location information instead of the actual vital equipment.

In addition, the fault tree models provide qualitative results that show the minimum number of areas that must be protected to ensure that the plant can be brought to a hot shutdown condition. This kind of qualitative information provides the NRC with a list of areas that can provide for safe plant shutdown in the event of a specific sabotage scenario.

EPA Approach to Human Intrusion

In contrast to the NRC, the EPA has chosen to include human intrusion (HI) in the quantitative analysis of performance assessment. In fact, the EPA not only requires that HI be considered, but also specifies how HI affects are to be calculated.

The EPA specifies a drilling density assumed to occur over a 10,000 year period. Further, the EPA allows no credit for active institutional controls beyond 100 years after repository closure. The EPA also states that passive institutional controls cannot be assumed to be a successful deterrent to a potential intruder.

To date, several attempts at developing and applying performance assessment methodologies to potential repository systems have been made[7,8,9]. In each case, the HI scenario has dominated the CCDF. In each case where the CCDF curves intersected the EPA requirements of part 191.13, removal of HI from the CCDF would eliminate the conflict. Figures 2 and 3 show CCDFs from studies along with the impact of HI on the numerical results.

COMMENTARY

Probabilistic techniques can be important tools in the regulatory arena. The products of probabilistic techniques can either be qualitative or quantitative in nature. The ability to use quantitative probabilistic techniques is highly dependent on the availability of data, the uncertainties in the data, and the uncertainties in the processes.

The dearth of data relating to sabotage events along with the uncertainties associated with the range of potential sabotage events and their impacts on engineered features led the NRC to chose a deterministic method for regulating licensee actions relating to physical plant protection in 10 CFR 73.55. The NRC uses qualitative probabilistic techniques as one measure of the effectiveness of licensee programs.

The EPA has decided to require development of a quantitative probabilistic

analysis in the form of a risk curve covering repository performance over a 10,000 year period as the basis for licensing a geologic HLW repository. Treatment of human intrusion is required as part of this analysis and the EPA standards specify that it must be included quantitatively. Whether this analysis should be quantitative, however, appears to be in question. Reasons for excluding human intrusion from the quantitative analysis follow.

Current PRA techniques have considerable difficulty quantifying human actions. The actions that PRAs try to include are those where operators fail to follow required actions (typically known as acts of omission). Acts of commission (such as sabotage or actions that operators might take that bypass engineered features when there is no compelling reason to take the action at all) are routinely excluded from quantitative risk assessments for nuclear power plants. The reason is simple. No one has produced a reliable method for predicting either the frequency or the effects of such actions. Qualitative methods using probabilistic techniques exist (such as confusion matrices and other tools) that can help to identify potential interactions, but none of these claim to be comprehensive even in the qualitative sense. Analyzing acts of commission over a 10,000 year time frame as required in the case of a geologic HLW repository would be even more difficult.

Except human intrusion, the EPA guidelines in 40CFR191 do not specify either the frequency of the scenarios that could adversely affect the protective features nor do they specify the ability of these features to withstand the potential scenario. Rather, the EPA requires that the analyses provide "reasonable expectation, based on performance assessments that the cumulative releases of radionuclides to the accessible environment for 10,000 years after disposal from all significant processes and events.." have less than a one in ten chance of exceeding the values in Table 1 of the rule and less than a one chance in 1,000 of exceeding ten times the Table 1 values.

For human intrusion, the EPA provides guidance on the frequency of the event, disallows any consideration of active institutional controls, and declares that passive controls can never be used to eliminate HI from consideration. This appears to be different from the other parts of the analyses that make up the quantitative risk curve. Limited performance assessment activities to date have indicated that the prescribed method of analyzing HI leads to CCDFs that exceed the EPA requirements.

The EPA regulations do not address the potential impact of human intrusion for alternate means of disposal compared to the deep geological HLW repository. HLW already exists and the only method currently approved for storing HLW is spent fuel pools or dry cask storage. Potential human intrusion leading to releases from these storage facilities over a 10,000 year period (or from some other means of disposal not addressed by the regulations) might be greater than that allowed for a deep geological repository.

CONCLUSIONS

Human actions have the potential to adversely affect the protective systems that limit the release of radioactive material to the environment. The NRC and EPA have chosen vastly different ways to deal with such actions in their regulations

for nuclear power plants and HLW repositories.

The EPA has opted for a quantitative, probabilistic analysis that includes human intrusion as one of its parts. The EPA guidelines specify the frequency of the HI events and the effectiveness of controls to prevent intrusion for the analysis. No such specification of frequencies or effectiveness of engineered systems for other scenarios is stipulated.

The NRC has opted for a deterministic approach for plant security. In a method similar to their treatment of design basis events, the NRC has specified a threat level that security plans must account for. The NRC requires identification of vital equipment and the areas encompassing vital equipment. Probabilistic techniques are used internally by the NRC staff to produce qualitative results that support the evaluation of the effectiveness of licensee security programs. Quantitative risk curves are not a licensing requirement for this issue. In fact, the NRC does not have any licensing criteria that require a risk curve comparison to a numerical standard.

This paper addresses the methods that the NRC and the EPA use to regulate protection from sabotage at reactors and inadvertent human intrusion at a potential HLW repository. While there may be concerns regarding the similarity of the events themselves (and therefore the applicability of comparing the types of regulation) and whether either agency has come upon the ultimate methodology for regulating them, this paper compares the regulations and applications as they currently exist. It is for the reader to determine the applicability of these techniques to the regulation of protection against sabotage at reactors and human intrusion at a HLW repository.

REFERENCES

1. Code of Federal Regulations, Title 10, Part 73, Physical Protection of Plants and Materials.

2. Code of Federal Regulations, Title 40, Part 191, Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes.

3. NUREG/CR-2300, PRA Procedures Guide.

4. NUREG/CR-1278, Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications.

5. NUREG-0800, Standard Review Plan, Chapter 13.6 Physical Security.

6. USNRC Review Guideline 17, Definition of Vital Areas and Equipment.

7. NUREG/CR-4510 (SAND86-0121), Assessing Compliance With the EPA High-Level Waste Standard: An Overview.

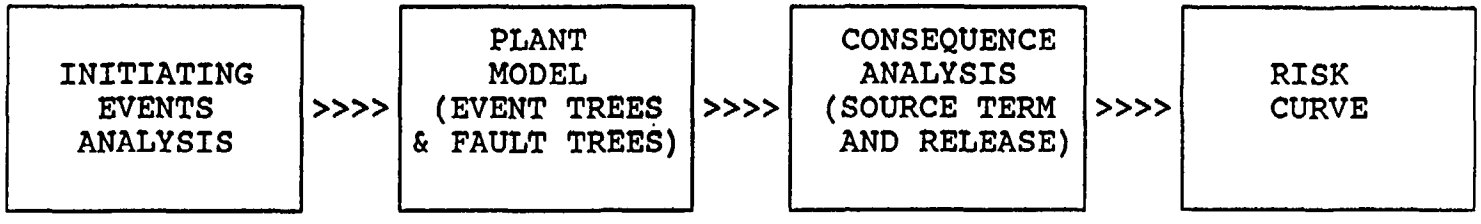
8. SANDIA presentation, 25th ACNW meeting transcript, October 24, 1990.

9. NRC staff presentation, 25th ACNW meeting transcript, October 25, 1990.

10. GAO Report to Congress, Security at Nuclear Power Plants- At Best, Inadequate, April 7, 1977.

11. GAO Report to NRC Chairman, Additional Improvements Needed in Physical Security at Nuclear Power Plants, July 13, 1983.

PROBABILISTIC RISK ASSESSMENT ELEMENTS



PERFORMANCE ASSESSMENT ELEMENTS

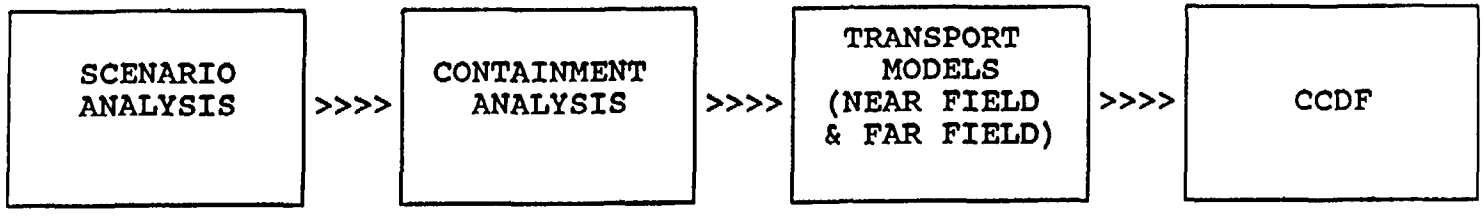
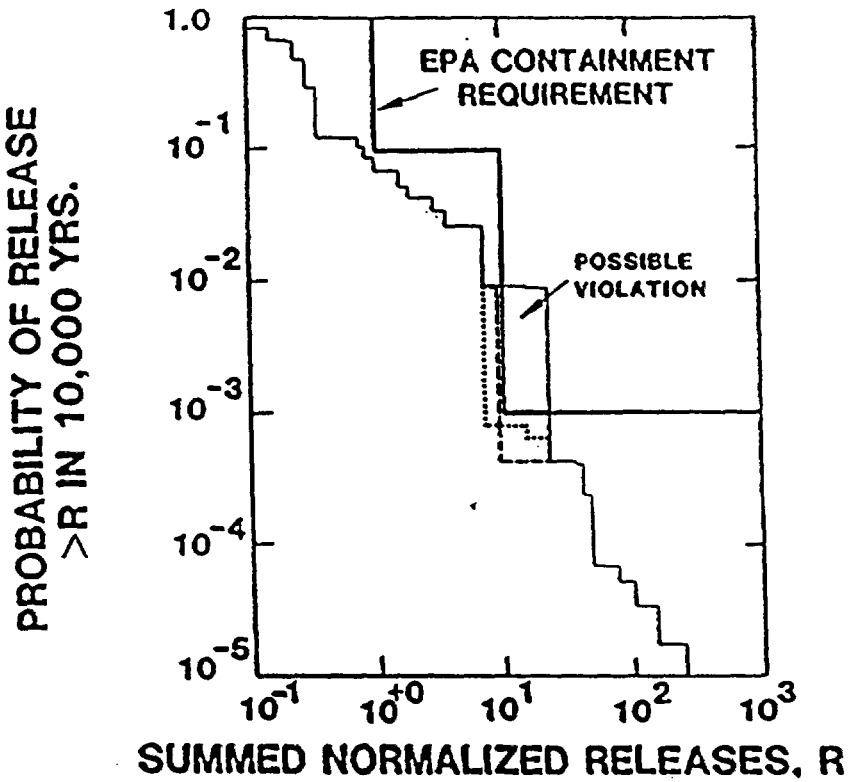
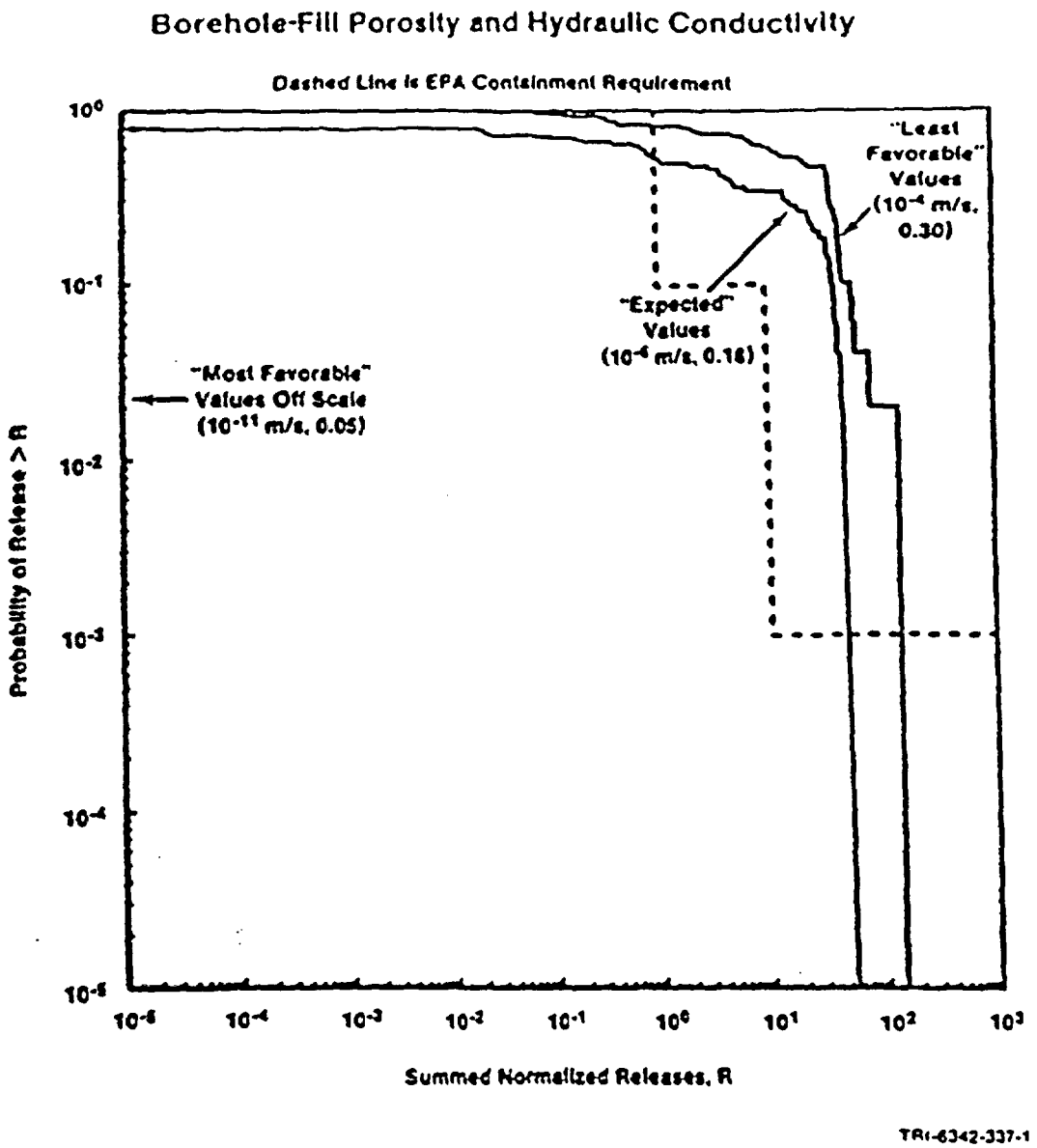


Figure 1. Comparison of PRA and PA Elements



CCDF for the Example plotted with EPA containment requirement.

Figure 3. SANDIA Report SAND86-0121-(NUREG/CR-4510) Overview of Assessing Compliance with 10 CFR 191



Conditional CCDF curves showing sensitivity to variations in borehole-plug porosity and hydraulic conductivity (Anderson et al., 1990). "Expected" and "least favorable" values for deteriorated borehole-plug porosity and hydraulic conductivity are shown. "Most favorable" values, corresponding to the properties of the repository seals, plot off-scale. Curves assume intrusion scenario E1 occurs. Curves were calculated using the preliminary modeling system described in Marietta et al. (1989) and cannot be used to judge compliance or noncompliance because all significant scenarios are not included, crucial models and data are missing, surface releases are omitted, and the Standard has been vacated. They simply measure modeling sensitivity to variations in the test parameters.

Figure 2. SANDIA Analysis of WIPP Performance for Human Intrusion

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

April 29, 1991

The Honorable Kenneth M. Carr
Chairman
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Chairman Carr:

SUBJECT: PROGRAM PLAN FOR THE ADVISORY COMMITTEE ON NUCLEAR WASTE

This is our fifth response to your memorandum of November 6, 1989, in which you requested that the Advisory Committee on Nuclear Waste (ACNW) provide a program plan at four-month intervals. This plan covers the period May-August 1991. We hope you will find this a convenient avenue for us to share information on our proposed upcoming activities and for you to provide feedback on issues on which the Commission wishes us to focus our efforts.

In preparing this program plan, we have considered the list of specific technical issues of particular interest to the Commission, requests of individual Commissioners, the EDO's list of proposed agenda items for the ACRS and the ACNW, the NRC's Five-Year Plan, and items of particular interest and/or concern to the Committee. The priorities proposed are based on information provided by representatives of NMSS, NRR, RES, and the EDO office, as well as our own interpretation of the subject in relation to our activities as a Committee and our input into the regulatory process.

This program plan is based on the current best estimates of work output by the DOE, EPA, NRC staff, and their consultants and contractors, as well as our own estimates of how to deal with these issues effectively. In addition to the full Committee meetings noted, Working Group meetings will be held as necessary to facilitate full Committee review and action. There may be some revisions to this plan associated with the completion of NRC staff, applicant, and/or contractor studies and reviews as well as other schedule problems beyond our control.

Full Committee meeting dates for this period are tentatively scheduled as follows:

31st Meeting	-	May 22-23, 1991
32nd Meeting	-	June 20, 1991
33rd Meeting	-	July 24-26, 1991
34th Meeting	-	August 28-29, 1991

The Committee anticipates considering the topics listed below during this four-month period.

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May 22-23, 1991

- The Committee will be briefed on Working Draft #3 of the Environmental Protection Agency's 40 CFR Part 191, High-Level Waste Repository Standards, if available. (High Priority)

- The Committee may continue discussions which address dealing with uncertainties in implementing the EPA High-Level Waste Standards. (High Priority)

- The Committee will hear a report from its Working Group Chairman on a recent meeting concerning Integration of Geophysics into Site Characterization of a High-Level Waste Repository. (Medium)

- The Committee will be briefed by representatives from the State of South Carolina on the implementation of its agreement state program. (Medium Priority)

- The Committee will discuss information obtained by members from attendance at the Second Annual International High-Level Radioactive Waste Management Conference and a field trip to Lunar Craters. (Medium Priority)

- The Committee will be briefed on a digital data set prepared for the Yucca Mountain site. (Medium Priority)

- The Committee will be briefed on research sponsored by the Department of Energy related to site characterization. An overview of this research is sought. (High Priority)

June 20, 1991

- The Committee will respond to a Staff Requirements Memorandum concerning the need for revision to 10 CFR Part 61 as it relates to low-level waste form leachability and groundwater protection requirements. (High Priority)

- The Committee will hear a report by a member on a recent visit to the West Valley Demonstration Project. (Medium Priority)

- The meeting with the Commission which was scheduled for the June ACNW meeting has been tentatively deferred to July by SECY. This meeting may still be scheduled for the June ACNW meeting if appropriate Commissioners can be available.

July 24-26, 1991

- The Committee will meet with the Commissioners to discuss items of mutual interest. (High Priority)

- The Committee will review and comment on an NRC staff report that discusses exemptions to 10 CFR Part 20 that allow sewer disposal for certain waste streams. (High Priority)

- Listing of Facilities and Structures in One Document. The Committee will review and comment on a proposed rule dealing with record keeping for modifications and procedures made during decommissioning. This rulemaking is in response to a Congressional request. (High Priority)

- The Committee will review and comment on the first of the two groups of draft Regulatory Guides implementing the revised 10 CFR Part 20, Standards for Protection Against Radiation. (High Priority)

- The Committee will discuss its recent trip to and meeting at the Center for Nuclear Waste Regulatory Analyses. (Medium Priority)

- The Committee will discuss and report on how expert judgment will be used in conducting performance assessments used in the licensing of high-level and low-level waste repositories. (High Priority)

August 28-29, 1991

- The Committee will invite the State of Nevada to present a summary and discussion of the State's review and comments on DOE's Site Characterization Plan and related Study Plans. (High Priority)

- The Committee will invite DOE to present a summary and discussion of the DOE responses to comments by EPA, NRC and State of Nevada on the Yucca Mountain Site Characterization Plan. (High Priority)

- The Committee will review and comment on the NRC staff's Technical Position on Investigations to Identify Fault Displacements and Seismic Hazards. (Medium Priority)

- The Committee will hear a presentation on the proactive program for HLW. This involves planned rulemakings, guidelines, and technical position in support of the HLW program. (High Priority)

- The Committee will hear a report from its Working Group on Quaternary Dating Methods. (Medium Priority)

- The Committee will review and comment on the staff's analysis of the benefits and limitations of using collective dose and individual dose approaches as the basis for establishing standards for a high-level waste repository. (High Priority)

Unscheduled Discussions: (Will be considered as documents and time become available.)

- The Committee will be briefed on the NRC HLW staff's position on penetration of the Calico Hills tuff. (High Priority)

- The Committee plans to invite a representative from AECL to discuss Canada's high-level waste standards. (Low Priority)

- The Committee will be briefed on the staff's review of the Exploratory Shaft Alternatives Study and the Surface Based Testing Prioritization study. The studies are being prepared by DOE. The Committee will review these studies when available. (High Priority)

- The Committee will be briefed by EPA on their adoption of a revised Hazard Ranking System used in assessing the threat associated with the release or potential release into the environment of hazardous chemicals and/or radioactive materials. (Low Priority)

- The Committee will be briefed by the NRC staff on a recent technical meeting on the Alligator River Analogue Project. This project is designed to investigate the Koongarra uranium ore body, a natural analogue to a high-level waste repository. (High Priority)

- The Committee will discuss an alternative probabilistic format for the containment requirements in EPA's high-level waste standards. Processes and events potentially affecting a repository would be divided into three categories (likely conditions, unlikely conditions, and very unlikely conditions). (High Priority)

- The Committee will discuss issues related to post closure monitoring of a high-level waste repository. (High Priority)

- The Committee will discuss a recent report concerning Mortality Among Workers at Oak Ridge National Laboratory.

- The Committee will discuss and make recommendations on criteria for the cleanup of sites contaminated with residual

level of radioactivity (e.g., natural uranium, depleted uranium, thorium, etc.).

This list represents our best estimate of the topics to be considered through August 1991. If you or your fellow Commissioners have additional items to suggest or proposed changes in priorities, please let us know.

Sincerely,

Dade W. Moeller

Dade W. Moeller
Chairman

cc: Commissioner Rogers
Commissioner Curtiss
Commissioner Remick
Samuel J. Chilk, SECY
James M. Taylor, EDO
Robert M. Bernero, NMSS

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

April 29, 1991

Mr. Robert M. Bernero, Director
Office of Nuclear Material Safety
and Safeguards
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Dear Mr. Bernero:

SUBJECT: INDIVIDUAL AND COLLECTIVE DOSE LIMITS AND RADIONUCLIDE RELEASE LIMITS

The Advisory Committee on Nuclear Waste has been developing comments, thoughts, and suggestions relative to individual and collective dose limits and radionuclide release limits. Since we understand that your staff is reviewing these same topics, we wanted to share our thoughts with you. In formulating these comments, we have had discussions with a number of people, including members of the NRC staff and Committee consultants. The Committee also had the benefit of the documents listed.

Basic Definitions

As a basic philosophy, individual dose limits are used to place restrictions on the risk to individual members of the public due to operations at a nuclear facility. If the limits have been properly established and compliance is observed, a regulatory agency can be confident that the associated risk to individual members of the public is acceptable. Because the determination of the dose to individual members of the public is difficult, the International Commission on Radiological Protection (ICRP) has developed the concept of the "critical group" and recommends that it be used in assessing doses resulting from environmental releases. As defined by the ICRP, a critical group is a relatively homogeneous group of people whose location and living habits are such that they receive the highest doses as a result of radionuclide releases. The group may be real (in which case their actual habits may be known or predicted) or hypothetical (in which case their habits may be assumed, based on observations of similar groups).

The dose to individuals within the critical group is assumed to be that received by a typical member of the group. The purpose of this approach is to ensure that members of the public do not receive unacceptable exposures while, at the same time, ensuring that decisions on the acceptability of a practice are not prejudiced by a very small number of individuals with unusual habits.

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If the number of people being exposed is large, the question often arises as to how to quantify the societal impact of the individual exposures. The collective dose concept was developed for expressing that impact in a quantitative manner and, as such, it is a numerical expression of the summed doses to a given population.

In many respects, placing limits on total radionuclide releases from a nuclear facility is comparable to placing a limit on its total societal impact. In other words, placing a limit on the quantity of a given radionuclide that can be released is equivalent to placing a limit on the total societal impact that the facility can exert. This was the basis used by the U.S. Environmental Protection Agency (EPA) in setting release limits for a high-level radioactive waste repository, and it relates directly to EPA's basic criterion that the number of health effects should not exceed 1,000 during the first 10,000 years.

Underlying Assumptions

Although it is generally accepted that the dose received by an individual is a reasonable expression of the associated risk, it is questionable whether the collective dose is a true measure of the societal impact of the aggregate of exposures to individual members of a population. Implicit in the concept of collective dose is the assumption that the linear hypothesis is correct, that is, that there is a linear (non-threshold) relationship between the total dose to a population group and the associated health impacts.

In many ways, application of the collective dose concept leads to a paradox. At high doses and high dose rates where the risk coefficients are best known, the concept of collective dose cannot be applied since the dose-response curve is nonlinear; at low doses and low dose rates where linearity between dose and the associated health effects is assumed to apply, the risk coefficients are far less certain. This leads to additional restrictions in the application of the collective dose concept, as follows:

- The exposed population must be well known with respect to size and possibly age, sex, and temporal distributions.
- The exposure pathways must be characterized for the population at risk.
- Individual contributions to the collective dose must consist only of doses to the whole body, or to specific organs or tissues for which stochastic risk coefficients are known.

In short, application of the collective dose concept requires detailed knowledge of the exposed population and the radiation doses to its members. The collective dose concept is valid for representing the collective risk only if both of these factors can

be described and quantified, and it should be used for risk assessments only if the associated uncertainties are sufficiently small that the calculated collective dose itself is within an acceptable range of uncertainty. In addition, it is important to note that a high individual risk to a small number of people is not necessarily the same as a low individual risk to a large number of people, even though the collective dose may be the same. For this reason, expressions of societal risk in terms of collective dose should always include detailed data not only on the number of people exposed, but also on the number of people receiving exposures within each dose range. Although collective dose can be used as a surrogate for societal risk, its interpretation requires care.

Truncation of Collective Dose Calculations

On a theoretical basis, there is no justification for excluding the application of the linear hypothesis to the evaluation and interpretation of the societal impact of low doses and low dose rates on population groups. This hypothesis, in fact, has been generally accepted by the scientific community, including organizations such as the National Council on Radiation Protection and Measurements (NCRP) and the ICRP, as a valid basis for estimating the stochastic risks associated with low doses of ionizing radiation. If one accepts this observation, calculations of collective doses should include the doses to all individuals within the population group, regardless of how small the associated doses and/or dose rates may be. At the same time, however, it is important to recognize that there may be cogent reasons for not including within collective dose calculations extremely low doses to individual members of a population group. Several approaches that have been proposed and/or applied to justify such omissions are discussed below.

Following the concept that certain risks to individual members of the population are negligible, the NCRP has recommended (under what it defines as the concept of a "Negligible Individual Risk Limit") that annual doses to individual members of the population that are less than 0.01 mSv (1 mrem) be excluded from collective dose calculations. In interpreting this recommendation, however, it is important to understand the underlying principle on which it was based. Informal discussions with representatives of the NCRP revealed that truncation in this case was considered to be acceptable from the standpoint of societal impact, because the burden on society represented by any additional cancers among people receiving exposures in this dose rate range would not necessitate any additional medical facilities. Another approach for truncation that has been informally suggested by representatives of the NCRP is that it might be permissible to discard a collective dose (calculated on the basis of extremely low dose rates to members of an exposed population) provided that the

associated collective dose would not be estimated to result in one additional cancer.

Variations in the dose rates from natural background radiation sources have been proposed as another basis on which to truncate collective dose calculations. The contribution to collective dose from natural sources is large relative to that from many artificial sources. Consequently, it is often difficult to measure in a meaningfully quantitative manner very low dose rates to individual members of the population that arise from artificial sources. Thus, although there may be no biological basis for excluding very low dose rates from collective dose calculations, there is justification for excluding them on a statistical basis because of the uncertainties in the associated calculations.

Determinations of Compliance With Standards

From the previous discussion, it follows that the establishment of limits on the concentration of individual radionuclides in various environmental media (e.g., air and water) is comparable to the establishment of dose limits for individual members of the population. Likewise, the placement of limits on total radionuclide releases from a nuclear facility is comparable to the establishment of limits on the associated permissible collective doses to the affected population. In terms of the determination of compliance with a set of standards, it is readily possible to measure the concentrations of individual radionuclides in various environmental media, and it is similarly possible to estimate the associated doses to individual members of the population. In contrast, estimates of the total releases of radionuclides from a nuclear facility would require not only knowledge of the concentrations of individual radionuclides in all environmental media, but also the determination of the rate of movement (transport) of each radionuclide (including the evaluation of site-specific pathways) within all such media from the facility to the accessible environment. Similar uncertainties would accompany estimates of the associated collective doses.

Summary

In summary, the Committee offers the following statements on the benefits of the application of various limits for determining the public health risks associated with nuclear operations.

1. Individual dose limits can be used to limit the risks to individual members of a population group.

2. Collective dose limits can be used to limit the societal impacts of doses to a large number of individuals. The accuracy of collective dose as a measure of societal risk, however, depends on the validity of the linear (non-threshold)

hypothesis in assessing the stochastic effects of ionizing radiation.

3. Collective dose calculations are representative of societal risk only if certain conditions are satisfied; namely, the exposed population is defined and characterized with respect to size, age, and sex; the distribution of doses to individual members of the population is within a limited range; the exposure pathways have been characterized for the population at risk; and individual contributions to the collective dose consist only of doses to the whole body, or to specific organs or tissues for which stochastic risk coefficients have been adopted.

4. Techniques for measuring the concentrations of individual radionuclides in various environmental media, and for estimating the associated dose rates to individual members of the population, are readily available, and compliance with such limits can be determined. In contrast, the measurements that would be required to determine the total releases of individual radionuclides from a nuclear facility and estimations of the associated collective dose to all offsite population groups would be difficult.

5. Given the general acceptance of the linear hypothesis, there is no biological basis on which to truncate calculations of collective doses. Nonetheless, regulators must recognize that estimates of dose rates from artificial radiation sources, that represent only a few percent of those from natural radiation sources, carry with them large uncertainties and relatively little aggregate risk. Such uncertainties may well serve as a basis for truncating collective dose calculations at very low dose rates without adverse impacts on estimates of the associated risks.

We trust that these comments will be helpful. We plan to review and comment on your report regarding this subject when it becomes available, consistent with the SRM dated April 18, 1991.

Sincerely,

Dade W. Moeller

Dade W. Moeller
Chairman

References:

1. International Commission on Radiological Protection, "1990 Recommendations of the International Commission on Radiological Protection," Publication 60, Annals of the ICRP (1991).
2. National Council on Radiation Protection and Measurements, "Recommendations on Limits for Exposure to Ionizing Radiation," Report No. 91 (1987).
3. National Radiological Protection Board, "Radiological Protection Objectives for the Land-based Disposal of Solid Radioactive Wastes." Consultative Document. NRPB-M279, March 1991.
4. "Possibilities and Limits of the Application of the collective Dose." A Recommendation of the Radiological Protection Commission (SSK). Bundesanzciger, No. 126a, July 1985.