Department of Energy
Washington, DC 20585

November 2, 1995

Mr. Ray Clark
National Academy of Sciences Report Comments
Radioactive Waste Management Branch (6602J)
Office of Radiation and Indoor Air
U.S. Environmental Protection Agency
401 M Street SW
Washington, D.C. 20460-001

Dear Mr. Clark:

On September 11, 1995, the Environmental Protection Agency published in the Federal Register a notice of availability of the National Academy of Sciences report, "Technical Bases for Yucca Mountain Standards," and requested comments on its contents. Pursuant to your request, enclosed for your consideration are the Department of Energy's comments and recommendations on the Academy report. At a later date, we expect to provide you with more detailed recommendations on several issues that we believe are critical to your future rulemaking activities.

We recognize that the Academy had a difficult task to perform, and while we do have some concerns with their recommendations, we generally applaud their efforts. We appreciate the difficult task before the Agency to develop reasonable standards for the protection of public health and safety. It is important that such standards be developed in an expeditious manner, as envisioned by the Energy Policy Act of 1992. This letter summarizes some overall concerns we have that are important for you to consider as you proceed with this rulemaking.

In the Nuclear Waste Policy Act of 1982, as amended, Congress found that high-level radioactive waste had created a potential risk to the public, that it requires safe and environmentally acceptable methods of disposal, and that the Federal Government has the responsibility to provide for its permanent disposal. In addition, Congress declared that permanent disposal of the waste and spent nuclear fuel is to be provided in a geologic repository. Promulgating an unworkable standard may result in the de facto rejection of geologic disposal. Such rejection will not remove the consequences of radioactive waste management, it will simply result in a different and currently unidentified long-term approach. The nation must develop a workable standard that protects the public health and safety and the environment.

The Department urges the Agency to be cognizant of the risk that a philosophically and technically logical standard may not be implementable in a licensing environment in which uncertainty may be viewed as failure to demonstrate compliance. There are several assumptions made in the Academy report that need to be carefully evaluated in terms of their implementation in a licensing process. For example, the Academy concluded that the geologic framework at Yucca Mountain was either geologically stable or was expected to vary in such a way as to be predictable for a period in the order of a million years. The Department believes that it will be extremely difficult to support such predictions against opposing viewpoints with sufficient

certainty to provide confidence in a licensing proceeding. The Academy also indicated that the biosphere can be modeled into the far future by making what it believes to be cautious but reasonable assumptions. The Department agrees that such assumptions should be defined in the standard as a matter of policy since future biosphere characteristics would be too controversial to be demonstrated with evidence in a proceeding.

The Academy was mindful that the development of the standard would have to take into account technical, policy, and other relevant considerations. In addition, the Academy noted that the Department would have to demonstrate compliance with the standard in a Commission licensing proceeding. The Department considers this point to be very important and believes that value judgments made on the basis of technical assumptions, like the ones referenced above, are inherently a matter of policy and should be treated as such in the standard-setting process.

Therefore, we strongly recommend that those of the Academy's technical conclusions or assumptions with which the Agency agrees, or any other assumptions ultimately relied upon by the Agency, be directly incorporated into the standard. This would eliminate the need to adjudicate them during the licensing proceedings. For example, as the Academy indicated, the Agency should define a reference biosphere in the standard. The Department also believes that the Agency should stipulate in the standard which of the predominant physical aspects of the site can be considered stable for the purposes of compliance demonstration. We believe that the Agency, through its rulemaking process, is the most appropriate forum to address these issues, which are inherently value judgments. The Commission licensing process, in turn, is the appropriate forum for the parties to probe whether the Department has adequately demonstrated that the repository will meet the Commission's requirements which flow from the standard.

While the Department has the concerns expressed above and further discussed in the enclosure, the Department supports the Academy's recommendation of the use of a health-based standard, the focus of a standard on the people in the vicinity of Yucca Mountain, and the application of negligible individual risk. We agree that the appropriate basis of a quantitative evaluation of compliance is the mean of calculated results, and we agree as well with the caution against the application of subsystem performance requirements.

In summary, we realize that development of this radiation protection standard will not be an easy task. We urge the Agency to evaluate carefully each of the Academy recommendations to separate technical issues from those that are a matter of policy and to consider the intent of Congress and the national significance of geologic disposal. The Department considers it important that Yucca Mountain standards not only be implementable and understandable, but also be consistent with other radiation standards and regulations. Demonstrating compliance with the standards should not require a degree of proof that is beyond what science can reasonably provide and defend in a licensing environment.

If you have any questions, please contact Dr. Stephan J. Brocoum of the Yucca Mountain Site Characterization Office at (702) 295-9611.

Sincerely,

Daniel A. Dreyfus, Director
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Enclosure

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Enclosure

DEPARTMENT OF ENERGY COMMENTS AND RECOMMENDATIONS ON THE NATIONAL ACADEMY OF SCIENCES REPORT "TECHNICAL BASES FOR YUCCA MOUNTAIN STANDARDS"

BACKGROUND

The Energy Policy Act of 1992 (Public Law 102-486, 1992) directed the EPA to contract with the National Academy of Sciences (NAS) to conduct a study to provide findings and recommendations on reasonable standards for protection of the public health and safety. The 1992 law also directed the EPA, based on the recommendations of the NAS, to promulgate public health and safety standards for protection of the public from releases of radioactive materials stored or disposed of in the repository at the Yucca Mountain site. Furthermore, the Nuclear Regulatory Commission (NRC) was directed to modify its requirements to be consistent with the EPA standards.

The NAS formed the Committee on Technical Bases for Yucca Mountain Standards to prepare its recommendations to the EPA. The committee held public meetings in May, August, November, December of 1993, and April of 1994. The committee report, Technical Bases for Yucca Mountain Standards (NAS, 1995), containing recommendations to the EPA, was issued in August of 1995. By Federal Register notice of September 11, 1995, the EPA requested comments on the NAS report. The DOE is providing the following comments on the NAS recommendations on Yucca Mountain standards in accordance with the request from the EPA for such input.

GENERAL COMMENTS

1. The NAS recommendations have potentially far-reaching implications for geologic disposal in general. EPA needs to be very careful in how they are addressed in the rulemaking. As stated at the first public meeting of the NAS committee in May of 1993, the DOE considers it important that Yucca Mountain standards be implementable and understandable, be consistent with other radiation standards and regulations, and not require a degree of proof that is beyond what science can reasonably provide and defend in a licensing environment.

2. The DOE notes that the 1995 report on Yucca Mountain standards is, in some ways, inconsistent with the 1990 NAS "Rethinking" report (NAS, 1990). Specifically, the 1990 report recommended de-emphasizing quantitative model predictions, and using models primarily for comparative purposes and for identifying sensitivities and uncertainties.

SPECIFIC CONCERNS AND RECOMMENDATIONS

1. Demonstration of Compliance for Periods Longer Than 10,000 Years

Summary of NAS Recommendation

The NAS recommended compliance with a risk-based standard at the time of greatest risk within the limits imposed by the long-term stability of the geologic environment. They stated that the fundamental geologic regime at Yucca Mountain could be expected to remain predictable for approximately 1,000,000 years. The NAS also stated that there is no technical reason to limit the time period of a standard to 10,000 years, but that the EPA may have policy or other non-technical reasons to do so.

DOE Concern and Recommendation

Quantitative demonstration of compliance for a period more than 10,000 years after closure is a concern. The time period of regulatory concern is ultimately a policy decision. Other EPA regulations include time frames of 1,000 years for the regulation of uranium mill tailings (EPA, 1987), and 10,000 years for the regulation of underground injection of hazardous waste (EPA, 1988). Therefore, a regulatory time frame between 1,000 and 10,000 years is consistent with other EPA regulations on long-lived radioactive or hazardous material. The general standard for geologic repositories, 40 CFR Part 191, incorporates a 10,000 year period of regulatory concern for evaluating radionuclide releases. In promulgating that regulation, the EPA stated:

> A period of 10,000 years ... appears to be long enough to distinguish geologic repositories with relatively good capabilities to isolate wastes from those with relatively poor capabilities. On the other hand, this period is short enough so that major geologic changes are unlikely and repository performance might be reasonably projected. (EPA, 1985)

The 10,000-year time frame of 40 CFR Part 191 was upheld in Natural Resources Defense Council, Inc. v. U.S. Environmental Protection Agency, 824 F.2d 1258 (1st Cir. 1987), as adequately justified. Furthermore, it has been endorsed by the NRC as a practical time period for determining compliance (NRC, 1993).

The DOE recognizes that health effects from a repository could occur at times much greater than 10,000 years after permanent closure. However, the uncertainty in calculated results increases with the time of the projection, to the point that extremely long-term performance calculations would have little value. DOE has never intended to ignore longer term impacts of repository performance. Indeed, DOE intends to conduct long-term assessments to gain some insight into the long-term performance of the repository system or for comparisons among alternative designs. Site characterization interactions with the NRC on Yucca Mountain issues have made it clear that the significant uncertainties inherent in long-term geological predictions make it difficult to successfully demonstrate compliance with standards that are applied for "only" 10,000 years. Demonstrating compliance at any site, including Yucca Mountain, by projecting doses which could occur hundreds of thousands of years in the future may not be feasible, given the current regulatory structure. Even if the conclusion reached by the NAS, that the geologic

framework at Yucca Mountain is either stable or varies in such a way as to be quantifiable for over a period of one million years, is accepted, the bounds that must be assumed for the geologic processes and events are expected to be too large to make a meaningful demonstration of compliance in a licensing proceeding.

The NAS noted that some performance assessment calculations indicate that the peak risk would occur after 10,000 years, which motivated them to consider compliance assessment at peak risk. The NAS acknowledged that the basis for its recommendation is limited to technical considerations and that the EPA may choose to adopt a different regulatory time frame based on policy or other considerations. The DOE recommends that the time frame for requiring meaningful quantitative projections should be no longer than 10,000 years. If time frames longer than 10,000 years are addressed in a standard, then the associated requirements should be qualitative. No regulatory time frame of any kind greater than 10,000 years should be imposed without first understanding the details of how the NRC would implement such a requirement, and how the DOE could demonstrate compliance with such a standard in a licensing proceeding.

2. The Risk Level of 10^{-6} to 10^{-5} Fatal Cancers per Year as a Starting Point

Summary of NAS Recommendation

The NAS did not recommend a level of acceptable risk; however, it recommended that such an acceptable level of risk be established through rulemaking. The NAS suggested that a risk level in the range of 10^{-6} to 10^{-5} fatal cancers per year be used as a reasonable starting point for the rulemaking.

DOE Concern and Recommendation

The NAS suggestion to use a risk level range of 10^{-6} to 10^{-5} fatal cancers per year as a starting point is based on their observation that such a range is consistent with other U.S. nuclear regulations cited in Table 2-4 on page 50 of the NAS report. However, none of the regulations listed in the table require that such a limit be used for compliance assessment at hundreds of thousands of years in the future, as the NAS is recommending for Yucca Mountain.

In calculating the risk levels, the NAS recommended using the assumption that future people behave similarly to present day society. This assumption makes the calculation tractable, but it is not considered realistic, considering the rate of technological and social change that can be observed in our modern society. As noted in the NAS Report, it is impossible to predict, in absolute terms, the makeup and characteristics of future societies. However, it is possible to make reasonable assessments of the possibilities and the implications of these possibilities on health risks to future inhabitants. Future societies will be either less advanced than, similar to, or more advanced than people today. Less advanced societies would most likely not possess the technology to access contaminated groundwater, or, if they did, the people would face other health risks (disease, malnutrition, etc.) that would overwhelm the risks posed by a repository. Present day society has the capability to test drinking water supplies, detect radioactive hazards, and take protective action. More advanced societies would be even more likely to detect hazards from contaminated groundwater and take steps to allay those hazards. Accordingly, the implicit

assumption that future humans (1) can and will access contaminated groundwater, but (2) will not test and treat their water supply, is extremely conservative. Absent the ability to predict the future it is impossible to quantify the exact degree of this conservatism, but it should be recognized and factored into setting the risk limits for the Yucca Mountain standard.

The DOE recommends that because of the overwhelming conservatism embodied in the underlying assumptions related to risk level calculations, a range of 10^{-5} to 10^{-4} fatal cancers per year be used as a starting point for the EPA's rulemaking.

In addition, DOE recommends that EPA should make it explicit and clear in the Yucca Mountain standard that the risk levels calculated by the NAS-proposed methodology are not predictive in nature, and therefore not real risk numbers. Instead they are a means for decision making using stylized calculations with implicit assumptions that cannot be verified but are considered extremely conservative.

3. Quantitative Treatment of Human Intrusion

Summary of NAS Recommendation

The NAS recommended that the "EPA should specify in its standard a typical intrusion scenario to be analyzed for its consequences on the performance of the repository" (NAS, 1995). This would not be integrated into a risk assessment, but would be considered separately. The NAS did not specify the typical intrusion scenario, but suggests a stylized scenario consisting of one borehole of a specified diameter drilled from the surface through a canister of waste to the underlying aquifer. The analysis should determine how the hypothesized intrusion event affects the risk to the critical group, with the "figure-of-merit" (presumably the risk limit) being the same as for the undisturbed case. The analysis would identify the "incremental effects from the assumed scenario." The "... EPA should require that the conditional risk as a result of the assumed intrusion scenario should be no greater than the risk levels that would be acceptable for the undisturbed-repository case."

The NAS acknowledged that analyses of intrusion consequences would be more meaningful "... in selecting among alternative sites (such as by avoiding sites that have potentially valuable mineral, energy, or groundwater resources) than in assessing the performance of a particular site or design."

DOE Concern and Recommendation

The "conditional risk" evaluation of human intrusion is a concern. The logical impact of this type of requirement is to require that the overall evaluation of repository risk include one stylized intrusion event. The NAS recommended that alternative scenarios of human intrusion should not be incorporated into a "... fully risk based compliance assessment that requires knowledge of the character and frequency of various intrusion scenarios." Assuming that the "intruded" repository performs worse than the "non-intruded" repository, and both evaluations are compared to the same risk limit, it is obvious that the "intruded" case will be limiting. Despite the fact that the NAS stated that human intrusion should not be included in a "fully risk based compliance

assessment," the only evaluation that would matter is the one that includes the assumed intrusion scenario.

The intrusion event that is assumed may well be the major factor in determining whether or not any geologic repository meets or does not meet the risk standard. However, the NAS admitted that there is no basis for specifying the scenario. The NAS noted that specifying the scenario requires judgment, and therefore recommended that the EPA make the determination of the required scenario via rulemaking. However, the rulemaking process does not reduce the uncertainty in the result. Lacking any technical basis for the specification of the intrusion scenario, the resulting scenario would likely be arbitrary, and would not have any demonstrable link to protecting the health and safety of the public.

The DOE recommends that a quantitative evaluation of human intrusion not be included in health and safety standards for Yucca Mountain. Intrusion should be addressed with qualitative design requirements and passive institutional controls. If, in making such qualitative assessments an intrusion scenario must be used, then a specific scenario should be specified in the standard.

4. Method of Specifying the Exposure Scenario to the Critical Group

Summary of NAS Recommendation

The NAS recommended that the critical group approach be used to determine the risk posed by a repository at Yucca Mountain. They state "The critical group risk calculated for the purpose of comparison to the risk limit established in the risk standard would be the mean of the risks to the members of the group." The NAS provided two recommendations for specifying the exposure scenario to the critical group, described in Appendices C and D of their report.

Appendix C advances a complicated, eight step approach that would base the critical group on probabilistic evaluations of observed characteristics of people currently living in the vicinity of the repository. The approach involves identifying lifestyle characteristics, quantifying those characteristics parametrically and correlating between characteristics, performing Monte Carlo simulations of exposure realizations, determining doses for the realizations, interpreting the results to identify critical subgroups and subareas (probably iteratively, using a variable grid), and determining the average risk for the critical group.

Appendix D proposes defining a subsistence farmer who uses water extracted from a well in the contaminated plume to grow all of his food and to drink. The well is located in the location of maximum concentration of radionuclides in the aquifer, provided that no natural geologic feature precludes drilling for water at that location. Radiation exposure to the subsistence farmer is determined based on the concentration of radionuclides in the extracted groundwater and on established relationships between ingestion and dose. The calculated risk to the maximally exposed subsistence farmer is found by multiplying the risk for a given scenario (radionuclide distribution in groundwater) by the probability of that scenario, and integrating over all scenarios. The expected risk to the average member of the critical group is taken as one-half of the risk to the maximally exposed subsistence farmer, based on an arbitrary assumption of fairly uniform risk within the critical group. The expected risk to the average member of the critical group is compared to the risk limit for compliance.

DOE Concern and Recommendation

A Yucca Mountain standard should include a relatively simple exposure scenario that is based on a realistically-defined critical group. The critical group should be developed as stated in Chapter 2 of the NAS report (page 54): "In the present and near future, these persons are real; that is, they are persons now living in the near vicinity of the repository that lies in the direction of the flow of the ground water plume of radionuclides that would occur far in the future."

The methodology described in Appendix C is not considered appropriate for use in a Yucca Mountain standard. It is important to remember that the calculated risk is not a true risk, but, at best, the conditional risk based on certain key assumptions (characteristics of future society, etc.). Given the broad range of unknowables that is inherent in geologic disposal at any site, it would be inappropriate to impose a requirement for precision in one area (exposure scenario) that is overwhelmed by the uncertainty in other areas. The approach in Appendix C is very complicated and requires a great deal of input data, computation, and judgment to accomplish. The DOE emphasizes the need for standards and regulations to be simple, understandable, and demonstrable in order to foster public confidence. The methodology proposed in Appendix C does not satisfy that criterion. Additionally, the methodology proposed in Appendix C has no precedent in application to a regulated facility.

On the other hand, the methodology described in Appendix D appears to be simple and implementable. The methodology is consistent with standard practices for calculating radiation doses. It would result in a very conservative exposure scenario, since it is based on the subsistence farmer. While there is farming today in the area downgradient of the potential repository, no persons meeting the very conservative definition of subsistence farmer has been identified in that region. The Appendix D methodology could be appropriate for use in a Yucca Mountain standard as long as the very conservative nature of the exposure scenario is recognized and factored into the specification of the risk limit (see Concern 2).

Alternatively, a methodology that is more straightforward than Appendix C and more realistic than Appendix D could be employed. This methodology would define the critical group as a community of people at any location downgradient of the repository that would reasonably support agriculture. The community would be assumed to get all of its water supply from groundwater. The people in the community would be assumed to be a mixture of occupations and lifestyles, including farming. Radionuclide exposure to the average individual in this critical group would be determined based on drinking contaminated groundwater and on ingesting some food grown locally (irrigated with contaminated groundwater). The fraction of food grown locally vs. the fraction imported would be specified in the regulation, based on a review of the current practices in communities in the Amargosa Valley. This type of exposure scenario is admittedly somewhat arbitrary, but any future exposure scenario necessarily shares that flaw.

Like the Appendix D methodology, this approach is also conservative, because it assumes that the community exists and does not test and treat its water supply.

Any methodology that is used must be applied in a reasonable manner. It would be inappropriate to lump worst-case assumptions on top of one another when attempting to determine something akin to risk thousands of years in the future. For example, it would be inappropriate to assume

that a farming community that uses contaminated groundwater is located on land that is unsuitable for that purpose (e.g., land with little or no topsoil).

5. Including Groundwater Protection in Yucca Mountain Standards

Summary of NAS Recommendation

The NAS did not address the issue of whether Yucca Mountain standards should include separate provisions for groundwater protection, as are included in 40 CFR Part 191, the general standard for geologic repositories. The NAS did not consider separate groundwater protection necessary for the purpose of limiting risk to individuals.

DOE Concern and Recommendation

The DOE agrees with the NAS that separate groundwater protection limits are not necessary to protect the health and safety of individuals in the vicinity of the repository. Groundwater is the primary mechanism for transporting radionuclides to the accessible environment in the vicinity of Yucca Mountain. While groundwater supplies are limited, they are currently the only source of water for people near the potential repository. A standard that protects individuals in the vicinity of the repository must include consideration of exposure to radiation via a groundwater pathway. Therefore no additional groundwater protection provisions are needed. Certainly it would be inappropriate to apply the limits of 40 CFR Part 141 (EPA, 1976), which are established for treated tap water, to untreated groundwater near a geologic repository at Yucca Mountain. Such an application would effectively supplant a health-based standard with a technology-based limit.

The DOE recommends that Yucca Mountain standards do not include separate groundwater protection provisions.

OTHER COMMENTS

DOE supports several of the recommendations contained in the NAS report, some of which are noted below.

1. The NAS recommended the use of a health-based standard that sets a limit on the risk to individuals of adverse health effects from releases from the repository. The DOE supports this concept of a health-based standard for Yucca Mountain.

2. The NAS advocated the use of the concept of negligible risk. It pointed out that the National Council on Radiation Protection (NCRP) has recommended a value of 1 millirem per year which corresponds to a projected risk of 5×10^{-7} per year for fatal cancers, assuming a linear hypothesis. The DOE supports this concept of negligible risk.

3. The NAS found that a standard that protects the people in the vicinity of a Yucca Mountain repository would be adequately protective. The DOE agrees that local inhabitants are the proper focus of protection for arid, isolated potential repository sites like Yucca Mountain that do not have a credible aqueous pathway for exposing the world population. Therefore,

there should be no need for the EPA standard to impose additional population-based limits such as the release limits in 40 CFR Part 191.

4. The NAS recommended basing the quantitative evaluation of compliance on the mean of the calculated results. The DOE agrees that this is appropriate for a risk standard that is applied for very long time frames.

5. The NAS noted that total system performance is the most important measure of repository performance, and that quantitative subsystem performance requirements may result in suboptimal repository design. The DOE agrees and recommends that the subsystem requirements in the NRC regulation 10 CFR Part 60 should be reconsidered in that light.

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