



The Secretary of Energy  
Washington, DC 20585

March 2, 1990

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

Dear Mr. Chairman:

Under section 113(b)(3) of the Nuclear Waste Policy Act of 1982 (NWPA), the Department has prepared the first of a series of reports on the progress of scientific investigations at Yucca Mountain.

Although the first of these reports had been scheduled for issuance in July 1989, I elected not to issue the report until the program review, which resulted in the "Report to Congress on Reassessment of the Civilian Radioactive Waste Management Program" on November 29, 1989, was complete. This delay has resulted in the first two progress reports being combined into a single document covering the period from September 15, 1988, through September 30, 1989, and it reflects the restructured program schedules detailed in the November report to Congress. The Department plans to issue subsequent progress reports at 6 month intervals, as specified in the NWPA, as amended.

The document titled "Progress Report on the Scientific Investigation Program for the Nevada Yucca Mountain Site" is being sent to you pursuant to section 113(b)(3) of the NWPA. Your copy will arrive under separate cover.

Sincerely,

*James D. Watkins*  
James D. Watkins  
Admiral, U.S. Navy (Retired)

Separate Cover:  
Progress Report on the Scientific  
Investigation Program for the Nevada  
Yucca Mountain Site

3/16....To GPA for Appropriate Action..Cpys to: RF, Chairman  
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UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
WASHINGTON, D. C. 20555

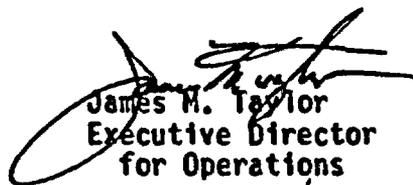
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MEMORANDUM FOR: The Commissioners  
FROM: James M. Taylor  
Executive Director for Operations  
SUBJECT: FUNDAMENTAL ASSUMPTIONS SUPPORTING EPA AND NRC HLW  
CRITERIA (WITS 8900235)

On November 20, 1989, the staff briefed the Commission on recommendations for implementing the U.S. Environmental Protection Agency's (EPA's) standards for high-level waste disposal, as outlined in the staff paper SECY-89-319. At that briefing, you requested that the staff provide you with an "...articulation of the fundamental assumptions in support of the EPA disposal standards and U.S. Nuclear Regulatory Commission (NRC) regulations for high-level radioactive waste, including both the positive and negative aspects of those assumptions, and identification of NRC/EPA consensus and controversy on the fundamental assumptions." (December 14, 1989, Staff Requirements Memorandum)

Enclosed is the information you requested. EPA's Office of Radiation Programs has reviewed the enclosed analysis and agrees with its content. NRC's Offices of Nuclear Material Safety and Safeguards and Nuclear Regulatory Research concur in the enclosure, and the General Counsel has no legal objection to it.

  
James M. Taylor  
Executive Director  
for Operations

Enclosure:  
Analysis of Fundamental Assumptions

cc: SECY  
OGC

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KEY ASSUMPTIONS IN DERIVATION OF  
EPA'S HIGH-LEVEL WASTE DISPOSAL STANDARDS  
AND NRC'S HIGH-LEVEL WASTE REGULATIONS

1. Agency Jurisdiction

**Background.** The U.S. Nuclear Regulatory Commission (NRC) and the U.S. Environmental Protection Agency (EPA) agree that EPA's authority to establish environmental standards for high-level waste (HLW) disposal stems from Reorganization Plan No. 3 of 1970. Section 2(a)(6) of the plan transferred to EPA:

The functions of the Atomic Energy Commission under the Atomic Energy Act of 1954, as amended, administered through its Division of Radiation Protection Standards, to the extent that such functions of the Commission consist of establishing generally applicable environmental standards for the protection of the general environment from radioactive material. As used herein, standards mean limits on radiation exposures or levels, or concentrations or quantities of radioactive material, in the general environment outside the boundaries of locations under the control of persons possessing or using radioactive material.

This authority was referenced by the Nuclear Waste Policy Act of 1982, which directed that:

Not later than 1 year after the date of the enactment of this Act, the Administrator [of EPA], pursuant to authority under other provisions of law, shall, by rule, promulgate generally applicable standards for protection of the general environment from offsite releases from radioactive material in repositories.

**Controversy.** NRC has taken a relatively narrow view of EPA's authority, arguing that EPA's standards are limited to definition of acceptable levels of environmental impacts, and that the standards may not specify the means to be used by a licensee to achieve compliance with the standards. EPA, on the other hand, has a broader interpretation of its authority. When EPA proposed its HLW standards, seven "assurance requirements" were included which EPA characterized as "...essential for developing the needed confidence that our long-term release limits should be met." These requirements addressed (a) prompt disposal of wastes, (b) restriction of releases to levels "as small as reasonably achievable," (c) use of multiple barriers, both engineered and natural, for waste isolation, (d) restriction of reliance on "active institutional controls" to achieve waste isolation, (e) use of permanent markers and records to identify disposal locations, (f) avoidance of mines and other resource locations as disposal sites, and (g) selection of disposal systems to allow removal of wastes after disposal. The proposed standards also contained "procedural requirements" specifying certain conditions to be

observed when conducting a performance assessment to evaluate compliance with the standards.

NRC's comments on EPA's proposed standards included a strong objection to the "assurance" and "procedural requirements," arguing that those provisions were "clearly within the exclusive jurisdiction of the NRC and beyond the jurisdiction provided for EPA by Reorganization Plan No. 3" (May 11, 1983, letter from Chairman Palladino to Acting Administrator Lee Verstandig of EPA). NRC's position reflects a Presidential Directive of 1973 concerning the respective responsibilities of EPA and the former Atomic Energy Commission.

Resolution. Controversy over the separation of NRC and EPA jurisdiction was resolved in 1985 when: (1) NRC undertook to revise its regulations so that the substance of all of EPA's "assurance requirements" would be incorporated within Part 60, and (2) EPA specified that the "assurance" and "procedural" requirements were not applicable to disposal facilities licensed by NRC. (This resolution was recorded in a December 2, 1985, letter from Chairman Palladino to Administrator Lee Thomas of EPA.)

## 2. Type of Impact to be Addressed

Background. Most radiation protection guidance and standards provide limits on potential impacts to the individual most severely affected by a facility or activity. Population impacts are usually addressed, if at all, by an additional requirement that such impacts be "as low as reasonably achievable." EPA's proposed HLW standards were a significant departure from this practice. As proposed, EPA's standards restricted only population impacts, and did so through limits on the total amount of radioactive material allowed to be released to the environment. In the final standards, EPA added provisions for protection of individuals and groundwater supplies, but these sections of the standards were applicable only for shorter times and more limited conditions than were the "containment requirements," which limited population impacts.

Controversy. NRC and EPA have generally agreed on the approach taken by EPA, although individual members of the NRC staff and persons outside NRC have disagreed (see EPA 520/1-85-024-1, "Response to Comments for Final Rule," August 1985). Two controversies are present here. First, some have argued that it would be better to follow the more traditional approach of limiting impacts to individuals rather than basing a standard on population impacts. And, second, EPA's generic translation of its population health effects goal (1,000 premature fatalities over 10,000 years from disposal of 100,000 tonnes of spent fuel) to specific release limits (curies of individual radionuclides) has been criticized as being overly conservative. In this view, the standards should be stated in terms of the health effects goal, allowing larger or smaller releases as permitted by the specific characteristics of a site.

Resolution. Population versus individual impact bases for HLW standards were addressed by NRC as follows in its comments on EPA's proposed standards.

The NRC strongly supports the current form of the containment requirements (Section 191.13) which limit the total amount of radioactivity projected to be released to the environment over 10,000 years. This approach would appropriately protect the environment while limiting the consideration of speculative and unnecessary dosimetry-related issues in a repository licensing review. A standard which specified maximum dose limits to individuals would have two major adverse effects:

- It would encourage dilution rather than containment of wastes (e.g., by siting repositories near prolific aquifers or large rivers), which the NRC considers to be an inappropriate approach to waste disposal, and
- It would needlessly inject into a licensing review questions of individual and societal lifestyles far into the future. These are difficult predictions to make even a few years into the future, and predictions over 10,000 years would be highly speculative. The approach adopted by EPA in developing these standards (limiting total activity released to the environment) would avoid this difficulty while still ensuring that a waste disposal system would achieve its intended function, i.e., long-term isolation of wastes from the environment (May 10, 1983, comment letter signed by John G. Davis).

Regarding conservatism in the relationship between EPA's proposed release limits and the health effects goal from which they were derived, NRC stated:

The NRC staff and its contractors have independently evaluated the relationship between the release limits of the proposed standards and the resulting level of health effects anticipated over 10,000 years. The results of these analyses indicate that EPA's environmental transport analyses may overestimate the number of expected health effects per curie of radioactivity released to the environment. We have not identified any systematic or gross over-conservatism in the models or data used by EPA. However, it appears that a number of marginally conservative assumptions (e.g., cancer risk estimates, fraction of river flow used for irrigation, etc.), when considered together, may result in the acceptance of overly conservative estimates of health effects per curie released. We encourage EPA to reevaluate its environmental transport models and release limits in light of more recent information such as that in NUREG/CR-3235.

EPA did, in fact, review its analyses, and the release limits of many radionuclides were increased by nearly an order of magnitude in the final standards. Because only "marginally conservative assumptions" were identified in the initial analyses, a review of EPA's revised analyses supporting the final standards was not conducted.

### 3. Bases for the Standards

**Background.** As support for the standards, EPA developed descriptions of several hypothetical repositories (in salt, basalt, granite and tuff) containing unprocessed spent nuclear fuel. EPA then used relatively simple mathematical models of the repositories to evaluate the ability of these hypothetical repositories to isolate wastes from the environment. These analyses of achievable release levels served as a major part of the technical support for EPA's HLW standards. EPA also developed estimates of the population health effects caused by natural background radiation exposure, unmined uranium ore deposits, nuclear power generation, and nuclear weapons fallout (Draft Environmental Impact Statement, EPA 520/1-82-025, December 1982). When the standards were proposed, EPA stated:

The standards that we are proposing would adequately protect the public from harm. Under them, the risks to future generations from the wastes would be no greater than the risks from equivalent amounts of unmined uranium ore. These risks would also be far less than the risks from other sources of natural background radiation (47 FR 58197, December 29, 1982).

NRC did not comment directly on the appropriateness of EPA's projections of repository isolation capabilities. Instead, the NRC staff and contractors conducted independent analyses of the achievability of the proposed release limits. The results of these analyses (NUREG/CR-3235, April 1983) supported EPA's estimates that the proposed release limits would be achievable.

**Controversy.** Some members of the NRC staff, others outside NRC (including EPA's Science Advisory Board) and, especially, the Waste Management Subcommittee of NRC's Advisory Committee on Reactor Safeguards (ACRS) argued that the release limits of the EPA HLW standards are overly restrictive. This view is based on comparisons with other risks experienced by society and, in effect, rejects the fundamental premise underlying EPA's standards -- i.e., that the release limits of the standards should be determined by the projected isolation capabilities of repositories. More recently, NRC's Advisory Committee on Nuclear Waste (ACNW) has repeated the argument that EPA's standards are overly stringent (December 21, 1989, letter from Dade W. Moeller to Chairman Carr).

EPA's standards have also been criticized by the ACNW for their perceived "risk-averse" nature - a characteristic at odds with the Commission's safety goals for nuclear power plants. Although EPA did not deliberately develop the standards to be risk-averse, EPA's analyses of hypothetical repository performance indicated that large releases were very unlikely. The achievability basis for the standards therefore resulted in a risk-averse formulation for the release limits of the standards.

**Resolution.** NRC's comments on EPA's proposed standards endorsed EPA's approach for developing the release limits of the standards (SECY-83-137, dated April 14, 1983, and May 10, 1983, comment letter signed by John G. Davis). Despite repeated recommendations by the ACRS Subcommittee and the ACNW, the Commission has not rescinded its earlier endorsement.

#### 4. Part 60 Performance Objectives

**Background.** When the proposed technical criteria for Part 60 were published for comment, the Commission included the following statement (46 FR 35283, July 8, 1981).

In the course of the Commission's deliberation, it becomes evident that in order to have confidence in the ability of a geological repository to contain and isolate the wastes for an extended period of time, the repository must consist of multiple barriers. In view of the uncertainties that attach to reliance on the geologic setting alone, the Commission believes that a repository should consist of two major engineered barriers (waste packages and underground facility) in addition to the natural barrier provided by the geological setting. The Commission is emphasizing these elements to take advantage of the opportunity to attain greater confidence in the isolation of the waste.

The Commission then went on to propose specific numerical performance objectives for each of the major barriers of a repository system. These performance objectives were to impose upon repository design and site selection a "defense-in-depth" approach analogous to that followed in design of nuclear power plants. By this means, the Commission proposed to attain the level of confidence referred to in the citation above.

**Controversy.** The numerical performance objectives of Part 60 have been highly controversial, both within and outside NRC (see NUREG-0804, "Staff Analysis of Public Comments....," December 1983). Criticisms have taken two forms. First, some have argued that the repository developer should have unlimited flexibility to determine the level of performance to be achieved by each barrier of a repository, and that subsystem performance objectives are inappropriate. In this view, the only criterion for repository acceptability should be compliance with the overall system performance standard developed by EPA. The Commission's stated concerns about the degree of confidence with which performance can be projected are viewed either as unwarranted, or as capable of being addressed in some other way.

The second criticism admits that subsystem performance objectives may have merit, but argues that there is no logical link between the specific performance objectives of Part 60 and the EPA standards for overall system performance. The supporting analyses of NUREG-0804 showed that the subsystem performance objectives contribute to achieving compliance with the overall system standard. However, NUREG-0804 also showed that the subsystem objectives are not sufficient, by themselves, to ensure compliance nor are they the only means by which compliance could be achieved. This criticism argues that any subsystem performance objectives developed by the Commission should be shown to be either sufficient or necessary for demonstrating compliance with the overall system performance standard.

It should be noted that there is no controversy with EPA regarding the subsystem performance objectives. EPA's comments on the proposed objectives endorsed the multiple barrier concept, and suggested refinements to the

specific objectives proposed (November 16, 1981, comment letter signed by Paul C. Cahill). Also, it should be recalled that Section 121 of the Nuclear Waste Policy Act mandates that NRC regulations provide for the use of a system of multiple barriers in the design of a repository.

Resolution. Although this was by far the most controversial issue involved in development of Part 60, numerical subsystem performance objectives were adopted by the Commission, as explained in NUREG-0804.

#### 5. Detailed Assumptions Underlying the EPA Standards

Assumption. Exposure to ionizing radiation will continue to impose risks on future human beings in the same way it does today, and future societies will value those risks as ours does today.

Discussion. Some people have suggested that future radiation exposures should be "discounted," analogous to economic discounting in monetary calculations. EPA rejects this suggestion by assuming that all future radiation exposures should be valued the same as current exposures. Implicit in this assumption is also an unwillingness to speculate on such future events as a potential cure for cancer. During EPA's rulemaking, this assumption was not an issue.

Assumption. Only detrimental processes and events need be considered in the technical analyses supporting EPA's HLW standards.

Discussion. As EPA described its hypothetical repositories, "undisturbed performance" resulted in little, if any, release of radioactive material to the environment. Consequently, the NRC staff projects that there would have been little effect on the amounts of radioactive waste projected to be released, even if EPA had included potentially beneficial processes and events in its analyses. Nevertheless, consideration of favorable conditions, such as those of Section 60.122 of Part 60, is not precluded by EPA's standards.

Assumption. "Active" institutional controls may not be relied on for more than 100 years.

Discussion. An assumption of limited reliance on "active" institutional controls (e.g., guarding or monitoring a disposal site, or performing maintenance activities at the site) is widely accepted in national and international radioactive waste disposal standards. (See, e.g., IAEA Safety Series No. 99, "Safety Principles and Technical Criteria for the Underground Disposal of High Level Radioactive Wastes.") However, the specific wording in EPA's standards, while not applicable to a licensed repository, is at variance with the Part 60 definition of "unanticipated processes and events," where it is presumed that remedial actions will be taken by future institutions.

Assumption. A repository capable of meeting EPA's release limits for 10,000 years is likely to continue to perform well for periods beyond 10,000 years.

Discussion. NUREG/CR-3235 extended analyses of repository performance to 50,000 years to test this assumption. No significant deterioration of repository performance was found for the hypothetical repositories evaluated in NUREG/CR-3235. The "favorable" and "potentially adverse" siting criteria of Part 60 are intended to preclude location of a repository at a site where sudden degradation of isolation capability could occur. Nevertheless, analyses in the U.S. and in other countries have shown that, with very long-lived radionuclides in an apparently good site, the peak releases don't occur until well after 10,000 years.

Assumption. EPA selected 10,000 years as the period for assessing repository performance for two reasons: (1) it is long enough for releases through groundwater to reach the environment, and (2) it is short enough to avoid consideration of the types of major geologic changes that occur only over much longer periods of time.

Discussion. The NRC staff agrees that 10,000 years is an appropriate period of time to assess repository performance for regulatory purposes. It appears to be long enough to distinguish good repositories from poor ones, especially when used in conjunction with the performance objectives and siting criteria of Part 60. Moreover, assessments over longer periods would be so uncertain as to have little value for evaluating the acceptability of repository performance.

Assumption. Health effects associated with specific releases were estimated using very general models of environmental transport and a linear, nonthreshold dose-effect relationship to project premature deaths from cancer.

Discussion. The linear, nonthreshold dose-effect relationship is well-accepted for regulatory purposes. Possible conservatisms in the environmental transport models are discussed in Item 2, above.

Assumption. World average environmental parameters, such as river flow rates and consumption of foods, can be used for generic determinations of health effects expected from releases of radioactive materials to the environment.

Discussion. For generic standards, this assumption seems reasonable. However, specific repository sites may be located where the population potentially affected by a release is small. If so, EPA's generic health effects calculations would over-estimate the number of health effects that would be expected at an actual site.

Assumption. A geologic barrier to waste migration, called the "controlled area," may be permanently committed for use as part of a geologic repository. Determination of compliance with the standards consists of calculating projected releases of radioactive materials from this barrier into the "accessible environment." The size of the controlled area is limited to 100 km<sup>2</sup>, and the area may extend no more than 5 km in any direction from the actual waste disposal location.

Discussion. This assumption recognizes that a geologic barrier is a major part of a geologic repository. This assumption also places reasonable bounds on the size of that barrier.

**Assumption.** Potentially disruptive processes and events, including human-initiated disruptions, can be identified and their probabilities and consequences can be evaluated numerically, with sufficient accuracy to permit determination of compliance with probabilistic standards.

**Discussion.** This is one of the most contentious issues regarding EPA's HLW standards, and is discussed extensively in SECY-89-319.

**Assumption.** EPA's descriptions and analyses of hypothetical repositories are realistic representations of the waste isolation capabilities of real disposal facilities. At the same time, EPA's descriptions and analyses are somewhat conservative in the sense of over-estimating expected releases. Thus, real repositories should be able to comply with EPA's standards "...with little, if any, effort beyond that already planned." (50 FR 38070, September 19, 1985)

**Discussion.** The analyses of NUREG/CR-3235 supported EPA's view that the standards should be achievable by real repositories. Nevertheless, those analyses were also based on hypothetical data. An actual demonstration of compliance with EPA's standards cannot be made until real data are acquired for a real site through the site characterization process.



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Dade W. Moeller, Chairman  
Advisory Committee on Nuclear Waste  
U.S. Nuclear Regulatory Commission  
Washington, D.C. 20555

Dear Dr. Moeller:

Thank you for your letter dated August 3, 1990, providing the Advisory Committee on Nuclear Waste's (ACNW's) comments on the draft Commission paper titled "Staff's Approach for Dealing with Uncertainties in Implementing the EPA HLW Standards." Your comments, as well as the July 1990, recommendations of the National Research Council's Board on Radioactive Waste Management (BRWM), suggest that significant revisions to the probabilistic format of the Environmental Protection Agency's (EPA's) standards might be appropriate. Accordingly, we plan a substantial expansion of the draft Commission paper.

As your comments recognize, uncertainties are inherent in repository performance assessments. In the draft Commission paper we described these as: (1) data uncertainty - uncertainty in our knowledge of the "as built" system, (2) future states uncertainty - our inability to accurately predict the future environment of the repository system, and (3) model uncertainty - our imperfect conceptual and mathematical descriptions of repository system performance. The revised paper will provide a discussion of methods for dealing with these uncertainties regardless of the form that the EPA standards might ultimately take. The paper will then go on to evaluate several possible forms for EPA's standards, including probabilistic, deterministic, dose-based, risk-based, and total release limits. The paper will discuss the relative advantages and disadvantages of each of these possible forms in terms of uncertainties in implementation. We anticipate that this review will provide the information needed by the Nuclear Regulatory Commission (NRC) staff and the Commission in the ongoing assessment of issues associated with implementation of EPA's standards.

As you are aware, the BRWM plans a symposium on radioactive waste repository licensing on September 17-18, 1990. The staff plans to attend this symposium and to use information acquired there, in addition to your comments, in

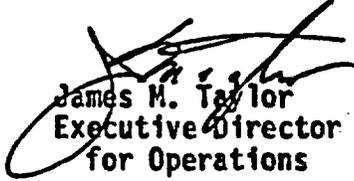
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Dr. Dade W. Moeller

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revising the draft Commission paper. After the revision has been completed (probably in October or November) we will forward the draft document to the ACNW for your review and comment.

Sincerely,



James M. Taylor  
Executive Director  
for Operations

cc: Chairman Carr  
Commissioner Rogers  
Commissioner Curtiss  
Commissioner Remick  
SECY