



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

August 29, 1990

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MEMORANDUM FOR: Commissioner Curtiss

FROM: James M. Taylor
Executive Director for Operations

SUBJECT: DRAFT OF NRC STAFF ANALYSES OF "RETHINKING HIGH LEVEL WASTE DISPOSAL"

In accordance with your request, enclosed is the subject draft analyses, dated August 27, 1990, of "A Position Statement of the Board of Radioactive Waste Management" of the National Research Council. I would like to caution you that this is a draft developed principally by the NMSS staff with some input from OGC and RES staff; it continues to be worked by the staffs of the offices involved. It does not have the concurrence of any Office or the EDO; thus, the final staff analyses may differ from the enclosed.


James M. Taylor
Executive Director
for Operations

Enclosure: As stated

cc: Chairman Carr ✓

Commissioner Rogers
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NRC STAFF ANALYSIS OF
"RETHINKING HIGH-LEVEL WASTE DISPOSAL"--A POSITION STATEMENT OF
THE BOARD ON RADIOACTIVE WASTE MANAGEMENT OF THE NATIONAL RESEARCH COUNCIL

BACKGROUND:

On July 18, 1990, the Board on Radioactive Waste Management of the National Research Council ("the Board") issued a report entitled "Rethinking High-Level Waste Disposal." The Board's report was developed from discussions at a study session convened by the Board in July 1988, to address U.S. policies and programs for high-level radioactive waste management. The week-long study session was attended by representatives of the U.S. Department of Energy (DOE), the U.S. Nuclear Regulatory Commission (NRC), and the U.S. Environmental Protection Agency (EPA), as well as other knowledgeable persons from the United States and abroad.

It should be recognized that a number of important events have occurred since the July 1988 study session that have caused or will cause changes to both the NRC and DOE programs. These events include DOE's issuance of the Site Characterization Plan (SCP) in December 1988, issuance of the NRC staff's comments on the SCP (i.e. NRC's Site Characterization Analysis (SCA)) in August 1989, DOE's announcement of revisions to its program and schedule in November 1989, and the issuance of NRC's Regulatory Strategy in October 1988 and first update in June 1990. While DOE's November 1989 announcement of revisions to its schedule and program is referred to in the Board's report, it is unclear if all the other events are included in the "current approach" referred to in the Board's findings.

The NRC staff has reviewed the Board's report, and this paper gives the staff's analysis. The staff's analysis is based on its understanding of the national HLW program as of August 1990. Section 1 of this paper summarizes the major findings in the Board's report and Section 2 gives the staff's analysis of these findings. The staff has chosen to focus its analysis on what it considers to be the Board's major findings related to NRC's regulatory responsibilities regarding high-level radioactive waste repository licensing. The specific recommendations made by the Board at the end of the report will be addressed separately.

DISCUSSION:

I. Summary of Major Findings in the Board's Report

A. Overall Findings

The Board considers that there is a worldwide scientific consensus that deep geologic disposal is the best option for disposing of high-level radioactive waste and that there is no reason not to proceed. However, the Board's overall finding is that the lack of satisfactory progress by the U.S. program is due to the regulatory requirements and program implementation. Furthermore, they concluded that the current program is unlikely to succeed. This overall finding is primarily based on the findings summarized below.

B. Major Findings in the Board's Report

1. Lack of Recognition of Uncertainties

The summary section on Treatment of Uncertainty and the finding section on Limitations of Analysis point out that quantitative predictions of repository performance far into the future are uncertain and that residual uncertainties will remain no matter how much information is obtained. Furthermore, all potential problems can not be anticipated. Therefore, the report concludes that science can not prove that a repository will be absolutely safe and that such unrealistic guarantees are sure to fail.

The Board concludes that the regulations and discussions of their application have resulted in an approach that assumes that future repository performance can be determined with a very high degree of certainty and that every problem can be anticipated. This approach encourages the public to expect absolute certainty about safety and encourages DOE to provide it.

Of the many issues discussed in the summary section on Moral and Ethical Questions and the findings section on Moral and Value Issues the major repository safety issue is that safety decisions should be made based on "what is acceptable to society, given the evidential uncertainties, perceptions of risk, and contentious stakeholder debates." In contrast, regulators are perceived as being pressured to seek a "scientifically correct" answer, even when there is none. The report concludes that it should be recognized that expecting to make decisions with certainty creates a "scientific trap" that will erode credibility.

2. Over Reliance on Modeling

The summary section on Modeling of Geological Processes and the findings section on Modeling and its Validity recognize that while models are a valuable tool for understanding repository performance and focusing the program on uncertainties significant to performance, the current models are limited in their ability to represent complex natural systems. Therefore, the Board considers it inappropriate to use modeling to stretch the uncertain understanding of a site into an accurate quantitative projection into the future of site behavior or repository safety. This conclusion is based on reviews of methods used by DOE and the regulatory agencies. The Board concludes that determining safety, therefore, can not rely on modeling results alone and some combination of modeling, natural analogues, expert judgement, engineering design, and applying geophysical principles is needed to determine safety.

3. Lack of Flexibility in Regulations and Program

The summary section on an Alternative Approach and the findings section on Strategic Planning conclude that the current approach is inflexible and not open to change as information from scientific investigations is obtained. It is therefore considered inappropriate for the variability expected in a geologic repository system and inconsistent with normal geologic and mining practice of "design as you go". The Board's report attributes the program's inflexibility to both the regulations and the program's implementation.

The report concludes that regulations have contributed to inflexibility because they have been predetermined in detail without regard to any particular geologic setting. As stated in the Board's report:

Almost all other countries have established limitations on the allowable levels of radiation dose to individuals or populations resulting from repository establishment--but have taken a 'wait and see' approach on design, while collecting data that may be of use in setting design...As a direct consequence, the U.S. HLW program is bound by requirements that may be impossible to meet, even though overall dose limits can be achieved.

The repository regulations are perceived to follow the regulatory philosophy developed for nuclear power plants where requirements could be pre-determined for man-made components. This philosophy is considered inappropriate for the geologic repository because it incorrectly assumes that the properties of the geologic medium can be determined and specified in advance. Finally, quality assurance is perceived as contributing to "a system that is hostile to surprises in a world that is full of them."

The Board also considers that the process mandated in detail in DOE's Site Characterization Plan restricts flexibility. Furthermore, DOE feels compelled to "get it right the first time" and is therefore reluctant to change.

As an alternative to the Board's perception of the current approach summarized above, the report proposes a flexible approach. This flexible approach would be open to changes and proceed iteratively in steps. There would need to be a willingness to make changes, for example, to schedules, designs, regulatory requirements, and the evidence needed to demonstrate safety (i.e., use of natural analogues and expert judgement to supplement quantitative model results). Such an approach would include: (a) conservative design changes in response to discovery of site attributes, (b) performance assessment modeling to identify additional information needs,

and (c) remediation if things do not turn out as planned. Some process is considered needed to identify unreasonable regulatory demands (i.e., one that is unlikely to be met at any site and is unnecessary to protect public health) and make appropriate corrections.

II. Evaluation of Board Findings

A. Evaluation of Overall Findings

The staff disagrees with the Board's conclusion that NRC's regulation has contributed to the lack of satisfactory progress in the U.S. program. Furthermore, the staff does not consider that its implementation of the regulation has impeded the program's progress.

The staff agrees with and considers that the regulation and the staff's ongoing implementation of the precicensing process have been consistent with the following general principles embodied in the Board's major findings:

- (a) Absolute certainty in safety decisions cannot be achieved;
- (b) Modeling contributes to identification of additional uncertainty but cannot be solely relied on for safety decisions;
- (c) Regulatory and programmatic flexibility are needed to best deal with uncertainty.

The staff also observes that while the regulation has always been consistent with these principles, improvements have been made by both NRC and DOE to the precicensing process since the Board's study session was held two years ago. Additional specific analysis is given below.

B. NRC Staff Evaluation of Board's Major Findings

1. Lack of Recognition of Uncertainties

Contrary to the perception of the Board, 10 CFR Part 60 and the NRC staff's implementation of this regulation clearly recognize the uncertainties inherent in a geologic repository. Both the regulation and statement of considerations state that reasonable assurance, not absolute proof is the standard. 10 CFR 60.101 (a) (2) gives the following standard of proof:

While these performance objectives and criteria are generally stated in unqualified terms, it is not expected that complete assurance that they will be met can be presented. A reasonable assurance, on the basis of the record before the Commission, that the objectives and criteria will be met is the general standard that is required. For 60.112, and other

portions of this subpart that impose objectives and criteria for repository performance over long times into the future, there will inevitably be greater uncertainties. Proof of the future performance of engineered barrier systems and the geologic setting over time periods of many hundreds or many thousands of years is not to be had in the ordinary sense of the word. For such long-term objectives and criteria, what is required is reasonable assurance, making allowance for the time period, hazards, and uncertainties involved, that the outcome will be in conformance with those objectives and criteria. Demonstration of compliance with such objectives and criteria will involve the use of data from accelerated tests and predictive models that are supported by such measures as field and laboratory tests, monitoring data and natural analog studies.

Moreover, the statement of considerations accompanying promulgation of 10 CFR Part 60 (48 FR 28194, June 21, 1983 at 28204) elaborated, in part as follows:

...the Commission will not be able to rigorously determine the probability of occurrence of an outcome that fails to satisfy the performance standards. It must use some other language, such as "reasonable assurance," to characterize the required confidence that the performance objectives will be met. In practice, this means that modeling uncertainties will be reduced by projecting behavior from well understood but simpler systems which conservatively approximate the systems in question. Available data must be evaluated in light of accepted physical principles; but, having done so, the Commission must make a judgement whether it has reasonable assurance that the actual performance will conform to the standards the Commission has specified in this rule.

The staff therefore, agrees with the Board's conclusion that recognition of uncertainty in decision making is necessary part of achieving public acceptability. The staff also believes, contrary to the Board's report, that public acceptability will be also enhanced by regulations prepared in advance and independent of the specific activities being regulated.

2. Over Reliance on Modeling

The staff agrees with the Board's observation that modeling is indispensable for understanding repository performance and focusing on uncertainties significant to performance. The staff also recognized the limitations of modeling and therefore 10 CFR 60.101 (a) (2), as quoted above, recognizes that predictive models will not be relied on solely but will need

to be supported by field and laboratory tests, monitoring data, and natural analog studies. The staff also recognizes that expert judgement will factor into such areas as interpretations of data and model assumptions.

The staff's concern over limitations of present modeling coupled with the value of modeling to focus both the DOE and NRC programs has led the staff to place a high priority on iterative performance assessment. One of the major comments in the staff's July 31, 1989, SCA on DOE's SCP was the need for DOE to begin using iterative performance assessment to help guide its site characterization and design programs and to improve methodologies. Likewise, the staff has an ongoing program to develop its own capability to conduct iterative performance assessments as a tool to help determine acceptable and feasible methods and to knowledgeably review DOE's total systems performance assessments. However, to date DOE has not come forward with any performance assessments of the Yucca Mountain Site.

3. Lack of Flexibility in Regulations and Program

The staff agrees with the Board's conclusions that flexibility is needed to deal with uncertainties. Flexibility was a major issue considered by the staff, Commission, and commenting parties as the regulation was developed. The significant differences between nuclear power plants and a geologic repository were recognized and resulted in a regulation and licensing process better suited for the unique problems expected in developing a first of a kind deep geologic repository. What resulted was a performance oriented regulation that attempts to give a reasonable degree of flexibility within a framework of general regulatory requirements. The staff recognized that a perfect balance between flexible performance oriented regulatory requirements and prescriptive requirements can not be achieved by the regulation alone. Therefore, the prelicensing, site characterization process was designed to complement the regulation. When implemented as intended, the NRC, DOE, and other parties might achieve consensus on what is needed to demonstrate compliance with the requirements for a specific site and, if justified, agree to adjustments to the general subsystem requirements. Issues important to flexibility features in both the regulation and prelicensing/licensing process are discussed further below.

a. Overall System Standard

The Board discusses two aspects of EPA's high-level waste (HLW) standards for overall system performance, and suggests that these limit flexibility in evaluating

compliance of a repository with EPA's standards. These are (1) the probabilistic format of EPA's standards and (2) EPA's use of limits on release of radioactive materials, rather than dose limits, as the measure of repository performance.

The Board states that "all other countries use only a dose requirement" rather than probabilistic safety standards of the type promulgated by EPA. This is not correct. Other countries (and international advisory organizations) have developed risk standards for protection of future individuals and populations. Risk standards require estimates of both the probabilities of future releases and the effects of those releases on future humans. Thus, they have a probabilistic nature very similar to that of EPA's standards. Flexibility in implementation of such probabilistic standards is not considered to be a relevant consideration. Rather, the need to consider probabilistic releases of waste is viewed as an inherent part of decisions regarding waste disposal systems. (See, for example, ICRP Publication 46, paragraph 2.) While the NRC has been concerned that the specific wording of EPA's standards not cause implementation difficulties, the optimism of the international HLW community suggests that there are no insurmountable problems inherent in probabilistic standards.

The staff recognizes that a standard expressed in terms of dose or risk is intellectually attractive because of its transparent correlation with protection of public health and safety. When a standard limits releases of radioactive materials, as EPA's HLW standards do, the relationship to public health protection is not as readily apparent. There is, however, a major advantage to such a release limit standard -- a significant simplification in the analyses required to evaluate compliance. Standards that limit dose or risk require identification of environmental pathways and demographic assumptions (e.g., population distributions and dietary habits) far into the future, and thus introduce large uncertainties into analyses of compliance. The alternative approach adopted by EPA eliminates these uncertainties by rulemaking, allowing a simpler evaluation of compliance for a specific repository. This simplification results in a somewhat less flexible standard which precludes consideration of potentially beneficial environmental pathways and demographic characteristics of a specific site. The staff considers that this loss in flexibility is far outweighed by the advantage of precluding large sources of additional uncertainty in repository performance assessments.

b. Subsystem Performance Objectives

As mentioned previously, the staff considers the subsystem performance objectives and criteria are general requirements rather than detailed requirements prescribing specific engineering design. Furthermore, the appearance of absoluteness given by the numerical nature of the subsystem performance objectives is mitigated by the qualifying language in the regulation that "reasonable assurance" rather than absolute certainty is the standard of proof for meeting these requirements (see section II.B.1.).

The regulation also recognizes the importance of both the natural and engineered barrier subsystems. Subsystem performance objectives and criteria are included for each of these subsystems. In addition, flexibility in meeting the subsystem performance objectives is given in the regulation in order to take into account unique features of a specific site or design that would contribute to overall performance. This is not an exemption to the regulation but a provision of the regulation. 10 CFR 60.113 (b) states that:

On a case-by-case basis, the Commission may approve or specify some other radionuclide release rate, designed containment period or pre-waste-emplacement groundwater travel time, provided that the overall system performance objective, as it relates to anticipated processes and events, is satisfied.

Questions have been raised by DOE and others about perceived limitations of the subsystem requirement for waste package containment in 10 CFR 60.113 (a)(1)(ii)(A). Specifically, it was unclear to DOE and others if this requirement was a cap on the waste package lifetime or a limitation on the credit that can be taken in engineered barrier system or overall repository system performance assessments. Such interpretations could also give the incorrect impression that the regulation deemphasizes the importance of the engineered barrier system and therefore emphasizes the natural system. In order to resolve this question about the regulation, the staff, based on the information in the statement of considerations, issued Staff Position 60-001 on July 27, 1990, which clarifies the meaning of this requirement and explains the flexibility in the regulation and the staff's interpretation of the regulation. The staff's position is that this requirement "... is a minimum performance requirement which is not intended, and should not be interpreted, as a cap on the waste package lifetime or a limitation on the credit that can be taken (in engineered barrier system and overall repository system performance assessments) if the waste package is designed to provide containment in excess of 1000 years."

c. Regulatory Strategy

The staff also considers that its Regulatory Strategy, issued in October 1988 (SECY-88-285) and updated in June 1990 (SECY-90-207), demonstrates the flexibility of the staff's internal process to identify and correct problems with the regulation or interpretation of the regulation (i.e., regulatory uncertainties). The staff has recently completed an independent analysis of the regulation to identify problems. The staff also has used and will continue to use the experience of the staff and DOE with implementing the regulation during site characterization at the Yucca Mountain site to identify problems.

Once problems are identified, the staff's Regulatory Strategy also identifies generally how the staff will correct the problems using rulemakings, staff positions, or regulatory guides. The first update to the Regulatory Strategy in SECY-90-207 lists a number of potential rulemakings, staff positions, and regulatory guides intended to reduce identified regulatory uncertainties. The Staff Position 60-001 mentioned previously is one example of how the staff has attempted to address a perceived regulatory uncertainty. Work is also underway to examine uncertainties associated with each of the post-closure subsystem performance objectives (i.e. substantially complete containment, engineered barrier system release, and groundwater travel time/distributed zone). The staff's strategy is to refine these requirements to reduce regulatory uncertainties.

Although, refinements appear to be beneficial, the staff sees no justification for eliminating the quantitative subsystem performance requirements. These requirements are a necessary feature of the regulation used to implement the multiple, independent barrier concept and to deal with uncertainties in estimating overall system performance.

d. Licensing and Prelicensing Process

The overall licensing process was also designed to account for an evolving program. The regulation and the Regulatory Strategy in SECY-88-285 describe the five phases of repository licensing. Each phase represents a step in an evolving decision making process incorporating new information and design changes with each step. The regulations encourage re-evaluation of data and design, and initiation of design changes, as construction proceeds (see 10 CFR 60.46(a)(5), 60.133(b), 60.141(a), and 60.142).

More specifically, the staff considers that the prelicensing phase of the licensing process has been designed to allow additional program flexibility in many ways. As mentioned previously, the prelicensing/site

characterization process established by the Nuclear Waste Policy Act (NWPA) and implemented by both NRC and DOE is the intended mechanism to develop the detailed site, design, and performance information necessary to demonstrate compliance with the regulation for the Yucca Mountain site. It is through review and consultation between NRC and DOE that agreements are reached on the implementation of the generic regulation for the Yucca Mountain site. The State of Nevada and affected counties have had and will continue to have the opportunity to participate in all such consultations between the staff and DOE and the public are invited to observe. This pre-licensing consultation process was set up in NWPA and the regulation in an iterative manner to account for the inevitable changes that are expected in characterization and design. NWPA and the regulation require DOE to issue a Site Characterization Plan (SCP) and SCP semi-annual progress reports which document progress and changes as the program evolves and adjusts to new information obtained about the site. This process is also documented for purposes of licensing as well as informing the public.

Within the site characterization process the NRC has also agreed to DOE's issue resolution strategy and performance allocation process. This process, described in DOE's SCP, is intended to be a decision aiding process for eventually determining if enough information has been collected and adequately assessed for the Yucca Mountain site to demonstrate compliance with the regulatory requirements. This process gives direct consideration to how uncertainties should be treated. It also permits DOE to propose adjustments to the performance allocation of the subsystem barriers and their components to fit the needs for a specific site and specific designs. These adjustments can then be reflected in "fine tuning" of the subsystem requirements as allowed for in 10 CFR 60.113(b). The staff would expect that initial performance allocation goals would change as new information about the site is obtained and as DOE refines its conceptual designs. Finally, the staff would review DOE's proposed adjustments and make a decision on any "fine tuning" as allowed for in 10 CFR 60.113(b) before DOE issues the License Application.

e. DOE Program Implementation and Quality Assurance

A source of perceived inflexibility that has been previously identified by the NAS is in the area of quality assurance. This concern prompted the NRC staff to examine both its regulation and the implementation of the regulation by DOE. Discussions also have been held with DOE and other parties. As a result NRC, DOE, USGS management and industry representatives (i.e., Edison Electric Institute) have all

agreed that NRC's regulations and guidance have not restricted flexibility. Rather, the root cause of any such perceived problems is probably due to DOE's and their contractors' misinterpretation of NRC requirements and guidance resulting in overly restrictive implementing procedures. We understand that DOE is pursuing this matter and the staff intends to follow DOE's resolution of implementation problems to ensure our current understanding of the root cause of the problems is correct.

Another source of inflexibility mentioned in the Board's report is DOE's attitude of "getting it right the first time." The staff has observed this attitude on the part of DOE in the past of taking a position and assuming that it is the right way without fully considering differing or alternative comments and positions. For example, in DOE's consultation draft SCP, it was reflected in DOE's preference for overly optimistic assumptions and lack of consideration of alternative conceptual models of the Yucca Mountain site given the current level of uncertainty about the site. (However, it needs to be noted that the staff's comments and consultations with DOE about this concern have ultimately resulted in improvements in DOE's consideration of alternative conceptual models in its SCP). It is also reflected in the difficulties the NRC staff has had in obtaining indepth technical dialogue on problems until DOE has developed a final position as reflected in our comments on the progress of the pre-license application consultation program in our Quarterly Progress Reports to the Commission.

CONCLUSIONS:

Based on the previous discussion, the staff's major conclusions are:

1. The staff disagrees with the Board's conclusion that NRC's regulation has contributed to the lack of satisfactory progress in the U.S. program. Furthermore, the staff does not consider that its implementation of the regulation has impeded the program's progress.
2. The staff agrees with many of the general principles described in the Board's report and more importantly considers that the regulation is consistent with these principles.
3. The regulation allows for uncertainty and provides a reasonable balance between performance oriented regulatory requirements and prescriptive requirements such that DOE should have adequate flexibility.

4. The iterative prelicensing process is intended to implement the regulations at a specific site. This process permits DOE to prepare adjustments to the the performance allocation for subsystem barriers and their components to fit the needs for a specific site and specific designs. The staff would review and make a decision on DOE's proposed adjustments as allowed for in 10 CFR 60.113(b) during prelicensing.
5. Proper implementation of the regulation by both NRC and DOE programs should continue through the prelicensing process. Features intended to allow flexibility need to be applied effectively by both NRC and DOE.