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DOCKET NUMBER
PROPOSED RULE PR-60
(46 FR 3528)

Mr. William J. Dircks
Executive Director
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Dircks:

Representatives of the American Nuclear Society met with you, Victor Stello, John Davis and other NRC staff members on September 10, 1982. The purpose of the meeting was to present ANS's initial reaction, from a technical perspective, to the July 29, 1982 version of 10CFR Part 60 (Technical Criteria for Geologic Repositories for High-Level Radioactive Waste), including NRC staff Recommendations and the technical Rationale Document. At the meeting, ANS reiterated its general position on proposed 10CFR Part 60 to NRC on October 14, 1981:

> "ANS strongly recommends that all numerical subsystem performance requirements be deleted in favor of more general statements permitting system trade-offs to achieve the desired overall system or repository performance". And,

> "It is our concerted view that overly restrictive and specific performance standards are not necessary, and that such standards in regulation form are likely to add to the overall cost of the waste disposal without achieving any degree of benefit to the public health and safety. Instead, using current engineering practices, a carefully sited, engineered, and designed repository coupled with effective confirmation and design validation can assure compliance with a single, overall performance criterion for the repository as a whole system. The application of such a single performance standard would not only coincide with the Environmental Protection Agency's recommended approach of the systems concept, but would permit repository designers to optimize the repository as a system of both natural and engineered barriers for differing site and geologic medium characteristics".

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Additionally, we expressed our concern about NRC staff's rejection of the overall system or repository standard approach (similar with EPA's) which was recommended by ANS and other technical specialists and organizations. There was a broad general technical consensus on this point which seems to have been inadequately considered by the NRC without substantive technical justification.

While ANS had a relatively brief period to review the July 29, 1982, technical Rationale Document prior to the September 10, 1982, meeting, knowledgeable ANS members on this subject are in general agreement that the numerical subsystem performance standards (now "objectives") cited in the proposed regulation have not been technically justified. Further, we believe it will be very difficult, if not impossible, for the NRC to technically justify any variation from these numerical subsystem performance objectives on a "case-by-case" basis with these unmeasurable and technically unjustified values cited in the regulation.

With the preceding in mind, ANS strongly recommends NRC take the following actions before approving 10CFR Part 60:

- o Based on a preponderance of technical community opinion, including ANS, supporting a single, overall repository performance standard, NRC should reconsider the proposed numerical subsystem performance objectives in favor of more generalized design objective statements in the regulation.
- o NRC should submit technical rationale documentation for 10CFR Part 60 to a peer review by the technical community for the adequacy of analytical methodology, parameters, assumptions and conclusions.

Relative to the preceding, ANS has taken the following steps:

- o A technical paper is being prepared to present ANS and technical community views on the approaches used and material presented in the Rationale Document. This paper is scheduled to be completed and available on November 22, 1982, and would provide the basis for a technical presentation to the NRC staff and Commissioners.

- o A special peer review session on 10CFR Part 60 is being organized to be held during the ANS Winter Meeting (Nov. 14-18, 1982) in Washington, D. C.

The American Nuclear Society would be pleased to meet with the Commission and the staff to assist in the development of a technically sound regulation.

Very sincerely,

L. Manning Muntzing
President
American Nuclear Society

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DOCKET NUMBER PROPOSED RULE PR-60 (46 FR 35280)

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Department of Energy
Washington, D.C. 20585

OCT 29 1982

MEMORANDUM FOR Honorable Nunzio J. Palladino
Chairman
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

On July 29, 1982, the Department of Energy met with the NRC staff in an open meeting to discuss the proposed final draft of 10 CFR Part 60. Others who had participated in the rulemaking proceeding were also invited to this meeting.

Draft copies of the final Rule and "Rationale for Performance Objectives in 10 CFR Part 60" were distributed. Based upon those documents and discussions at that meeting, it is clear that a number of basic Department concerns are not being adequately addressed by the NRC staff as it proceeds with the development of the Rule. Accordingly, I am writing to advise the Commission directly that the Department has serious difficulties with certain aspects of the Rule as now written, despite extensive discussions with NRC staff management and the apparent accommodations of our concerns.

The Department's major concern with the proposed Rule, which has been noted in our comments and in those of other reputable reviewers, is the inclusion of ad hoc numerical design requirements for subsystems (individual barriers). Because the degree to which a repository contains radionuclides over time is the ultimate test of its adequacy, we believe the Rule should be based on and derived from an overall system performance objective, as were the curie release limits which have been proposed by EPA in their draft Standard. Instead, the Rule centers on the imposition of performance requirements for individual components that are neither derived from nor related to an overall system performance objective.

Further, inclusion in the Rule of numerical performance requirements for individual barriers will, because of the difficulties in demonstrating compliance, significantly complicate the licensing process and add needless expense of the disposal of high-level waste. The NRC has issued drafts for public review and comment twice, first on May 13, 1980, and again on July 8, 1981. In response, the Department and other concerned parties have expressed reservations about the NRC's approach. These comments, however, have not been fully addressed by the NRC staff, perhaps partially because of a failure to appreciate the potential licensing pitfalls involved.

In its current form the Rule still contains rigid, numerical requirements for individual components that are not justified. For example, the Rule states in section 60.113(a)(1)(ii)(A):

> "Containment of HLW within the HLW waste package will be substantially complete for a period of 1,000 years after permanent closure of the geologic repository, or such other period as may be approved or specified by the Commission."

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The NRC staff position is that the phrase "or such other period as may be approved or specified by the Commission" sufficiently addresses the Department's concern that the 1,000-year period constitutes a firm requirement. We, however, cannot agree. As a practical matter, case-by-case approvals of deviations from specific numerical requirements are almost never granted, require extensive litigation, and, accordingly, are not a realistic alternative to compliance with specific numerical criteria.

We are seriously concerned over the numerical requirements prescribed in 60 113 for components in the Rule for three reasons. First, we believe that the need to demonstrate compliance will unnecessarily complicate and prolong the licensing process. Simply determining the requirements necessary for demonstrating a 1,000-year waste package, for example, is likely to consume considerable time. Secondly, the requirements in the Rule are not technically justifiable. For example, as discussed in our previous comments on the proposed Rule, a long lived (1,000-year) waste package makes no measurable contribution toward protecting the health and safety of the public. The third reason for concern is that of unnecessary cost. The cost of a very long-lived waste package--and exotic, very low release rate waste forms, which also appear to be required by the Rule--would needlessly add to the expense of the disposal of the Nation's waste.

In addition, we have found that the NRC staff's "Rationale" document, which accompanies the draft Rule and sets forth the staff's bases for the requirements it contains, does not, in fact, support the specific requirements in the Rule. During their presentation to the Commission on the proposed Rule, the NRC staff acknowledged that the imposition of the numerical values will not in and of themselves ensure that the proposed EPA Standards will be met. The geologic conditions in the repository must provide a measure of protection from premature radionuclide release. In assessing the effectiveness of the geology, however, minimal credit was allowed because of assumed conditions which were seriously flawed compared to geologic options the Department is investigating.

Enclosed are excerpts from the comments of others on the NRC Rule. You can see that the Department is not alone in taking a position against the specific design requirements included in the proposed Rule. Even one of the NRC staff's principal contractors, Sandia National Laboratories, has stated "If a constant release rate and a groundwater travel time greater than approximately 500 years is assumed, then the presence of (a) canister has little effect on releases."

We understand that on November 2, 1982, the NRC staff is scheduled to brief the Commission on alternative procedures to finalize the technical criteria portion of 10 CFR 60. Given our concerns with the requirements of the Rule as presently drafted, we urgently request an opportunity to present to the Commission our concerns and to suggest alternatives which we believe will significantly improve the Rule. Unfortunately, senior members of DOE management will be out of the country on November 2. Consequently, we request that the Commission reschedule the NRC's staff presentation to a mutually convenient time. Additionally, we request that the Commission defer any action on this matter until we have had an opportunity to present our concerns to the Commission.

Thank you for your consideration of our request. I am sure that we can work together to develop a useful, technically sound rule.

Sincerely,

Shelby T Brewer
Assistant Secretary
for Nuclear Energy

Enclosure

cc:
John F. Ahearne, Commissioner
James Asselstine, Commissioner
Victor Gilinsky, Commissioner
Thomas Morgan Roberts, Commissioner

SUMMARY OF OTHER PARTICIPANTS' COMMENTS

I. SYSTEMS APPROACH

Many commentors supported the systems approach to performance assessment and suggested elimnation of subsystem performance requirements. A few of these comments are quoted below.

NRC Advisory Committee on Reactor Safeguards

". . . we believe that the licensee should be given a greater degree of flexibility for compliance with the overall safety goal. One approach would be to emphasize the fact that the NRC will be evaluating the anticipated performance of the total waste repository as a system, in contrast to the performance of its individual components. Since we foresee only one or two repositories being built within the next several decades, we believe that each should be evaluated in relation to overall performance on a case-by-case basis."

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". . . ANS strongly recommends that all subsystem numerical performance requirements be deleted in favor of more general statements permitting system trade-offs to achieve the desired overall system or repository performance. Specifically, the following values should be deleted:

1000-Year Waste Package Life (Section 60.111(b)(2))
10 Long-Term Release Rate (Section 60.111(b)(2)(ii)(A))
1000-Year Undistrubed Water Travel Time (Section 60.112(c))
50-Year Retrieval Time (Section 60.111(a)(2))"

"It is our concerted view that overly restrictive and specific performance standards are not necessary, and that such standards in regulation form are likely to add to the overall cost of waste disposal without achieving any degree of benefit to the public health and safety. Instead, using current engineering practices, a carefully sited, engineered, and designed repository coupled with effective confirmation and design validation can assure compliance with a single, overall performance criterion for the repository as a whole system. The application of such a single performance standard would not only coincide with the Environmental Protection Agency's recommended approach of the systems concept, but would permit repository designers to optimize the repository as a system of both natural and engineered barriers for differing site and geologic medium characteristics."

Utility Nuclear Waste Management Group

". . . the NRC barrier performance objectives approach, as embodied in the current proposed regulations, can only be viewed as the arbitrary imposition, on individual system components, of special-value standards that are without scientific or other technical support."

". . . we cannot agree that the inclusion of such component requirements will increase the ability to show compliance with an overall system performance requirement (e.g., EPA protection standards), since such a showing will necessarily involve the use of mathematical models independent of specific component performance requirements."

"UNMWG is firmly of the view that overall repository performance should be addressed directly by means of the systems approach. Utilization of an overall performance standard would correctly serve to focus attention on total repository performance. In addition, it would provide for appropriate design flexibility; something which is important in order to both be able to take advantage of new developments, as this new undertaking proceeds, and to accommodate and effectively utilize the specific characteristic of individual sites."

National Research Council/National Academy of Sciences

"The BRWM (Board on Radioactive Waste Management) questions the adequacy of the proposed numerical criteria to accomplish these (their) purposes." . . . "Specifically, our conclusions regarding the proposed numbers are as follows:

1. NRC has not presented adequate evidence that these numerical criteria can "support a finding of no unreasonable risk to the health and safety of the public" . . .

2. NRC has not shown that these numerical criteria are either necessary or sufficient to meet the "EPA Standard." . . .

3. It has not been shown that adoption of the numerical criteria will simplify the licensing process . . .

4. No attempt has been made to demonstrate the technical validity of the proposed criteria. . .

5. NRC has not shown how the proposed numerical criteria for the waste package can be verified . . ."

". . . we recommend that precise numerical criteria for major elements of the repository system be eliminated."

II. 1000-YEAR WASTE PACKAGE

The NRC received many technical comments questioning the validity of the 1000-year waste package containment requirement. A few of the comments are quoted below.

Lawrence Livermore Laboratory

"The zero-released containment limit as proposed by the Commission is not necessary because more reliance can and should be placed on the other barriers . . ." "In addition, it should be recognized that small releases are not intolerable, in view of the vast inventory of naturally-occuring radionuclides in the earth's crust . . ." "The containment time proposed by the Commission is not reasonable because the function of the waste package should be to provide containment primarily during handling and shipping, including possible retrieval, not long-term containment."

American Nuclear Society

"The requirement for a 1,000-year containment period by engineered barriers is grossly excessive and unsupported by scientific fact." "NRC claims that the basis for the choice of 1,000 years is mainly that the heat induced by the waste in the geologic medium will increase the waste package leachability and reduce the near-field transport time, with the net result that the radiological source term from the "distrubed zone" increases. NRC does not argue that the 1,000-year containment period is necessary to reduce the overall radiological releae to man's environment to an acceptable level."

It is agreed that the postulated release from the underground facility would be accelerated due to resulting higher temperatures in the geologic medium but, generally, the calculational models used do not take credit for any holdup or delay of radionuclides in the region of relatively higher temperatures. Rather, the radiological source term for the far-field transport models are derived directly from the waste package release rate as if the heated geologic medium region or "distrubed zone" did not exist. Thus, any acceleration of release from the underground facility due to temperature effects has already been discounted and, therefore, should not be used to penalize the waste package design."

Dr. T. H. Pigford, University of California at Berkeley

Dr. Pigford has prepared a detailed analysis of the NRC's proposed 1,000-year waste package containment period. Seven areas were analyzed: (1) the NRC's purpose; (2) the importance of 1,000-year containment to overall performance; (3) temperatures assumed by the NRC; (4) temperature effects; (5) extrapolation from current knowledge; (6) compliance verification; and (7) cost estimate.

Dr. Pigford summarizes:

"The above analysis shows that NRC's proposed criterion that the radionuclides be confined within the waste package for 1,000 yr is without adequate or valid technical foundation, is based upon questionable assumptions, and may not be important to long term public health and safety. There is no showing by NRC that the proposed criterion is necessary or sufficient for NRC's stated purposes."

Environmental Protection Agency

"Although we strongly support the multiple barrier approach, we think that the 1000 year waste package requirement may be excessive. Studies published by the Electric Power Research Institute (EPRI) and confirmed by EPA indicate that in almost all situations improvements in canister life are less important for reducing long-term risks than improvements in waste form or careful selection of site characteristics. If the waste package lasted only a few hundred years, it would guard against uncertainties during the period of greatest heat generation; however, the 1000-year life requirement for the waste package could necessitate the use of very expensive or exotic materials (such as titanium) for waste canisters. The supporting documentation for the rule does not consider the potential cost of this requirement. In light of the relatively small benefits and possible high cost, we believe the Commission should reexamine this requirement."

Institute of Electrical and Electronics Engineers

"The 1000-year requirement for Waste Package integrity would probably be unduly restrictive in cases where engineered barriers are available and/or groundwater travel times are longer than 1000 years. In addition, it may be prohibitively difficult and expensive to fabricate waste packages that will remain intact for 1000 years, and impossible to provide assurance that the requirement will be met."

III. RELEASE RATE REQUIREMENT

The NRC proposed release limit of one part in 100,000 per year was also disputed by most of the technically qualified commentors.

Dr. T. H. Pigford, University of California at Berkeley

"The numerical specification of a fractional release rate of 10^{-5}/yr is of questionable importance to long-term safety and is proposed without a technically valid basis and with invalid assumptions of existing technology and cost if such a numerical criterion were adopted, compliance could probably not be verified. It would be more appropriate for NRC to state the considerations which may help guide DOE in its development and proof of the waste package as one of the possible barriers that may aid in meeting whatever safety standards that emerge."

Dr. H. P. Ross, Geophysical Consultant

"The one part in 100,000 release requirement for the engineered system again will be impossible to verify and ignores the positive features of a good geologic site to contain or delay transport of radionuclides. The requirement as stated requires engineering overkill for a single component of the system which will be unnecessarily costly and still impossible to verify. Sorption, long travel paths, and dilution all tend to offset the effects of release from the engineered system."

IV. 1,000-Year Groundwater Travel Time

Several commentors disagreed with the 1,000-year groundwater travel time requirement.

Dr. T. H. Pigford, University of California at Berkeley

"NRC has not shown need or adequate technical basis for its proposed numerical criterion for water travel time. It would be more appropriate for NRC to state its considerations of water travel time as a contributor to overall safety performance. It would be appropriate for DOE to have the flexibility to select sites with water travel times sufficient so that, in combination with the other properties of the site and of the engineering design, there will be reasonable assurance that a regulatory specified overall performance standard will be achieved."

Institute of Electrical and Electronics Engineers

"Placing the requirement on water travel time, rather than on radionuclide travel time, may, in effect, result in focusing on an implicit assumption that no retardation occurs. This is another compounding conservatism."

V. INTERNATIONAL COMMENTS

Agencies from two countries, the Netherlands and the United Kingdom, were concerned about the performance criteria proposed by the NRC.

Netherland Energy Research Foundation

" . . . there should be only one approach for setting performance criteria for a high-level waste repository. That approach should be the prescription of a single performance standard for the overall disposal system." . . . "It is only by means of an iterative process of safety assessment and repository system improvement that the relative importance of the different components to the overall system can be evaluated."

"At least for a carefully designed HLW-repository in salt the waste package is therefore not a key component of the overall engineered system . . ."

"The restrictive containment or confinement of the radioactive waste to its waste package is an irrational requirement. The boundary of confinement can easily be shifted more outward without any consequences from the point of view of radiological hazard to man and his environment."

Department of the Environment, United Kingdom

"Document 10 CFR 61 illustrates the setting of overall performance objectives whilst allowing some flexibility in designing and operating each individual repository, whereas document 10 CFR 60 appears to set acceptance criteria not always justified by technical evidence."

"The rule has been developed in the absence of raidological protection criteria (environmental standards), for disposal of high-level wastes; the proposed technical criteria are, therefore, arbitrary. This approach to setting technical criteria is incorrect in principle. It leads to criteria which are inflexible because, since they have no clear basis, there can be no basis for changing them. In addition the approach is very likely to lead to criteria which are too restrictive, thus causing more expenditure on high-level waste disposal than is warranted by radiological protection consideration."

"The rule does not define in any detail the means by which compliance with performance objectives is to be demonstrated. As a consequence the proposed performance objectives have little meaning and it is very difficult to decide whether they are appropriate or achievable."

". . . the proposed rule is unsatisfactory and should not be adopted in its present form. It would be preferable to leave the rule in "proposed" form until the EPA standards have been published and until there is sufficient information available to derive technical criteria from these standards. The rule should then be revised."

"We feel that too many firm numbers are being laid down without sufficient experimental and theoretical justification. Particularly if disposal will not take place for many years it is better to set overall dose limits to define the required performance of the multiple barrier. It is then up to designers to optimize the individual elements in the system as models and experimental data are improved over the years. The proposed rule would freeze options too soon."

NOTE: DOE refers to a statement made by Sandia National Laboratories in its comment letter (#91). The NRC staff has provided this copy of the report from which the statement was quoted by DOE so that the statement may be reviewed in its original context.

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ASSESSMENT OF TECHNICAL CRITERIA OF
10CFR60 FOR GEOLOGIC DISPOSAL OF
HIGH-LEVEL WASTE

M. S. Y. Chu
N. R. Ortiz
R. E. Pepping
M. D. Siegel

Fuel Cycle Risk Analysis Division
Sandia National Laboratories

The Environmental Protection Agency (EPA) has issued a draft standard (40CFR191)[1] which specifies permissible radionuclide release limits from a repository for high-level waste to the accessible environment. The U. S. Nuclear Regulatory Commission (NRC) has published a proposed rule (10CFR60)[2] which specifies technical criteria for geologic disposal of high-level waste designed to facilitate compliance with the EPA draft standard. One of the purposes of the rule is to enhance NRC's confidence that the EPA standard will be met. NRC has requested support from Sandia National Laboratories (SNLA) in the assessment of the 10CFR60 technical criteria and their relation to the EPA draft standard. The assessment includes but is not limited to:

1) Evaluating the effect of the 10CFR60 numerical-technical criteria on reducing the risk and/or uncertainties associated with meeting the EPA draft standard.
2) Identifying potential modifications of 10CFR60 to further reduce the risk and/or uncertainties of meeting the EPA draft standard.
3) Identifying possible interpretations of the numerical criteria and their impact regarding compliance with the EPA draft standard.
4) Identifying the state of the ... for assessing compliance with the 10CFR60 numerical criteria.
5) Assessing the impact of the non-quantitative criteria in 10CFR60 on the risk to the public.

This paper presents preliminary results and observations related to item (1) above. The other issues will be addressed before

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completion of the project which is scheduled for September 1982.

The impacts of the following three numerical-technical criteria on compliance with the EPA draft standard were examined:

1) Waste package containment of at least 1,000 years.
2) Control release rate of at most 10^{-5} part/year from the underground facility.
3) Groundwater travel time of at least 1,000 years to the accessible environment.

In this study all the calculations are limited to the post-closure period and only transport by groundwater is considered. The waste containment period is considered synonymous to canister lifetime, and radionuclide release from the underground facility begins immediately after the waste containment period. The preliminary results of the analysis are expressed in terms of a "release ratio" (RR). This ratio is defined as $\sum Qi/(RL)i$ where Qi is the cumulative release of radionuclide i over 10,000 years; (RL)i is the release limit for radionuclide i from 1,000 metric tons of heavy metal (MTHM) as specified in the EPA draft standard.

The analysis consists of three sets of parametric calculations:

1) Generic parametric analysis.
2) Parametric analysis including geochemical retardation for basalt.
3) Parametric analysis for a hypothetical basalt site.

In the first set, a simple model with point value estimates of input parameters was specified. No assumptions about the variability or uncertainty in input parameters were made and no credit for retardation of radionuclides by geomedia was considered. In the second set of analyses, ranges of input values for groundwater travel times and radionuclide retardation factors representative of basaltic host rock were sampled. In these calculations the effect of the uncertainty in input data upon the uncertainty in the release ratio was assessed. In the third calculation, release ratios for a hypothetical basalt site were calculated.

<u>Generic Parametric Analysis</u>

In this study, an inventory of 46,800 MTHM of spent fuel was assumed. For releases occurring with a probability greater than 10^{-2}, a release ratio of less than 46.8 indicates compliance with

the EPA standard. Integrated discharges over 10,000 years for radionuclides were calculated with the following assumptions:

1) All canisters fail at the end of the waste containment period t_c.
2) Release rate (τ yr.$^{-1}$) is a constant and is set at a specified fraction of the inventory present at time t_c.
3) Dispersion is neglected in transport.
4) Radionuclides in the inventory are divided into two groups. Group I consists of ^{99}Tc, ^{14}C, ^{129}I, ^{90}Sr, ^{135}Cs and ^{137}Cs which are assumed to be unretarded by all geomedia. Group II consists of all actinides and ^{126}Sn, which are assumed to be retarded by the same factor.

The DVM (Distributed Velocity Method) computer code developed at Sandia[3] was used to calculate the discharges of radionuclides with decay chains. Analytical closed-form solutions were used to describe the transport of single member radionuclides. Figure 1 shows release ratio for Group I (unretarded) radionuclides as a function of groundwater travel time and release rate. For example, with a release rate of 10^{-4} yr^{-1}, the EPA standard is violated by these radionuclides alone for sites with groundwater travel time less than ~7600 years. Figure 2 shows the results of similar calculations for the Group II (retarded) radionuclides. We calculated a set of "residual" release ratio curves (Fig. 3) for the radionuclides in Group II as ($46.8 - RR_{I,\tau_i}$), where RR_{I,τ_i} is the release ratio curve for the τ_i release rate in Fig. 1. We can estimate the amount of radionuclide retardation necessary to ensure compliance from these data. The minimum radionuclide migration time associated with a particular release rate that is needed to ensure compliance with the EPA standard is found at the intersection of appropriate RR curve for Group II radionuclides (Fig. 2) and the corresponding residual RR curve (Fig. 3). The minimum retardation factor for radionuclides in Group II is the ratio of this radionuclide migration time to the groundwater migration time. Table I summarizes the results of these calculations. The numbers in parentheses are results for a 1,000 year canister lifetime.

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Table I. For Spent-Fuel Inventory.

For an Engineered System with: Canister	Release Rate	And a Site with: Groundwater Travel Time	Need Minimum Retardation for "all other" RN's
300 (1,000)y.	10^{-3}/y.	9300 y. (8600)	Violation of EPA STANDARD
	10^{-4}/y.	8300 y. (7600)	Violation of EPA STANDARD
	10^{-5}/y.	500 y.	20 (18.2)
		1000 y.	9.9 (9.0)
		2000 y.	4.9 (4.5)
		3000 y.	3.3 (3.0)
		5000 y.	1.9 (1.8)
		8000 y.	1.2 (1.1)
	10^{-6}/y.	500 y.	18.5 (17.0)
		1000 y.	9.3 (8.5)
		2000 y.	4.6 (4.3)
		5000 y.	1.7 (1.7)
	10^{-7}/y.	1000 y.	7.7 (7.1)
		2000 y.	3.8 (3.6)
		5000 y.	1.5 (1.4)

The effect of different canister lifetimes (t_c, years) on the release of nuclides in Group I is shown in Fig. 4. Note that if a constant release rate and a groundwater travel time greater than ~500 years is assumed, then the presence of canister has little effect on releases.

Temperature dependence of the release rate of radionuclides from waste form has been demonstrated in laboratory studies [4]. This temperature dependence can be converted to a time dependence. In Fig. 5 the results of similar calculations on the effect of canister lifetimes are shown when a time-dependent release rate is used. For our calculations we arbitrarily assumed a release rate of 10^{-1} yr^{-1} from 0 to 100 yr. after closure of the repository, 10^{-3} yr^{-1} between 100 yr. and 400 yr., and 10^{-5} yr^{-1} thereafter. When this release behavior is assumed, the significance of canister lifetime becomes apparent. Effort is underway to collect realistic data for time (temperature) dependent release rates.

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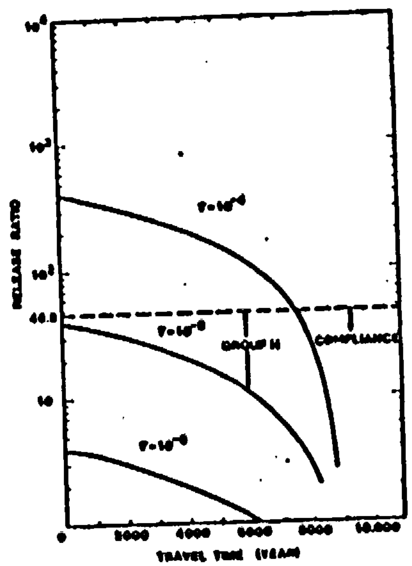
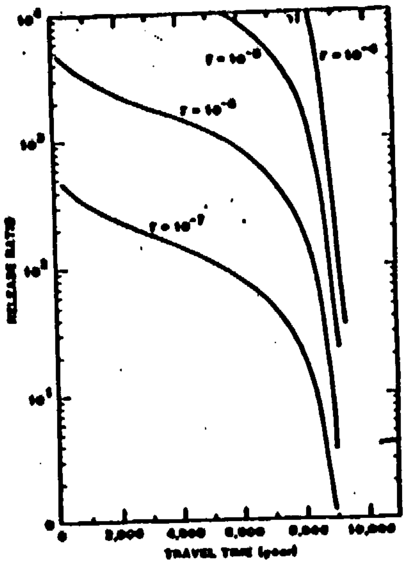
Fig. 1



Release Ratio Curves for Group I Radionuclides. τ = Release Rate (Yr^{-1}). Canister Lifetime = 1,000 Yr.

Fig. 2



Release Ratio Curves for Group II Radionuclides. τ = Release Rate (Yr^{-1}). Canister Lifetime = 1,000 Yr.

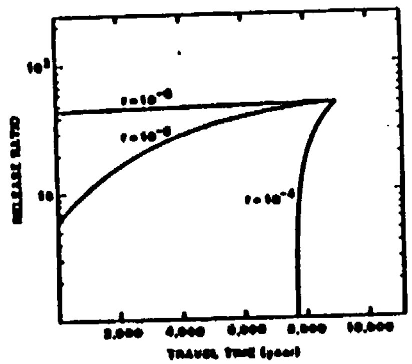


Fig. 3 "Residual" Release Ratio Curves for Group II Radionuclides.

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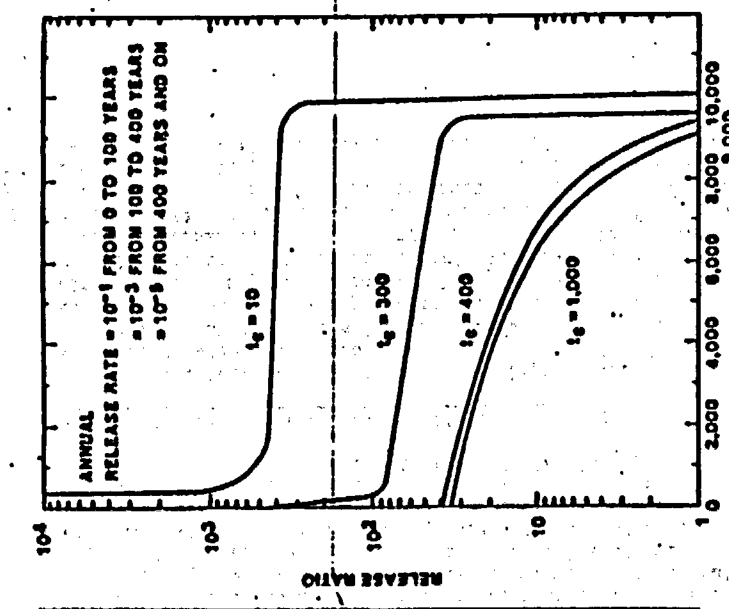

Fig. 5 Effect of Different Canister Lifetimes (t_c) for a Time-Dependent Release Rate.

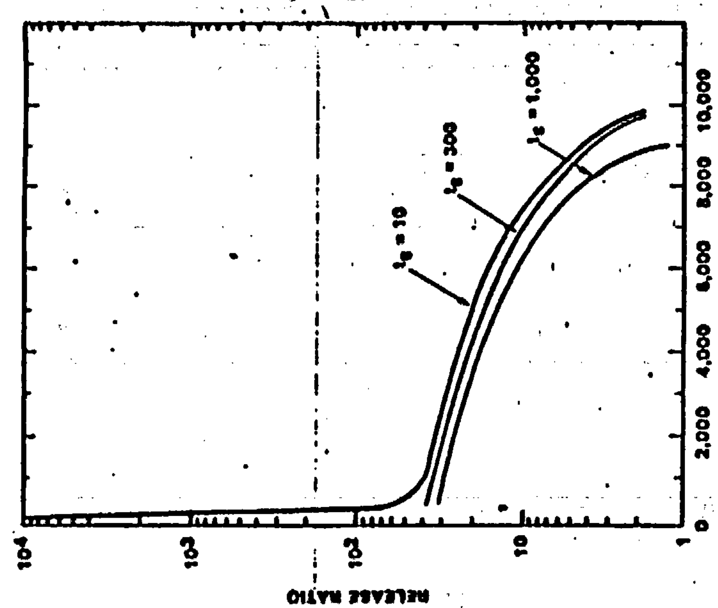

Fig. 4 Effect of Different Canister Lifetimes (t_c). Release Rate = 10^{-5} Yr^{-1}.

Parametric Analysis Including Geochemical Retardation for Basalt

There are large uncertainties associated with many of the input parameters used in modeling the performance of a real waste isolation system. In our models, these uncertainties are treated by:

1) Assigning a probability distribution to the range of values for each parameter.
2) Dividing the input parameter ranges into finite intervals of equal probability.
3) Computing the consequence (using DYM code) for combinations of input values selected by the Latin-Hypercube Sampling technique (LHS)[5].

With this scheme, the uncertainties of input are reflected as a range of output values (consequences). The results are presented in a plot which shows the fraction of calculations with release ratio greater than some value.

In this analysis three sets of calculations were performed for an inventory of 1,000 MTHM of spent-fuel. Each set of calculation involves a parametric variation of one of the performance objectives of 10CFR60. Ranges of all other parameters were divided into 25 intervals and sampled by LHS. A computation was performed to calculate the release ratio for each combination of input variables. Ranges of retardation for each radionuclide in the inventory were chosen from the published data to represent the range of chemical retardation in a reducing basalt environment. The detailed geologic properties of a basalt site are not considered. Calculations were performed for several values of the groundwater travel time from the underground facility to the discharge location. The dispersivity was sampled over a range of 50-500 ft. The release rate was constant with respect to time for each calculation. The input data for each set of calculations are summarized in Table II.

TABLE II

SET	CANISTER LIFETIME (yr)	RELEASE RATE (yr^{-1})	GROUNDWATER TRAVEL TIME (yr)
1	100 300 500 1,000	(10^{-7} - 10^{-3})	(10^{2} - 10^{4})
2	300	(10^{-7} - 10^{-3})	200 500 1,000 5,000
3	300	10^{-3} 10^{-4} 10^{-5} 10^{-6}	(10^{2} - 10^{4})

Figures 6 through 8 presents the results of these calculations. In these figures, the curves indicate the fraction of calculation results in release ratios greater than the value on the abscissa. In Fig. 5 it can be seen that the waste containment period has little effect on compliance. Longer groundwater travel times and slower release rates result in a reduction in release as demonstrated by the shifting of the curves to the left in Figs. 7 and 8.

Parametric Analysis for a Hypothetical Basalt Site

These calculations were based on a hypothetical basalt site with the stratigraphy shown in Fig. 9. Ranges of hydraulic properties and retardation factors for radionuclides were assigned to each unit based on its postulated lithology and mineralogy respectively. Figures 10 and 11 show the two scenarios considered in this analysis. The first scenario is a base case (routine release) scenario; the second scenario involves fracturing the dense basalt unit that contains the underground facility. In these calculations 100 combinations of input values were sampled from the data ranges, producing 100 consequences for each scenario. Two canister lifetimes (300 and 1,000 yrs.) and two release rate

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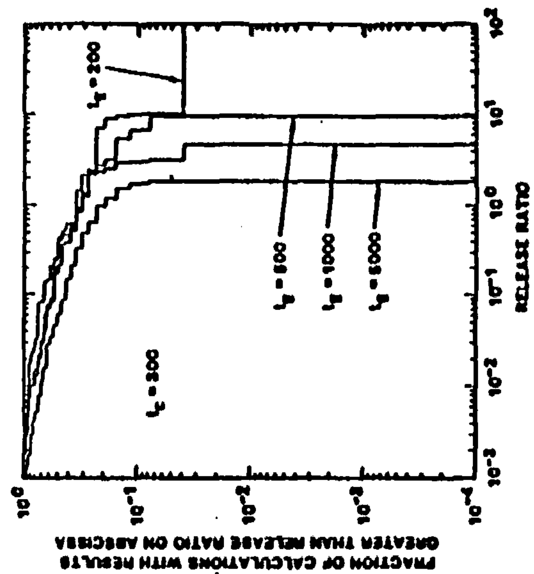

Fig. 7

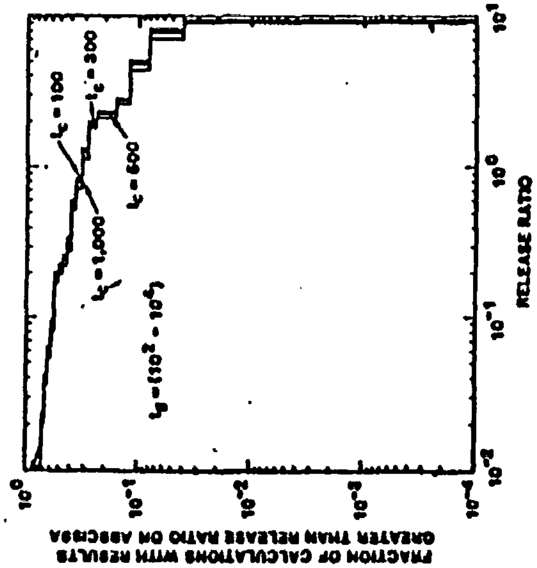

Fig. 6

Fraction versus Release Ratio Curves for a Generic Basalt Site.
t_c = Canister Lifetime (Yr), τ = Release Rate = (10^{-7} - 10^{-3}) Yr^{-1},
t_g = Groundwater Travel Time (Yr).

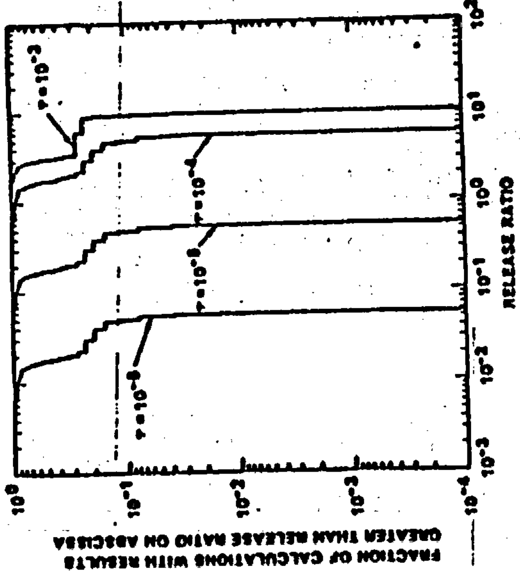

Fig. 8 Fraction versus Release Ratio Curves for a Generic Basalt Site. Canister = 300 Yr., τ = Release Rate, τ_g = Groundwater Travel Time.

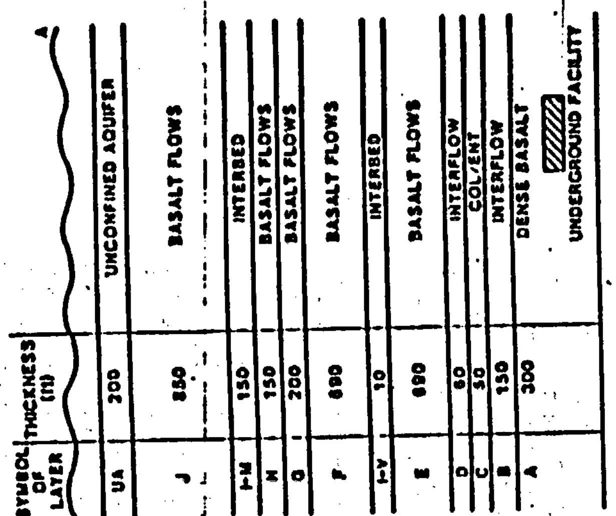

Fig. 9 Stratigraphic Cross-section of Hypothetical Repository in Basalt.

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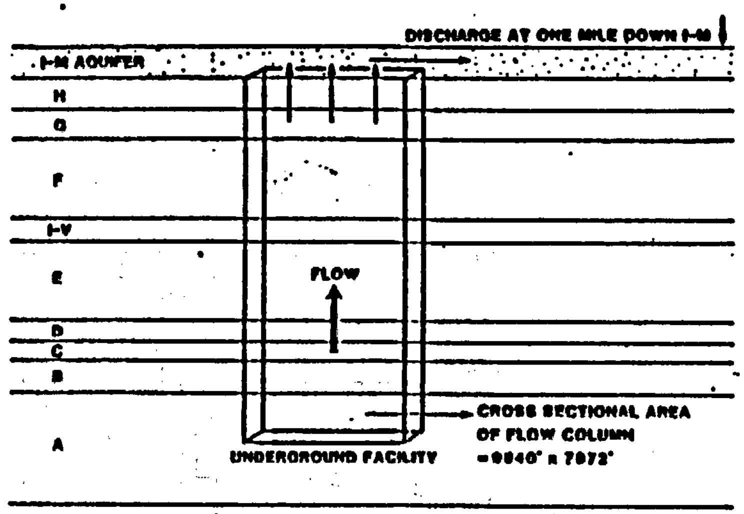

Fig. 10 Routine Release Scenario in a Hypothetical Basalt Site.

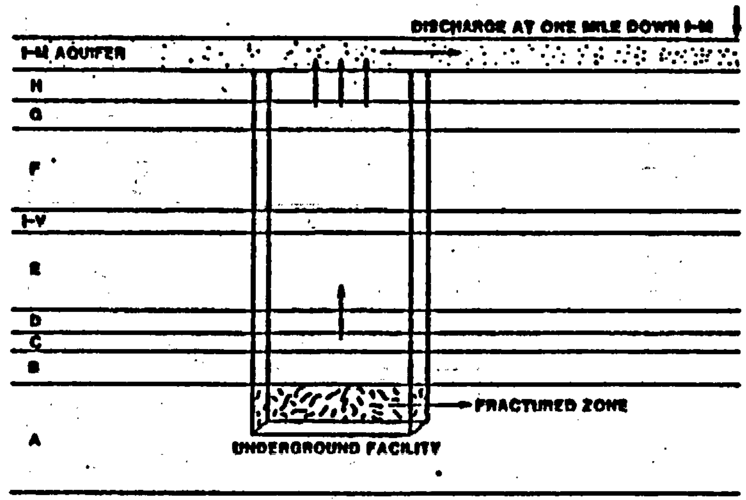

Fig. 11 Fractured Dense Basalt Scenario in a Hypothetical Basalt Site.

ranges (10^{-7} - 10^{-3} and 10^{-7} - 10^{-5} yr^{-1}) were considered. Figures 12 and 13 show the results of these calculations for Scenarios I and II respectively. These results are similar to those obtained from the generic parametric analyses. It can be seen that varying the lifetime of the canister has a *minor effect* on the shape or position of the fraction-release ratio curves when a temperature independent release rate is assumed. Variations in the groundwater travel time caused by choice of scenario or variability in hydraulic or geochemical parameters significantly affect the curves. Variation in the range of sampled release rates also has a strong effect on these curves. The shifting of these curves to the left could be interpreted as an increase in the safety margin with respect to compliance.

Summary and Comments

In these preliminary analyses, the ability of the three numerical criteria in 10CFR60 to facilitate compliance with the EPA draft standard was examined. It was found that the waste containment period had minor importance in assisting compliance with the EPA draft standard, if the release rate of radionuclides is independent of time (temperature). However, the waste containment period will have a significant impact if the release rate changes significantly with time (temperature). In the latter case, the regulation of the waste containment period, or the temperature at which radionuclide release could occur, may have a significant impact in meeting the EPA draft standard.

It was noticed that for relatively large release rates ($>10^{-4}$/yr.) and if some radionuclides were unretarded by the geomedia (e.g., ^{99}Tc and ^{14}C), these radionuclides alone could violate the EPA standard unless compensated by a good site (e.g., long groundwater travel time). For relatively smaller release rates ($<10^{-5}$/yr.) compliance with the EPA draft standard could be obtained if the site exhibited a minimum retardation factor for those radionuclides which could be retarded. In the present draft of 10CFR60, geochemical retardation of radionuclides is addressed only by non-quantitative (soft) requirements. In this study, minimum retardation factors were calculated for simple generic sites and for several combinations of groundwater travel time, release rate and canister lifetime.

The criterion on groundwater travel time showed a significant effect on compliance with the EPA draft standard. Sites with relatively long groundwater travel times will help in meeting the

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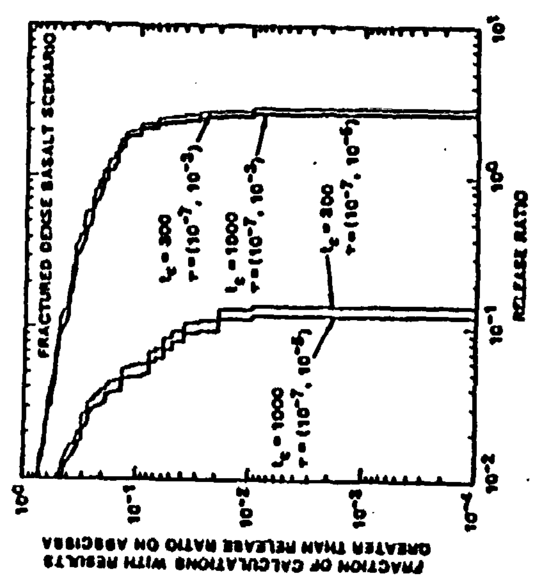

Fig. 13

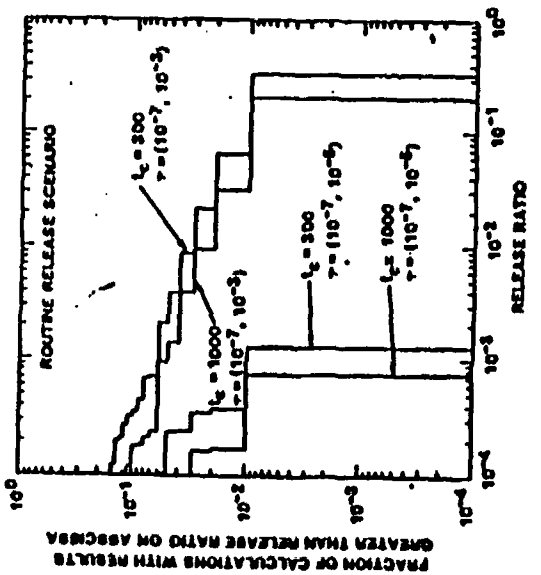

Fig. 12

Fraction versus Release Ratio Curves for a Hypothetical Basalt Site. t_c = Canister Lifetime (Yr), τ = Release Rate (Yr^{-1}).

EPA draft standard. It is interesting to note that for very short waste containment periods (Figs. 4 & 5), the release ratio versus groundwater travel time curves show a large change in slope near 1,000 year groundwater travel time. This implies that in the event of premature failure of canisters, a site would have to have about 1,000 years groundwater travel time to prevent massive releases of radionuclides.

The 10CFR60 rule defines discrete minimum values for the performance objectives (technical criteria) in regulating the risk involved in HLW isolation. However, the characteristics of natural systems and the performance of engineered systems cannot be described without a degree of uncertainty. The calculations described in this paper demonstrate a method to estimate the impact on compliance with the EPA draft standard from uncertainties in the input data. Similar analyses can be performed to estimate the impact on compliance with the EPA draft standard from other interpretations of the performance objectives. For example, the values of the technical criteria may be set equal to the lower limit or the mean of a probability distribution which describes the engineered system performance or the natural variability of the site.

It is important to note that 10CFR60 also contains "soft" (non-quantitative) requirements described as favorable conditions and potentially adverse conditions for the geologic setting. These requirements shall be considered together with the numerical criteria in assessing the impact of 10CFR60 in reducing the risk and/or uncertainty in meeting the EPA draft standard. The above conditions intend to guide the applicant in selecting a site that protects the health and safety of the public. For example, compliance with these requirements could help to reduce the probability of having scenarios (e.g., faults, volcanic activity) which could lead to radionuclide releases to the accessible environment. An assessment of the impact of these requirements on compliance with the EPA draft standard will be performed.

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REFERENCES

1. "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes," 40CFR191, Draft #19, March 1981.

2. "Technical Criteria for Regulating Geologic Disposal of High-Level Radioactive Waste," 10CFR60, July 1981.

3. Campbell, J.E., et al., 1980, "Risk Methodology for Geologic Disposal of Radioactive Waste: The Distributed Velocity Method of Solving the Convective-Dispersion Equation," SAND80-0717, NUREG/CR-1376, Sandia National Laboratories, Albuquerque, NM.

4. Westik, J. and R. D. Peters, 1981. Scientific Basis for Nuclear Waste Management, Vol. 3: 356-362.

5. Iman, R. L., et al., 1980, "Latin-Hypercube Sampling (Program User's Guide)," SAND79-1473, Sandia National Laboratories, Albuquerque, NM.

STATE OF WISCONSIN

RADIOACTIVE WASTE REVIEW BOARD

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Assistant Director - Lisa Vinson Beaman

DOCKETED USNRC

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OFFICE OF SECRETARY DOCKETING & SERVICE BRANCH

(92)

DOCKET NUMBER PROPOSED RULE PR-60
(46 FR 352

December 7, 1982

U.S. Nuclear Regulatory Commission
Washington, DC 20555

Re: NRC Rulemaking--10CFR60, Technical Criteria for Geological Repositories

Gentlemen:

The State of Wisconsin Radioactive Waste Review Board strongly objects to the attempt made by the United States Department of Energy to eliminate the 1000 year containment criterium for high level waste packaging. This action comes well after the comment period has ceased. Should the Nuclear Regulatory Commission consider revising its rule in accordance with the Department of Energy request, the State Radioactive Waste Review Board demands that the Commission reopen its rulemaking to allow further comment from interested parties regarding the Department of Energy proposal. The department's attempt to unilaterally influence the current rulemaking after-the-fact is legally indefensable and may require legal action should such a procedure be adopted by the Commission.

Sincerely,

Patrick Walsh

Patrick Walsh
Executive Director
Wisconsin Radioactive Waste Review Board

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ENCLOSURE E

OFFICE OF THE SECRETARY

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

January 4, 1983

ACTION - Minogue
Cys: Dircks
Roe
Rehm
Stello
Davis
MBell
GCunningham
Philips

MEMORANDUM FOR: William J. Dircks, Executive Director for Operations

FROM: Samuel J. Chilk, Secretary

SUBJECT: SECY 82-427 - COMMISSION OPTIONS ON DEVELOPING FINAL TECHNICAL CRITERIA FOR DISPOSAL OF HLW IN GEOLOGIC REPOSITORIES

This is to advise you that the Commission (with Chairman Palladino and Commissioners Gilinsky and Asselstine agreeing) has approved Option 3 of the subject paper and the attached modifications to the rule. Commissioners Ahearne and Roberts would have preferred Option 1.

The staff is directed to finalize the high level waste rule including the two performance objectives for the engineered barrier system; state that the NRC will review the performance standards after the EPA standard is issued in final form and revise them in a subsequent rulemaking, if necessary.

~~(NMSS)~~ RES (SECY Suspense: 1/25/83)
(EDO Suspense: 1/21/83)

Attachment:
As stated

cc: Chairman Palladino
Commissioner Gilinsky
Commissioner Ahearne
Commissioner Roberts
Commissioner Asselstine
Commission Staff Offices

Rec'd Off. EDO
Date..... 1-5-83
Time..... 2:47 p

Enclosure

PROPOSED REVISION OF § 60.113

§ 60.113 Performance of particular barriers after permanent closure.

(a) General provisions.

(1) Engineered barrier system.

(i) The engineered barrier system shall be designed so that assuming anticipated processes and events (A) containment of HLW will be substantially complete during the period when radiation and thermal conditions in the [~~underground-facility~~] engineered barrier system are dominated by fission product decay; and (B) any release of radionuclides from the engineered barrier system shall be a gradual process which results in small fractional releases to the geologic setting over long times. [~~In-the-case-of-disposal-in-the-saturated-zone,-it-shall-be-assumed-in-designing-the-engineered-barrier-system-that-partial-or-complete-filling-with-groundwater-of-available-void-spaces-in-the-underground-facility-occurs.~~] For disposal in the saturated zone, both the partial and complete filling with groundwater of available void spaces in the underground facility shall be appropriately considered AND ANALY among the anticipated processes and events in designing the engineered barrier system.

(ii) In satisfying the preceding requirement, the engineered barrier system shall be designed, assuming anticipated processes and events, so that:

(A) Containment of HLW within the waste packages will be substantially complete for a period to be determined by the Commission taking into account the factors specified in subsection 60.113 (b) [~~of~~]

provided, that such period shall be not less than ~~200~~ 300 years nor more than 1,000 years after permanent closure of the geologic repository [,-or-such-other-period-as-may-be-approved-or-specified-by-the Commission,] ; and

(B) the release rate of any radionuclide from the engineered barrier system following the containment period shall not exceed one part in 100,000 per year of the inventory of that radionuclide calculated to be present at 1,000 years following permanent closure, or such other fraction of the inventory as may be approved or specified by the Commission; provided, that this requirement does not apply to any radionuclide which is released at a rate less than 0.1% of the calculated total annual release rate limit. The calculated total release rate limit shall be taken to be one part in 100,000 per year of the inventory of radioactive waste, originally emplaced in the underground facility, that remains after 1,000 years of radioactive decay.

(2) Geologic setting. The geologic repository shall be located so that pre-waste emplacement groundwater travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment shall be at least 1,000 years or such other travel time as may be approved or specified by the Commission.

(b) On a case-by-case basis, [DOE-may-propose-and-the-Commission-may-consider-some-alternative-combination-of] the Commission may approve or specify some other radionuclide release rate, designed containment period, [and] or pre-waste emplacement groundwater travel time, provided that the overall system performance objective, as it relates to anticipated processes and events is satisfied. Among the factors that the Commission may take into account [in-approving-such-alternatives] are:

(1) Any generally applicable environmental standard for radioactivity established by the Environmental Protection Agency;

(2) the age and nature of the waste, and the design of the underground facility, particularly as these factors bear upon the time during which the thermal pulse is dominated by the decay heat from the fission products;

(3) the geochemical characteristics of the host rock, surrounding strata and groundwater; and

(4) particular sources of uncertainty in predicting the performance of the geologic repository.

(c) Additional requirements may be found to be necessary to satisfy the overall system performance objective as it relates to unanticipated processes and events.

ENCLOSURE F

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 191

[A-FRL 1810-1]

Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes

AGENCY: Environmental Protection Agency.

ACTION: Proposed rule.

SUMMARY: The Environmental Protection Agency requests comments on proposed environmental standards for the management and disposal of spent nuclear reactor fuel and high-level and transuranic wastes. Subpart A of the proposed standards would limit the radiation exposure of members of the public from management of spent fuel and of waste prior to disposal. Subpart B would establish both containment requirements for disposal systems and requirements to assure that these containment requirements should be met. The containment requirements would limit the amount of radioactivity that may enter the environment for ten thousand years after disposal. The assurance requirements provide seven principle necessary for developing confidence that these long-term containment requirements will be complied with. The requirements of Subpart B would apply to disposal by any method, except disposal directly into the oceans or ocean sediments.

After we consider the comments received on this proposal, we will develop a final version of these standards and promulgate them as a new Part 191 to Title 40 of the Code of Federal Regulations (40 CFR Part 191). The standards would be implemented by the Nuclear Regulatory Commission and the Department of Energy under their respective statutory responsibilities.

DATE: Public hearings on this proposed rule will be held during May of 1983. Specific dates and arrangements will be announced in a later Federal Register notice. Comments on the proposed rule and requests to participate in the public hearings should be received on or before May 2, 1983.

In addition, a panel of EPA's Science Advisory Board (SAB) will review the technical analyses supporting the proposed standards during the comment period. The meetings of the SAB panel will be open to the public and will be announced in the Federal Register.

ADDRESS: Comments should be submitted (in duplicate if possible to: Central Docket Section (A-130), Environmental Protection Agency, Attn: Docket No. R-82-3, Washington, D.C. 20460.

Docket No. R-82-3, containing material relevant to this rulemaking, is located in the West Tower Lobby, Gallery 1, Central Docket Section, Environmental Protection Agency, 401 M Street, S.W., Washington, D.C. The docket may be inspected between 8 a.m. and 4 p.m. on weekdays, and a reasonable fee may be charged for copying.

Single copies of the Draft Environmental Impact Statement for this action may be obtained by writing to: Director, Criteria and Standards Division (ANR-460), Office of Radiation Programs, Environmental Protection Agency, Washington, D.C. 20460.

Requests to participate in the public hearings should be made in writing to the Director, Criteria and Standards Division. All requests for participation must include at least an outline of the topics to be addressed in the opening statement(s), the amount of time requested for the statement(s), and the names of the participants. Statements should not repeat information already presented in written comments, but should address additional information or issues.

FOR FURTHER INFORMATION CONTACT: Daniel Egan, telephone number (703) 557-8610.

SUPPLEMENTARY INFORMATION: Fissioning of nuclear fuel in nuclear reactors creates a small quantity of highly radioactive materials. This concentrated radioactivity is retained in the spent fuel elements when they are removed from the reactor. If the fuel is then reprocessed to recover unused uranium and plutonium, the concentrated radioactivity goes into acidic liquid wastes that will later be converted into solid forms. These highly radioactive liquid or solid wastes from reprocessing spent nuclear fuel, or the spent fuel elements themselves if they will be disposed of without reprocessing, are called "high-level wastes." The nuclear reactors operated by the nation's electrical utilities currently generate about 2,000 metric tons of spent fuel per year. For comparison, chemically hazardous wastes regulated under the Resource Conservation and Recovery Act are produced at a rate of about 40,000,000 metric tons per year.

Although they are produced in small quantities, proper management and disposal of high-level wastes are important because of the inherent hazards of the large amounts of radioactivity they contain. This nee careful control has been recognized since the inception of the nuclear ag The Federal Government has alway assumed responsibility for the ultim care and disposal of these wastes, regardless of whether they are prod by commercial or national defense activities. Over the last several year the Federal Government has intensif its program to develop and demonstr a permanent disposal method for hig level wastes. President Reagan's Apr 28, 1982 message to Congress on nucl waste disposal reaffirmed this commitment and called for a Federal owned and operated permanent repository to be available at the earli practicable date. The environmental protection requirements that we are proposing today will provide the basi framework for the long-term controls that these wastes need.

High-level wastes contain many different radionuclides. Some of these nuclides emit alpha particles; other en beta particles. Some radionuclides em gamma rays in addition to alpha or be particles. The radionuclides decay wit half-lives ranging from less than one year to millions of years. We have concentrated our attention on radionuclides with half-lives greater than 20 years because they must be isolated from people for very long time Thus, we exclude radionuclides such a tritium, krypton-85, and plutonium-241, which are present in large quantities in freshly discharge fuel, but which decay so rapidly that they do not require long term isolation.

Reprocessing reactor fuel used for national defense activities has produce about 500 million curies of radionuclide with half-lives greater than 20 years. Most of the activity is due to strontium-90 and cesium-137, which have half-live of about 30 years. These wastes are stored in various liquid and solid forms on three Federal reservations in Idaho, Washington, and South Carolina. Relatively small additions are being made from ongoing defense programs.

Spent fuel from commercial nuclear power reactors contains about 800 million curies of radionuclides with half-lives greater than 20 years. About 10 million curies of this radioactivity are due to radionuclides, such as plutonium, which emit alpha particles. Most of this spent fuels is stored at reactor sites. Over the next few years, this inventory is expected to grow at a rate of about 200 million curies per year from reactors currently licensed to operate. At some reactor sites, spent fuel storage capacity

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is almost used up. Electrical utilities, the operators of commercial reactors, are pursuing a variety of techniques to increase storage capacities, and legislation concerning Federal assistance for spent fuel storage is under consideration in Congress.

Nuclear reactors use some isotopes of uranium, plutonium, or thorium to produce energy from nuclear fission. These elements are sometimes referred to as "heavy metals." The amount of wastes produced is roughly proportional to the amount of these elements placed into a ractor. We use the unit "wastes generated per metric ton of heavy metal (MTHM)" to measure the amount of waste placed in disposal systems.

The amount of natural uranium ore needed to produce one MTHM depends on the reactor type, degree of reprocessing, and quality of ore. For the light water reactors currently used in the United States, about 6,000 metric tons of uranium ore are used to produce one MTHM of reactor fuel. We have used this relationship to associate amounts of waste from reactor fuel with uranium ore.

In proposing these environmental protection requirements, we do not advocate any specific method for disposing of high-level wastes. However, in developing our proposed standards, we considered the long-term risks from disposal in mined geologic repositories. We concluded that well-designed repositories at well-chosen sites can keep potential radiation exposures to very low levels. In fact, because repositories appear to provide such good protection, we have chosen to propose disposal standards that limit the risks to future generations to a level no greater than the risks which those generations would be exposed to from equivalent amounts of unmined uranium ore. Thus, any risks to future generations from disposal of high-level wastes would be no greater than, and probably much less than, risks which those generations would face if the wastes had not been created in the first place.

Description of the Proposed Action

Under authorities established by the Atomic Energy Act and Reorganization Plan No. 3 of 1970, we are proposing generally applicable environmental standards for managing and disposing of these wastes. When such standards are promulgated, the Nuclear Regulatory Commission (NRC) and the Department of Energy (DOE) will be responsible for implementing and enforcing them through appropriate regulations and procedures. The Draft Environmental Impact Statement (EIS) published with this proposal includes detailed discussions of the reasons for our selections of these standards, and it provides extensive summaries of the technical analyses used. This preamble describes our proposed action, highlights features that we believe are of major interest, and points out issues on which we particularly seek public comment.

The proposed standards apply to spent reactor fuel, the highly radioactive wastes derived from reprocessing spent fuel, and to certain wastes containing long-lived radionuclides of elements heavier than uranium ("transuranic wastes"). Transuranic wastes are covered if they contain 100 nanocuries or more of alpha-emitting transuranic isotopes, with half-lives greater than 20 years, per gram of waste. People could receive, under some circumstances, more than 500 millirems per year from wastes containing more than 100 nanocuries of transuranic elements per gram if these wastes were not well isolated. 500 millirems per year is the Federal Radiation Protection Guide for individuals in the general population. Because transuranic wastes have very long half-lives and represent a potential hazard for very long times, we are proposing the same controls for these wastes as would be required for high-level wastes. Protection requirements for transuranic wastes containing less than 100 nanocuries per gram will be considered in future standards.

Some wastes produced from reprocessing spent fuel, particularly when changing the form of the wastes, may not need the same degree of control as the high-level wastes themselves. (For example, processing of certain defense wastes may leave large volumes of salt cake containing relatively low concentrations of technetium-99.) Accordingly, we are proposing a definition of high-level waste that would exclude wastes that contain less radioactivity than the concentration levels specified in Table 1 of the standards. Disposal of wastes with less radioactivity will be considered in future standards.

The levels in Table 1 are equivalent to the maximum concentrations for acceptance at shallow-land burial sites that the Nuclear Regulatory Commission (NRC) will soon promulgate as part of 10 CFR Part 61. The concentration limits in 10 CFR 61 have been derived so that a person intruding into a shallow-land site, after institutional controls were no longer effective, should not receive a radiation exposure greater than 500 millirem per year. However, because no method to generically classify radio active wastes by their need for isolation has been widely accepted yet, we particularly seek comment on our proposed definition of high-level waste.

The proposed standards do not apply to wastes that have already been disposed of. Although no high-level wastes have ever been disposed of in this country, some transuranic wastes have been buried at a number of sites. Most of these wastes, produced in support of national defense programs, were disposed of before the current Department of Energy (DOE) procedures for transuranic waste management were adopted in 1970. We do not currently have enought information on costs and risks to develop generally applicable standards for these wastes.

Also, our standards do not apply to ocean disposal because such disposal of high-level waste is prohibited by the Marine Protection, Research, and Sanctuaries Act of 1972.

In developing the proposed standards, we estimated the risks from waste management and disposal systems that use methods of controlling releases which either are available now or are likely to be available in the near future. From these evaluations, we concluded that:

1. Any harm to people, including future generations, from the management and disposal of spent fuel, high-level, and transuranic wastes can be kept very small. The assessments which support this conclusion are outlined below and are discussed extensively in the Draft EIS.

2. 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.

In selecting the release limits given in the standards, we projected the performance of disposal systems which have not yet been demonstrated. There are significant uncertainties inherent in such projections. To avoid underestimating the risks associated with such systems, we often made pessimistic assumptions about how well a repository would perform. For example, we assumed that human intrusion into a repository would take place as if no site markers or records discouraged it beginning 100 years after disposal. Our estimates may, therefore, be considered upper bounds of the risks. When actual control methods are selected and demonstrated at specific sites, expected releases are likely to be well below the amounts allowed by the

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proposed standards. Accordingly, the proposed standards instruct the implementing agencies to take steps to reduce releases below these upper bounds to the extent reasonably achievable, taking into account technical, social, and economic considerations.

Our environmental standards apply to both management and disposal. Subpart A applies to management and includes storage, preparation of the wastes for disposal, and placing them in a disposal site. Off-site transportation is not covered. In his April 28, 1982 message to Congress, President Reagan recommended that both temporary storage facilities and long-term, monitored retrievable storage (MRS) facilities be considered to manage spent fuel and high-level waste until a permanant repository is available. Subpart A would apply to both types of storage systems. Subpart B applies once the wastes are isolated enough so that it would be much harder to get them out of a disposal system than it was to put them in. With a geologic repository, for example, Subpart B would take effect when the mine was backfilled and sealed.

Waste Management

(40 CFR Part 191 Subpart A)

Certain operations required before disposing of high-level or transuranic radioactive wastes are not regulated under our Uranium Fuel Cycle Standards (40 CFR Part 190). These operations principally involve storage of the materials, solidification or other preparation for disposal, and placing the wastes in disposal sites. Subpart A applies to spent fuel management, regardless of whether the fuel is considered to be waste or is destined for reprocessing, except for management already regulated by 40 CFR Part 190.

We estimated the largest expected radiation exposures to members of the public from waste management and storage operations associated with geologic disposal and found them to be somewhat smaller than the requirements set in 40 CFR 190. We propose to extend the limitations contained in Part 190 to the operations addressed by this new Part 191 for two reasons:

1. Some strategies for disposal could involve operations, such as chemical separation of transuranic elements, which are similar to those of spent fuel reprocessing. Reprocessing operations were a significant consideration in selecting the limits of 40 CFR 190. Setting the standards in Part 191 at the levels indicated by assessments based only on geologic disposal activities could preclude other disposal strategies which might be better overall.

2. Some of the operations addressed by Part 191 may take place near operations regulated by Part 190. Establishing different limitations for different operations at the same site would create difficult implementation problems with little, if any, additional public health protection. The provisions of Part 191 require the combined impacts from multiple operations to meet a single set of dose limitations which will be the same in both Parts 190 and 191.

Section 191.03 therefore requires that the combined annual dose equivalent to any member of the public due to operations covered by Part 190, and to direct radiation and planned discharges of radioactive materials covered by this Subpart, shall not exceed 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ. It also requires that waste management operations be conducted so as to reduce exposures for members of the public below this level to the extent reasonably achievable, taking into account technical, social, and economic considerations.

Disposal

(40 CFR 191 Subpart B)

Environmental protection standards for the disposal of high-level and transuranic radioactive wastes require far different considerations than those for management. These include the following:

1. The intent of disposal is to isolate the wastes from the environment for a longer time than any period over which active controls, such as monitoring the disposal site to detect releases of radioactivity, can reasonably be relied upon for protection.

2. These disposal systems will be designed so that very little, if any, radioactivity returns to the environment if the system performs as intended. Thus, the principal concern is the possibility of accidental releases, either due to unintended events or due to failure of parts of the disposal system to perform as expected.

These considerations have several ramifications for developing environmental protection standards. First, the requirements we establish can only be implemented by the NRC and DOE in the design phase—by setting design principles or by analytically projecting disposal system performance. The more familiar concepts of implementation involving monitoring of emissions or ambient levels of pollutants are not applicable because such surveillance cannot be relied upon for the long time periods involved.

Second, the standards must address unintentional releases such as those resulting from human intrusion or geologic faulting. Their provisions must be applicable to a variety of disposal strategies because the Agency does not have the authority to specify details of disposal method designs. Regulations to be developed by the NRC or DOE, as appropriate, will control specific designs.

Third, the standards must accommodate large uncertainties. These include both uncertainties in our current knowledge about disposal techniques and inherent uncertainties about the distant future. Thus, protecting the environment involves encouraging use of disposal systems that are tolerant of potential mistakes in engineering design or site selection.

We addressed these issues by developing numerical containment requirements for disposal systems accompanied by qualitative requirements to assure that these containment requirements should be met. These two parts of our proposed action are complementary: the containment requirements set limits on potential releases of radioactive materials from disposal systems for 10,000 years after disposal; the assurance requirements provide the framework necessary to develop appropriate confidence in meeting the containment requirements in spite of the inherent uncertainties. In addition, the standards contain procedural requirements to insure that the containment requirements are properly applied.

Containment Requirements

(Section 191.13)

To develop the long-term containment requirements, we assumed that we can predict some aspects of the future well enough to use the predictions for comparing and selecting disposal methods. Thus, we evaluated ways that waste might be released from a mined geologic repository, developed analytical models to predict potential releases and their distribution throughout the ecosystem over 10,000 years, and estimated the possible risks that could result from these releases if they occured in an environment similar to today's.

We concentrated on geologic repositories because much more information is available on this approach than on other disposal methods, and because the Department

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of Energy has decided to focus the national program on this method (46 FR 26677). Furthermore, when we evaluated the limited information available on other disposal methods, we did not identify any other methods which were clearly better than geologic disposal. Our disposal standards, however, are meant to apply to any method of disposal, except disposal directly into the ocean or ocean sediments. Thus, any other disposal method would have to provide at least as much protection as that projected for geologic disposal.

There are significant uncertainties in the analytical models are used to assess the long-term performance of geologic repositories, and there are substantial uncertainties in the data we used in the models. The primary objective of the review to be conducted by the Agency's Science Advisory Board will be to judge whether our models and assumptions are adequate for the purpose they served in our development of containment requirements. The following paragraphs more fully describe how we formulated these requirements.

In our assessments of geologic disposal, we identified expected and accidental releases of radioactivity from a generic model of a repository. The model repository contains 100,000 MTHM of spent reactor fuel, about as much as would be generated during the operating lifetimes of 100 reactors of current design. The initial amounts of some of the principal radionuclides in this model repository would be: eight billion curies of cesium-137; six billion curies of strontium-90; 200 million curies of americium-241; 30 million curies of plutonium-239; and one million curies of technetium-99.

We examined the capabilities of waste canisters, waste chemical forms, respository design, and geologic media to prevent or delay the release of radionuclides. We selected reasonably achievable characteristics for each portion of the disposal system. For accidental releases, we estimated the probabilities of events leading to releases. Intentional disruption of the disposal system was not considered.

Radionuclides were considered to be released from the disposal system if they reached the "accessible environment," which includes surface waters, land surfaces, the atmosphere, and the oceans. Our definition of the "accessible environment" also includes all groundwater formations that are more than ten kilometers in any direction from the original location of the radioactive wastes in a disposal system. Although this approach does not provide any direct protection for the relatively small amount of groundwater that could within ten kilometers of a geologic respository, it recognizes that adjacent geologic formations serve as part of the containment system for a repository. Since the amount of groundwater left unprotected should be kept as small as possible, consistent with other requirements, we expect that the Federal environmental impact statement for each disposal system will identify all sources of groundwater within ten kilometers of the disposal system, will describe the potential long-term environmental effects of possible contamination of these sources of groundwater, and will consider these effects as one the factors in evaluating alternative sites.

Our regulations and the assessments on which we base them cover releases of radionuclides to the accessible environment for a period of 10,000 years after disposal. We believe that a disposal system capable of meeting these requirements for 10,000 years will continue to protect people and the environment beyond 10,000 years. We selected 10,000 years as the assessment period for two reasons:

1. It is long enough for releases through groundwater to reach the accessible environment. If we had selected a shorter time, such as 1,000 years, our estimates of long-term risks in the accessible environment would be deceptively low, because groundwater could take 1,000 years to travel a mile at a well-selected site, and most radionuclides would take much longer. Choosing 10,000 years for assessment encourages selection of sites where the geochemical properties of the rock formations can significantly reduce releases of radioactivity through groundwater.

2. Major geologic changes, such as development of a faulting system or a volcanic region, take much longer than 10,000 years. Thus, the likelihood and characteristics of geologic events which might disrupt the disposal system are reasonably predictable over this period.

We estimated the amounts of radioactivity that could reach the accessible environment over this time period under various circumstances. Releases from geologic repositories fall into three general categories. Relatively small releases would be caused by expected processes and by fairly likely but unintended events. These processes and events lead to what we call "reasonably foreseeable" releases. Moderate releases would result from much less likely events, such as fault movements or other disruptive geologic events and these we call "very unlikely releases." Very large releases would result only from the intrusion of volcanos or impacts by huge meteorites. If sites are selected away from regions of volcanic activity, these large releases will be extremely unlikely.

We used our estimates of releases and their likelihood to select limits on total releases of radioactivity over 10,000 years. Limits were set for two categories of releases in terms of their probabilities: "reasonably foreseeable," and "very unlikely." The release limits for the "very unlikely" category are ten times larger than those for the "reasonably forseeable" category. Reasonably forseeable releases are those which have more than one chance in 100 of occurring within 10,000 years. Very unlikely releases are those whose chance of occurring within 10,000 years is less than one in 100 and more than one in 10,000. No limits were set for releases which have less than one chance in 10,000 of occurring within 10,000 years.

To select the specific release limits for the various radionuclides in a disposal system, we first estimated the health effects that might be caused by these releases. For these calculations, we used very general models of environmental transport and a linear, nonthreshold dose-effect relationship between exposure and premature deaths from cancer. This relationship, which is based on studies prepared by the National Academy of Sciences (NAS), assumes that the number of cancers induced in a population is proportional to the total dose received by the population, even at very low individual doses. At the low levels of exposures that might be associated with releases from amined geologic repository, any actual incidence of health impacts may be less than that calculated by this relationship, and it certainly would not be distinguishable from natural occurrences of cancer. However, the Agency believes that health impact estimates using a linear, nonthreshold relationship are a prudent consideration in developing radiation protection requirements.

Our assessments of repository performance gave estimates of the possible health effects expected from releases after disposal. These estimates can vary considerably depending upon the assumptions used and the geologic media considered. For well-designed 100,000 MTHM model repositories in salt and granite—using engineering controls that we believe are readily achievable—we estimate that the health risks over 10,000 years would be no greater than the risks from an equivalent amount of unmined uranium ore. To provide a specific basis for our proposed

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standards, we selected a limit on long term risks of 1,000 health effects over 10,000 years for a 100,000 MTHM repository. Our assessments show that a wide variety of respository designs and sites can reduce risks below this level. We then used this level of protection as the basis for calculating the release limits specified in Table 2 of the standards.

According to our modes, at well-chosen repository sites more of the projected risk from releases is due to possible human intrusions than from releases by geologic processes—if we make the very conservative assumption that passive institutional controls have no effect in deterring or limiting inadvertent human intrusion for more than 100 years after disposal. However, predicting human actions is much more uncertain than predicting natural events. In particular, we can only guess at the frequency of some actions (such as drilling for resources). We considered setting separate containment requirements that would limit the radioactivity that could be released by any one likely human intrusion, in order to avoid having to estimate such frequencies. However, we did not do this because: (1) setting separate requirements for natural and human events would not place an upper limit on risk; and (2) setting separate requirements for individual intrusions in addition to the total combined requirements would not appreciably increase confidence that the overall requirements would be met unless we made the limits on individual intrusions unreasonably low.

The release limits are given in Table 2 in terms of curies released per 1,000 MTHM. The release limit for each radionuclide is the number of curies of that radionuclide that we estimate could cause 1,000 health effects over 10,000 years if it were the only radionuclide released from a 100,000 MTHM repository. For releases involving more than one radionuclide, the allowed release for each radionuclide is reduced to the fraction of its limit that insures that the overall limit on harm is not exceeded. For transuranic wastes, the release limits are in terms of curies released from units of an amount of wastes containing one million curies of alpha-emitting transuranic radionuclides. These units were chosen so that the standards would require alpha-emitting radioactivity from either high-level or transuranic wastes to be isolated with about the same degree of effectiveness. This procedure for using the release limits is described in Table 2 to the proposed standards. Compliance with these containment requirements will be achieved if the projected releases from a disposal system do not exceed these release limits.

Assurance Requirements

(Section 191.14)

Closely associated with our numerical containment requirements are seven qualitative requirements we believe are essential for developing the needed confidence that our long-term release limits should be met. These assurance requirements address and compensate for the uncertainties that necessarily accompany plans to isolate these dangerous wastes from the environment for a very long time. No matter how promising analytical projections of disposal system performances appear to be, high-level and transuranic wastes should be disposed of in a cautious manner that reduces the likelihood of unanticipated releases. Our assurance requirements provide the context necessary for application or our containment requirements, and they should insure very good long-term protection of the environment.

Several of the concepts incorporated in these assurance requirements have been adapted from the Federal Radiation Protection Guidance for all types of radioactive waste disposal that we proposed for public comment on November 15, 1978 (43 FR 53262). After reviewing the responses we received, we decided that the characteristics of different kinds of radioactive waste are not sufficiently similar for generally applicable criteria to be appropriate. Therefore, we stopped developing this Federal Radiation Protection Guidance (46 FR 17567). Howev-- ve also determined that, because of the uncertainties inherent in 10,000-year containment requirements, several of the principles included in this earlier proposal needed to be incorporated as integral parts of these standards for disposal of high-level and transuranic wastes.

The seven assurance requirements in Section 191.14 include the following principles. We expect that the specific steps taken by the implementing agencies to comply with each of these requirements will be described in the Federal environmental impact statement—and other appropriate decision documents—for each disposal system.

1. These wastes shall be disposed of promptly once adequate methods are available in order to reduce the chance of accidents during long-term storage. We have not established a time limit for this requirement, because the appropriate length of storage may depend on details on the disposal method. For example, it may be desirable to store high-level wastes for ten years or more to allow for decay of most of the short-lived radionuclides. The primary intent of this requirement is to prevent wastes from being stored indefinitely in order to avoid ultimate disposal.

2. Because they must be effective for so long, disposal systems shall offer as much protection as is reasonably achievable. Confidence in complying with the numerical release limits can only be assured through adopting this approach. There will always be substantial uncertainties in predicting the long-term performance of these systems, and a conservative approach to site selection and system design is essential to reduce the chances of serious harm. This concern, of course, must be balanced by judgments about cost, technical feasibility, and social considerations. Although the intent of the requirement cannot be reduced to a quantitative form, it is a concept that has been successfully applied to radiation protection matters for a long time.

3. Disposal systems shall reduce the consequences of possible mistakes in selection, design, or construction by using several different types of engineered and natural barriers against release of the wastes, and by taking full advantage of the protection each has to offer. With this redundancy, the unexpected failure of one or more barriers will be compensated for by other barriers. Different kinds of engineered barriers may be appropriate, depending upon the type of waste involved. They could include canisters, the physical and chemical forms of the waste itself, waste package overpacks, or other structures within the disposal system that will prevent or substantially delay release of the waste to the environment.

4. Protection from the wastes shall not depend on people to take active measures to control them for more than a reasonable period of time after disposal, although the Federal Government plans to retain perpetual control over all disposal sites for high-level wastes. The appropriate role for institutional controls was discussed extensively during the development and public review of the Federal Radiation Protection Guidance for radioactive waste disposal that we proposed on November 15, 1978 (43 FR 53262)—since one of those Guides would have limited reliance on institutional controls for not longer than 100 years. Public comments

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on this issue were divided fairly evenly among four positions: (1) That institutional controls should be relied upon for only about one generation, or 20–30 years; (2) that the 100-year period was appropriate; (3) that the 100-year period should be extended to 500–1,000 years or even longer; and (4) that we should limit reliance on controls, but let the implementing agencies select the appropriate period. Several commenters also made a distinction between "active" controls, such as restricting access to disposal sites, and "passive" controls, such as warning markers and records.

In these assurance requirements for high-level and transuranic radioactive waste disposal, we have decided to limit reliance on "active" controls—such as guarding a disposal site, performing maintenance operations, or controlling or cleaning up any releases from a site—to a "reasonable" period of time after disposal, which we believe should be no more than a few hundred years. However, because the Federal Government is committed to retaining control over these disposal sites in perpetuity, we expect that "passive" institutional measures should substantially reduce the chance of inadvertent human intrusion well beyond this period. Such passive controls will include permanent markers placed at a disposal site, public records or archives, Federal ownership or control of land use, and other methods of preserving knowledge about the disposal system. The assumptions that we believe are appropriate when considering the effectiveness of passive institutional controls are described in our procedural requirements (§ 191.15). These proposed provisions regarding institutional controls only apply to disposal of high-level and transuranic wastes and are not intended to have implications for regulations regarding other radioactive wastes. We particularly seek comment on all of our provisions regarding institutional controls.

5. The dangers and locations of disposal systems shall be recorded in the most permanent ways practicable in order to reduce the chances of unintended disruption of disposal systems by future generations.

6. Disposal systems shall not be located where there has been mining for resources, or where there is a reasonable potential for future exploration for scarce or easily accessible resources. Furthermore, disposal systems shall not be located where there is a significant concentration of any material which is not widely available from other sources. This requirement would discourage the use of geologic formations which are often associated with resources or mining activity. For example, the frequent mining of salt domes either for their relatively pure salt or for use as storage caverns would argue against locating a repository in this type of structure. However, this same concern would generally not apply to bedded salt deposits because they are much more common. We particularly seek comment on this requirement because it could rule out sites which might otherwise be advantageous in meeting all of our other requirements.

7. Recovery of most of the wastes should not be precluded for a reasonable period after disposal if unforeseen events require this in the future. The various isolation requirements of these standards would make recovery after disposal very difficult and expensive and probably dangerous. Nevertheless, because some of our scientific understanding may prove to be wrong in a way that would produce much greater risks than we expect, future generations should be able to recover the wastes if they deem it essential. An important implication of this requirement is that the physical location of most of the wastes must be reasonably predictable after disposal. Current plans for mined geologic disposal would meet this requirement. However, some possible disposal methods, such as deep well injection of liquid wastes or rock melting concepts, may not. Since this requirement could eliminate some otherwise feasible and perhaps advantageous disposal methods, we particularly seek public comment about it.

Procedural Requirements

(Section 191.15)

The containment requirements in § 191.13 were derived with the assistance of our performance assessments of long-term repository performance. When these requirements are applied to a particular disposal system, some of the procedures we used in our assessments must be retained to insure that the intent of our containment requirements is met. On the other hand, some of the assumptions we made should be replaced with the specific information developed for each particular system. The requirements in § 191.15 establish the procedures necessary for proper application of our containment requirements.

We based our performance assessments on relatively simple models of generic repositories and the data that was available for such models. Where information was unc[illegible]in, we made conservative assumptions that should tend to overestimate the long-term risks of disposal. However, we do not intend that the implementing agencies should use all of the same models, data, and assumptions that we did in making performance assessments. Instead, the implementing agencies generally should use the best information available for each particular disposal site.

In particular, the assumptions we made about the frequency of human intrusion were conservative because they ignored the substantial protection that passive institutional controls should offer. The performance assessments made for specific sites by the implementing agencies do not need to be as pessimistic with regard to human intrusion. Because of the uncertainties of controls requiring the active participation of people over a long time, performance assessments should not assume that active institutional controls can prevent or reduce releases beyond a reasonable period of time (e.g., a few hundred years) after disposal. However, because the Federal Government is commited to retaining control over these disposal sites in perpetuity, passive institutional controls should substantially reduce the chance of inadvertent human intrusion well beyond this period. These passive controls should not be assumed to prevent all possibilities of inadvertent intrusion, because there is always a chance that the controls will be overlooked or misunderstood. However, such measures should be effective in deterring systematic or persistent exploitation of a disposal site. Furthermore, the chance of human intrusion should be very small as long as the Federal Government retains passive control of disposal sites.

In developing the standards for disposal, we considered the overall protection which should be achievable by the combination of barriers in a geologic repository. Accordingly, the analyses used by NRC and DOE to evaluate compliance with our requirements should consider realistic assessments of the protection provided by all of the engineered and natural barriers of a disposal system. For example, performance assessments of a geologic repository system should include the protection afforded by geochemical retardation of radionuclides and by the limited solubility of radionuclides in groundwater, provided that reasonable evidence is developed to support such mechanisms for that particular site.

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Implementation

The standards for waste management operations (Subpart A) will be implemented by the NRC for commercial nuclear power activities and by the DOE for national defense facilities. Implementation procedures for Subpart A will be very similar to those for the Uranium Fuel Cycle Standards (40 CFR Part 190).

The standards for disposal (Subpart B) will be implemented by the NRC for all high-level wastes, whether the wastes come from commercial or military activities. The NRC will do this by developing the necessary regulations (primarily 10 CFR Part 60) and by issuing appropriate licenses. Under current law, disposal of transuranic wastes from military activities is not regulated by NRC; therefore, DOE will implement our requirements for disposal of these transuranic wastes.

The containment requirements in § 191.13 will be applied through design specifications, and the implementing agencies will have to evaluate long-term projections of the disposal system performance. As a result, a vital part of implementation will be the use of adequate models, including the probabilities of unplanned events, to relate appropriate site and engineering data to projected performance. The NRC has made substantial progress in developing such analytical models to predict long-term performance of actual geologic repositories. These models are quite detailed, and they are capable of evaluating how important any uncertainties in specific types of data are to the overall projections of repository performance. Thus, they can provide information about any needs for obtaining better data to determine if repositories meet the containment requirements of these standards.

At our request, the National Academy of Sciences studied the difficulties in verifying compliance with long-term environmental protection requirements for geologic disposal. Our NAS panel developed an approach that specifies the types of information needed and outlines appropriate methods for obtaining this data at prospective sites. Based on this NAS study, NRC's models, our own analytical efforts, and the confidence that should be provided by our assurance requirements, we have concluded that our containment requirements can be effectively implemented.

Effects on Health

A disposal system complying with these standards would confine almost all of the radioactive wastes to the immediate vicinity of the repository for a very long time. Because the wastes would be so well isolated from the environment, any risks to future individuals and populations would be very small.

Potential risks to individuals would depend upon the characteristics of particular disposal sites. However, the following examples are typical of the exposures which individuals in the vicinity of a repository might encounter. After many hundreds or thousands of years, some of the waste may dissolve, be carried by groundwater to nearby aquifers, and flow along those aquifers to surface streams. Individuals using the water from such a stream could receive doses of a few millirem per year. (Even if a person were to ignore available records and sink a water well into an aquifer as close as two kilometers from the repository, projected doses would not be expected to exceed about one rem per year.) Such potential exposures are modest when compared to the approximately 100 millirem per year that everyone continuously receives from natural background radiation. Indeed, in most cases we would expect that any additional exposure would be so small as to be considered trivial to the individuals involved.

With regard to exposures to populations, we estimated the potential long-term health risks to future generations using very general models of environmental transport and the linear, nonthreshold dose-effect relationship that was described earlier. Food chains, ways of life, and the size and geographical distributions of populations will undoubtedly change over a 10,000 year period. Unlike geological processes, factors such as these cannot be usefully predicted over such long periods of time. Thus, in making our health effects projections we found it necessary to depend upon very general models of environmental pathways, and to assume current population distributions and death rates. As a consequence, these projections are intended to be used primarily as a tool for comparing the performance of one waste disposal system to another and for comparison of the risks of waste disposal with those of undisturbed ore bodies. The results of these analyses should not be considered a reliable projection of the "real" or absolute number of health effects resulting from compliance with our standards.

Using our generalized models, we assessed the long-term risk from a repository containing the wastes from 100,000 MTHM—which could include all existing wastes and the future wastes from all currently operating reactors. We estimate that this quantity of waste, when disposed of in accordance with the proposed standards, could cause no more than 1,000 premature deaths from cancer in the first 10,000 years after disposal: an average of no more than one permature death every 10 years. Any such increase would be far too small to be detectable in any manner compared to today's incidence of cancer, which kills about 350,000 people per year. Similarly, any such increase would be undetectable compared to the approximately 4,000 premature cancer deaths per year that the same linear dose-effect relationship predicts for natural background radiation.

However, although this long-term population risk is clearly very small, the discontinuity between when the wastes are generated and when the projected health effects manifest themselves makes it difficult to determine what level of residual risk should be allowed by these standards. The difficulty arises because most of the benefits derived in the process of waste production fall upon the current generation, while most of the risks fall upon future generations. Thus, a potential problem of intergenerational equity with respect to the distribution of risks and benefits becomes apparent. This problem is sometimes referred to as the intergenerational risk issue, and it is not unique to the disposal of high-level radioactive wastes. If we tried to insure that our standards fully satisfy a criterion of intergenerational equity with respect to the distribution of risks and benefits, it might appear that we should require that no risk be passed on to future generations. This is a condition which we conclude cannot be met by disposal technologies foreseeable within this century. However, there is one particular factor which has reinforced our decision about the reasonableness of the risks permitted under our proposed standards. This is our evaluation of the risks associated with undisturbed uranium ore bodies.

Uranium Ore: Most uranium ore in the United States occurs in permeable geologic strata containing flowing ground water. Radionuclides in the ore, particularly uranium and radium, continuously enter this ground water. We estimated the potential risks from these undisturbed ore bodies using the same generalized environmental models that we used for releases from a waste repository. The effects associated with the amount of ore needed to produce the high-level wastes that would fill the model geologic repository can vary considerably. Part of this variation corresponds to actual differences from

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one ore body to another; part can be attributed to uncertainties in the assessment. Our estimates ranged from 300 to more than 1,000,000 excess cancer deaths over 10,000 years. Thus, leaving the ore unmined appears to present at least as great a risk to future generations as disposal of the wastes covered by these standards.

We are not sure that this analysis provides an adequate means of resolving the question of intergenerational risk. It has, however, helped to influence our decision of what is an acceptable level of residual risk given our current scientific, technological, and fiscal capabilities. We particularly invite comment upon the questions of intergenerational risk and the acceptability of risk. Additionally, for purposes of comparisons of risks permitted under the standards to radiation risks we are currently exposed to, we have included a brief discussion of the risks from natural background.

Variations in Natural Background: Radionuclides occur naturally in the earth in very large amounts, and are produced in the atmosphere by cosmic radiation. Everyone is exposed to natural background radiation from these natural radionuclides and from direct exposure to cosmic radiation. Individual exposures average about 100 millirem per year, with variations between 60 and 200 millirem/year. These natural background radiation levels have remained relatively constant for a very long time. According to the same linear, nonthreshold dose effect relationship used in our other analyses, an increase of one millirem per year (about one percent) in natural background in the United States would result in about 40 additional deaths per year, or 400,000 over a 10,000 year period.

Regulatory Impact Analysis

This proposed rule was submitted to the Office of Management and Budget (OMB) for review as required by Executive Order 12291. Any comments we received from OMB and our responses to those comments are available for public inspection in the docket cited above under the heading "ADDRESSES."

We have had to take an unusual approach to evaluating the regulatory impact of this proposed action—as required by Executive Order 12291. In most cases, a regulation concerns an ongoing activity and may be considered a burden whose costs should be judged against the regulatory benefits. Here, we could not quantify the costs and benefits of our action compared to the consequences of no regulation because there is no "baseline" program to consider. The appropriate regulations must be established before development of the regulated activity can even begin. Thus, the typical perspectives on costs and benefits are altered. We evaluated how the costs of commercial waste management and disposal might change in response to different levels of protection from our containment requirements and to changes in our assurance requirements.

To evaluate the effects of different levels of protection, we considered the performance of differenct repository designs in three different geologic media: salt, granite, and basalt. We estimated the costs of the various engineering controls that might be needed to meet different levels, and we made some assumptions about the increased site selection costs that might occur if more stringent standards made it harder to find an adequate site for a repository.

We found that the increased costs of setting the standards at the proposed level could range from zero to 50 million (1981) dollars per year when compared to the costs of choosing a level more than ten times less stringent (release limits ten times greater than our proposed limits). This potential increase is much less than the uncertainty in the total costs for waste management and disposal, which range from about 700 million to almost 1.5 billion (1981) dollar per year. For comparison, electrical utility revenues were about 100 billion dollars in 1980. We estimate that the potential economic impact of choosing the more stringent level of protection could be about a 0.2 percent increase in the costs of generating electricity from nuclear power plants and a much smaller increase (about 0.05 percent) in average electricity rates. The details of these calculations are provided in the report of our regulatory impact analysis.

Alternative Approaches

Besides considering different levels of protection, we also considered several different approaches to our proposed standards. These alternatives are evaluated in our Draft Environmental Impact Statement, and we encourage public comment on these options. We particularly seek comment on a different approach to our standards for disposal (Subpart B)—an alternative that would establish radiation exposure limits for individuals, such as the limit of 25 millirem per year in Subpart A of this proposal, rather than the radionuclide release limits that we are proposing.

Standards based on individual exposure limits, or equivalent standards which limit radionuclide concentrations in air or water, restrict the risks that an particular individual may be exposed to. Particularly when the limits are comparable to or less than natural background levels, they may be more effective at communicating how small the chance of harm from disposal of these wastes should be. However, we chose not to use individual exposure limits in Subpart B because of two unique aspects of these disposal standards:

First, these disposal systems have to protect the environment from these highly concentrated radioactive wastes for much longer than institutional controls can be guaranteed to be effective. Any individual exposure limit we set could only apply at some distance from a repository, or it would have to ignore the risks from unplanned events like inadvertent intrusion—because individuals who fail to understand passive warnings and penetrate directly into or close to a disposal system (through exploratory drilling for water or mineral resources, for example) could receive very large exposures. These exposures would probably exceed any reasonable individual exposure standard.

Second, the disposal standards have to be applied through analytical performance projections—implementing such standards through environmental monitoring and potential remedial actions over thousands of years is not a credible approach. When we compared the analyses needed for compliance with exposure limits to the analyses needed for compliance with release limits, we found that our proposed disposal standards would be much easier to implement than exposure limits. The NRC, which is responsible for applying our standards for high-level waste disposal, made a similar evaluation and also found that standards based on radioactivity release limits could be implemented more readily than standards based on exposures to individuals.

Thus, we believe our proposed approach will facilitate licensing of good disposal systems while providing appropriate environmental protection from the long term risks presented by high-level wastes. However, the arguments favoring individual exposure limits are also persuasive, and we particularly seek comments on which approach we should ultimately select.

Questions for Public Comment

In describing our proposed environmental standards, we have highlighted several issues about which we particularly seek comment. For

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convenience, we summarize these questions here:

1. Is our definition of high-level waste, which excludes any material with concentrations below the values specified in Table 1, a proper approach to distinguish between wastes which require maximum isolation (as in a geologic repository) and wastes which may be disposed of in less secure facilities?

2. In choosing the proposed level of protection provided by the standards, have we taken an appropriate approach with regard to the long-term residual risks we may pass on to future generations?

3. Have we chose an appropriate approach with regard to the degree of protection that should be anticipated from active and passive institutional controls?

4. Should we adopt our proposed requirement to avoid siting disposal systems where there may be scarce or easily accessible resources—a requirement which could rule out sites which might be advantageous in meeting all of our other requirements?

5. Should we adopt our proposed requirement that recovery of most of the wastes should be feasible if unforeseen events require this in the future—a requirement which might rule out some alternatives to mined geologic disposal?

6. Is our choice of limits on total radioactivity released an appropriate approach to protecting the environment from these long-lived wastes? Or should we develop standards that limit maximum exposures to individuals instead?

List of Subjects in 40 CFR Part 191

Environmental protection, Nuclear energy, Radiation protection, Uranium, Waste treatment and disposal.

Regulatory Flexibility Certification

In accordance with the Regulatory Flexibility Act of 1980, 5 U.S.C. 605(b), the Administrator hereby certifies that this proposed rule would not, if adopted, have any significant impact on small businesses or other entities, and that a Regulatory Flexibility Analysis is not required. The rule woud affect only a small number of facilities, most of which would be operated by the United States Government.

Dated: December 17, 1982.

Anne M. Gorsuch,

Administrator.

A new Part 191 is proposed to be added to Title 40, Code of Federal Regulations, as follows:

SUBCHAPTER F—RADIATION PROTECTION PROGRAMS

PART 191—ENVIRONMENTAL RADIATION PROTECTION STANDARDS FOR MANAGEMENT AND DISPOSAL OF SPENT NUCLEAR FUEL, HIGH-LEVEL AND TRANSURANIC RADIOACTIVE WASTES

Subpart A—Environmental Standards for Management and Storage

Sec.

Subpart B—Environmental Standards for Disposal

Authority: The Atomic Energy Act of 1954, as amended; Reorganization Plan No. 3 of 1970.

Subpart A—Environmental Standards for Management and Storage

§ 191.01 Applicability.

This Subpart applies to radiation doses received by members of the public as a result of the management (except for transportation) and storage of spent nuclear fuel, high-level, or transuranic radioactive wastes, to the extent that these operations are not subject to the provisions of Part 190 of Title 40.

§ 191.02 Definitions.

Unless otherwise indicated in this Subpart, all terms shall have the same meaning as in Subpart A of Part 190.

(a) "Spent nuclear fuel" means any nuclear fuel removed from a nuclear reactor after it has been irradiated.

(b) "High-level radioactive wastes" means any of the following that contain radionuclides in concentrations greater than those identified in Table 1 (Appendix): (1) Liquid wastes resulting from the operation of the first cycle solvent extraction system, or equivalent, in a facility for reprocessing spent nuclear fuels; (2) the concentrated wastes from subsequent extraction cycles, or equivalent; (3) solids into which such liquid wastes have been converted; or (4) spent nuclear fuel if disposed of without reprocessing.

(c) "Transuranic wastes," as used in this Part, means wastes containing more than 100 nanocuries of alpha emitting transuranic isotopes, with half-lives greater than one year, per gram of waste.

(d) "Storage" means placement of radioactive wastes with planned capability to readily retrieve such materials.

(e) "Management and storage" means any activity, operation, or process, except for transportation, conducted to prepare spent nuclear fuel, high-level or transuranic radioactive wastes for storage or disposal, the storage of any of these materials, or activities associated with the disposal of these materials.

(f) "General environment" means the total terrestial, atmospheric, and aquatic environments outside sites within which any operation associated with the management and storage of spent nuclear fuel, high-level or transuranic radioactive wastes is conducted.

(g) "Member of the public" means any individual who is not engaged in operations involving the management, storage, and disposal of materials covered by these standards. A worker so engaged is a member of the public except when on duty at a site.

§ 191.03 Standards for normal operations.

(a) Operations covered by this Subpart should be conducted so as to reduce exposures to members of the public to the extent reasonably achievable, taking into account technical, social, and economic considerations. As an upper limit, except for variances in accordance with 191.04, these operations shall be conducted in such a manner as to provide reasonable assurance that the combined annual dose equivalent to any member of the public due to: (1) Operations covered by Part 190, (2) planned discharges of radioactive material to the general environment from operations covered by this Subpart, and (3) direct radiation from these operations; shall not exceed 25 millirems to the whole body, 75 millirems to the thyroid, or 25 millirems to any other organ.

§ 191.04 Variances for unusual operations.

(a) The implementing agency may grant a variance temporarily authorizing operations which exceed the Standards specified in 191.03 when abnormal operating conditions exist if: (1) A written request justifying continued operation has been submitted, (2) the costs and benefits of continued operation have been considered to the extent possible, (3) the alternatives to continued operation have been considered, and (4) continued operation is deemed to be in the public interest.

(b) Before the variance is granted, the implementing agency shall announce, by publication in the Federal Register and by letter to the governors of affected States: (1) The nature of the abnormal operating conditions, (2) the degree to which continued operation is expected to result in doses exceeding the standards, (3) the proposed schedule for achieving conformance with the standards, and (4) the action planned by the implementing agency.

§ 191.05 Effective date.

The standards in this Subpart shall be effective 12 months from the promulgation date of this rule.

Subpart B—Environmental Standards for Disposal

§ 191.11 Applicability.

This Subpart applies to radioactive materials released into the accessible environment as a result of the disposal of high-level or transuranic radioactive wastes, incuding the disposal of spent nuclear fuel. This Subpart does not apply to disposal directly into the oceans or ocean sediments.

§ 191.12 Definitions.

Unless otherwise indicated in this Subpart, all terms shall have the same meaning as in Subpart A of this Part.

(a) "Disposal" means isolation of radiocative wastes with no intent to recover them.

(b) "Barriers" means any materials or structures that prevent or substantially delay movement of the radioactive wastes toward the accessible enviornment.

(c) "Disposal system" means any combination of engineered and natural barriers that contains radioactive wastes after disposal.

(d) "Groundwater" means water below the land surface in a zone of saturation.

(e) "Lithosphere" means the solid part of the Earth, including any groundwater contained within it.

(f) "Accessible environment" includes: (1) The atmosphere, (2) land surfaces, (3) surface waters, (4) oceans, and (5) parts of the lithosphere that are more than ten kilometers in any direction from the original location of any of the radioactive wastes in a disposal system.

(g) "Reasonably foreseeable releases" means releases of radioactive wastes to the accessible environment that are estimated to have more than one chance in 100 of occurring within 10,000 years.

(h) "Very unlikely releases" means releases of radiocative wastes to the accessible environment that are estimated to have between one chance in 100 and one chance in 10,000 of occurring within 10,000 years.

(i) "Performance assessment" means an analysis which identifies those events and processes which might affect the disposal system, examines their effects upon its barriers, and estimates the probabilities and consequences of the events. The analysis need not evaluate risks from all identified events. However, it should provide a reasonable expectation that the risks from events not evaluated are small in comparison to the risks which are estimated in the analysis.

(j) "Active institutional controls" means: (1) Guarding a disposal site, or (2) performing maintenance operations or remedial actions at a disposal site, or (3) controlling or cleaning up releases from a disposal site.

(k) "Passive institutional controls" means: (1) Permanent markers placed at a disposal site, (2) public records or archives, (3) Federal Government ownership or control of land use, or (4) other methods of preserving knowledge about the location, design, or contents of a disposal system.

(l) "Heavy metal" means all uranium, plutonium, or thorium placed into a nuclear reactor.

§ 191.13 Containment requirements.

Disposal systems for high-level or transuranic wastes shall be designed to provide a reasonable expectation that for 10,000 years after disposal:

(a) Reasonably foreseeable releases of waste to the accessible environment are projected to be less than the quantities calculated accoring to Table 2 (Appendix).

(b) Very unlikely releases of waste to the accessible environment are projected to be less than ten times the quantities calculated according to Table 2 (Appendix).

§ 191.14 Assurance requirements.

To provide the confidence needed for compliance with the containment requirements of § 191.13, disposal of high-level or transuranic wastes shall be conducted in accordance with the following requirements:

(a) Wastes shall be disposed of promptly once disposal systems are available and the wastes have been suitably conditioned for disposal.

(b) Disposal systems shall be selected and designed to keep releases to the accessible environment as small as reasonably achievable, taking into account technical, social, and economic considerations.

(c) Disposal systems shall use several different types of barriers to isolate the wastes from the accessible environment. Both engineered and natural barriers shall be included. Each such barrier shall separately be designed to provide substantial isolation.

(d) Disposal systems shall not rely upon active institutional controls to isolate the wastes beyond a reasonable period of time (e.g., a few hundred years) after disposal of the wastes.

(e) Disposal systems shall be identified by the most permanent markers and records practicable to indicate the dangers of the wastes and their location.

(f) Disposal systems shall not be located where there has been mining for resources or where there is a reasonable expectation of exploration for scarce or easily accessible resources in the future. Furthermore, disposal systems shall not be located where there is a significant concentration of any material which is not widely available from other sources.

(g) Disposal systems shall be selected so that removal of most of the wastes is not precluded for a reasonable period of time after disposal.

§ 191.15 Procedural requirements.

Performance assessments to determine compliance with the containment requirements of § 191.13 shall be conducted in accordance with the following:

(a) The assessments shall consider realistic projections of the protection provided by all of the engineered and natural barriers of a disposal system.

(b) The assessments shall not assume that active institutional controls can prevent or reduce releases to the accessible environment beyond a reasonable period (e.g., a few hundred years) after disposal. However, it should be assumed that the Federal Government is committed to retaining passive institutional control of disposal sites in perpetuity. Such passive controls should be effective in deterring systematic or persistent exploitation of a disposal site, and it should be assumed that they can keep the chance of inadvertent human intrusion very small as long as the Federal Government retains such passive control of disposal sites.

(c) The assessments shall use information regarding the likelihood of human intrusion, and all other unplanned events that may cause releases to the accessible environment, as determined by the implementing agency for each particular disposal site.

§ 191.16 Effective date.

The standards in this Subpart shall be effective immediately upon promulgation of this rule; however, this Subpart does not apply to wastes disposed of before promulgation of this rule.

Enclosure F

Appendix

TABLE 1.—CONCENTRATIONS IDENTIFYING HIGH-LEVEL RADIOACTIVE WASTES

Radionuclide	Concentration (curies per gram of waste)
Carbon-14	8×10^{-6}
Cesium-135	8×10^{-6}
Cesium-137	5×10^{-8}
Plutonium-241	3×10^{-6}
Strontium-90	7×10^{-8}
Technetium-99	3×10^{-6}
Tin-126	7×10^{-7}
Any alpha-emitting transuranic radionuclide with a half-life greater than 20 years	1×10^{-7}
Any other radionuclide with a half-life greater than 20 years	1×10^{-6}

Note.—In cases where a waste contains a mixture of radionuclides, it shall be considered a high-level radioactive waste if the sum of the ratios of the radionuclide concentration in the waste to the concentration in Table 1 exceeds one.

For example, if a waste containing radionuclides A, B, and C in concentrations C_a, C_b, and C_c, and if the concentration limits from Table 1 are CL_a, CL_b, and CL_c, then the waste shall be considered high-level radioactive waste if the following relationship exists:

$$\frac{C_a}{CL_a}+\frac{C_b}{CL_b}+\frac{C_c}{CL_c}>1$$

TABLE 2.—RELEASE LIMITS FOR CONTAINMENT REQUIREMENTS

[Cumulative Releases to the Accessible Environment for 10,000 Years After Disposal]

Radionuclide	Release Limit (curies per 1000 MTHM)
Americium-241	10
Americium-243	4
Carbon-14	200
Cesium-135	2000
Cesium-137	500
Neptunium-237	20
Plutonium-238	400
Plutonium-239	100
Plutonium-240	100
Plutonium-242	100
Radium-226	3
Strontium-90	80
Technetium-99	10000
Tin-126	80
Any other alpha-emitting radionuclide	10
Any other radionuclide which does not emit alpha particles	500

Note 1.—The Release Limits in Table 2 apply either to the amount of high-level wastes generated from 1,000 metric tons of heavy metal (MTHM), or to an amount of transuranic (TRU) wastes containing one million curies of alpha-emitting transuranic radionuclides. To develop Release Limits for a particular disposal system, the quantities in Table 2 shall be adjusted for the amount of wastes included in the disposal system. For example:

(a) If a particular disposal system contained the high-level wastes from 50,000 MTHM, the Release Limits for that system would be the quantities in Table 2 multiplied by 50 (50,000 MTHM divided by 1,000 MTHM).

(b) If a particular disposal system contained five million curies of alpha-emitting transuranic wastes, the Release Limits for that system would be the quantities in Table 2 multiplied by five (five million curies divided by one million curies).

(c) If a particular disposal system contained both the high-level wastes from 50,000 MTHM *and* 5 million curies of alpha-emitting transuranic wastes, the Release Limits for that system would be the quantities in Table 2 multiplied by 55:

$$\frac{50{,}000\ \text{MTHM}}{1{,}000\ \text{MTHM}}+\frac{5{,}000{,}000\ \text{curies TRU}}{1{,}000{,}000\ \text{curies TRU}}=55$$

Note 2.—In cases where a mixture of radionuclides is projected to be released, the limiting values shall be determined as follows: For each radionuclide in the mixture, determine the ratio between the cumulative release quantity projected over 10,000 years and the limit for that radionuclide as determined from Table 2 and Note 1. The sum of such ratios for all the radionuclides in the mixture may not exceed one.

For example, if radionuclides A, B, and C are projected to be released in amounts Q_a, Q_b, and Q_c, and if the applicable Release Limits are RL_a, RL_b, and RL_c, then the cumulative releases over 10,000 years shall be limited so that the following relationship exists:

$$\frac{Q_a}{RL_a}+\frac{Q_b}{RL_b}+\frac{Q_c}{RL_c}<1$$

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Enclosure F

ENCLOSURE G

RATIONALE FOR THE PERFORMANCE OBJECTIVES IN 10 CFR PART 60

DISPOSAL OF HIGH LEVEL RADIOACTIVE WASTE IN GEOLOGIC REPOSITORIES

TABLE OF CONTENTS

I. INTRODUCTION

On July 8, 1981, the Nuclear Regulatory Commission (NRC) proposed technical criteria (46 FR 35280) which would be used in the evaluation of license applications under procedural rules established by the Commission for licensing of geological disposal by the U.S. Department of Energy (DOE) of high-level radioactive waste (HLW), 46 FR 13971. NRC received 86 comment letters on these proposed technical criteria. Many commenters focused their commentary on the proposed numerical performance objectives, among other things, and identified the issues related to them that are the subject of this rationale. In particular, the rationale shows how the numerical performance objectives for individual sub-systems of the geologic repository, as revised in consideration of the public comment received, contribute to meeting the overall system performance objective, which is whatever generally applicable environmental standard as may have been established by the Environmental Protection Agency (EPA), and which for purposes of this analysis is assumed to be the working draft of the EPA standard found in Appendix C of NUREG-0806, of which this rationale is a part.

This chapter briefly delineates the authority of the three federal agencies mentioned above as involved in disposal of high-level radioactive wastes -- NRC, DOE, and EPA. Chapter II describes the nature of the high-level waste problem, including the inventories, hazards, and heat generation rates associated with various types of HLW, and how they change with time. Chapter III briefly discusses the functions which a repository must perform to protect public health and safety in light of the hazards discussed in Chapter II, and Chapter IV describes both the engineered and geologic features of a repository which must be considered in evaluating those functions. Chapter V contains a discussion of the uncertainties associated with assessing the performance of the features of a repository described in Chapter IV. Chapter VI discusses how the uncertainties discussed in Chapter V affect the alternatives considered in selecting a regulatory approach and the rationale for the approach selected. Chapter VII describes an assumed environmental standard for the allowable releases from a HLW repository and a model which both relates this standard to the numerical criteria for the performance objectives in the rule and reflects the uncertainties mentioned in Chapter V. Chapter VII also discusses the results of this model for the routine long term performance of the repository. Chapter VIII applies the model to two failure scenarios for long term repository performance, and describes the impact of the numerical criteria on whether the assumed environmental standard is met. Chapter IX describes the rationale for requiring the repository to be designed so that the option to retrieve the wastes is preserved. Chapter IX also contains the basis for the numerical value selected for the design period during which the retrieval option is to be preserved.

Three Federal agencies have major roles in the national program for disposal of high-level radioactive wastes. The EPA is responsible for developing a generally applicable environmental standard which will serve as the overall performance objective for releases from high-level waste disposal. The NRC will develop and issue regulations which cover all aspects of high-level waste disposal, and which will implement the EPA standard. The NRC will then consider license applications for HLW disposal to determine whether the proposal will conform to the regulation. The DOE has lead responsibility for formulating national policy for disposal of HLW, and has determined that national policy should focus on disposal of HLW in mined geologic repositories (Ref. 1-1). Further, DOE is responsible for constructing and operating a waste disposal facility in accordance with NRC regulations.

Disposal of high-level radioactive waste in a manner that will assure safety for many thousands of years represents a unique problem not previously dealt with in other NRC or EPA standards. Throughout the rulemaking process for the technical criteria, the NRC staff has considered several approaches that might be applied to this unusual regulatory problem. The remainder of this report provides the bases for the approach selected for siting and design of the repository to assure effective long-term isolation of the wastes.

II. NATURE OF THE HIGH-LEVEL WASTE PROBLEM

In this chapter we describe the types and quantities of high-level wastes, and their properties, such as radioactivity and heat generation rates, that could affect the design and performance of a HLW facility. For perspective, we compare the hazard of the HLW, as a function of time, with the hazard of the natural uranium ore that was mined to make the fuel that produced the wastes. From these considerations we attempt to draw some inferences about the relevant time periods for isolation of HLW.

Types and Quantities of Wastes

HLW may be disposed of in two basic forms: spent fuel discharged from nuclear power plants (if it is disposed of as a waste), and the residue resulting from reprocessing spent fuel for recovery of uranium and/or plutonium.

Substantial quantities of HLW currently exist in the United States as a result of both U.S. defense programs and commercial nuclear power operations, and additional quantities of wastes are projected to be generated in the future by both programs. The amount of radioactivity in defense wastes is less than 10% of that in the commercial wastes which are expected to be generated by the time a repository is constructed and in operation; the following discussion is therefore limited to commercial waste inventories. It should be recognized that defense wastes will add a small but significant increment to the total HLW inventory, and that commercial wastes represent an upper bound with respect to heat generation rates and concentrations of radioactivity.

Commercial light-water reactors of the type currently in use in the U.S. generate spent fuel at a rate of about 35 metric tons of heavy metal (MTHM) per GWe-yr* of electrical energy production. Currently operating

* GWe-yr means the amount of electrical energy, in billions of watts, produced in a year of continuous operation.

nuclear power plants have a generating capacity of about 55 GWe, and additional plants which are planned or under construction could increase the total generating capacity to about 130-150 GWe.

Depending on the rate at which new plants are placed in service, the cumulative year 2000 inventory of spent fuel is likely to lie in the range from about 45,000 to 72,000 MTHM* (Ref. 2-1), or about the capacity of a single repository (Ref. 2-2). By the year 2040, 1 to 3 additional repositories would be required depending on the growth rate of nuclear power generation, whether or not the waste is reprocessed, and the geologic media selected for disposal.

Waste Characteristics

As nuclear fuel is irradiated in a nuclear reactor, three types of radioactive products are formed. Fission products are generated by fissioning uranium and plutonium isotopes and, with a few exceptions, are characterized by relatively short half-lives and low radiotoxicity. Actinides are radionuclides with atomic numbers greater than 88, and result from non-fission neutron absorptions in uranium. The actinides typically have longer half-lives and higher radiotoxicities than the fission products. Small quantities of additional radionuclides, called activation products, are produced by neutron absorption in the structural materials which support and contain the fuel in a reactor. The activation products make only a minor contribution to the overall radiotoxicity of HLW, and will not be discussed further.

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* The small current inventories of commercially generated reprocessing wastes are insignificant.

Figure 1 presents the radioactivity of pressurized water reactor (PWR) spent fuel as a function of time after removal from a reactor, while Figures 2 and 3 present the same information for the wastes which would result from reprocessing the spent fuel from the uranium recycle and mixed oxide fuel cycles, respectively.* (Figures 1-3 as well as subsequent figures and tables in this chapter are all normalized on the basis of one metric tonne of heavy metal (MTHM) initially charged to a reactor.)

In all three fuel cycles, the fission product radioactivity decreases by 5 orders of magnitude during the first thousand years and then stays relatively constant until about 100,000 years after disposal. Much of this change (about 99.9 % or more) occurs within the first few hundred years, primarily because of decay of Sr-90, Cs-137 and other short-lived fission products. Some of the shorter-lived actinides such as Pu-238 also decay significantly during the first few hundred years.

Figures 4, 5 and 6 display the decay heat generation for spent fuel and reprocessing wastes from these same fuel cycles. In all three fuel cycles, the fission product decay heat generation rate decreases by almost 6 orders of magnitude during the first 1000 years and stays relatively constant for the next 100,000 years. The rate at which total heat is generated by the waste decreases less rapidly than the total radioactivity, but at least

*In the uranium recycle fuel cycle, it has been assumed that 99.5% of the plutonium in spent fuel is recovered and placed in storage, while the recovered uranium is returned to the fuel cycle. In the mixed oxide fuel cycle, both plutonium and uranium are returned to the fuel cycle. Reference 2-3 discusses additional assumptions.

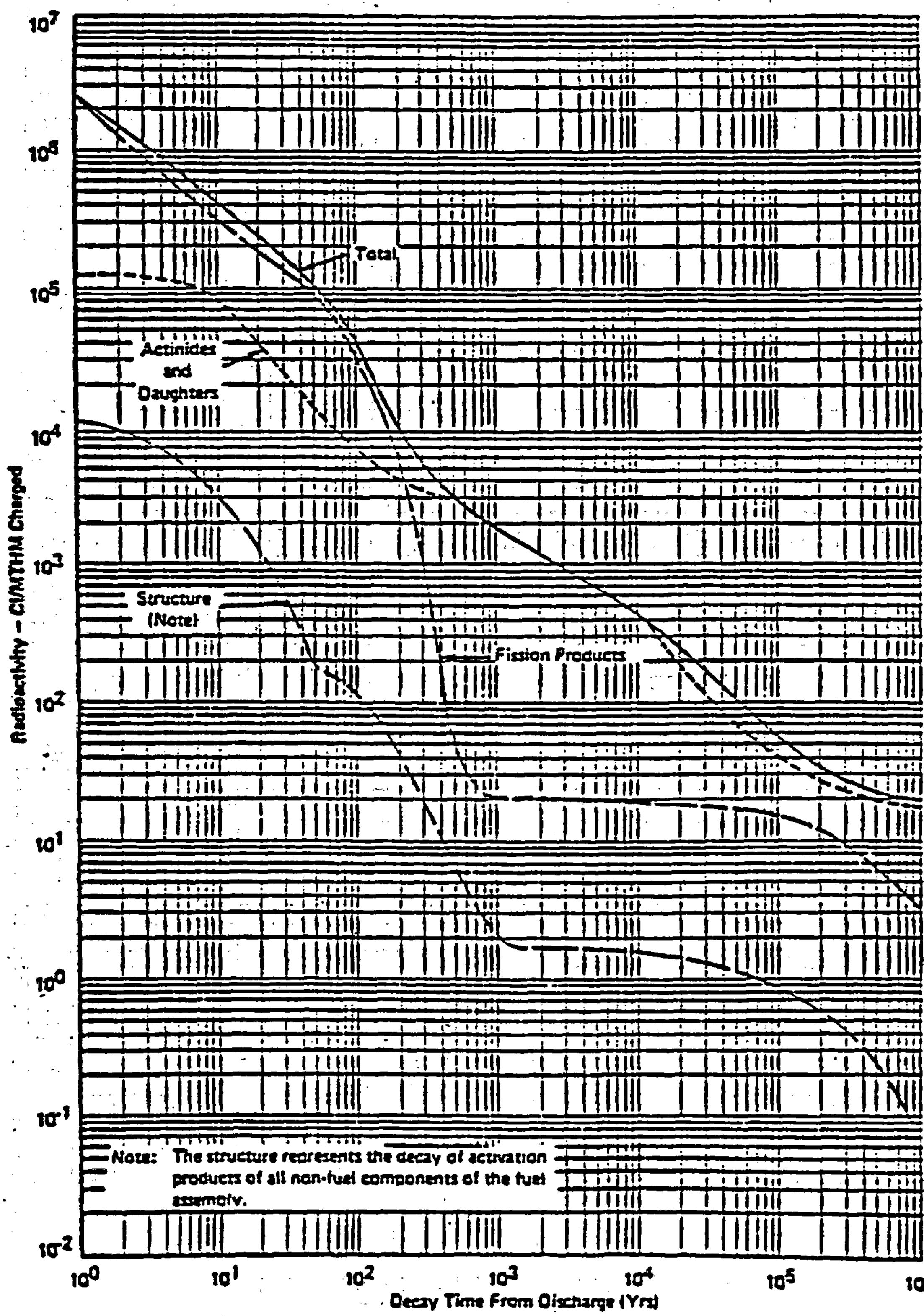

FIGURE 1. PWR SPENT FUEL -- RADIOACTIVITY
(Ref. 2-3)

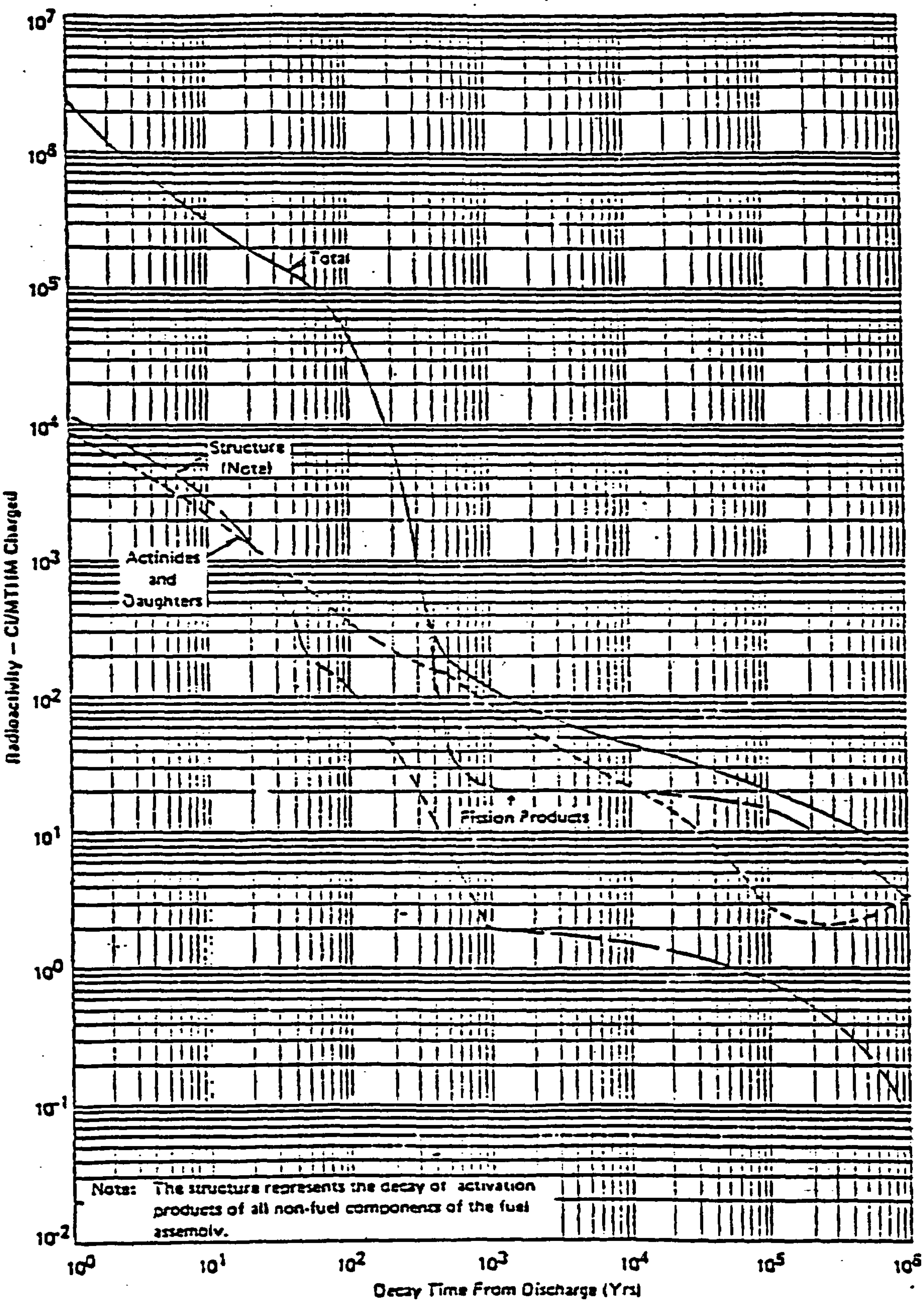

FIGURE 2. URANIUM RECYCLE REPROCESSING WASTE -- RADIOACTIVITY (Ref. 2-3)

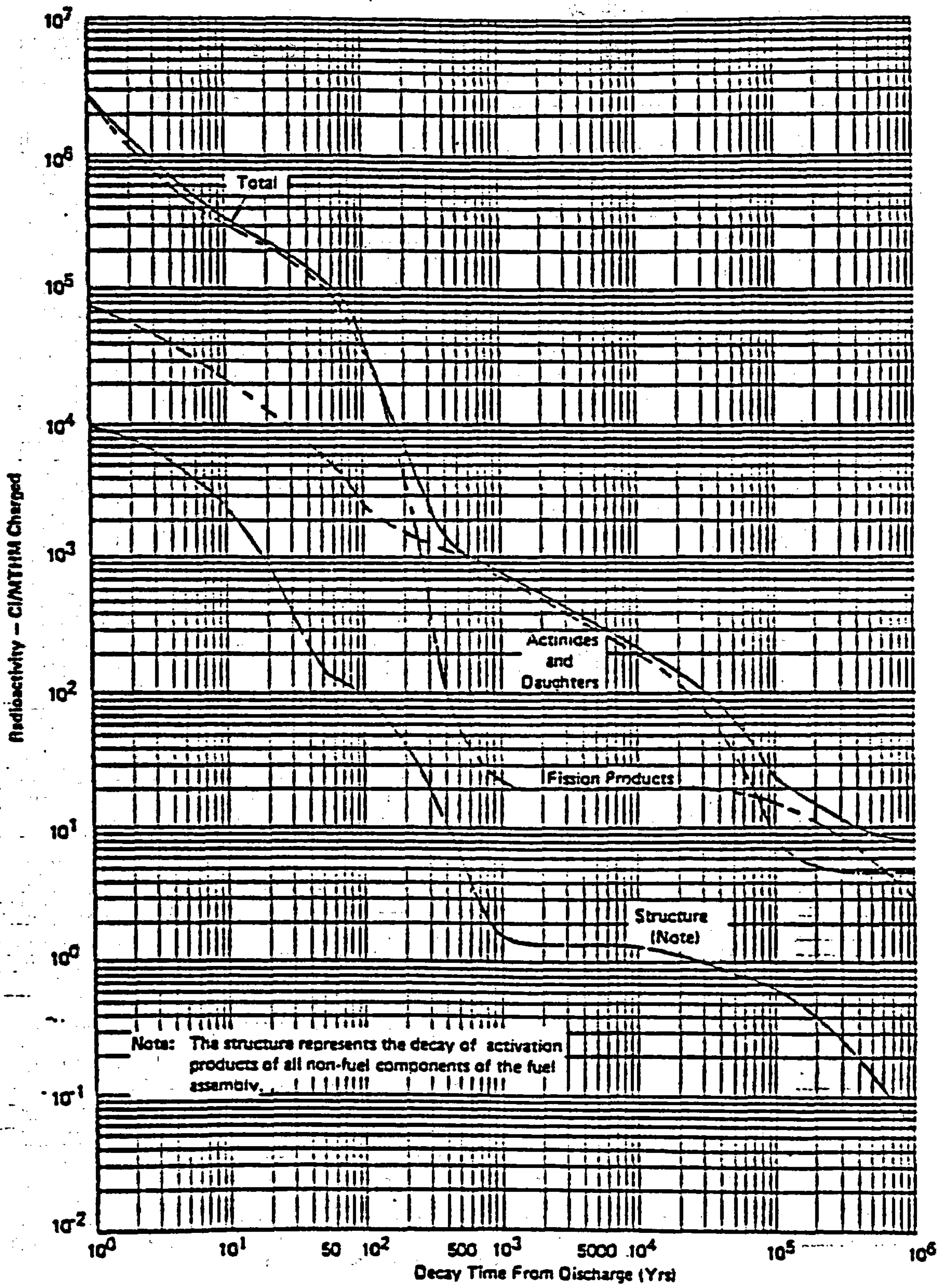

FIGURE 3. MIXED OXIDE REPROCESSING WASTE — RADIOACTIVITY (Ref. 2-3)

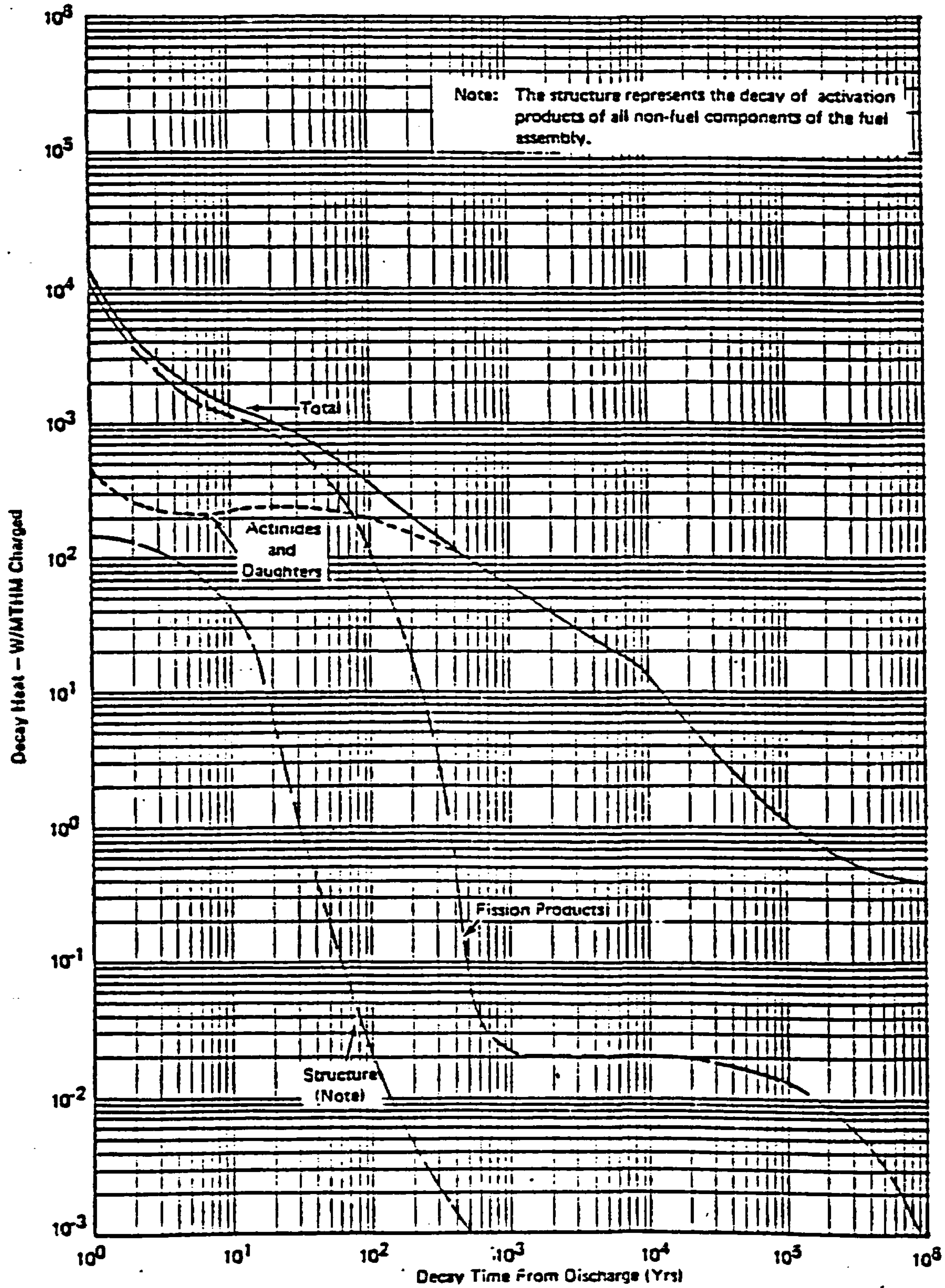

FIGURE 4. PWR SPENT FUEL -- DECAY HEAT GENERATION (Ref. 2-3)

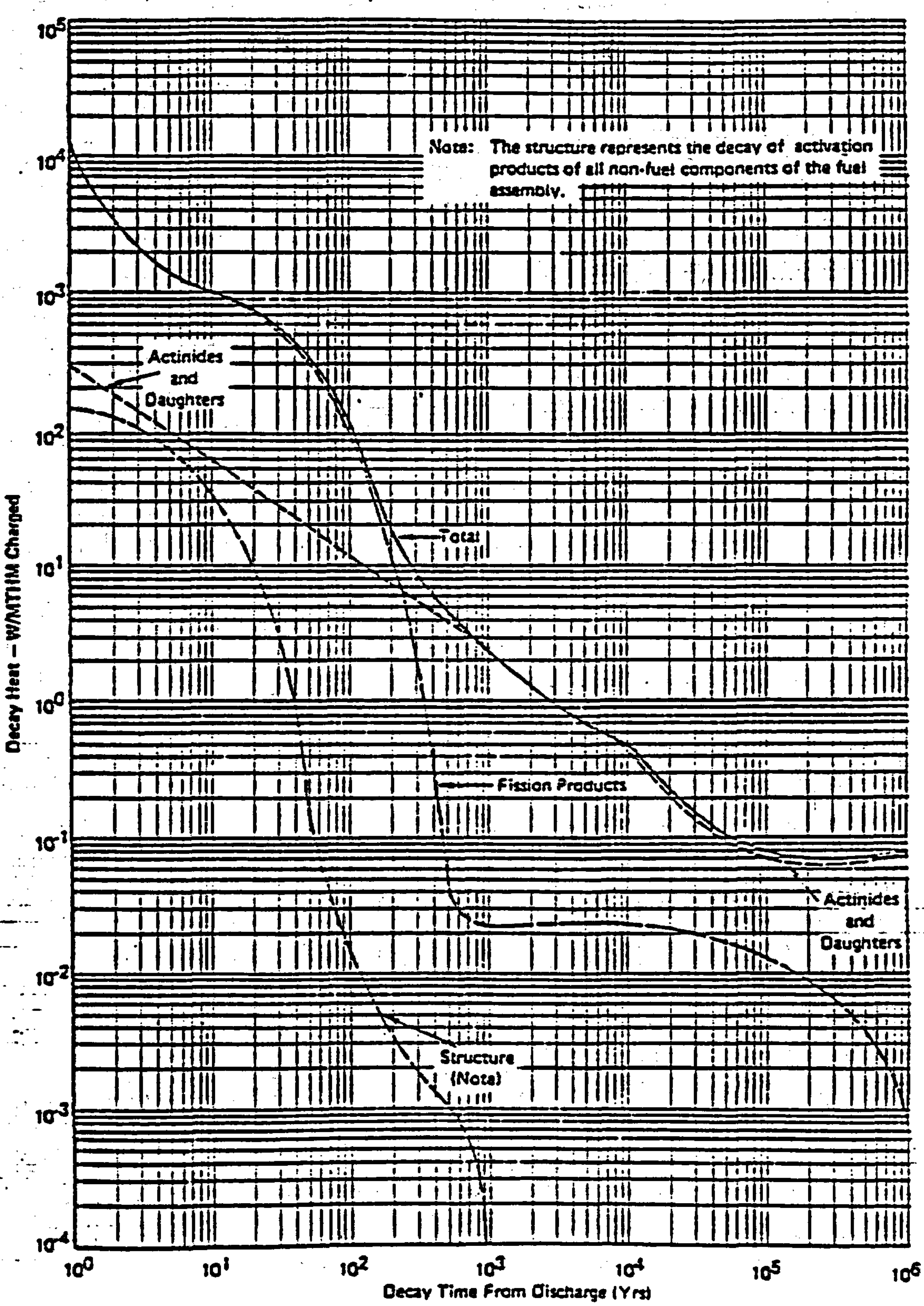

FIGURE 5. URANIUM RECYCLE REPROCESSING WASTE -- DECAY HEAT GENERATION (Ref. 2-3)

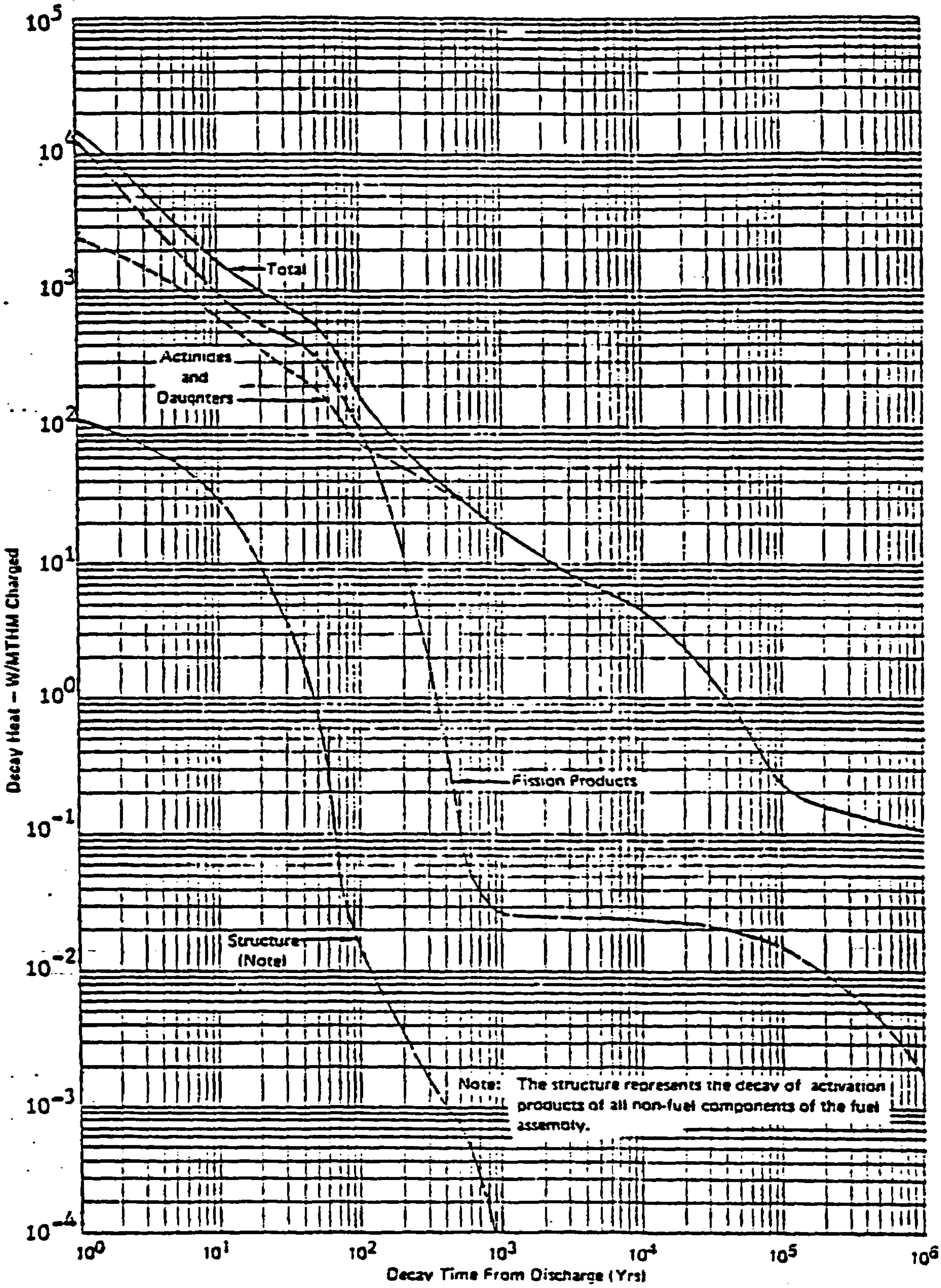

FIGURE 6. MIXED OXIDE REPROCESSING WASTE -- DECAY HEAT GENERATION (Ref. 2-3)

a 99% reduction in heat generation rate is achieved within the first few hundred years for each of the waste types.

The preceding discussion does not address the differing radiotoxicities of the nuclides present in HLW. A rough estimate of the intrinsic hazard of a radioactive waste material can be obtained by calculating the "hazard index" or "untreated dilution index" (UDI) defined by:

$$UDI = \sum_i \frac{Qi}{MPC_i}$$

where Qi is the activity of nuclide i in the waste and MPC_i is the concentration limit for the nuclide in effluents as presented in 10 CFR 20. This "untreated dilution index" then represents the quantity of water (in cubic meters) which would be required to dilute the waste to meet the effluent concentration limits of Part 20. Figures 7, 8 and 9 present this index as a function of time for spent fuel and reprocessing wastes. These figures also include, for perspective, the "untreated dilution index" for an equivalent amount of unmined uranium ore.

Recent revisions in the ICRP's recommendations for dosimetry calculations (Ref. 2-4) would cause some significant changes in this measurement of the relative hazard of HLW as a function of time. This effect has been noted recently in the scientific literature by a number of authors (Ref. 2-5, 2-6 and 2-7). Revised curves, based on the more recent ICRP recommendations (ICRP-30), are displayed in Figures 10, 11 and 12 for spent fuel and reprocessing wastes. The most significant results of the ICRP revisions are:

1) the hazard of some of the fission products (primarily Sr-90) is reduced,

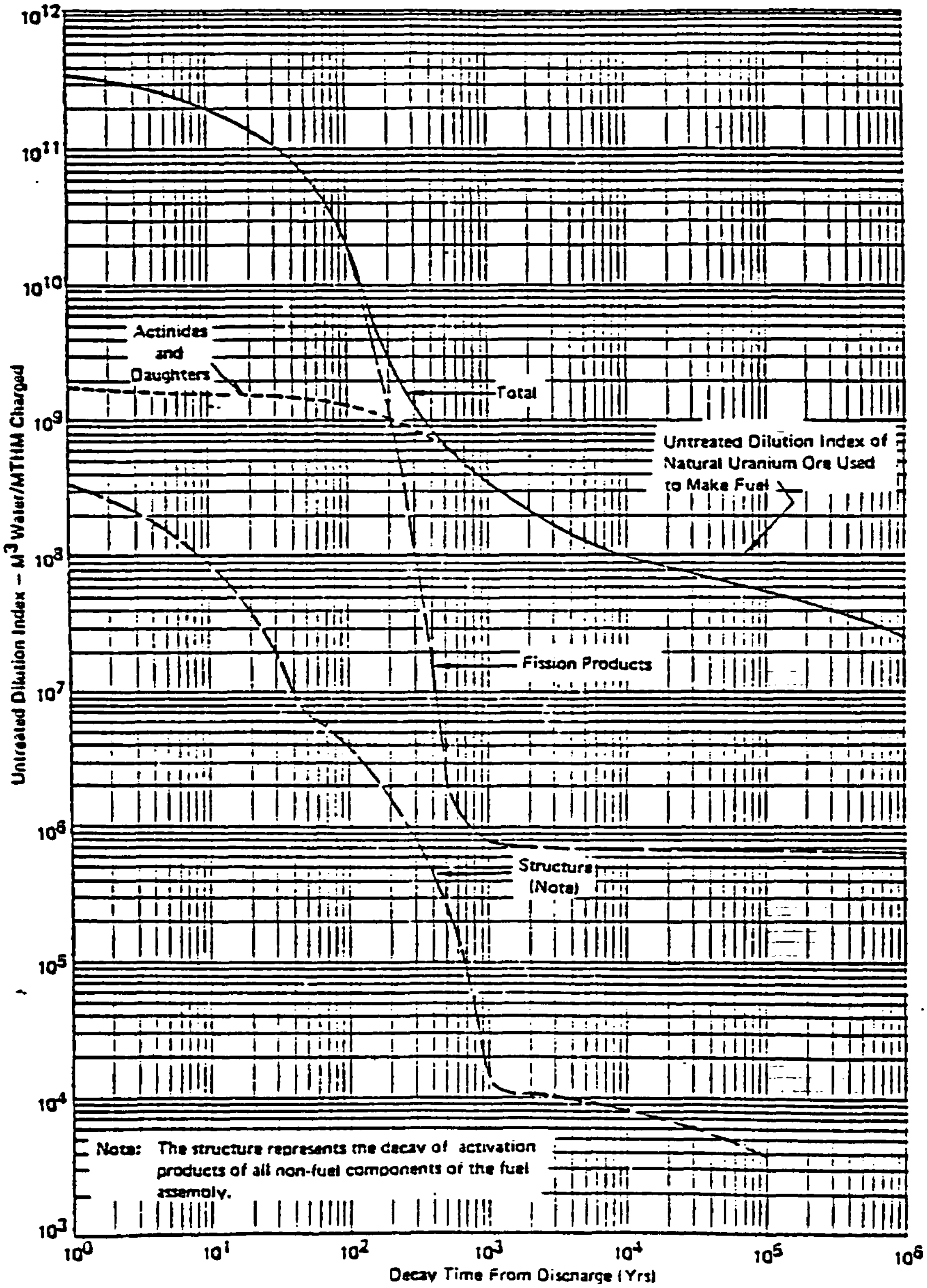

FIGURE 7. PWR SPENT FUEL -- UNTREATED DILUTION INDEX (Ref. 2-3)

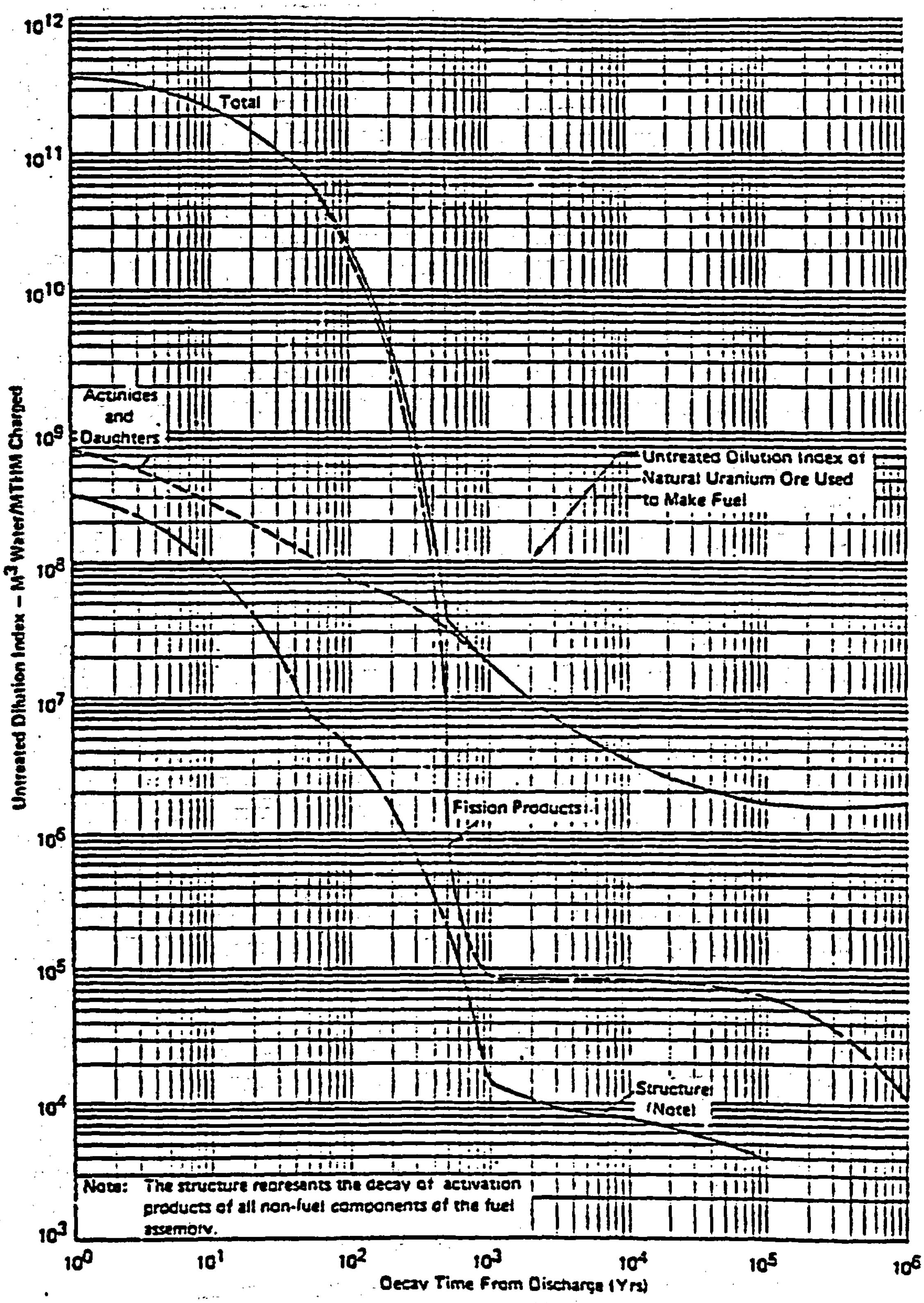

FIGURE 3. URANIUM RECYCLE REPROCESSING WASTE -- UNTREATED DILUTION INDEX (Ref. 2-3)

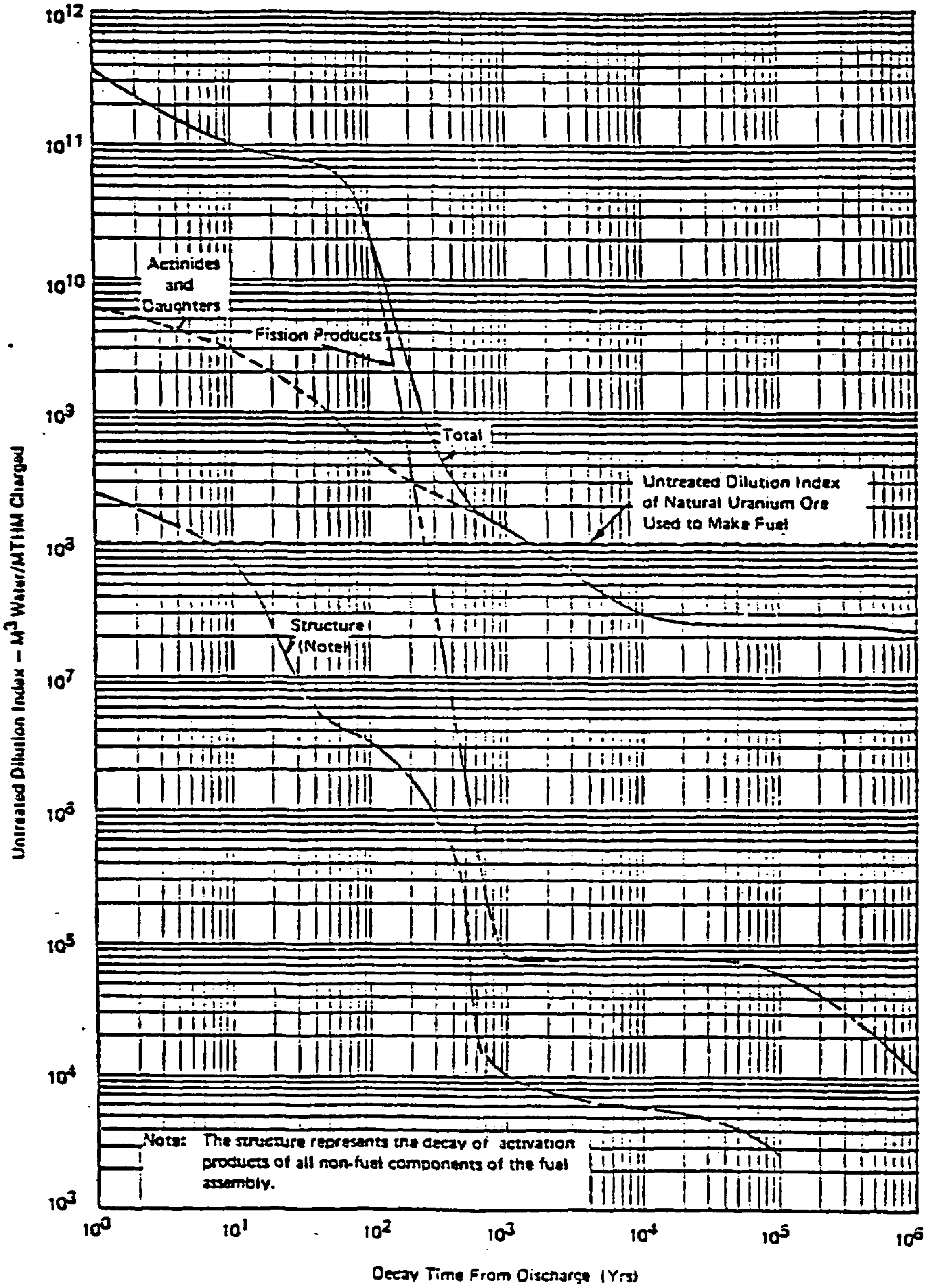

FIGURE 9. MIXED OXIDE REPROCESSING WASTE --
UNTREATED DILUTION INDEX (Ref. 2-3)

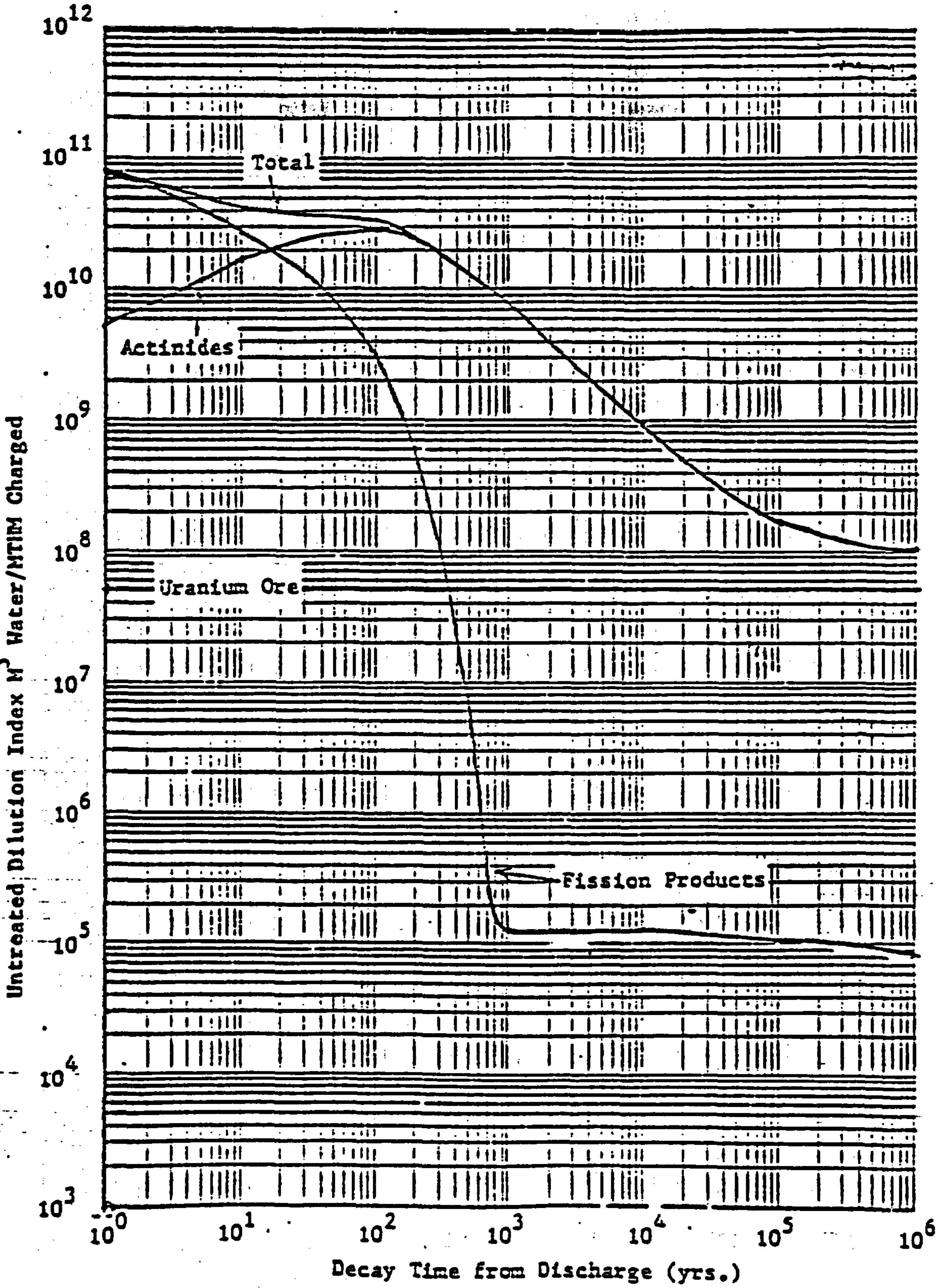

Figure 10. PWR Throwaway Cycle - Untreated Dilution Index Based on ICRP-30 Dosimetry.

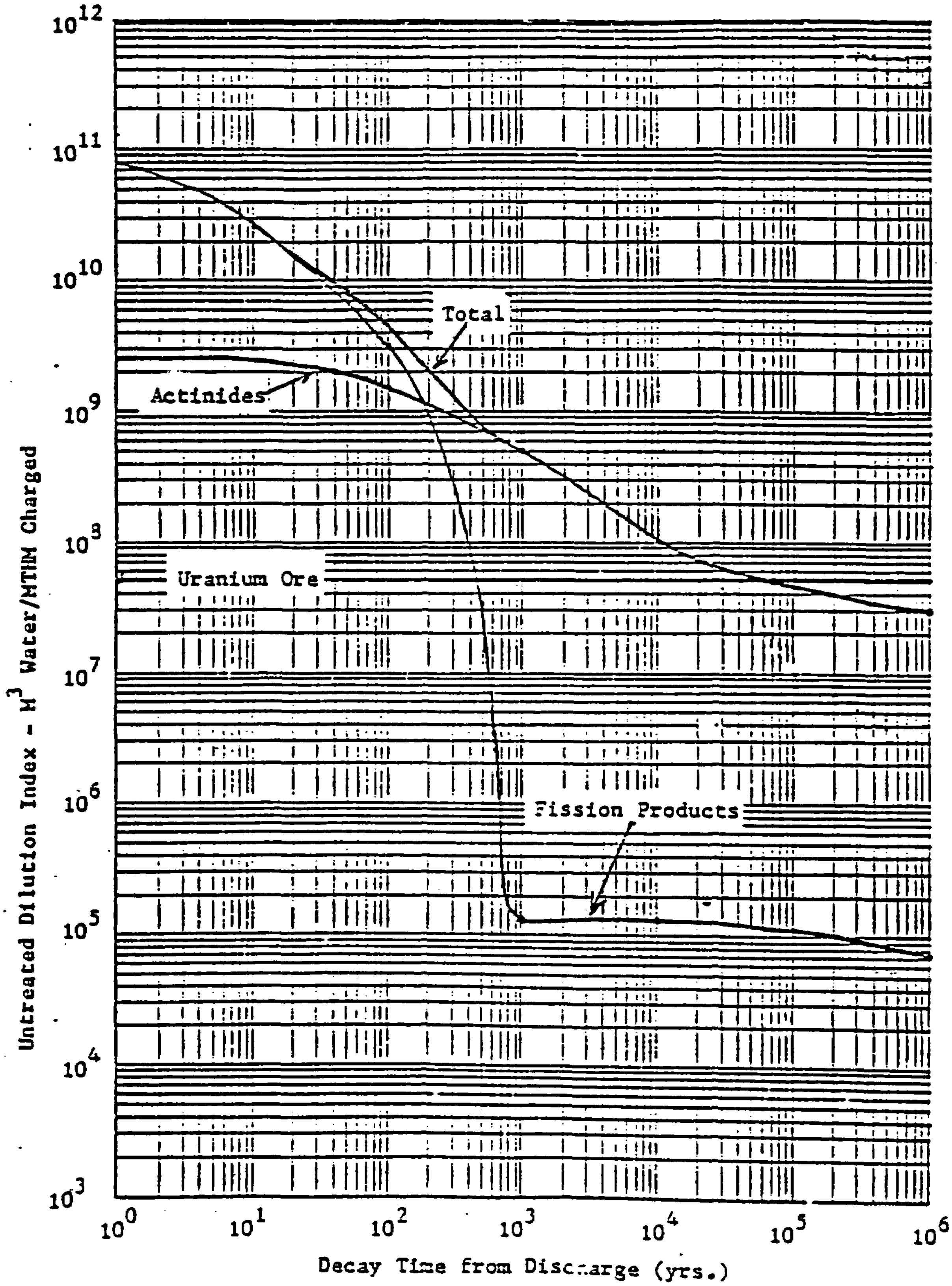

Figure 11. Reprocessed Waste - Untreated Dilution Index Based on ICRP-30 Dosimetry.

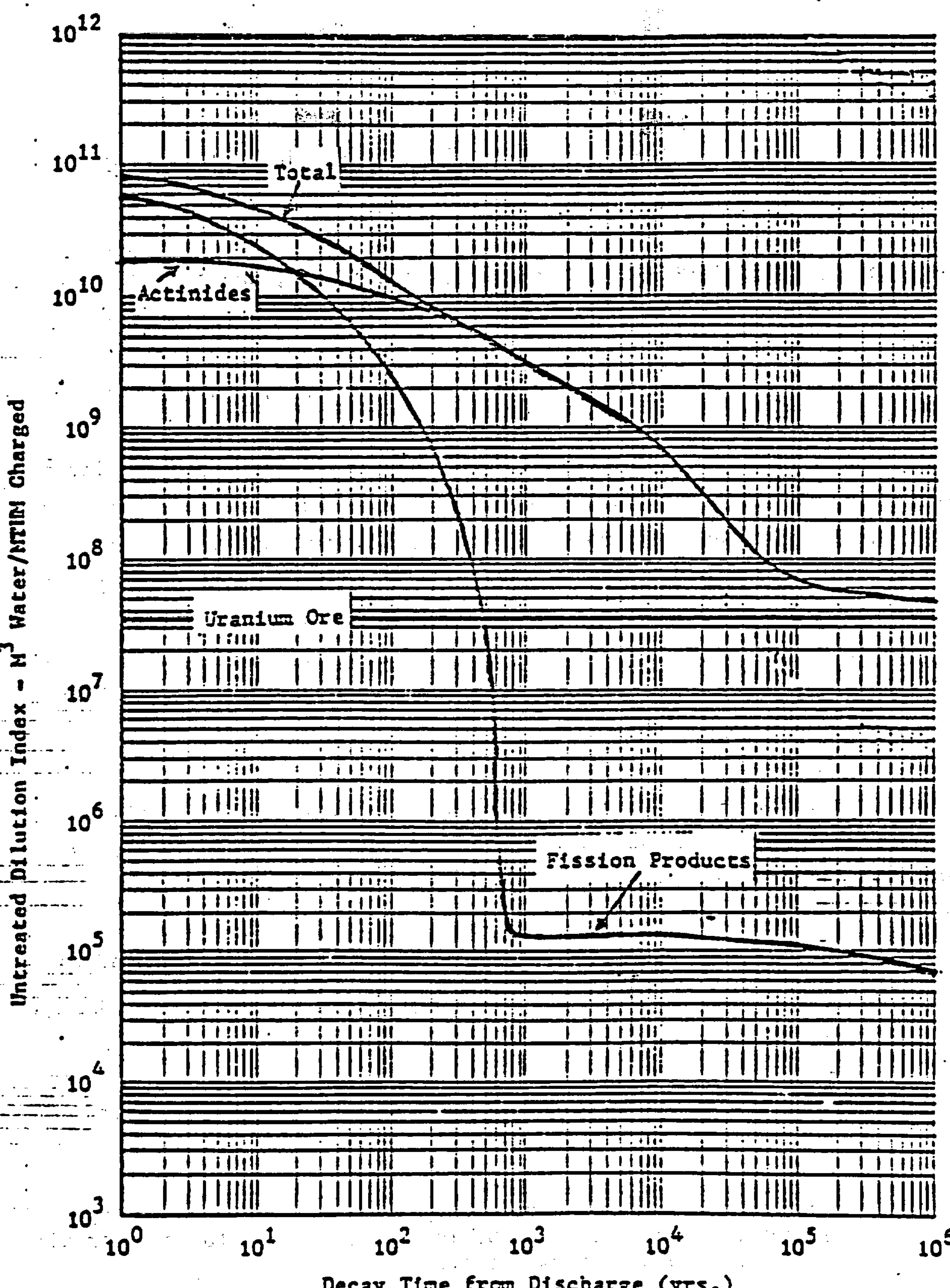

Figure 12. Mixed Oxide Reprocessing Waste - Untreated Dilution Index Based on ICRP-30 Dosimetry.

2) the hazard of several of the long-lived actinides is increased (especially Am-241, Am-243 and Np-237), and

3) the hazard of Ra-226 is reduced and, as a result, the hazard of the original uranium ore is reduced.

The UDI curves of Figures 7-12 indicate that the toxicity decreases substantially (90% - 99.9%) during the first 1000 years for all three waste types and for both dosimetry approaches considered. The toxicity of the fission products decreases by more than five orders of magnitude during the first 1,000 years and then remains essentially constant for the next 100,000 years. Table 1 lists the nuclides and their inventories which dominate the UDI curves using the revised ICRP-30 calculational procedure. (The NRC has not formally adopted ICRP-30, but the procedures described in it have been used here because it is the most current ICRP publication on internal dosimetry available.)

The "untreated dilution index" can provide some perspective regarding the intrinsic toxicity of a radioactive material, but is subject to the following limitations:

- The UDI does not consider the physical or chemical form of the radioactive material. Properties such as solubility or leachability may significantly affect the true hazard to human health.

- The location of the material and the pathways through which it could reach humans are not considered.

- There is considerable uncertainty inherent in the dosimetry parameters upon which the UDI is based, leading to considerable uncertainty in the index itself.

Despite these limitations, the UDI and the comparison with uranium ore are useful in understanding the magnitude of the hazard associated with HLW and how this hazard changes with time. In order to gain further

TABLE 1 - Dominant Nuclides* in Spent Fuel

Nuclide	Curies/ MTHM	UDI (m^3/ MTHM)	Percent of Total UDI
10 Years			
Sr-90	6.0E4	2.0E10	43
Am-241	1.7E3	1.1E10	24
Cs-137	8.6E4	7.2E9	16
Pu-241	8.0E4	2.7E9	6
Pu-238	2.2E3	2.5E9	5
Cm-244	1.4E3	5.2E8	1
1000 Years			
Am-241	9.2E2	6.1E9	80
Pu-240	4.4E2	7.5E8	10
Pu-239	3.2E2	5.4E8	7
Np-237	1.0E0	1.1E8	1
Am-243	1.6E1	1.1E8	1
I-129	3.8E-2	6.4E4	—
Tc-99	1.4E1	4.7E4	—
100,000 Years			
Np-237	1.2E0	1.4E8	78
Pu-239	2.0E1	3.4E7	19
Ra-226	9.8E-1	4.7E6	3
I-129	3.8E-2	6.4E4	—
Tc-99	1.0E1	3.3E4	—

*Tc-99 and I-129 are included because of their mobility in geohydrologic systems.

understanding of the potential impacts of disposal of high level wastes, it is necessary to consider the rate of releases of the radioactive materials from the location where the wastes are emplaced and the physical and chemical processes that transport the radioactivity back to parts of the environment where it can be contacted by humans. These rates and processes are addressed in detail in the following chapters.

III FUNCTION OF A GEOLOGIC REPOSITORY

At present, national policy is focusing on disposal of HLW in mined geologic repositories (Ref. 3-1). The primary function of a mined geologic repository is to isolate the waste so that only small quantities of the wastes would return to the environment over such long times that disposal would not constitute an unreasonable risk to public health and safety. The principal mechanism by which radioactive material is anticipated to be released to the environment from a geologic repository is by contamination of groundwater (Ref. 3-2) that contacts the emplaced waste and transports the radioactive materials from the repository to locations in the environment where they can be ingested or contacted by humans. Thus, the assessment of how well a repository performs its isolation function involves consideration of the time when groundwater initially contacts the waste, the rates at which groundwater can contact the waste, the quantities and concentrations of radioactive materials which may be transported away from the disposal facility, and the rates of transport of the radionuclides through the geologic, hydrologic and geochemical systems to the accessible environment.

In order to emplace the wastes, the repository must be open for a period of years during which wastes would be received and handled in surface facilities, transported to the underground facility and placed in disposal locations. After this period of operation, the repository would be sealed and permanently closed. Until the time of permanent closure, handling of the radioactive materials would be carried out so that the public and workers would be protected from excessive exposure to radiation. The measures taken to protect the public and workers during the pre-closure period would be similar to those taken for radiation protection at other nuclear facilities and are not discussed further.

In light of the hazards of the radioactive materials in the HLW and the time periods involved, the measures required to achieve successful isolation of HLW are unique. As discussed in Chapter II, there are substantial uncertainties involved in estimating the toxicity of the waste material itself, and these uncertainties are compounded by uncertainties in such factors as the release rate of wastes from a repository and the pathways by which the wastes might reach the environment. These uncertainties will be discussed in more detail in the following chapters.

IV DESCRIPTION OF A GEOLOGIC REPOSITORY

A mined geologic repository is a facility which achieves isolation (limiting the rate of waste release to the accessible environment to acceptable levels) by means of two major subsystems. These are the geologic setting itself, which is selected for geologic, hydrologic and geochemical attributes which can contribute to isolation; and the engineered system consisting principally of waste packages and materials used to backfill and seal the underground facility, boreholes and shafts. The geologic setting and the engineered system differ both in their contributions to isolation and in the degree of confidence which can be placed on predictions of their long-term performance. Any mined geologic repository will contain some combination of these engineered and natural barriers which together must provide isolation. This is commonly called the multiple-barrier or the defense-in-depth approach. A major issue the Commission has had to deal with in promulgating technical criteria for geologic disposal of HLW is "how do the components of these two subsystems contribute to isolation and what confidence can be placed on their relative contributions to overall system performance?" To answer this question, the staff considered what the respective contributions of the geologic setting and the engineered system to overall performance should be so that the Commission can determine that there is reasonable assurance that a particular repository can isolate wastes.

ENGINEERED BARRIER SYSTEM

As currently envisioned by DOE in its GEIS on Commercial Waste Management (Ref. 4-1), wastes placed in a geologic repository will be in solid form and will be in a container or canister which, as a minimum, is needed to facilitate shipping and handling. Packages can be made of long-lived corrosion resistant materials, and special low permeability and absorbent materials can be placed around the canisters and in the underground facility to contribute to isolation. In fact DOE, in its GEIS, states that one of the functions of the waste package is to contain the waste for periods sufficient to allow most of the fission products to decay to very low levels. This action protects the waste from groundwater contact until the temperature and radiation levels have decreased to the point where technically supportable predictions of radionuclide release rates to the host rock can be made. It is expected that, at the end of repository decommissioning, the underground facility will have been backfilled and the boreholes and shafts which connect the underground facility with the ground surface will have been sealed with low permeability materials. The combination of waste packages and the underground facility we have called the engineered barrier system. The engineered barrier system can contribute to isolation first by controlling the release rate of radioactive materials to the geologic setting, thereby reducing the contribution which the geologic setting must make, and second, by providing a source of isolation which is relatively independent of the geologic setting and which can therefore mitigate the consequences of unforeseen failure of that setting.

This control of the source term can be achieved in several ways. First, the engineered barrier system can be designed of materials that limit the rate at which groundwater can contact the wastes. Second, the waste form itself can be comprised of, or encapsulated in, leach resistant materials. Third, materials which can retard migration once leaching has occurred can be placed in the underground facility and around the canisters to further control release of radioactive materials to the geologic setting.

One means by which waste-groundwater contact can be limited is by containment. In this context, containment means confining the wastes within a sealed boundary, such as a metal or ceramic container or canister, to protect the waste form from groundwater and to delay the onset of leaching and migration until the containment boundary is breached. Such a container can protect the waste form from water during the period when radiation and temperatures are high and release rate predictions are difficult. Even after an initial breach of a canister, which may only be a small pinhole or crack, the waste package may continue to contribute substantially to control of release for decades or centuries by limiting the amount of water which may contact the waste form.

Use of a long lived package to achieve containment is a means, therefore, to compensate for, and to an extent avoid, uncertainties in the prediction of rates of release and migration of the individual radionuclides, particularly during the critical period when the hazard of the wastes is greatest and the heat generation rates are the highest. This is important, because, as explained in Chapter V, temperature is one of the principal factors in calculating what the source term to the geologic setting is. During this critical period the uncertainties in predicting release rates are very great. Even if we did understand the mechanisms completely, the data scatter increases with temperature so that test programs to gather the data to narrow the uncertainties to reasonable bounds are very cumbersome (Ref. 4-2).

THE GEOLOGIC SETTING

Following release of the radioactive materials from the engineered barrier system, the geologic setting alone must provide whatever additional isolation is needed to keep radioactive materials entering the accessible environment to acceptable levels. The geologic setting can provide the needed isolation by two principal means. First, the geologic setting can exhibit hydrologic conditions which result in low groundwater velocities and long groundwater travel times to the accessible environment. Second, the geologic setting can be comprised of materials that chemically inhibit transport of radionuclides by groundwater by, for example, ion-exchange or precipitation reactions. The objective is for the geologic setting, through long groundwater travel times and geochemical retardation, to delay the arrival time of radionuclides at the accessible environment for many thousands of years. During this time additional radioactive decay will take place, so that only a small fraction of the material released from the engineered barrier system will enter the accessible environment, and then only very far in the future.

V. UNCERTAINTIES ASSOCIATED WITH GEOLOGIC DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTES

In the two previous chapters we discussed the function of geologic disposal of HLW (Chapter III) and gave a brief description of current concepts for a geologic repository (Chapter IV). Assessments of the long-term performance of such a HLW repository require the use of quantitative models, and substantial uncertainties are associated with both the models themselves and with the input data necessary for their use. In this chapter we discuss the uncertainties associated with long-term performance assessments, the effects of those uncertainties on the confidence that can be placed in such assessments, and the means by which these uncertainties may be reduced or compensated for.

In Section 1 of this chapter, we begin by reviewing the functions of engineered barriers for isolating HLW, noting specific processes which control or determine these functions. For each process, we cite 1) the properties important in the process, 2) the methods available to measure those properties, 3) ways to determine whether the function is achieved, and 4) the uncertainties associated with those determinations. In Section 2, we treat the key elements of the geologic setting in a similar manner. Finally, we discuss the implications of the uncertainties with respect to confidence that the wastes will continue to remain isolated long into the future.

The specific processes discussed are chosen to follow current concepts of a geologic repository. A canister containing a leach-resistant waste form is emplaced within a backfilled underground facility. Hence, in Section 1 we discuss the engineering by focusing upon the containment properties of a canister, leach properties of waste forms, and sorption/chemical/mechanical properties of backfill. The processes discussed (corrosion, leaching, etc.) would be relevant to any engineering scheme which might be proposed to control release of radionuclides to the geologic setting. Similarly, groundwater flow, geochemical retardation, and the general suitability of a location to host a geologic repository are discussed in Section 2.

1. Uncertainties in the control of radionuclide release to the geologic setting through engineering.

If an engineered barrier system is used to control the release of radionuclides to the geologic setting by methods such as containing the wastes for some period or controlling the rate at which the nuclides are released, then there must be some level of confidence that the materials will perform as planned. This section discusses those processes which determine how engineered materials will behave and affect containment or release of radionuclides, methods for determining and projecting the performance of engineered materials and the uncertainties associated with projecting barrier performance.

To assess the performance of barrier materials it is necessary to understand the environment which they experience, as altered by the effects of these materials on that environment. The central feature of the environment will be groundwater, whose naturally occurring properties such as chemistry and temperature will be altered by thermal and radiation effects of the waste, as well as by chemical interactions with the barrier materials. The complexity of these interactions will result in an uncertainty in the understanding of the environment experienced by the barrier materials which will contribute to the uncertainties in the prediction of their performance.

a) Leach-resistant waste forms

(i) Properties

Leach-resistant waste forms can control releases of radionuclides to the geologic setting in two ways. First, the rate at which nuclides are released can be reduced, reducing nuclide concentrations in groundwater. Second, retention of radionuclides in the waste form allows time for decay, reducing the total quantity of radioactivity ultimately released to the geologic setting.

Leaching will depend on parameters associated with the ground (or repository) water contacting the waste form, such as composition, pH and Eh; parameters pertinent to the waste form itself, such as surface area and structure; and parameters which affect properties of both the water and the waste form, such as temperature and radiation. (Ref. 5-1, 5-2 and 5-3).

(ii) Determination of leach rate

Leaching of a waste form by groundwater is a very complex process. There is as yet no rigorous, well determined rate expression available to describe the leaching of a waste form and its dependence on all the physical, chemical and geometric properties that are known to affect it. Moreover, much of the data available indicate a complex interplay between leach rates and parameters such as pH, Eh, flow rates, leachant chemistry and how these parameters may change with temperature. As a result the models presently available to estimate the rate of leaching generally reflect empirical correlations rather than theoretical principles.

Experimental measurements can be conducted under conditions intended to represent the expected leacning environment (Ref. 5-4 and 5-5).

Controlled perturbations of leach rate experiments may lead to a broader understanding of fundamental leach rate phenomena (e.g., the influence of temperature and pH on leaching) and, in principle, can aid in the development of and improve the validity of the models. However, in all cases, predictions of long term performance will be based on the results of tests and analyses of those results. From such analyses, it is known that certain parameters such as temperature and radiation alter the measured leach rates significantly (Ref. 5-6 and 5-7). As the temperature increases the mechanism of leaching may change, the nature of the leaching medium may change, and the ability to precisely and reproducibly determine the leach rate may be hampered. Radiation will alter characteristics of the leaching medium, such as, its pH (Ref. 5-8), and thus will alter measured leach rates. The combined effects of increased temperature and radiation can potentially increase the uncertainties in the leach performance of the waste form to a point where they may not easily be quantifiable.

Further, there will always remain the question as to whether the conditions by which leach rates are determined in the laboratory are the same as those which will be encountered by the waste form in the repository. Uncertainties in measurements of current hydrologic characteristics (e.g., flow rates) and, particularly, in predictions of future hydrologic conditions (Ref. 5-9), place limits on the reliability of long-term leaching extrapolations.

(iii) Implications

Several conditions must be met if a leach resistant waste form is to serve as a major barrier to waste release:

1) The influence of significant parameters (e.g., temperature, groundwater chemistry) must be thoroughly investigated. An understanding of the influence of these parameters may require that the waste form be contained to prevent the initiation of leaching until temperature and radiation levels are low enough that a greater degree of confidence can be placed on the long term leach behavior.

2) Predictions of the repository environment far into the future must be bounded, including changes in the environment between closure and resaturation of the underground facility. Such predictions need not be precise, but the bounds must lie within the range of conditions for which the waste form has been experimentally tested.

3) Manufacturing quality control must be adequate to assure that the properties of "production line" waste forms do not deviate significantly from the properties of the waste forms evaluated in the laboratory.

If these conditions are met, leach rates may be extrapolated with less uncertainty. Furthermore, long-term leach rates can probably be predicted with more confidence than can near-term leach rates because of the elevated temperature conditions shortly after waste emplacement. A low leach rate waste form can therefore serve as a high performance engineered barrier over the long-term after thermal and radiation effects have decreased. The level of confidence would probably be lower in the short-term (hundreds of years) when elevated temperatures and radiation may cause extreme repository conditions.

The waste form testing, groundwater measurement and manufacturing quality control conditions discussed above seem reasonable in light of the degree of confidence which could be placed on a low-leach rate waste form as an engineered barrier. A numerical limit for the leach rate to be achieved by such a waste form will be discussed in a later chapter.

(b) Canister

(i) Properties

The use of a canister to contain the wastes can overcome some of the difficulties with predicting leach rate and radionuclide sorption (to be discussed in section (c)) at the elevated temperatures and radiation levels likely to be present during the first few centuries following closure. Containment can delay the onset of the leaching process until temperatures have fallen to a level where the leach rate is predictable with a higher degree of confidence.

The mechanism of containment functions not so much to keep wastes within a specified volume (e.g., the canister), but to keep the groundwater from contacting the waste-form until temperature and radiation levels are within the range where laboratory data can be relied on to predict long term performance with reasonable assurance. Hence, the process of concern is deterioration of the canister. Some of the physical and chemical parameters which determine corrosion rates are the same as those which determine leach rates. Principal among these are groundwater chemistry (Eh, pH and chemical composition), temperature and radiation (Ref. 5-10).

(ii) Determination of expected containment time

Actual containment time can not be observed directly because of the long periods involved. Rather, the expected containment time must be inferred from extrapolation of experiments, noting both the modes and rates of deterioration and failure. Typically, specimens of the material to be used, including weldments, will be subjected to conditions simulating the groundwater and, possibly, the radiation environment expected to be present.

(iii) Implications

The principal advantage of containment is that it permits the system to be simplified by separating the waste from the groundwater until such time as temperature and radiation effects decrease to where laboratory tests can better simulate repository conditions.

Container degradation or failure can be experimentally measured over a wide range of anticipated repository conditions (e.g., typical repository water chemistries, temperatures and radiation fields). As with leaching from a waste form, corrosion of a metallic barrier is a complex kinetic process which may be difficult to predict. At higher temperatures, new mechanisms may arise and the uncertainties in the data may increase. However, failure rates for some processes, or the conditions under which a specific process can cause failure, may be investigated. Failure rates under the range of conditions expected in the repository can be estimated and their accompanying uncertainties bounded. These can then be used to assess the performance of canister materials and to bound the confidence in that assessment.

The conditions previously discussed for leach rate predictions (predictions of groundwater conditions, testing that bounds these conditions, and manufacturing quality control) also apply to containment time predictions. If these conditions are met, containment times may be extrapolated with confidence. A numerical limit for the containment time to be achieved will be discussed in a later chapter.

(c) Backfill

(i) Properties

Backfill materials can serve a number of purposes. They can retard migration from the underground facility of radionuclides leached from the waste form, can condition groundwater within the underground facility both to slow corrosion of canisters and to lower leach rates, and can physically limit the rate of groundwater contact with a canister or waste form (Ref. 5-11). The chemical, thermal, and mechanical (physical) properties of the backfill and its interaction with the groundwater determine its performance. When groundwater interacts with a canister or a waste form, the chemical composition of the resultant solutions must be considered if backfill is used to retard radionuclide migration, limit leach rates or reduce solubility limits. Further, for backfill to be a useful agent for conditioning groundwater or retarding radionuclide movement it must contact the groundwater effectively. That is, the backfill must be emplaced in such a way that there are no extensive voids or channels that would permit the groundwater to bypass the backfill materials. In addition, the backfill must be able to perform its function in the changing thermal, chemical, and radiation environment of the repository.

(ii) Determination of backfill performance

Standard engineering tests for compaction, permeability, homogeneity, and gradation can be performed on backfill emplaced within an underground facility to assure the proper mechanical properties for its intended function. Groundwater conditioning and radionuclide retardation properties can be determined by laboratory tests which focus on the chemical properties of the backfill. Backfill materials can be tested in the laboratory and in-situ to determine their behavior in the repository environment (Ref. 5-11 and 5-12).

(iii) Implications

The functions of a backfill material can be considered to be of two basic types:

(1) An adjunct to other barriers. A backfill can condition groundwater to increase containment times and reduce leach rates, and can limit the rate of groundwater contact with a canister or waste form.

(2) A barrier in its own right. A backfill can retard movement of nuclides away from their location of emplacement.

The uncertainty in the performance of a backfill material probably cannot be quantified very precisely. Rather, the backfill serves largely to reduce the uncertainty in the performance of the other barriers. (For example, by controlling the pH of the groundwater, uncertainty in the corrosion rate of a canister may be reduced.) The backfill can, nevertheless, serve an important function in overall repository performance, and can be instrumental in predicting the performance of the other engineered barriers.

2. Uncertainties with respect to transport of radionuclides through the geologic setting.

Regardless of the extent to which engineering is used to contain wastes or control the release of radionuclides, the geologic setting determines the environment in which the engineering must perform its intended function. Hence, the geologic setting must be characterized and understood at least with respect to the design parameters of the engineering. Moreover, to the extent that the geologic setting is used to isolate the wastes from the accessible environment, or that it is relied upon to mitigate the consequences of premature or unanticipated failure of the engineering, it must be characterized and understood with respect to its ability to control the movement of radionuclides to the accessible environment. In this section we discuss the parameters which describe the processes and characteristics of the geologic setting relevant to the functions described above.

(a) Groundwater Hydrology

(i) Properties

The groundwater is the likely means by which radionuclides would be transported from a geologic repository to the accessible environment. Hence a long groundwater flow time between the underground facility and the accessible environment is a highly favorable condition for waste isolation. Further, our confidence in the ability of a geologic repository to isolate wastes is directly dependent upon an understanding of the groundwater flow between the repository and the accessible environment. The characteristics by which we describe the groundwater flow through porous media typically are those by which any fluid system is described: hydraulic gradient, porosity, permeability, temperature, density, viscosity, and the geometry of the system. For flow in fractured media, an effective porosity and an effective permeability can be developed based on average fracture size and length and the porosity and permeability of the unfractured rock. (The chemical properties of the groundwater also are important to the design of the engineering used to contribute to the isolation of the wastes. The measurements of the chemical properties relevant to engineering, and their associated uncertainties were discussed in the previous section.)

(ii) Determination of groundwater flow

The hydraulic properties of the groundwater system particularly important to isolation of radioactive wastes are related to groundwater flow (rate, quantity, direction, and, in the saturated zone, time for resaturation of the underground facility). Groundwater flow can be measured directly for simple aquifers with rapid groundwater flow. However, the underground facility is likely to be constructed in an aquitard or aquiclude, nearby groundwaters are likely to be very slow flowing, and flow paths may be complex and fractured. Such slow flow or complex heterogeneous conditions make direct measurement of groundwater flow difficult. Fluid systems models that incorporate the properties described in the preceding section can be used in place of direct measurement to estimate groundwater flow. Such models have been developed, but have not been validated, for estimating groundwater flow in the slow-flow conditions expected in the stratum in which an underground facility would be constructed. Moreover fracture-flow will likely be of importance in many host rocks, but the development of fracture-flow models is in its infancy and the utility of these models for predictive purposes has not yet been demonstrated (Ref. 5-13 through 5-16).

Groundwater dating is an alternative to direct measurement for estimating groundwater flow, and does not require measurement of all the properties which determine groundwater flow. Hence, groundwater dating can provide a semi-independent check on groundwater flow estimates (Ref. 5-17). Groundwater dating involves uncertainties which are potentially important, however. Among these are uncertainties in initial isotope ratios, chemical or physical processes which could alter isotope ratios or concentrations along the flow-path, and mixing with groundwaters from other sources between measurement locations. At present, groundwater dating techniques applicable to waste repositories are mostly in the early stages of development, except for methods using C-14 (Ref. 5-18).

(iii) Implications

Some of the uncertainties associated with estimates of groundwater flow for repository performance can be assessed quantitatively by means of parameter sensitivity analyses and statistical sampling techniques (Ref. 5-19, 5-20 and 5-21). However, the utility of uncertainties estimated in this way is limited with regard to actual flow at a repository site for several reasons. Validation is lacking for flow estimates under slow-flow and fracture-flow conditions. Also, the models used to make the estimates may not properly account for (1) the diverse and heterogeneous geologic environments which are likely to be encountered over the distance of groundwater travel from the underground facility to the accessible environment, and (2) the effects of natural geologic processes, as well as the thermomechanical perturbations caused by the wastes themselves, which may significantly alter groundwater flow patterns over the time period required for waste isolation.

(b) Geochemistry

(i) Properties

Favorable geochemistry would tend to retard the movement of radionuclides with the groundwater. The movement of radionuclides typically is described by the groundwater flow rate and the empirical retardation factor. The latter is a shorthand for the complex geochemical processes which affect radionuclide transport in groundwater. The retardation factor is described in terms of characteristics of the geologic medium (e.g., bulk density and porosity for porous-medium flow) and the radionuclide distribution coefficient, Kd, which accounts for the chemical interactions among a radionuclide, the constituents of the groundwater, and the host rock/aquifer of concern.

Solubility limits may also be important, particularly for the actinide elements. If the rate of groundwater contact with a waste form is very low (e.g., because of favorable backfill material properties), or if the solubility limit of an element is very low, the apparent "leach rate" of a waste form will be reduced independent of the inherent leaching characteristics of that material. Solubility limits are dependent primarily on the groundwater chemistry (for a given element). Thus, a combination of a favorable groundwater chemistry and a low rate of groundwater contact with a waste form (e.g., good backfill properties) could substantially reduce nuclide dissolution rates from a waste form.

(ii) Determination of geochemistry conditions

The relevant processes which must be measured or inferred to predict geochemical retardation of radionuclides include, among others, precipitation/dissolution (controlled by solubility), the chemical forms of nuclides in solution, sorption/desorption interactions, and colloid transport and ultrafiltration. Generally, the limiting geochemical processes are chemical complexing (which determines species present in the groundwater), and precipitation and sorption/desorption (which affect the amounts of radionuclides dissolved in groundwater).

Laboratory tests can be used to estimate maximum solubilities, and field measurements can be made to verify laboratory measurements. Similarly, laboratory measurements can be used to determine sorption/desorption properties. However, the relevance of laboratory measurements to actual field conditions is only beginning to be investigated.

Theoretical geochemical models have recently been developed to investigate element speciation in realistic geochemical environments. (Ref. 5-22 and 5-23). However, the requisite field data and thermodynamic data, particularly for transuranic elements, are difficult to obtain. Most of the available thermodynamic data are at a temperature of 25°C and standard atmospheric pressure (Ref. 5-24) and need to be adjusted to expected repository conditions. Experiments at elevated temperatures are being conducted (Ref. 5-25). In addition, the models involve important assumptions, such as that of chemical equilibrium, which may be unrealistic if the spatial variation in geochemical properties of the geologic setting is severe. Finally, theoretical models do not yet incoporate kinetic effects in the predictions of element speciation, nor do they relate speciation to predictions of retardation in groundwater transport. Theoretical geochemical models alone cannot provide an adequate substitute for empirical data from experiments approximating anticipated repository conditions, especially for elements such as Pu, Np, U, and Tc, whose mobility characteristics depend strongly on geochemistry (Ref. 5-26). All three approaches: experimental solubility and sorption measurements, field migration studies, and theoretical calculations are necessary to provide and understanding of radionuclide migration.

(iii) Implications

A large body of experimental data on solubilities and Kd's has been obtained for many of the important radionuclides in HLW (Ref. 5-27 and 5-28). However, serious questions have been raised about the relevance of Kd's to observed retardation effects, and about the ability to measure and to predict the in situ conditions which must be known to reduce the uncertainties associated with both solubilities and Kd's to tractable levels (Ref. 5-29). Nonetheless, estimates of solubilities and Kd's and the uncertainties associated with them have been made for the geologic media of interest to the national program (Ref. 5-30) and are used in the calculations appearing in Chapters VII and VIII of this document.

(c) Geologic Environment

(i) Properties

The characteristics customarily used to describe the geologic environment relate to its mechanical and thermal properties, its mineralogy, and its geologic structure. The processes which affect these characteristics include climatic changes, surface erosion/deposition, diagenesis, and tectonic processes such as uplift, subsidence, folding, and faulting.

(ii) Characterization of the geologic environment

Geologic characteristics, i.e., both the present thermal, mechanical, chemical, etc., properties of a given location and the geologic processes anticipated to be operating there now and in the future, are essential not only for understanding factors relevant to transport of wastes by groundwater, but also for confidence in the performance of any engineering over the long term. Not only must conditions in the present be favorable for waste isolation, but also there must be some assurance that the processes expected in the future at the location will have no significant adverse effect. That is, the processes and events which occur at this location either 1) leave the relevant characteristics unchanged, or 2) change them in a way that allows confident predictions of no adverse consequence to the isolation of the wastes. Measurements can be made of the mechanical and thermal properties, mineralogy, and structure of a particular location, although complexity of a location and spatial inhomogeneity add to the difficulty of interpreting the results of such measurements. Inferences are made from the geologic record as to the likelihood of continued or renewed activity of geologic processes.

(iii) Implications

Uncertainties in our understanding of the present state of a geologic environment result from the potentially complex spatial variations in pressure, structure, and mineralogy. In order to reduce uncertainties, field measurements should employ sample sizes and spacings of sampling locations which match the scale of important inhomogeneities at the location. Some uncertainties are quantifiable, e.g., those associated with the extrapolations and interpolations based on field data which are numerical and, thus, are subject to statistical analyses (Ref. 5-31). The magnitude and significance of these uncertainties are site specific.

The predictions as to which geologic processes are likely to be active into the future and which events are likely to occur are based primarily on interpretations and temporal extrapolations of the geologic record. Significant uncertainties may result from the incompleteness or possible misinterpretation of the geologic record. Predictions based on the geologic record are inherently judgmental, particularly for discrete events at specific locations. Nonetheless, the geologic record can be used to estimate bounds for the future effects of anticipated geologic processes and events. At locations which have exhibited little change since the beginning of the Quaternary, the uncertainties in predicting the effect of geologic processes on repository performance are likely to be unimportant for time periods of about 10^4 years or less, but may become significant for longer times (Ref. 5-32). However, there is always a residual uncertainty as to whether a process or event might occur which is not expected or considered likely on the basis of the geologic record and which will cause the engineering to fail.

Thermal and mechanical perturbations of the natural geologic environment caused by development and operation of a repository and emplacement of wastes also need to be taken into account in determining the suitability of a location for waste disposal (Ref. 5-33). For about the first 10^3 years, when the decay heat generated in the waste is most important (see Fig. 4-6), it is likely that the thermal perturbations will have important effects in the rock in close proximity to the underground facility. In principle, uncertainties associated with predicting the post-closure effects of thermal and mechanical perturbations (e.g., in salt) are quantifiable on the basis of field tests. Testing is difficult, however, both because of the long time period over which the decay heat is significant and because the physical size and layout of a test facility should simulate expected repository conditions.

3. Assessment of performance over long periods of time

In the previous sections we discussed the properties by which engineered and geologic systems could contribute to isolation of radioactive wastes. We also discussed the kinds of measurements and experiments needed to conclude that those systems would perform the various functions that might be attributed to them. Finally, we discussed the uncertainties associated with those measurements and experiments and touched upon the implications of those uncertainties with respect to confidence in the isolation of high-level radioactive wastes.

From the preceding discussions of this chapter it is seen that, of the uncertainties which affect confidence in geologic disposal of HLW, the most easily accommodated is measurement uncertainty. There are, of course, practical limitations to the accuracy and precision of measurements of the relevant properties, especially field measurements of the geologic setting in which a repository might be located. Yet, measurement uncertainty is quantifiable and amenable to statistical analyses. Not only the values of properties deemed relevant can be known, but also some quantitative statement can be made as to how well those values are known.

Mathematical models must figure prominently in any assessment of long-term performance of a HLW repository since there will be no opportunity to observe actual repository performance prior to licensing. The reliability of the predictions of these models is limited by the reliability of the input data to these models and by the reliability of the models themselves. The geologic sciences are far from being precisely predictive and, as a result, the models and most of the geological data upon which they rely are subject to sizeable uncertainties. These uncertainties could make repository licensing problematical for the Commission unless adequate compensating measures are employed. Engineered barriers can, as the preceeding paragraphs indicate, substantially reduce and compensate for these uncertainties. Some engineered barriers, e.g., waste forms, can reduce uncertainties by reducing the source term which the geologic environment must control. Other engineered barriers, such as canisters, can reduce uncertainties by preventing contact between the waste form and the groundwater until the temperature and radiation levels are low enough that the mechanisms controlling radionuclide releases to the geologic setting are understood and the data scatter in measuring and predicting these releases is reduced to tractable levels. Additional engineered barriers, such as backfill materials, can compensate for uncertainties in ways which may be largely qualitative, but which will nevertheless lend confidence to a decision on overall repository performance.

In a complementary manner, the geologic setting will compensate for uncertainties in the performance of the engineered barrier system. A minimum groundwater travel time can provide quantifiable compensation for premature failure of or excessive early releases from the waste package and underground facility. Siting criteria addressing resources can reduce the liklihood of inadvertant intrusion into the engineered barriers system. Overall, this element of redundancy of barriers is expected to play a significant role in any Commission decision to license a HLW repository.

The specific contributions which individual barriers can make to overall repository performance and to reductions in uncertainty, are discussed in more detail in subsequent chapters.

VI. IMPACT OF UNCERTAINTIES ON REGULATIONS FOR GEOLOGIC DISPOSAL OF HLW

1. Regulatory policy

If we examine the implications of uncertainties (discussed in Chapter V) associated with determining whether the engineered and natural barrier systems will function as desired as components of a geologic repository, we see that none is free from the uncertainties discussed above. Further, no matter how good the design or how excellent the site, and no matter how precise and accurate the measurements and observations of the components of the repository, the best that can be known is the state of the repository at the time the Commission must decide whether to allow closure. The state of the repository beyond that decision point is an inference. While it is conceivable that the DOE could develop a design that does not require anything of the geology other than to provide a location, or could choose a site so good that no engineered barriers would be needed, there will be no opportunity to see the engineering or the site work under all the anticipated conditions, or to observe whether the actual conditions are those for which the engineering is designed or the site selected. Further, there is always the uncertainty as to whether processes and events not anticipated in the design or not expected to occur at the site will indeed occur, and fail the repository.

Faced with this same type of uncertainty for other licensing decisions in the past, although not to the same degree, the Commission has applied a policy of multiple protective systems. This is commonly known as the defense-in-depth approach. In the case of geologic disposal of HLW, this policy would be realized as a requirement that the site and the engineering share in the task of isolating the wastes. Moreover, no one who has been involved in the formulation of national policy for the disposal of HLW, including the DOE, the USGS, the EPA, and the Interagency Review Group on the management of radioactive wastes has suggested exclusive reliance on either geology or engineering for isolation of HLW. The reasoning behind the implementation of the Commission's policy and its advantages for licensing geologic disposal of HLW are discussed below.

First, requiring both engineering and geology to contribute to isolation can be used to limit the consequences of an unanticipated process or event, which could cause failure of one barrier to properly perform its isolation function. Since the Commission will need to make a judgement as to whether it has reasonable assurance that the public health and safety suffers no unreasonable risk from permitting disposal of HLW within a repository in the absence of any experience and proof-testing, the knowledge that mechanisms are in place which limit the consequences of partial failure will add to confidence in that judgement, despite the knowledge that unanticipated processes and events could occur. Further, since some of the functions of the engineering and the site operate by different mechanisms (e.g., groundwater flow and canister corrosion), requiring DOE to use both in a repository provides multiplicity in the methods by which safety is provided. Although one can never be sure that all eventualities have been addressed, viewing possible failure modes/mechanisms from more than one perspective adds confidence that nothing major has been ovelooked.

Finally, although isolation of wastes through engineering or geology involves many of the same properties, and indeed in some instances involves similar processes (e.g., both containment of wastes by a waste package and retardation of radionuclides by the geochemistry of the geologic setting could rely on sorption of radionuclides suspended in groundwater), the major contributors to uncertainty for each arise from different considerations. For example, poor correspondence between laboratory and field measurements has resulted in considerable uncertainty associated with retardation factors for the geologic setting. In the case of material incorporated in the waste package to retard radionuclides, however, retardation factors can be measured with relatively little uncertainty. Hence, to the extent, and over the times, that we can rely on waste packages to contain radionuclides, the uncertainties associated with retardation by the geology are less important. On the other hand, as time progresses our confidence in the waste package's continued performance diminishes. The long history of geologic conditions provided by the geologic record permits more confident evaluation of the ability of the location to maintain some level of retardation of radionuclides into the future. Hence confidence in the geologic record compensates for the uncertainty in the survivability of engineering, while confidence in containment for an initial period compensates for uncertainty in geochemical retardation.

2. Numerical requirements

Numerical specification of the contribution to isolation to be made by the site and by the engineering should be consistent with both the standard to be met (the generally applicable standard for radiation in the environment from the disposal of HLW), and whatever the Commission regards as an appropriate level of risk from unanticipated processes and events.

Although no HLW standard exists at present, the Commission can proceed to specify numerical performance objectives by assuming a standard based upon a reasonable expectation of what an HLW standard might be. Several comments on the proposed rule referred to Draft 19 of the EPA standard, which has been under development for some time. We have therefore chosen this draft as the basis for an assumed standard*, and in Chapter VII we consider numerical requirements for containment, controlled release, and groundwater flow time which, if met, will contribute to meeting it.

3. Additional considerations

Use of an assumed HLW standard provides a basis for specifying numerically, at this time, performance of individual barriers (e.g., containment) under anticipated processes and events. However, when a HLW standard is promulgated, the Commission should have the discretion to review and change as needed the numerical values specified for those barriers in light of that standard. Among the factors the Commission might take into account in exercising this discretion are the age and

* On December 29, 1982 the EPA published a Proposed HLW Standard which is somewhat different from Draft 19. An analysis of the impact of the differences between the two versions appears in Appendix A to this Rationale.

nature of the wastes, characteristics of the geologic setting, and particular sources of uncertainty in predicting the performance of the engineered barrier system or the geologic setting. Finally, in specifying performance numerically at this time, we have not foreclosed the possibility that considerations related to unanticipated processes and events could form a basis for changing the specification, for requiring additional specifications, or both.

VII IMPACT OF NUMERICAL REQUIREMENTS ON ROUTINE RELEASES

As stated in Chapter VI, Draft 19 of the EPA standard, referenced by a number of comments on the proposed rule, has been employed to show the relationship between overall system performance and the numerical requirements on the engineered barrier system and the geologic setting. We expect EPA to publish soon a proposed standard for public comment similar to this draft. This chapter contains an assessment of the contributions to overall performance under anticipated processes and events. An assessment of the mitigation of unanticipated processes and events appears in Chapter VIII. The working draft of the assumed standard fixes a number of parameters against which the overall performance of a repository will be evaluated, including a location at which performance is to be measured (the boundary of the accessible environment), a measure of performance (cumulative releases of specific radionuclides measured in curies), and an interval during which performance is to be measured (10,000 years). In the draft Supplementary Information accompanying the working draft, the EPA also notes its judgment that regulation of releases for a 10,000 year interval will protect public health and safety beyond 10,000 years. Specific limits for releases for reasonably foreseeable (anticipated) processes and events appear in Table 2, and were applied here in accordance with the footnote to that table.

Table 2

Limits of Cumulative Releases to the Accessible Environment for 10,000 Years After Disposal According to the Assumed Standard

Radionuclide	Release Limit Curies Per 1000 MT
Americium-241	10
Americium-243	4
Carbon-14	200
Cesium-135	2000
Cesium-137	500
Neptunium-237	20
Plutonium-238	400
Plutonium-239	100
Plutonium-240	100
Plutonium-242	100
Radium-226	3
Strontium-90	80
Technetium-99	2000
Tin-126	80
Any other alpha-emitting radionuclide	10
Any other radionuclide which does not emit alpha particles	500

NOTE: In cases where a mixture of radionuclides is projected to be released, the limiting values shall be determined as follows: For each radionuclide in the mixture, determine the ratio between the cumulative release quantity projected over 10,000 years and the limit for that radionuclide as determined from Table 2. The sum of such ratios for all the radionuclides in the mixture may not exceed one.

For example, if radionuclides A, B, and C are projected to be released in amounts Q_a, Q_b, and Q_c, and if the applicable Release Limits are RL_a, RL_b, RL_c, then the cumulative releases over 10,000 years shall be limited so that the following relationship exists:

$$\frac{Q_a}{RL_a} + \frac{Q_b}{RL_b} + \frac{Q_c}{RL_c} \leq 1$$

For purposes of our assessment, consistent with the assumed standard, the accessible environment is assumed to be all areas on the land surface regardless of distance from the repository and to include all subsurface locations beyond a vertical surface one mile away from the location of the emplaced wastes. These boundaries appear in Figure 13. (A more recent working draft of the standard allows a distance of up to 10 km rather than 1 mile. This change does not significantly affect the results of the present study, however, since only the groundwater travel time explicitly appears). For an actual repository the distance from the wastes to the vertical boundary of the accessible environment is expected to be site specific but not to exceed 10 km.

Routine Release Scenario: The Undisturbed Repository

The NRC staff identified a scenario for the purpose of showing the effect of numerical requirements for the engineered barrier system and the geologic setting on the performance of a geologic repository which is operating normally. A diagram of this scenario appears in Figure 13.

It is anticipated that if radionuclides are released from an undisturbed repository to the accessible environment, this release will take place by failure of the container surrounding the wastes, dissolution of the wastes by groundwater, and migration of the radioactive material dissolved from the wastes with the groundwater to the accessible environment. For this reason, location of the underground facility in the saturated zone is considered a realistic bounding case for routine release. In this scenario, groundwater is presumed to resaturate the repository within a few centuries after closure and to initiate deterioration of the waste packages, causing eventual breaching of the waste packages and start of radionuclide release to the underground facility. In time, the radionuclides are released to the geologic

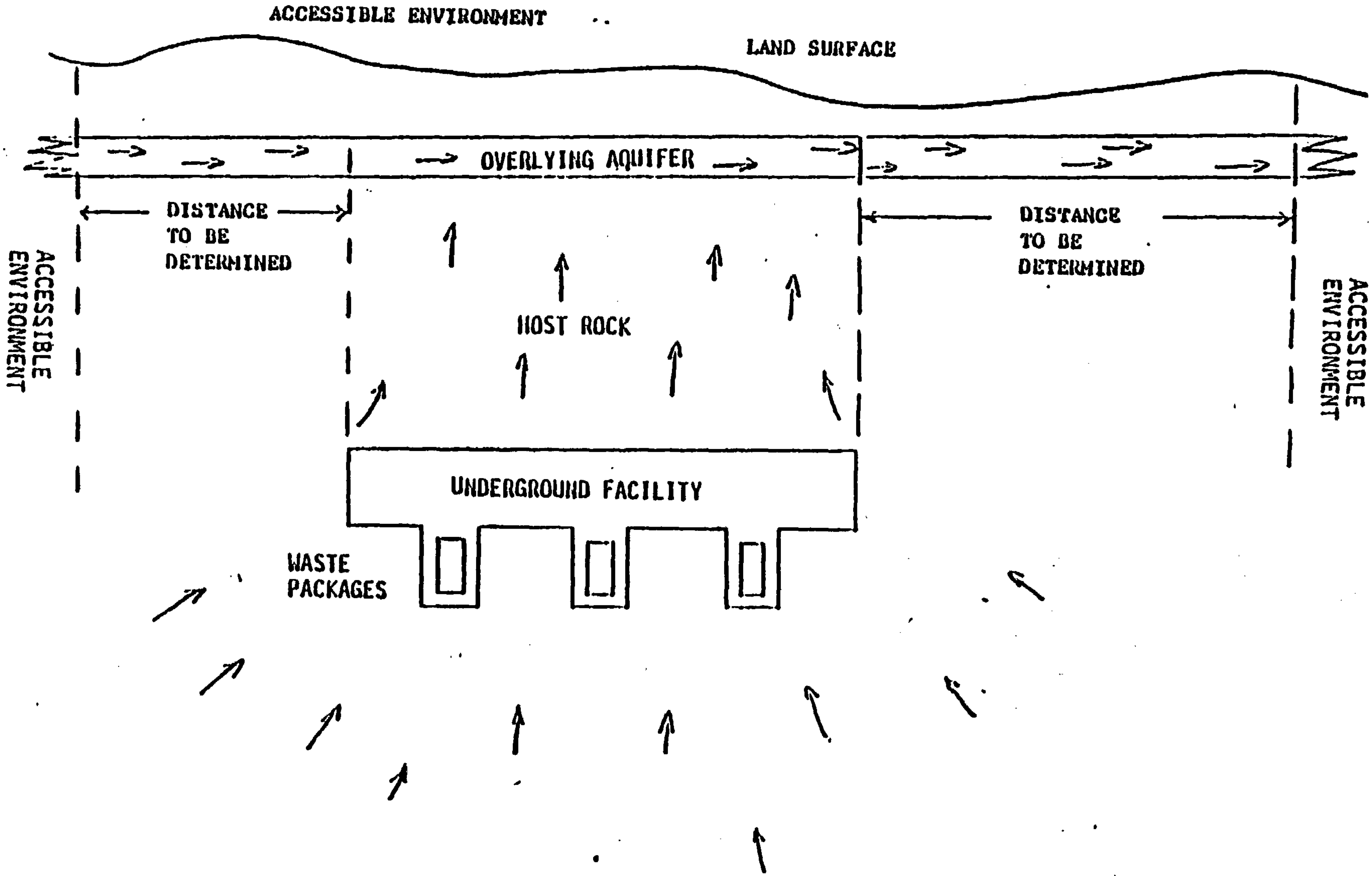

FIGURE 13 - DIAGRAM OF ENGINEERED BARRIER SYSTEM AND GEOLOGIC SETTING FOR THE ROUTINE RELEASE SCENARIO FOR ALL MEDIA.

setting. The assumption of prompt resaturation is conservative but reasonable because void spaces in the backfilled repository will result in a hydraulic gradient that will tend to promote flow inward, and because some natural leakage is anticipated. An upward hydraulic gradient in the geologic setting is assumed, causing groundwater carrying the radionuclides to move vertically through the host rock from the repository to an overlying aquifer. The radionuclides then follow the groundwater flowpath horizontally along the aquifer away from the repository and eventually reach the accessible environment. Transport of some radionuclides through both the host rock and the aquifer is assumed to be impeded by chemical retardation and by limitations on radionuclide solubility. Alternative release paths might be selected, such as a downward gradient which could move radionuclides to an underlying aquifer. However, thermal effects will tend to enhance transport to an overlying aquifer, so this upward case is considered realistic. This scenario will be considered for the three media currently of greatest interest for HLW disposal: basalt, tuff, and salt. Evaluation of this scenario involves prediction of the behavior of an undisturbed repository taking into account uncertainties associated with significant parameters.

Numerical Assessment: The Model Chosen

To quantify the effects of numerical requirements for the engineered barrier system and the geologic setting in the routine release scenario, it is necessary to specify a quantitative model which corresponds to the qualitative description above. That model may then be used to determine how each of the barriers affects the performance of the overall geologic repository. The model selected for describing this scenario is a quasi-two dimensional model in which the radionuclides travel vertically upward, both through the repository and from it to the aquifer, after which they travel horizontally along the aquifer. This model approximates the groundwater flow shown in Figure 13 by a series of legs, shown in Figure 14. Legs A and B correspond to the upper aquifer, leg C corresponds to flow through the underground facility itself, and leg D corresponds to flow from the underground facility through the host rock to the upper aquifer.

A number of simplifying assumptions have been made in order to implement this model. These assumptions are consistent with generally accepted practice in transport modeling and are not intended to introduce either conservatism or non-conservatism into the analysis. First, one-dimensional Darcy flow is assumed, implying low Reynolds number flow in porous media, and implying that all significant flow is unidirectional. Low Reynolds number flow is reasonable in view of the small conductivities and hydraulic gradients involved in geologic disposal systems. Porous flow is reasonable for sandstone aquifers assumed to overlie bedded salt, but for basalt and tuff flow through fractures is likely. Therefore, the hydraulic conductivity has been adjusted for basalt and tuff to roughly approximate fracture flow. Presumption of unidirectional flow in the legs has been shown to lead to good agreement with complex multi-dimensional models such as SWIFT (Ref. 7-1) for applications similar to this one (Ref. 7-2 and 7-3).

The model also presumes that rock properties are invariant for the length of an individual leg, so that properties such as permeability and chemical retardation are constants. A radionuclide passing through an actual unit is likely to encounter a spatially varying environment that may affect its velocity. The constant properties of the leg specified in the model therefore are spatial averages of estimates of the aquifer properties, so that a radionuclide is modeled to traverse the leg in the same length of time it would take to traverse the aquifer unit the leg

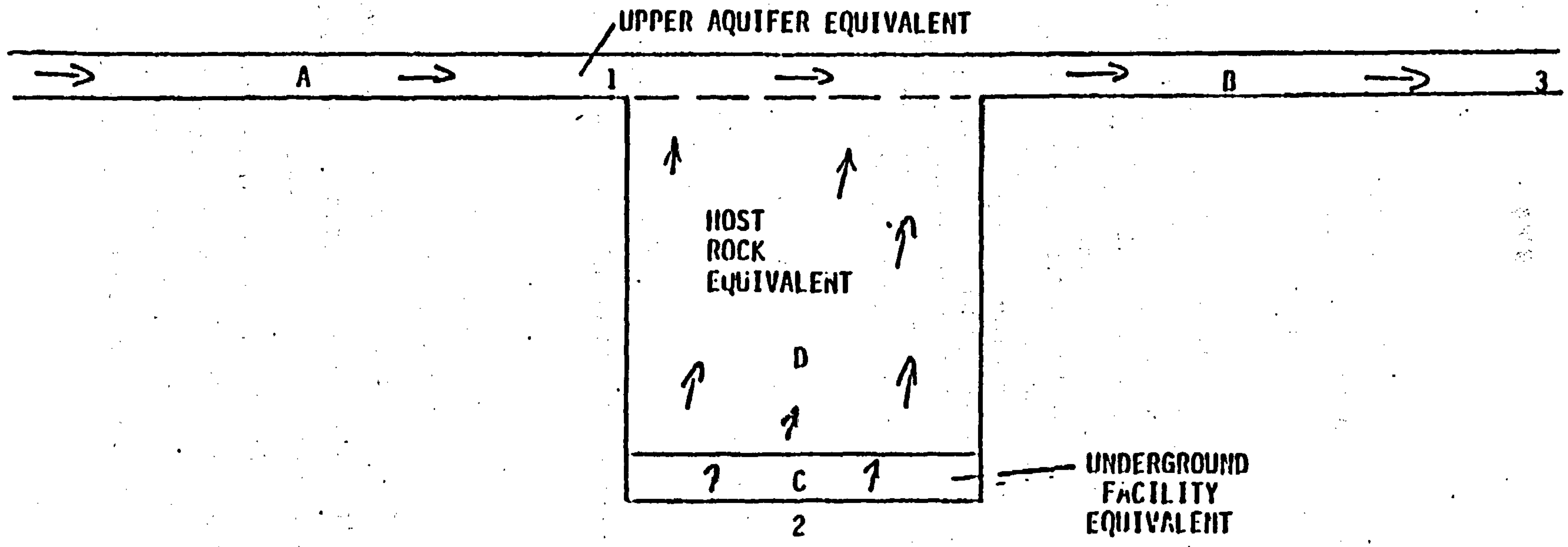

FIGURE 14 - UNIDIRECTIONAL FLOW MODEL CORRESPONDING TO FIGURE 1, ROUTINE RELEASE SCENARIO

represents. Further, the ranges of the properties considered below are considered to encompass the changes in these properties that are anticipated to occur along actual aquifer units.

Another simplification made by this model is that it does not account for all of the effects of the heat released by the waste. The model does account for thermal buoyancy effects on flow in leg D, by adjusting the pressure at point 2, the point where flow enters the underground facility. The model does not account, however, for possible permeability changes in the overlying host rock which might result from thermomechanical effects. Finally, as applied here, the model does not deal with the specific processes which cause canister failure or which affect radionuclide release rates from the engineered barrier system. It therefore does not deal with the uncertainties associated with early failure of containment such as hydrothermal dissolution of waste forms or failure of the backfill to retard radionuclides due to elevated temperatures or radiation fluxes.

Clearly, the model described above is highly idealized, and the behavior and models of an actual site will probably be much more complex. However, it is the staff's view that the model is more than sufficient to accomplish its purpose in this document. That is, the model provides significant, realistic insight into the relationship between numerical criteria and repository performance.

To implement this model, the NWFT/DVM code was used (Ref. 7-4 and 7-5), which requires an extensive set of parameters as input data. These parameters, whose selection reflects the assumptions mentioned above, have been divided into two groups; the first is subject to relatively little uncertainty, the second reflects many of the sources of uncertainty discussed in Chapter V. The first, to be called fixed parameters, are those quantities which define the system and which are specified as point values. In an actual case these parameters would be fixed by the geometry of the site and the properties of the fluid and waste which are relatively well known. These include the distances along the legs shown in Figure 14, the cross-sectional area of the legs, fluid properties such as density and viscosity, and waste properties such as initial inventory and half-lives. The second group, to be called variables, consists of parameters whose values are subject to uncertainties which may span several orders of magnitude. These parameters are not taken as point values in the calculation, but are approximated by distributions. These variables include solubility and retardation factors for individual radionuclides, and factors affecting groundwater travel time, such as permeability and hydraulic gradients. In addition, this group includes parameters for which numerical criteria were established in the Proposed Technical Rule, such as containment time by the waste packages and radionuclide release rates from the underground facility, so that repository performance can be assessed as these parameters vary over the given ranges.

Table 3 identifies the fixed parameters used by the model and the values used in the analyses. Table 4 identifies the variables whose values are approximated by distributions in the calculations, and gives the ranges of those values used in these analyses.

Input Data for Routine Release Scenario

The point values for the fixed parameters shown in Table 3 reflect the media and underground facility designs currently being given the most emphasis by DOE. The dimensions of the underground facility which lead to the areas of leg C and D and the length of leg C are taken from EPA's granite reference repository (Ref. 7-6). The areas of legs A and B are consistent with overlying aquifers for repositories located in basalt, tuff, and salt (Ref. 7-7) and the length of leg B corresponds to the one mile distance to the accessible

TABLE 3. FIXED PARAMETERS FOR ROUTINE RELEASES IN BASALT, TUFF, AND SALT

Description	Value	Units
Area of leg A	1×10^6	ft^2
" " " B	1×10^6	"
" " " C	8×10^6	"
" " " D	8×10^6	"
Length of leg A	Not needed	ft
" " " B	5280	"
" " " C	16	"
" " " D (Basalt)	1530	"
" " " " (Tuff)	1825	"
" " " " (Salt)	1850	"
Conductivity of leg C	infinite	
Porosity of leg C	Not needed	
Pressure at point 1	0	psi
Initial radionuclide inventory	*	Curies
Radionuclide half lives	*	years
Water Density	62.3	$\#/ft^3$
Water Viscosity	1.02	Centipoise

*From Ref. 7-7.

TABLE 4. Variables and their ranges. (For normal and lognormal distributions, ranges are for .001 and .999 quantiles.)

Variable	Distribution	Range in basalt	Range in welded tuff non-zeolitized	Range in bedded salt	units
Kd for Am in host rock	Lognormal	(2.5E1, 2.0E6)	(8.5E1, 9.5E3)	(5.0E1, 1.0E4)	ml/g
Kd for Pu in host rock	Lognormal	(4.5E1, 5.2E3)	(7.0E1, 2.0E3)	(3.0E1, 1.0E4)	ml/g
Kd for U in host rock	Lognormal	(4.0E0, 1.3E3)	(1.0E-2, 1.5E1)	(1.0E-2, 2.7E2)	ml/g
Kd for Np in host rock	Lognormal	(1.5E0, 2.8E4)	(4.5E0, 3.1E1)	(2.0E0, 4.0E2)	ml/g
Kd for fission products in host rock	Lognormal	(1.7E1, 5.8E3)	(5.0E1, 2.1E5)	(1.0E-2, 3.0E3)	ml/g
Kd for Am in aquifer	Lognormal	(1.0E-2, 1.0E5)	(8.5E1, 3.6E2)	(5.0E1, 1.0E4)	ml/g
Kd for Pu in aquifer	Lognormal	(1.0E-2, 1.0E4)	(7.0E1, 4.5E2)	(3.0E1, 1.0E4)	ml/g
Kd for U in aquifer	Lognormal	(1.0E-2, 1.0E4)	(1.0E-2, 1.1E1)	(1.0E-2, 2.7E2)	ml/g
Kd for Np in aquifer	Lognormal	(1.0E-2, 5.0E1)	(5.0E0, 7.0E0)	(2.0E0, 4.0E2)	ml/g
Kd for fission products in aquifer	Lognormal	(1.0E-2, 5.0E2)	(1.2E2, 8.6E3)	(1.0E-2, 3.0E3)	ml/g
Solubility limit for Am		leach-limited	leach-limited	leach-limited	g/g
Solubility limit for Pu	Lognormal	(2.5E-12, 2.5E-8)	leach-limited	(6.0E-17, 4.0E-4)	g/g
Solubility limit for U	Lognormal	(2.0E-6, 2.0E-4)	leach-limited	(1.6E-8, 3.0E-2)	g/g
Solubility limit for Np	Lognormal	(2.5E-19, 2.5E-13)	leach-limited	(1.3E-25, 5.0E-7)	g/g
Solubility limit for Tc	Lognormal	(1.0E-9, 1.0E-7)	leach-limited	(1.9E-9, 9.5E-5)	g/g
Solubility limit for fission products		leach-limited	leach-limited	(6.3E-17, 1.6E-4)	g/g
Dispersivity	Uniform	(5.0E1, 5.0E2)	(5.0E1, 5.0E2)	(5.0E1, 5.0E3)	ft
Radionuclide release time	Loguniform	(1.0E3, 1.0E7)	(1.0E3, 1.0E7)	(1.0E3, 1.0E7)	yr
Conductivity in aquifer (legs A & B)	Lognormal	(1.0E0, 1.0E4)	(1.0E-5, 2.0E0)	(1.5E-1, 6.8E2)	ft/da
Porosity in aquifer (legs A & B)	Normal	(1.0E-1, 3.0E-1)	(2.0E-1, 4.8E-1)	(1.0E-1, 2.0E-1)	--
Conductivity in host rock (legs C & D)		Loguniform (1.0E-7, 1.0E0)	Lognormal (3.1E-5, 9.1E0)	Lognormal (2.3E-10, 3.3E-2)	ft/da
Porosity in host rock (legs C & D)	Lognormal	(1.1E-3, 1.0E-1)	(1.8E-5, 1.3E-2)	(8.8E-4, 7.2E-2)	--
Gradient in host rock	Uniform	(5.0E-3, 3.0E-2)	(1.0E-2, 4.0E-2)	(5.0E-3, 3.0E-2)	ft/ft
Gradient in aquifer		Uniform (1.0E-4, 1.0E-2)	Loguniform (1.0E-3, 1.0E-1)	Uniform (2.0E-3, 1.0E-2)	ft/ft
Canister life	Loguniform	(1.0E2, 1.0E4)	(1.0E2, 1.0E4)	(1.0E2, 1.0E4)	yr

environment. The initial radionuclide inventory is taken from DOE's projections for spent fuel (Ref. 7-8).

The variables which appear in Table 4 reflect many of the uncertainties discussed at length in Chapter V. Uncertainties in geohydrology include predictions of conductivities, porosities, hydraulic gradients and dispersivities. These sources of uncertainty are accounted for in the model by expressing these variables as distributions of values which span the range of available data. Similarly, distributions of solubilities and distribution coefficients (Kd's) are used in recognition of the uncertainties involved in predicting these properties. Three radionuclides, ^{129}I, ^{14}C, and ^{99}Tc, do not appear to be retarded chemically, and are therefore presumed to move at the same speed as the groundwater. This information was developed by Sandia National Laboratory under contract to NRC through a review of the available data for pertinent sites and rock formations (Ref. 7-7). These data are consistent with conditions to be found in the media being investigated by DOE and are considered appropriate for this modelling exercise. However, it is recognized that a thorough analysis of a specific site might well make use of additional or different data which would be more pertinent to that particular site. The ranges and distributions for waste package life and radionuclide release rate were selected to uniformly bound the numerical values in the proposed rule.

Output From Routine Release Scenario

The effects of the variables whose uncertainties are modeled by the distributions in Table 4 on repository performance were investigated by repeatedly running NWFT/DVM using a standard statistical sampling technique (Ref. 7-9, 7-10). In this statistical technique, a "case" composed of 26 values, one for each of the variables in Table 4, was selected from within the ranges shown in the table. By selecting the values at random and by running enough cases to investigate the entire data range, the effects of each of the variables on repository performance can be determined.

The effect of radionuclide release rate from the underground facility to the host rock on the fraction of cases tested which meet the assumed standard can be seen in Figure 15 for routine releases from basalt. In this figure, release rates are varied along the horizontal axis and groundwater travel times are varied along the vertical axis. It should be noted that the release rates shown are limits which apply to all radionuclides for a particular case; if the solubility for a particular nuclide for that case was sufficiently low, that radionuclide might be released more slowly than the release limit associated with that case. The lines plotted on the figure are for constant fractions of cases tested which fail to meet the assumed standard. For example, for a groundwater travel time of 1000 years and a release rate from the underground facility of about 1 part in 40,000 per year, the fraction of cases failing to meet the assumed standard is 0.10 or 10%. Similarly, at a groundwater travel time of 100 years, the release rate from the underground facility at which the fraction of cases failing to meet the standard is 0.10 is about 1 part in 300,000 per year.

Engineered Barrier System Release Rate Requirement

Impact of Release Rate on Performance

Figures 16 and 17 are like Figure 15, but for bedded salt and non-zeolitized tuff, rather than basalt. In interpreting all three figures it is very important to note that the range of groundwater travel times in each figure has been selected to illustrate the impact of the numerical value

ROUTINE RELEASE
BASALT

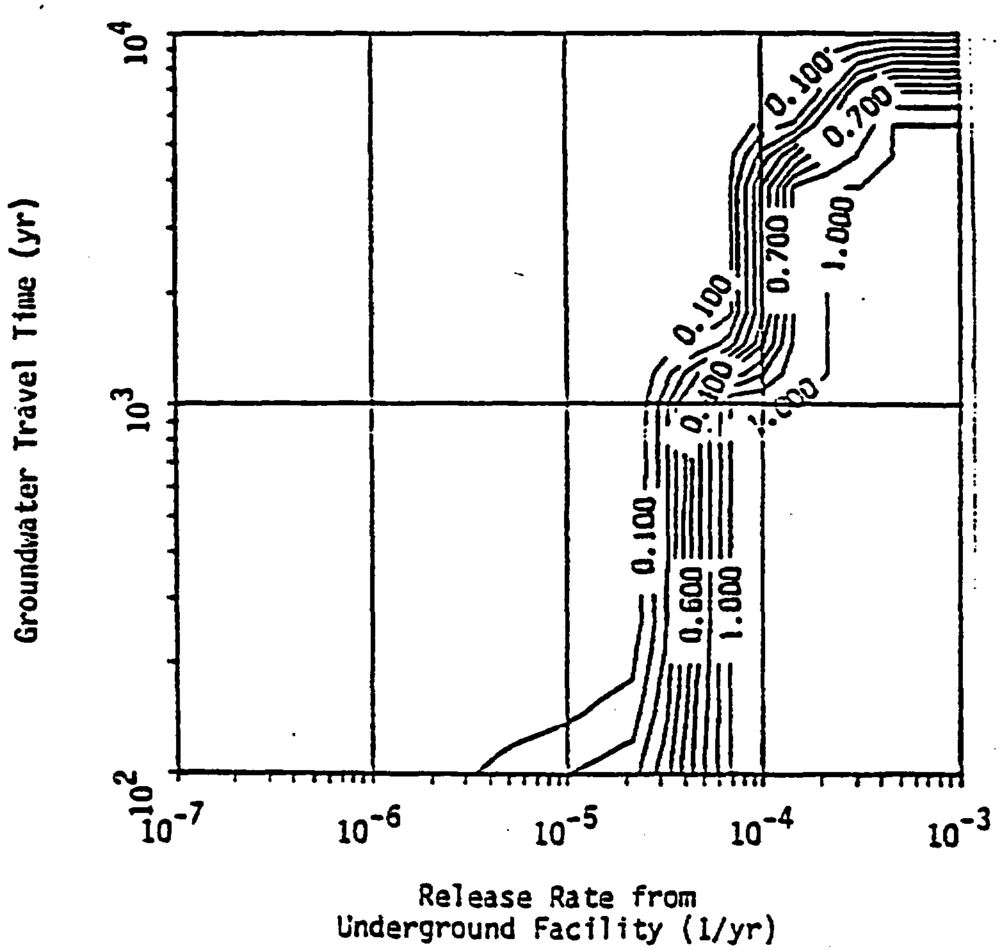

Figure 15. Contours of constant fraction of cases failing to comply with the assumed standard, as a function of limiting release rate and travel time. Medium is basalt.

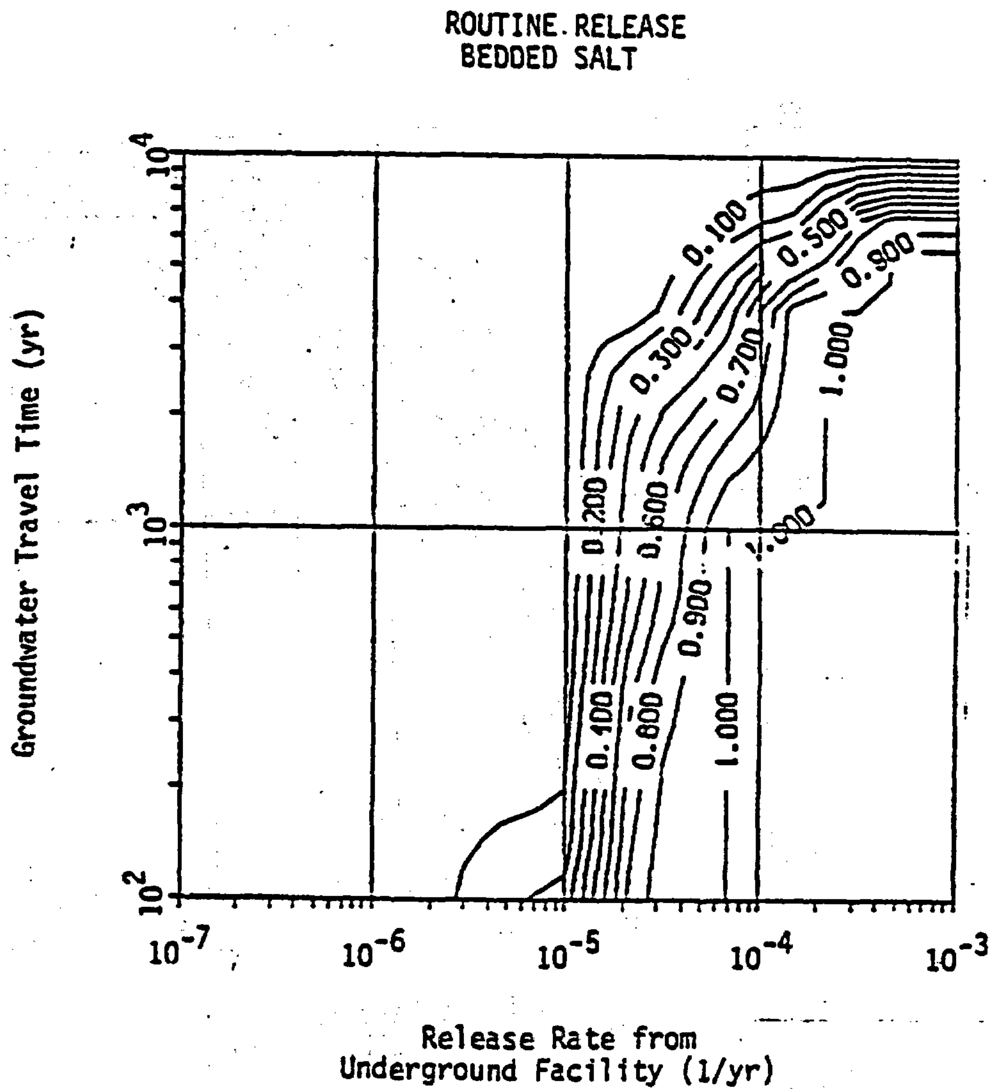

Figure 16. Contours of constant fraction of cases failing to comply with the assumed standard, as a function of limiting release rate and travel time. Medium is bedded salt.

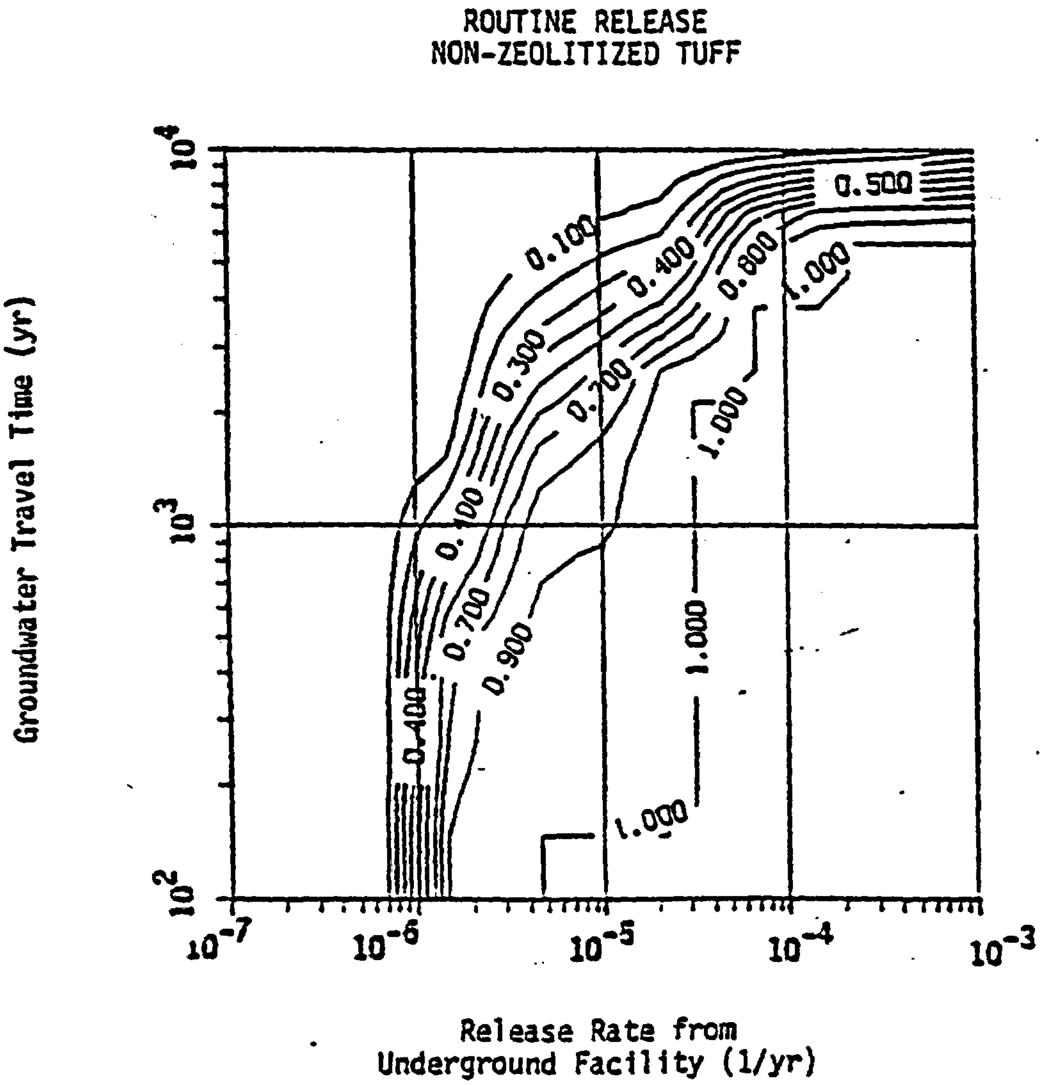

Figure 17. Contours of constant fraction of cases failing to comply with the assumed standard, as a function of limiting release rate and travel time. Medium is non-zeolitized tuff.

of 1,000 years proposed in 10 CFR 60. The staff does not intend to imply that this range is necessarily likely for an actual site. In particular, the staff recognizes that the generally low permeability of salt may result in longer groundwater travel times. Nevertheless, a routine release scenario in salt is considered because of the uncertainties discussed previously.

In Figures 15 and 16, it is seen that as the release rate from the repository decreases, the probability of failing to meet the assumed standard decreases significantly for both basalt and bedded salt. It may also be seen that there is a region in each figure in which the lines of constant fractions of cases lie relatively close to each other. In these regions, relatively small changes in release rate from the underground facility or in groundwater travel time are observed to make relatively large changes in the fraction of cases whose releases fail to comply with the assumed standard. Outside these regions, changes in release rate from the underground facility and in the groundwater travel time have less impact, since they do not cause the lines of constant failure rate to be crossed. (Although no fractions less than 0.10 are shown in the figure, it is apparent that the largest gradients are near the lines shown.)

For basalt (Figure 15), decreasing release rates from the underground facility from about 1 part in 5,000 per year to about 1 part in 50,000 per year reduces the fraction of cases failing to meet the assumed standard from about 1.00 to 0.10, while for bedded salt (Figure 16) reducing release rates from the underground facility to about 1 part in 100,000 per year is needed to achieve a fraction of failures below 0.10. For these media, it is therefore quite advantageous to have a release rate from the underground facility as low as about 1 part in 100,000 per year, but there is little further improvement to be gained from a substantially slower release rate, since this release rate results in compliance with the assumed standard for most travel times.

On the other hand, inspection of Figure 17 reveals that for a repository in the saturated zone in non-zeolitized tuff, the greatest improvement is gained by having releases less than about 1 part in 1,000,000 per year. This result is due to inferior geochemical retardation of uranium in non-zeolitized tuff compared to basalt or bedded salt, consistent with the relatively lower range of Kd's for uranium in non-zeolitized tuff which appears in Table 4. However, it is recognized that many tuffs are zeolitized, with geochemical retardation properties substantially better than non-zeolitized tuffs. Table 4-A consists of a comparison of the retardation properties of zeolitized and non-zeolitized tuff aquifers (Ref. 7-7). Figure 18 results from an analysis identical to that of

Table 4-A. Kd Ranges in Zeolitized and Non-Zeolitized Tuff Aquifers (All distributions are lognormal)

Variable	Range Zeolitized Tuff	Range Non-Zeolitized Tuff
Kd for Am	(6.0E2, 9.5E3)	(8.5E1, 3.6E2)
Kd for Pu	(2.5E2, 2.0E3)	(7.0E1, 4.5E2)
Kd for U	(5.0E0, 1.5E1)	(1.0E-2, 1.1E1)
Kd for Np	(4.5E0, 3.1E1)	(5.0E0, 7.0E0)
Kd for fission products	(2.9E2, 2.2E5)	(1.2E2, 8.6E3)

Figure 17, except that the aquifer is presumed to be zeolitized, and for that case, the behavior of a tuff repository is very much like those in basalt and bedded salt. In Figure 17, reducing release rates from the underground facility to about 1 part in 100,000 per year will achieve a fraction of failures below 0.10. Figure 17 also demonstrates that the impact of the rate of release of radionuclides from the engineered barrier system is media specific. The staff does not intend to imply that at an actual tuff site radionuclide transport must be through either zeolitized or non-zeolitized tuff, but recognizes that both types of tuff are likely to be traversed.

Alternatively, the influence of the engineered barrier release rate can be evaluated by directly comparing releases from the engineered barriers with the release limits of Table 2. Table 5 presents such a comparison for a release rate of 10^{-5} per year following an initial 1000 year containment period. The quantities released do not greatly exceed the limits for any of the nuclides except Am and Pu. This table demonstrates that a low release rate from the engineered barriers is able to contribute substantially to overall repository performance, and may provide a very desirable degree of redundancy for nuclides such as ^{99}Tc which are unlikely to be controlled very effectively by the geologic barriers.

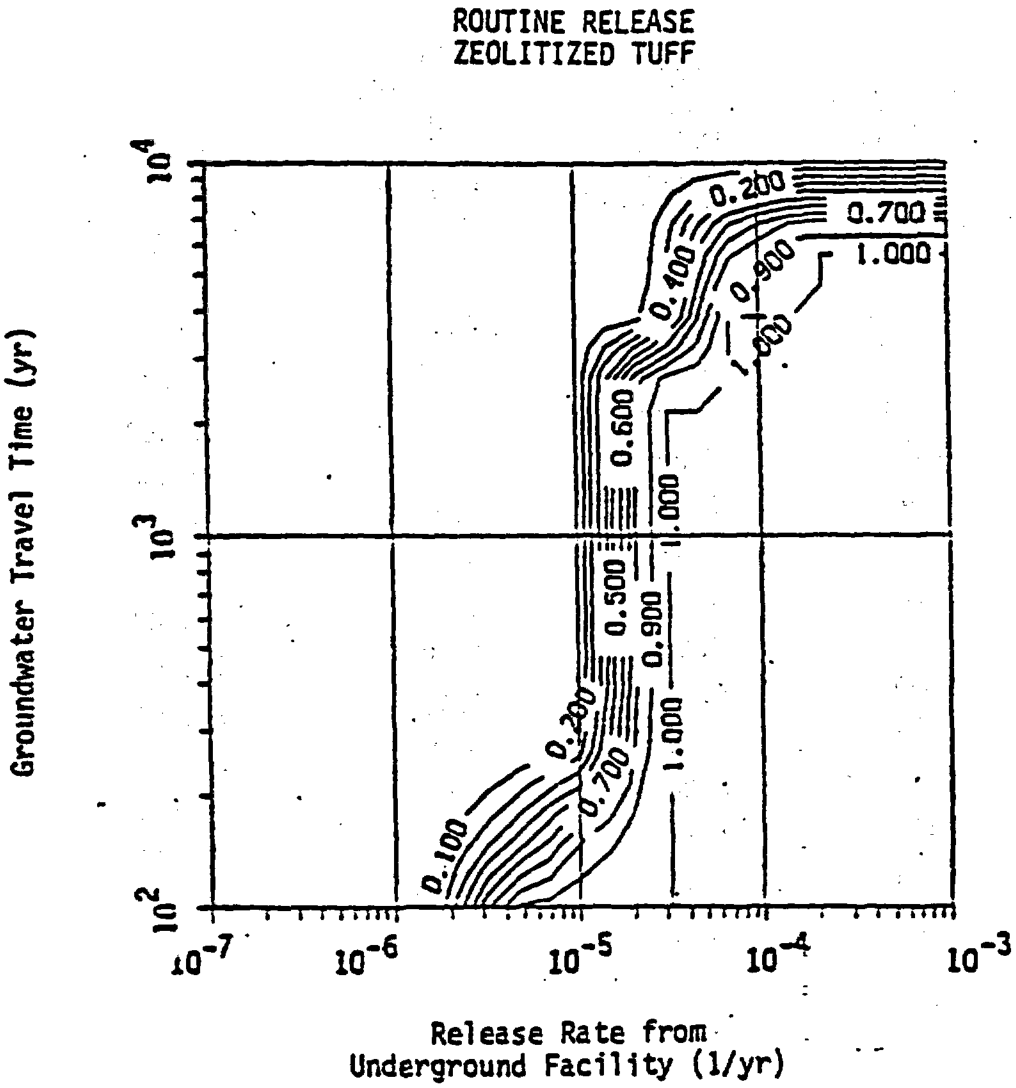

Figure 18. Contours of constant fraction of cases failing to comply with the assumed standard, as a function of limiting release rate and travel time. Medium is zeolitized tuff.

Table 5. Effectiveness of 10^{-5} per year release rate in complying with the EPA standard.

NUCLIDE	REPOSITORY INVENTORY @ 1000 yr (Ci/100,000 MTHM)	RELEASE RATE IF EQUAL TO INVENTORY TIMES 10^{-5}* (Ci/yr)	TOTAL RELEASES (YEARS 1000 to 10,000) (Ci)	EPA LIMIT (Ci/100,000 MTHM)	RATIO OF TOTAL RELEASE TO EPA LIMIT
Am-241	9.24E7	9.2E2	3.0E6	1000	3,000
Am-243	1.57E6	1.6E1	1.4E5	400	350
C-14	1.35E3	1.4E-2	1.2E2	20,000	0.006
Cs-135	2.23E4	2.2E-1	2.0E3	200,000	0.01
Cs-137	1.00	1.0E-5	3.4E-3	50,000	0
Np-237	1.0E5	1.0E0	9.0E3	2,000	4.5
Pu-238	9.8E4	9.8E-1	8.2E2	40,000	0.02
Pu-239	3.2E7	3.2E2	2.9E6	10,000	290
Pu-240	4.4E7	4.4E2	4.0E6	10,000	400
Pu-242	1.7E5	1.7E0	1.5E4	10,000	1.5
Ra-226	2.84E2**	2.84E-3	2.6E1	300	0.09
Sr-90	1.5E-1	1.5E-6	4.8E-4	8,000	0
Tc-99	1.4E6	1.4E1	1.3E5	200,000***	0.65**
Sn-126	5.6E4	5.6E-1	5.0E3	8,000	0.62
Total	1.7×10^8	1.7E3			

*Equal to 10^{-5} x values in column 1. Note that release rates at or below 1.7 Ci/yr (0.1% of total rate) meet the rule.

**Release calculations based on inventory at 1000 years. In the absence of leaching, the quantity of Ra-226 would increase to 1.22E4 Ci per 100,000 MTHM at 10,000 years.

***The proposed EPA standard published in the Federal Register revised the Tc-99 release limit to 1,000,000 Ci/100,000 MTHM. The corresponding ratio of total release to the EPA limit would be 0.13. This change has no impact on the overall conclusions regarding the effectiveness of a 10^{-5} per year release rate in complying with the EPA standard. See Appendix A for further discussion.

Achievability

As stated in the proposed rule, "Proof of the future performance of engineered systems and geologic media over time periods of a thousand or many thousands of years is not to be had in the ordinary sense of the word." Demonstration of compliance with any of the performance objectives will be accomplished through extrapolations and data using physical models based on accelerated tests and natural analogs which are subject to uncertainties. These uncertainties can only be expressed as a statement of reliability or probability that the criterion will be achieved. To require absolute assurance of exact numerical compliance is neither reasonable nor intended. Rather the quantity and quality of the data and the methods will be carefully reviewed as part of the licensing process.

While DOE has not proposed a particular design to control releases from the engineered barrier system, considerable research and development has been devoted to the subject. The NRC staff has been following DOE's technology development program closely, and has been assessing the uncertainties associated with achieving a release rate of 1 part in 100,000 per year.

Brookhaven National Laboratory (Ref. 7-11) has concluded that the criterion is readily achievable, and in some cases exceeded, using borosilicate glass encased in non-radioactive glass.

Savannah River Laboratories consider that this requirement can be met by either of their waste forms currently receiving most attention, borosilicate glass or SYNROC (Ref. 7-12). The Department of the Interior in its comments on the proposed rule supported the achievability of this criterion by means of a succession of barriers at low temperature conditions (Ref. 7-13).

Nowak considers that a one-foot-thick backfill barrier around the waste can delay breakthrough of most fission products for 1000 to 10,000 years, and the breakthrough of transuranics for substantially longer (Ref. 7-14). Smith, Salter and Jacobs suggest that, for the case of Hanford basalts, low solubility alone may limit releases from the underground facility to very low levels (Ref. 7-15). Therefore, having reconsidered the matter, the staff continues to conclude that the requirement to limit the release rate from the engineered system to 1 part in 100,000 per year at 1000 years is reasonably achievable, particularly in view of the Commission's statement that absolute proof of compliance is not required.

The staff also notes that in proceeding from the proposed rule to the final rule the performance objectives have been stated with significantly more flexibility. The staff recognizes that a limit on the rate at which wastes can be released will depend on such factors as the nature of the waste, the properties of the geologic setting, and the uncertainties associated with all aspects of geologic disposal. Proper consideration of such factors must be a part of any requirement on release rates from the engineered barrier system.

Geologic Setting Groundwater Travel Time Requirement

Impact of Travel Time Requirement on Performance

Figures 15 and 16 also show the effect of groundwater travel time on the fraction of cases whose results fail to comply with the assumed standard for basalt and bedded salt. In each figure, groundwater travel times of several hundred years are required to reduce the fraction of cases which fail to 0.10 or less, without simultaneously requiring excessively low release rates from the underground facility. It is also seen that groundwater travel times approaching 10,000 years are needed to reach the region where rapid release rates from the engineered barrier system such as 1 part in 5,000 per year and faster can be tolerated. (This is intuitively reasonable since the model assesses repository performance over a 10,000 year interval and a 10,000 year groundwater travel time would prevent radionuclides from reaching the accessible environment during that time.)

It has already been demonstrated that a release rate from the underground facility of 1 part in 100,000 per year is appropriate, and a nominal groundwater travel time requirement should be consistent with it. Such a value could lie between several hundred and several thousand years for basalt and bedded salt, and a value of 1,000 years, in conjunction with reasonably achievable leach rates, can significantly increase confidence that the assumed EPA standard will be met.

Figure 17 shows that a groundwater travel time of more than 6,000 years is needed to achieve reasonably low repository failure rates in tuff if the release rate from the underground facility is 1 part in 100,000 per year and if the aquifer is non-zeolitized. As shown in Figure 18 and as noted in the discussion of the release rate criterion, this result is improved if the aquifer is assumed to be zeolitized, in which case a groundwater travel time of 1,000 years can significantly increase confidence that the assumed EPA standard will be met.

Achievability

The NRC staff has estimated the time necessary for groundwater to travel one mile from the underground facility. Using data from Table 4, the staff evaluated the fraction of these travel times which exceeded 1,000 years. Those fractions are 0.67 for basalt, 0.93 for bedded salt, and 0.98 for welded tuff. While the permeability and hydraulic gradient data (from Table 4) used in these analyses are not intended to represent a particular site, it is considered that these data are representative of conditions likely to be found in these media.

Further, Battelle has modeled the Hanford site, and reports (Ref. 7-16) that the average distance which groundwater travels from the underground facility in 10,000 years is 5,800 feet, (less than 1.1 miles). Rockwell has also modelled the Hanford site, and shows how far groundwater travels in 100,000 year increments (Ref. 7-17). According to this report, after 800,000 years, the groundwater has moved less than 5 kilometers (about 3 miles) from the underground facility.

The staff considers that these results provide significant support for the achievability of a minimum groundwater travel time requirement of 1,000 years between the disturbed zone and an accessible environment which is located up to 10 kilometers away.

Conclusion

A 1000 year groundwater travel time can be of significant value in providing reasonable assurance that the assumed standard can be met without placing an undue reliance on the ability of the underground facility to minimize release rates, and is readily achievable.

Further, the 1000 year groundwater travel time requirement is an essential component of the defense-in-depth concept as applied to waste disposal. This requirement constitutes a quantifiable criterion for the geologic setting to meet, in contrast to the remainder of the siting criteria for which compliance will be determined by expert judgement. The 1000 year groundwater travel time requirement thus constitutes an invaluable measure of the quality of the geologic setting.
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The staff again notes that performance objectives have been stated with significantly more flexibility in the final rule than in the proposed rule. The staff recognizes that a minimal groundwater travel time will depend on such factors as the age and nature of the waste, the design of the engineered system, the properties of the geologic setting, and the uncertainties associated with all aspects of geologic disposal. Proper consideration of such factors must be a part of any minimal groundwater travel time requirement.

Engineered Barrier System Containment Time Requirement

Impact of Containment Time on Performance

The impact of a containment interval on repository performance is discussed from a different perspective than criteria on release rates from the engineered barrier system or groundwater travel time. Use of a long lived package to achieve containment is a means to compensate for, and to an extent avoid, uncertainties in the prediction of rates of release and migration of the individual radionuclides, particularly during the critical period when the hazard of the wastes is greatest and the heat generation rates are the highest. These uncertainties have been discussed in Chapter V, but for convenience, they are briefly reviewed below.

Temperature is one of the principal factors in calculating what the source term to the geologic setting is. During the initial period the uncertainties in predicting release rates for long times are very great. Even if we did understand the mechanisms completely, the data scatter increases with temperature so that test programs to gather the data to narrow the uncertainties to reasonable bounds are very cumbersome (Ref.7-18).

Additional uncertainties due to thermal effects influence radionuclide transport following release. Thermally induced convection near the underground facility may occur and may transport radionuclides in unanticipated ways. Thermomechanical effects may create pathways for groundwater to travel through the host rock in the disturbed zone. By containing the wastes until the repository temperatures have peaked and are spatially relatively uniform, much of the uncertainty associated with these effects can be avoided.

A further source of uncertainty arises from the large number of different fission product radionuclides, each of which has a variety of solubilities and retardation factors. The latter uncertainties recall Chapter II and the Untreated Dilution Indices appearing in Figures 10, 11, and 12. By containing the wastes until the fission products are nearly depleted, these uncertainties can be greatly reduced.

In order to determine a nominal containment time requirement which can be expected to reduce these sources of uncertainty, it is necessary to consider how fission product inventories and near-field temperatures change as a function of time. Fission product inventories and their changes appear in Figures 1 through 12, and have the same general characteristic in each figure. It is seen in Figures 4, 5, and 6, that the rate at which total heat is generated by the waste decreases so that at least a 99% reduction in heat generation rate occurs within the first few hundred years for each of the waste types. Repository temperatures may have peaked and become spatially relatively uniform by this time, or may require additional time, depending on parameters such as the thermal properties of the host rock and the design of the engineered barrier system. As seen in Figures 7 through 12, the toxicity of the fission products decreases by more than five orders of magnitude during the first 1,000 years and then remains essentially constant for the next 100,000 years. Thus, to a large extent, the uncertainties introduced by the heat generation rate and the fission product contributions to hazard can be compensated for by containment times in the range of several hundred to 1,000 years. However, the staff recognizes that the interval during which wastes should be contained will depend on such factors as the age and nature of the waste, the design of the engineered system, the properties of the geologic setting, and the uncertainties associated with all aspects of geologic disposal. Proper consideration for such factors must be a part of any containment requirement. Therefore, by compensating for several of the principal sources of uncertainty in assessing repository performance, a containment time of several hundred to 1,000 years is appropriate to contribute to reasonable assurance that the EPA standard, as it pertains to anticipated processes and events, can be satisfied.

Achievability of Containment Requirement

As expressed more generally in the discussion of the achievability of release rates, the staff does not intend that the containment time requirement be achieved absolutely for all of the waste (i.e., absolute proof of zero release for 1000 years is not required). It is expected that containment of the waste will be substantially complete, with releases during the containment time limited to a small fraction of the inventory present. What is intended is that the waste package design have a high reliability, taking into account anticipated processes and events that could affect package performance. It is realized that a small fraction of the approximately 100,000 packages will be breached before 1000 years due to variations in materials, manufacturing processes, etc. that can only be estimated using statistical procedures. Similarly, a significant fraction of the packages may remain intact for much longer than 1000 years.

There has been considerable emphasis in the DOE program over the last several years on the research and development needed to design a long lived waste package. NRC has, in its own program, been reviewing DOE's R&D and has been performing assessments of the uncertainties involved in designing a waste package that could reasonably be expected to contain waste for 1000 years.

Brookhaven National Laboratory (Ref. 7-11) states that a multilayered metal container can provide containment for 1,000 years, as can carbon coated particles and high silica glass coated waste forms. Westinghouse has developed for DOE conceptual designs for titanium clad and self-shielded cast steel and cast iron containers which they consider will contain wastes for 1,000 years in basalt (Ref. 7-19). A report for the Electric Power Research Institute describes a container capable of retaining its integrity for 13,000 years (Ref. 7-20). While DOE has not yet proposed a waste package design, the NRC staff considers that the concepts being considered have promise and that a design objective for containment by the waste package of 1000 years is reasonable.

Combined Performance Objectives For The Routine Release Scenario

Impact of the Proposed NRC Requirements

The combined impact of all three performance objectives for the case of the routine release scenario in basalt is shown in Figure 19. Like Figures 15 through 18, Figure 19 results from repeatedly running NWFT/DVM using a standard statistical sampling technique (Ref. 7-10). However, in the analyses leading to Figure 19, groundwater travel times were not limited to those shown in the preceeding figures, but took the values naturally resulting from the distributions of gradients and permeabilities appearing in Table 4. In this figure, the horizontal axis displays ratios of releases of radionuclides determined by NWFT/DVM to the releases permitted by the assumed EPA standard for routine releases described on page 49 and Table 2. The vertical axis displays the fraction of cases in the sample which exceed the value appearing on the horizontal axis. The figure displays results for the unrestricted cases, whose variables span the entire data ranges in Table 4 regardless of whether or not they satisfy the 10 CFR 60 criteria, and the results for all cases which are in compliance with 10 CFR 60. It may be seen that for a given frequency of releases, the consequences associated with that frequency decrease by two to three orders of magnitude. For example, in the unrestricted case there is about a 0.05 or 5% probability of exceeding the assumed standard by a factor of 10. However, for the case of a repository which complies with 10 CFR 60, the probability of about 0.05 or 5% is associated with releases of about 1/30 of the assumed standard, an improvement by a factor of 300. Likewise, about the worst 1% or 2% of the unrestricted cases result in releases exceeding the assumed standard by a factor of about 200, but the worst 1% or 2% of the restricted cases result in releases of about 15% of the assumed standard, an improvement by a factor of more than 1,000.

Figures 20 and 21 contain similar results for bedded salt and non-zeolitized tuff, respectively. In each case, the releases resulting from about the worst

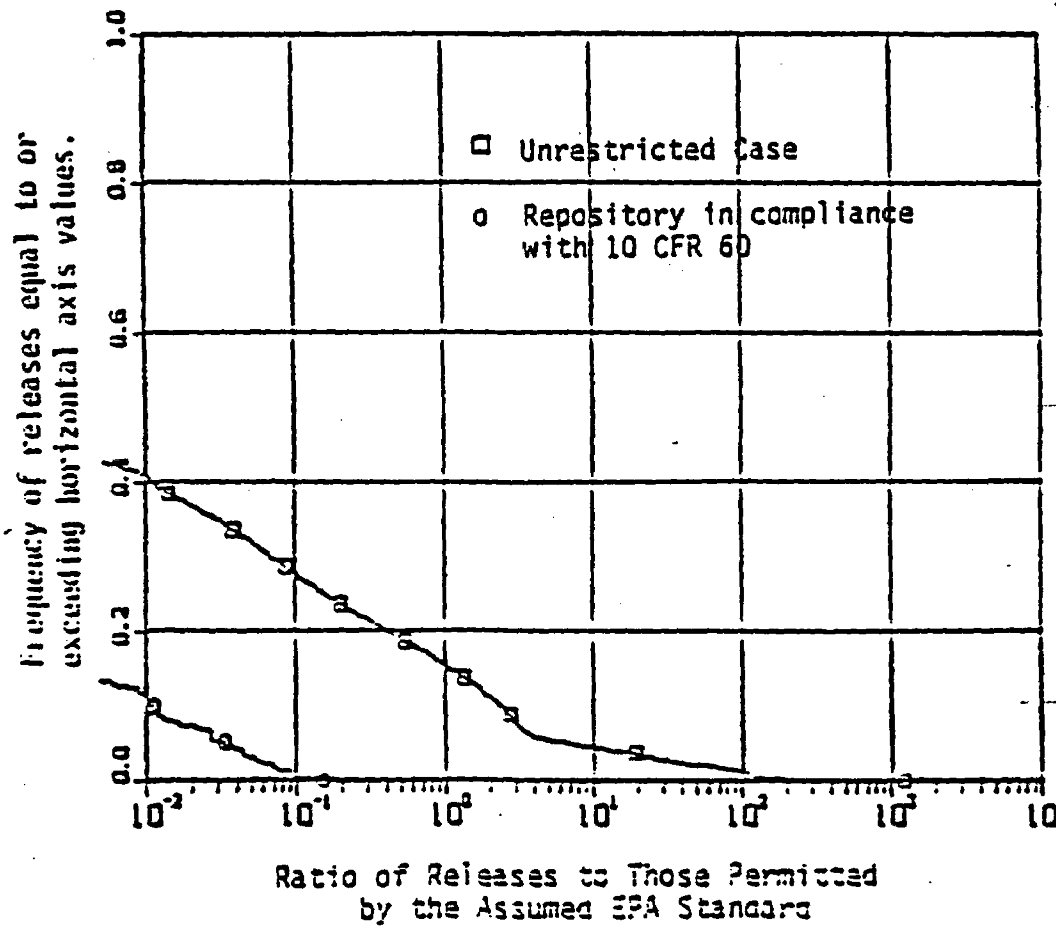

Figure 19. Relationship Between Releases From a Geologic Repository and the Probability of Those Releases for the Routine Release Scenario for Basalt.

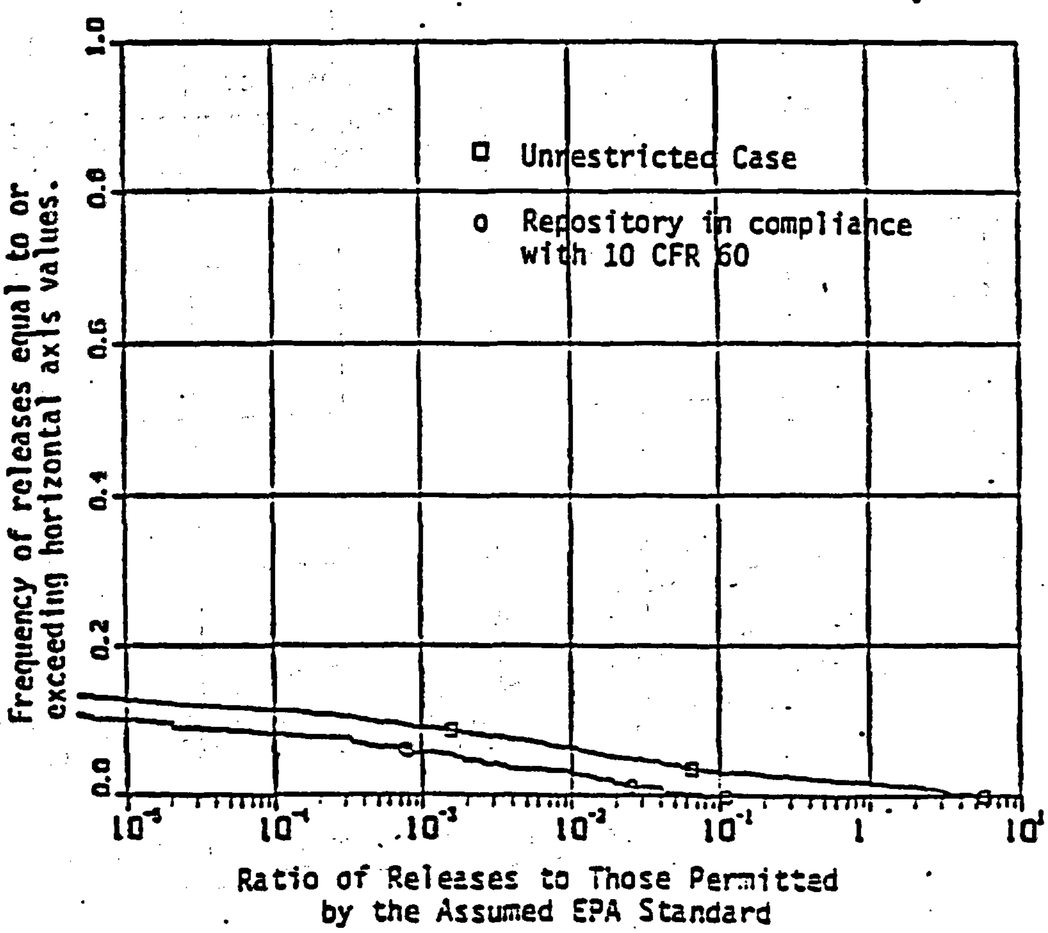

Figure 20. Relationship Between Releases From a Geologic Repository and the Probability of Those Releases for the Routine Release Scenario for Bedded Salt.

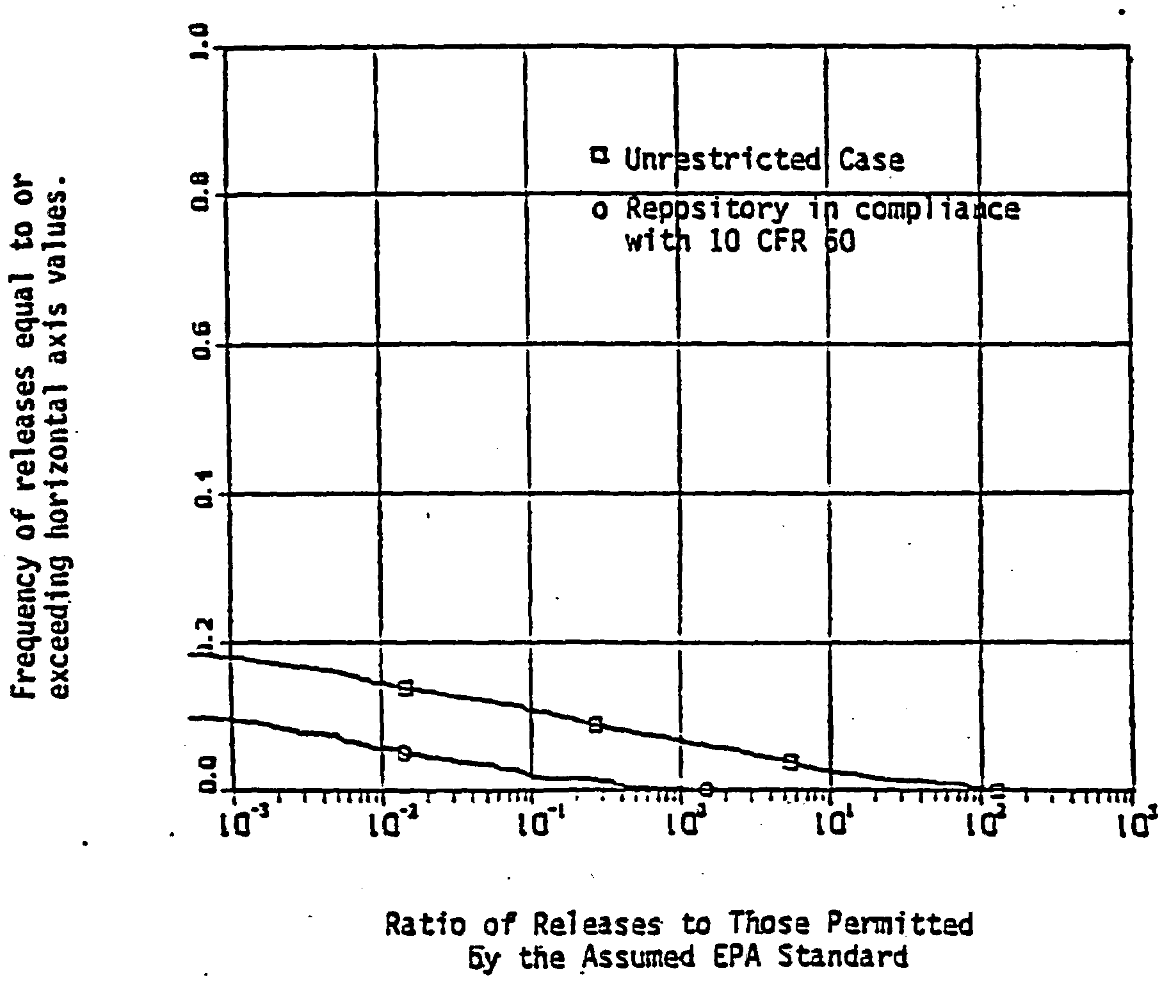

Figure 21. Relationship Between Releases From a Geologic Repository and the Probability of Those Releases for the Routine Release Scenario for Non-Zeolitized Tuff.

1% or 2% of the cases tested are reduced by about a factor of 50 and are brought within the release limits permitted by the assumed standard.

A comparison of Figures 17 and 21, for non-zeolitized tuff, raises the point that in Figure 17, compliance with the release rate and groundwater travel time values still permits about a 90% probability of repository failure to meet the assumed standard, but Figure 21 indicates that similar compliance will result in a near-zero probability of failure. These figures are consistent, because the permeability and hydraulic gradient data for tuff which appear in Table 4 generally result in long groundwater travel times, and the entire range of these data was used to arrive at Figure 21. Thus, for non-zeolitized tuff, the relatively low geochemical retardation of uranium compared to other media, which was discussed in connection with Figure 17, is compensated for by relatively long groundwater travel times. Therefore, in Figure 21, both the unrestricted case and the case in compliance with 10 CFR 60 have sample points with groundwater travel times which generally exceed thousands of years, and therefore result in releases to the accessible environment below the assumed standard.

In summary, for a routine release scenario in basalt, bedded salt, and non-zeolitized tuff, for the variable ranges tested, the consequences associated with various probabilities of releases are reduced by between a factor of 50 and a factor of 1,000 by complying with the performance objectives in 10 CFR 60. The staff considers that these improvements demonstrate that compliance with 10 CFR 60 can substantially increase confidence that the assumed EPA standard will be met.

VIII IMPACT OF NUMERICAL REQUIREMENTS ON UNANTICIPATED EVENTS

In the previous chapter we showed how meeting the controlled release rate of 1 part in 100,000 per year and minimum groundwater travel time of 1000 years to the accessible environment contributed to meeting the assumed

HLW standard. We also discussed how requiring containment of the wastes within the waste package substantially contributed to confidence that the assumed standard would be met. In this chapter we show how the numerical requirements, if met, would limit the consequences of a failure of a portion of the repository system (the natural barriers). We present this chapter by way of illustration only. We have made no estimate of the probability of such events actually occuring. Estimates of the likelihood of a low probability geologic event that could disrupt the repository can only be made on the basis of the geologic record for a particular site, and even then will involve considerable uncertainty. However, we illustrate how the numerical requirements for the individual barriers mitigate the consequences of failure of the natural barriers with respect to the assumed EPA standard as it applies to unanticipated processes and events.

1. FAULTING SCENARIO

There are plausible scenarios in which the geologic barrier is breached. One such scenario assumes a fault through the underground facility, extending through an overlying aquifer. We assume that the fault offers no hydrologic resistance to vertical flow to the overlying aquifer, which carries the contaminant to the accessible environment. However, we assume that the fault does not breach any waste packages and does not influence the release rate from the engineered barrier system.

The code used to evaluate this scenario is the same NWFT/DVM code that was used in the routine release scenario. In this case leg 0 has been modified to simulate the result of the fault described above by assuming infinite permeability and a zero retardation factor. The variable ranges for the fluid parameters are those for basalt shown in Table 4 of Chapter

VII. Figure 22 shows the flow model for this scenario, and Table 3 shows the fixed parameters selected. The time of the occurrence of the fault was a random variable distributed uniformly over the 10,000 years.

Conclusions

Figure 23 shows the fraction of outcomes of the faulting scenario exceeding various multiples of the assumed EPA standard. Results are displayed both for repositories which meet the numerical criteria associated with the engineered barrier system and for repositories whose containment interval and release rates span the ranges for these variables shown in Table 4. The staff has not attempted to establish a standard for releases for this scenario. However, for comparison purposes, it may be seen that for an unrestricted repository, the 20 per cent of the cases whose releases are highest result in releases from about 1,000 to 15,000 times those permitted by the assumed standard. For a repository which complies with 10 CFR 60, the 20 per cent of the cases whose releases are highest result in releases from about 30 to 450 times those permitted by the assumed standard. Clearly, for this scenario, controlling the rate of release of radionuclides to the geologic setting does have the effect of limiting consequences.

2. Borehole Scenario

We have re-examined the human intrusion question in light of the public comment on the proposed technical criteria. We make no assumption with respect to the question of whether small-scale unintentional intrusion may warrant examination at the time of licensing, and, therefore, may be appropriate for inclusion in the safety analysis report to be prepared by DOE as part of a license application. Nevertheless, in this section we

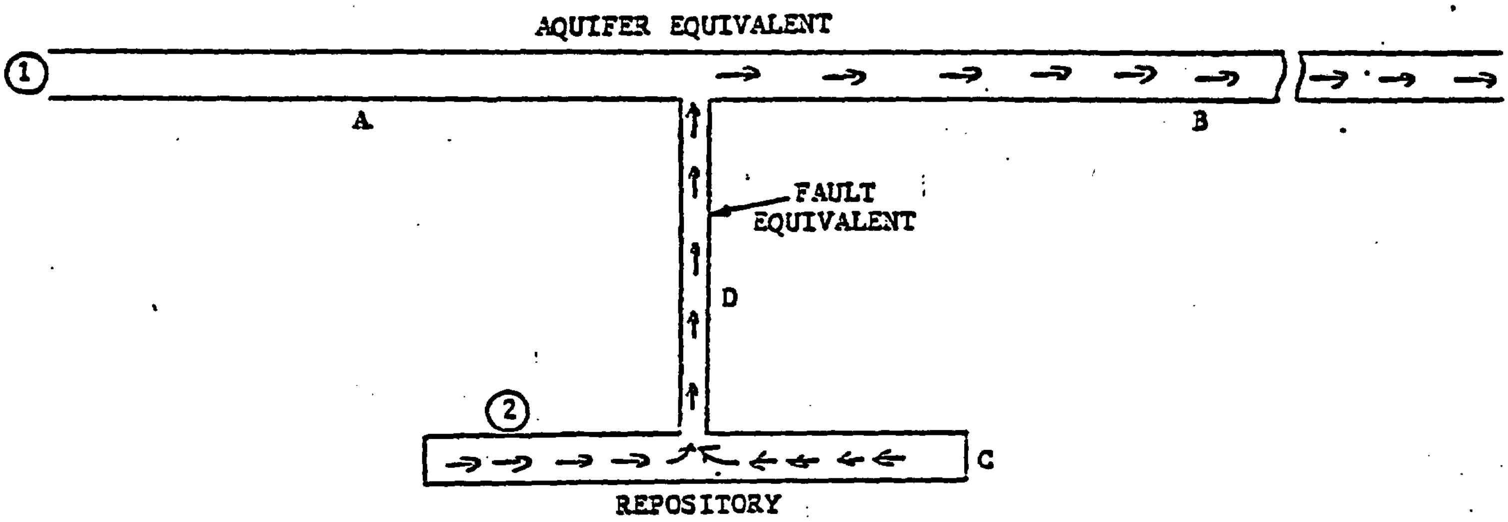

FIGURE 22. FLOW MODEL FOR FAULT SCENARIO

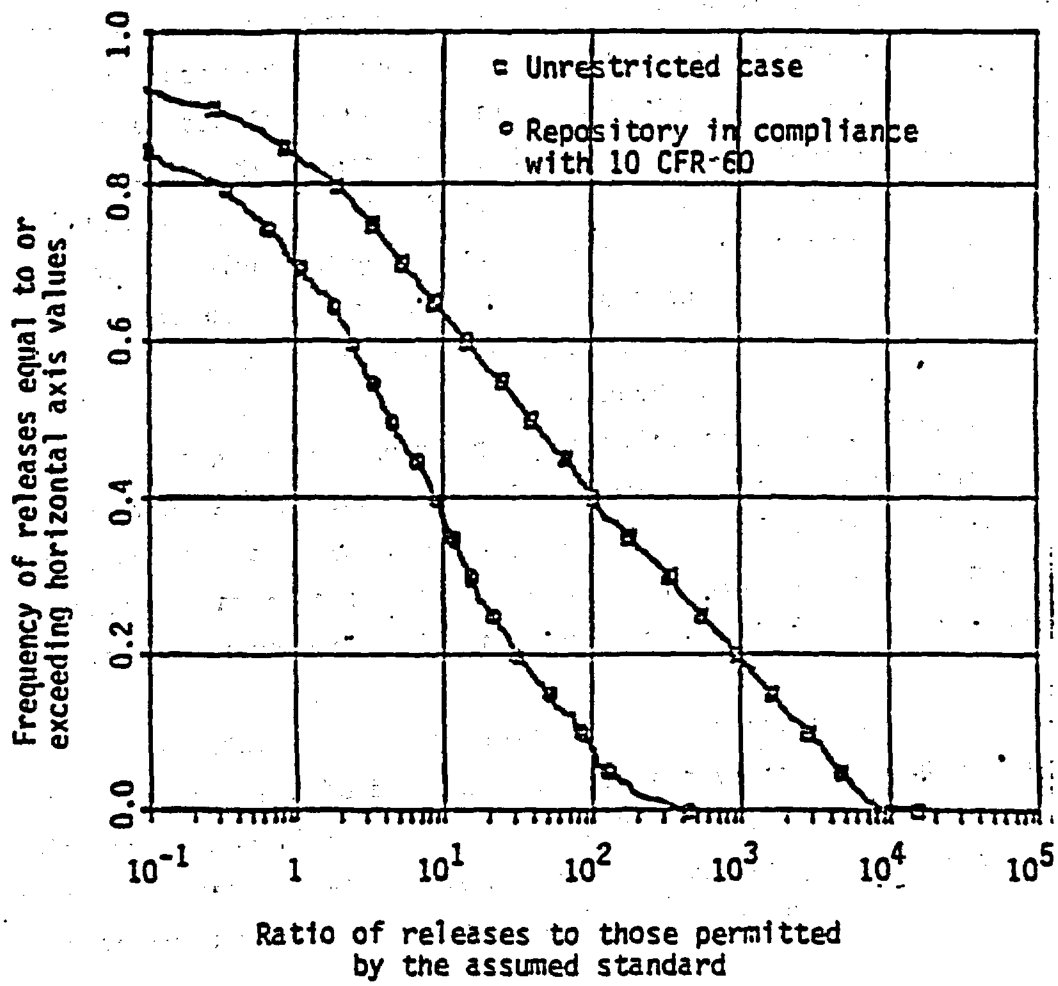

Figure 23. Relationship between releases in the fault scenario and probability of those releases.

examine the consequences of a small scale intrusion scenario which assumes a borehole penetration into the underground facility as an example of such small-scale intrusion, and examine the consequences. The model for this scenario appears in Figure 24. As in the preceeding scenarios, groundwater is presumed to resaturate the repository shortly after closure and to initiate deterioration of the waste packages. The eventual breach of the packages releases radionuclides to the underground facility, and in time, to the geologic setting. The time when the borehole is drilled is distributed uniformly between 100 and 10,000 years after repository closure. Release occurs by the bulk removal of contaminated water during the drilling process. A volume of 200 m^3 (7058 ft^3) of water from the underground facility is assumed to mix with the drilling fluid and to be brought to the surface. (Ref 8-1). The concentrations of radionuclides in the groundwater in the repository determine the quantity of each nuclide brought to the surface (the accessible environment). If a larger quantity of contaminated water were brought to the surface, or if more frequent small-scale intrusions were considered credible, the consequences would be proportionately greater.

Figure 25 illustrates the effect this small-scale intrusion in terms of consequence relative to the assumed standard of Chapter VII. We note that under the assumptions of this scenario, small-scale intrusion of this type is mitigated by the engineered barriers already required to meet the assumed EPA standard as it applies to routine releases.

IX RETRIEVABILITY

In its licensing procedures for disposal of high-level radioactive waste in geologic repositories, the NRC has adopted a step-by-step approach that consists of four principal stages:

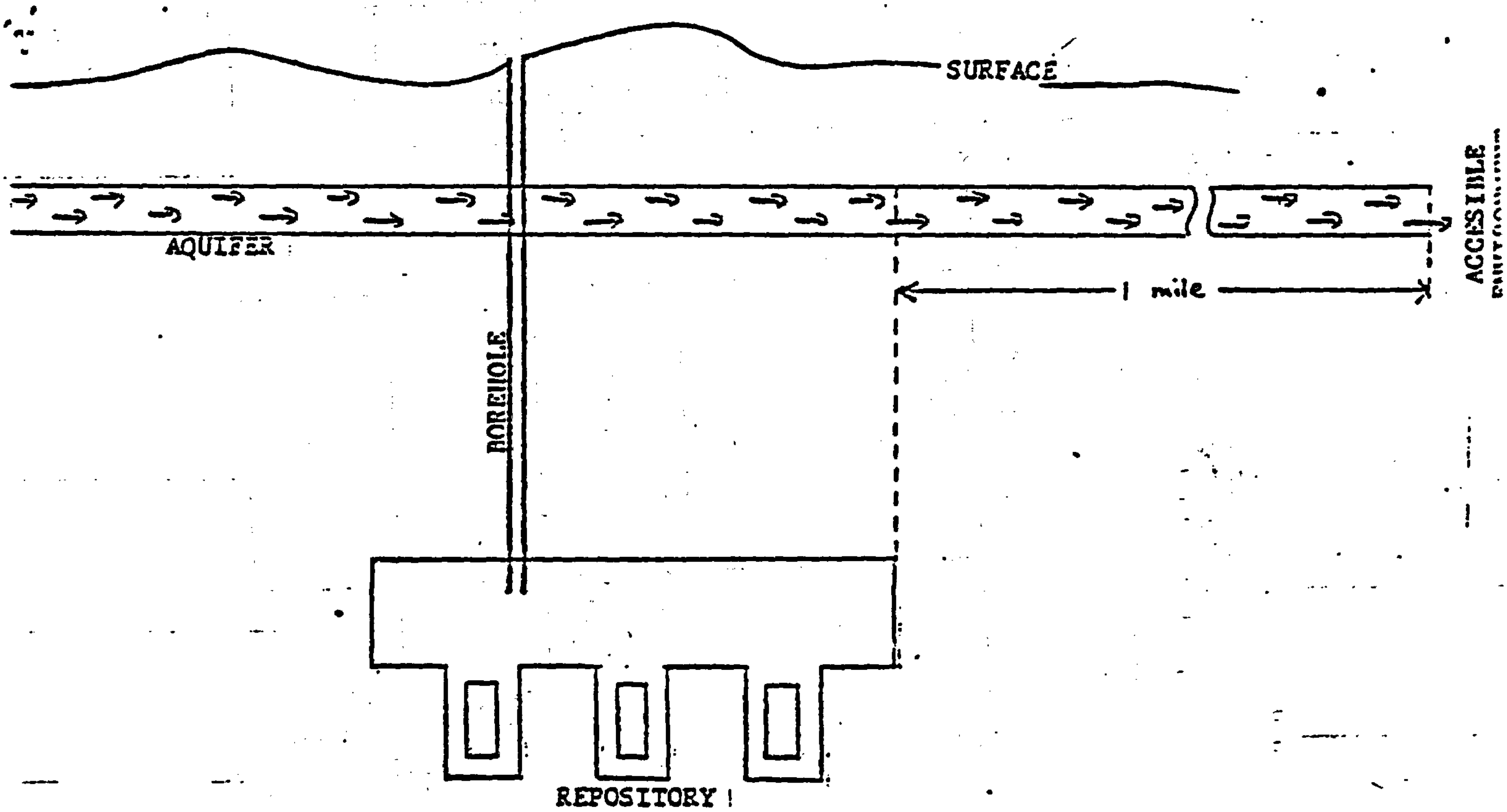

FIGURE 24. MODEL FOR BOREHOLE SCENARIO

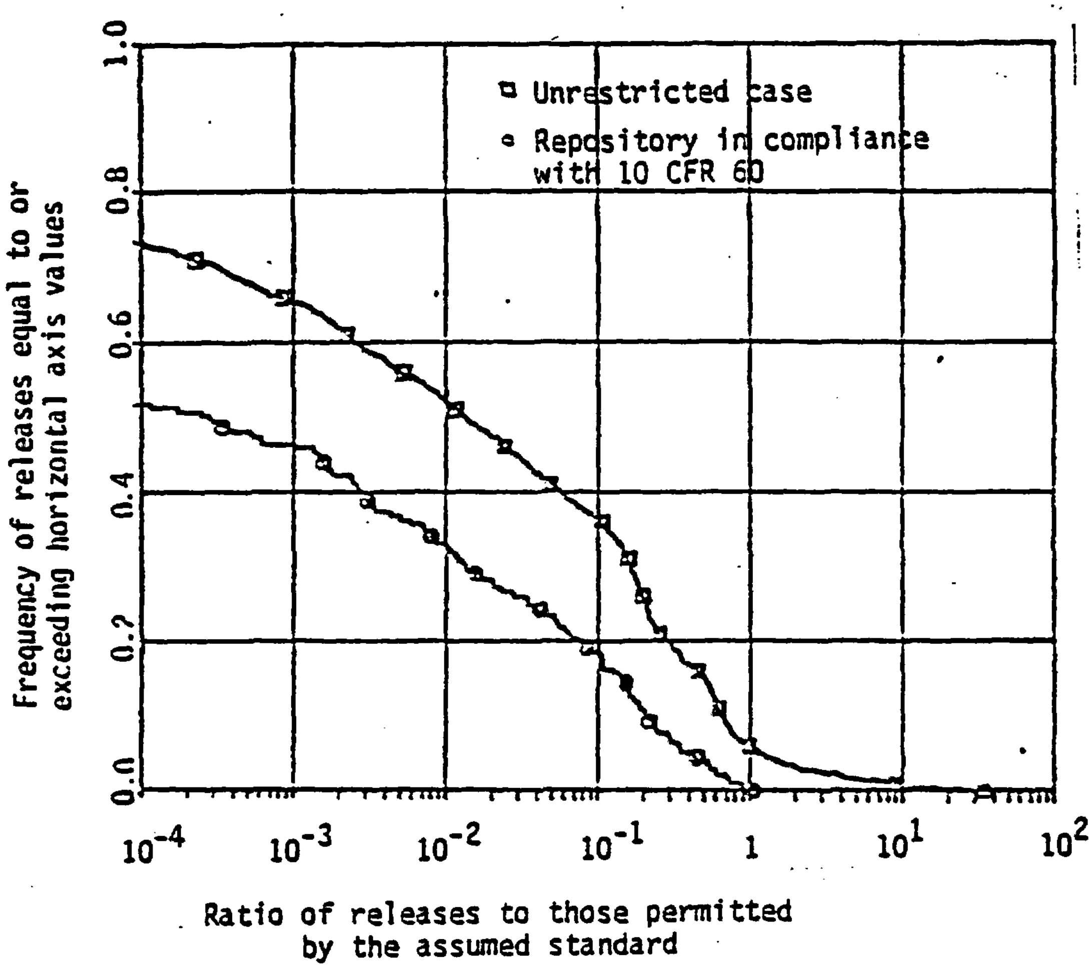

Figure 25. Relationship between releases in the borehole scenario and probability of those releases.

(1) Site characterization, during which detailed studies of alternative candidate sites are conducted before selection of one of the sites for development as a repository.

(2) Construction authorization, during which NRC reviews a license application that contains a detailed design and an analysis of the performance of the repository based on the site specific information obtained during a site characterization.

(3) License to receive wastes, when the application is reviewed again prior to operation. At this time, the repository design and performance assessment are updated in light of new information obtained about the site during construction of the repository.

(4) Permanent closure, at which time an application to terminate operations and seal the repository is submitted. The application will again contain updated analyses of the performance of the repository in light of: (1) information obtained about the site during the operation of the repository; and (2) data collected about the performance of the engineered barrier system to verify that performance can be expected to be within design limits.

At the permanent closure stage, the Commission will determine whether the DOE's performance confirmation program demonstrates that the repository can be expected to work as planned. Here performance confirmation means the program of tests, experiments, and analyses which is conducted to evaluate the accuracy and adequacy of the information used to determine reasonable assurance that the performance objectives for the period after permanent closure can be met. Commission's intent in separating the license application and permanent closure decisions was to be able, following emplacement of the waste, to obtain further information concerning the workability of the repository and to use this information in making its final decision on the acceptability of permanent closure. The retrievability option provides the capability to implement this regulatory approach.

The NRC staff therefore considers that the option to retrieve the wastes must be preserved long enough to complete a program of monitoring and verification of repository performance. The design must also ensure that the option is preserved long enough to permit a decision to permanently close the repository or take any corrective actions shown to be necessary by the verification and monitoring program. Since some of the assumptions and issues that will need to be verified and resolved by the monitoring program may not be identified until the underground facility is excavated, it is not possible to specify prior to construction the complete content of the verification program or how long it will take. We expect the verification program to evolve throughout the operating lifetime of the repository.

On the other hand, important design decisions will need to be made before submitting an application. Some of these design decisions will affect the length of time available to take corrective action or conduct retrieval, if found to be necessary. For example, the thermal loading of the waste in the emplacement areas will affect the temperature of the host rock and the stability of the underground structure. These factors will have a large effect on the ability to retrieve the wastes, since the structure could become too unstable or the rocks too hot to safely recover the wastes. Therefore the staff concluded that a retrievability period must be chosen early in the design process to permit the design to go forward, and a retrievability requirement was included in the proposed technical criteria.

For the licensing procedures to be workable, the staff considers that the option to retrieve should be preserved for the time necessary to emplace all of the wastes, complete a performance confirmation program, arrive at a decision as to whether retrieval must be undertaken, and execute retrieval, if found to be necessary. The design for retrievability should encompass all of these considerations.

Present estimates of the time to be devoted to the operation of the repository are 25 to 30 years (Ref. 9-1, 9-2). Performance confirmation programs have been suggested which require a variety of periods to complete. For example, some proposed hydro-thermomechanical studies (Ref. 9-3) will require 8 years to complete. Alternatively, performance confirmation may require approaching maximum temperatures in the host rock near the waste package. Reaching these temperatures will require up to 10 years for reprocessed high level waste and 20 to 25 years for spent fuel depending on the geologic medium, according to the DOE Final GEIS (Ref. 9-4). For some media and conceptual repository designs more than 25 years may be required according to TM-36 (Ref. 9-5). While the appropriate length of such a program will be site and design specific, the above estimates suggest that a program extending through the period waste is being emplaced is not unreasonable.

Clearly, such a program should be initiated as early in the operational phase as practicable, both to provide guidance during operations and to ensure that completion of the program does not delay closure. However, common sense dictates that the option to modify or to initiate a new phase of a performance confirmation program late in the operational phase should be maintained to be able to respond to variability in the host rock or to technological developments which lead to engineering changes. The capacity to keep the repository open for 10 to 15 years after the operational phase if needed is therefore advisable.

Adding the time needed for the operational phase to the time needed to provide the options discussed above results in a total interval of around 35 to 45 years.

Therefore, we have concluded that the repository should be designed so that the waste could be retrieved on a reasonable schedule starting at any time up to 50 years after waste emplacement is initiated. We consider a reasonable schedule to be one in which the waste could be retrieved in the same overall time that the repository was constructed and wastes were emplaced. We do not intend to preclude a decision to permanently close the repository before 50 years has elapsed, if sufficient data are available to support an earlier decision, and if the people charged with the decision to seal the repository are satisfied. However, we do not want the underground facility design to be such that retrieval would be so expensive or difficult or entail such high occupational exposures that the option is foreclosed and needed corrective actions could not be taken.

As discussed earlier, the staff recognizes that site and design specific factors will strongly influence selection of the design for retrievability. The performance objective has therefore been expressed to permit flexibility to take these factors into account during licensing.

Maintaining the option to retrieve the wastes does not entail keeping the mined areas open, although DOE may choose to do so in some geologic media. A design in which the emplacement rooms are backfilled and sealed, but corridors and shafts are kept open and surface handling facilities are maintained could be acceptable, provided that the rooms could be remined and the wastes removed, if necessary. Remining of the backfill should not be precluded because of high temperatures or because it was needed for structural stability. Trade-offs between keeping rooms open and ventilated, backfilling, and areal heat densities are design options that DOE must consider in meeting this requirement. Both the proposed and final rules do not require that retrieval be essentially the reverse of emplacement. We can foresee no situation where protection of the public health and safety would require the waste to be removed very rapidly.

Rather, we envision that if, as the result of years of data collection and analysis, a decision is made that the site or design is not adequate to isolate the wastes for the long term, corrective actions could be taken. These actions could be performed over a period of years or decades without an imminent health and safety hazard. Therefore, the final rule requires that if a decision to retrieve is made, the design should be such that the inventory of wastes could be removed in about the same number of years in which it was emplaced. We intend for DOE to have considerable flexibility in the design of the repository in meeting these requirements.

A repository designed to permit retrieval of the waste has advantages in addition to the limiting case of preserving a Commission option to order abandonment of the site at as late a stage as permanent closure. From the time waste emplacement starts until permanent closure any of a variety of eventualities may require corrective action. Examples might include repair or replacement of canisters that prove to have manufacturing defects, changes to more effective backfill, or perhaps installation of additional barriers in the exits. Design of the repository for retrievability of the waste assures that it will remain practical to take corrective actions should they become necessary.

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RATIONALE FOR THE PERFORMANCE OBJECTIVES IN 10 CFR PART 60

APPENDIX A - IMPACT OF PROPOSED EPA STANDARD (40 CFR PART 191)

On December 29, 1982, the Environmental Protection Agency published its proposed Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes (Ref. A-1). The proposed standards contain environmental standards for management and storage (Subpart A) and environmental standards for disposal (Subpart B), which are further partitioned into containment, assurance, and procedural requirements. The containment requirements, along with related definitions, are comparable to Draft No. 19 of the Standard, and are the subject of this appendix.

The containment requirements (§191.13) and definitions (§191.12) of the proposed standards differ from Draft No. 19 as follows.

1) The definition of 'Underground Sources of Drinking Water' has been deleted.

2) Defintions of 'Groundwater', 'Lithosphere'. 'Active Institutional Controls' and 'Passive Institutional Controls' have been added.

3) In the definition of 'Performance Assessment' the following sentences have been deleted:

"The [Performance Assessment] analysis should address the uncertainties in the estimates. To provide reasonable confidence in the results, the analysis shall be subjected to peer review by technically competent individuals independent of the organization preparing the assessment."

4) The first paragraph of §191.13 has been deleted. This paragraph read:

"(a) Disposal systems shall be designed to comply with the projected performance requirements of this section [191.13]. These requirements are upper limits. In accordance with Appendix A [Table 2 of the proposed version], the implementing agency should establish design objectives which will reduce releases as far below these limits as reasonably achievable."

5) In the second paragraph in §191.13, reproduced below, the lined-out phrase has been deleted.

"(b) Disposal systems for high-level or transuranic wastes shall be designed to provide a reasonable expectation, based ~~upon quantitative performance assessments~~, that for 10,000 years after disposal:"

6) The definition of accessible environment has been changed so that the distance from the original location of the radioactive wastes to the accessible environment, which was 1 mile in Draft No. 19, is 10 kilometers in the proposed standard.

7) The release limit for technetium-99 which appears in Table A of Draft 19 was increased from 2,000 to 10,000 curies in the corresponding table (Table 2) of the proposed version of the standard.

Only the latter two of the above changes, Items 6 and 7, could have any effect upon the calculations and, hence, the conclusions of the analysis upon which the Rationale document is based. In particular, potentially affected calculations (and conclusions) involve Figures 15-21, 23, and 25 and Table 5 in Chapters VII and VIII. Therefore, these calculations were redone, reflecting these two differences, and results compared with the earlier calculations, as discussed below. For ease in comparison, Figures 15A-21A, 23A, and 25A, based on the proposed standard, are presented side-by-side with the corresponding figures based on Draft No. 19.

Figures 15 and 15-A contrast the results, assuming anticipated processes and events, for a geologic repository in basalt, using Draft No. 19 and the proposed standard as the performance measure, respectively. Comparison of the two figures leads to the conclusion that the differences between the results of Draft No. 19 and proposed standard calculations are negligible and do not change the validity of the conclusion based on the Draft No. 19 calculations. The same result and conclusion obtain for the geologic repository in non-zeolitized tuff, Figures 17 and 17-A.

Figures 16 and 16-A contrast the results, assuming anticipated processes and events, for a bedded salt repository, while Figures 18 and 18-A treat a geologic repository in zeolitized tuff. A change in the repository system is found as a result of the changes in the EPA standard. For example, in both media, for a groundwater travel time of 1,000 years, to achieve a fraction of failures below 0.10, it is necessary to reduce release rates from the underground facility to about 1 part in 100,000 per year if Draft No. 19 is assumed to be the standard, while the same fraction of failures can be achieved with a release rate from the underground facility as high as about 1 part in 40,000 if the proposed version of the standard is assumed, a difference of about 2 - 2½ or less.

Given the two to four order of magnitude range of the variables and results, the staff does not consider that a factor of 2 - 2½ difference constitutes a basis for altering the conclusions in the rationale document.

Figures 19 and 19-A contrast the results, assuming anticipated processes and events, of the relationship between releases and the probability of those releases for a geologic repository in basalt, using Draft No. 19 and proposed standard assumptions, respectively. Comparison of the two figures leads to a conclusion that the differences between Draft No. 19 and proposed standard calculations are negligible for the range of conditions considered in this case and do not change the validity of the conclusion based on the Draft No. 19 calculations. Similar results and conclusions obtain for a geologic repository in bedded salt, Figures 20 and 20-A.

Comparison of the respective figures for non-zeolitized tuff, Figures 21 and 21-A, however, shows a significant difference in performance with respect to the two standards being considered. These differences arise out of the different distances to the accessible environment which are reflected in different lengths of the horizontal leg in the model. In the tuff model, the horizontal leg makes a major contribution to isolation; by increasing its length, the performance of the repository can be significantly improved. The proposed standard establishes a distance to the accessible environment of 10 kilometers, whereas Draft No. 19 set a distance of 1 mile, a difference of about a factor of 6. It is important to note, however, that in both figures, compliance with 10 CFR Part 60 reduces the releases resulting from about the worst 1% or 2% of the cases by a factor of about 50 to 100. Thus the results for non-zeolitized tuff for both Draft No. 19 and the proposed standard demonstrate the contribution of the multi-barrier approach of 10 CFR Part

60 to confidence in meeting an EPA standard.

However, if this kind of result were to occur at a real site, it could support a decision to take advantage of the flexibility provisions in the performance objectives. Since the proposed final version of 10 CFR Part 60 allows DOE to consider 'up to 10 kilometers' to be within the controlled area, the Commission could use such a result as part of a basis for approving some other performance requirements for particular barriers.

Figures 23 and 23-A contrast the results for the fault scenario in basalt for the Draft 19 and proposed versions of the standard. For both the unrestricted case and for a repository in compliance with 10 CFR Part 60, the differences between Draft No. 19 and the proposed standard cause the releases associated with a particular probability of those releases to be reduced by about 10% to 20 %. The relative impact of 10 CFR Part 60 on limiting the consequences of this scenario is not significantly affected.

Figures 25 and 25-A display the consequences of the borehole scenario. Comparison of the two figures again leads to the conclusion that the differences in performance, based on the ranges of parameters considered by the staff, between Draft No. 19 and proposed standard calculations are negligible and do not change the validity of the conclusion based on the Draft No. 19 calculations.

The change to Table 5 is minor and is discussed in a footnote to that table where it appears in the Rationale.

In summary, the staff concludes that the differences which result from the changes to the EPA Standard do not form a basis for altering the conclusions in the Rationale.

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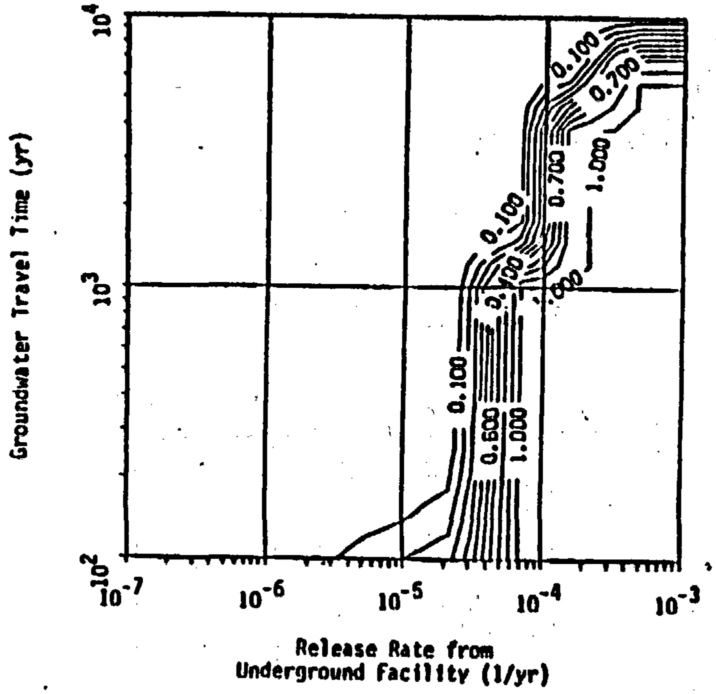
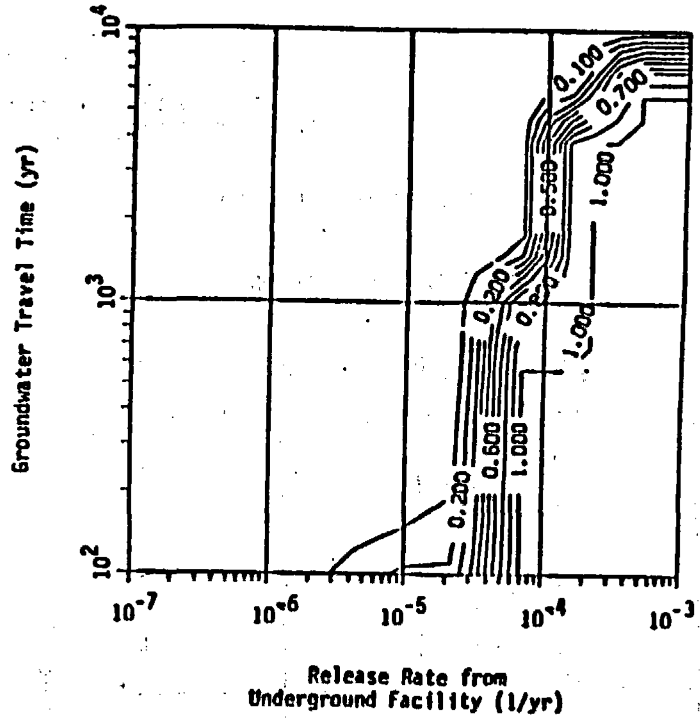
A-1 U. S. Environmental Protection Agency, "Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes," Federal Register 47, 58196, December 29, 1982.

ROUTINE RELEASE
BASALT



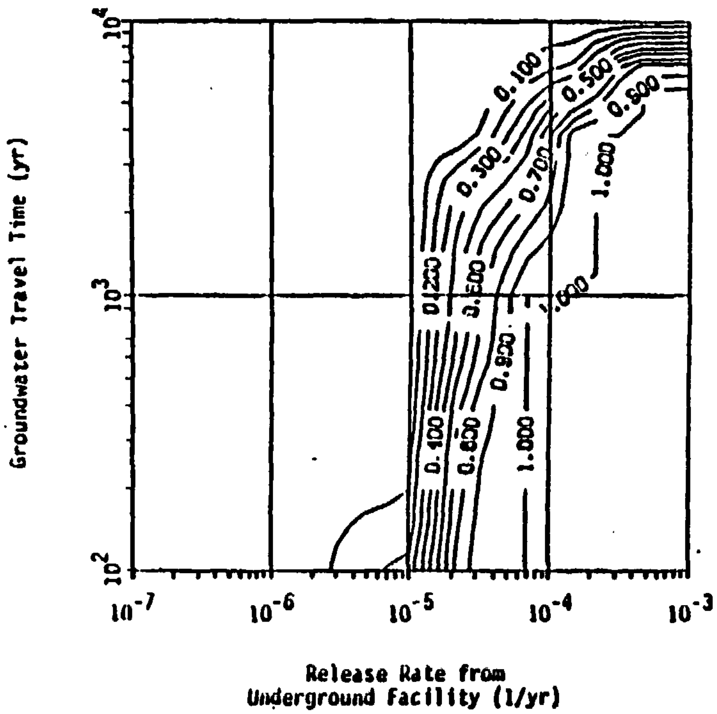
15. Draft 19 Assumed



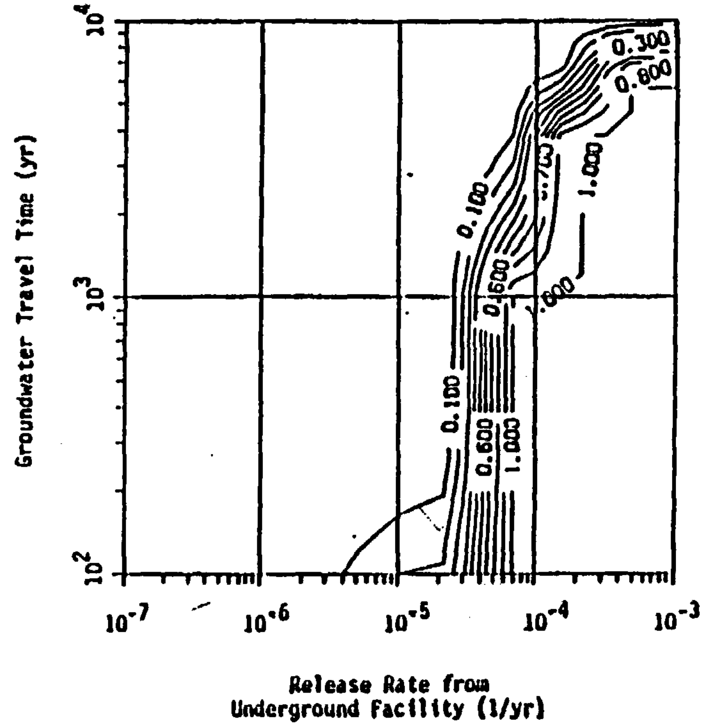
15A. Proposed Version Assumed

Figures 15 and 15A. Contours of constant fraction of cases failing to comply with the assumed standard, as a function of limiting release rate and travel time. Medium is basalt. Figure 15 assumes Draft 19 of the EPA standard; Figure 15A assumes the proposed version.

ROUTINE RELEASE
BEDDED SALT



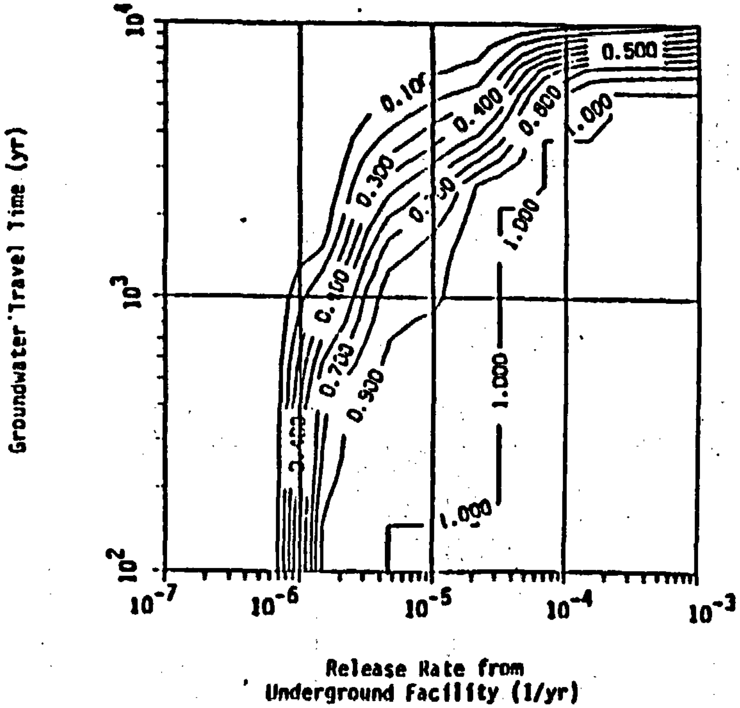
16. Draft 19 Assumed



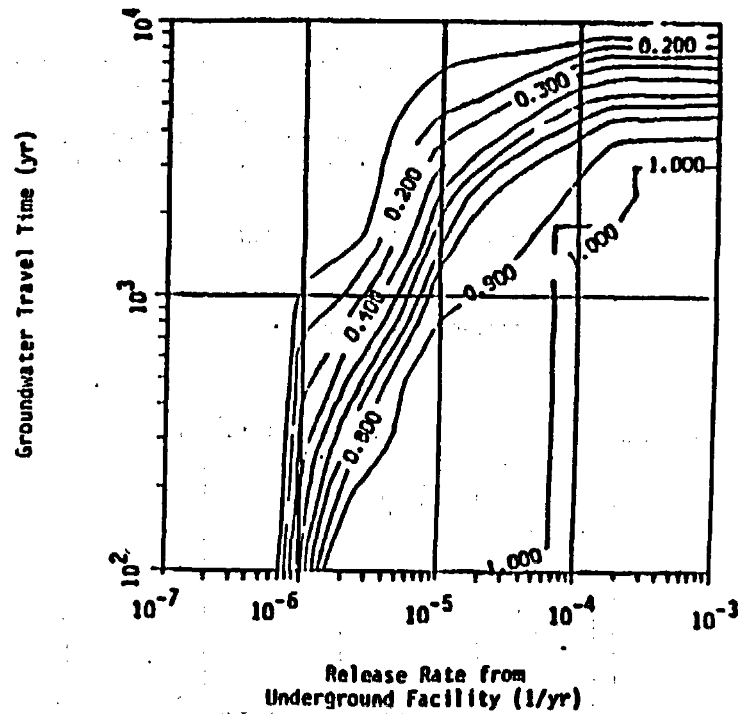
16A. Proposed Version Assumed

Figures 16 and 16A. Contours of constant fraction of cases failing to comply with the assumed standard, as a function of limiting release rate and travel time. Medium is bedded salt. Figure 16 assumes Draft 19 of the EPA standard; Figure 16A assumes the proposed version.

ROUTINE RELEASE
NON-ZEOLITIZED TUFF



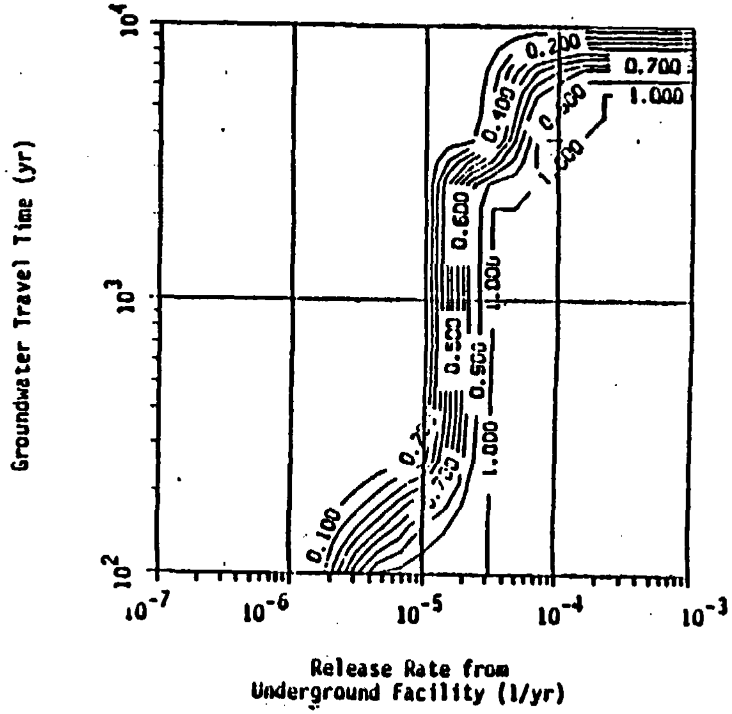
17. Draft 19 Assumed



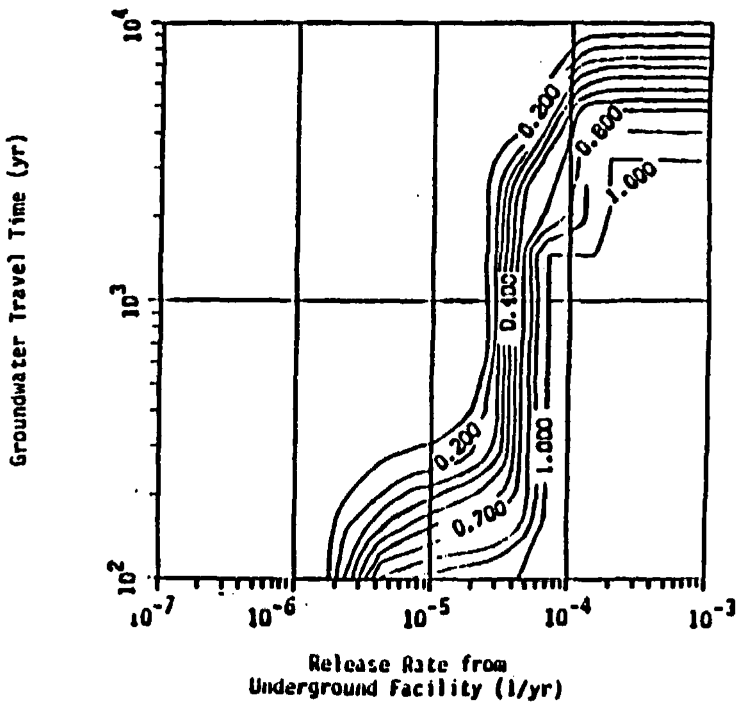
17A. Proposed Version Assumed

Figures 17 and 17A. Contours of constant fraction of cases failing to comply with the assumed standard, as a function of limiting release rate and travel time. Medium is non-zeolitized tuff. Figure 17 assumes Draft 19 of the EPA standard; Figure 17A assumes the proposed version.

ROUTINE RELEASE
ZEOLITIZED TUFF

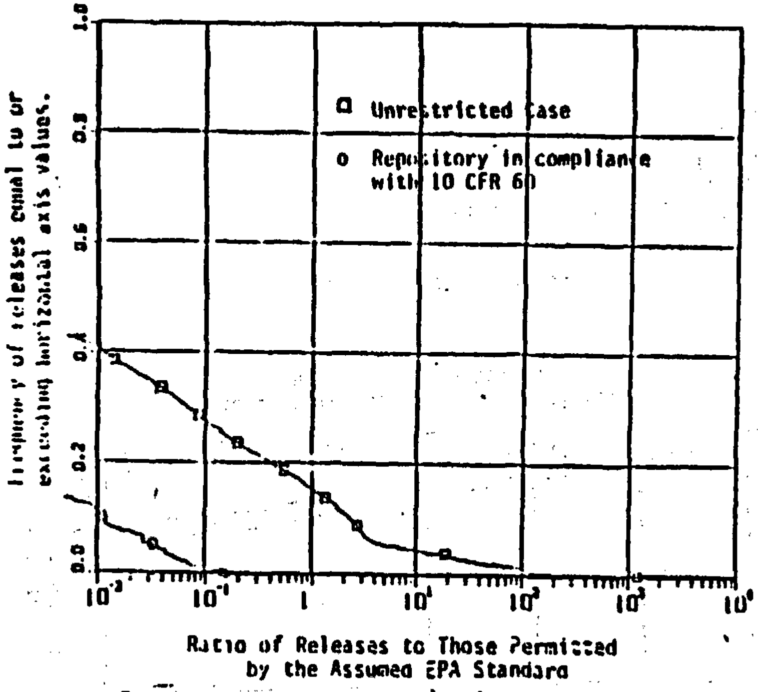


18. Draft 19 Assumed

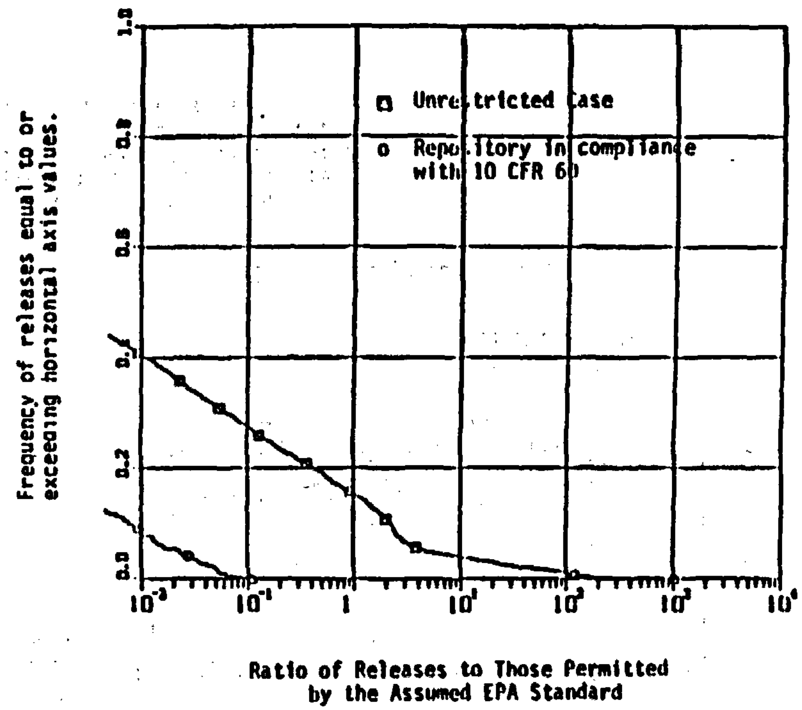


18A. Proposed Version Assumed

Figures 18 and 18A. Contours of constant fraction of cases failing to comply with the assumed standard, as a function of limiting release rate and travel time. Medium is zeolitized tuff. Figure 18 assumes Draft 19 of the EPA standard; Figure 18A assumes the proposed version.

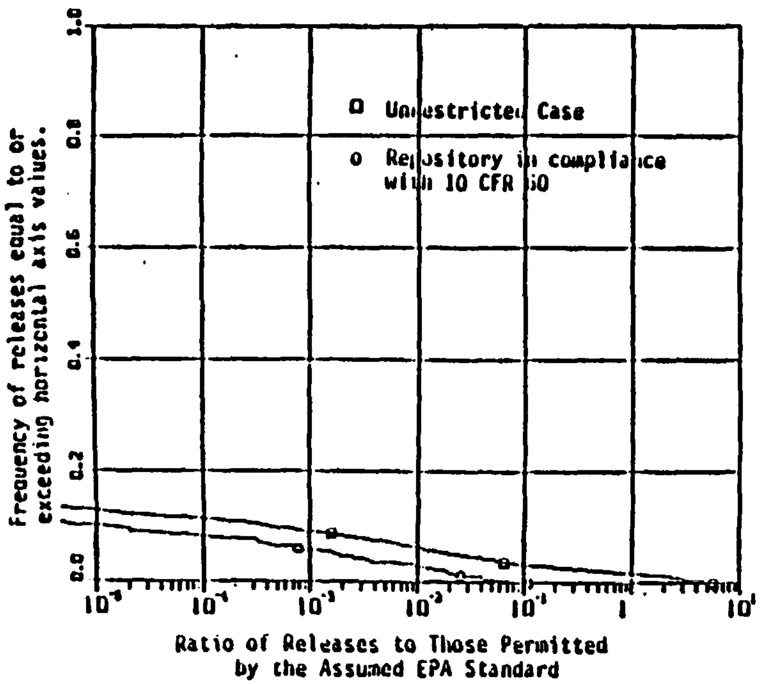


19. Draft 19 Assumed

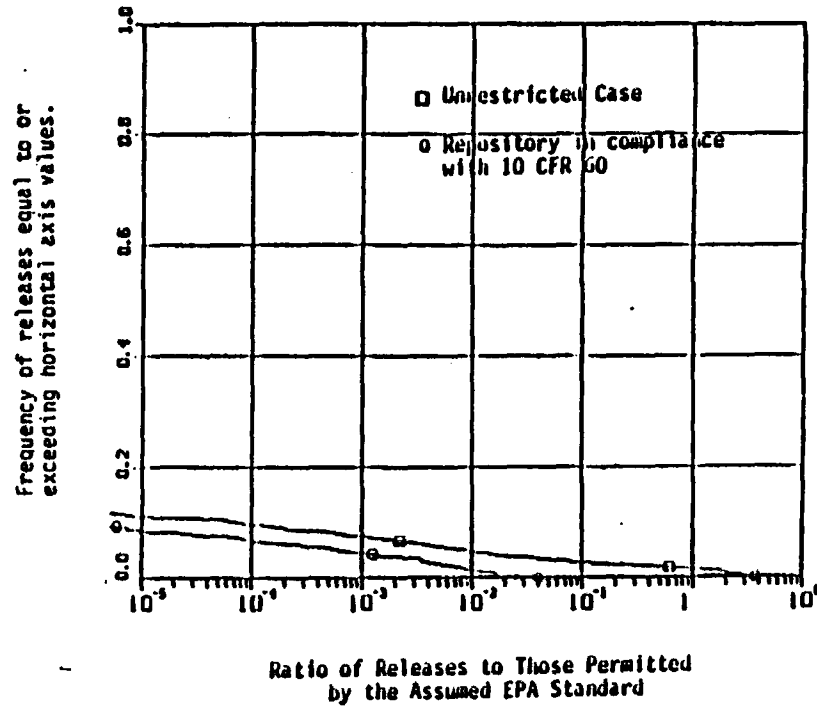


19A. Proposed Version Assumed

Figures 19 and 19A. Relationship between releases from a geologic repository and the probability of those releases for the routine scenario for basalt. Figure 19 assumes Draft 19 of the EPA standard; Figure 19A assumes the proposed version.

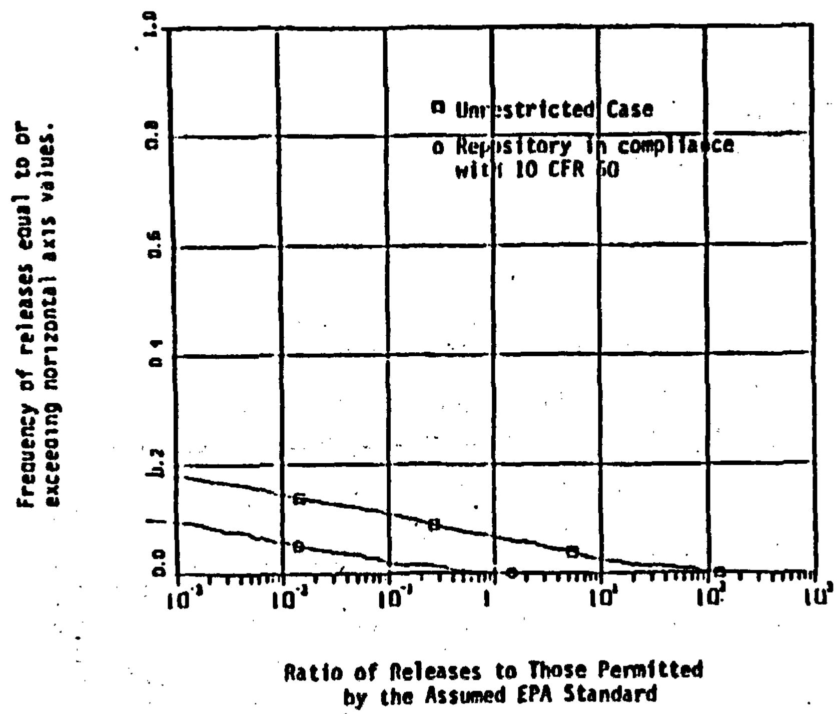


20. Draft 19 Assumed

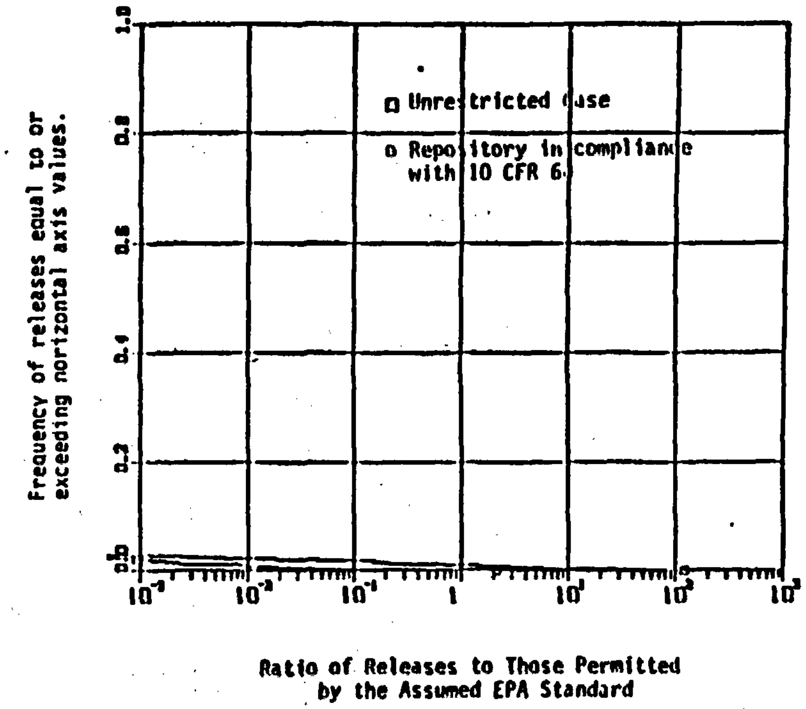


20A. Proposed Version Assumed

Figures 20 and 20A. Relationship between releases from a geologic repository and the probability of those releases for the routine release scenario for bedded salt. Figure 20 assumes Draft 19 of the EPA standard; Figure 20A assumes the proposed version.

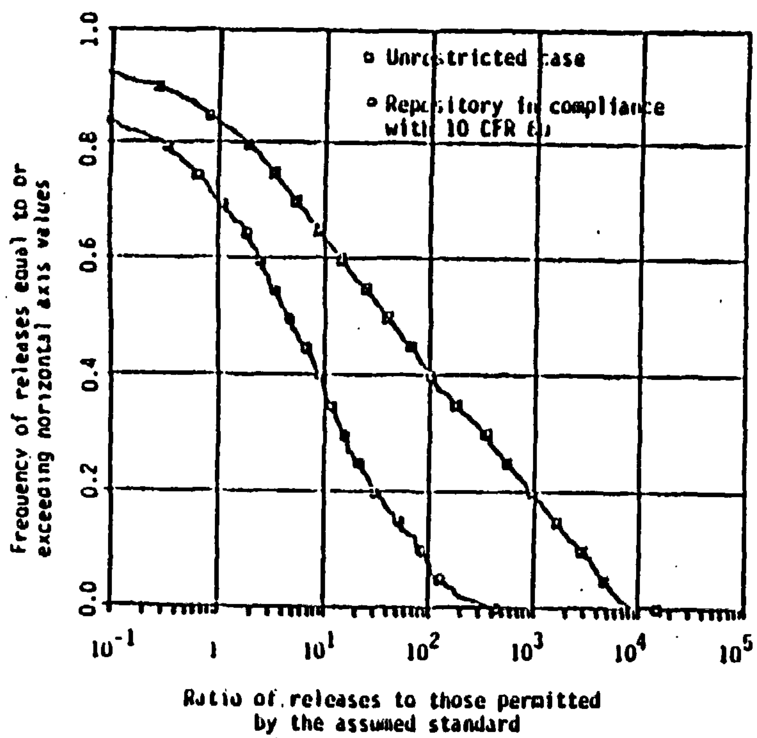


21. Draft 19 Assumed

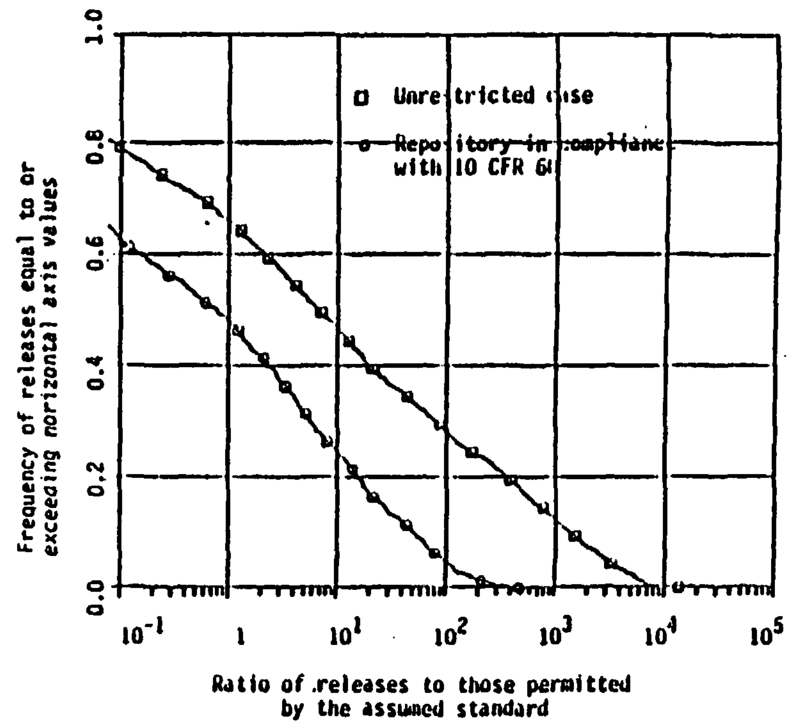


21A. Proposed Version Assumed

Figures 21 and 21A. Relationship between releases from a geologic repository and the probability of those releases for the routine release scenario for non-zeolitized tuff. Figure 21 assumes Draft 19 of the EPA standard; Figure 21A assumes the proposed version.

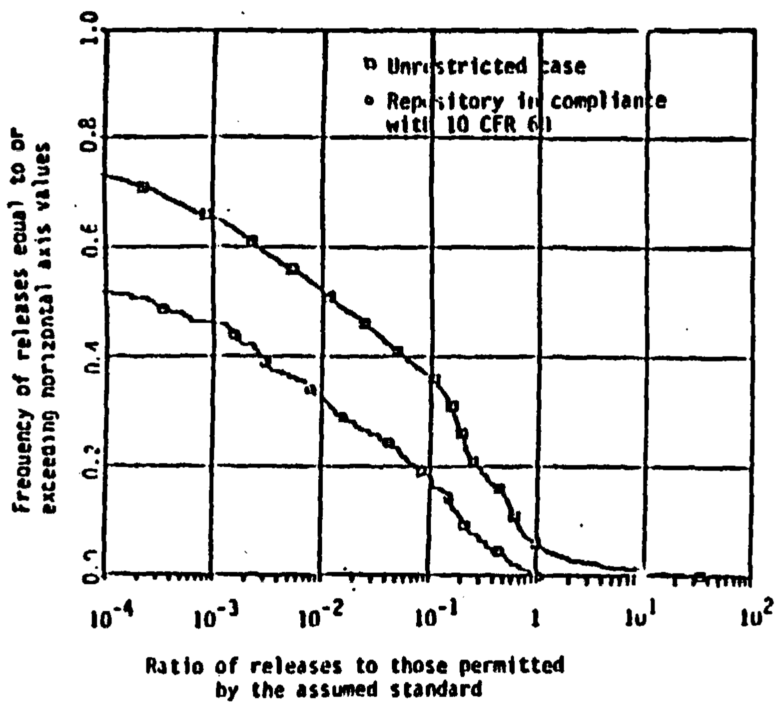


23. Draft 19 Assumed

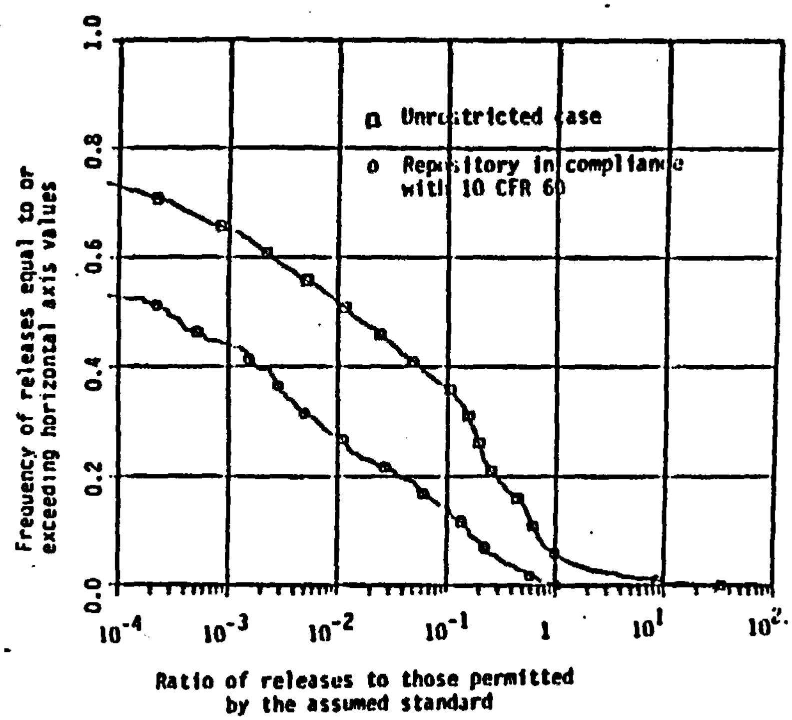


23A. Proposed Version Assumed

Figures 23 and 23A. Relationship between releases in the fault scenario and probability of those releases. Figure 23 assumes Draft 19 of the EPA standard; Figure 23A assumes the proposed version.



25. Draft 19 Assumed



25A. Proposed Version Assumed

Figures 25 and 25A. Relationship between releases in the borehole scenario and probability of those releases. Figure 25 assumes Draft 19 of the EPA standard; Figure 25A assumes the proposed version.

ENCLOSURE H

DRAFT CONGRESSIONAL LETTER

Dear Mr. Chairman:

Enclosed for your information are copies of a notice of final rulemaking to be published in the Federal Register and a public announcement concerning that rulemaking.

The Commission has adopted regulations containing licensing procedures for the disposal of high-level radioactive wastes in geologic repositories to be constructed and operated by the Department of Energy. They were published in final form in the Federal Register on February 25, 1981 (46 Fed. Reg. 13971).

On July 8, 1981 the Commission published for public comment a proposed rule which set forth the technical criteria that the Department of Energy must follow in order to construct and operate a geologic repository for the disposal of high-level radioactive waste (46 Fed. Reg. 35280). The final rule contains a number of changes that reflect concerns addressed in the many comments submitted by the technical community, government agencies and members of the public.

The purpose of the technical criteria is to define more clearly the bases upon which licensing determinations will be made and to provide guidance to the Department of Energy and information for the public with respect to the Commission's policies in this regard. The final rule addresses siting, design and performance of a geologic repository. The rule also contains provisions for design of the waste package, performance confirmation requirements, quality assurance, and training of personnel.

The notice of final rulemaking addresses, as appropriate, certain provisions of the Nuclear Waste Policy Act of 1982, including those dealing with a multiple-barrier approach and retrievability. The Commission regards the present action as constituting full compliance with the statutory requirement that the Commission promulgate technical criteria for geologic repositories not later than January 1, 1984. The Commission also intends to reexamine its licensing procedures in light of the Nuclear Waste Policy Act so as to ensure that the Commission's regulation is consistent with current law. Any proposed changes will be forwarded to you in a timely manner.

Sincerely,

Robert B. Minogue, Director
Office of Nuclear Regulatory Research

Enclosures:
1. Notice of Final Rule
2. Public Announcement

ENCLOSURE I

NRC ISSUES TECHNICAL CRITERIA FOR REGULATING
GEOLOGIC DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTES

The Nuclear Regulatory Commission is amending its regulations to specify technical criteria for the disposal of high-level radoactive wastes in geologic repositories.

The technical criteria, which are contained in an amendment to Part 60 of the Commission's regulations, will be used to review any application from the Department of Energy for a license to receive and dispose of high-level waste at a geologic repository. The criteria will apply to all actions taken by the Commission with respect to the license application, including authorization for construction, operation and closure.

The rule sets forth requirements for the siting, design and performance of the geologic repository and for the design and performance of the waste package. Also included are criteria for performance confirmation, quality assurance and personnel training and certification.

Because of the uncertainties associated with predicting the behavior of a geologic repository over the thousands of years during which high-level waste may present hazards to public health and safety, the Commission is requiring that the repository use a multiple-barrier approach. An engineered barrier system will be required to compensate for uncertainties in predicting the performance of the geologic setting, especially during the initial period of high radioactivity. Similarly, because performance of the engineered system is also subject to considerable uncertainty, the geologic setting will have to be able to contribute significantly to isolation.

The overall system performance objective is that the geologic setting, the engineered barrier system, and the shafts, boreholes and their seals should be selected and designed so as to ensure that releases of radioactive materials to the accessible environment following permanent closure will conform to such generally applicable environmental standards for radioactivity as may be established by the Environmental Protection Agency.

Specifically, the regulation requires that the engineered barrier system under anticipated conditions, be designed so that:

(1) Wastes will be contained within the waste packages for a period to be determined by the Commission, but normally ranging from 300 to 1000 years after permanent closure of the geologic repository.

(2) The release rate of any radioactive material from the engineered barrier system following the containment period will not exceed one part in 100,000 per year of the inventory of that radioactive material calculated to be present 1,000 years following permanent closure, or such other fraction of the inventory as may be approved or specified by the Commission.

The geologic setting chosen must be one where pre-waste-emplacement groundwater travel time along the fastest path of likely radioactive material travel from the disturbed zone to the accessible environment, as defined in the rule, will be at least 1,000 years or such other time as may be approved by the Commission.

Wastes placed in the repository are to be retrievable for a period sufficient to allow for confirmation of repository performance.

A proposed rule on this subject was published in the Federal Register for public comment on July 8, 1981. Changes made as a result of the comments received and further details on the final rule, which is effective __________, are contained in a Federal Register notice published on ____________.

Procedural requirements for reviewing any application from DOE for a license for a geologic repository were published in the Federal Register on February 25, 1981.

ENCLOSURE J

VALUE IMPACT STATEMENT ON 10 CFR 60--DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTES IN GEOLOGIC REPOSITORIES: TECHNICAL CRITERIA

On July 8, 1981 the proposed rule, 10 CFR Part 60 was published for public comment in the Federal Register accompanied by notification that the Preliminary Value/Impact Analysis for the proposed rule was also available and open for public comment.

In summary, the preliminary analysis concluded that "in regard to the disposal of high-level radioactive waste in subsurface excavated areas, the NRC should provide guidance to DOE through regulations which establish performance objectives and associated technical criteria. The method of meeting the performance objectives and criteria should be contained in regulatory guides and staff position papers. The development of guidance should be done by NRC with external technical assistance as needed. The guidance should contain both performance objectives to clearly state what is expected of a geologic repository, and to the extent needed, prescriptive requirements to constrain and direct design and siting such that the health and safety findings necessary for licensing can be made with confidence."

The public comment period resulted in a total of 92 comments on the proposed rule. No significant comments were received on the Preliminary Value/Impact Analysis. As a result, the basic findings of the Preliminary Value/Impact Analysis have not changed and are applicable, as written, to the final version of 10 CFR Part 60.

It should be noted additionally, that under the Nuclear Waste Policy Act of 1982, the Commission is required to publish technical criteria no later than January 1, 1984.

ENCLOSURE K

AMERICAN NUCLEAR SOCIETY
555 North Kensington Avenue, LaGrange Park, Illinois 60525 USA
Telephone: (312) 352-6611 • Telecopier: (312) 352-0499 • Telex: 254635

January 24, 1983

Honorable Nunzio J. Palladino
Chairman
U. S. Nuclear Regulatory Commission
Washington, D. C.20555

Dear Chairman Palladino:

The American Nuclear Society has reviewed the proposed technical rule of 10CFR Part 60 and its Rationale Document (July 30, 1982) as prepared by the Commission staff. The attached paper reports the review and the Society's Statement of Position.

After review of the proposed technical rule, 10CFR Part 60, and its Rationale Document (July 30, 1982), the American Nuclear Society concludes that the numerical standards on the performance of a nuclear waste repository proposed by the Nuclear Regulatory Commission (NRC) in sections 113 (a)(1)(ii)(A), 113 (A)(1)(ii)(B) and 113 (a)(2) of 10CFR Part 60 are technically indefensible, are premature in advance of the Environmental Prtection Agency's (EPA's) generally applicable standards for releases of radioactivity from a repository, are inappropriate in their generic application to any and all prospective geologic media and sites, and are structured in such a way as to add to the overall cost of waste disposal without achieving any degree of relative benefit to public health and safety.

It is the position of the Society that nuclear wastes must be managed and disposed of in a manner that preserves the public well being, including public health and safety as well as financial burden. Further, the Society is of the concerted view that all regulatory and developmental activities pursuant to a nuclear waste repository must be technically, legally and procedurally comprehensive and defensible, in order to assure protection of the public well being and to secure the confidence of the public that their well being is indeed protected.

The Society would be pleased to pursue our findings and their rationale with the Commission and staff.

Very sincerely,

L. Manning Muntzing, President

LMM:evm
Enclosures

cc: Commissioner John F. Ahearne
Commissioner James K. Asselstine
Commissioner Victor Gilinsky
Commissioner Thomas M. Roberts
Mr. William J. Dircks

REVIEW

AND

STATEMENT OF POSITION

OF THE

AMERICAN NUCLEAR SOCIETY

ON THE

PROPOSED TECHNICAL RULE

10CFR PART 60

AND

RATIONALE DOCUMENT

(JULY 30, 1982)

OF THE

NUCLEAR REGULATORY COMMISSION

January 1983

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REVIEW AND STATEMENT OF POSITION OF THE AMERICAN NUCLEAR SOCIETY ON THE PROPOSED TECHNICAL RULE 10CFR PART 60 AND RATIONALE DOCUMENT (July 30, 1982) OF THE NUCLEAR REGULATORY COMMISSION

The American Nuclear Society has reviewed the proposed technical rule of 10CFR Part 60 and its Rationale Document (July 30, 1982) as prepared by the Commission staff. This document reports the review and the Society's Statement of Position.

I. SUMMARY

After review of the proposed technical rule, 10CFR Part 60, and its Rationale Document (July 30, 1982), the American Nuclear Society concludes that the numerical standards on the performance of a nuclear waste repository proposed by the Nuclear Regulatory Commission (NRC) in sections 113 (a)(1)(ii)(A), 113 (a)(1)(ii)(B) and 113 (a)(2) of 10CFR Part 60 are technically indefensible, are premature in advance of the Environmental Protection Agency's (EPA's) generally applicable standards for releases of radioactivity from a repository, are inappropriate in their application to any and all geologic media and sites, and are structured in such a way as to add to the overall cost of waste disposal without achieving any degree of benefit to public health and safety. It is the position of the Society that nuclear wastes must be managed and disposed of in a manner that preserves the public well being, including public health and safety as well as financial burden. Further, the Society is of the concerted view that all regulatory and developmental activities pursuant to a nuclear waste repository must be technically, legally and procedurally comprehensive and defensible, in order to assure protection of the public well being and to secure the confidence of the public that their well being is indeed protected.

II. INTRODUCTION

The American Nuclear Society has undertaken a review of the NRC proposed technical rules and Rationale Document for the technical criteria of a geologic, high-level radioactive waste repository, and has formed a statement of position. This review was undertaken to determine the technical propriety and defensibility of the proposed rules.

The review of the numerical requirements of the proposed rule examines the rationale of the NRC staff in proposing each numerical value, the defensibility of the staff's conclusions, and the implications of the proposed rule. The review is based upon the July 2, 1982 draft of the rule, and the June 30, 1982 rationale document authored by the staff, which were made public by NRC on July 29, 1982 at an NRC public briefing held in Germantown, MD. The review focuses upon three numerical requirements contained in Section 113 of 10CFR Part 60. The evaluations in this review were based on three criteria:

(1) The adequacy with which the public's health and safety were protected by the proposed technical rule numerical requirements.

(2) The reasonableness of the cost/benefit to meet these requirements.

(3) The quality of the technical basis of the requirements.

The chronology of key events leading to the completion of this review is listed below.

- December 6, 1979 - NRC publishes draft procedural rules of 10CFR Part 60 for public comment.
- February 25, 1981 - NRC publishes final procedural rules of 10CFR Part 60.
- July 8, 1981 - NRC published draft technical rules of 10CFR Part 60.
- October 14, 1981 - ANS transmits written comments to NRC on draft technical rules (see Appendix A).
- July 29 1982 - NRC staff makes public its proposed final technical rule with technical Rationale Document.
- September 10, 1982 - Representatives of ANS meet with NRC staff to express ANS initial technical assessment of proposed final technical rule and its technical Rationale Document.
- October 5, 1982 - ANS transmits to NRC letter comments on proposed technical rule and Rationale Document (see Appendix B).
- January, 1983 - ANS completes its technical review and statement of position on the proposed final technical rule.

III. REVIEW CONCLUSIONS AND RATIONALE

It is the conclusion of the ANS review of the proposed final technical rule of 10CFR Part 60 that the three numerical standards specified in Sections 113 (a)(1)(ii)(A), 113 (a)(1)(ii)(B) and 113 (a)(2) are: (1) technically indefensible, (2) premature in advance of EPA's generally applicable standards for releases of radioactivity from a repository, (3) inappropriate in their application to any and all geologic media and sites, (4) structured in such a way as to potentially constrain the ability to design and fabricate or construct waste packages and repositories that have a realistic cost/benefit to public health and safety. The three above-referenced sections of 10CFR Part 60 specifies (1) the minimum waste package life, (2) the acceptable rate of release of radionuclides from the engineered system, and (3) the minimum groundwater travel time at the repository site. Specific review comments on these three sections in the proposed technical rule are presented in the discussion that follows.

The American Nuclear Society concludes that the numerical subsystem performance objectives are technically indefensible. The Society believes that all regulatory and developmental activities associated with nuclear power and nuclear waste repositories must be founded on a basis that will withstand the strictest technical review. In the case of the three numerical subsystem performance objectives, the Society believes that technically defensible objectives for overall repository performance must be established and then numerical design criteria calculated from these objectives. The NRC acknowledges that its reponsibility is to implement the generally applicable environmental standards established by EPA. This acknowledgement is made by the NRC in the Federal Register on February 25, 1981, and reiterated in the NRC staff's 10CFR Part 60 Rationale Document of June 30, 1982. Indeed, in the staff discussion accompanying the Rationale Document (Enclosure A, Page 5), recognition is given to the "extensive" criticism to the approach of establishing numerical subsystem performance objectives in the NRC's proposed technical rule:

> While the usefulness of multiple barriers was recognized, the establishment of fixed numerical values for performance was extensively criticized. The criticism took two forms. First, numerous commenters argued that until such time as an EPA standard is established, no logical connection can be demonstrated between the performance of the particular standard. The second criticism was that the performance appropriate to a particular barrier is greatly dependent upon design features and site characteristics and that values such as those proposed by the Commission could unduly restrict the applicant's flexibility - possibly imposing great additional expense without compensating protection of public health and safety.

However, review of the NRC's rationale for the three numerical standards reveals that the NRC standards are neither derived from nor assure compliance with the draft EPA standards. The NRC staff position implicitly acknowledges this finding when it states (Rationale Document, page 48),

> ...we [the NRC staff] consider numerical requirements for containment, controlled release, and groundwater flow time which, if met, will contribute to meeting it" [the EPA standard, draft 19 of proposed 40CFR Part 191]. (emphasis added)

The Society's review has also found that the NRC staff has not based its numerical subsystem performance objective on any overall performance requirement for a repository. Further, the rationale for all three standards are subjectively based upon reasoning that could lead to many alternate conclusions, other than those arrived at by the NRC staff. For example, based on the reasoning used by the Commission staff, a waste package lifetime range of 100 to 10,000 years might be specified with equal defensibility as the 1000-year requirement.

The second conclusion of the review is that the NRC's proposed numerical requirements are premature in advance of the EPA standards. As presented above, the NRC acknowledges its responsibility to implement the standards established by EPA. That responsibility was established through the President's Reorganization Plan No. 3 of 1970, and is reaffirmed in the Nuclear Waste Policy Act of 1982. The NRC staff acknowledges some consideration of EPA draft 19 of 40CFR Part 191 in developing its numerical requirements. However, at the time the NRC staff made public its rationale report, the EPA had issued two additional drafts (at least for internal review) which were different from draft 19, which NRC considered. Further, the EPA on December 29, 1982, published for comment its draft 40CFR Part 191 which has standards that are yet different from any considered by NRC. It should be noted that draft 19 of 40CFR Part 191 differs significantly from the December 29, 1982 version, and raises the question of technical compatability between NRC staff rationale for 10CFR Part 60 with the latest version of 40CFR Part 191. Also, Congress has directed the NRC to assure that its regulations are consistent with and implement EPA's standards. Such consistency cannot be attained by NRC if it develops its regulations while the EPA standard is open for public comment. Thus, it is clearly premature for NRC to promulgate the three numerical requirements at this time.

The third review conclusion of the Society is that it is inappropriate to develop and apply regulations on repository subsystem performance that do not reflect inherent differences in geologic media and sites under consideration. The three leading prospects for the first repository are the basalt site at Hanford, the tuff site at the Nevada Test Site, and a site in salt in either Utah, Texas, Louisiana or Mississippi. Each site will be selected so as to protect man's environment by preventing any significantly radionuclide contaminated groundwater contacting humans in concentrations which are hazardous to their health. However, each site is hydrologically very unique in comparison to others. The basalt site is fractured and saturated. Within a very few years after closure, waste packages may be immersed in water as the repository resaturates. Radiologic protection will be provided by low radionuclide solubility in groundwaters large mass transfer resistances outside the waste form, long travel times to man's environment, and sorption provided by the natural geochemistry of the site. In selected salt formations, water is virtually precluded from flowing through the repository because after closure large masses of salt would have to be dissolved before external water could come into contact with the waste. The waste form characteristics and the sorption provided in the natural surroundings provides isolation from man's environment. The tuff repository site will likely be in the unsaturated zone of Yucca Mountain. In order for a release to man's environment to occur, rain water would be required to flow downward to the waste form, flow further downward to the water table, and be transported to man's environment. Again, the same type of retarding mechanisms discussed above will add protection to this system. In another medium, granite, it is possible that in some fractures, very small quantities of water could move quickly over long distances. However, the quantities of flow can be exceedingly small. Any releases would be inhibited by mechanisms such as sorption, corrosion resistance and solubility. Thus, while the principal of isolation is constant, and while each medium and site can be required to achieve a common, acceptable level of performance in terms of human radiation dose, the strengths of certain designs, site specifications and rock types are lost if general numerical subsystem requirements are applied to the subsystems or all rock types and sites in a generic manner.

In spite of the fact that U.S. high-level waste management and geologic disposal program is examining a number of geologic media, the Nation is only likely to have two or three repositories for the foreseeable future. Therefore, the selected sites will have specific individual charateristics and repository design problems will have a variety of engineering methods that can be applied which should be stressed for cost/benefit in protecting public health and safety, rather than some preselected generic numerical value, as in the proposed rule.

The final conclusion of the Society's review is that the three numerical requirements are structured in such a way as to potentially limit the ability to engineer a repository that protects the public health and safety at a rational and acceptable cost for the realized benefits. The review has found that implementation of the regulations may require large expenditures because of the generic application of groundwater travel time, as well as because of imprecisions in the language applying that numerical subsystem performance requirement. Further, the review has found that large expenditures in engineering and construction may be required because of performance requirements on the engineered system.[1] Indeed, overall cost optimization would be essentially impossible with generic numerical requirements specified for the component performances. The Society is not convinced, nor does the NRC staff provide support that the requirements which may be exceedingly costly to implement are necessary to preserve the public health and safety, nor that the requirements necessarily even substantially contribute to improved public health and safety.

With regard to the different hydrologic nature of the candidate repository geologies and site, the intent of the proposed NRC rule concerning minimum acceptable pre-emplacement water travel time may be difficult to meet. Moreover, the requirement is stated in a very imprecise manner in which the bounds of the travel time determination are set from the extent of the

[1] For example, it is clear that a waste package with a design lifetime of 1000 years will be substantially more costly than a package with a 100 year design lifetime.

"disturbed zone" to the "accessible environment". The "disturbed zone" is defined such that it could be in the very near proximity to the repository excavation, or it could intersect the "accessible environment". This requirement and its imprecision, if interpreted in the strictest sense, could force an intensive and perhaps futile siting effort. Yet the NRC staff does not demonstrate that this requirement is, by itself, a prerequisite to some level of public health and safety.

The requirements on the engineered system are that packages must survive with no leakage for at least 1000 years, and that following this period, one part in one hundred thousand of the radionuclide inventory may be released each year to the geologic setting. The NRC staff defends the 1000-year package life not because of public health and safety but because of the difficulties they assume in predicting performance when the waste is hottest.

The NRC selects 1000 years as the thermal period of concern with a "logic" that could equally well lead to a selection of a large range of values. Likewise, the 10^{-5} per year release limit is selected as an apparently reasonable number. However, the NRC staff analysis shows that it is not well founded, nor does it necessarily achieve the desired effect. Further, its selection and application to all radionuclides ignores the scientific knowledge base for radiation dosimetry, which is acknowledged by NRC in 10CFR Part 20, by treating all nuclides the same irrespective of their potential, individual impacts to the overall repository system performance. The consequence of these two requirements is that repositories may be designed at a large and excessive cost to meet standards which have no demonstrated foundation in protecting the public health and safety.

With regard to the preceding point, a significant change has occurred in the assumed thermal loading requirement for EPA's proposed 40CFR Part 191. Whereas EPA specified the disposal of "five-year old" high-level radioactive waste in earlier drafts of 40CFR Part 191, the December 29, 1982 version no longer specifies this requirement. Consequently, the waste form can be allowed to cool even further before geologic disposal. This practical mechanism, in addition to the option of further dilution of radionuclide concentrations in the fabrication of the waste form, brings into question the validity of the NRC staff's thermal assumptions in the analysis for the proposed 10CFR Part 60.

NRC has opted, and Congress has affirmed, that no environmental impact statement will be prepared for issuance of 10CFR Part 60. This decision will allow promulgation of this standard without public scrutiny of the real costs and benefits associated with it. The Society concludes that NRC still has a responsibility to enact responsible regulations which protect the public health and safety at a rationale and acceptable cost, and to make the accounting for that judgment available for technical and public review.

IV. CRITIQUE OF CONTAINMENT REQUIREMENT

Section 113(a)(1)(ii)(A) of 10CFR Part 60 establishes the following waste package containment requirement:

> [In satisfying the preceding requirement, the engineered barrier system shall be designed, assuming anticipated processes and events, so that] containment of HLW within the HLW waste package will be substantially complete for a period of 1,000 years after permanent closure of the geologic repository, or such other period as may be approved or specified by the Commission.

The NRC does not base this requirement on meeting EPA standards but rather upon the belief that leach rates and transport mechanisms will be difficult to predict when temperatures in the repository are highest. The specification of 1000 years is based upon the following statement, excerpted from page 73 of the 10CFR Part 60 Rationale Document.

> <u>At about 1000 years</u>, the fission product contribution (to inventory and heat generation) either becomes extremely small or, having decreased dramatically up to that time, becomes relatively constant. Thus, on the basis of the fission product contributions to either radionuclide inventory in curies, to heat generation rate, or to hazard, <u>containment for about 1000 years appears to be appropriate</u>. Therefore, from the perspective of impact on repository performance, <u>a containment time of 1000 years</u>, with provision for flexibility, <u>is most approoriate</u> for dealing with uncertainties invovled in assessing routine releases (emphasis added).

The Society believes that neither the rationale for imposing a containment period nor the logic for selecting one are technically sound. If the NRC is to justify a specific, numerical waste package containment requirement, it should show that anything less in time results in unacceptable performance from an overall isolation system perspective. In its Rationale Document, the NRC staff argues that leach rates probably cannot be predicted in "high" temperatures while canister lifetimes, under the same thermal, geochemical, the mechanical forces, "may be extrapolated with confidence". In contrast, studies, such as ONWI-286 and -352, show that delaying release initiation from the waste form has no impact on the potential, maximum doses to the public within the range of waste package lifetimes or containment periods being considered by the NRC. Therefore, the Society concludes that this numerical subsystem performance requirement should not be promulgated.

V. CRITIQUE OF RELEASE RATE REQUIREMENT

Section 113(a)(1)(ii)(B) of 10CFR60 imposes the following release rate requirement:

> [In satisfying the preceding requirement, the engineered barrier system shall be designed, assuming anticipated processes and events, so that]

the release rate of any radionuclide following the containment period shall not exceed one part in 100,000 per year of the inventory of that radionuclide calculated to be present at 1000 years following permanent closure, or such other fraction of the inventory as may be approved or specified by the Commission; provided that this requirement does not apply to any radionuclide which is released at a rate less than 0.1 percent of the calculated total annual release at 1000 years following permanent closure.

The NRC staff does not derive this limit in a technically rigorous manner, but rather determines that the value is able to contribute substantially to overall repository performance. In making this argument, the staff does not demonstrate that the value leads to compliance with an EPA standard. The staff likewise does not consider the impact of varying toxicities of individual radionuclides in a waste repository.

"The NRC staff does put forward an "uncertainty analysis" of repository performance to defend its selection of the 10^{-5} per year release limit. Table 4 of the 10CFR Part 60 Rationale Document presents the data ranges used in the uncertainty analysis. The ranges of input data used by the NRC are so large as to be without credibility. For example, the NRC staff asserts that the solubility limit for Neptunium ranges over eighteen orders-of-magnitude. The NRC staff provides no reference for this input data. Further, the NRC staff presents data distributions for its input parameters. However, neither does the staff present a defense for these input distributions, nor does it provide a reference for them. Further, DOE has not to date, to the knowledge of the Society put forward any such distributions. Thus without reference of defense, these values and distributions are viewed without validity. a final criticism of this input data is that it is doubtful that the NRC would issue a license for a site that had such a wide variation in predicted properties, nor such an indefensible analysis of site performance. Thus, it is not acceptable nor rational to establish regulations on the basis of an unacceptable level of input data and indefensible analysis."

"In interpreting its uncertainty analysis, the NRC staff implicitly asserts that a confidence level of 90% is satisfactory to determine acceptable repository performance. The Society applauds this step, provided the NRC will codify in the standard or in regulatory guidance, such a value (that is defensible) as an acceptable level of performance uncertainty in repository performance."

The Society believes that any proposed NRC regulation for releases of radionuclides from the engineered system must be firmly based upon the generally applicable environmental release standards of the EPA. The Society believes that the engineering and construction costs associated with meeting this proposed NRC regulation value are unnecessary because little to no credit is allowed to be taken for the radionuclide decay that will occur during sorptive holdpu even if the radionuclides are released to the geologic setting. Thus, the Society concludes that this proposed numerical subsystem performance requirement should not be issued.

VI. CRITIQUE OF PRE-EMPLACEMENT HYDROLOGY REQUIREMENT

In Section 113(a)(2) of 10CFR60, the following requirement is placed upon the candidate repository site.

> The geologic repository shall be located so that pre-waste emplacement groundwater travel time along the fastest of likely radionuclide travel from the distributed zone to the accessible environment shall be at least 1000 years, or such other travel time as may be approved or specified by the Commission.

The requirement for a minimum pre-emplacement groundwater travel time of 1000 years is the most ill-defined of the three values discussed in this review. The first difficulty is that the language of the requirement potentially has the impact of excluding any repository site in which heat-generating wastes are to be placed. This is because the requirement specifics that the 1000-year travel time be measured from the extent of the "disturbed zone" to the "accessible environment". The "disturbed zone" has a subjective definition that allows a large range of interpretations. Contractor studies for both NRC and DOE have shown that heat generated by wastes will result in uplift of the controlled zone at the surface in nearly all sites and geologies.[2] Further, NRC and DOE studies have shown that the thermal driving force from decaying wastes can alter the flow regime over a repository, and to the "accessible environment". Thus, narrowly interpreted, it could be argued that for a high-level waste repository, the "disturbed zone" and the "accessible environment" intersect. If this interpretation is made, then the travel time from the "disturbed zone" to the "accessible environment" is zero. While this interpretation was not the apparent intent of the NRC staff, once promulgated, only the words are codified, not their intent.

A more fundamental error with this proposed performance objective is that pre-emplacement grondwater travel time is, at best, a weak substitute for terms that are actually relevant to isolation of radioactive wastes and the protection of public health and safety. Release of radionuclides to man's environment is, mathematically, a function of (1) the release rate of nuclides from the engineered system to the geologic setting, (2) the volume flow rate of groundwater, (3) the hydraulic conductivity, (4) the effective porosity, the (5) the retardation factors for each radionuclide, which reflect sorption, reconcentration, and filtering. The speed of groundwater flow is not a direct factor in this equation, though obviously is a function of volume flow rate, hydraulic conductivity and porosity. The impact of applying this substitute measure as a regulatory requirement may be to exclude fractured rock from

[2] For example, see Appendix K of U.S. Department of Energy, "Final Environmental Impact Statement, Management of Commercially Generated Radioactive Waste", DOE/EIA-0046F, October 1980.

consideration. In some fractured rock, the actual amount of water present is very small, and the flow area of factures is also quite small. This may lead to very rapid flow speeds, accompanied by very small flow rates. While this numerical subsystem performance requirement leaves the Commission a means for accepting shorter pre-emplacement travel time, past practices of the Commission support the premise that adopting an alternative position is unlikely.

The final problem with this numerical performance requirement standard is that it cannot be shown to have been derived from any version of 40CFE191. Nor can this value be defended as being necessary to meet any overall repository performance requirements. In the Society's view all numerical requirements related to overall repository performance must be defensible and shown to be necessary to meet performance requirements for the repository as a total system. The Society further concludes that if the NRC staff wishes to establish into regulation a minimum groundwater travel time, that the NRC must do so not only with the objective of meeting an overall repository system performance requirement, but with the cognizance that such a property will vary widely over otherwise acceptable sites. Clearly, this property is a site-specific characteristic.

VII. CONCLUSIONS AND RECOMMENDATIONS

The American Nuclear Society concludes that the three numerical subsystem performance objectives contained in Section 113 of the proposed final technical rules of 10CFR Part 60 are technically indefensible. The American Nuclear Society is concerned that the final issuance of these three numerical subsystem requirements by the NRC would be an error that would greatly handicap sound engineering and scientific practice in isolating nuclear wastes. Clearly, these performance objectives greatly limit the alternatives engineers have to optimize waste disposal systems in terms of public health and safety, environmental impact, cost and schedule. Therefore, the Society strongly urges the following:

(1) The NRC should not promulgate the above referenced sections of 10CFR60.113.

(2) The NRC should promulgate the balance of 10CFR Part 60, within the framework of our previous comments.

(3) The NRC should actively support the efforts of the EPA in finalizing 40CFR Part 191.

(4) The NRC should reexamine the need for geologic media-specific and subsystem performance objectives. If such subsystem performance objectives are needed and justified, they could be issued in regulatory guide form, rather than as numerical performance objectives in regulation form.

AMERICAN NUCLEAR SOCIETY
555 North Kensington Avenue, LaGrange Park, Illinois 60525 USA
Telephone: (312) 352-6611 Telex: 254635

October 14, 1981

Secretary of The Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Docketing and Service Branch
Room 1121
1717 H Street, N.W.

Gentlemen:

On behalf of the American Nuclear Society, I respectfully submit the Society's comments and position on the proposed rule, 10 CFR Part 60 (Technical Criteria for Disposal of High-Level Radioactive Waste in Geological Repositories). ANS has actively followed the progress of the rule-making with a technical support committee of interested and technically qualified members of the Fuel Cycle and Waste Management Technical Division. These official ANS comments and position were prepared and reviewed by members of the aforementioned Technical Division, a special committee of senior ANS members, and the Society's Executive Committee.

The American Nuclear Society respectfully submits that the proposed regulation should be withdrawn or, at a minimum, extensively revised. If it is withdrawn, we would hope that a substitute proposed rule would be developed expeditiously. Further, ANS strongly recommends that all subsystem numerical performance requirements be deleted in favor of more general statements permitting system trade-offs to achieve the desired overall system or repository performance. Specifically, the following values should be deleted:

- 1000-Year Waste Package Life [Section 60.111(b)(2)]
- 10^{-5} Long-Term Release Rate [Section 60.111(b)(2)(ii)
- 1000-Year Undisturbed Water Travel Time [Section 60.1
- 50-Year Retrieval Time [Section 60.111(a)(2)]

It is our concerted view that overly restrictive and specific performance standards are not necessary, and that such standards in regulation form are likely to add to the overall cost of waste disposal without achieving any degree of benefit to the public health and safety. Instead, using current engineering practices, a carefully sited, engineered, and designed repository coupled with effective confirmation and design validation can assure compliance with a single, overall performance criterion for the repository as a whole system. The application of such a single performance standard would not only coincide with the Environmental Protection Agency's recommended approach of the systems concept, but would permit repository designers to optimize the repository as a system of both natural and engineered barriers for differin site and geologic medium characteristics.

We would be pleased to discuss these comments further with the Commission and assist you in the development of appropriate, alternative criteria.

Sincerely,

Corwin L. Rickard

Corwin L. Rickard
President

cc: N. J. Palladino, Chairman
J. Ahearne
P. A. Bradford
V. Gilinsky
T. Roberts

PACIFIC LEGAL FOUNDATION

COMMENTS OF THE AMERICAN NUCLEAR SOCIETY ON PROPOSED RULE FOR TECHNICAL CRITERIA: DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTES IN GEOLOGIC REPOSITORIES

46 Fed. Reg. 35280 (July 8, 1981)
(to be codified at 10 C.F.R. Part 60)

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ACKNOWLEDGEMENT

The enclosed official comments were prepared and reviewed by American Nuclear Society members of the Fuel Cycle and Waste Management Division and the Ad Hoc Overview Committee on 10 C.F.R. Part 60 and the Society's Executive Committee.

TABLE OF CONTENTS

I

SUMMARY

The American Nuclear Society (ANS) respectfully submits that the proposed regulation should be withdrawn or, at a minimum, extensively revised.

ANS is of the concerted view that the draft regulation should apply the systems concept, instead of the present stress on subsystems, and as recommended by the Environmental Protection Agency (EPA) in the March 19, 1981, Working Draft of 40 C.F.R. Part 191.[1] Further, the present draft regulation contains significant sections, with related arguments, that are technically unjustifiable and that overly constrain the design of specific components and subsystems.

The concept of the repository as a system requires consideration of both natural and engineered barriers in arriving at a regulatory decision. Each repository site will differ in the reliance that can be placed on natural barriers and, therefore, varying degrees of compensating design margins through engineered systems should be permitted. The designer should not be constrained from optimizing these relationships by the imposition of "design specifications" or subsystem numerical performance requirements such as those stated by the Nuclear Regulatory Commission (NRC) in the proposed rule.

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1 Environmental Protection Agency, 40 C.F.R. Part 191 (1981), Environmental Standards and Federal Radiation Protection Guidance for Management and Disposal of Spent Fuel, HLW and TRU Wastes, Working Draft 19 (March 19, 1981).

ANS strongly recommends that all subsystem numerical performance requirements be deleted in favor of more general performance objectives which would permit subsystem trade-offs to achieve the desired overall repository system performance. Specifically the following values should be deleted:

1. 1,000-Year Waste Package Life (Section 60.111(b)(2));
2. 10^{-5} Long Term Release Rate (Section 60.111(b)(2)(ii)(A))
3. 1,000-Year Undisturbed Water Travel Time (Section 60.112(c)); and
4. 50-Year Retrieval Time (Section 60.111(a)(2)).

II

INTRODUCTION

A. The American Nuclear Society

ANS, an international organization of engineers and scientists, now in its 27th year, is a nonprofit scientific, technical, and educational organization. ANS currently has an individual membership of over 13,000 and is governed by its officers and a Board of Directors elected by the individual membership.

To carry out its purposes, ANS has 16 separate technical divisions. The objective of each division is to provide means for furthering the science, engineering, and art of that branch of scientific discipline. The disciplines range from those related to nuclear power--such as nuclear fuel cycles, waste management, radiation protection and shielding, reactor safety, and reactor operations--to other disciplines, such as controlled nuclear fusion, isotopes and radiation, environmental sciences, and alternative energy technologies and systems.

B. Scope of American Nuclear Society Review

These comments are in response to NRC's proposed rule on "Disposal of High-Level Radioactive Wastes in Geologic Repositories," 46 Fed. Reg. 35280 (July 8, 1981) (to be codified at 10 C.F.R. Part 60, Subpart E--Technical Criteria, Nuclear Regulatory Commission). ANS has actively followed the progress of this proposed rule with a technical support committee of interested and technically qualified members of the Fuel Cycle and Waste Management Technical Division. Based on a technical presentation of these division members and the overview of a special committee of senior ANS members, ANS has developed and formulated the enclosed formal, official position on the proposed rule.

III

REGULATORY APPROACH

A. The Proposed Performance Standards for the Repository Are Overly Restrictive and Unnecessary

NRC lists three alternatives to regulate geologic disposal of high-level waste. They are:

1. Alternative No. 1: Prescribe a single overall performance standard for the repository that must be met. The standard in this case would be the EPA standard.

2. Alternative No. 2: Prescribe minimum performance standards for each of the major elements or subsystems, in addition to requiring the overall system to meet EPA standards.

3. Alternative No. 3: Prescribe detailed numerical criteria on critical engineering attributes of the repository system.

NRC concludes that Alternative No. 2 appears to be the most practical compromise between Alternative Nos. 1 and 3. However, a compromise alternative is not necessarily the best alternative. Alternative No. 1 is more acceptable because it permits the use of a systems concept to incorporate the contributions from natural and engineered barriers. Overly restrictive and specific component and subsystem performance standards are not necessary and are likely to add to the overall cost of waste disposal, without achieving any significant degree of benefit to the public health and safety.

Using current engineering practices, a carefully sited, engineered, and designed repository coupled with effective confirmation and design validation can assure compliance with a single, overall performance criterion for the repository as a whole system. In satisfying a system or repository performance standard, the use of natural and engineered barriers will assure acceptable containment of the waste for the appropriate period of time and provide the required protection of the public health and safety and man's environment.

During operation of the first repository, appropriate modifications can be made in design features and repository layout if results of operation necessitate such changes. Therefore the overly restrictive standards now proposed for components and subsystems are not warranted.

B. The Proposed Multiple Barrier Approach Should Allow Appropriate Credit for Natural Barriers

In evaluating multiple barriers, NRC has considered three alternatives. These are:

1. rely entirely on the natural barriers of the site to meet the system performance standard;

2. rely entirely on engineered barriers to meet the system performance standard; and

3. rely on a combination of engineered and natural barriers to meet the system performance standards. 46 Fed. Reg. 35281 (July 8, 1981).

Alternative Nos. 1 and 2 were abandoned by NRC because of (1) uncertainties in the natural barrier performance under the stress of waste-induced changes, and (2) avoiding "unduly constraining system design."

In adopting Alternative No. 3, NRC states (see, Enclosure J at 26)[2] that the "staff decided to set a long-term release rate for the underground facility and waste packages working together," without mention of the natural barriers as a part of the system. This is not Alternative No. 3; but rather a more tightly constrained Alternative No. 2.

The concept of the repository as a radioactive waste isolation system requires consideration of the contribution of all barriers in arriving at a regulatory decision. Each repository site will be able to place differing reliance on the natural barriers and, therefore, the site-independent numerical subsystem performance specifications stated in Sections 60.111 and 60.112 should be withdrawn.

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2 Enclosure J, Commission Paper SECY-81-267, Rationale for Performance Objectives and Required Characteristics of the Geologic Setting (April 27, 1981).

EPA in its working draft of 40 C.F.R. Part 191 (1981) has commented on the system concept in several places. Specifically, EPA's draft notes: "We believe that making the overall disposal system meet numerical performance requirements by taking advantage of substantial protection from each of its components will provide adequate protection most economically" (40 C.F.R. Part 191 at 13). This concept more nearly complies with Alternative No. 3 than specific numerical design specifications for each subsystem or component.

C. The Proposed Rule Should Recognize that Performance Uncertainties Can Be Minimized by Bounding Analysis and Design

NRC has placed undue emphasis on the nature of the uncertainties associated with the transport of the waste through the geosphere to the exclusion of other important considerations. For example, uncertainties can be ascertained and made inconsequential by bounding analysis and design. Potential performance uncertainties are better addressed and minimized in the design of a repository and other features through the establishment and incorporation of acceptable nonregulatory design limits for the uncertainties which may reside in a particular set of circumstances, rather than the establishment of overly conservative technical criteria in the form of a rule to cover all supposed repository arrangements and contingencies. Further, a careful site selection process, using currently available investigatory techniques and engineering practices and based on the proven historical stability of the geologic setting, can minimize tectonic and hydrogeologic uncertainties and provide adequate protection of the public health and safety and man's environment.

IV

PERFORMANCE OBJECTIVES

A. The Requirement for a 1,000-Year Containment Period by Engineered Barriers Is Grossly Excessive and Unsupported by Scientific Fact

Section 60.111(b)(2)(i) requires that the waste packages contain all* radionuclides for the first 1,000 years after permanent closure.

NRC claims that the basis for the choice of 1,000 years is mainly that the heat induced by the waste in the geologic medium will increase the waste package leachability and reduce the near-field transport time, with the net result that the radiological source term from the "disturbed zone" increases. NRC does not argue that the 1,000-year containment period is necessary to reduce the overall radiological release to man's environment to an acceptable level.

It is agreed that the postulated release from the underground facility would be accelerated due to resulting higher temperatures in the geologic medium but, generally, the calculational models used do not take credit for any holdup or delay of radionuclides in the region of relatively higher

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* The use of "all" could be interpreted that no waste package failure could be allowed in 1,000 years. Using probabilistic design analyses, it must always be concluded that some chance of failure exists. Consequently, percent of failure allowed must be defined if any fixed life is to be required for the waste package. Therefore, the proposed wording is unrealistic.

temperatures. Rather, the radiological source term for the far-field transport models are derived directly from the waste package release rate as if the heated geologic medium region or "disturbed zone" did not exist. Thus, any acceleration of release from the underground facility due to temperature effects has already been discounted and, therefore, should not be used to penalize the waste package design.

Furthermore, heat or high temperature does not make waste-package containment more necessary, only more difficult to achieve. The waste-package containment requirement during any period should be based on the acceptable release quantity during that period, not on changes in nearby or adjacent conditions. A relatively higher temperature environment and the presence of water in a repository will make the waste package more difficult to design, but these factors should not influence the required waste-package performance, particularly when no credit is taken for near-field or "disturbed zone" retardation.

In addition, analyses have shown that NRC's stipulated 1,000-year containment period for waste packages or an engineered barrier would not have the suggested effect of supposedly reducing the release of radionuclides via hydrogeologic transport to man's environment. For example, Cloniger, et al.,[3] have shown that a waste-package containment period between 0 and 100,000 years does not contribute to reducing radiological consequences

[3] M. O. Cloniger, et al., An Analysis on the Use of Engineered Barriers for Geologic Isolation of Spent Fuel in a Reference Salt Site Repository, PNL-3356 (December 1980).

to man's environment; instead, this reduction is satisfied through the regional geology or natural barriers. Thus, the 1,000-year containment period results in relatively no benefit for reduction in radionuclide releases, as compared to that for the natural barriers. It should also be noted that NRC's implied "zero leakage" criterion in the proposed 1,000-year containment period is impossible to prove.

Using somewhat different models, an almost identical conclusion is reached by Pigford, et al.[4] Their results indicate that in varying waste package containment times from 1 to 10,000 years makes no difference to release rates for a spectrum of important long-lived isotopes.

For the above reasons, the 1,000-year containment period by engineered barriers provides no added safety and is unsupported by scientific evidence.

B. The Long-Term Release Rate Is Unsupported by Analyses and Studies

Section 60.111(b)(2)(ii) requires that the engineered system design shall provide the annual release of any radionuclides not exceeding one part in 10^5 of the waste inventory after 1,000 years. Three alternatives for the criterion for the release rate from the engineered system after the containment period were proposed (see Footnote No. 2, Enclosure J).

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[4] T. H. Pigford, et al., Migration of Radionuclides Through Sorbing Media, Analytical Solution, - II, LBL-11616, UC-70, Vol. 1 (October, 1980).

"(i) a range of 10^{-3} to 10^{-4}/year, which is typical of leach rates of many borosilicate glasses at low temperature;

(ii) a release rate of 10^{-5}/year;

(iii) a release rate of 10^{-7} year."

Alternative No. (i) states that the borosilicate glass "is expected ... to crack into fragments 10 cm on a side." The section goes on to state that the 10^{-5} to 10^{-6} g/cm^2/day leach rates of the glass in conjunction with the expected cracking results "in a range of annual release rates of 10^{-3} to 10^{-4} of the waste inventory." The basis for this conclusion is not clear since the dissolution rate of the waste inventory will depend on waste matrix parameters, groundwater flow rates and properties, local geochemistry characteristics, and local temperature, as well as fragment size and leach rate. Thus, the annual release rate is expected to be a strong function of the repository system design, the selected geologic medium, and local hydrogeologic characteristics.

EPA rationale expressed for leach rates appears to be more appropriate. The leach rates of various waste forms must be cast in the role of contributing to confinement in conjunction with the repository. Borosilicate glass has excellent low leach rates over the long term. NRC-quoted high rates of 10^{-5} gm/cm^2/day are usually for shorter term tests for 90 Sr and 137 Cs leaching, which are likely to be chemically retained in quantity in the near-field or "disturbed zone"; longer term tests with actinides fall in a much lower range of values. The setting of annual release rates would be better handled through the establishment of an overall repository release limit by incorporating this limit in an overall system performance standard.

NRC has chosen the annual release rate of waste of 10^{-5}/year as the long-term performance objectives for the engineered system or barriers. In arriving at this number, NRC argues that a larger number, such as 10^{-3}/year, would require relying almost entirely on the geology and the far-field geochemistry while the selected number of 10^{-5}/year would contribute to reducing doses and substantially reduce reliance on geochemical retardation. This argument is provided without reference to supporting analyses or studies.

As an example, the preceding argument by NRC is contrary to an analysis by Cloniger, et al. (see Footnote No. 3) who concludes:

> "While the need for and the effectiveness of a release rate limiting barrier function is somewhat dependent on the sorption properties of the geologic media, generally a release rate of less than $10^{-3} yr^{-1}$ (fractional) is necessary to reduce the potential dose from 14C, 99Tc, and 129I to a baseline level below that of the actinides. Beyond that, a release rate of less than $10^{-5} yr^{-1}$ is required before the potential dose from the actinide chains can be further lowered by this mechanism. This is because the distribution of actinide chain members in time and space, due to their different sorption properties and the characteristics of the groundwater flow field, has the same effect as a release rate reduction of between 10^{-5} to $10^{-6} yr^{-1}$. Only in extreme cases of the intrusion water well scenario is there a direct relationship between release rate from the repository and release to the biosphere."

C. The Water Travel Time to the Accessible Environment Is Invalid Without a Clear Definition of "Accessible Environment" and Analysis of Differing Site Specific Characteristics

Section 60.112(c) states a requirement that prewaste emplacement groundwater travel times through the far-field to the accessible environment are at least 1,000 years.

While the "water travel time" concept may have validity in assessing multiple barriers, the ambiguity of what constitutes the "accessible environment" can lead to a number of interpretative results for this factor, as applied to differing site specific characteristics. It would be better to more clearly define the "accessible environment" as a surface or near surface water body or body of significant quantities of water that could conceivably realize extensive use. In the absence of analyses justifying 1,000 years for differing site specific characteristics and a clear definition of "accessible environment," ANS recommends deleting this numerical value.

D. The Retrievability Criteria Is Unnecessary

Section 60.111(a)(2) states a requirement for a waste retrievability period for up to 50 years after waste emplacement operations are completed. NRC's concept of retrievability and the states' arguments concerning related time periods are inappropriate.

NRC decision to require a final licensing step prior to decommissioning or permanent closure provides the opportunity for examination of the repository performance up to that time. Since the repository is planned to be operational for more than 30 years, the first waste emplaced will have been in monitored storage for this time period when the last waste is emplaced. If the applicant can demonstrate safety based on these data, no further period of retrievability should be necessary.

We understand that the 50-year retrievability period is designated to assure the retrieval option remains open during repository operation and is not precluded by repository design. This objective can be achieved without defining an artificial time frame if the rule is so worded to set forth this objective. The retrieval option can be easily exercised, for one of the distinguishing features of deep geologic disposal is that the waste inventory and location is well documented. Technologically there should be no problem, for what can be emplaced can also be removed. The design and engineering of such retrieval are well within current state of the art. This concept is reflected in the current National Waste Terminal Storage (NWTS) position[5] which we believe presents a logical approach for satisfying the retrievability objective.

V

CONCLUSIONS AND RECOMMENDATIONS

ANS is of the concerted view that the present draft regulation should apply the systems concept instead of the present stress on subsystems, and contains significant sections, with related arguments, that are technically unjustifiable and overly constrain the design of specific components and

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5 W. A. Carbiener, Retrievability: The NWTS Position, Proceedings of the Symposium on Waste Management in Tucson, Arizona (February 23-26, 1981).

subsystems. Therefore, the proposed regulation should be withdrawn or, at a minimum, extensively revised. The following general conclusions are made:

- With regard to the regulatory approach and the technical criteria alternatives, Alternative No. 1 or a single overall repository performance standard is more acceptable. Overly restrictive component and subsystem performance standards are not necessary and are likely to add to the overall cost of waste disposal, without achieving any significant degree of benefit to the public health and safety.

- The concept of the repository as a radioactive waste isolation system requires consideration of the contribution of all barriers in arriving at a regulatory decision. Each repository site will be able to place differing reliance on the natural barriers and, therefore, design margins through engineered systems should be provided on a site-specific basis.

- NRC has placed undue emphasis on the nature of the uncertainties associated with the transport of the waste through the geosphere to the exclusion of other important considerations. Such uncertainties can be ascertained and made inconsequential by bounding analysis and design.

- Analyses have shown that NRC's stipulated 1,000-year waste-package containment period results in relatively no benefit for reduction in radionuclide releases as compared to that for the natural barriers.

- The setting of annual release rates for radionuclides would be better handled through the establishment of an overall repository release limit by incorporating this limit in an overall system performance standard.

- In the absence of analyses justifying 1,000-year water travel time for differing site-specific characteristics and a clear definition of "accessible environment," the validity of this numerical value is questionable.

- The retrievability concept reflected in the current NWTS position presents a logical approach for satisfying the retrievability objective and is more appropriate than the proposed 50-year period.

ANS strongly recommends all subsystem numerical performance requirements be deleted in favor of more general performance objectives which would permit subsystem trade-offs to achieve the desired overall repository system performance. Specifically the following values should be deleted:

1. 1,000-Year Waste Package Life;
2. 10^{-5} Long-term Release Rate;

3. 1000-Year Undisturbed Water Travel Time;

4. 50-Year Retrieval Time;

DATED: October 19, 1981.

Respectfully submitted,

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PRESIDENT
L. Manning Muntzing
Doub and Muntzing, Chartered
1875 Eye Street, NW - Suite 775
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October 5, 1982

Mr. William J. Dircks
Executive Director
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Dircks:

Representatives of the American Nuclear Society met with you, Victor Stello, John Davis and other NRC staff members on September 10, 1982. The purpose of the meeting was to present ANS's initial reaction, from a technical perspective, to the July 29, 1982 version of 10CFR Part 60 (Technical Criteria for Geologic Repositories for High-Level Radioactive Waste), including NRC staff Recommendations and the technical Rationale Document. At the meeting, ANS reiterated its general position on proposed 10CFR Part 60 to NRC on October 14, 1981:

> "ANS strongly recommends that all numerical subsystem performance requirements be deleted in favor of more general statements permitting system trade-offs to achieve the desired overall system or repository performance". And,
>
> "It is our concerted view that overly restrictive and specific performance standards are not necessary, and that such standards in regulation form are likely to add to the overall cost of the waste disposal without achieving any degree of benefit to the public health and safety. Instead, using current engineering practices, a carefully sited, engineered, and designed repository coupled with effective confirmation and design validation can assure compliance with a single, overall performance criterion for the repository as a whole system. The application of such a single performance standard would not only coincide with the Environmental Protection Agency's recommended approach of the systems concept, but would permit repository designers to optimize the repository as a system of both natural and engineered barriers for differing site and geologic medium characteristics".

Additionally, we expressed our concern about NRC staff's rejection of the overall system or repository standard approach (similar with EPA's) which was recommended by ANS and other technical specialists and organizations. There was a broad general technical consensus on this point which seems to have been inadequately considered by the NRC without substantive technical justification.

While ANS had a relatively brief period to review the July 29, 1982, technical Rationale Document prior to the September 10, 1982, meeting, knowledgeable ANS members on this subject are in general agreement that the numerical subsystem performance standards (now "objectives") cited in the proposed regulation have not been technically justified. Further, we believe it will be very difficult, if not impossible, for the NRC to technically justify any variation from these numerical subsystem performance objectives on a "case-by-case" basis with these unmeasurable and technically unjustified values cited in the regulation.

With the preceding in mind, ANS strongly recommends NRC take the following actions before approving 10CFR Part 60:

- o Based on a preponderance of technical community opinion, including ANS, supporting a single, overall repository performance standard, NRC should reconsider the proposed numerical subsystem performance objectives in favor of more generalized design objective statements in the regulation.

- o NRC should submit technical rationale documentation for 10CFR Part 60 to a peer review by the technical community for the adequacy of analytical methodology, parameters, assumptions and conclusions.

Relative to the preceding, ANS has taken the following steps:

- o A technical paper is being prepared to present ANS and technical community views on the approaches used and material presented in the Rationale Document. This paper is scheduled to be completed and available on November 22, 1982, and would provide the basis for a technical presentation to the NRC staff and Commissioners.

o A special peer review session on 10CFR Part 60 is being organized to be held during the ANS Winter Meeting (Nov. 14-18, 1982) in Washington, D. C.

The American Nuclear Society would be pleased to meet with the Commission and the staff to assist in the development of a technically sound regulation.

Very sincerely,

L. Manning Muntzing
President
American Nuclear Society

LMM:DB:evm

February 9, 1983

RULEMAKING ISSUE

SECY-83-59

(Affirmation)

For: The Commissioners

From: William J. Dircks, Executive Director for Operations

Subject: 10 CFR PART 60--DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTES IN GEOLOGIC REPOSITORIES: TECHNICAL CRITERIA AND CONFORMING AMENDMENTS

Category: This paper involves a major policy question.

Purpose: To request Commission approval to publish as final amendments to 10 CFR Part 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories," the technical criteria for regulating geologic disposal of high-level radioactive wastes (Enclosure A).

Discussion: Background. In November 1978, the Commission published for comment a proposed General Statement of Policy (43 FR 53869; SECY-78-366) which set forth a regulatory framework for licensing geologic repositories for the disposal of high-level radioactive wastes (HLW). In December 1979, the Commission published for public comment a proposed rule--10 CFR Part 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories; Proposed Licensing Procedures" (44 FR 70408; SECY-79-580). This proposed rule addressed the specific procedures under which geologic disposal of HLW by the Department of Energy (DOE) would be regulated. Final licensing procedures were published on February 25, 1981 (46 FR 13971; SECY-80-474 and SECY-81-48).

On May 13, 1980, the Commission published for public comment an Advance Notice of Proposed Rulemaking on the technical criteria for regulating geologic disposal of HLW (45 FR 31393; SECY-80-177). Proposed technical criteria against which license applications would be reviewed under 10 CFR Part 60 were published for public comment on July 8, 1981 (46 FR 35280; SECY-81-267). A copy of the proposed rule as published in the Federal Register is provided as Enclosure B. The differences between the proposed and final technical criteria are provided in comparative text in Enclosure C.

Contact:
P. A. Comella (427-4616)
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J. R. Wolf (492-8694)

A total of ninety-two groups and individuals commented on the proposed rule. Eighty-nine letters were received in time to be considered in the staff's analysis of the public comments. The remaining three letters are provided as Enclosure D for the Commission's information. The staff has reviewed these letters and believes that they raised no significant new issues with respect to this rulemaking. The eighty-nine letters that were analyzed by the staff contained about seven hundred individual comments. These individual comments addressed a wide range of issues, including those for which specific comment was requested by the Commission, and all parts of the rule. The concerns expressed by these commenters are discussed in detail in the draft Federal Register notice (FRN) (Enclosure A), and the staff analysis of public comment presented in draft NUREG-0804. (This latter document will be forwarded separately once conforming changes consistent with the January 4, 1983, Commission guidance have been made.)

When the staff had completed its preliminary analysis of the public comments and had formulated, consistent with this analysis, its preliminary recommendations with respect to the final technical criteria, it forwarded SECY-82-288 to the Commission on July 7, 1982, to provide early opportunity to the Commission to review these preliminary recommendations. SECY-82-288 also contained a draft rationale document for the performance objectives in the technical criteria. The analyses conducted by the staff in conjunction with this rationale document were based on a draft EPA standard, referenced by some of the commenters.

By early October 1982, the Environmental Protection Agency (EPA) had not as yet issued a proposed HLW standard. (Subsequently EPA issued a proposed standard for public comment on December 29, 1982 (47 FR 58196).) Therefore, on October 21, 1982, the staff forwarded SECY-82-427 to the Commission to seek guidance on how to proceed in developing final technical criteria in the absence of an EPA standard. The Commission met at an open meeting on November 19, 1982, to discuss this issue; and the Secretary, in a memorandum dated January 4, 1983, provided guidance to the staff concerning the Commission's decision on this matter (Enclosure E).

The enclosed rulemaking package (Enclosures A and G) reflects this guidance. See Enclosure A, pp 7-8. It also addresses, as appropriate, issues related to the proposed EPA standard as well as provisions of the recently enacted Nuclear Waste Policy Act of 1982, Pub. L. 97-425. These additional areas are identified below. Commission attention is directed to those sections of the draft FRN which treat the identified areas.

Proposed EPA Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes. EPA's proposed standards (Enclosure F) contain environmental standards for management and storage (Subpart A) and environmental standards for disposal (Subpart B), which are further partitioned into containment requirements (§191.13), assurance requirements (§191.14), and procedural requirements (§191.15). The staff has reflected the proposed EPA standards in the enclosed rulemaking package as follows:

a. Prior to publication of the proposed EPA standards, the NRC staff had used an internal EPA working draft standard (Draft No. 19) as the "assumed EPA standard" for the analyses which provided a basis for the rationale document for the performance objectives set forth in the final technical criteria. The staff has reexamined the rationale document (Enclosure G) in light of the proposed standards related to containment requirements (§191.13), along with related definitions, which together are analogous to Draft No. 19, to determine if any revision of the technical criteria is necessary as a result of differences between the proposed EPA standard and Draft No. 19. Staff analysis indicates no changes are necessary. The results of this analysis are provided in an appendix to the rationale document (Enclosure G). Reference is made to this analysis in the draft FRN. See Single vs. Multiple Performance Standards, Enclosure A, p. 6.

b. The draft FRN relates the concepts of "anticipated" and "unanticipated" processes and events to the evaluation of releases addressed in the proposed EPA standard. See Anticipated and Unanticipated Processes and Events, Enclosure A, p. 19.

c. The term "accessible environment" is defined in both Part 60 and the proposed EPA standard, but differently in each. The draft FRN discusses these differences and goes on to show why the definitions are nevertheless consistent. See Accessible Environment/Controlled Area, Enclosure A, pp. 24 ff.

d. The draft FRN explicitly addresses the Commission's position on ALARA determinations and the EPA proposed guidance in §191.14(b), concerning keeping releases to the accessible environment as small as reasonably achievable. See ALARA, Enclosure A, pp. 14 ff.

Nuclear Waste Policy Act of 1982: As appropriate, the draft FRN (Enclosure A) now makes reference to relevant provisions of the Nuclear Waste Policy Act of 1982 as follows:

a. The draft FRN indicates that publication of the final technical criteria is regarded as constituting full compliance with Section 121(b)(1)(A) of the Act, which requires promulgation of the Commission's technical criteria for geologic repositories not later than January 1, 1984. See Background, Enclosure A, p. 4.

b. The draft FRN indicates that the Commission will review these criteria after EPA's environmental standards are published in final form and will initiate subsequent rule-making actions, as necessary, to take any such standards into account. See Background, Enclosure A, p. 4.

c. Under 121(b)(1)(B) of the Nuclear Waste Policy Act of 1982, the Commission's technical criteria "shall provide for the use of a system of multiple barriers in the design of the repository... as the Commission deems appropriate." The draft FRN indicates that this provision has been satisfied. See Background, Enclosure A, p. 3.

d. Under Section 121(b)(1)(B) the Commission's technical criteria "shall include such restrictions on the retrievability of the solidified high-level radioactive waste and spent fuel in the repository as the Commission deems appropriate." The draft FRN indicates that this provision has been satisfied. Also, Section 122 of the Nuclear Waste Policy Act provides that, at the time a repository is designed, DOE shall specify an appropriate period during which spent fuel could be retrieved for any reason pertaining to the public health and safety, or the environment, or for the purpose of permitting recovery of the economically valuable components of such spent fuel. The period of retrievability is subject to approval or disapproval by the Commission as part of the construction authorization process. The draft FRN states, insofar as health and safety considerations are concerned, the Commission's intent to grant approval so long as the technical criteria are satisfied and to modify the licensing procedures to so specify. See Retrievability, Enclosure A, p. 10.

e. The draft FRN also addresses the relationship between the technical criteria and the guidelines DOE is required to promulgate with Commission concurrence. These guidelines are to be used in screening and selecting sites that may be used to host a repository. Under Section 112(a) of the Nuclear Waste Policy Act of 1982, DOE is required to develop guidelines that, among other things, will specify (1) population factors that will disqualify a site from development as a repository and (2) detailed geologic considerations that shall be primary criteria for the selection of sites in various geologic media. Issuance of these siting guidelines is subject to the concurrence of the Commission. The draft FRN would indicate that the Commission has made no determination whether such guidelines, when issued, should in some manner be reflected in 10 CFR Part 60. See Enclosure A, Population-Related Siting Criteria, pp. 12 ff. and Siting Criteria, pp. 21 ff.

Further Rulemaking: The staff believes that it is necessary to reexamine the licensing procedures in light of the Nuclear Waste Policy Act of 1982 to ensure that the Commission's regulation is consistent with current Law. For example, the staff believes that the provisions of 10 CFR Part 60 which deal with State, local, and Indian tribal participation in the licensing process must be reexamined. The staff would also give further consideration to the question of the degree, if any, to which the relationship between the technical criteria and DOE's siting guidelines should be elaborated through rulemaking. This effort would commence immediately upon publication of the FRN for the final technical criteria. The staff would expect to return to the Commission with any proposed revisions in late 1983.

Although the technical criteria as written are generally applicable to disposal in both the saturated and unsaturated zones, some distinctions do need to be made. Rather than including the criteria which will apply to the unsaturated zone as part of the present rulemaking, staff will present such criteria to the Commission for consideration at the same time as proposed revisions in light of the Nuclear Waste Policy Act of 1982 are presented. See draft FRN, Enclosure A, Unsaturated Zone, pp. 28 ff., for further discussion.

Commission resource needs to implement the provisions of this regulation have been reflected in programmatic budget requests. Thus, no significant new resource expenditures will be required by issuance of the amendments as effective. With respect to further rulemaking, the staff presently has under active consideration the resource implications associated with the implementation of all provisions of the Nuclear Waste Policy Act of 1982.

Recommendations: That the Commission:

1. Approve for publication as a final rule that part of 10 CFR Part 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories" dealing with the technical criteria,

and conforming amendments, and the accompanying Statement of Considerations, as set forth in the draft Federal Register notice in Enclosure A.

Certify that this rule, if promulgated, will not have a significant economic impact on a substantial number of small entities. This certification is necessary in order to satisfy the requirements of the Regulatory Flexibility Act, 5.U.S.C. 605(a).

2. Note:

a. A copy of the proposed technical criteria as published in the Federal Register on July 8, 1981 (46 FR 35280) is provided as Enclosure B.

b. The changes made to the proposed 10 CFR Part 60 technical criteria as published in the Federal Register are provided in comparative text in Enclosure C.

c. Criteria which apply to disposal in the unsaturated zone will be forwarded to the Commission in late 1983 as a proposed rule.

d. Draft NUREG-0804 containing the detailed staff analysis of the public comments (#1-89) will be forwarded within the next three weeks. It is the staff's view that the Commission could meet to begin consideration of the enclosed package prior to receipt of this document if it so wished. Copies of the comment letters not included in the staff analysis are provided in Enclosure D and Enclosure K.

e. The January 4, 1983 memorandum from Samuel J. Chilk to William J. Dircks is provided as Enclosure E.

f. A copy of the EPA's proposed standards (47 FR 58196) is contained in Enclosure F.

g. The rationale document for the performance objectives is provided in Enclosure G.

h. As provided by the Nuclear Waste Policy Act of 1982, no environmental assessment is being prepared in connection with this action.

i. This rule contains no new or amended recordkeeping, reporting, or application requirement, or any other type of information collection requirement, subject to the Paperwork Reduction Act (P.L. 96-511).

j. The Chief Counsel for Advocacy of the Small Business Administration will be informed by the Division of Rules and Records of the certification regarding economic impact on small entities.

k. The Subcommittee on Energy and the Environment of the House Interior and Insular Affairs Committee, the Subcommittee on Nuclear Regulation of the Senate Committee on the Environment in Public Works, the Subcommittee on Energy, Nuclear Proliferation and Federal Services of the Senate Committee on Government Affairs, and the Subcommittee on Energy and Power of the House Interstate and Foreign Commerce Committee would be informed by a letter similar to Enclosure H.

l. The final rule contains conforming amendments to the 10 CFR Part 60 "licensing procedures" (Subparts A-D).

m. Copies of the final Federal Register notice and the detailed staff analysis of public comments will be distributed to all individuals who submitted comments on the proposed rule.

n. A public announcement such as Enclosure I will be issued on filing of the notice of final rulemaking with the Office of the Federal Register.

o. A statement of the final value/impact analysis is contained as Enclosure J.

p. The most recent letter of the American Nuclear Society, dated January 24, 1983, concerning the technical criteria, is in the process of being docketed and will be treated in the same manner as comment letters, #90-92, as it too raised no significant new issues with respect to this rulemaking. A copy is provided for information in Enclosure K.

William J. Dircks
Executive Director for Operations

Enclosures:
A - Draft Federal Register Notice
B - Federal Register Notice for Proposed 10 CFR Part 60
C - Copy of Amendments of 10 CFR Part 60 in Comparative Text
D - Public Comment Letters (#90-92)
E - Copy of 1-4-83 Memorandum from S. Chilk to W. Dircks
F - Copy of the Federal Register Notice for the Proposed EPA Standards
G - Rationale Document
H - Draft Congressional letters
I - Draft Public Affairs Announcement
J - Statement of Value/Impact Analysis
K - ANS Letter of 1-24-83

Commissioners' comments or consent should be provided directly to the Office of the Secretary by c.o.b. Friday, February 25, 1983.

Commission Staff Office comments, if any, should be submitted to the Commissioners NLT Friday, February 18, 1983, with an information copy to the Office of the Secretary. If the paper is of such a nature that it requires additional time for analytical review and comment, the Commissioners and the Secretariat should be apprised of when comments may be expected.

This paper is tentatively scheduled for affirmation at an Open Meeting during the Week of February 28, 1983. Please refer to the appropriate Weekly Commission Schedule, when published, for a specific date and time.

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ENCLOSURE A

NUCLEAR REGULATORY COMMISSION

10 CFR Part 60

Disposal of High-Level Radioactive Wastes in Geologic Repositories Technical Criteria

AGENCY: Nuclear Regulatory Commission.

ACTION: Final rule.

SUMMARY: The Nuclear Regulatory Commission (NRC) is publishing technical criteria for disposal of high-level radioactive wastes (HLW) in geologic repositories. The criteria address siting, design, and performance of a geologic repository, and the design and performance of the package which contains the waste within the geologic repository. Also included are criteria for monitoring and testing programs, performance confirmation, quality assurance, and personnel training and certification.

EFFECTIVE DATE: 30 days after publication in the Federal Register.

FOR FURTHER INFORMATION CONTACT: Patricia A. Comella, Deputy Director of the Division of Health, Siting and Waste Management, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Telephone (301)427-4616.

SUPPLEMENTARY INFORMATION:

Background

On February 25, 1981, the Nuclear Regulatory Commission published rules which established procedures for the licensing of geologic disposal, by the U.S. Department of Energy (DOE), of high-level radioactive wastes (HLW). 46 FR 13971. On July 8, 1981, NRC proposed technical criteria which would be used in the evaluation of license applications under those procedural rules. 46 FR 35280. NRC received 92 comment letters on these proposed technical criteria, 89 of which were received in time for the Commission to consider in preparing the final technical criteria that are published here. No significant new issues were raised in the three letters received too late for consideration. The principal comments, and the Commission's responses, are reviewed in the discussion below. A more detailed analysis of the comments is contained in an NRC staff report (NUREG-0804) which is being distributed to all commenters on the proposed rule and which may be purchased by other interested parties from the NRC's GPO Sales Program, Washington, D.C. 20555. A copy has also been placed in the Public Document Room (PDR), 1717 H Street N.W., Washington, D.C. 20555. This staff report includes a technical rationale for the performance objectives in 10 CFR Part 60 as well as the comment analysis. The final rules contain a number of changes, explained in this statement, that reflect concerns addressed in the public comments.

The licensing procedures referenced above provide for DOE to submit site characterization reports to NRC prior to characterizing sites that may be suitable for disposal of HLW. NRC would analyze these reports, taking into account public comments, and would make appropriate comments to DOE.

The licensing process will begin with the submission of a license application with respect to a site that has been characterized. Following a hearing, DOE may be issued a construction authorization. Prior to emplacement of HLW, DOE would be required to obtain a license from NRC; an opportunity for hearing is provided prior to issuance of such a license. Permanent closure of the geologic repository and termination of the license would also require licensing action for which there would be opportunity for hearing.

The purpose of the technical criteria is to define more clearly the bases upon which licensing determinations will be made and to provide guidance to DOE and information for the public with respect to the Commission's policies in this regard. The criteria also indicate the approach the Commission is taking with respect to implementation of an Environmental Protection Agency (EPA) standard, particularly with respect to the classification of processes and events as "anticipated" or "unanticipated" and the definition of the "accessible environment" from which radionuclides must be isolated.[1]

The Commission anticipates that licensing decisions will be complicated by the uncertainties that are associated with predicting the behavior of a geologic repository over the thousands of years during which HLW may present hazards to public health and safety. It has chosen to address this difficulty by requiring that a DOE proposal be based upon a multiple barrier approach. An engineered barrier system is required to compensate for uncertainties in predicting the performance of the geologic setting, especially during the period of high radioactivity. Similarly, because the performance of the engineered barrier system is also subject to considerable uncertainty, the geologic setting must be able to contribute significantly to isolation.

The multibarrier approach is implemented in these rules by a number of performance objectives and by more detailed siting and design criteria.[2] In addition to the objective of assuring that licensed facilities will adequately isolate HLW over the long term, these provisions also address considerations related to health and safety during the operational period prior to permanent closure of the geologic repository.

In this statement of considerations the Commission will first discuss six issues on which it had specifically requested public comment. It will then review other principal changes to the rule which have been adopted in the light of comments received. The discussion will then take up suggestions of a policy nature which the Commission has declined to adopt. Finally, a section-by-section analysis reviews all changes made

[1]Reorganization Plan No. 3 of 1970 authorizes EPA to establish generally applicable environmental standards for radioactivity. EPA's recently proposed standard would allow higher levels of radioactivity for "unanticipated processes and events" than would be permitted if "anticipated processes and events" were to occur. The proposed standard also relates these levels to places within the "accessible environment." The Commission has assumed that these concepts will be reflected in final standards that may be established by EPA.

[2]Under the Nuclear Waste Policy Act of 1982, the Commission's technical criteria "shall provide for the use of a system of multiple barriers in the design of the repository...as the Commission deems appropriate." Section 121(b)(1)(B). The criteria set forth in this rule represent the criteria which, for purposes of this provision, the Commission deems appropriate.

other than those of a strictly editorial nature. As appropriate, reference is made to relevant provisions of the Nuclear Waste Policy Act of 1982, Pub. L. 97-425, approved January 7, 1983, and to the Environmental Protection Agency's proposed Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level, and Transuranic Radioactive Wastes, 47 FR 58195, December 29, 1982. The Commission regards the publication of these rules as constituting full compliance with Section 121(b)(1)(A) of the Nuclear Waste Policy Act, which requires promulgation of the Commission's technical criteria for geologic repositories not later than January 1, 1984.[3] The Commission will review these criteria after EPA's environmental standards are published in final form and will initiate subsequent rulemaking actions, as necessary, to take any such standards into account. The Commission further intends additional rulemaking to deal with any changes in licensing procedures that may be necessary in light of the Nuclear Waste Policy Act.

[3]The technical criteria are explicitly stated to be applicable to construction authorization, § 60.101(b), and to the issuance of licenses to receive and possess high-level radioactive waste at geologic repositories, § 60.101(a). An application to authorize permanent closure requires a license amendment, § 60.51(a); the relevant technical requirements and criteria are set out in the rules here being adopted, inasmuch as the Commission is to be "guided by the considerations that govern the issuance of the initial license, to the extent applicable," § 60.45(b). The Commission interprets the statutory provision pertaining to applications for "decommissioning" to refer to the procedure described in § 60.52, pertaining to termination of a license; such an application would also require a license amendment, and the Commission here, too, would be guided by the present rules to the extent applicable, together with the additional criteria already set out at § 60.52(c). Thus, at every stage of the licensing process, the central inquiry will be the adequacy of DOE's plans and activities as they relate to the isolation of wastes (as well as to safety during operations); and for each decision point we have provided, as is appropriate, for an evaluation that takes into account both the performance objectives and the more detailed criteria that the Commission here adopts. (If Section 121(b)(1)(A) applies to the decommissioning of surface facilities, the required criteria have been included in § 60.132(a). That paragraph provides that surface facilities must be designed to facilitate decontamination or dismantling to the same extent as would be required, under other NRC regulations, for equivalent activities. This topic may be treated again, in greater detail, in connection with the development of rules that would be generally applicable to decontamination and dismantlement of facilities at which activities subject to Commission regulatory authority are carried out.)

Issues Raised by the Commission

As noted above, the Commission specifically requested public comment on six issues, each of which will be reviewed here before turning to other considerations. These issues dealt with: (1) a single overall performance standard vs. minimum performance standards for each of the major elements of the geologic repository; (2) the need for, and appropriate duration of, a waste retrievability period; (3) the level of detail to be used in the criteria, particularly with respect to design and construction requirements; (4) the desirability of population-related siting criteria; (5) the application of an ALARA (as low as reasonably achievable) principle to the performance requirements dealing with containment and control of releases; and (6) alternative approaches on dealing with possibilities of human intrusion into the geologic repository.

Single vs. Multiple Performance Standards

The Commission identified two potentially viable approaches to assuring achievement of the desired isolation goal of controlling releases so as to assure that radioactivity in the general environment is kept to sufficiently low levels. The Commission suggested that a course that would be "reasonable and practical" would be to adopt a "defense-in-depth" approach that would prescribe minimum performance standards for each of the major elements of the geologic repository, in addition to prescribing the EPA standard as a single overall performance standard. However, as an alternative, the Commission invited comment on an approach that would specify the EPA standard as the sole measure of isolation performance.

There was general acceptance of the Commission's multiple barrier approach, with its identification of two major engineered barriers (waste packages and underground facility), in addition to the natural barrier provided by the geologic setting.

While the usefulness of multiple barriers was recognized, the establishment of fixed numerical values for performance was extensively criticized. The criticism took two forms. First, numerous commenters argued that until such time as an EPA standard is established, no logical connection can be demonstrated between the performance of the particular barriers and the overall system performance objective. The values specified by NRC, it was argued, had not been shown to be either necessary or sufficient to meet any particular standard. The second criticism was that the performance appropriate to a particular barrier is greatly dependent upon design features and site characteristics and that values such as those proposed by the Commission could unduly restrict the applicant's flexibility - possibly imposing great additional expense without compensating protection of public health and safety.

The Commission recognizes the force of both these arguments. Nevertheless, if the Commission were simply to adopt the EPA standard as the sole measure of performance, it would have failed to convey in any meaningful way the degree of confidence which it expects must be achieved in order for it to be able to make the required licensing decisions. More should be done. To that end, the Commission considers it appropriate to include reasonable generic requirements that, if satisfied, will ordinarily contribute to meeting the standards even though modifications may need to be made for some designs and locations.

The Commission's response, therefore, has been to apply, for illustrative purposes, an assumed EPA standard and to examine the values for particular barriers that would assist in arriving at the conclusion that the EPA standard has been satisfied. For this purpose, a draft EPA standard which was referred to in some of the comments has been used. A copy of this draft standard has been placed in the PDR and is also contained in NUREG-0804. Following publication of EPA's proposed standard in the Federal Register, on December 29, 1982, a supplemental evaluation was made to take into account certain departures from EPA's earlier draft. In this way, the Commission has been able to demonstrate the logical connection which it makes between the overall system performance objective for anticipated processes and events, as set out in EPA's proposed standard, and the performance of specific barriers. One of the considerations that affects its judgment in this regard is the need to take proper account of uncertainties in the performance of any of the barriers. As one commenter noted, "To provide a safety factor to compensate for this uncertainty, a multi-barrier system has many advantages. Since the Commission cannot answer the global problem and predict every possible combination of circumstances that might cause releases of waste, multiple, independent mechanisms of slowing or limiting the discharge of radioactive materials to the environment are desirable." There is nothing inconsistent between the multiple barrier, defense-in-depth approach and a unitary EPA standard; on the contrary, in view of the many possible circumstances that must be taken into account, the Commission firmly believes that the performance of the engineered and natural barriers must each make a definite contribution in order for the Commission to be able to conclude that the EPA standard will be met. The Commission's task is not only a mathematical one of modeling a system and fitting values for particular barriers into the model in order to arrive at a "bottom line" of overall system performance. The Commission is also concerned that its final judgments be made with a high degree of confidence. Where it is practical to do so, the Commission can and will expect barrier performance to be enhanced so as to provide greater confidence in its licensing judgments. Accordingly, a variance between actual and assumed EPA standards will not necessarily require a change of corresponding magnitude in the individual barrier performance requirements.

While use of an assumed EPA standard provides a basis for specifying anticipated performance requirements for individual barriers, it does not deal with the concern about undue restriction upon the applicant's flexibility. The Commission's response to this has not been to abandon the values altogether, but rather to allow them to be modified as the particular case warrants. Thus, to take one example, the Commission continues to be concerned that thermal disturbances of the area near the emplaced waste add significantly to the uncertainties in the calculation of the transport of radionuclides through the geologic environment. The proposed rule addressed this problem by providing that all radionuclides should be contained within the waste packages for a period of 1,000 years. The Commission continues to consider it important to limit the source term by specifying a containment period (as well as a release rate). But the uncertainties associated with the thermal pulse will be affected by a number of factors, such as the age and nature of the waste and the design of the underground facility. For some repositories, a period substantially shorter than 1,000 years may be sufficient to allow for some of the principal sources of uncertainty to be eliminated from the evaluation of repository performance. For cases analyzed by the Commission on the basis of specified assumptions, a range of 300 years to 1,000 years would be appropriate. (These values appear in § 60.113(a)(ii)(A)). Yet even a shorter designed containment period might be specified, pursuant to § 60.113(b), in the light of conditions that are materially different from those that had been assumed. For example, if the wastes had been processed to remove the principal heat-generating radionuclides (cesium-137 and strontium-90), the 300-years provision would not be controlling. Similarly, the Commission may approve or specify a radionuclide release rate or a pre-waste-emplacement groundwater travel time that differs from the normal values, provided that the EPA standard, as it relates to anticipated processes and events, is satisfied. Appropriate values will be determined in the course of the licensing process, in a manner sensitive to the particular case, using the principles set out in the performance objectives, without having to have recourse to the exemption provisions of the regulations.

The numerical criteria for the individual barriers included in the rule are appropriate, insofar as anticipated processes and events are concerned, in assisting the Commission to determine with reasonable assurance that the proposed EPA standard has been satisfied. It should be noted, however, that in order to meet the EPA standard as it applies to unanticipated processes and events, higher levels of individual barrier performance may be required.

<u>Retrievability</u>

The purpose of this requirement was to implement in a practical manner the licensing procedures which provided for temporal separation of the emplacement decision from the permanent closure decision. Since the period of emplacement would be lengthy and since the knowledge of expected repository performance could be substantially increased through a carefully planned program of testing, the Commission wished to base its decision to permanently close on such information. The only way it could envision this was to insist that ability to retrieve - retrievability - be incorporated into the design of the geologic repository.

The proposed rule would have required in effect that the repository design be such as to permit retrieval of waste packages for a period of up to 110 years (30 years for emplacement, 50 years to confirm performance, 30 years to retrieve). The Commission solicited comment, noting that it would not want to approve construction of a design that would unnecessarily foreclose options for future decisionmakers, but that it was concerned that retrievability requirements not unnecessarily complicate or dominate repository design.

While the benefits of retaining the option of retrieval were recognized, the length of the proposed requirement, in the opinion of several commenters, was excessive. In their view, the Commission had given inadequate consideration to the additional costs of design, construction, and operations implied in the original proposal; however, no new cost or design information was presented by the commenters.

The Commission adheres to its original position that retrievability is an important design consideration. However, in response to the concerns expressed, the Commission has decided to rephrase the requirement in functional terms. The final rule thus specifies that the design shall keep open the option of waste retrieval throughout the period during which the wastes are being emplaced and, thereafter, until the completion of a performance confirmation program and Commission review of the information obtained from such a program. By that time, significant uncertainties will have been resolved, thereby providing greater assurance that the performance objectives will be met. In particular, the performance confirmation program can provide indications whether engineered barriers are performing as predicted and whether the geologic and hydrologic response to excavation and waste emplacement is consistent with the models and tests used in the Commission's earlier evaluations. While the Commission has provisionally specified that the design should allow retrieval to be undertaken at any time within 50 years after commencement of emplacement operations, this feature is explicitly subject to modification in the light of the planned emplacement schedule and confirmation program for the particular geologic repository.

Some commenters suggested that the technical criteria specify the conditions that would require retrieval operations to be initiated. Such provisions would not belong in Subpart E, which is concerned with siting and design. Nor are they needed elsewhere. In the Commission's view, it is clear that retrieval could be required at any time after emplacement and prior to permanent closure if the Commission no longer had reasonable assurance that the overall system performance objective would be met. This situation could exist for a variety of reasons and the Commission believes that it should retain the flexibility to take into account all relevant factors and that it would be imprudent to limit the Commission's discretion by specifying in advance the particular circumstances that would make it necessary to retrieve wastes. It should be noted that DOE may elect to maintain a retrievability capability for a longer period than the Commission has specified, so as to facilitate recovery of the economically valuable contents of the emplaced materials (especially spent fuel). So long as the other provisions of the rule are satisfied this would not be prohibited. This consideration, however, plays no role in the Commission's requirement pertaining to retrievability. The Commission's purpose is to protect public health and safety in the event the site or design proves unsuitable. The provision is not intended to facilitate recovery for resource value.[4]

The Commission has also included a specific provision clarifying its prior intention that the retrievability design features do not preclude decisions allowing earlier backfilling or permanent closure. A related clarifying change has been the incorporation of a definition of "retrieval." This definition indicates that the requirement of retrievability does not imply ready or easy access to emplaced wastes at all

[4]Under the Nuclear Waste Policy Act of 1982, the Commission's technical criteria "shall include such restrictions on the retrievability of the solidified high-level radioactive waste and spent fuel in the repository as the Commission deems appropriate," Section 121(b)(1)(B). The criteria set forth in this rule represent the criteria which, for purposes of this provision, the Commission deems appropriate.

Section 122 of the Nuclear Waste Policy Act provides that, at the same time a repository is designed, DOE shall specify an appropriate period during which spent fuel could be retrieved for any reason pertaining to the public health and safety, or the environment, or for the purpose of permitting recovery of the economically valuable components of such spent fuel. The period of retrievability is subject to approval or disapproval by the Commission as part of the construction authorization process. Insofar as health and safety considerations are concerned, the Commission intends to grant such approval so long as its technical criteria are satisfied, and the Commission further intends to modify the licensing procedures to so specify.

times prior to permanent closure. Rather, the Commission recognizes that any actual retrieval operation would be an unusual event and may be an involved and expensive operation. The idea is that it should not be made impossible or impractical to retrieve the wastes if such retrieval turns out to be necessary to protect the public health and safety. DOE may elect to backfill parts of the repository with the intent that the wastes emplaced there will never again be disturbed; this is acceptable so long as the waste retrieval option is preserved.

The Commission has thus retained the essential elements of the retrievability design feature, but has provided greater flexibility in its application. The Commission recognizes that retrievability implies additional costs - more, perhaps, for some media and designs than for others - yet it believes this is an acceptable and necessary price to pay if it enables the Commission to determine with reasonable assurance, prior to an irrevocable act of closure, that the EPA standard will be satisfied.

Level of Detail

The proposed rule contained general and detailed prescriptive requirements, derived from Commission experience and practice in licensing other facilities, with respect to the design and construction of a geologic repository. The Commission noted, however, that it was continuing to examine other possibilities for promulgating the more detailed of these requirements and it invited comments on the topic.

The public response included arguments addressed both to the level of detail generally and to specific criteria which were deemed to be unduly restrictive.

The Commission has concluded that there is merit in describing, in functional terms, the principal features which should be incorporated into geologic repository design - such as protection against dynamic effects of equipment failure, protection against fire and explosions, emergency capability, etc. Certain of these proposed criteria, however, such as those dealing with subsurface ventilation and shaft and borehole seals, were excessively detailed and, in some cases, inappropriate. At this stage of development, the Commission believes it should place emphasis upon the objectives that must be met and not become unduly concerned about the particular techniques that may be used in doing so. The changes that have been made are addressed in some detail in the section-by-section analysis of the rule.

Population-Related Siting Criteria

The proposed rule did not include any siting requirements which dealt directly with population density or proximity of population centers to a geologic repository operations area. The Commission indicated its belief that a more realistic approach, given the long period of time involved, would be to address the issue indirectly through consideration of resources in the geologic setting.

The numerous comments submitted in response to the Commission's specific question on this issue fell generally into two categories - those that endorsed the proposed approach and those that argued that population factors were important. The latter group addressed not only the geologic repository's long-term isolation capability, but also the relevance of population considerations in connection with the period when wastes are being received and emplaced.

The Commission is persuaded that population factors may need to be considered in connection with the period when wastes are being received and emplaced through evaluation of the adequacy of DOE's emergency plans. That section of the safety analysis report dealing with emergency planning (see 60.21(c)(9)) will be reviewed on a case-by-case basis in the licensing process according to criteria that will be set forth in the future in Subpart I. (It should also be noted that under Section 112(a) of the Nuclear Waste Policy Act of 1982, DOE is required to develop guidelines that, among other things, will specify population factors that will disqualify a site from development as a repository. Issuance of these guidelines is subject to the concurrence of the Commission. The Commission has made no determination whether such guidelines, when issued, should in some manner be reflected in either the technical criteria or licensing procedures portions of 10 CFR Part 60.)

Population distribution over the long term is immaterial if the geologic repository operates as anticipated. Demographic factors could nevertheless be of concern to the extent that they could increase the probability or the consequences of releases associated with unanticipated processes or events. As to probability, it is difficult to relate the likelihood of releases to population factors; it is the view of the Commission that it is more realistic, as originally stated, to reduce the probability by avoiding sites with significant resource potential and by using records and monuments to caution future generations. Consequences of unanticipated releases would be greater if they should occur in densely populated areas. Nevertheless, it is the view of the Commission that it makes little sense to attempt to limit such consequences by means of a population-related siting criterion, since long-range demographic forecasts are so inherently speculative and unreliable; instead, the Commission is taking the approach that releases that result from the occurrence of unanticipated processes and events must be evaluated and must satisfy the EPA standard.

While the Commission considers, based on the above, that the rule should not now contain explicit requirements, particularly numerical limits, on population density or distance from population centers, it notes that considerations related to future human activities, particularly uses of groundwater, are an important source of uncertainty in assessing future performance of a geologic repository. The Commission would consider it a favorable condition if these sources of uncertainty, which would be affected by a large nearby population, were not present at a particular site. Therefore, the Commission has included in the final rule, as a favorable condition, a low population density within the geologic setting and a controlled area that is remote from population centers.

The Commission anticipates that the selection of a densely populated area would be unlikely even in the absence of express constraints in NRC regulations. For one thing, such a site would be disqualified under the guidelines to be developed under the Nuclear Waste Policy Act. Additionally, DOE will need to acquire interests in land within the controlled area and may have to have additional powers beyond the boundaries of the controlled area. These requirements may be difficult to satisfy unless a remote location is selected for the geologic repository.

ALARA

The notice of proposed rulemaking requested comment on "whether an ALARA (as low as reasonably achievable) principle should be applied to the performance requirements dealing with containment and control of releases." Some commenters believed that ALARA should be applied to all licensed activities, and that no exception should be made for geologic repositories. Other commenters argued against incorporating ALARA, since the allowable releases under the EPA standard would already be so low as to eliminate any significant risk to public health and safety.

Based in part upon the standard recently proposed by EPA, the Commission considers it reasonable to anticipate that the permissible amounts of radioactivity in the general environment will be established at such a low level that efforts to reduce releases further would have little, if any, demonstrable value commensurate with their costs. Accordingly, the ability of a geologic repository to perform at levels superior to the EPA standard should not be the issue in licensing proceedings. The central issue with respect to the EPA standard is whether DOE's proposal, and the data presented in its support, will enable the Commission to determine with reasonable assurance that the established EPA standard will be met. The Commission may insist upon the adoption of a variety of design features, tests, or other measures in order to be able to conclude with confidence that the EPA standard is met. The result may be the same as if the Commission were to impose similar requirements in the name of keeping releases as low as reasonably achievable. But when the Commission finds that certain measures are needed to improve confidence in dealing with uncertainties, it is making a substantial safety judgment.

The same kinds of balancing that are undertaken in ALARA determinations may be appropriate. That is, if confidence in the performance of the geologic repository is sensitive to a particular source of uncertainty, it will be in order for the Commission to take into account both the significance of the factor involved and the costs of reducing or eliminating it.

In short, the Commission has concluded that the long-term performance requirements should not be tied to an ALARA principle, and the rule remains as it was when proposed. The Commission believes the concerns of the commenters in support of the ALARA approach will be largely accommodated in connection with its treatment of uncertainties in the course of the licensing process.[5]

Human Intrusion

The Commission observed, in the preamble of the proposed rule, that everything that is reasonable should be done to discourage people from intruding into the geologic repository. Those measures which it believed to be reasonable included directing site selection toward sites having little resource value and marking and documentation of the site. Beyond that, the Commission felt there would be no value in speculating on the "virtual infinity of human intrusion scenarios and whether they will or will not result in violation of the EPA standard." The Commission explained that inadvertent intrusion was highly improbable, at least for the first several hundred years during which time the wastes are most hazardous; and even if it should occur, it is logical to assume that the intruding society would have capability to assess the situation and mitigate consequences. The Commission recognized that deliberate intrusion to recover the resource potential of the wastes could result in elevated releases of radioactivity, but concluded that the acceptability of such releases was properly left to those making the decision to undertake resource recovery operations. It noted that comment on its proposal and alternative approaches would be welcome.

[5]The proposed EPA standard calls for disposal systems to be selected and designed to keep releases to the accessible environment as small as reasonably achievable, taking into account technical, social, and economic considerations. Proposed 40 CFR § 191.14(b). The Commission's rules will accommodate the underlying concerns of EPA, as they are articulated in the preamble to the Agency's proposed standards. There EPA explains that it is concerned, as is the Commission, with assuring confidence in complying with the numerical release limits. The Commission also notes that the definition of "generally applicable environmental standards" in Reorganization Plan No. 3 of 1970 refers to limits such as those contained in proposed § 191.13 and related definitions. Accordingly, the Commission would not contemplate making any revision to its rule even if EPA were to adopt a provision such as proposed § 191.14(b). Because of the measures that will be required to address the uncertainties, the Commission fully expects that actual releases are likely to be well below the upper bounds expressed in the EPA standard.

Commenters generally accepted the approach outlined. A number of commenters did emphasize the importance of intrusion scenarios as having the potential to lead to releases of radionuclides to the environment, but they suggested no alternative means for dealing with the prospect. One commenter correctly calls attention to the possibility of a third category of intrusion - that which is "intentional yet indifferent" - which was not covered in the earlier discussion of "inadvertent" or "deliberate" intrusion. This behavior presupposes knowledge (albeit imperfect) of the existence and nature of the geologic repository and a level of technology that could be applied to remedial action as well as to the intrusion itself, yet makes no judgment as to whether a societal decision has been made concerning the intrusion. The Commission has addressed this and other concerns in the revised language that is being adopted, as explained below.

Although the discussion accompanying the proposed rule indicated that intrusion scenarios need not be considered, the rule itself was not explicit on this point. The Commission considers it necessary to clarify its position and, in doing so, allows for examination of intrusion under appropriate bounding conditions. After careful consideration of the public comments received on questions relating to human intrusion, the Commission is of the view that while the passive control-measures it is requiring will reduce significantly the likelihood of inadvertent intrusion into a geologic repository, occasional penetration of the geologic repository over the period of isolation cannot be ruled out, and some provision should be made in the final rule for consideration of intrusion should these measures fail. Its objective is to provide a means for evaluating events that are reasonably of concern, while at the same time excluding speculative scenarios that are inherently implausible. The Commission will not require this generation to design for fanciful events which the Commission has an abiding conviction will never occur; on the contrary, it will grant a license if it is satisfied that the risk to the health and safety of future generations is not unreasonable.

The rule now incorporates a definition of "unanticipated processes and events" which are reviewable in a licensing proceeding; such processes and events expressly include intrusion scenarios that have a sufficiently high likelihood and potentially adverse consequence to exceed the threshold for review. The scenarios must be "sufficiently credible to warrant consideration." The Commission is requiring that certain assumptions be made in assessing this likelihood. First, the monuments required by the rule are assumed to be sufficiently permanent to serve their intended purpose. The Commission takes this position because of its confidence that monuments can be built to survive. While it assumes that the monuments will last, it does not automatically assume that their significance will continue to be understood. Second, the Commission requires an assumption that the value to future generations of potential resources can be assessed adequately at this time. Consistent with its previously stated views, it thinks that the selection of a site with no foreseeably valuable resources could so reduce the likelihood of intrusion as to reduce, or eliminate, any further need for it to be considered. Third, the Commission requires the assumption that some functioning institutions - though not necessarily those undertaking the intrusion - understand the nature of radioactivity and appreciate its hazards. The extent of intergenerational transfer of knowledge is, of course, debatable; it is conservative, in the light of human history to date, to predict this minimal level of information and to take it into account in assessing the likelihood that intrusion will occur. Fourth, the Commission provides that relevant records are preserved, and remain accessible, for several hundred years after permanent closure. While perhaps this period could not be justified on the basis of historic precedents alone, the Commission considers the required deposit in land records and archives, together with current data handling technology, to provide a sufficient basis for assuming that information about the geologic repository will continue to be available for several hundred years.

The definition of "unanticipated processes and events" also implicitly bounds the consequences of intrusion scenarios. This is accomplished not only by the assumption of continued understanding of radioactivity and survival of records, but also by the further assumptions that if there are institutions that can cause intrusion at depth in the first place, there will also be institutions able to assess the risk and take remedial action. It need not be assumed that today's technology would be used - merely that a level of social organization and technological competence equivalent to that applied in initiating the processes or events concerned would be available to deal with the situation.

It was suggested that another way to reduce the likelihood of human intrusion would be to adopt additional design criteria for the waste form or waste package. These would prohibit, or at least discourage, the emplacement of materials which themselves might attract recovery operations - for example, operations to recover the residual energy resource value in spent fuel or scarce and expensive materials in the waste package. But, under the definition of "unanticipated processes and events" in the final rule, intrusion for such purposes would have to be reviewed in the licensing process if the particular circumstances are sufficiently credible to warrant consideration. This imposes a reasonable constraint. The Commission believes that any further limitation would unduly interfere with the flexibility of DOE as a designer and could, in the case of spent fuel disposal, conflict with other national objectives.

In summary, the Commission has retained the principle that highly speculative intrusion scenarios should not be allowed to become the driving force in license reviews, but has introduced some flexibility to permit consideration of intrusion on a case-by-case basis where circumstances warrant.

Other Principal Changes

Anticipated/Unanticipated Processes and Events

The proposed rule defined anticipated processes and events as "those natural processes and events that are reasonably likely to occur during the period the intended performance objective must be achieved and from which the design bases for the engineered system are derived." At the same time, the Commission was requiring that the facility be designed so as to assure that long-term releases conform to standards established by EPA. The statement of considerations pointed out that if the process or event is unlikely, the overall system must still limit the release consistent with the EPA standard as applied to such events. This created a contradiction because on the one hand it was stated that the design bases should be derived from anticipated processes and events while, on the other hand, the design was to meet an EPA standard as applied to what was unanticipated.

The Commission has resolved this conflict by eliminating the reference to design bases from the definition of "anticipated processes and events." It has also included a definition of "unanticipated processes and events." In the final rule, numerical performance objectives are established for particular barriers, assuming "anticipated processes and events." Such numerical criteria are not established for "unanticipated processes and events." Rather, additional requirements may be found to be necessary to satisfy the overall system performance objective as it relates to unanticipated processes and events.

It should be noted that the distinction between anticipated and unanticipated processes and events relates solely to natural processes and events affecting the geologic setting. The Commission intends that a judgment whether a natural process or event is anticipated or unanticipated be based upon a careful review of the geologic record. Such processes or events would not be anticipated unless they were reasonably likely, assuming that processes operating in the geologic setting during the Quaternary Period were to continue to operate but with the perturbations caused by the presence of emplaced waste superimposed thereon. Unanticipated processes and events would include those that are judged not to be reasonably likely to occur during the period the intended performance objective must be achieved, but which nevertheless are sufficiently credible to warrant consideration. These include processes and events which are not evidenced during the Quaternary Period or which, though evidenced during the Quaternary, are not likely to occur during the relevant time frame. Identification of anticipated and unanticipated processes and events for a particular site will require considerable judgment and will not be amenable to accurate quantification, by statistical analysis, of their probability of occurrence.[6]

[6]The Commission views the proposed EPA standard as being directed to the evaluation of releases arising out of the categories that we have defined as "anticipated processes and events" and "unanticipated processes and events." As EPA itself recognizes, there can only be estimates rather than rigorous demonstrations of probabilities of occurrence. The Commission's translation of the EPA language into qualitative terms provides a clearer basis for judging, under the Atomic Energy Act, whether there is unreasonable risk to the health and safety of the public.

Because the design basis for the engineered barrier system will be derived from the identification of anticipated and unanticipated processes and events, such identification will have a pervasive effect on the basic structure of the licensing proceedings. The Commission therefore contemplates directing that rulings made in the course of construction authorization hearings on the scope of anticipated and unanticipated processes and events be separately identified by the presiding officers and certified to the Commission for interlocutory review, pursuant to 10 CFR 2.718(i).

The license review will thus need to include a determination whether the proposed activities will meet the EPA standard as applied to anticipated processes and events and as applied to such unanticipated processes and events, if any, as have been found to warrant consideration. Each determination will be made in the light of assessments which will involve interpretation of the geologic record and consideration of credible human-induced events as bounded by the assumptions set forth above. Worst-case scenarios would be analyzed to the extent they may be encompassed by the definition of unanticipated processes and events. Complex quantitative models will need to be employed, and a wide range of factors considered in arriving at a determination of whether there is reasonable assurance, making allowance for the time period and hazards involved, that the EPA standard will be met. There are two principal elements that will go into the Commission's application of this "reasonable assurance" concept. First, the performance assessment which has been performed must indicate that the likelihood of exceeding the EPA standard is low. Second, the Commission must be satisfied that the performance assessment is sufficiently conservative, and its limitations are sufficiently well understood, that the actual performance of the geologic repository will be within predicted limits.

<u>Transuranic Waste (TRU)</u>.

The proposed rule included a definition of transuranic waste and performance objectives that would apply to the disposal of TRU in a licensed geologic repository. This was widely misconstrued as a requirement that radioactive material conforming to the definition must be disposed of in this manner. This was not the intention, nor in fact did the rule so specify. Rather, the Commission was merely indicating what performance objectives would apply if TRU were disposed of in a licensed geologic repository. Some commenters also took exception to the definition of TRU in the rule.

Whether or not a geologic repository is subject to licensing depends upon the applicability of Sections 202(3) and 202(4) of the Energy Reorganization Act of 1974. (See definition of "HLW facility.") If a facility is licensed, then the Commission must consider the radiological hazards associated with whatever wastes may be emplaced. The Commission attempted, in the proposed rule, to address the requirements for one such kind of waste - TRU. But the Commission was too restrictive, in that its definition of TRU was too limited for present purposes and in that wastes other than HLW and TRU were not covered at all. For the time being, the Commission has concluded that the matter is best handled by eliminating all references to TRU. The remaining performance objectives provide adequate guidance to deal with TRU-related issues that may arise.

The Commission has also reviewed the waste package requirements, which as originally written would have applied to all emplaced radioactive waste. It is appropriate to include such requirements for HLW, which must necessarily be disposed of in a licensed facility. Since the Commission does not know what other radioactive wastes, if any, will also be emplaced, and what their chemical, radiological, thermal, and other characteristics may be, it has decided to leave pertinent waste package requirements to be determined on a case-by-case basis as the need arises.

Siting Criteria

Although provisions relating to site characteristics have been revised, the Commission has retained the same two basic concepts. First, a site should exhibit an appropriate combination of favorable conditions, so as to encourage the selection of a site that is among the best that reasonably can be found. By referring to a "combination" of conditions, it implies that the analysis must reflect the interactive nature of geologic systems. Second, any potentially adverse conditions should be assessed in order to assure that they will not compromise the ability of the geologic repository to meet the performance objectives. It is important to recognize that a site is not disqualified as a result of the absence of a favorable condition or the presence of a potentially adverse condition. The Commission emphasizes this point here because several commenters who characterized the siting criteria as unduly restrictive failed to appreciate that the presence of potentially adverse conditions would not exclude a site from further consideration while others mistakenly assumed that favorable conditions were requirements.

The changes do not reflect any departure from the Commission's original philosophy, but they are designed to express its purpose more clearly. Thus, its interest in specifying that the geologic setting shall have exhibited "stability" since the start of the Quaternary Period was to assure only that the processes be such as to enable the recent history to be interpreted and to permit near-term geologic changes to be projected over the relevant time period with relatively high confidence. This concept is best applied by identifying, as potentially adverse conditions, those factors which stand in the way of such interpretation and projection; this is the approach the Commission has chosen to follow.

One revison is the elimination of the classification of potentially adverse conditions into one set pertaining to the "geologic setting" (corresponding to "site" in the final rule) and one set pertaining to the "disturbed zone." The Commission has determined that by defining these conditions as potentially adverse only when they occur in the site or disturbed zone, respectively, some significant factors bearing upon waste isolation may not be assessed. The Commission has changed the siting criteria, therefore, so that the presence of any of the enumerated conditions is to be regarded as potentially adverse if it applies to the controlled area and, in addition, such a condition outside the controlled area is to be regarded as potentially adverse if it may affect isolation within the controlled area .

Another change, discussed under Single vs. Multiple Performance Standards, may have the effect of increasing the importance of the geological conditions. Under the final rule, the performance objectives for the engineered barrier system (§60.113(a)(1)) may be adjusted, on a case-by-case basis, if the overall system performance objective, as it relates to anticipated processes and events, is satisfied. This feature of the final rule may provide the designer additional incentive to select the site so as to maximize its isolation capabilities.

The Commission's review of the siting criteria, as modified, has led it to conclude that the isolation capabilities of the geologic repository will be given the emphasis that they merit. This review has included a consideration of suggestions that the rule require that the slate of sites be among the best that can be found on the basis of geological factors alone and that the geologic characteristics of the site provide the highest reasonably available degree of the site's isolation capabilities. These topics are discussed below, under the heading Geologic Conditions.

A detailed review of the siting criteria is contained in the Section-by-Section Analysis.[7]

Containment

Several commenters took exception to the performance objective calling for a design of the waste packages to "contain all radionuclides" for a specified period after permanent closure. The objections were: first, that 100% performance cannot be expected in view of the very large number of containers that may be emplaced; second, that 100% performance cannot be justified as being needed in order to meet any likely EPA standard; and, third, that the adequacy of design to contain "all" radionuclides for long periods of time is not demonstrable. The commenters failed, in part, to recognize that under the specified standard of proof (see Reasonable Assurance, below), the applicant would not be forced to carry an impossible burden. Nevertheless, since the Commission does not expect proof that literally all radionuclides will be contained, the

[7]Under Section 112(a) of the Nuclear Waste Policy Act of 1982, DOE is required to develop guidelines for the recommendation of sites for repositories. Among other things, such guidelines are to "specify detailed geologic considerations that shall be primary criteria for the selection of sites in various geologic media." Issuance of these guidelines is subject to the concurrence of the Commission. The Commission has made no determination whether such guidelines, when issued, should in some manner be reflected in either the technical criteria or licensing procedures portions of 10 CFR Part 60.

performance objective now requires design so that containment of HLW within the high-level waste packages will be "substantially complete" for the specified period.

Terminology

Several commenters criticized, as vague or confusing, the terms used by the Commission to describe the various geographical locations that are addressed by the rule. There are many such locations--and there must be--because the Commission must deal with different concerns during site characterization, during operations, and after permanent closure. The Commission has nevertheless attempted to clarify the terms. In addition to the significant changes reviewed here, see also the discussion in the Section-by-Section Analysis.

Accessible Environment/Controlled Area. The isolation capability of a geologic repository is evaluated at a boundary which the Commission has referred to as the "accessible environment." Under the proposed rule, this was defined as "portions of the environment directly in contact with or readily available for use by human beings." Several commenters criticized this definition as being excessively vague; further, the definition failed to assure that the isolation capability of the rock surrounding the underground facility would be given appropriate weight in licensing reviews.

The Commission agrees with the criticism and has revised the definition in several respects--most importantly by excluding from the accessible environment that portion of the lithosphere that is inside what the Commission is calling, in the final rule, a "controlled area." This is an area marked with monuments designed to caution future generations against subsurface penetrations. The size and shape of the controlled area will depend upon the characteristics of the particular geologic repository, but it must be small enough to justify confidence that the monuments will effectively discourage subsurface disturbances. The Commission has therefore limited the size of the controlled area so that it extends no more than 10 kilometers from the emplaced waste. The term "accessible environment" also appears in the proposed EPA standard. The Commission has used the EPA language as a starting point--for example, in specifying the surface locations that are part of the accessible environment. But there is an important difference between the two definitions, in that EPA includes in the accessible environment only those parts of the lithosphere that are more than 10 kilometers from the emplaced waste, whereas NRC may include parts of the lithosphere that are less than 10 kilometers from the emplaced waste, depending on the extent of the "controlled area" for a geologic repository. In other words, the accessible environment may be larger under 10 CFR Part 60 than might be the case under the proposed EPA Standard. The two definitions are nevertheless consistent in the sense that if the isolation requirements are satisfied at the boundary of the accessible environment specified by 10 CFR Part 60, they will necessarily be satisfied at the boundary defined by EPA as well.

Both technical and legal considerations have influenced the Commission's decision not to adopt an unqualified 10-kilometer standard. The technical consideration is that uncertainties about activities that may be undertaken in the area outside the controlled area are so great that the Commission would not be warranted in giving credit to the isolation capability of the undisturbed lithosphere there. The legal consideration is that the standards established by EPA are to apply outside the boundaries of locations controlled by NRC licensees, and in the context of 10 CFR Part 60 this refers most appropriately to the "controlled area" as defined by the regulation. The Commission believes that the final rule is fully responsive to the concerns of the commenters while conforming as well to the policies underlying EPA's proposed standard.

Geologic Setting. The proposed rule limited this term to systems that provide isolation of the waste. This is too restrictive a definition to cover the wider region of interest which the Commission seeks to encompass by "geologic setting." The definition has accordingly been extended to include the geologic, hydrologic, and geochemical systems of the region in which a geologic repository operations area is or may be located.

Site. "Site" had been defined in the proposed rule as being equivalent to "geologic setting." This was appropriate where geologic setting referred to an area having isolation capability. In the final rule, isolation is to be provided within a controlled area rather than within the geologic setting and accordingly "site" now refers to the location of this controlled area.

Decommissioning. As used in the proposed technical criteria, the term "decommissioning" was intended to apply to that stage at which the underground facility was closed and shafts and boreholes were sealed. It was these activities that were addressed in § 60.51, "License amendment to decommission." This intention is better expressed by employing the term "permanent closure." Several commenters on the proposed rule expressed the opinion that including the requirement for dismantlement of all surface facilities in the definition of the term "decommissioning" may be unnecessary and overly restrictive. Upon consideration of these comments the Commission believes that where there is a need to refer to decontamination or dismantlement of surface facilities, this can readily be done without referring to "decommissioning."

Accordingly, references to "decommissioning" with one exception (see §60.132(e)), have been deleted from the rule, and the language now refers to "permanent closure" or to "decontamination or dismantlement of surface facilities," as appropriate.

Important to Safety. In past NRC usage, the term "important to safety" has only been defined qualitatively (e.g., 10 CFR Part 50, App. A). In response to public comments on Part 60, the NRC staff has adopted a numerical criterion for determining which structures, systems and components are important to safety. Structures, systems, and components are important to safety if, in the event they fail to perform their intended function, an accident could result which causes a dose commitment greater than 0.5 rem to the whole body or any organ of an individual in an unrestricted area. The value of 0.5 rem is equal to the annual dose to the whole body of an individual in an unrestricted area that would be permitted under 10 CFR Part 20 for normal operations. The definition that has been adopted defines as important to safety, therefore, any system, structure or component whose failure to operate as intended could result in an annual dose commitment to an individual in an unrestricted area in excess of what would be permitted for normal operations of certain other activities licensed by NRC. Such systems, structures, and components would be subject to additional design requirements and to a quality assurance program to ensure that they performed their intended functions. This conservative approach is possible because, as noted by several commenters, the materials received and possessed at a HLW facility will be in a form, and the operations that are carried out will be of a nature, that little potential exists for large releases of radioactive materials to unrestricted areas. The choice of 0.5 rem in this instance should not be construed as implying that it would be appropriate if applied to any other types of activities subject to regulation by the Commission.

The term "important to safety" has traditionally been linked to structures, systems, and components which must operate under accident conditions in a manner that will prevent serious offsite consequences. The proposed rule inappropriately referred to structures, systems, and components which must operate to meet the performance objectives--including those pertaining to long-term isolation under anticipated conditions--as being "important to safety." The effect of this was to extend accident-related design criteria to elements not subject to relevant kinds of accidents. Design criteria related to isolation are important, and are included, but not because the structures, systems, and components in question are "important to safety" in the traditional sense.

"Important to safety" is also important in defining the actions that are necessary elements of a quality assurance program. For a geologic repository, however, quality assurance must be extended to structures, systems, and components important to waste isolation. Since, for the reasons discussed above, these concerns are no longer encompassed by the term "important to safety," the quality assurance provisions have been amended to apply to structures, systems, and components "important to waste isolation" as well.

Other Principal Comments

These issues raised by commenters merit discussion here even though they have resulted in no change to the rule.

Comparative Safety Analyses

Several commenters took exception to the proposed requirement that the safety analysis report include a comparative evaluation of alternatives to the major design features that are important to radionuclide containment and isolation, [now termed "important to waste isolation"], on the ground that a safety analysis should be directed at the specific design being proposed. As a general principle, the commenters are correct. In the context of licensing activities at a geologic repository operations area, however, the Commission thinks it is well within its discretion to seek the requested information. If the Commission finds, on the basis of its review, that the adoption of some alternative design feature would significantly increase its confidence that the performance objectives would be satisfied, and that the costs of such an approach are commensurate with the benefits, it should not hesitate to insist that the alternative be so adopted. This is consistent with the views expressed above in the discussion of the ALARA principle and, also, with the provisions of the revised performance objectives which contemplate that the performance objectives for particular barriers are subject to modification, on a case-by-case basis, as needed to satisfy applicable EPA standards.

Unsaturated Zone.

The Commission had explained that the proposed criteria were developed for disposal in saturated media, and that additional or alternative criteria might need to be developed for regulating disposal in the unsaturated zone. Accordingly, the performance objective for the engineered barrier system (proposed § 60.113(b)(2)(i)) was written so as to require the assumption of full or partial saturation of the underground facility and the favorable and potentially adverse conditions concerned only siting in the saturated zone.

This approach was criticized on the basis that disposal in the unsaturated zone was a viable alternative, and that since the criteria were generally applicable without regard to the possibility of saturation, their scope and applicability should not be unduly restricted. The Commission has reviewed the criteria in the light of the comments and finds this criticism to be well-founded. Although the criteria as written are generally appropriate to disposal in both the saturated zone and the unsaturated zone, some distinctions do need to be made. Rather than promulgating the criteria which will apply to the unsaturated zone at this time, the Commission will shortly issue such criteria in proposed form so as to afford a further opportunity for public comment. However, those criteria that are uniquely applicable to the saturated zone are so indicated.

Geologic Conditions

One commenter recommended that the rule should require that the slate of sites characterized by DOE be among the best that can reasonably be found on the basis of geological factors alone. The Commission did indicate, when it adopted licensing procedures, that the site characterization requirements will assure that DOE's preferred site will be chosen from a slate of sites that are among the best that reasonably could be found. The standard proposed by the commenter is quite different. The Commission intended that DOE should be able to take into account a variety of non-geological considerations in its screening process. It could properly exclude such locations as (1) areas, such as national parks and wilderness, devoted to other paramount uses, (2) locations which would be subject to unusually severe environmental and socioeconomic impacts, and (3) locations where necessary surface, mineral, and water rights may be obtainable only at great expense and with severe dislocating effects on residents. The Commission considers the rule, as written, properly conveys its meaning on this score.

The same commenter urged it to require a demonstration that the geologic characteristics of the chosen site provide the highest reasonably achievable degree of enhancement of the waste isolation capabilities of the geologic repository. Again, the Commission declines to accept the suggestion. In the first place, it anticipates that DOE would on its own initiative strive to maximize isolation capabilities in order to demonstrate more conclusively the facility's compliance with the performance objectives and other technical criteria. Beyond this, however, the Commission believes the proposal could have undesirable and unintended consequences. Maximizing isolation capabilities could dictate development at one particular location instead of at another a few miles away; this could result in the same kind of adverse environmental or other effects as were described above. Furthermore, adherence to the proposed standard could unduly interfere with, or increase the cost of, achievement of other goals, such as maintenance of retrievability, providing for worker safety, etc.

There were other related comments which argue that the Commission's approach places too great an emphasis on engineered barriers and provides insufficient incentive to select a site with optimal geologic and hydrologic characteristics. The Commission considers both engineered and natural barriers to be important, and it has structured the technical criteria in a manner that demands not only the use of advanced engineering methods, but also selection of a site with excellent isolation capabilities. As explained in the discussion of Reasonable Assurance, below, uncertainties in the models used in the analysis of repository performance must be considered in the Commission's deliberations on the issuance of a construction authorization or license. Selection of a site with favorable geologic conditions will greatly enhance the Commission's ability to make the prescribed findings. Moreover, since the final rule provides flexibility for the Commission to approve or specify performance objectives for the engineered barriers on a case-by-case basis, the applicant is afforded still a further incentive to pick a site in which the host rock has favorable geochemical characteristics or in which other particular sources of uncertainty about hydrogeologic conditions are substantially reduced. But in any event, the Commission anticipates that a high standard of engineering will be necessary -- not only to compensate for geologic uncertainties at even the best reasonably available sites, but perhaps also to mitigate the consequences of unanticipated processes and events (including potential intrusion) during the years when fission product inventories remain high.

Although the Commission agrees with the underlying appraisal of the commenters that the isolation capabilities of the site play a key role in assuring that the performance objectives will be met, it finds no reason to change the rule's basic approach.

Reasonable Assurance

The proposed rule stated that with respect to the long-term objectives and criteria under consideration, "what is required is reasonable assurance, making allowance for the time period and hazards involved, that the outcome will be in conformance with those objectives and criteria." A number of commenters took exception to this formulation on the ground that it provides inadequate guidance as to the required level of proof. Others were concerned that "reasonable assurance" was too weak a test and that the Commission should not license DOE activities without a "high degree of confidence" that releases would be very small. Some commenters suggested that a statistical definition of acceptability should be employed. For the reasons set forth below, the Commission has not modified the language.

In the Commission's view, the "reasonable assurance" standard neither implies a lack of conservatism nor creates a standard which is impossible to meet. On the contrary, it parallels language which the Commission has applied in other contexts, such as the licensing of nuclear reactors, for many years. See 10 CFR 50.35(a) and 50.40(a). The reasonable assurance standard is derived from the finding the Commission is required to make under the Atomic Energy Act that the licensed activity provide "adequate protection" to the health and safety of the public; the standard has been approved by the Supreme Court. Power Reactor Development Co. v. Electrical Union, 367 U.S. 396, 407 (1961). This standard, in addition to being commonly used and accepted in the Commission's licensing activities, allows the flexibility necessary for the Commission to make judgmental distinctions with respect to quantitative data which may have large uncertainties (in the mathematical sense) associated with it.

The Commission has not modified the language, but has explained elsewhere (see Anticipated/Unanticipated Processes and Events, above) how the concept will be applied. The Commission expects that the information considered in a licensing proceeding will include probability distribution functions for the consequences from anticipated and unanticipated processes and events. Even if the calculated probability of meeting the

Commission's standards is very high that would not be sufficient for the Commission to have "reasonable assurance"; the Commission would still have to assess uncertainties associated with the models and data that had been considered. This involves qualitative as well as quantitative assessments. The Commission would not issue a license unless it were to conclude, after such assessments, that there is reasonable assurance that the outcome will in fact conform to the relevant standards and criteria.

It is important to keep in mind this distinction between, first, a standard of performance and, second, the quality of the evidence that is available to support a finding that the standard of performance has been met. In principle, there is no reason why the first of these - the performance standard - cannot be expressed in quantitative terms. The rule does this in several places - notably, in including as performance objectives a designed containment period, a radionuclide release rate, and a pre-waste-emplacement groundwater travel time. Similarly, EPA's standard will establish limits on concentrations or quantities of radioactive material in the general environment.

Expressing a requisite level of confidence in quantitative terms is far more problematical. To be sure, measurement uncertainties are amenable to statistical analyses. Even though there may be practical limitations on the accuracy and precision of measurements of relevant properties, it is possible to make some quantitative statement as to how well these values are known. The licensing decisions which the Commission will be called upon to make involve additional uncertainties - those pertaining to the correctness of the models being used to describe the physical systems - which are not quantifiable by statistical methods. Conclusions as to the performance of the geologic repository and particular barriers over long periods of time must largely be based upon inference; there will be no opportunity to carry out test programs that simulate the full range of relevant conditions over the periods for which waste isolation must be maintained.

The validity of the necessary inferences cannot be reduced, by statistical methods, to quantitative expressions of the level of confidence in predictions of long-term repository performance. Similarly, 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 the light of accepted physical principles; but, having done so, the Commission must make a judgment whether it has reasonable assurance that the actual performance will conform to the standards the Commission has specified in this rule.

It should also be borne in mind that the factfinding process is an administrative task for which the terminology of law, not science, is appropriate. The degree of certainty implied by statistical definition has never characterized the administrative process. It is particularly inappropriate where evidence is "difficult to come by, uncertain or conflicting because it is on the frontiers of scientific knowledge." Ethyl Corp. v. EPA, 541 F.2d 1, 28 (D.C. Cir. 1976).

Population vs. Individual Dose

Some commenters noted that the performance objectives are derived from an assumed EPA standard that is based upon consideration of doses to populations as a whole rather than to the maximally exposed individual. Several other analyses of repository design have examined prospective requirements in terms of keeping individual doses below specified values, and as a consequence have led to different conclusions. The differences represent a source of potential uncertainty regarding the overall goal for safety performance. However, the resolution of this question is a matter within the province of EPA. The Commission has assumed that the EPA approach will be based upon population dose, since that is the direction reflected in its working documents and its recently proposed standard. The Commission's rule, especially as modified to allow performance objectives for particular barriers to be adapted in the light of the EPA standard, can be applied whether the overall safety goal is expressed in terms of total releases to the environment or in terms of maximum dose to an individual or maximum concentration at any place or time.

If EPA were to establish a standard based upon individual doses, the Commission would review the provisions dealing with the content of the license application (§ 60.21) so as to develop requirements for any additional analyses that might be needed to evaluate site-specific pathways for released radionuclides to reach humans.

Long-Term Post-Closure Monitoring

Several of the commenters suggested that the performance confirmation program be required to be continued for as long as one thousand years after permanent closure of the underground facility. The Commission considers such measures unnecessary and unlikely to provide useful information on the performance of a geologic repository. The multiple barrier approach the Commission has adopted will result in containment of substantially all of the radioactive materials within the waste packages for centuries after permanent closure, the feasibility of obtaining reliable data on subsurface conditions over a period of centuries is questionable, and the practicality of taking remedial action after sealing of the shafts is doubtful. Moreover, the emplacement of remote subsurface monitoring instruments and the provision of data transmission capabilities, could provide additional pathways for release that would make it more difficult to achieve isolation. Rather, the Commission has adopted an approach where the retrievability option is maintained until a performance confirmation program can be completed that will allow the Commission to decide, with reasonable assurance, that permanent closure of the facility, with no further active human intervention with the emplaced wastes, will not cause an unreasonable risk to public health and safety. See also, Retrievability, above.

Section-by-Section Analysis

The final rule included numerous changes that reflect the considerations discussed above. Other changes, not involving significant policy issues, have also been incorporated in the final rule. The following section-by-section analysis identifies the changes from the proposed rule and includes an appropriate explanation for the revisions not previously discussed. Principal references are to the text of the final rule.

Where the counterpart provision of the proposed (or procedural) rule appeared in a different place, that citation is given in brackets.

§ 60.2 Definitions.

"Accessible environment." See Accessible Environment/Controlled Area, above.

"Anticipated processes and events." See Anticipated/Unanticipated Processes and Events, above.

"Candidate area." This term is unchanged, but will be considered again in connection with the Commission's review of the licensing procedures in the light of the Nuclear Waste Policy Act.

"Controlled area." New. See Accessible Environment/Controlled Area, above.

"Decommissioning." Deleted. See Decommissioning, above.

"Disposal." The undefined term "biosphere" has been changed to "accessible environment." As used in these rules, "isolation" refers specifically to radioactive materials entering the accessible environment. The definition here is related to the concept of isolation rather than to the concept of emplacement, as in Section 2(9) of the Nuclear Waste Policy Act; the Commission believes that in each instance the term is defined in a manner appropriate to its context, and that the differences in the definitions will not result in confusion or conflict.

"Disturbed zone." The term "disturbed zone" has been modified to relate changes in the physical or chemical properties of the controlled area to the performance of the geologic repository.

"Engineered barrier system." Formerly "engineered system." This clarifying change reflects the fact that shaft and borehole seals, though engineered, are not part of the system that is being referred to. The

Commission considers this definition to be synonymous with the term "engineered barriers" which appears at Section 2(11) of the Nuclear Waste Policy Act of 1982.

"Far field." The term "far field" has been deleted from the rule. Therefore, the definition is no longer necessary.

"Floodplain." Deleted. This definition was taken from Executive Order 11988, which relates to environmental consequences of occupancy and modification of floodplains. Those effects need to be considered as part of the Commission's environmental review, but they do not implicate the radiological concerns that are addressed in Part 60. The term "floodplain" still appears in §60.122(c)(1). However, rather than establishing any particular frequency as the means for defining its extent, the Commission will allow the factors specified in §60.122(a)(3) to be used in assessing the significance of flooding, whenever it may occur.

"Geologic repository." Clarifying change, to bring the terminology into line with common usage. The new definition includes only that portion of the geologic setting that provides isolation - not the entire geologic setting. The term, as defined, is considered to be synonymous with "repository" as defined at Section 2(18) of the Nuclear Waste Policy Act.

"Geologic setting." See Terminology, above. The phrase "spatially distributed" was superfluous and has been deleted.

"High-level radioactive waste." The Nuclear Waste Policy Act distinguishes between "high-level radioactive waste" and "spent nuclear fuel." These technical criteria are applicable equally to both categories. Accordingly, no change in the definition of high-level radioactive waste is required at this time.

"Important to safety." See "Important to Safety," above.

"Medium" or "geologic medium." Deleted. For the sake of clarity, the term "medium" is now replaced by "geologic medium" throughout the rule. Since the term "geologic medium" should be sufficiently clear to the professional community, it no longer appears necessary to define it.

"Overpack." This term has been deleted. Because the overpack could be a component of the waste package, it was included in the definition of the term "waste package." However, this term is not used in the final rule.

"Performance confirmation." The final rule's performance objective with respect to retrievability of the waste refers to the completion of a performance confirmation program and Commission review of the information obtained from such a program. The addition of this definition is intended to clarify the intended purpose of the performance confirmation program.

"Permanent closure." New. See Decommissioning, above.

"Restricted Area." New. See Important to Safety, above.

"Retrieval." New. See Retrievability, above.

"Saturated zone." New. Since the performance objectives in the final rule specifically refer to disposal in the saturated zone, a definition derived from Water Supply Paper 1988 (U.S.G.S., 1972) has been included.

"Site." See Terminology, above.

"Stability." Deleted. See Siting Criteria, above. Also, Section by Section Analysis, § 60.113, below.

"Subsurface facility." Deleted. Both "subsurface facility" and "underground facility" were defined in the proposed rule. The use of the two closely similar terms resulted in some confusion. "Subsurface facility" has been deleted and replaced (see definition of "Permanent closure") by explicit reference to shafts and boreholes, as well as the underground facility, where appropriate.

"Transuranic wastes." Deleted. See Transuranic Waste, above.

"Unanticipated processes and events." New. See Human Intrusion, above.

"Waste form." Clarifying change to bring terminology into line with common usage.

"Waste package." Revised. Commenters questioned the clarity of this proposed definition and one commenter suggested an alternative definition. One commenter misinterpreted the proposed definition to require that the outermost component of the waste package be an airtight, watertight sealed container. The revised definition no longer uses the terms "discrete backfill" or "overpack," which were ambiguous. To the extent that absorbent materials or packing are placed around a container to protect it from corrosion by groundwater, or to retard the transport of radioactive material to the host rock, these materials would be considered part of the waste package. However, while the final rule no longer imposes a requirement for an airtight, watertight, sealed container as part of the waste package, the Commission believes it likely that DOE will incorporate such a component into the design of the waste package in order to meet the performance objectives for the engineered barrier system for the period following permanent closure. The related terms "disposal package" and "package," as defined at Section 2(10) of the Nuclear Waste Policy Act, include unspecified overpacks; for purposes of the Commission's rules, and specifically in connection with the performance objective set out at Section 60.113(a)(1)(ii)(A), a more precise definition is needed. The differences in the definitions will not, in the judgment of the Commission, result in confusion or conflict.

"Water table." New. Required because the term appears in the definition of "saturated zone." The definition is derived from Water Supply Paper 1988 (U.S.G.S., 1972).

§ 60.10 Site characterization.

One amendment clarifies the point that investigations shall be conducted in such a manner as to limit adverse effects; the original language could have been construed to mean that the purpose of the investigations was to limit such effects. The provision calling, as a minimum, for the selection of borehole locations to limit subsurface penetrations was said to be confusing; the revision, which expresses the Commission's intention more clearly, includes a phrase that emphasizes that the number of penetrations must be adequate to obtain needed site characterization data. References to the "repository" have been replaced by terms that are more appropriate in their context.

§ 60.11 Site characterization report.

The ambiguous term "repository" has been replaced by defined terms ("geologic repository operations area" and "geologic repository") as appropriate in the context (in § 60.11(a)(6)(ii)).

§ 60.21 Content of application.

§ 60.21(c)(1)

Proposed § 60.21(c)(1) called for information regarding subsurface conditions "in the vicinity of the proposed underground facility." This has been clarified to refer to the controlled area and to other areas to the extent that subsurface conditions there may affect isolation within the controlled area.

§ 60.21(c)(1)(i)

The requirement for analysis of potential pathways has been extended to include "potentially permeable features" whether or not they are, as stated in the proposed rule, "permeable anomalies." Whether the feature is actually permeable or anomalous is not the point; what matters is the potential permeability.

The adjective "bulk," as applied to geomechanical, hydrogeologic, and geochemical properties, has been deleted as ambiguous and confusing.

§ 60.21(c)(1)(ii)(A)

Clarifying change to include analysis of climatology as well as meteorology.

§ 60.21(c)(1)(ii)(B) [§ 60.123(b)]

This paragraph concerns analyses of the favorable and potentially adverse conditions listed in § 60.122. The addition of language pertaining to the depth and breadth of investigations assures that the information needed to analyze these conditions will be available for NRC review. This is a modification of proposed §60.123(b) for conduct of such investigations. The modification ties the extent of investigations to effects of potentially adverse conditions on waste isolation within the controlled area, rather than to specified distances, as originally proposed.

§ 60.21(c)(1)(ii)(C)

References to "expected" performance and releases have been deleted from § 60.21(c)(1)(ii)(C) because, as revised, the evaluation must also take into account the assumed occurrence of unanticipated processes and events. Since the performance objectives provide for consideration of unanticipated processes and events, relevant information must be included in the safety analysis report. The evaluation is limited to periods after permanent closure, as the option to retrieve the wastes is available earlier.

§ 60.21(c)(1)(ii)(D) [§ 60.21(c)(3)(iii)]

This paragraph reflects text that formerly was in § 60.21(c)(3). The latter paragraph relates to structures, systems, and components "important to safety." The term "important to safety," as used in the final rule, pertains to the period of operations. Because the requirement for evaluating the effectiveness of the barriers was directed to questions regarding containment and isolation, it was relocated so as to place it in the proper context.

§ 60.21(c)(1)(ii)(E) [§ 60.21(c)(1)(ii)(D)]

This paragraph, as proposed, was duplicative insofar as it related to performance of the geologic repository after permanent closure. It has therefore been revised so as to pertain solely to identification of structures, systems, and components important to safety. [As in § 60.21(c)(1)(ii)(C) reference to "expected" has been deleted as confusing.]

§ 60.21(c)(1)(ii)(F) [§ 60.21(c)(1)(ii)(E)]

This paragraph has been revised to require that analyses and models used to predict future conditions and changes in the geologic setting be "supported by" rather than "confirmed by" an appropriate combination of methods such as enumerated in the rule. Such support concerns not only the reliability of the codes themselves, but also the representativeness of the models with respect to the physical conditions of the site. The Commission recognizes that confirmation, in the strict sense, is not achievable. The term "field verified laboratory tests" has been clarified to read "laboratory tests which are representative of field conditions."

§ 60.21(c)(4)

Section 60.21(c)(4) has been amended to reflect the limitation on the scope of "important to safety." The footnote reference to 10 CFR Part 50 has been deleted because of the cross-reference contained in Subpart G.

§ 60.21(c)(8)

Section 60.21(c)(8) required a description of controls to restrict access. After permanent closure, monuments will be an important control. The paragraph has been amended to require that a conceptual design of such monuments be provided.

§ 60.21(c)(9) and § 60.21(c)(11)

Conforming changes required by elimination of the term "decommissioning."

§ 60.21(c)(13)

The changes in this paragraph reflect the revised definitions of "geologic setting," "site," "geologic repository," and "disturbed zone." No substantive change is intended.

§ 60.21(c)(14)

Conforming change reflecting limitation of "important to safety" to concerns related to the period of operations.

§ 60.21(c)(15)(i)

Editorial change limiting information on DOE organizational structure to that which pertains to construction and operation of the geologic repository operations area.

§ 60.21(c)(15)(ii)

Conforming change from quality assurance "program" to "organization"; and consistent with changes to §60.21(c)(4).

§ 60.21(c)(15)(vii)

Conforming change required by elimination of the term "decommissioning."

§ 60.21(c)(15)(viii)

Conforming change reflecting limitation of "important to safety" to concerns related to the period of operations.

§ 60.22 Filing and distribution of application.

Section 60.22(a) has been revised to conform to § 60.3(a). In both places, the rule now refers to receipt and possession of source, special nuclear, and byproduct material "at a geologic repository operations area."

The reference in § 60.22(d) to "geologic repository" has also been changed to "geologic repository operations area", as the latter term is a more precise designation of the HLW facility that is the subject of the proposed licensing action.

§ 60.31 Construction authorization.

The overall safety finding is related to the "geologic repository operations area" because that term refers to the HLW facility subject to NRC licensing authority. [This is also the reason for the change in § 60.31(a)(1)(ii).] In order to assure that the relevant features of the controlled area are considered in arriving at this finding, § 60.31(a)(2) now specifically refers to consideration of the "geologic repository." Because siting and design criteria are supplemental to performance objectives in Subpart E, § 60.31(a)(2) has been amended to provide for evaluation of the geologic repository's compliance with the performance objectives as well. The reference to Subpart F has been deleted; that subpart, which pertains to DOE's performance confirmation program, is now referenced in § 60.74.

§ 60.32 Conditions of construction authorization.

The change of "site data" to "data about the site," in § 60.32(b), is a clarifying editorial amendment.

In § 60.32(c), "repository" has been replaced by the defined term "geologic repository." The restrictions that may be imposed under this paragraph can include measures to prevent adverse effects on the geologic setting as well as measures related to the design and construction of the geologic repository operations area.

§ 60.43 License specifications.

Section 60.43(b)(3) has been clarified by substituting "host rock" for the ambiguous and undefined term "storage medium" that previously appeared.

Section 60.43(b)(5) has been amended to require that license conditions include items in the category of controls related to the controlled area rather than the geologic repository operations area. This is a conforming change, which is made possible by the new definition of "controlled area" as an area which may extend beyond the boundaries of the geologic repository operations area. However, since additional controls may be needed outside of the controlled area (see § 60.121), the provision is not limited to the controlled area alone. Under 10 CFR Part 20 and this part, the licensee will have to establish restricted areas for purposes of assuring radiological protection during the period of operations, but this will not necessarily require the incorporation of specific conditions in the license. (See 10 CFR § 50.36, a corresponding provision in the Commission's facility licensing regulations.)

§ 60.46 Particular activities requiring license amendment.

Section 60.46(a)(3) has been amended for the reasons stated in the discussion of § 60.43(b)(5), to refer to the controlled area. This requirement would continue to be applicable even after permanent closure unless and until the license is terminated pursuant to § 60.52.

Section 60.46(a)(6). See Decommissioning, above.

A conforming change has been made to § 60.46(a), "Particular activities requiring license amendment," which adds a new paragraph (a)(7) to make clear that any activity involving an unreviewed safety question requires a license amendment. In its proposed form § 60.46(a) could have been read to require a license amendment only for the six specific activities listed. While the enumerated activities are quite broad and may well include any change involving an unreviewed safety question, the conforming language is intended to make this point explicit. It is of course clear that an amendment would also be necessary to accomplish a change in the license conditions incorporated in the license. (The revision in no way affects the authority of DOE, under § 60.44(a)(1), without prior Commission approval, to make changes, tests, or experiments that involve neither a change in the license conditions incorporated in the license nor an unreviewed safety question.)

§ 60.51 License amendment for permanent closure.

Conforming changes have been made to refer to "permanent closure" instead of "decommissioning." See Decommissioning, above.

The area required to be identified is now stated to be the "controlled area" because that encompasses the region in which waste isolation is required.

The significance of preserving information is discussed in the section on Human Intrusion, above. To assure complete recording of the location of the geologic repository, the Commission has now provided for information to be placed in land record systems as well as archives; this better reflects its original intention. It also includes a reference to State government agencies in order to further assure comprehensiveness. It is not the Commission's intention to require that any new systems or archives be created, but only that those that are available and appropriate should be employed. A further modification expresses the intention that information concerning the detailed location of the underground facility and boreholes and shafts, as well as the boundaries of the controlled area, must be recorded.

In § 60.51(a)(4), the undefined phrase "emplacement media" has been changed to "host rock."

§ 60.52 Termination of license.

Conforming changes. See Decommissioning, above.

Subpart D - Records, Reports, Tests, and Inspections.

There are two substantive changes in Subpart D. First, the specification of required construction records has been determined to be more appropriately included here rather than in the design criteria in Subpart E. Editorial changes, including renumbering of sections, have been made to accomplish this. Second, the final rule now requires not only that the geologic repository operations area be designed so as to permit implementation of a performance confirmation program but, as the Commission had originally intended, that such a performance confirmation program should actually be required to be carried out.

§ 60.71 General recordkeeping and reporting requirement.

Paragraphs (a) and (b) have been retained. Paragraph (c) is moved to § 60.73. The caption has been changed because records and reports are now treated in §§ 60.71-60.73, rather than § 60.71 alone.

§ 60.72 Construction records [§ 60.134(c)].

Transferred from Subpart E. Survey records are to cover "underground facility excavations, shafts, and boreholes" rather than "underground excavations and shafts." This makes the inclusion of borehole records explicit. A clarifying amendment was made to indicate that the records must include a description of materials encountered rather than the materials themselves.

§ 60.73 Reports of deficiencies [§ 60.71(c)].

Renumbered. The change of "site characteristics" to "characteristics of the site" is editorial.

§ 60.74 Tests. [§ 60.72].

A new paragraph (§ 60.74(b)) of a clarifying nature has been added which requires tests carried out under this section to include a performance confirmation program carried out in accordance with Subpart F of this part. The proposed rule inadvertently did not require such a program, merely a description of one.

§ 60.75 Inspections. [§ 60.73]

References to "site" have been changed to "geologic repository operations area" or "location" where appropriate. See Terminology.

Subpart E - Technical Criteria

§ 60.101 Purpose and nature of findings

A change has been made to § 60.101(a)(2) with respect to evaluations of performance of the engineered barrier systems and geologic media. The point that is being made is that the further into the future one must project, the greater the uncertainties will be. The Commission did not mean to suggest that the specific period of a thousand years is especially significant; the more general "many hundreds of years" specified in the final rule better expresses the Commission's intent.

A sentence has been added to § 60.101(a)(2) that emphasizes that demonstration of compliance with long-term performance objectives and criteria will involve the use of data from accelerated tests and suitably supported predictive models.

A reference to "repository" in § 60.101(b) has been changed to "geologic repository operations area" to conform with a parallel change in § 60.31.

§ 60.102 Concepts.

An introductory paragraph has been added to explain the purpose of this section and to indicate that it is subordinate to the definitions contained in § 60.2.

See Transuranic Waste (TRU), above, with respect to the deletion of the reference to TRU.

The section on Terminology, above, explains changes affecting the terms "accessible environment," "controlled area," "geologic setting," and "site." These changes are reflected in amended § 60.102(c). The reference to the host rock was deleted so as to avoid any implication that other characteristics of the geologic setting might not, where appropriate, also receive "particular attention."

See Decommissioning, above, for an explanation of the change in the discussion of "permanent closure." Because activities unrelated to waste isolation may continue at the geologic repository operations area after permanent closure, the last sentence of § 60.102(d) has been deleted.

The treatment of containment and isolation has been consolidated in light of changes made in the performance objectives. The reference to assessment of uncertainties instead of prediction of consequences takes into account the need to compensate for a broader range of factors, such as identification of the events which are to be considered in the license review. See Reasonable Assurance and Anticipated/Unanticipated Processes and Events, above. A second reason for the change stems from a commenter's criticism of the statement that consequences of events are "especially difficult to predict rigorously" early during the life of a repository; on the contrary, he suggested, consequences would be more difficult to predict over longer periods of time. The matter need not be resolved in those terms. The point the Commission was trying to make is that containment measures are appropriate to compensate for the uncertainties involved in assessing radionuclide transport in the presence of high radiation and thermal levels.

The respective contributions of the engineered barrier system and the geologic setting to the achievement of isolation are highlighted in a new sentence. Other changes are made to conform with revised definitions. See analysis of § 60.2.

PERFORMANCE OBJECTIVES

§ 60.111 Performance of the geologic repository operations area through permanent closure. [§ 60.111(a)].

The provisions of §60.111(a) dealing with radiation protection and releases of radioactive material for the period through permanent closure of the underground facility are unchanged in substance from the proposed rule. The paragraph has been renumbered and some editorial changes have been made.

The provisions of §60.111(b) dealing with retrievability of waste have been modified to link the period of retrievability more closely to the performance confirmation program and to allow the Commission to modify the retrievability period on a case-by-case basis based on the waste emplacement schedule and the planned performance confirmation program. The final rule also specifies that the period of retrievability begin at the initiation of waste emplacement rather than after waste emplacement is complete. Finally, the final rule explicitly states that backfilling of portions of the underground facility is not precluded, provided the retrievability option is maintained, and that the Commission may decide to allow permanent closure of the underground facility prior to the end of the designed retrievability period. While these provisions were discussed in the supporting information, they were not explicitly stated in the proposed rule. Also see Retrievability, above.

§ 60.112 Overall system performance objective for the geologic repository after permanent closure. [§ 60.111(b)(1)].

The term "subsurface facility" has been deleted, as explained in the analysis of § 60.2, and conforming changes have been made.

There is no conceptual difference between the proposed rule's reference to releases from the geologic repository and the final rule's reference to releases to the accessible environment. The Commission prefers the latter formulation because it more closely conforms to the standard-setting authority of EPA. The proposed rule's definition of "accessible environment" was too general to allow such an approach. Under the final rule, however, the subsurface portions of the accessible environment and the geologic repository are contiguous. See Terminology, above.

See also the discussion, above, relating to Anticipated/Unanticipated Processes and Events.

Several commenters recommended that it would be preferable to leave the rule in proposed form until the EPA standard had been published, at which time NRC could adapt its regulations to the standards that EPA actually promulgates. The Commission would, of course, prefer to have final EPA rules available; and, if they were, it could build EPA's provisions, where appropriate, into Part 60. In the absence of the final EPA standard, however, the Commission deems it important to provide not only to DOE but also to other interested persons, including governmental institutions, firm guidance with respect to the Commission's regulatory approach. As discussed under Single vs. Multiple Performance Standards above, the technical criteria provide some flexibility to take into account a range of standards that might be adopted by EPA. Should such standards, when adopted, depart from those that the Commission has assumed for purposes of analysis, the Commission would consider whether further rulemaking on its part would be desirable. The procedure that is being followed conforms to that prescribed by Section 121(b) of the Nuclear Waste Policy Act. See also the discussion regarding Population vs. Individual Dose.

§ 60.113 Performance of particular barriers after permanent closure. [§ 60.111(b)(2)-(3); § 60.112].

The performance objectives for particular barriers have been modified for reasons discussed at length above.

The analysis of Single vs. Multiple Performance Standards explains the basis for retaining numerical values, while allowing them to be modified as the particular case warrants. The factors alluded to there as among those that might be taken into account are set out in § 60.113(b). Section 60.113(c) reflects the observation there that considerations related to unanticipated processes and events could form the basis for additional performance requirements for individual barriers.

For the reasons presented under the heading ALARA, above, the Commission has elected not to apply an ALARA principle to the performance requirements in this section.

The reasons for elimination of requirements referring specifically to TRU are described in the section on Transuranic Waste, above. It should be noted, however, that the release requirements in § 60.113 apply to all radionuclides, including those that may be contained in any TRU that may be disposed of at a geologic repository operations area.

The proposed rule required an assumption that groundwater saturate the facility and that the performance of the waste packages be evaluated on this basis. This approach was proposed because mechanisms exist for groundwater transport to the underground facility, in salt formations as well as hard rock. It may not always be necessary or technically reasonable to assume the specified saturation conditions, provided that appropriate evaluations are made in the context of a particular application; the final rule therefore calls for the partial and complete filling with groundwater of available void spaces in the underground facility to be considered and analysed among the anticipated processes and events in designing the engineered barrier system. This provision would not appear to be needed for disposal in the unsaturated zone, even though there may be water transport from the underground facility, primarily because the design can, in principle, provide for adequate drainage. (Criteria applicable to disposal in the unsaturated zone will be the subject of additional rulemaking.) Other changes in the provision are of a clarifying or editorial nature.

Editorial changes have been made to avoid repetitious language in the performance objectives relating to the engineered barrier system's containment and controlled-release capabilities.

The proposed requirement with respect to containment would have specified that the HLW waste packages contain all radionuclides for at least the first 1,000 years after permanent closure. In response to comments relating to the demonstrability of a design to contain "all" radionuclides for an extended period, the Commission has modified the requirement so that the design must provide "substantially complete" containment. The reason for relying on containment as one means for assuring achievement of the overall system performance objective is that many sources of uncertainty are particularly significant during the period when radiation and thermal conditions in the underground facility are dominated by fission product decay. This period will depend, to some extent, on the characteristics of the particular facility. The Commission has therefore allowed the containment period to be fixed, where appropriate, at a shorter period. See, also, the discussion of Single vs. Multiple Performance Standards.

The incorporation of a general standard for release of radionuclides from the engineered barrier system ("a gradual process which results in small fractional releases to the geologic setting over long times") places the specific criteria into context, thereby emphasizing the policy objective underlying these criteria. Moreover, it indicates the close relationship between the provisions dealing with containment and limited release. These are coupled parameters that should not be varied independently, but rather should be viewed as a system to control the release to the geologic setting. Again, see Single vs. Multiple Performance Standards.

The fractional release rate has been modified slightly to eliminate an ambiguity identified by one commenter. The new language makes it clear that "one part in 100,000 per year" refers to the activity at 1,000 years following permanent closure. This is a substitute for 1 part in 100,000 of the maximum inventory of the particular radionuclide at any time after 1,000 years after permanent closure. The underlying concern in the proposed rule was that the amounts of certain radionuclides, such as Ra-226 and other actinide daughters, increased with time, and that it was necessary to consider the maximum inventory of these nuclides in assessing repository performance. The analyses performed in the rationale document indicate that these nuclides are not important with respect to meeting the EPA standard as presently formulated. Accordingly, the Commission has chosen the less complicated formulation that appears in the final rule. It should be noted that the release rate refers to activity at 1,000 years after closure, even though a different containment period may be approved or specified by the Commission; the rate may also be modified, however, under the provisions of the final rule. DOE, in its comments on the proposed rule, suggested that the fractional release rate requirement should not apply to nuclides that constituted less then 0.1% of the inventory remaining at 1,000 years. This recommendation has not been adopted since it could lead to excessive releases. Table 5 of the rationale document in NUREG-0804 shows that the inventory of radioactive material in a repository containing 100,000 metric tons of spent fuel is 1.7×10^8 curies after 1,000 years. The DOE suggestion would eliminate nuclides whose inventories were less than 170,000 curies from consideration of their release rate from the engineered barrier system, whereas the NRC provisions of § 60.113(a)(1)(ii)(B) would eliminate nuclides whose release rates were less than 1.7 curies/yr from further consideration. While the Commission has not adopted the recommended change it notes that, under the provisions of the final rule, DOE could recommend an alternative release rate for nuclides in the light of the standard adopted by EPA or the geochemical characteristics of the host rock, surrounding strata, and groundwater. In particular, the characteristics of the host rock immediately adjacent to the underground facility may be well understood because of the excavation activities and, where appropriate, such characteristics could be taken into account in specifying the nuclide release rate.

The previously proposed performance objective for the geologic setting [§ 60.111(b)(3)] has been deleted. The new definition of "anticipated processes and events" includes the assumption that processes operating in the Quaternary Period continue to operate but with perturbations caused by the presence of emplaced radioactive waste superimposed thereon. The remainder of the proposed paragraph merely restates part of the overall system performance objective with respect to performance of the geologic setting and would be redundant.

The references to "stability" in the geologic setting since the start of the Quaternary Period have been deleted. What the Commission had intended was that the structural, tectonic, hydrogeologic, geochemical, and geomorphic processes be such as to enable the recent history to be interpreted and to permit near-term geologic changes to be projected with relatively high confidence. The selection of the term "stability" to convey this meaning was unfortunate. Commenters correctly pointed out that a geologic setting can only be said to exhibit stability in a relative sense. As they noted, the proposed rule gave no guidance as to the degree of required stability and, accordingly, the provision would introduce ambiguity with respect to one of the major elements of the geologic repository. The factors the Commission had identified are all important, but the appropriate way to consider them is to assess them in the context of favorable and unfavorable conditions and to evaluate the extent to which the geologic repository's achievement of the overall system performance objective might be affected. If the relevant processes are not well understood, one or more of the potentially adverse conditions will be exhibited and such an evaluation will be required.

The pre-waste-emplacement groundwater travel time provision is subject to adjustment on a case-by-case basis. See Single vs. Multiple Performance Standards. A clarifying amendment relates the travel time provision, as previously only implied, to the "fastest path of likely radionuclide travel from the disturbed zone to the accessible environment." Relating this provision to the "disturbed zone" instead of the "far field" involves no substantive change. As stated in the analysis of § 60.2, the term "far field" has been deleted from the rule.

Some commenters suggested that the groundwater travel time be expressed in terms of post-emplacement as well as pre-emplacement conditions. This assumes that post-emplacement changes would be significant. By definition, however, the portion of the geologic setting significantly affected by waste emplacement constitutes the "disturbed zone." The groundwater travel time provision applies to transport from the disturbed zone to the accessible environment. This parameter is not dependent upon the effects of waste emplacement.

One commenter characterized the travel time performance objective as " invalid" without a clear definition of "accessible environment." The Commission agrees that the proposed rule was subject to a number of interpretations. However, the modified definition provides a means for delineating the limits of the accessible environment so as to take proper account of site-specific conditions. Under this revised definition, a subsurface area extending no more than 10 kilometers from the underground facility may be used to isolate the waste from the accessible environment. This, in effect, places an upper limit on the rate of groundwater travel to the accessible environment. Refer to the discussion of "accessible environment" and "controlled area" under Terminology, above.

LAND OWNERSHIP AND CONTROL

§ 60.121 Requirements for ownership and control of interests in land.

The proposed rule set out ownership and control requirements for the "geologic repository operations area." The text, however, related these requirements to the achievement of isolation. To express this concept properly, the Commission has made the requirements in § 60.121(a) applicable not only to the geologic repository operations area, but to the controlled area as well. Section 60.121(b), which deals with isolation and not with the period of operations, is amended so as to refer to the controlled area. (The reference here to the "geologic repository" instead of "site or engineered system" is not substantive; it reflects the revised definitions identified in the analysis of § 60.2.) A conforming change has also been made to the caption of the section.

In response to a commenter's suggestion, the acquisition of appropriate water rights is now explicitly required. This will not necessitate any separate action on the part of DOE if it appears that such needed water rights have been obtained, by implication, as a result of reservation or acquisition of lands. See U.S. v. New Mexico, 438 U.S. 696 (1978), Cappaert v. U.S., 426 U.S. 128 (1976). The "purpose of the geologic repository operations area" is intended to be construed broadly to include the isolation of radioactive wastes after permanent closure as well as any water rights needed during the period of operations.

The Commission declines an invitation to define a specific area that must be acquired to assure public health and safety prior to permanent closure. The size of this area will depend upon the particular activities to be carried out by DOE. There must be an "unrestricted area" to which releases of radioactive materials will be maintained within the limits specified in 10 CFR Part 20. § 60.111(a). The establishment of this unrestricted area must also take accidents into consideration, since structures, systems, and components "important to safety," as defined in § 60.2, must be designed so as to limit radiation doses under accident conditions to 0.5 rem at the boundary of the unrestricted area.

SITING CRITERIA

§ 60.122 Siting criteria [§ 60.122-60.124].

The following detailed comments supplement the discussion under the caption "Siting Criteria" in the main text, above.

Section 60.122(a) consolidates the introductory paragraphs of proposed §§ 60.122 and 60.123, together with proposed § 60.124. This change is designed to provide a clearer statement of the relationship between the favorable and potentially adverse conditions. The revised language makes it clear that all such conditions relate to isolation of the waste after permanent closure.

Proposed § 60.124 had specified ways to demonstrate that potentially adverse conditions would not "impair significantly" the isolation ability of the geologic repository. This has been modified so as to refer instead to "compromise" of such site suitability. This change is made to eliminate any question regarding the difference between the two terms. No such difference was intended. Both terms relate to conditions which would potentially preclude the Commission from finding that the geologic repository would achieve the performance objectives.

The rule now provides for evaluating the effect of the potentially adverse conditions on the "site" rather than the "geologic setting" or "disturbed zone." See Siting Criteria, above.

In the provision which states that potentially adverse conditions may be compensated by the presence of favorable conditions, the Commission has specified the standard for measuring the adequacy of such compensation -- namely, achievement of the performance objectives relating to isolation of waste.

§ 60.122(b)(1) [§60.122(a)-(e)]

Proposed paragraphs 60.122(a), (c), (d), and (e) have been consolidated for editorial reasons. Even if some of the cited processes might have an adverse effect on the geologic repository's ability to isolate the waste, the Commission intends that the other processes may nevertheless be treated as favorable conditions. The distinction between "tectonic" and "structural" processes is so "fine," as it was characterized by one commenter, that the final rule uses only the former term. The references to "the start of the Quaternary Period" have been removed because of the difficulties that might be involved in dating this point with precision; for present purposes, all that is important is that processes "operating during the Quaternary Period" be identified and evaluated, and this is reflected in the revised language. Note the fact that while the provision, as before, applies to favorable conditions in the "geologic setting," the broader definition of that term in the final rule recognizes that processes operating more remotely from the geologic repository must be taken into account.

§ 60.122(b)(2) [§60.122(f)]

The proposed rule included siting criteria applicable only to disposal in the saturated zone. This paragraph adapts the provision that dealt with hydrogeologic conditions in the host rock and is appropriately limited to the saturated zone option. The Commission no longer identifies "low groundwater content" as a favorable condition because it is the rate and direction of groundwater movement rather than the amount of groundwater present that is of primary significance; thus, instead, the final rule substitutes a reference to low permeability and downward hydraulic gradient. This change also addresses more clearly the prior consideration about inhibition of groundwater circulation in the host rock. Similarly, instead of referring to inhibition of groundwater flow between hydrogeologic units, the Commission specifies the properties which result in such inhibition, namely low vertical permeability and low hydraulic potential. Since the paragraph relates to the host rock, the reference to shafts, drifts, and boreholes was not fully appropriate and, in any event, is dealt with by identification of the pertinent properties.

The reference to groundwater travel time has been modified to conform with the language of the related performance objective. The proposed rule measured this property from the underground facility. However, the changes that may occur in the disturbed zone may negate the favorable condition in that part of the geologic setting and, accordingly, the final rule specifies that the travel time in question is to be measured from the disturbed zone to the accessible environment. There is no basis for identifying a particular number of years that will be deemed to be substantially in excess of 1,000 years. If for a particular site the value is sufficiently high to enhance the Commission's confidence that the performance objectives will be met, then it can appropriately be considered as a favorable condition.

§60.122(b)(3) [§60.122(g)]

Since the listed geochemical conditions may or may not occur simultaneously, yet since any of them may retard the transport of radionuclides, the paragraph has been stated in the disjunctive in the final rule (by substituting "or" in place of "and").

§60.122(b)(4) [§60.122(h)]

This paragraph concerns transformation of "mineral assemblages" under thermal loading. It would be a favorable condition if changes left the capacity to inhibit radionuclide transport unaffected; the proposed rule, which spoke only of "increased" capacity, was too restrictive.

The paragraph is concerned primarily with the behavior of mineral assemblages which form coatings along the fracture paths along which radionuclides are anticipated to migrate; it would be incorrect, when referring to this surface zone, to adopt a commenter's suggestion that the Commission refers instead to "rock" or "geologic media."

§60.122(b)(5) [§60.122(i)]

This paragraph, relating to depth of emplacement, is unchanged. The purpose of the provision is to reflect the consideration that wastes buried at least 300 meters below the surface are less subject to disturbance, especially by human intrusion, than wastes closer to ground level would be. As in the case of the other favorable conditions, it should be emphasized that the absence of a particular one or more of them does not rule out a site or even demand explanation; it simply means that other favorable conditions must be cited to show that the criterion set out in §60.122(a)(1) has been satisfied. (The elevation being referred to is the altitude above mean sea level of the lowest point on the surface, but the Commission perceives no need to express the concept, as one commenter had suggested, in such detail.)

§60.122(b)(6)

New. See Population - Related Siting Criteria, above.

[§60.122(j)]

The proposed rule would have treated as a favorable condition "any local condition of the disturbed zone that contributes to isolation." This was criticized as being unduly general and vague. As the key favorable conditions appear to have been identified, the Commission has concluded that inclusion of such a "catch all" is unwarranted.

§ 60.122(c)(1) [§ 60.123(a)(1) and (6)]

This paragraph is adapted from two provisions of the proposed rule. Unlike most of the potentially adverse conditions, the prospect of flooding is of most concern prior to permanent closure. Even though criteria in § 60.133 provide that the underground facility be designed to handle water intrusion, the anticipated design features need not be sufficient to cope with massive inflows that could result from submersion of boreholes and shafts. Should such a situation develop, the ability of the geologic repository to achieve isolation of the wastes that had been emplaced could be compromised.

Because the concern relates to waste isolation, the paragraph has been rewritten so as to be limited to flooding of the underground facility. The design criteria for structures, systems, and components important to safety require that appropriate measures be taken to protect surface facilities against the consequences of flooding.

As there is no reason to differentiate between floods resulting from natural causes (i.e., from occupancy and modification of floodplains) and those resulting from failure of impoundments, the two pertinent paragraphs have been combined.

With respect to required investigations [§60.123(b)], see Section-by-Section Analysis, §60.21(c)(1)(ii)(B).

§ 60.122(c)(2) [§ 60.123(a)(2) and (3)].

Two paragraphs related to the groundwater flow system have been consolidated. The conditions are to be regarded as potentially adverse if the activities in question are "foreseeable." This is more conservative than the original rule, which only identified "planned" activities. The proposed rule encompassed such activities with a potential to "significantly" affect groundwater flow. Any "adverse" effect should be treated as significant, and the final rule makes a change to reflect this.

§ 60.122(c)(3) [§ 60.123(a)(7)].

No substantive change from proposed rule.

§ 60.122(c)(4) [§ 60.123(b)(8)].
[§ 60.123(a)(5)].
[§ 60.123(b)(6)].
[§ 60.123(b)(7)].

Structural deformation would have been regarded as a potentially adverse condition only if occurring within the disturbed zone during the Quaternary Period. This approach was unduly limiting. Structural deformation in the geologic setting, whether or not of recent origin, is potentially adverse because of the effects which it may have upon the regional groundwater flow system. Of course, it is to be expected that structural deformation remote from the site, especially if ancient, can readily be found not to significantly affect the ability of the geologic repository to isolate the waste. Still, it is a potentially adverse condition and should be recognized as such.

Faulting is one kind of structural deformation. By including it here, the prior specific references to faulting can be eliminated.

§ 60.122(c)(5) [§ 60.123(b)(12)].

This paragraph is no longer restricted to the disturbed zone, but otherwise is unchanged in substance.

§ 60.122(c)(6) [§ 60.123(a)(8)].

The proposed rule referred to "expected climatic changes." Climatology is not sufficiently understood to enable us to limit our concern to "expected" changes, and the final rule therefore refers to characteristics of the geologic setting likely to be affected directly by reasonably foreseeable climatic change, viz., the hydrologic conditions.

§ 60.122(c)(7) [§ 60.123(b)(14)].

This paragraph referred to groundwater conditions that could "affect" solubility and chemical reactivity. The concern is not with effects per se, but rather with effects that increase the solubility or chemical reactivity of the engineered barrier system. This was not made explicit. In order to be more comprehensive, chemical composition of the host rock is added to the relevant groundwater conditions.

§ 60.122(c)(8) [§ 60.123(b)(15)].

Aside from the extension of this paragraph beyond the disturbed zone, there are no changes in substance. One clarifying addition, "of radionuclides," following "sorption" was made.

§ 60.122(c)(9) [§ 60.123(b)(13)].

This paragraph, related to non-reducing groundwater conditions, is only appropriate to disposal in the saturated zone.

§ 60.122(c)(10) [§ 60.123(b)(5)].

Dissolutioning will be treated as a potentially adverse condition throughout the geologic setting. Examples of the kinds of features that provide evidence of dissolutioning have been included so as to make it clear that the paragraph refers to processes that provide gross manifestations of their presence.

§ 60.122(c)(11) [§ 60.123(b)(8)].

No substantive changes.

§ 60.122(c)(12). [§ 60.123(a)(4)].
§ 60.122(c)(13). [§ 60.123(b)(10)].
§ 60.122(c)(14). [§ 60.123(b)(9)].
§ 60.122(c)(15). [§ 60.123(b)(11)].
§ 60.122(c)(16) [§ 60.123(b)(4)].

Extended from disturbed zone to the entire geologic setting, but otherwise unchanged.

§ 60.122(c)(17) [§ 60.123(b)(3)].

Consistent with the references to resources in the requirements for the content of the safety analysis report, § 60.21(c)(13), the presence of naturally occurring materials for which economic extraction is currently feasible or potentially feasible during the foreseeable future may give rise to a potentially adverse condition. The provision now applies to the site, rather than the disturbed zone, since it is the site that provides isolation of the waste.

§ 60.122(c)(18) [§ 60.123(b)(1)].

Extended from the disturbed zone to the site.

§ 60.122(c)(19) [§ 60.123(b)(2)].

Extended from the disturbed zone to the site.

§ 60.122(c)(20) [§ 60.123(b)(16)].

The paragraph refers to "rock or groundwater" conditions that would require complex engineering measures. Although the engineering measures being referred to would be applied before permanent closure, the reason for having this criterion -- as in the remainder of § 60.122(c) -- stems from concerns about the ability of the geologic repository to satisfy the performance objectives with respect to isolation of the waste. Although complex engineering measures are not inherently unacceptable, their reliability must be carefully scrutinized in a licensing process. A geologic setting that requires the adoption of such complex engineering measures therefore can be viewed as exhibiting a potentially adverse condition. Although the final rule applies to the geologic setting instead of the disturbed zone, this paragraph would apply over only that part of the geologic setting that has features relevant to the selection of engineering measures.

§ 60.122(c)(21) [§ 60.123(b)(17)].

The criterion pertaining to stable underground openings is also unchanged in substance, except that it is no longer expressly limited to the disturbed zone. This is another criterion that pertains to the period of operations. However, like the preceding one, its underlying purpose is to assure that waste isolation objectives can be achieved. Failure of underground openings could result in the inability of the licensee to retrieve the wastes practicably, should such a course of action be found to be warranted. The consequence of this failure could be a transport of radionuclides to the accessible environment at levels exceeding the performance objectives.

DESIGN CRITERIA FOR THE GEOLOGIC REPOSITORY OPERATIONS AREA

§ 60.130 Scope of design criteria for the geologic repository operations area. [§ 60.130(a)]

The separation of final § 60.130 from related sections is an editorial change.

As indicated in § 60.131, Subpart E is intended to specify site and design criteria. References to construction requirements are therefore inappropriate and have been deleted.

§ 60.131 General design criteria for the geologic repository operations area.

(a) Radiological protection. [§ 60.130(b)(1)]

Aside from editorial changes, the only revision relates to the design of the radiation alarm system; the language has been modified to conform to 10 CFR § 72.74(b), and reference to radioactivity in effluents was deleted since this section has to do with radiation protection in restricted areas. Provisions for control of radioactivity in effluents are contained in § 60.131(b)(4), for emergency conditions, and in § 60.132(c), for normal operations.

(b) Structures, systems and components important to safety.

(1) Protection against natural phenomena and environmental conditions. [§ 60.130(b)(2)]

The two proposed subparagraphs were duplicative and have been consolidated. The change of "site" to "geologic repository operations area" is appropriate because the concern being addressed is accident conditions at the HLW facility that could result in specified doses at the boundary. Similarly, "any relevant time period" has been deleted since this provision deals with the prevention or mitigation of accidents associated with waste storage and handling activities. Also, since it is accident conditions that are of concern, the provisions of the proposed rule dealing with operations, maintenance and testing were inappropriate and have been deleted. (The effects of natural phenomena and environmental conditions on waste isolation are addressed in § 60.122.)

(2) Protection against dynamic effects of equipment failure and similar events. [60.130(b)(3)]

Editorial change, characterizing missile impacts as dynamic effects.

(3) Protection against fires and explosives. [§ 60.130(b)(4)]

The design criterion pertaining to continued operation during and after fires has been limited to such events as are "credible." This responds to comments that suggested that the proposed language could be interpreted to require protection against any fire or explosion that might be physically possible.

Because Subpart E is concerned with siting and design criteria, the Commission has not adopted a suggestion to incorporate, at this point, a requirement that explosives be excluded from areas containing radioactive materials. However, such a provision could be one of the license specifications found to be appropriate under § 60.43.

(4) Emergency capability. [§ 60.130(b)(5)]

Provision has been made to require control of effluents during emergency conditions, see §§ 60.131(a). Otherwise unchanged.

(5) Utility services. [§ 60.130(b)(6)]

Paragraph (i) has been clarified by inserting an explicit reference to systems "important to safety." Since the definition of "important to safety" refers to "accidents," the term "emergency conditions" has been changed to "accident conditions."

Proposed paragraph (iii) has been deleted because it was redundant with the general provision for inspection, testing, and maintenance.

Proposed paragraph (iv) [now (iii)] has been abbreviated. As proposed, it could have been interpreted as requiring systems, even if redundant, to be functional at all times. The intent was to assure that timely emergency power can be provided to structures, systems, and components important to safety. The provision has been modified accordingly. There is no need to state that emergency power be sufficient to allow safe conditions to be maintained, since this is implicit in the remainder of the text.

(6) Inspection, testing, and maintenance. [§ 60.130(b)(7)]

No change from proposed rule.

(7) Criticality control. [§ 60.130(b)(8)]

No change from proposed rule.

(8) Instrumentation and control systems. [§ 60.130(b)(9)]

The adjective "engineered" has been deleted, in reference to systems important to safety, so as to retain uniform terminology throughout the rule.

The provision for design "with sufficient redundancy to ensure that adequate margins of safety are maintained," which was criticized as being vague, has been deleted. The objective was to ensure that the design incorporate needed instrumentation and this has been accomplished more clearly by the amended language.

(9) Compliance with mining regulations. [§ 60.130(b)(10)]

No change from proposed rule. It should be noted that this provision is not intended to assert NRC authority over mining safety practices generally; but to the extent that the safety of workers is necessary for systems important to safety to perform their intended functions, the relevant design features are of legitimate concern to NRC.

(10) Shaft conveyances used in radioactive waste handling. [§ 60.133(c)]

The specific criteria applicable to hoists important to safety have remained unchanged. The general requirement that shaft conveyances used to transport radioactive materials be designed to satisfy the requirements for systems, structures, and components important to safety has been deleted because it was unduly broad; to the extent that the shaft conveyances are in fact important to safety, the applicable design requirements will still apply.

§ 60.132 Additional design criteria for surface facilities in the geologic repository operations area. [§ 60.131]

(a) Facilities for receipt and retrieval of waste. [§ 60.131(a)]

This paragraph has been shortened by deleting redundant and unnecessary detail. The requirement for safe handling and storage implies provision for inspection, repair, and decontamination as appropriate. Similarly, it is not necessary to state that surface storage capacity need not be provided for all emplaced waste; there must be sufficient capacity,however, to allow safe handling and storage.

(b) Surface facility ventilation. [§ 60.131(b)]

The only change is the reference to § 60.111(a) by paragraph. This is not a substantive amendment, as this is the only part of the performance objectives relevant to ventilation.

(c) Radiation control and monitoring. [§ 60.131(c)]

The reference to emergency operations is omitted because that subject is covered by § 60.131(b)(4). Editorial changes have been made here for the same reasons as were discussed in connection with that paragraph.

(d) Waste treatment. [§ 60.131(d)]

No change from proposed rule.

(e) Consideration of decommissioning. [§ 60.131(e)]

See Decommissioning, above. The term "decommissioning" has been retained in this context because surface facilities may continue to be used even after permanent closure. The requirement has been made more precise by specifying that the same standards apply here as to other activities licensed by NRC.

§ 60.133 Additional subsurface design criteria. [§ 60.132]

(a) General criteria for the underground facility. [§ 60.132(a)]

Proposed paragraphs (a)(1) and (a)(2) have been deleted because they were redundant.

The requirement that design features "enhance [containment and isolation of radionuclides] to the extent practicable at the site" has been changed to provide that the design shall "contribute" to such containment and isolation. As proposed, this provision could have been construed as imposing requirements substantially in excess of those needed to satisfy the performance objectives. This was not the intention. See also the discussion of ALARA, above.

The requirement to design the underground facility against the effects of disruptive events has been modified to apply to events occurring during the period of operations and to exclude water and gas intrusions to eliminate redundancy with other provisions of the rule. The requirement is also limited to consideration of credible disruptive events.

(b) Flexibility of design. [§ 60.132(b)]

The only change, in punctuation, is editorial.

(c) Retrieval of waste. [§ 60.132(d)]

Proposed paragraph (d)(2) has been deleted because it was redundant with proposed paragraph (d)(1) and was read to prohibit backfilling.

Proposed paragraph (d)(3) has been deleted because it is subsumed in the remaining text of the paragraph.

(d) Control of water and gas. [§ 60.132(g)]

Because of confusion about the meaning of the term "service water," the design requirement has been rephrased so as to refer more generally to "water or gas intrusion."

Additional proposed requirements have been deleted in response to comments regarding the level of detail in the rule. (See <u>Level of Detail</u>, above.) While each of the items that had been addressed will in all probability be needed, the remaining general design criterion for control of water and gas is adequate to ensure that each of the features will be incorporated in the design where necessary.

(e) Underground openings. [§ 60.132(e)]

This paragraph has been rewritten in functional terms so as to require design so that operations in the underground facility "can be carried out safely and the retrievability option maintained."

The requirement that the design reduce the potential for deleterious rock movement or fracturing of rock has been retained. The identification of considerations that must be taken into account has been deleted as being more appropriate for treatment in regulatory guides. The Commission anticipates, however, that each of the factors that had been listed would in fact have been included in complying with this paragraph.

(f) Rock excavation. [§ 60.132(f)]

The proposed rule required design to "limit damage to and fracturing of rock." The extent to which damage should be "limited" was not stated. Moreover, for some geologic media and sites, the requirement could be interpreted to prescribe particular excavation methods, which was not the intent. The paragraph has been rephrased to indicate that the design must reduce the potential for creating a preferential pathway to the accessible environment.

(g) Underground facility ventilation. [§ 60.132(h)]

The term "subsurface facility" has been eliminated, conforming to the caption of the section. Paragraph (g)(1) now refers to control within and from the "underground facility."

Proposed paragraph (h)(2), which would have required design to permit continuous occupancy of all excavated areas through permanent closure, was excessively restrictive. Ventilation will need to be maintained, however, where normal operations are being carried out, so as to satisfy paragraph (g)(1).

Proposed paragraph (h)(3) was deleted. It is adequately covered by paragraph (g)(1).

As in some other contexts, reference is now made to "accident conditions" instead of "emergency conditions" (see discussion of § 60.131(b)(5) above). The requirement for design to assure continued function is retained, but the means for accomplishing this is left to the designer. Redundant equipment and fail-safe control systems would continue to be employed where necessary and appropriate.

(h) Engineered barriers. [§ 60.132(i)]

The proposed rule, in paragraph (i), would have specified several design requirements for the engineered barriers, including backfill and barriers at shafts. While the Commission continues to expect that such features will ordinarily be incorporated into the design, it has concluded that its earlier approach would have been unduly restrictive. The Commission has therefore left only the general functional statement that the engineered barriers shall be designed to assist the geologic setting in meeting long term performance objectives.

(i) Thermal loads. [§ 60.132(k)]

This provision retains the substance of proposed paragraph (k)(1). The reference to the "ability of the natural or engineered barriers to retard radionuclide migration" is deleted because it is already covered by requiring that the performance objectives be met.

Proposed (k)(2), identifying factors to be taken into account in the design of waste loading and waste spacings, has been omitted as containing excessive detail.

Other omitted provisions. [§§ 60.132(c), 60.132(j)]

Proposed § 60.132(c), dealing with the modular concept, was excessively restrictive. The Commission recognizes that to some degree the concurrent conduct of excavation with waste emplacement could "impair" waste emplacement or retrieval operations. Concurrent excavation and waste emplacement would be acceptable, provided that all other applicable requirements are satisfied. The provision for insulation of individual modules is not necessary, since paragraph (a)(3) requires that the design limit the effects of disruptive events and paragraph (g)(2) provides that the design assure continued function of ventilation systems under accident conditions. Section 60.131(a), including the design requirement to control the dispersal of radioactive contamination, is also relevant.

Proposed § 60.132 (j) would have specified fail-safe designs in systems for handling, transporting, and emplacing wastes. This too was excessively restrictive. What protective measures are needed will be determined in the light of a range of factors, including the probability and consequences of mishaps and the costs of alternative means for dealing with them. Similarly, the final rule does not require that handling systems "minimize the potential for operator error;" specifications for such systems will depend upon an evaluation of the particular risks involved. Where protective measures are needed, particularly insofar as they relate to radiological consequences, the remaining design requirements suffice.

[§ 60.134 Construction specifications for surface and subsurface facilities.]

The proposed rule contained a section on construction specifications that was not appropriate, since (under § 60.31(a)(2)), the scope of Subpart E was limited to site and design criteria.

Although the section has therefore been deleted, this does not mean that construction procedures are not of vital significance. As stated in § 60.31(a)(1)(iv), the Commission will consider whether DOE has adequately described construction procedures which may affect the capability of the geologic repository to serve its intended function. Appropriate provisions will be included in a construction authorization, as provided in § 60.32.

Proposed § 60.134(c), dealing with construction records, has been retained, with minor modifications. It now appears as § 60.72, and is discussed in the analysis of that section.

§ 60.134 Design of seals for shafts and boreholes. [§ 60.133]

The proposed rule contained a number of provisions which commenters criticized as being unachievable, or at least incapable of being demonstrated. Specifically, there was objection to the requirements that shaft and seal design not create preferential pathways and that sealed shafts and boreholes inhibit radionuclide transport to, at the least, the same degree as the undisturbed rock. The Commission acknowledges that in some cases a pathway may be created that may be preferential in relation to the undisturbed rock. Whether or not this is acceptable will depend upon the characteristics of the rock in question, the quality of the seal under projected conditions, the age, nature, and location of the waste, and the design of the underground facility. The important thing is that the seals not become pathways that compromise the geologic repository's ability to meet the performance objectives for the period relating to isolation of the waste. This concept now appears as § 60.134(a).

Additionally, although the Commission's general approach has been to avoid ALARA-type concepts, it has in this instance specified that materials and placement methods for seals be selected to reduce to the extent practicable, the potential for creating a preferential pathway or the migration of radionuclides through existing pathways. This approach is based upon a concern that significant deficiencies in seal design could largely, or entirely, eliminate the contribution to waste isolation which is to be provided by the geologic setting. By insisting that seal design reduce preferential pathways to the extent practicable, the Commission ensures that the design will facilitate its arriving at licensing decisions.

Proposed § 60.133(b)(1) provided that shafts and boreholes be sealed as soon as possible after they have served their operational purpose. As in the other portions of the section, the objective was to address the question of long-term isolation. Early sealing can prevent deformations that might otherwise develop prior to permanent closure; such events could make it more difficult or impractical to achieve maximum integrity of the permanent seals when they are put into place. To the extent that this is an important concern, it too is covered under the text of the final § 60.134.

DESIGN CRITERIA FOR THE WASTE PACKAGE

§ 60.135 Criteria for the waste package and its components.

A geologic repository operations area, by definition, is a facility that may be used for the disposal of high-level radioactive waste. The rule must therefore address matters related to HLW, including as appropriate requirements as to HLW waste form and waste package. Whether or not other radioactive materials are emplaced in the facility is speculative, and even if this should occur, the quantities, specific activity, half-lives and other relevant factors may be so variable as to make it impossible at this time to establish reasonable rules. The final rule accordingly expressly limits the applicability of the requirements of this section to high-level radioactive waste. Nonradioactive wastes are not addressed at all. The Commission defers for later consideration, should the occasion arise, an examination of the legal and technical questions that would be presented if the disposal of nonradioactive wastes in a geologic repository operations area were to be proposed.

§ 60.135(a) High-level waste package design in general.

This paragraph has been revised editorially. It is now limited to HLW packages, but is otherwise unchanged in substance from the proposed rule.

§ 60.135(b) Specific criteria for HLW package design. [§ 60.135(c)]

Two paragraphs relate to contents of the waste package--one dealing with explosive, pyrophoric, and chemically reactive materials and a second dealing with free liquids. Editorial changes have been made so as to provide parallel language. Insofar as the period of operations is concerned, this is done by adopting the proposed language that has applied to free liquids. Insofar as waste isolation is concerned, both paragraphs are related to the relevant performance objective, adapting for this purpose the proposed provisions on explosive, pyrophoric, and chemically reactive materials.

Also, as revised, the provision pertaining to explosive, pyrophoric, and chemically reactive materials avoids the possible interpretation that insignificant quantities of such materials may not be incorporated in waste packages.

Other changes are merely editorial.

§ 60.135(c) Waste form criteria for HLW. [§ 60.135(b)]

The portion of this paragraph that deals with combustibles has been modified so as to specify that a fire involving waste packages containing combustibles will not affect the integrity of other waste packages, adversely affect any structures, systems or components important to safety, or compromise the ability of the underground facility to contribute to waste isolation. This parallels the corresponding changes in the waste package design criteria.

The reference to structures, systems, or components is modified by the defined term "important to safety" rather than the undefined adjective "safety-related."

§ 60.135(d) Design criteria for other radioactive wastes.

This paragraph is new. Its purpose is described in the introductory analysis for this section.

PERFORMANCE CONFIRMATION REQUIREMENTS

§ 60.137 General requirements for performance confirmation.

Unchanged from proposed rule.

Subpart F - Performance Confirmation Program

§ 60.140 General requirements.

The proposed rule would have specified that the performance confirmation program "ascertain" certain data. While achievement of that goal would be desirable; it is more accurate to state that the program is to "provide data which indicates, where practicable," whether conditions are within assumed limits and systems are functioning as intended.

The proposed requirement that the confirmation program be implemented so as not to "adversely affect" the natural and engineered barriers, § 60.140(d)(1), also needed to be qualified. The Commission's intention was not to prohibit useful tests that would have trivial impacts upon the repository's performance; instead, it wishes to assure that significant potentially adverse effects are taken into account in designing the performance confirmation program. The paragraph has been modified accordingly.

See also the amendment to § 60.74, which provides for the conduct of the performance confirmation program.

§ 60.141 Confirmation of geotechnical and design parameters.

Unchanged from proposed rule.

§ 60.142 Design testing.

Unchanged from proposed rule.

§ 60.143 Monitoring and testing waste packages.

The ambiguous term "repository" has been replaced by the defined terms "geologic repository operations area" or "underground facility," as appropriate. Other changes are editorial in nature.

Subpart G - Quality Assurance

§ 60.150 Scope.

This section has been revised to correspond to the counterpart provision of 10 CFR Part 50, Appendix B. Where the same term (here, "quality assurance") is employed in related contexts, it is generally desirable to use a common definition. For this reason, the Commission has declined to substitute "reasonable assurance" for "adequate confidence" as the measure of satisfactory performance.

§ 60.151 Applicability.

The final rule defines "important to safety" in a manner related to the period of operations. Because quality assurance requirements must be applied with a view to long-term performance, Subpart G is also made applicable to those elements of the geologic repository that must function in a prescribed manner so as to satisfy the performance objectives for the period after permanent closure. The proposed rule's reference to "events that could cause an undue risk to the health and safety of the public" has been deleted because of the inclusion of the more definite standards that are referred to in the revised first sentence of the section.

Further, the Commission has adopted a suggestion to revise the list of activities to which Subpart G pertains so as to correspond more closely with the structure of the rule.

§ 60.152 Implementation.

Unchanged from proposed rule.

[§ 60.153 Quality assurance for performance confirmation.]

This section of the proposed rule has been deleted because performance confirmation is now made subject, by § 60.151(b), to explicit requirements for the conduct of performance confirmation.

Subpart H - Training and Certification of Personnel

Provisions for Training and Certification of Personnel are unchanged in substance from the proposed rule. The rule has been clarified by replacing the undefined term "operations important to safety" with the phrase "operations of systems and components important to safety." Other changes are merely editorial.

Subpart I - Emergency Planning Criteria

Section 60.31(a) provides that one of the considerations bearing upon the issuance of a construction authorization is whether DOE's emergency plan complies with the criteria contained in Subpart I. The proposed technical criteria were silent with respect to Subpart I, and the contents of that subpart here continue to be reserved.

ENVIRONMENTAL IMPACT

Pursuant to Section 121(c) of the National Waste Policy Act of 1982, the promulgation of these criteria shall not require the preparation of an environmental impact statement under Section 102(2)(C) of the National Environmental Policy Act of 1969 or any environmental review under subparagraph (E) or (F) of Section 102(2) of such Act.

PAPERWORK REDUCTION ACT

This rule contains no new or amended recordkeeping, reporting, or application requirement, or any other type of information collection requirement, subject to the Paperwork Reduction Act (Pub. L. 96-511).

REGULATORY FLEXIBILITY ACT CERTIFICATION

As required by the Regulatory Flexibility Act of 1980, 5 U.S.C. 605(b), the Commission certifies that this rule, if adopted, will not have a significant economic impact upon a substantial number of small entities. The only entity subject to regulation under this rule is the U.S. Department of Energy.

LIST OF SUBJECTS IN 10 CFR PART 60

High-level waste, Nuclear power plants and reactors, Nuclear materials, Penalty, Reporting requirements, Waste treatment and disposal.

ISSUANCE

For the reasons set out in the preamble and under the authority of the Atomic Energy Act of 1954, as amended, the Energy Reorganization Act of 1974, as amended, the Nuclear Waste Policy Act of 1982, and 5 U.S.C. 553, the Nuclear Regulatory Commission is adopting the following amendments to 10 CFR Part 60.

10 CFR PART 60 - DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTES IN GEOLOGIC REPOSITORIES

1. The Table of Contents for Part 60 is revised to read as follows:

SUBPART A--GENERAL PROVISIONS

SUBPART B--LICENSES

PREAPPLICATION REVIEW

LICENSE APPLICATIONS

CONSTRUCTION AUTHORIZATION

LICENSE ISSUANCE AND AMENDMENT

PERMANENT CLOSURE

SUBPART C--PARTICIPATION BY STATE GOVERNMENTS AND INDIAN TRIBES

SUBPART D--RECORDS, REPORTS, TESTS, AND INSPECTIONS

SUBPART E--TECHNICAL CRITERIA

PERFORMANCE OBJECTIVES

LAND OWNERSHIP AND CONTROL

60.121 Requirements for ownership and control of the geologic repository operations area.

SITING CRITERIA

60.122 Siting criteria.

DESIGN CRITERIA
FOR THE GEOLOGIC REPOSITORY OPERATIONS AREA

60.130 Scope of design criteria for the geologic repository operations area.

60.131 General design criteria for the geologic repository operations area.

60.132 Additional design criteria for surface facilities in the geologic repository operations area.

60.133 Additional design criteria for the underground facility.

60.134 Design of seals for shafts and boreholes.

DESIGN CRITERIA FOR THE WASTE PACKAGE

60.135 Criteria for the waste package and its components.

PERFORMANCE CONFIRMATION REQUIREMENTS

60.137 General requirements for performance confirmation.

SUBPART F - PERFORMANCE CONFIRMATION PROGRAM

SUBPART G - QUALITY ASSURANCE

SUBPART H - TRAINING AND CERTIFICATION OF PERSONNEL

SUBPART I - EMERGENCY PLANNING CRITERIA

[RESERVED]

2. The authority citation for Part 60 is revised to read as follows:

Authority: Secs. 51, 53, 62, 63, 65, 81, 161, 182, 183, 68 Stat. 929, 930, 932, 933, 935, 948, 953, 954, as amended (42 U.S.C. 2071, 2073, 2092, 2093, 2095, 2111, 2201, 2232, 2233); secs. 202, 206, 88 Stat. 1244, 1246 (42 U.S.C. 5842, 5846); sec. 14, Pub. L. 95-601, 92 Stat. 2591 (42 U.S.C. 2021a); sec. 102, Pub. L. 91-190, 83 Stat. 853 (42 U.S.C. 4332); sec. 121, Pub. L. 97-425, 96 Stat. 2228.

For the purposes of sec. 223, 68 Stat. 958, as amended (42 U.S.C. 2273), §§ 60.71-60.75 are issued under sec. 161o, 68 Stat. 950, as amended (42 U.S.C. 2201(o)).

3. Section 60.2 is revised to read as follows:

§ 60.2 Definitions.

As used in this part--

"Accessible environment" means (1) the atmosphere, (2) the land surface, (3) surface water, (4) oceans, and (5) the portion of the lithosphere that is outside the controlled area.

"Anticipated processes and events" means those natural processes and events that are reasonably likely to occur during the period the intended performance objective must be achieved. To the extent reasonable in the light of the geologic record, it shall be assumed that those processes operating in the geologic setting during the Quaternary Period continue to operate but with the perturbations caused by the presence of emplaced radioactive waste superimposed thereon.

"Barrier" means any material or structure that prevents or substantially delays movement of water or radionuclides.

"Candidate area" means a geologic and hydrologic system within which a geologic repository may be located.

"Commencement of construction" means clearing of land, surface or subsurface excavation, or other substantial action that would adversely affect the environment of a site, but does not include changes desirable for the temporary use of the land for public recreational uses, site characterization activities, other preconstruction monitoring and investigation necessary to establish background information related to the suitability of a site or to the protection of environmental values, or procurement or manufacture of components of the geologic repository operations area.

"Commission" means the Nuclear Regulatory Commission or its duly authorized representatives.

"Containment" means the confinement of radioactive waste within a designated boundary.

"Controlled area" means a surface location, to be marked by suitable monuments, extending horizontally no more than 10 kilometers in any direction from the underground facility, and the underlying subsurface, which area has been committed to use as a geologic repository and from which incompatible activities would be restricted following permanent closure.

"Director" means the Director of the Nuclear Regulatory Commission's Office of Nuclear Material Safety and Safeguards.

"Disposal" means the isolation of radioactive wastes from the accessible environment.

"Disturbed zone" means that portion of the controlled area the physical or chemical properties of which have changed as a result of underground facility construction or as a result of heat generated by the emplaced radioactive wastes such that the resultant change of properties may have a significant effect on the performance of the geologic repository.

"DOE" means the U.S. Department of Energy or its duly authorized representatives.

"Engineered barrier system" means the waste packages and the underground facility.

"Geologic repository" means a system for the disposal of radioactive wastes in excavated geologic media. A geologic repository includes (1) the geologic repository operations area, and (2) the portion of the geologic setting that provides isolation of the radioactive waste.

"Geologic repository operations area" means a high-level radioactive waste facility that is part of a geologic repository, including both surface and subsurface areas, where waste handling activities are conducted.

"Geologic setting" means the geologic, hydrologic, and geochemical systems of the region in which a geologic repository operations area is or may be located.

"High-level radioactive waste" or "HLW" means (1) irradiated reactor fuel, (2) liquid wastes resulting from the operation of the first cycle solvent extraction system, or equivalent, and the concentrated wastes from subsequent extraction cycles, or equivalent, in a facility for reprocessing irradiated reactor fuel, and (3) solids into which such liquid wastes have been converted.

"HLW facility" means a facility subject to the licensing and related regulatory authority of the Commission pursuant to Sections 202(3) and 202(4) of the Energy Reorganization Act of 1974 (88 Stat 1244).[1]

[1]These are DOE "facilities used primarily for the receipt and storage of high-level radioactive wastes resulting from activities licensed under such Act [the Atomic Energy Act]" and "Retrievable Surface Storage Facilities and other facilities authorized for the express purpose of subsequent long-term storage of high-level radioactive wastes generated by [DOE], which are not used for, or are part of, research and development activities."

"Host rock" means the geologic medium in which the waste is emplaced.

"Important to safety," with reference to structures, systems, and components means those engineered structures, systems, and components essential to the prevention or mitigation of an accident that could result in a radiation dose to the whole body, or any organ, of 0.5 rem or greater at or beyond the nearest boundary of the unrestricted area at any time until the completion of permanent closure.

"Indian tribe" means an Indian tribe as defined in the Indian Self-Determination and Education Assistance Act (Public Law 93-638).

"Isolation" means inhibiting the transport of radioactive material so that amounts and concentrations of this material entering the accessible environment will be kept within prescribed limits.

"Permanent closure" means final backfilling of the underground facility and the sealing of shafts and boreholes.

"Performance confirmation" means the program of tests, experiments, and analyses which is conducted to evaluate the accuracy and adequacy of the information used to determine with reasonable assurance that the performance objectives for the period after permanent closure will be met.

"Public Document Room" means the place at 1717 H Street N.W., Washington, D.C., at which records of the Commission will ordinarily be made available for public inspection and any other place, the location of which has been published in the Federal Register, at which public records of the Commission pertaining to a particular geologic repository are made available for public inspection.

"Radioactive waste" or "waste" means HLW and any other radioactive materials other than HLW that are received for emplacement in a geologic repository.

"Restricted area" means any area access to which is controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials. "Restricted area" shall not include any areas used as residential quarters, although a separate room or rooms in a residential building may be set apart as a restricted area.

"Retrieval" means the act of intentionally removing radioactive waste from the underground location at which the waste had been previously emplaced for disposal.

"Saturated zone" means that part of the earth's crust beneath the deepest water table in which all voids, large and small, are ideally filled with water under pressure greater than atmospheric.

"Site" means the location of the controlled area.

"Site characterization" means the program of exploration and research, both in the laboratory and in the field, undertaken to establish the geologic conditions and the ranges of those parameters of a particular site relevant to the procedures under this part. Site characterization includes borings, surface excavations, excavation of exploratory shafts, limited subsurface lateral excavations and borings, and in situ testing at depth needed to determine the suitability of the site for a geologic repository, but does not include preliminary borings and geophysical testing needed to decide whether site characterization should be undertaken.

"Tribal organization" means a tribal organization as defined in the Indian Self-Determination and Education Assistance Act (Public Law 93-638).

"Unanticipated processes and events" means those processes and events affecting the geologic setting that are judged not to be reasonably likely to occur during the period the intended performance objective must be achieved, but which are nevertheless sufficiently credible to warrant consideration. Unanticipated processes and events may be either natural processes or events or processes and events initiated by human activities other than those activities licensed under this part. Processes and events initiated by human activities may only be found to be sufficiently credible to warrant consideration if it is assumed that: (1) the monuments provided for by this part are sufficiently permanent to serve their intended purpose; (2) the value to future generations of potential resources within the site can be assessed adequately under the applicable provisions of this part; (3) an understanding of the nature of radioactivity, and an appreciation of its hazards, have been retained in some functioning institutions; (4) institutions are able to assess risk and to take remedial action at a level of social organization and technological competence equivalent to, or superior to, that which was applied in initiating the processes or events concerned; and (5) relevant records are preserved, and remain accessible, for several hundred years after permanent closure.

"Underground facility" means the underground structure, including openings and backfill materials, but excluding shafts, boreholes, and their seals.

"Unrestricted area" means any area, access to which is not controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials, and any area used for residential quarters.

"Waste form" means the radioactive waste materials and any encapsulating or stabilizing matrix.

"Waste package" means the waste form and any containers, shielding, packing and other absorbent materials immediately surrounding an individual waste container.

"Water table" means that surface in a groundwater body at which the water pressure is atmospheric.

4. Section 60.10 is amended by revising paragraphs (a) and (d) to read as follows:

§ 60.10 Site characterization.

(a) Prior to submittal of an application for a license to be issued under this part DOE shall conduct a program of site characterization with respect to the site to be described in such application.

(b) Unless the Commission determines with respect to the site described in the application that it is not necessary, site characterization shall include a program of in situ exploration and testing at the depths that wastes would be emplaced.

(c) As provided in § 51.40 of this chapter, DOE is also required to conduct a program of site characterization, including in situ testing at depth, with respect to alternative sites.

(d) The program of site characterization shall be conducted in accordance with the following:

(1) Investigations to obtain the required information shall be conducted in such a manner as to limit adverse effects on the long-term performance of the geologic repository to the extent practical.

(2) The number of exploratory boreholes and shafts shall be limited to the extent practical consistent with obtaining the information needed for site characterization.

(3) To the extent practical, exploratory boreholes and shafts in the geologic repository operations area shall be located where shafts are planned for underground facility construction and operation or where large unexcavated pillars are planned.

(4) Subsurface exploratory drilling, excavation, and in situ testing before and during construction shall be planned and coordinated with geologic repository operations area design and construction.

5. Section 60.11 is amended by revising paragraphs (a) and (b) to read as follows:

§ 60.11 Site characterization report.

(a) As early as possible after commencement of planning for a particular geologic repository operations area, and prior to site characterization, DOE shall submit to the Director a Site Characterization Report. The report shall include[2] (1) a description of the site to be characterized; (2) the criteria used to arrive at the candidate area; (3) the method by which the site was selected for site characterization; (4) identification and location of alternative media and sites at which DOE intends to conduct site characterization and for which DOE anticipates submitting subsequent Site Characterization Reports; (5) a description of the decision process by which the site was selected for characterization, including the means used to obtain public, Indian tribal and State views during selection; (6) a description of the site characterization program including (i) the extent of planned excavation

[2]To the extent that the information indicated in items 2 through 5 appears in an Environmental Impact Statement prepared by DOE for site characterization at the named site, it may be incorporated into DOE's Site Characterization Report by reference.

and plans for in situ testing, (ii) a conceptual design of a geologic repository operations area appropriate to the named site in sufficient detail to allow assessment of the site characterization program, with respect to investigation activities which address the ability of the site to host a geologic repository and isolate radioactive waste, or which may affect such ability, and (iii) provisions to control any adverse, safety-related effects from site characterization, including appropriate quality assurance programs; (7) a description of the quality assurance program to be applied to data collection; and (8) any issues related to site selection, alternative candidate areas, or other sites, or design of the geologic repository operations area which the DOE wishes the Commission to review. Also included shall be a description of the research and development activities being conducted by DOE which deal with the waste form and packaging which may be considered appropriate for the site to be characterized, including research planned or underway to evaluate the performance of such waste forms and packaging.

*   *   *   *   *

6. Section 60.21 is amended by revising paragraphs (c)(1), (c)(3), (c)(4), (c)(8), (c)(9), (c)(11), (c)(13), (c)(14), and (c)(15) to read as follows:

§ 60.21 Content of application.

*   *   *   *   *

(c) The Safety Analysis Report shall include:

(1) A description and assessment of the site at which the proposed geologic repository operations area is to be located with appropriate attention to those features of the site that might affect geologic

repository operations area design and performance. The description of the site shall identify the location of the geologic repository operations area with respect to the boundary of the accessible environment.

(i) The description of the site shall also include the following information regarding subsurface conditions. This description shall, in all cases, include such information with respect to the controlled area. In addition, where subsurface conditions outside the controlled area may affect isolation within the controlled area, the description shall include such information with respect to subsurface conditions outside the controlled area to the extent such information is relevant and material. The detailed information referred to in this paragraph shall include--

(A) The orientation, distribution, aperture in-filling and origin of fractures, discontinuities, and heterogeneities;

(B) The presence and characteristics of other potential pathways such as solution features, breccia pipes, or other potentially permeable features;

(C) The geomechanical properties and conditions, including pore pressure and ambient stress conditions;

(D) The hydrogeologic properties and conditions;

(E) The geochemical properties; and

(F) The anticipated response of the geomechanical, hydrogeologic, and geochemical systems to the maximum design thermal loading, given the pattern of fractures and other discontinuities and the heat transfer properties of the rock mass and groundwater.

(ii) The assessment shall contain--

(A) An analysis of the geology, geophysics, hydrogeology, geochemistry, climatology, and meteorology of the site,

(B) Analyses to determine the degree to which each of the favorable and potentially adverse conditions, if present, has been characterized, and the extent to which it contributes to or detracts from isolation. For the purpose of determining the presence of the potentially adverse conditions, investigations shall extend from the surface to a depth sufficient to determine critical pathways for radionuclide migration from the underground facility to the accessible environment. Potentially adverse conditions shall be investigated outside of the controlled area if they affect isolation within the controlled area.

(C) An evaluation of the performance of the proposed geologic repository for the period after permanent closure, assuming anticipated processes and events, giving the rates and quantities of releases of radionuclides to the accessible environment as a function of time; and a similar evaluation which assumes the occurrence of unanticipated processes and events.

(D) The effectiveness of engineered and natural barriers, including barriers that may not be themselves a part of the geologic repository operations area, against the release of radioactive material to the environment. The analysis shall also include a comparative evaluation of alternatives to the major design features that are important to waste isolation, with particular attention to the alternatives that would provide longer radionuclide containment and isolation.

(E) An analysis of the performance of the major design structures, systems, and components, both surface and subsurface, to identify those that are important to safety. For the purposes of this analysis, it shall be assumed that operations at the geologic repository operations area will be carried out at the maximum capacity and rate of receipt of radioactive waste stated in the application.

(F) An explanation of measures used to support the models used to perform the assessments required in paragraphs (A) through (D). Analyses and models that will be used to predict future conditions and changes in the geologic setting shall be supported by using an appropriate combination of such methods as field tests, in situ tests, laboratory tests which are representative of field conditions, monitoring data, and natural analog studies.

* * * * *

(3) A description and analysis of the design and performance requirements for structures, systems, and components of the geologic repository which are important to safety. This analysis shall consider-- (i) the margins of safety under normal conditions and under conditions that may result from anticipated operational occurrences, including those of natural origin; and (ii) the adequacy of structures, systems, and components provided for the prevention of accidents and mitigation of the consequences of accidents, including those caused by natural phenomena.

(4) A description of the quality assurance program to be applied to the structures, systems, and components important to safety and to the engineered and natural barriers important to waste isolation.

* * * * *

(8) A description of the controls that the applicant will apply to restrict access and to regulate land use at the site and adjacent areas, including a conceptual design of monuments which would be used to identify the controlled area after permanent closure.

(9) Plans for coping with radiological emergencies at any time prior to permanent closure and decontamination or dismantlement of surface facilities.

* * * * *

(11) A description of design considerations that are intended to facilitate permanent closure and decontamination or dismantlement of surface facilities.

* * * * *

(13) An identification and evaluation of the natural resources of the geologic setting, including estimates as to undiscovered deposits, the exploitation of which could affect the ability of the geologic repository to isolate radioactive wastes. Undiscovered deposits of resources characteristic of the area shall be estimated by reasonable inference based on geological and geophysical evidence. This evaluation of resources, including undiscovered deposits, shall be conducted for the site and for areas of similar size that are representative of and are within the geologic setting. For natural resources with current markets the resources shall be assessed, with estimates provided of both gross and net value. The estimate of net value shall take into account current development, extraction and marketing costs. For natural resources without current markets, but which would be marketable given credible projected changes in economic or technological factors, the resources shall be described by physical factors such as tonnage or other amount, grade, and quality.

(14) An identification of those structures, systems, and components of the geologic repository, both surface and subsurface, which require research and development to confirm the adequacy of design. For

structures, systems, and components important to safety and for the engineered and natural barriers important to waste isolation, DOE shall provide a detailed description of the programs designed to resolve safety questions, including a schedule indicating when these questions would be resolved.

(15) The following information concerning activities at the geologic repository operations area:

(i) The organizational structure of DOE as it pertains to construction and operation of the geologic repository operations area including a description of any delegations of authority and assignments of responsibilities, whether in the form of regulations, administrative directives, contract provisions, or otherwise.

(ii) The quality assurance organization to be used to ensure safety.

(iii)***

(vii) Plans for permanent closure and plans for the decontamination or dismantlement of surface facilities.

(viii) Plans for any uses of the geologic repository operations area for purposes other than disposal of radioactive wastes, with an analysis of the effects, if any, that such uses may have upon the operation of the structures, systems, and components important to safety and the engineered and natural barriers important to waste isolation.

7. Section 60.22 is amended by revising paragraphs (a) and (d) to read as follows:

§ 60.22 Filing and distribution of application.

(a) An application for a license to receive and possess source, special nuclear, or byproduct material at a geologic repository operations area at a site which has been characterized, and an accompanying environmental report, and any amendments thereto, shall be filed in triplicate with the Director and shall be signed by the Secretary of Energy or the Secretary's authorized representative.

* * * * *

(d) At the time of filing of an application and environmental report, and any amendments thereto, one copy shall be made available in an appropriate location near the proposed geologic repository operations area (which shall be a public document room, if one has been established) for inspection by the public and updated as amendments to the application or environmental report are made. An updated copy shall be produced at any public hearing on the application for use by any parties to the proceedings.

* * * * *

8. Section 60.31 is amended by revising paragraphs (a) (1) and (a) (2) to read as follows:

§ 60.31 Construction authorization.

* * * * *

(a) Safety. That there is reasonable assurance that the types and amounts of radioactive materials described in the application can be received, possessed, and disposed of in a geologic repository operations area of the design proposed without unreasonable risk to the health and safety of the public. In arriving at this determination, the Commission shall consider whether:

(1) DOE has described the proposed geologic repository including but not limited to (i) the geologic, geophysical, geochemical and hydrologic characteristics of the site; (ii) the kinds and quantities of radioactive waste to be received, possessed, stored, and disposed of in the geologic repository operations area; (iii) the principal architectural and engineering criteria for the design of the geologic repository operations area; (iv) construction procedures which may affect the capability of the geologic repository to serve its intended function; and (v) features or components incorporated in the design for the protection of the health and safety of the public.

(2) The site and design comply with the performance objectives and criteria contained in Subpart E of this part.

* * * * *

9. Section 60.32 is amended by revising paragraphs (b) and (c) to read as follows:

§ 60.32 Conditions of construction authorization.

(a) * * * *

(b) The Commission will incorporate in the construction authorization provisions requiring DOE to furnish periodic or special reports regarding: (1) progress of construction, (2) any data about the site obtained during construction which are not within the predicted limits upon which the facility design was based, (3) any deficiencies in design and construction which, if uncorrected, could adversely affect safety at any future time, and (4) results of research and development programs being conducted to resolve safety questions.

(c) The construction authorization will include restrictions on subsequent changes to the features of the geologic repository and the procedures authorized. The restrictions that may be imposed under this paragraph can include measures to prevent adverse effects on the geologic setting as well as measures related to the design and construction of the geologic repository operations area. These restrictions will fall into three categories of descending importance to public health and safety as follows: (1) those features and procedures which may not be changed without (i) 60 days prior notice to the Commission, (ii) 30 days notice of opportunity for a prior hearing, and (iii) prior Commission approval; (2) those features and procedures which may not be changed without (i) 60 days prior notice to the Commission, and (ii) prior Commission approval; and (3) those features and procedures which may not be changed without 60 days prior notice to the Commission. Features and procedures falling in paragraph (c)(3) of this section may not be changed without prior Commission approval if the Commission, after having received the required notice, so orders.

*   *   *   *   *

10. Section 60.43 is amended by revising paragraphs (b)(3) and (b)(5) to read as follows:

§ 60.43 License specifications.

(a)   *   *   *   *

(b) License conditions shall include items in the following categories--

(1) * * *

(3) Restrictions as to the amount of waste permitted per unit volume of storage space considering the physical characteristics of both the waste and the host rock.

(4) * * *

(5) Controls to be applied to restricted access and to avoid disturbance to the controlled area and to areas outside the controlled area where conditions may affect isolation within the controlled area.

*   *   *   *   *

11. Section 60.46 is amended by revising paragraphs (a)(3) and (a)(6) and adding (a)(7) to read as follows:

§ 60.46 Particular activities requiring license amendment.

(a) Unless expressly authorized in the license, an amendment of the license shall be required with respect to any of the following activities--

(1) * * *

(3) Removal or reduction of controls applied to restrict access to or avoid disturbance of the controlled area and to areas outside the controlled area where conditions may affect isolation within the controlled area.

(4) * * *

(6) Permanent closure.

(7) Any other activity involving an unreviewed safety question.

12. Section 60.51 is amended by changing the undesignated center heading immediately preceding the section from DECOMMISSIONING to

PERMANENT CLOSURE and by revising paragraphs (a)(1), (2), (4), (5) and (6), and paragraph (b).

§ 60.51 License amendment for permanent closure.

(a) DOE shall submit an application to amend the license prior to permanent closure. The application shall consist of an update of the license application and environmental report submitted under §§60.21 and 60.22, including:

(1) A description of the program for post-permanent closure monitoring of the geologic repository.

(2) A detailed description of the measures to be employed--such as land use controls, construction of monuments, and preservation of records--to regulate or prevent activities that could impair the long-term isolation of emplaced waste within the geologic repository and to assure that relevant information will be preserved for the use of future generations. As a minimum, such measures shall include--

(i) Identification of the controlled area and geologic repository operations area by monuments that have been designed, fabricated, and emplaced to be as permanent as is practicable; and

(ii) Placement of records in the archives and land record systems of local State, and Federal government agencies, and archives elsewhere in the world, that would be likely to be consulted by potential human intruders -- such records to identify the location of the geologic repository operations area, including the underground facility, boreholes and shafts, and the boundaries of the controlled area, and the nature and hazard of the waste.

(3) * * *

(4) The results of tests, experiments, and any other analyses relating to backfill of excavated areas, shaft sealing, waste interaction with the host rock, and any other tests, experiments, or analyses pertinent to the long-term isolation of emplaced wastes within the geologic repository.

(5) Any substantial revision of plans for permanent closure.

(6) Other information bearing upon permanent closure that was not available at the time a license was issued.

(b) DOE shall update its environmental report in a timely manner so as to permit the Commission to review, prior to issuance of an amendment, substantial changes in the permanent closure activities proposed to be carried out or significant new information regarding the environmental impacts of such permanent closure.

13. Section 60.52 is amended by revising paragraphs (a) and (c)(2) to read as follows:

§ 60.52 Termination of license.

(a) Following permanent closure and the decontamination or dismantlement of surface facilities, DOE may apply for an amendment to terminate the license.

* * * * *

(c) A license shall be terminated only when the Commission finds with respect to the geologic repository--

(1) * * *

(2) That the final state of the geologic repository operations area conforms to DOE's plans for permanent closure and DOE's plans for the

decontamination or dismantlement of surface facilities, as amended and approved as part of the license.

*　　　　*　　　　*　　　　*　　　　*

14. Subpart D is revised to read as follows:

SUBPART D--RECORDS, REPORTS, TESTS, AND INSPECTIONS

§ 60.71 General recordkeeping and reporting requirements.

(a) DOE shall maintain such records and make such reports in connection with the licensed activity as may be required by the conditions of the license or by rules, regulations, and orders of the Commission as authorized by the Atomic Energy Act and the Energy Reorganization Act.

(b) Records of the receipt, handling, and disposition of radioactive waste at a geologic repository operations area shall contain sufficient information to provide a complete history of the movement of the waste from the shipper through all phases of storage and disposal.

§ 60.72 Construction records.

(a) DOE shall maintain records of construction of the geologic repository operations area.

(b) The records required under paragraph (a) shall include at least the following --

(1) Surveys of the underground facility excavations, shafts, and boreholes referenced to readily identifiable surface features or monuments;

(2) A description of the materials encountered;

(3) Geologic maps and geologic cross sections;

(4) Locations and amount of seepage;

(5) Details of equipment, methods, progress, and sequence of work;

(6) Construction problems;

(7) Anomalous conditions encountered;

(8) Instrument locations, readings, and analysis;

(9) Location and description of structural support systems;

(10) Location and description of dewatering systems; and

(11) Details, methods of emplacement, and location of seals used.

§ 60.73 Reports of deficiencies.

DOE shall promptly notify the Commission of each deficiency found in the characteristics of the site, and design and construction of the geologic repository operations area which, were it to remain uncorrected, could (a) be a substantial safety hazard, (b) represent a significant deviation from the design criteria and design bases stated in the application, or (c) represent a deviation from the conditions stated in the terms of a construction authorization or the license, including license specifications. The notification shall be in the form of a written report, copies of which shall be sent to the Director and to the appropriate Nuclear Regulatory Commission Regional Office listed in Appendix D of Part 20 of this chapter.

§ 60.74 Tests.

(a) DOE shall perform, or permit the Commission to perform, such tests as the Commission deems appropriate or necessary for the administration of the regulations in this part. These may include tests of (1) radioactive waste, (2) the geologic repository including its structures, systems, and components, (3) radiation detection and monitoring instruments, and (4) other equipment and devices used in connection with the receipt, handling, or storage of radioactive waste.

(b) The tests required under this section shall include a performance confirmation program carried out in accordance with Subpart F of this part.

§ 60.75 Inspections.

(a) DOE shall allow the Commission to inspect the premises of the geologic repository operations area and adjacent areas to which DOE has rights of access.

(b) DOE shall make available to the Commission for inspection, upon reasonable notice, records kept by DOE pertaining to activities under this part.

(c)(1) DOE shall upon request by the Director, Office of Inspection and Enforcement, provide rent-free office space for the exclusive use of the Commission inspection personnel. Heat, air-conditioning, light, electrical outlets and janitorial services shall be furnished by DOE. The office shall be convenient to and have full access to the facility and shall provide the inspector both visual and acoustic privacy.

(2) The space provided shall be adequate to accommodate a full-time inspector, a part-time secretary and transient NRC personnel and will be generally commensurate with other office facilities at the geologic repository operations area. A space of 250 square feet either within the geologic repository operations area's office complex or in an office trailer or other onsite space at the geologic repository operations area is suggested as a guide. For locations at which activities are carried out under licenses issued under other parts of this chapter, additional space

may be requested to accomodate additional full-time inspectors. The office space that is provided shall be subject to the approval of the Director, Office of Inspection and Enforcement. All furniture, supplies and communication equipment will be furnished by the Commission.

(3) DOE shall afford any NRC resident inspector assigned to that location, or other NRC inspectors identified by the Regional Administrator as likely to inspect the facility, immediate unfettered access, equivalent to access provided regular employees, following proper identification and compliance with applicable access control measures for security, radiological protection and personal safety.

15. Subparts E, F, G, H, and I are added to read as follows:

SUBPART E - TECHNICAL CRITERIA

§ 60.101 Purpose and nature of findings.

(a)(1) Subpart B of this part prescribes the standards for issuance of a license to receive and possess source, special nuclear, or byproduct material at a geologic repository operations area. In particular, § 60.41(c) requires a finding that the issuance of a license will not constitute an unreasonable risk to the health and safety of the public. The purpose of this subpart is to set out performance objectives and site and design criteria which, if satisfied, will support such a finding of no unreasonable risk.

(2) 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.

(b) Subpart B of this part also lists findings that must be made in support of an authorization to construct a geologic repository operations area. In particular, § 60.31(a) requires a finding that there is reasonable assurance that the types and amounts of radioactive materials described in the application can be received, possessed, and disposed of in a geologic repository operations area of the design proposed without unreasonable risk to the health and safety of the public. As stated in that paragraph, in arriving at this determination, the Commission will consider whether the site and design comply with the criteria contained in this subpart. Once again, while the criteria may be written in unqualified terms, the demonstration of compliance may take uncertainties and gaps in knowledge into account, provided that the Commission can make the specified finding of reasonable assurance as specified in paragraph (a) of this section.

§ 60.102 Concepts.

This section provides a functional overview of Subpart E. In the event of any inconsistency with definitions found in § 60.2, those definitions shall prevail.

(a) The HLW facility.

NRC exercises licensing and related regulatory authority over those facilities described in section 202(3) and (4) of the Energy Reorganization Act of 1974. Any of these facilities is designated a HLW facility.

(b) The geologic repository operations area.

(1) This part deals with the exercise of authority with respect to a particular class of HLW facility--namely a geologic repository operations area.

(2) A geologic repository operations area consists of those surface and subsurface areas that are part of a geologic repository where radioactive waste handling activities are conducted. The underground structure, including openings and backfill materials, but excluding shafts, boreholes, and their seals, is designated the underground facility.

(3) The exercise of Commission authority requires that the geologic repository operations area be used for storage (which includes disposal) of high-level radioactive wastes (HLW).

(4) HLW includes irradiated reactor fuel as well as reprocessing wastes. However, if DOE proposes to use the geologic repository operations area for storage of radioactive waste other than HLW, the storage of this radioactive waste is subject to the requirements of this part.

(c) Areas related to isolation.

Although the activities subject to regulation under this part are those to be carried out at the geologic repository operations area, the licensing process also considers characteristics of adjacent areas that are defined in other ways. There is to be an area surrounding the underground facility referred to above, which is designated the controlled area, within which DOE is to exercise specified controls to prevent adverse human actions following permanent closure. The location of the controlled area is the site. The accessible environment is the atmosphere, land surface, surface water, oceans, and the portion of the lithosphere that is outside the controlled area. There is an area, designated the geologic setting, which includes the geologic, hydrologic, and geochemical systems of the region in which a geologic repository operations area is or may be located. The geologic repository operations area plus the portion of the geologic setting that provides isolation of the radioactive waste make up the geologic repository.

(d) Stages in the licensing process.

There are several stages in the licensing process. The site characterization stage, though begun before submission of a license application, may result in consequences requiring evaluation in the license review. The construction stage would follow, after issuance of a construction authorization. A period of operations follows the issuance of a license by the Commission. The period of operations includes the time during which emplacement of wastes occurs; any subsequent period before permanent closure during which the emplaced wastes are retrievable; and permanent closure, which includes sealing of shafts. Permanent closure represents the end of active human intervention with respect to the engineered barrier system.

(e) Isolation of waste.

During the first several hundred years following permanent closure of a geologic repository, when radiation and thermal levels are high and the uncertainties in assessing repository performance are large, special emphasis is placed upon the ability to contain the wastes by waste packages within an engineered barrier system. This is known as the containment period. The engineered barrier system includes the waste packages and the underground facility. A waste package is composed of the waste form and any containers, shielding, packing, and absorbent materials immediately surrounding an individual waste container. The underground facility means the underground structure, including openings and backfill materials, but excluding, shafts, boreholes, and their seals.

Following the containment period special emphasis is placed upon the ability to achieve isolation of the wastes by virtue of the characteristics of the geologic repository. The engineered barrier system works to control the release of radioactive material to the geologic setting and the geologic setting works to control the release of radioactive material to the accessible environment. Isolation means inhibiting the transport of radioactive material so that amounts and concentrations of the materials entering the accessible environment will be kept within prescribed limits.

PERFORMANCE OBJECTIVES

§ 60.111 Performance of the geologic repository operations area through permanent closure.

(a) Protection against radiation exposures and releases of radioactive material. The geologic repository operations area shall be designed so that until permanent closure has been completed, radiation exposures and radiation levels, and releases of radioactive materials to unrestricted areas, will at all times be maintained within the limits specified in Part 20 of this chapter and such generally applicable environmental standards for radioactivity as may have been established by the Environmental Protection Agency.

(b) Retrievability of waste.

(1) The geologic repository operations area shall be designed to preserve the option of waste retrieval throughout the period during which wastes are being emplaced and, thereafter, until the completion of a performance confirmation program and Commission review of the information obtained from such a program. To satisfy this objective, the geologic repository operations area shall be designed so that any or all of the emplaced waste could be retrieved on a reasonable schedule starting at any time up to 50 years after waste emplacement operations are initiated, unless a different time period is approved or specified by the Commission. This different time period may be established on a case-by-case basis consistent with the emplacement schedule and the planned performance confirmation program.

(2) This requirement shall not preclude decisions by the Commission to allow backfilling part or all of, or permanent closure of, the geologic

repository operations area prior to the end of the period of design for retrievability.

(3) For purposes of this paragraph, a reasonable schedule for retrieval is one that would permit retrieval in about the same time as that devoted to construction of the geologic repository operations area and the emplacement of wastes.

§ 60.112 Overall system performance objective for the geologic repository after permanent closure.

The geologic setting shall be selected and the engineered barrier system and the shafts, boreholes and their seals shall be designed to assure that releases of radioactive materials to the accessible environment following permanent closure conform to such generally applicable environmental standards for radioactivity as may have been established by the Environmental Protection Agency with respect to both anticipated processes and events and unanticipated processes and events.

§ 60.113 Performance of particular barriers after permanent closure.

(a) General provisions.

(1) Engineered barrier system.

(i) The engineered barrier system shall be designed so that assuming anticipated processes and events (A) containment of HLW will be substantially complete during the period when radiation and thermal conditions in the engineered barrier system are dominated by fission product decay; and (B) any release of radionuclides from the engineered barrier system shall be a gradual process which results in small fractional releases to the geologic setting over long times. For disposal in the saturated zone, both the partial and complete filling with groundwater of available void spaces in the underground facility shall be appropriately considered and analysed among the anticipated processes and events in designing the engineered barrier system.

(ii) In satisfying the preceding requirement, the engineered barrier system shall be designed, assuming anticipated processes and events, so that:

(A) Containment of HLW within the waste packages will be substantially complete for a period to be determined by the Commission taking into account the factors specified in subsection 60.113(b) provided, that such period shall be not less than 300 years nor more than 1,000 years after permanent closure of the geologic repository; and

(B) The release rate of any radionuclide from the engineered barrier system following the containment period shall not exceed one part in 100,000 per year of the inventory of that radionuclide calculated to be present at 1,000 years following permanent closure, or such other fraction of the inventory as may be approved or specified by the Commission; provided, that this requirement does not apply to any radionuclide which is released at a rate less than 0.1% of the calculated total release rate limit. The calculated total release rate limit shall be taken to be one part in 100,000 per year of the inventory of radioactive waste, originally emplaced in the underground facility, that remains after 1,000 years of radioactive decay.

(2) Geologic setting. The geologic repository shall be located so that pre-waste-emplacement groundwater travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment shall be at least 1,000 years or such other travel time as may be approved or specified by the Commission.

(b) 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. Among the factors that the Commission may take into account are--

(1) Any generally applicable environmental standard for radioactivity established by the Environmental Protection Agency;

(2) The age and nature of the waste, and the design of the underground facility, particularly as these factors bear upon the time during which the thermal pulse is dominated by the decay heat from the the fission products;

(3) The geochemical characteristics of the host rock, surrounding strata and groundwater; and

(4) Particular sources of uncertainty in predicting the performance of the geologic repository.

(c) Additional requirements may be found to be necessary to satisfy the overall system performance objective as it relates to unanticipated processes and events.

LAND OWNERSHIP AND CONTROL

§ 60.121 Requirements for ownership and control of interests in land.

(a) Ownership of land.

(1) Both the geologic repository operations area and the controlled area shall be located in and on lands that are either acquired lands under the jurisdiction and control of DOE, or lands permanently withdrawn and reserved for its use.

(2) These lands shall be held free and clear of all encumbrances, if significant, such as: (i) rights arising under the general mining laws; (ii) easements for right-of-way; and (iii) all other rights arising under lease, rights of entry, deed, patent, mortgage, appropriation, prescription, or otherwise.

(b) Additional controls.

Appropriate controls shall be established outside of the controlled area. DOE shall exercise any jurisdiction and control over surface and subsurface estates necessary to prevent adverse human actions that could significantly reduce the geologic repository's ability to achieve isolation. The rights of DOE may take the form of appropriate possessory interests, servitudes, or withdrawals from location or patent under the general mining laws.

(c) Water rights.

(1) DOE shall also have obtained such water rights as may be needed to accomplish the purpose of the geologic repository operations area.

(2) Water rights are included in the additional controls to be established under paragraph (b) of this section.

SITING CRITERIA

§ 60.122 Siting criteria.

(a)(1) A geologic setting shall exhibit an appropriate combination of the conditions specified in paragraph (b) so that, together with the engineered barrier system, the favorable conditions present are sufficient to provide reasonable assurance that the performance objectives relating to isolation of the waste will be met.

(2) If any of the potentially adverse conditions specified in paragraph (c) of this section is present, it may compromise the ability of the geologic repository to meet the performance objectives relating to isolation of the waste. In order to show that a potentially adverse condition does not so compromise the performance of the geologic repository the following must be demonstrated:

(i) The potentially adverse human activity or natural condition has been adequately investigated, including the extent to which the condition may be present and still be undetected taking into account the degree of resolution achieved by the investigations; and

(ii) The effect of the potentially adverse human activity or natural condition on the site has been adequately evaluated using analyses which are sensitive to the potentially adverse human activity or natural condition and assumptions which are not likely to underestimate its effect; and

(iii)(A) The potentially adverse human activity or natural condition is shown by analysis pursuant to paragraph (2)(ii) of this section not to affect significantly the ability of the geologic repository to meet the performance objectives relating to isolation of the waste, or

(B) The effect of the potentially adverse human activity or natural condition is compensated by the presence of a combination of the favorable characteristics so that the performance objectives relating to isolation of the waste are met, or

(C) The potentially adverse human activity or natural condition can be remedied.

(b) Favorable conditions.

(1) The nature and rates of tectonic, hydrogeologic, geochemical, and geomorphic processes (or any of such processes) operating within the

geologic setting during the Quaternary Period, when projected, would not affect or would favorably affect the ability of the geologic repository to isolate the waste.

(2) For disposal in the saturated zone, hydrogeologic conditions that provide--

(i) A host rock with low horizontal and vertical permeability;

(ii) Downward or dominantly horizontal hydraulic gradient in the host rock and immediately surrounding hydrogeologic units; and

(iii) Low vertical permeability and low hydraulic potential between the host rock and surrounding hydrogeologic units; or

(iv) Pre-waste-emplacement groundwater travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment that substantially exceeds 1,000 years.

(3) Geochemical conditions that--(i) Promote precipitation or sorption of radionuclides; (ii) Inhibit the formation of particulates, colloids, and inorganic and organic complexes that increase the mobility of radionuclides; or (iii) Inhibit the transport of radionuclides by particulates, colloids, and complexes.

(4) Mineral assemblages that, when subjected to anticipated thermal loading, will remain unaltered or alter to mineral assemblages having equal or increased capacity to inhibit radionuclide migration.

(5) Conditions that permit the emplacement of waste at a minimum depth of 300 meters from the ground surface. (The ground surface shall be deemed to be the elevation of the lowest point on the surface above the disturbed zone.)

(6) A low population density within the geologic setting and a controlled area that is remote from population centers.

(c) Potentially adverse conditions.

The following conditions are potentially adverse conditions if they are characteristic of the controlled area or may effect isolation within the controlled area.

(1) Potential for flooding of the underground facility, whether resulting from the occupancy and modification of floodplains or from the failure of existing or planned man-made surface water impoundments.

(2) Potential for foreseeable human activity to adversely affect the groundwater flow system, such as groundwater withdrawal, extensive irrigation, subsurface injection of fluids, underground pumped storage, military activity or construction of large scale surface water impoundments.

(3) Potential for natural phenomena such as landslides, subsidence, or volcanic activity of such a magnitude that large-scale surface water impoundments could be created that could change the regional groundwater flow system and thereby adversely affect the performance of the geologic repository.

(4) Structural deformation, such as uplift, subsidence, folding, or faulting that may adversely affect the regional groundwater flow system.

(5) Potential for changes in hydrologic conditions that would affect the migration of radionuclides to the accessible environment, such as changes in hydraulic gradient, average interstitial velocity, storage coefficient, hydraulic conductivity, natural recharge, potentiometric levels, and discharge points.

(6) Potential for changes in hydrologic conditions resulting from reasonably foreseeable climatic changes.

(7) Groundwater conditions in the host rock, including chemical composition, high ionic strength or ranges of Eh-pH, that could increase the solubility or chemical reactivity of the engineered barrier system.

(8) Geochemical processes that would reduce sorption of radionuclides, result in degradation of the rock strength, or adversely affect the performance of the engineered barrier system.

(9) For disposal in the saturated zone, groundwater conditions in the host rock that are not reducing.

(10) Evidence of dissolutioning such as breccia pipes, dissolution cavities, or brine pockets.

(11) Structural deformation such as uplift, subsidence, folding, and faulting during the Quaternary Period.

(12) Earthquakes which have occurred historically that if they were to be repeated could affect the site significantly.

(13) Indications, based on correlations of earthquakes with tectonic processes and features, that either the frequency of occurrence or magnitude of earthquakes may increase.

(14) More frequent occurrence of earthquakes or earthquakes of higher magnitude than is typical of the area in which the geologic setting is located.

(15) Evidence of igneous activity since the start of the Quaternary Period.

(16) Evidence of extreme erosion during the Quaternary Period.

(17) The presence of naturally occurring materials, whether identified or undiscovered, within the site, in such form that:

(i) economic extraction is currently feasible or potentially feasible during the foreseeable future; or

(ii) such materials have greater gross value or net value than the average for other areas of similar size that are representative of and located within the geologic setting.

(18) Evidence of subsurface mining for resources within the site.

(19) Evidence of drilling for any purpose within the site.

(20) Rock or groundwater conditions that would require complex engineering measures in the design and construction of the underground facility or in the sealing of boreholes and shafts.

(21) Geomechanical properties that do not permit design of underground openings that will remain stable through permanent closure.

DESIGN CRITERIA FOR THE GEOLOGIC REPOSITORY OPERATIONS AREA

§ 60.130 Scope of design criteria for the geologic repository operations area.

Sections 60.131 through 60.134 specify minimum criteria for the design of the geologic repository operations area. These design criteria are not intended to be exhaustive, however. Omissions in §§ 60.131 through 60.134 do not relieve DOE from any obligation to provide such safety features in a specific facility needed to achieve the performance objectives. All design bases must be consistent with the results of site characterization activities.

§ 60.131 General design criteria for the geologic repository operations area.

(a) Radiological protection.

The geologic repository operations area shall be designed to maintain radiation doses, levels, and concentrations of radioactive material in air in restricted areas within the limits specified in Part 20 of this chapter. Design shall include--

(1) Means to limit concentrations of radioactive material in air;

(2) Means to limit the time required to perform work in the vicinity of radioactive materials, including, as appropriate, designing equipment for ease of repair and replacement and providing adequate space for ease of operation;

(3) Suitable shielding;

(4) Means to monitor and control the dispersal of radioactive contamination;

(5) Means to control access to high radiation areas or airborne radioactivity areas; and

(6) A radiation alarm system to warn of significant increases in radiation levels, concentrations of radioactive material in air, and of increased radioactivity released in effluents. The alarm system shall be designed with provisions for calibration and for testing its operability.

(b) Structures, systems, and components important to safety.

(1) Protection against natural phenomena and environmental conditions.

The structures, systems, and components important to safety shall be designed so that natural phenomena and environmental conditions anticipated at the geologic repository operations area will not interfere with necessary safety functions.

(2) Protection against dynamic effects of equipment failure and similar events.

The structures, systems, and components important to safety shall be designed to withstand dynamic effects such as missile impacts, that could result from equipment failure, and similar events and conditions that could lead to loss of their safety functions.

(3) Protection against fires and explosions.

(i) The structures, systems, and components important to safety shall be designed to perform their safety functions during and after credible fires or explosions in the geologic repository operations area.

(ii) To the extent practicable, the geologic repository operations area shall be designed to incorporate the use of noncombustible and heat resistant materials.

(iii) The geologic repository operations area shall be designed to include explosion and fire detection alarm systems and appropriate suppression systems with sufficient capacity and capability to reduce the adverse effects of fires and explosions on structures, systems, and components important to safety.

(iv) The geologic repository operations area shall be designed to include means to protect systems, structures, and components important to safety against the adverse effects of either the operation or failure of the fire suppression systems.

(4) <u>Emergency capability.</u>

(i) The structures, systems, and components important to safety shall be designed to maintain control of radioactive waste and radioactive effluents, and permit prompt termination of operations and evacuation of personnel during an emergency.

(ii) The geologic repository operations area shall be designed to include onsite facilities and services that ensure a safe and timely response to emergency conditions and that facilitate the use of available offsite services (such as fire, police, medical and ambulance service) that may aid in recovery from emergencies.

(5) <u>Utility services.</u>

(i) Each utility service system that is important to safety shall be designed so that essential safety functions can be performed under both normal and accident conditions.

(ii) The utility services important to safety shall include redundant systems to the extent necessary to maintain, with adequate capacity, the ability to perform their safety functions.

(iii) Provisions shall be made so that, if there is a loss of the primary electric power source or circuit, reliable and timely emergency power can be provided to instruments, utility service systems, and operating systems, including alarm systems, important to safety.

(6) <u>Inspection, testing, and maintenance.</u> The structures, systems, and components important to safety shall be designed to permit periodic inspection, testing, and maintenance, as necessary, to ensure their continued functioning and readiness.

(7) <u>Criticality control.</u> All systems for processing, transporting, handling, storage, retrieval, emplacement, and isolation of radioactive

waste shall be designed to ensure that a nuclear criticality accident is not possible unless at least two unlikely, independent, and concurrent or sequential changes have occurred in the conditions essential to nuclear criticality safety. Each system shall be designed for criticality safety under normal and accident conditions. The calculated effective multiplication factor (k_{eff}) must be sufficiently below unity to show at least a 5% margin, after allowance for the bias in the method of calculation and the uncertainty in the experiments used to validate the method of calculation.

(8) Instrumentation and control systems. The design shall include provisions for instrumentation and control systems to monitor and control the behavior of systems important to safety over anticipated ranges for normal operation and for accident conditions.

(9) Compliance with mining regulations. To the extent that DOE is not subject to the Federal Mine Safety and Health Act of 1977, as to the construction and operation of the geologic repository operations area, the design of the geologic repository operations area shall nevertheless include such provisions for worker protection as may be necessary to provide reasonable assurance that all structures, systems, and components important to safety can perform their intended functions. Any deviation from relevant design requirements in 30 CFR, Chapter I, Subchapters D, E, and N will give rise to a rebuttable presumption that this requirement has not been met.

(10) Shaft conveyances used in radioactive waste handling.

(i) Hoists important to safety shall be designed to preclude cage free fall.

(ii) Hoists important to safety shall be designed with a reliable cage location system.

(iii) Loading and unloading systems for hoists important to safety shall be designed with a reliable system of interlocks that will fail safely upon malfunction.

(iv) Hoists important to safety shall be designed to include two independent indicators to indicate when waste packages are in place and ready for transfer.

§ 60.132 Additional design criteria for surface facilities in the geologic repository operations area.

(a) Facilities for receipt and retrieval of waste. Surface facilities in the geologic repository operations area shall be designed to allow safe handling and storage of wastes at the geologic repository operations area, whether these wastes are on the surface before emplacement or as a result of retrieval from the underground facility.

(b) Surface facility ventilation. Surface facility ventilation systems supporting waste transfer, inspection, decontamination, processing, or packaging shall be designed to provide protection against radiation exposures and offsite releases as provided in § 60.111(a).

(c) Radiation control and monitoring.

(1) Effluent control. The surface facilities shall be designed to control the release of radioactive materials in effluents during normal operations so as to meet the performance objectives of § 60.111(a).

(2) Effluent monitoring. The effluent monitoring systems shall be designed to measure the amount and concentration of radionuclides in any effluent with sufficient precision to determine whether releases conform

to the design requirement for effluent control. The monitoring systems shall be designed to include alarms that can be periodically tested.

(d) Waste treatment. Radioactive waste treatment facilities shall be designed to process any radioactive wastes generated at the geologic repository operations area into a form suitable to permit safe disposal at the geologic repository operations area or to permit safe transportation and conversion to a form suitable for disposal at an alternative site in accordance with any regulations that are applicable.

(e) Consideration of decommissioning. The surface facility shall be designed to facilitate decontamination or dismantlement to the same extent as would be required, under other parts of this chapter, with respect to equivalent activities licensed thereunder.

§ 60.133 Additional subsurface design criteria for the underground facility.

(a) General criteria for the underground facility.

(1) The orientation, geometry, layout, and depth of the underground facility, and the design of any engineered barriers that are part of the underground facility shall contribute to the containment and isolation of radionuclides.

(2) The underground facility shall be designed so that the effects of credible disruptive events during the period of operations, such as flooding, fires, and explosions, will not spread through the facility.

(b) Flexibility of design. The underground facility shall be designed with sufficient flexibility to allow adjustments where necessary to accommodate specific site conditions identified through in situ monitoring, testing, or excavation.

(c) Retrieval of waste. The underground facility shall be designed to permit retrieval of waste in accordance with the performance objectives of § 60.111.

(d) Control of water and gas. The design of the underground facility shall provide for control of water or gas intrusion.

(e) Underground openings.

(1) Openings in the underground facility shall be designed so that operations can be carried out safely and the retrievability option maintained.

(2) Openings in the underground facility shall be designed to reduce the potential for deleterious rock movement or fracturing of overlying or surrounding rock.

(f) Rock excavation. The design of the underground facility shall incorporate excavation methods that will limit the potential for creating a preferential pathway for groundwater or radioactive waste migration to the accessible environment.

(g) Underground facility ventilation.

The ventilation system shall be designed to--

(1) Control the transport of radioactive particulates and gases within and releases from the underground facility in accordance with the performance objectives of § 60.111(a).

(2) Assure continued function during normal operations and under accident conditions; and

(3) Separate the ventilation of excavation and waste emplacement areas.

(h) Engineered barriers.

Engineered barriers shall be designed to assist the geologic setting in meeting the performance objectives for the period following permanent closure.

(i) Thermal loads. The underground facility shall be designed so that the performance objectives will be met taking into account the predicted thermal and thermomechanical response of the host rock, and surrounding strata, groundwater system.

§ 60.134 Design of seals for shafts and boreholes.

(a) General design criterion. Seals for shafts and boreholes shall be designed so that following permanent closure they do not become pathways that compromise the geologic repository's ability to meet the performance objectives for the period following permanent closure.

(b) Selection of materials and placement methods. Materials and placement methods for seals shall be selected to reduce, to the extent practicable, (1) the potential for creating a preferential pathway for groundwater; or (2) radioactive waste migration through existing pathways.

DESIGN CRITERIA FOR THE WASTE PACKAGE

§ 60.135 Criteria for the waste package and its components.

(a) High-level-waste package design in general.

(1) Packages for HLW shall be designed so that the in situ chemical, physical, and nuclear properties of the waste package and its interactions with the emplacement environment do not compromise the function of the waste packages or the performance of the underground facility or the geologic setting.

(2) The design shall include but not be limited to consideration of the following factors: solubility, oxidation/reduction reactions, corrosion, hydriding, gas generation, thermal effects, mechanical strength, mechanical stress, radiolysis, radiation damage, radionuclide retardation, leaching, fire and explosion hazards, thermal loads, and synergistic interactions.

(b) Specific criteria for HLW package design.

(1) Explosive, pyrophoric, and chemically reactive materials. The waste package shall not contain explosive or pyrophoric materials or chemically reactive materials in an amount that could compromise the ability of the underground facility to contribute to waste isolation or the ability of the geologic repository to satisfy the performance objectives.

(2) Free liquids. The waste package shall not contain free liquids in an amount that could compromise the ability of the waste packages to achieve the performance objectives relating to containment of HLW (because of chemical interactions or formation of pressurized vapor) or result in spillage and spread of contamination in the event of waste package perforation during the period through permanent closure.

(3) Handling. Waste packages shall be designed to maintain waste containment during transportation, emplacement, and retrieval.

(4) Unique identification. A label or other means of identification shall be provided for each waste package. The identification shall not impair the integrity of the waste package and shall be applied in such a way that the information shall be legible at least to the end of the period of retrievability. Each waste package identification shall be consistent with the waste package's permanent written records.

(c) Waste form criteria for HLW.

High-level radioactive waste that is emplaced in the underground facility shall be designed to meet the following criteria:

(1) Solidification. All such radioactive wastes shall be in solid form and placed in sealed containers.

(2) Consolidation. Particulate waste forms shall be consolidated (for example, by incorporation into an encapsulating matrix) to limit the availability and generation of particulates.

(3) Combustibles. All combustible radioactive wastes shall be reduced to a noncombustible form unless it can be demonstrated that a fire involving the waste packages containing combustibles will not compromise the integrity of other waste packages, adversely affect any structures, systems, or components important to safety, or compromise the ability of the underground facility to contribute to waste isolation.

(d) Design criteria for other radioactive wastes.

Design criteria for waste types other than HLW will be addressed on an individual basis if and when they are proposed for disposal in a geologic repository.

PERFORMANCE CONFIRMATION REQUIREMENTS

§ 60.137 General requirements for performance confirmation.

The geologic repository operations area shall be designed so as to permit implementation of a performance confirmation program that meets the requirements of Subpart F of this part.

SUBPART F - PERFORMANCE CONFIRMATION PROGRAM

§ 60.140 General requirements.

(a) The performance confirmation program shall provide data which indicates, where practicable, whether--

(1) Actual subsurface conditions encountered and changes in those conditions during construction and waste emplacement operations are within the limits assumed in the licensing review; and

(2) Natural and engineered systems and components required for repository operation, or which are designed or assumed to operate as barriers after permanent closure, are functioning as intended and anticipated.

(b) The program shall have been started during site characterization and it will continue until permanent closure.

(c) The program shall include in situ monitoring, laboratory and field testing, and in situ experiments, as may be appropriate to accomplish the objective as stated above.

(d) The program shall be implemented so that:

(1) It does not adversely affect the ability of the natural and engineered elements of the geologic repository to meet the performance objectives.

(2) It provides baseline information and analysis of that information on those parameters and natural processes pertaining to the geologic setting that may be changed by site characterization, construction, and operational activities.

(3) It monitors and analyzes changes from the baseline condition of parameters that could affect the performance of a geologic repository.

(4) It provides an established plan for feedback and analysis of data, and implementation of appropriate action.

§ 60.141 Confirmation of geotechnical and design parameters.

(a) During repository construction and operation, a continuing program of surveillance, measurement, testing, and geologic mapping shall be conducted to ensure that geotechnical and design parameters are confirmed and to ensure that appropriate action is taken to inform the Commission of changes needed in design to accommodate actual field conditions encountered.

(b) Subsurface conditions shall be monitored and evaluated against design assumptions.

(c) As a minimum, measurements shall be made of rock deformations and displacement, changes in rock stress and strain, rate and location of water inflow into subsurface areas, changes in groundwater conditions, rock pore water pressures including those along fractures and joints, and the thermal and thermomechanical response of the rock mass as a result of development and operations of the geologic repository.

(d) These measurements and observations shall be compared with the original design bases and assumptions. If significant differences exist between the measurements and observations and the original design bases and assumptions, the need for modifications to the design or in construction methods shall be determined and these differences and the recommended changes reported to the Commission.

(e) In situ monitoring of the thermomechanical response of the underground facility shall be conducted until permanent closure to ensure that the performance of the natural and engineering features are within design limits.

§ 60.142 Design testing.

(a) During the early or developmental stages of construction, a program for in situ testing of such features as borehole and shaft seals, backfill, and the thermal interaction effects of the waste packages, backfill, rock, and groundwater shall be conducted.

(b) The testing shall be initiated as early as is practicable.

(c) A backfill test section shall be constructed to test the effectiveness of backfill placement and compaction procedures against design requirements before permanent backfill placement is begun.

(d) Test sections shall be established to test the effectiveness of borehole and shaft seals before full-scale operation proceeds to seal boreholes and shafts.

§ 60.143 Monitoring and testing waste packages.

(a) A program shall be established at the geologic repository operations area for monitoring the condition of the waste packages. Waste packages chosen for the program shall be representative of those to be emplaced in the underground facility.

(b) Consistent with safe operation at the geologic repository operations area, the environment of the waste packages selected for the waste package monitoring program shall be representative of the environment in which the wastes are to be emplaced.

(c) The waste package monitoring program shall include laboratory experiments which focus on the internal condition of the waste packages. To the extent practical, the environment experienced by the emplaced waste packages within the underground facility during the waste package monitoring program shall be duplicated in the laboratory experiments.

(d) The waste package monitoring program shall continue as long as practical up to the time of permanent closure.

SUBPART G - QUALITY ASSURANCE

§ 60.150 Scope.

As used in this part, "quality assurance" comprises all those planned and systematic actions necessary to provide adequate confidence that the geologic repository and its subsystems or components will perform satisfactorily in service. Quality assurance includes quality control, which comprises those quality assurance actions related to the physical characteristics of a material, structure, component, or system which provide a means to control the quality of the material, structure, component, or system to predetermined requirements.

§ 60.151 Applicability.

The quality assurance program applies to all systems, structures and components important to safety, to design and characterization of barriers important to waste isolation and to activities related thereto. These activities include: site characterization, facility and equipment construction, facility operation, performance confirmation, permanent closure, and decontamination and dismantling of surface facilities.

§ 60.152 Implementation.

DOE shall implement a quality assurance program based on the criteria of Appendix B of 10 CFR Part 50—as applicable, and appropriately supplemented by additional criteria as required by § 60.151.

SUBPART H - TRAINING AND CERTIFICATION OF PERSONNEL

§ 60.160 General requirements.

Operations of systems and components that have been identified as important to safety in the Safety Analysis Report and in the license shall be performed only by trained and certified personnel or by personnel under the direct visual supervision of an individual with training and certification in such operation. Supervisory personnel who direct operations that are important to safety must also be certified in such operations.

§ 60.161 Training and certification program.

DOE shall establish a program for training, proficiency testing, certification and requalification of operating and supervisory personnel.

§ 60.162 Physical requirements.

The physical condition and the general health of personnel certified for operations that are important to safety shall not be such as might cause operational errors that could endanger the public health and safety. Any condition which might cause impaired judgment or motor coordination must be considered in the selection of personnel for activities that are important to safety. These conditions need not categorically disqualify a person, so long as appropriate provisions are made to accommodate such conditions.

SUBPART I - EMERGENCY PLANNING CRITERIA

[RESERVED]

Dated at Washington, D.C., this __________ day ____ of ____, 1983.

For the Nuclear Regulatory Commission.

Samuel J. Chilk
Secretary of the Commission

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were reviewed and published in summary form, on March 31, 1980 (45 FR 21168). In general, the comments were supportive of the agency's efforts.

It was also at this time, March 1980, that Packers and Stockyards printed its timetable for review anticipating the publication of a specific set of regulations for review every 6 months until all regulations were considered or a total time period of approximately 5 years. Fourteen specific regulations, six policy statements and various report forms were selected for review, and comments were again solicited.

In response to the March request, 21 additional comments were received concerning the specific areas targeted for review, i.e.: (1) Current levels of required bonding; (2) proper maintenance of custodial accounts; (3) packer sales promotion policies; and (4) required annual reporting for market agencies and dealers. The agency's third Federal Register publication, dated December 31, 1980 (45 FR 87002), discussed these comments and detailed specific changes in these target areas designed to be responsive to suggestions by the industry, to lessen regulatory burdens on the industry, and to encourage competitive markets within the industry.

Present Activities

The agency has decided to accelerate the regulatory review and reform process which it has already begun. To assist the agency in achieving this end, the Deputy Administrator, Packers and Stockyards, AMS, established an internal task force in January 1981 to review each rule and regulation and to suggest changes thereto which would lessen or eliminate any regulatory burden imposed without restricting the agency's ability to enforce the Packers and Stockyards Act. An interim report of the task force has been prepared and a final report is expected by the Administrator of Packers and Stockyards Administration on August 1, 1981.

Revised Plan

Packers and Stockyards Administration will not follow its previously published plan for regulatory review. Rather, the agency will review all currently effective regulations, policy statements and reporting requirements by the close of fiscal year 1983 (September 30, 1983). As a part of this review, effort will be made to obtain input from the affected industries, State Departments of Agriculture, and other interested persons prior to formal publication of proposals. Proposed changes and deletions will then be published in the Federal Register for comments prior to final adoption. Additionally, by September 30, 1981, the agency will publish, pursuant to the requirements of the Regulatory Flexibility Act, a listing of all rules having a significant economic impact on a substantial number of small business entities which will be reviewed during the succeeding 12 months. the proposed regulations published December 31, 1980, in the Federal Register will be reconsidered by the agency to incorporate, where appropriate, the recommendations of the task force and comments filed by the industry, and where necessary, such regulations will be republished for comment.

Done at Washington, D.C., this 1st day of July 1981.

James L. Smith,

Acting Administrator, Packers and Stockyards Administration.

[FR Doc. 81-19890 Filed 7-7-81; 8:45 am]

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NUCLEAR REGULATORY COMMISSION

10 CFR Part 60

Disposal of High-Level Radioactive Wastes in Geologic Repositories

AGENCY: Nuclear Regulatory Commission.

ACTION: Proposed rule.

SUMMARY: The NRC is publishing proposed amendments which specify technical criteria for disposal of high-level radioactive wastes (HLW) in geologic respositories. The proposed criteria address siting, design, and performance of a geologic repository, and the design and performance of the package which contains the waste within the geologic repository. Also included are criteria for monitoring and testing programs, performance confirmation, quality assurance, and personnel training and certification. The proposed criteria are necessary for the NRC to fulfill its statutory obligations concerning the licensing and regulating of facilities used for the receipt and storage of high-level radioactive waste.

DATE: Comments received after November 5, 1981 will be considered if it is practical to do so, but assurance of consideration cannot be given except for comments received on or before this date.

ADDRESS: Written comments or suggestions on the proposed amendments should be sent to the Secretary of the Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Docketing and Service Branch. Copies of comments may be examined in the U.S. Nuclear Regulatory Commission Public Document Room, 1717 H Street NW, Washington, D.C. Comments may also be delivered to Room 1121, 1717 H Street NW, Washington, D.C., between 8:15 a.m. and 5:00 p.m.

FOR FURTHER INFORMATION CONTACT: Frank J. Arsenault, Director of the Division of Health, Siting and Waste Management, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Telephone (301) 427-4350.

SUPPLEMENTARY INFORMATION:

Background

On December 6, 1979 the Nuclear Regulatory Commission (Commission or NRC) published for comment proposed procedures for licensing geologic disposal of high-level radioactive wastes. The licensing procedures were published in final form on February 25, 1981 (46 FR 13971). On May 13, 1980 (45 FR 31393) the Commission published for comment an Advance Notice of Proposed Rulemaking (ANPR) concerning technical criteria for regulating disposal of high-level radioactive wastes (HLW) in geologic respositories. Included with the advance notice was a draft of the technical criteria under development by the staff. The public was asked to provide comment on several issues discussed in the advance notice and to reflect on the draft technical criteria in light of that discussion. The comments received were numerous and covered the full range of issues related to the technical criteria. The technical criteria being proposed here are the culumination of a number of drafts, and were developed in light of the comments received on the ANPR. It is the Commissions's belief that the regulation proposed here is one which is both practical for licensing and this notice provides a flexible vehicle for accommodating comments in that it points out alternatives and calls for comment in a number of critical plans. The Commission has prepared an analysis of the comments which explains the changes made from the ANPR, and intends to publish soon the comments and the analysis as a NUREG document. A draft of this NUREG has been placed in the Commission's Public Document Room for review. In addition, the staff has begun a program to develop guidance as to the methods that it regards as satisfactory for demonstrating compliance with the requirements of the proposed rule.

The technical criteria being set forth here as proposed rulemaking are a result of the Commission's further effort in regulating geologic disposal of HLW by the Department of Energy (DOE). The rationale for the performance objectives and the Environmental Impact Assessment supporting this rulemaking are also being published separately and are available free of charge upon written request to Frank Arsenault at the above address. In developing these criteria we have not reexaminated DOE's programmatic choice of disposal technology resulting from its Generic Environmental Impact Statement, inasmuch as the Commission has expressly reserved until a later time possible consideration of matters within the scope of that generic statement (44 FR 70408). Accordingly, the technical criteria apply only to disposal in geologic respositories and do not address other possible or potential disposal methods. Similarly, in that DOE's current plans call for dispoal at sufficient depth to be in the area termed the saturated zone, these criteria were developed for disposal in saturated media. Additional or alternative criteria may need to be developed for regulating disposal in the unsaturated or vadose zone.

Authority

Sections 202 (3) and (4) of the Energy Reorganization Act of 1974, as amended, provide the Commission with licensing and regulatory authority regarding DOE facilities used primarily for the receipt and storage of high-level radioactive wastes resulting from activities licensed under the Atomic Energy Act and certain other long-term HLW storage facilities of DOE. Pursuant to that authority, the Commission is developing criteria appropriate to regulating geologic disposal of HLW by DOE. The requirements and criteria contained in this proposed rule are a result of that effort.

Relation to Generally Applicable Standards for Radiation in the Environment Established by the Environmental Protection Agency

The Environmental Protection Agency (EPA) has the authority and responsibility for setting generally applicable standards for radiation in the environment. It is the responsibility of the NRC to implement those standards in its licensing actions and assure that public health and safety are protected. Although no EPA standard for disposal of HLW yet exists, these proposed technical criteria for regulating geologic disposal of HLW have been developed to be compatible with a generally applicable environmental standard. Specifically, the performance objectives and criteria speak to the functional elements of geologic disposal of HLW and the analyses required to give confidence that these functional elements will perform as intended.

Disruptive Processes and Events

The NRC's implementing regulations assume that licensing decisions will be based, in part, on the results of analysis of the consequences of processes and events which potentially could disrupt a repository. Thus, throughout the criteria are requirements that the design basis take into account processes and events with the potential to disrupt a geologic repository. If the process or event is anticipated, i.e., likely, then the design basis requires barriers which would not fail in a way that would result in the repository not meeting the performance objectives. Anticipated processes and events would include such items as waste/rock interactions that result from emplacement of the wastes or the gradual deterioration of borehole seals. If the process or event is unlikely, then the overall system must still limit the release of radionuclides consistent with the EPA standard as applied to such events. An example of an unlikely event would be reactivation of a fault within the geologic setting which had not exhibited movement since the start of the Quaternary Period. In general, both likely and unlikely processes and events are expected to be site and design specific and would be identified by DOE in its license application.

Multiple Barriers

The proposed technical criteria were developed not only with the understanding that EPA's generally applicable environmental standard would need to be implemented, at least in part, by performing calculations to predict performance, but also with the knowledge that some of those calculations would be complex and uncertain. Natural systems are difficult to characterize and any understanding of the site will have significant limitations and uncertainties. Those properties which pertain to isolation of HLW are difficult to measure and the measurements which are made will be subject to several sources of error and uncertainty. The physical and chemical processes which isolate the wastes are themselves varied and complex. Further, those processes are especially difficult to understand in the area close to the emplaced wastes because that area is physically and chemically disturbed by the heat generated by those wastes.

However, a geologic repository consists of engineered features as well as the natural geologic environment. Any evaluation of repository performance, therefore, will consider the waste form and other engineering factors which are elemental to the performance of the repository as a system. By partitioning the engineered system into two major barriers, the waste package and the underground facility, and establishing performance objectives for each, the Commission has sought to exploit the ability to design the engineered features to meet specific performance objectives as a means of reducing some of the uncertainties in the calculations of overall repository performance.

In addition, the requirements for containment, controlled release rate, and 1,000-year groundwater transit time are three criteria which act independently of the overall repository performance to provide confidence that the wastes will be isolated at least for as long as they are most hazardous.

Containment and Isolation

During the first several hundred years following emplacement of the wastes, both the radiation from and the heat generated by the wastes are attributable mainly to the decay of the shorter-lived nuclides, primarily fission products. At about 1,000 years after emplacement both the radiation from and heat generated by decay of the wastes have diminished by about 3 orders of magnitude. As the decay of the longer-lived nuclides, primarily actinides, begins to dominate, both the radiation from and thermal output of the wastes continue to fall until almost 100,000 to 1,000,000 years after emplacement. By that time both have diminished by about 5 orders of magnitude and both heat and radiation become roughly constant due to the ingrowth of daughter nuclides, primarily Ra-223, Ra-226 and their decay products.

The technical criteria would require the engineered system to be designed so that the wastes are contained within the waste package for the first thousand years following emplacement. Following this period, containment is no longer assumed and the function of the waste package and underground facility is to control the release of radionuclides from the underground facility. By requiring containment during the period when the thermal conditions around the waste packages are most severe, evaluation of repository performance is greatly simplified to considerations of the degree of conservatism in the containment design relative to events

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and processes that might affect the performance during the containment period.

Although both the radiation from and heat generated by the decay of the wastes have diminished about 3 orders of magnitude during the containment period, the area surrounding the emplaced wastes will not return to temperatures near those before the wastes were emplaced until after about 10,000 years. As mentioned earlier, the thermal disturbance of the area near the emplaced wastes adds significantly to the uncertainties in the calculation of the transport of the radionuclides through the geologic environment. The technical criteria are intended to compensate for uncertainties by imposing further design requirements on the waste package and underground facility, thereby limiting the source term by controlling the release rate.

Role of the Site

The Commission neither intends nor expects either containment to be lost completely at 1,000 years following emplacement or the engineered system's contribution to the control of the release of wastes to cease abruptly at some later time. However, the Commission recognizes that at some point the design capabilities of the engineered system will be lost and that the geologic setting—the site—must provide the isolation of the wastes from the environment, and has translated this requirement into a performance objective for the geologic setting. The Commission also recognizes that isolation is, in fact, a controlled release to the environment which could span many thousands of years, and that the release of radionuclides and the potential exposures to individuals which could result, should be addressed in the evaluation of a repository. A complement to the evaluation of the effects of design basis processes and events which might disrupt the repository is a projection of how the repository, unperturbed by discrete external events, will evolve through the centuries as a result of the geologic processes operating at the site. Hence, an amendment is being proposed to that portion of Subpart B of 10 CFR Part 60 which describes the contents of the Safety Analysis Report of DOE's application for geologic disposal of HLW which would require DOE to project the expected performance of the proposed geologic repository noting the rates and quantities of expected releases of radionuclides to the accessible environment as a function of time.

Retrievability

The licensing procedures of 10 CFR Part 60 were written assuming that there would be a program of testing and measurement of the thermal, mechanical, and chemical properties of the major engineered barriers to confirm their expected performance. The Commission would like to tie the requirement for retievability of the wastes to the expected time needed to execute the performance confirmation program. However, at present it appears to the Commission that neither the specific nature nor the period needed for execution of the performance confirmation program will be certain until construction of the repository is substantially complete; that is, until the actual licensing to receive wastes at a geologic repository. Hence it is difficult at this time to use the performance confirmation program as a basis for establishing a period of retrievability. Nonetheless, DOE is now making critical decisions regarding the design of geologic repositories which will have a direct effect upon how long the optio to retrieve wastes can be maintained, and upon the difficulty which will be encounted in exercising that option, should that be necessary for protection of public health and safety. Therefore, to provide a suitable objective in this regard, the proposed rule sets forth a requirement that the engineered system be designed so that the option to retrieve the waste can be preserved for up to fifty years following completion of emplacement. Thus, the waste package and the underground facility would be designed so that the period of retrievability would not be the determinant of when the Commission would decide to permit closure of the repository. Rather, the Commission would be assured of the option to let the conduct of the performance confirmation program indicate when it is appropriate to make such a decision. In particular, the Commission is concerned that the thermo-mechanical design of the underground facility be such that access can be maintained until the Commission either decides to permit permanent closure of the repository or to take corrective action, which may include retrieval.

As it is now structured, the rule would require in effect that the repository design be such as to permit retrieval of waste packages for a period of up to 110 years. The components of this total period are as follows: the first waste packages to go in the repository are likely to be in place about thirty years before all wastes are in place; thereafter, a 50-year period is required by the rule; finally, a retrieval schedule is suggested of about the same time as the original construction plus emplacement operations—another 30-odd years. Since it is probably not practical to adjust the retrievability design aspects of the repository according to the order of emplacement of the waste packages, the 110-year requirement will apply to all of the waste. The Commission is particularly interested in comments on the degree to which this requirement will govern the thermal and mechanical design of the repository and on whether some shorter period would be adequate or whether there are other ways than an overall retrievability requirement to preserve options before permanent closure. The Commission does not want to approve construction of a design that will foreclose unnecessarily options for future decisionmakers, but it is also concerend that retrievability requirements not unnecessarily complicate or dominate repository design.

The retrievability requirement does not specify the form in which the wastes are to be retrievable or that wastes are "readily retrievable." The requirement is simply that all the wastes be retrievable during a period equal to the period of construction and emplacement. DOE's plans for retrieval are specifically requested as part of its license application and the practicability of its proposal will be considered by the Commission. Waste may be retrieved upon NRC approval of a DOE application or upon order by NRC, or otherwise, where authorized by DOE's license.

Human Intrusion

Some concern has been raised on the issue of human intrusion into a geologic repository. Human intrusion could conceivably occur either inadvertently or deliberately. Inadvertent intrusion is the accidental breaching of the repository in the course of some activity unrelated to the existence of the repository, e.g., exploration for or development of resources. For inadvertent intrusion to occur, the institutional controls, site markers, public records, and societal memory of the repository's existence must have been ineffective or have ceased to exist. Deliberate or intentional intrusion, on the other hand, assumes a conscious decision to breach the repository; for example, in order to recover the high-level waste itself, or exploit a mineral associated with the site.

Historical evidence indicates that there is substantial continuity of

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information transfer over time. There are numerous examples of knowledge, including complex information, being preserved for thousands of years. This has occurred even in the absence of printing and modern information transfer and storage systems. Furthermore, this information transfer has survived disruptive events, such as wars, natural disasters, and dramatic changes in the social and political fabric of societies. The combination of the historical record of information transfer, provisions for a well-marked and extensively documented site location, and the scale and technology of the operation needed to drill deeply enough to penetrate a geologic repository argue strongly that inadvertent intrusion as described above is highly improbable, at least for the first several hundred years during which time the wastes are most hazardous. Selecting a site for a repository which is unattractive with respect to [illegible] resource value and scientific [illegible] further adds to the improbability of inadvertent human intrusion. It is also logical to assume that any future generation possessing the technical capability to locate and explore for resources at the depth of a repository would also possess the capability to assess the nature of the material discovered, to mitigate consequences of the breach and to reestablish administrative control over the area if needed. Finally, it is inconsistent to assume the scientific and technical capability to identify and explore an anomalous heat source several hundred meters beneath the Earth's surface and not assume that those exploring would have some idea of either what might be the cause of the anomaly or what steps to take to mitigate any untoward consequence of that exploration.

The above arguments do not apply to the case of deliberate intrusion. The repository itself could be attractive and invite intrusion simply because of the resource potential of the wastes themselves. Intrusion to recover the wastes demands (1) knowledge of the existence and nature of the repository, and (2) effort of the same magnitude as that undertaken to emplace the wastes. Hence intrusion of this sort can only be the result of a conscious, collective societal decision to recover the wastes.

Intrusion for the purpose of sabotage or terrorism has also been mentioned as a possibility. However, due to the nature of geologic disposal, there seems to be very little possibility that terrorists or saboteurs could breach a repository. Breach of the repository would require extensive use of machinery for drilling and excavating over a considerable period of time. It is highly improbable that a terrorist group could accomplish this covertly.

In light of the above, the Commission adopted the position that commonsense dictates that everything that is reasonable be done to discourage people from intruding into the repository. Thus, the proposed technical criteria are written to direct site selection towards selection of sites of little resource value and for which there does not appear to be any attraction for future societies. Further, the proposed criteria would require reliable documentation of the existence and location of the repository and the nature of the wastes emplaced therein, including marking the site with the most permanent markers practical. However, once the site is selected, marked, and documented, it does no use to argue over whether these measures will be adequate in the future, or to speculate on the virtual infinity of human intrusion scenarios and whether they will or will not result in violation of the EPA standard. Of course, the Commission recognizes that there are alternative approaches to the Human Intrusion question. Accordingly, comment on this and alternative approaches is welcome.

Relation to Other Parts of NRC Regulations

The proposed rule contemplates that DOE activities at a geologic repository operations area may in appropriate cases be licensed under other parts of NRC regulations and would then not be governed by these technical criteria. We note, in this connection, that the scope section of the procedural rule specifically provides that Part 60 shall not apply to any activity licensed under another part. This allows an independent spent fuel storage installation to be licensed under Part 72, even though located at a geologic repository operations area (provided, of course, it is sufficiently separate to be classified as "independent"). Other DOE activities of the geologic repository operations area could be licensed under Parts 30 or 70 if an exemption from Part 60 is determined to be appropriate.

Alternative Approach

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. Having reached these conclusions, the Commission considers next whether or not and to what level of detail the performance criteria for a geological repository should be prescribed. In this regard the Commission considers the following 3 alternatives:[3]

1. Prescribe a single overall performance standard that must be met. The standard in this case would be the EPA standard;

2. Prescribe minimum performance standards for each of the major elements, in addition to requiring the overall system to meet the EPA standards; and

3. Prescribe detailed numerical criteria on critical enginneering attributes of the repository system.

Alternative 3 is considered overly restrictive on the design flexibility and judged to be inappropriate at this stage of technological development. Therefore, this alternative is quickly eliminated as a viable regulatory approach.

Alternative 1 has as its principal advantage the fact that it provides maximum flexibility in apportioning credit for containment and isolation to the several elements of the repository. It also allows the designer to incorporate and apply new technological developments and knowledge from the site characterization phase to the repository design. Notwithstanding some concern over its practicality in the regulatory framework, the Commission cannot at this time eliminate it from further consideration. The Commission is, therefore, specifically requesting the general public, particularly those from the technical communities, to comment on this point. In addition, the Commission requests commentors espousing this alternative to address specifically ways in which the Commission might find reasonable assurance that the ultimate standards

[3] Detailed discussions on the advantages and disadvantages of each of these alternatives are given in Appendix J to Commission Paper SECY-81-287, April 27, 1981, "Rationale for Performance Objectives and Required Characteristics of the Geologic Setting." This appendix is being published separately and is available without charge on request to the Commission's Public Document Room, 1717 H St. NW. Washington, D.C. 20555.

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are met without prescribing standards for the major elements of a repository.

In relation to the first and the third alternatives that are briefly discussed above, Alternative 2 appears to offer a reasonable and practical compromise. In addition to retaining the single overall performance standard in Alternative 1 as the final performance objective, this approach establishes the minimum performance objectives for each of the 3 major barriers of the repository. While this approach limits the repository designer's flexibility, it is clear that meeting these minimum design goals would substantially enhance the Commission's confidence that the final EPA standard will be met. Therefore, the Commission prefers a technical rule established upon this approach.

It should be noted that, in the event that the Commission decides to adopt the Alternate 1 approach in the final rulemaking, portions of the proposed rule (e.g., the section on requirements for the geological setting) would have to be further studied and possibly revised. In addition, it is possible that further public comments would have to be sought.

Major Features of the Proposed Rule

1. *Overall Description.* The proposed technical criteria have been written to address the following: performance objectives and requirements for siting, design and construction of the repository, the waste package, confirmation of repository performance, quality assurance, and the training and certification of personnel. As appropriate, these topics are divided in turn to address separately requirements which apply during construction, waste emplacement, and after permanent closure (decommissioning) of the repository. Although the licensing procedures indicate that there would be separate subparts for siting and design requirements, viz. Subparts E and F, respectively (cf. § 60.31(a)(2)), the NRC now believes that the site and design are so interdependent that such a distinction is artificial and misleading. For example, although the requirement to place the underground facility at a minimum depth of 300 meters is clearly a design requirement, it is manifested as a siting requirement since unless the site has a host rock of sufficient thickness at sufficient depth, the above design requirement cannot be met. Hence the proposed Subpart E to 10 CFR Part 60 contains both site and design requirements.

To enable the Commission to reach a finding as to whether the generally applicable environmental standard for disposal of HLW is met and that public health and safety will be protected, a careful and exhaustive analysis of all the features of the repository will be needed. That analysis necessarily must be both qualitative and quantitative although the analysis can and will be largely quantitative during the period that greatest reliance can be placed upon the engineered system. Thereafter, although the issues of concern, and certainly the physics of a repository itself, do not change, the numerical uncertainties begin to become so large that calulations become a weak indicator of expected repository performance.

In sum, the technical criteria perform two tasks. First they serve to guide DOE in siting, designing, constructing, and operating a repository in such a manner that there can be reasonable confidence that public health and safety will be protected. Second, they serve to guide DOE in those same areas in such a manner that there can be reasonable confidence that the analyses, needed to determine whether public health and safety is protected, can be performed.

2. *Performance Objectives.* The design and operation of the repository are prescribed to be such that during the period that wastes are being emplaced and performance assessed, exposure to workers and releases of radioactivity to the environment must be within limits set by the Commission and the EPA. Further, the repository is to be designed so that the option can be preserved to retrieve the emplaced wastes beginning at anytime up to 50 years following completion of emplacement. Following permanent closure, the repository must perform so that releases are within the limits prescribed by the generally applicable environmental standard which will be set by the EPA. Further, the design of the repository must include a waste package and an underground facility, as well as the site, as barriers to radionuclide migration.

The performance of the engineered system (waste package and underground facility) following permanent closure is specified to require containment of the wastes within the waste package for at least 1000 years following closure, when temperatures in the repository are substantially elevated, and control of the release of nuclides to the geologic environment thereafter.

Transuranic waste (TRU) may be disposed of in a geologic repository. Since transuranic waste does not generate significant amounts of heat, there is no advantage to containment for any specified period. Hence, the requirement for TRU waste is simply a controlled release equivalent to that for HLW, provided they are physically separted from the HLW so that they will not experience a significant increase in temperature.

Although a minimum 1,000-year containment and a maximum one part in 100,000 release rate will satisfy these criteria, the Commission considers it highly desirable that wastes be contained as long thereafter as is reasonably achievable, and that release rates be as far below one part in 100,000 as is reasonably achievable.

3. *Siting Requirements.* Although no specific site suitability or exclusion requirements are given in the criteria, stability and minimum groundwater travel times are specified as required site characteristics. ALARA (as low as reasonably achievable) principles have not been applied to the natural features of a site because they are not amenable to modification once a site is chosen. However, the technical criteria do identify site characteristics considered favorable for a repository as well as characteristics which, if present at the site, may compromise site suitability and which will require careful analysis and such measures as may be necessary to compensate for them adequately. The impact of these characteristics on overall performance would be site specific. Thus, the Commission has judged that these should not be made absolute requirements. Presence of all the favorable characteristics does not lead to the conclusion that the site is suitable to host a repository. Neither is the presumption of unsuitability because of the presence of an unfavorable characteristic incontrovertible. Rather, the Commission's approach requires a sufficient combination of conditions at the selected site to provide reasonable assurance that the performance objectives will be achieved. If adverse conditions are identified as being present, they must be thoroughly charaterized and analyzed and it must be demonstrated that the conditions are compensated for by repository design or by favorable conditions in the geologic setting.

The Commission has not included any siting requirements which directly deal with population density or proximity to population centers. Rather, the issue has been addressed indirectly through consideration of resources in the geologic setting. The Commission believes this to be a more realistic approach given the long period of time involved with geologic disposal. Nonetheless, the Commission invites comment on whether population related siting requirements should be included in the final rule and how they might be implemented.

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4. *Design and Construction.* In addition to the requirements on designing for natural phenomena, criticality control, radiation protection, and effluent control, the proposed technical criteria require the design of the repository to accommodate potential interaction of the waste, the underground facility, and the site. Requirements are also placed upon the design of the equipment to be used for handling the wastes, the performance and purpose of the backfill material, and design and performance of borehole and shaft seals. Further, there are requirements related to the methods of construction. The Commission believes such requirements are necessary to assure that the ability of the repository to contain and isolate the wastes will not be compromised by the construction of the repository.

The proposed technical criteria would require that the subsurface facility be designed so that it could be constructed and operated in accordance with relevant Federal mining regulations, which specify design requirements for certain items of electrical and mechanical equipment and govern the use of explosives.

These criteria are a blend of general and detailed prescriptive requirements. They have been developed from Commission experience and practice in the licensing of other nuclear facilities such as power plants and fuel cycle facilities. While there are differences in the systems and components addressed by these criteria from those of power plants or fuel cycle facilities, and the criteria have been written to be appropriate for a geologic repository, the proposed criteria represent a common practice based on experience which has shown that the above items need to be regulated. The level of detail of these criteria reflects the Commission's current thinking on how to regulate effectively geologic disposal of HLW. However, the Commission continues to examine other possibilities for promulgating the more detailed of these requirements. Comments are invited on formulations for the design and construction criteria in the rule, perhaps in a more concise form; these may be supplemented, of course, with more details in staff guidance documents such as Regulatory Guides.

5. *Waste Package.* The proposed requirements for the design of the waste package emphasize its role as a key component of the overall engineered system. Besides being required to contribute to the engineered system's meeting containment and controlled release performance objectives, both compatibility with the underground facility and the site and a method of unique identification are required of the waste package. Included in the section of the proposed technical criteria which deals with the waste package are requirements that the waste form itself contained within the package be consolidated and non-pyrophoric.

6. *Performance Confirmation.* The proposed technical criteria include requirements for a program of testing and measurement (Subpart F). The main purpose of this program is to confirm the assumptions, data, and analyses which led to the findings that permitted construction of the repository and subsequent emplacement of the wastes. Further, the performance confirmation program includes requirements for monitoring of key geologic and hydrologic parameters throughout site characterization, construction, and emplacement to detect any significant changes in the conditions which supported the above findings during, or due to operations at the site. Also included in the program would be tests of the effectiveness of borehole and shaft seals and of backfill placement procedures.

Regulatory Flexibility Certification

In accordance with the Regulatory Flexibility Act of 1980, 5 U.S.C. 605(b), the Commission hereby certifies that this rule will not, if promulgated, have a significant economic impact on a substantial number of small entities. This proposed rule affects only the Department of Energy, and does not fall within the purview of the Act.

Pursuant to the Atomic Energy Act of 1954, as amended, the Energy Reorganization Act of 1974, as amended, the National Environmental Policy Act of 1969, as amended, and sections 552 and 553 of title 5 of the United States Code, notice is hereby given that adoption of the following amendments to Title 10, Chapter I, Code of Federal Regulations is contemplated.

PART 60—DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTES IN GEOLOGIC REPOSITORIES

1. The authority citation for Part 60 reads as follows:

Authority: Secs. 51, 53, 62, 63, 65, 81, 161b, i, o, p, 182, 183, Pub. L. 83-703, as amended, 68 Stat. 929, 930, 932, 933, 935, 948, 953, 954, as amended (42 U.S.C. 2071, 2073, 2092, 2093, 2095, 2111, 2201, 2232, 2233); Secs. 202, 206, Pub. L. 93-438, 88 Stat. 1244, 1246 (42 U.S.C. 5842, 5846); Sec. 14, Pub. L. 95-601 (42 U.S.C. 2021a); Sec. 102(2)(c), Pub. L. 91-190, 83 Stat. 853 (42 U.S.C. 4332)

2. Section 60.2 is revised to read as follows:

§ 60.2 Definitions.

For the purposes of this Part—

"Accessible Environment" means those portions of the environment directly in contact with or readily available for use by human beings.

"Anticipated Processes and Events" means those natural processes and events that are reasonably likely to occur during the period the intended performance objective must be achieved and from which the design bases for the engineered system are derived.

"Barrier" means any material or structure that prevents or substantially delays movement of water or radionuclides.

"Candidate area" means a geologic and hydrologic system within which a geologic repository may be located.

"Commencement of construction" means clearing of land, surface or subsurface excavation, or other substantial action that would adversely affect the environment of a site, but does not include changes desirable for the temporary use of the land for public recreational uses, site characterization activities, other preconstruction monitoring and investigation necessary to establish background information related to the suitability of a site or to the protection of environmental values, or procurement or manufacture of components of the geologic repository operations area.

"Commission" means the Nuclear Regulatory Commission or its duly authorized representatives.

"Containment" means the confinement of radioactive waste within a designated boundary.

"Decommissioning," or "permanent closure," means final backfilling of subsurface facilities, sealing of shafts, and decontamination and dismantlement of surface facilities.

"Director" means the Director of the Nuclear Regulatory Commission's Office of Nuclear Material Safety and Safeguards.

"Disposal" means the isolation of radioactive wastes from the biosphere.

"Disturbed zone" means that portion of the geologic setting that is significantly affected by construction of the subsurface facility or by the heat generated by the emplacement of radioactive waste.

"DOE" means the U.S. Department of Energy or its duly authorized representatives.

"Engineered system" means the waste packages and the underground facility.

"Far field" means the portion of the geologic setting that lies beyond the disturbed zone.

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"Floodplain" means the lowland and relatively flat areas adjoining inland and coastal waters including flood prone areas of offshore islands and including at a minimum that area subject to a one percent or greater chance of flooding in any given year.

"Geologic repository" means a system for the disposal of radioactive wastes in excavated geoligic media. A geologic repository includes (1) the geologic repository operations area, and (2) the geologic setting.

"Geologic repository operations area" means an HLW facility that is part of a geologic repository, including both surface and subsurface areas, where waste handling activities are conducted.

"Geologic setting" or "site" is the spatially distributed geologic, hydrologic, and geochemical systems that provide isolation of the radioactive waste.

"High-level radioactive waste" or "HLW" means (1) irradiated reactor fuel, (2) liquid wastes resulting from the operation of the first cycle solvent extraction system, or equivalent, and the concentrated wastes from subsequent extraction cycles, or equivalent, in a facility for reprocessing irradiated reactor fuel, and (3) solids into which such liquid wastes have been converted.

"HWL facility" means a facility subject to the licensing and related regulatory authority of the Commission pursuant to Sections 202(3) and 202(4) of the Energy Reorganization Act of 1974 (88 Stat. 1244).[3]

"Host rock" means the geologic medium in which the waste is emplaced.

"Important to safety," with reference to structures, systems, and components, means those structures, systems, and components that provide reasonable assurance that radioactive waste can be received, handled, and stored without undue risk to the health and safety of the public.

"Indian Tribe" means an Indian tribe as defined in the Indian Self-Determination and Education Assistance Act (Public Law 93-638).

"Isolation" means inhibiting the transport of radioactive material so that amounts and concentrations of this material entering the accessible environment will be kept within prescribed limits.

"Medium" or "geologic medium" is a body of rock characterized by lithologic homogeneity.

"Overpack" means any buffer material, receptacle, wrapper, box or other structure, that is both within and an integral part of a waste package. It encloses and protects the waste form so as to meet the performance objectives.

"Public Document Room" means the place at 1717 H Street NW., Washington, D.C., at which records of the Commission will ordinarily be made available for public inspection and any other place, the location of which has been published in the Federal Register, at which public records of the Commission pertaining to a particular geologic repository are made available for public inspection.

"Radioactive waste" or "waste" means HLW and any other radioactive materials other than HLW that are received for emplacement in a geologic repository.

"Site" means the geologic setting.

"Site characterization" means the program of exploration and research, both in the laboratory and in the field, undertaken to establish the geologic conditions and the ranges of those parameters of a particular site relevant to the procedures under this part. Site characterization includes borings, surface excavations, excavation of exploratory shafts, limited subsurface lateral excavations and borings, and in situ testing at depth needed to determine the suitability of the site for a geologic respository, but does not include preliminary borings and geophysical testing needed to decide whether site characterization should be undertaken.

"Stability" means that the nature and rates of natural processes such as erosion and faulting have been and are projected to be such that their effects will not jeopardize isolation of the radioactive waste.

"Subsurface facility" means the undergound portions of the geologic repository operations area including openings, backfill materials, shafts and boreholes as well as shaft and borehole seals.

"Transuranic wastes" or "TRU wastes" means radioactive waste containing alpha emitting transuranic elements, with radioactive half-lives greater than five years, in excess of 10 nanocuries per gram.

"Tribal organization" means a Tribal organization as defined in the Indian Self-Determination and Education Assistance Act (Public Law 93-638).

"Underground facility" means the undergound structure, including openings and backfill materials, but excluding shafts, boreholes, and their seals.

"Unrestricted area" means any area, access to which is not controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials, and any area used for residential quarters.

"Waste form" means the radioactive waste materials and any encapsulating or stabilizing materials, exclusive of containers.

"Waste package" means the airtight, watertight, sealed container which includes the waste form and any ancillary enclosures, including shielding, discrete backfill and overpacks.

3. Section 60.10 is revised to read as follows:

§ 60.10 Site characterization.

(a) Prior to submittal of an application for a license to be issued under this part the DOE shall conduct a program of site characterization with respect to the site to be described in such application.

(b) Unless the Commission determines with respect to the site described in the application that it is not necessary, site characterization shall include a program of in situ exploration and testing at the depths that wastes would be emplaced.

(c) As provided in § 51.40 of this chapter, DOE is also required to conduct a program of site characterization, including in situ testing at depth, with respect to alternative sites.

(d) The program of site characterization shall be conducted in accordance with the following:

(1) Investigations to obtain the required information shall be conducted to limit adverse effects on the long-term performance of the geologic repository to the extent practical.

(2) As a minimum the location of exploratory boreholes and shafts shall be selected so as to limit the total number of subsurface penetrations above and around the underground facility.

(3) To the extent practical, exploratory boreholes and shafts in the geologic repository operations area shall be located where shafts are planned for repository construction and operation or where large unexcavated pillars are planned.

(4) Subsurface exploratory drilling, excavation, and in situ testing before and during construction shall be planned and coordinated with repository design and construction.

4. Paragraphs (c)(1), (c)(3), and (c)(13) of § 60.21 are revised to read as follows:

§ 60.21 Content of application.

* * * * *

[3] These are DOE "facilities used primarily for the receipt and storage of high-level radioactive wastes resulting from activities licensed under such act (the Atomic Energy Act)" and "Retrievable Surface Storage Facilities and other facilities authorized for the express purpose of subsequent long-term storage of high-level radioactive wastes generated by (DOE), which are not used for, or are part of, research and development activities."

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(c) The Safety Analysis Report shall include:

(1) A description and assessment of the site at which the proposed geologic repository operations area is to be located with appropriate attention to those features of the site that might affect facility design and performance. The description of the site shall identify the limits of the accessible environment with respect to the location of the geologic repository operations area.

(i) The description of the site shall also include the following information regarding subsurface conditions in the vicinity of the proposed underground facility—

(A) The orientation, distribution, aperture in-filling and origin of fractures, discontinuities, and heterogeneities;

(B) The presence and characteristics of other potential pathways such as solution features, breccia pipes, or other permeable anomalies;

(C) The bulk geomechanical properties and conditions, including pore pressure and ambient stress conditions;

(D) The bulk hydrogeologic properties and conditions;

(E) The bulk geochemical properties; and

(F) The anticipated response of the bulk geomechanical, hydrogeologic, and geochemical systems to the maximum design thermal loading, given the pattern of fractures and other discontinuities and the heat transfer properties of the rock mass and groundwater.

(ii) The assessment shall contain—

(A) An analysis of the geology, geophysics, hydrogeology, geochemistry, and meteorology of the site;

(B) Analyses to determine the degree to which each of the favorable and adverse conditions, if present, has been characterized, and the extent to which it contributes to or detracts from isolation.

(C) An evaluation of the expected performance of the proposed geologic repository noting the rates and quantities of expected releases of radionuclides to the accessible environment as a function of time. In executing this evaluation DOE shall assume that those processes operating on the site are those which have been operating on it during the Quaternary Period and superpose the perturbations caused by the presence of emplaced radioactive waste on the natural processes.

(D) An analysis of the expected performance of the major design structures, systems, and components, both surface and subsurface, that bear significantly on the suitability of the geologic repostory for disposal of radioactive waste assuming the anticipated processes and events and natural phenomena from which the design bases are derived. For the purposes of this analysis, it shall be assumed that operations at the geologic repository operations area will be carried out at the maximum capacity and rate of receipt of radioactive waste stated in the application.

(E) An explanation of measures used to confirm the models used to perform the assessments required in paragraphs (A) through (D). Analyses and models that will be used to predict future conditions and changes in the geologic setting shall be confirmed by using field tests, in situ tests, field-verified laboratory tests, monitoring data, or natural analog studies.

* * * * *

(3) A description and analysis of the design and performance requirements for structures, systems, and components of the geologic repository which are important to safety. This analysis shall consider—(i) the margins of safety under normal and conditions that may result from anticipated operational occurrences, including those or natural origin; (ii) the adequacy of structures, systems, and components provided for the prevention of accidents and mitigation of the consequences of accidents, including those caused by natural phenomena; and (iii) the effectiveness of engineered and natural barriers, including barriers that may not be themselves a part of the geologic repository operations area, against the release of radioactive material to the environment. The analysis shall also include a comparative evaluation of alternatives to the major design features that are important to radionuclide containment and isolation, with particular attention to the alternatives that would provide longer radionuclide containment and isolation.

* * * * *

(13) An identification and evaluation of the natural resources at the site, including estimates as to undiscovered deposits, the exploitation of which could affect the ability of the site to isolate radioactive wastes. Undiscovered deposits of resources characteristic of the area shall be estimated by reasonable inference based on geological and geophysical evidence. This evaluation of resources, including undiscovered deposits, shall be conducted for the disturbed zone and for areas of similar size that are representative of and are within the geologic setting. For natural resources with current markets the resources shall be assessed, with estimates provided of both gross and net value. The estimate of net value shall take into account current development, extraction and marketing costs. For natural resources without current markets, but which would be marketable given credible projected changes in economic or technological factors, the resources shall be described by physical factors such as tonnage or other amount, grade, and quality.

* * * * *

5. Paragraph (a)(2) of § 60.31 is revised to read as follows:

§ 60.31 Construction authorization.

* * * * *

(a) * * *

(2) The site and design comply with the criteria contained in Supart E.

* * * * *

6. Paragraph (a)(2) of § 60.31 is revised to read as follows:

§ 60.51 License amendment to decommission.

(a) * * *

(2) a detailed description of the measures to be employed—such as land use controls, construction of monuments, and preservation of record—to regulate or prevent activities that could impair the long-term isolation of emplaced waste within the geologic repository and to assure that relevant information will be preserved for the use of future generations. As a minimum, such measures shall include—

(i) Identification of the geologic repository operations area by monuments that have been designated, fabricated, and emplaced to be as permanent as is practicable; and

(ii) Placement of records of the location of the geologic repository operations area and the nature and hazard of the waste in the archives of local and Federal government agencies, and archives elsewhere in the world, that would be likely to be consulted by potentional human intruders.

* * * * *

7. New Subpart E, "Technical Criteria," Subpart F "Performance Confirmation," Subpart G, "Quality Assurance" and Subpart H, "Training and Certification of Personnel" are added to 10 CFR Part 60.

Subpart E—Technical Criteria

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Subpart E—Technical Criteria

§ 60.101 Purpose and nature of findings.

(a)(1) Subpart B of this part prescribes the standards for issuance of a license to receive and possess source, special nuclear, or byproduct material at a geologic repository operations area. In particular, § 60.41(c) requires a finding that the issuance of a license will not constitute an unreasonable risk to the health and safety of the public. The purpose of this subpart is to set out performance objectives and site and design criteria which, if satisfied, will support such a finding of no unreasonable risk.

(2) 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 § 60.111, 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 systems and geologic media over time periods of a thousand 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 and hazards involved, that the outcome will be in conformance with those objectives and criteria.

(b) Subpart B of this part also lists findings that must be made in support of an authorization to construct a geologic repository operations area. In particular, § 60.31(a) requires a finding that there is reasonable assurance that the types and amounts of radioactive materials described in the application can be received, possessed, and disposed of in a repository of the design proposed without unreasonable risk to the health and safety of the public. As stated in that paragraph, in arriving at this determination, the Commission will consider whether the site and design comply with the criteria contained in this subpart. Once again, while the criteria may be written in unqualified terms, the demonstration of compliance may take uncertainties and gaps in knowledge into account, provided that the Commission can make the specified finding of reasonable assurance as specified in paragraph (a) of this section.

§ 60.102 Concepts.

(a) *The HLW facility*. NRC exercises licensing and related regulatory authority over those facilities described in section 202 (3) and (4) of the Energy Reorganization Act of 1974. Any of these facilities is designated an *HLW facility*.

(b) *The geologic repository operations area*.

(1) This part deals with the exercise of authority with respect to a particular class of HLW facility—namely a *geologic repository operations area*.

(2) A *geologic repository operations area* consists of those surface and subsurface areas that are part of a geologic repository where radioactive waste handling activities are conducted. The underground structure, including openings and backfill materials, but excluding shafts, boreholes, and their seals, is designated the *underground facility*.

(3) The exercise of Commission authority requires that the geologic repository operations area be used for *storage* (which includes *disposal*) of *high-level radioactive wastes (HLW)*.

(4) HLW includes irradiated reactor fuel as well as reprocessing wastes. However, if DOE proposes to use the geologic repository operations area for storage of *radioactive waste* other than HLW, the storage of this radioactive waste is subject to the requirements of this part. Thus, the storage of *transuranic-contaminated waste (TRU)*, though not itself a form of HLW, must conform to the requirements of this part if it is stored in a geologic repository operations area.

(c) *Areas adjacent to the geologic repository operations area*. Although the activities subject to regulation under this part are those to be carried out at the geologic repository operations area, the licensing process also considers characteristics of adjacent areas. First, there is to be an area within which DOE is to exercise specified controls to prevent adverse human actions. Second, there is a larger area, designated the *geologic setting* or *site* which includes the spatially distributed geologic, hydrologic, and geochemical systems that provide isolation of the radioactive waste from the accessible environment. The geologic repository operations area plus the geologic setting make up the *geologic repository*. Within the geologic setting, particular attention must be given to the characteristics of the host rock as well as any rock units surrounding the host rock.

(d) *Stages in the licensing process*. There are several stages in the licensing process. The *site characterization* stage, though begun before submission of a license application, may result in consequences requiring evaluation in the license review. The *construction stage* would follow, after issuance of a construction authorization. A *period of operations* follows the issuance of a license by the Commission. The period of operations includes the time during which *emplacement* of wastes occurs; and any subsequent period before permanent closure during which the emplaced wastes are *retrievable*; and *permanent closure*, which includes final backfilling of subsurface facilities, sealing of shafts, decontaminating and dismantling of surface facilities. Permanent closure represents the end of active human activities with the geologic repository operations area and engineered systems.

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(e) *Containment.* Early during the repository life, when radiation and thermal levels are high and the consequences of events are especially difficult to predict rigorously, special emphasis is placed upon the ability to contain the wastes by waste packages within an engineered system. This is known as the *containment period.* The *engineered system* includes the waste packages as well as the underground facility. A *waste package* includes:

(1) The *waste form* which consists of the radioactive waste materials and any associated encapsulating or stabilizing materials.

(2) The *container* which is the first major sealed enclosure that holds the waste form.

(3) *Overpacks* which consist of any buffer material, receptable, wrapper, box or other structure, that is both within and an integral part of a waste packa[illegible] It encloses and protects the wast[illegible]r so as to meet the performance objectives.

(f) *Isolation.* Following the containment period special emphasis is placed upon the ability to achieve isolation of the wastes by virtue of the characteristics of the geologic repository. *Isolation* means the act of inhibiting the transport of radioactive material to the accessible environment in amounts and concentrations within limits. The *accessible environment* means those portions of the environment directly in contact with or readily available for use by human beings.

Performance Objectives

§ 60.111 Performance objectives.

(a) *Performance of the geologic repository operations area through permanent closure.*—(1) *Protection against radiation exposures and releases of radioactive material.* The geologic repository operations area shall be designed so that until permanent closure has been completed, radiation exposures and radiation levels, and releases of radioactive materials to unrestricted areas, will at all times be maintained within the limits specified in Part 20 of this chapter and any generally applicable environmental standards established by the Environmental Protection Agency.

(2) *Retrievability of waste.* The geologic repository operations area shall be designed so that the entire inventory of waste could be retrieved on a reasonable schedule, starting at any time up to 50 years after waste emplacement operations are complete. A reasonable schedule for retrieval is one that requires no longer than about the same overall period of time than was devoted to the construction of the geologic repository operations area and the emplacement of wastes.

(b) *Performance of the geologic repository after permanent closure.*—(1) *Overall system performance.* The geologic setting shall be selected and the subsurface facility designed so as to assure that releases of radioactive materials from the geologic repository following permanent closure conform to such generally applicable environmental radiation protection standards as may have been established by the Environmental Protection Agency.

(2) *Performance of the engineered system.*—(i) *Containment of wastes.*[*] The engineered system shall be designed so that even if full or partial saturation of the underground facility were to occur, and assuming anticipated processes and events, the waste packages will contain all radionuclides for at least the first 1,000 years after permanent closure. This requirement *does not apply to TRU waste* unless TRU waste is emplaced close enough to HLW that the TRU release rate can be significantly affected by the heat generated by the HLW.

(ii) *Control of releases.*[2]

(A) For HLW, the engineered system shall be designed so that, after the first 1,000 years following permanent closure, the annual release rate of any radionuclide from the engineered system into the geologic setting, assuming anticipated processes and events, is at most one part in 100,000 of the maximum amount of that radionuclide calculated to be present in the underground facility (assuming no release from the underground facility) at any time after 1,000 years following permanent closure. This requirement does not apply to radionuclides whose contribution is less than 0.1% of the total annual curie release as prescribed by this paragraph.

(B) For TRU waste, the engineered system shall be designed so that following permanent closure the annual release rate of any radionuclide from the underground facility into the geologic setting, assuming anticipated processes and events, is at most one part in 100,000 of the maximum amount calculated to be present in the underground facility (assuming no release from the underground facility) at any time following permanent closure. This requirement does not apply to radionuclides whose contribution is less than 0.1% of the annual curie release as prescribed by this paragraph.

(3) *Performance of the geologic setting.*—(i) *Containment period.* During the containment period, the geologic setting shall mitigate the impacts of premature failure of the engineered system. The ability of the geologic setting to isolate wastes during the isolation period, in accordance with paragraph (b)(3)(ii) of this section, shall be deemed to satisfy this requirement.

(ii) *Isolation period.* Following the containment period, the geologic setting, in conjunction with the engineered system as long as that system is expected to function, and alone thereafter, shall be capable of isolating radioactive waste so that transport of radionuclides to the accessible environment shall be in amounts and concentrations that conform to such generally applicable environmental standards as may have been established by the Environmental Protection Agency. For the purpose of this paragraph, the evaluation of the site shall be based upon the assumption that those processes operating on the site are those which have been operating on it during the Quaternary Period, with perturbations caused by the presence of emplaced radioactive wastes superimposed thereon.

§ 60.112 Required characteristics of the geologic setting.

(a) The geologic setting shall have exhibited structural and tectonic stability since the start of the Quaternary Period.

(b) The geologic setting shall have exhibited hydrogeologic, geo-chemical, and geomorphic stability since the start of the Quaternary Period.

(c) The geologic repository shall be located so that pre-waste emplacement groundwater travel times through the far field to the accessible environment are at least 1,000 years.

Ownership and Control of the Geolocghic Repository Operations Area

§ 60.121 Requirements for ownership and control of the geologic repository operations area.

(a) *Ownership of the geologic repository operations area.* The geologic repository operations area shall be located in and on lands that are either acquired lands under the jurisdiction and control of DOE, or lands permanently withdrawn and reserved for its use. These lands shall be held free and clear of all encumbrances, if

[*]The Commission specifically seeks comment on whether an ALARA principle should be applied to the performance requirements dealing with containment and control of releases. In particular, the Commission has considered whether the technical criteria should explicitly require containment to be for "as long as is reasonably achievable" and the release rate to be "as low as is reasonably achievable." Comments should address the merits of such a requirement, how to best frame it, and the practicality of its implementation.

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significant, such as: (1) rights arising under the general mining laws; (2) easements for right-of-way; and (3) all other rights arising under lease, rights of entry, deed, patent, mortgage, appropriation, prescription, or otherwise.

(b) *Establishment of controls.* Appropriate controls shall be established outside of the geologic repository operations area. DOE shall exercise any jurisdiction and control over surface and subsurface estates necessary to prevent adverse human actions that could significantly reduce the site or engineered system's ability to achieve isolation. The rights of DOE may take the form of appropriate possessory interests, servitudes, or withdrawals from location or patent under the general mining laws.

Additional Requirements for the Geologic Setting

§ 60.122 Favorable conditions.

Each of the following conditions may contribute to the ability of the geologic setting to meet the performance objectives relating to isolation of the waste. In addition to meeting the mandatory requirements of § 60.112, a geologic setting shall exhibit an appropriate combination of these conditions so that, together with the engieered system, the favorable conditions present are sufficient to provide reasonable assurance that such performance objectives will be met.

(a) The nature and rates of tectonic processes that have occurred since the start of the Quaternary Period are such that, when projected, they would not affect or would favorably affect the ability of the geologic repository to isolate the waste.

(b) The nature and rates of structural processes that have occurred since the start of the Quaternary Period are such that, when projected, they would not affect or would favorably affect the ability of the geologic repository to isolate the waste.

(c) The nature and rates of hydrogeological processes that have occurred since the start of the Quaternary Period are such that, when projected, they would not affect or would favorably affect the ability of the geologic repository to isolate the waste.

(d) The nature and rates of geochemical processes that have occurred since the start of the Quaternary Period are such that when projected, they would not affect or would favorably affect the ability of the geologic repository to isolate the waste.

(e) The nature and rates of geomorphic processes that have occurred since the start of the Quarternary period are such that, when projected they would not affect or would favorably affect the ability of the geologic repository to isolate the waste.

(f) A host rock that provides the following groundwater characteristics— (1) low groundwater content; (2) inhibition of groundwater circulation in the host rock; (3) inhibition of groundwater flow between hydrogeologic units or along shafts, drifts, and boreholes; and (4) groundwater travel times, under pre-waste emplacement conditions, between the underground facility and the accessible environment that substantially exceed 1,000 years.

(g) Geochemical conditions that (1) promote precipitation or sorption or radionuclides; (2) inhibit the formation of particulates, colloids, and inorganic and organic complexes that increase the mobility of radionuclides; and (3) inhibit the transport of radionuclides by particulates, colloids, and complexes.

(h) Mineral assemblages that, when subjected to anticipated thermal loading, will remain unaltered or alter to mineral assemblages having increased capacity to inhibit radionuclide migration.

(i) Conditions that permit the emplacement of waste at a minimum depth of 300 meters from the ground surface. (The ground surface shall be deemed to be the elevation of the lowest point on the surface above the disturbed zone.)

(j) Any local condition of the disturbed zone that contributes to isolation.

§ 60.123 Potentially adverse conditions.

The following are potentially adverse conditions. The presence of any such conditions may compromise site suitability and will require careful analysis and such measures as are necessary to compensate for them adequately pursuant to § 60.124.

(a) *Adverse conditions in the geologic setting.*

(1) Potential for failure of existing or planned man-made surface water impoundments that could cause flooding of the geologic repository operations area.

(2) Potential, based on existing geologic and hydrologic conditions, that planned cnstruction of large-scale surface water impoundments may significantly affect the geologic repository through changes in the regional groundwater flow system.

(3) Potential for human activity to affect significantly the geologic repository through changes in the hydrogeology. This activity includes, but is not limited to planned groundwater withdrawal, extensive irrigation, subsurface injection of fluids, underground pumped storage facilities, or underground military activity.

(4) Earthquakes which have occurred historically that if they were to be repeated could affect the geologic repository significantly.

(5) A fault in the geologic setting that has been active since the start of the Quaternary Period and which is within a distance of the disturbed zone that is less than the smallest dimension of the fault rupture surface.

(6) Potential for adverse impacts on the geologic repositroy resulting from the occupancy and modification of floodplains.

(7) Potential for natural phenomena such as landslides, subsidence, or volcanic activity of such a magnitude that large-scale surface water impoundments could be created that could affect the performance of the geologic repository through changes in the regional groundwater flow.

(8) Expected climatic changes that would have an adverse effect on the geologic, geochemical, or hydrologic characteristics.

(b) *Adverse conditions in the disturbed zone.* For the purpose of determining the presence of the following conditions within the distrubed zone, investigations should extend to the greater of either its calculated extent or a horizontal distance of 2 km from the limits of the underground facility, and from the surface to a depth of 500 meters below the limits of the repository excavation.

(1) Evidence of subsurface mining for resources.

(2) Evidence of drilling for any purpose.

(3) Resources that have either greater gross value, net value, or commercial potential than the average for other representative areas of similar size that are representative of and located in the geologic setting.

(4) Evidence of extreme erosion during the Quaternary Period.

(5) Evidence of dissolutioning of soluble rocks.

(6) The existence of a fault that has been active during the Quaternary Period.

(7) Potential for creating new pathways for radionuclide migration due to presence of a fault or fracture zone irrespective of the age of last movement.

(8) Structural deformation such as uplift, subsidence, folding, and fracturing during the Quaternary Period.

(9) More frequent occurrence of earthquakes or earthquakes of higher

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magnitude than is typical of the area in which the geologic setting is located.

(10) Indications, based on correlations of earthquakes with tectonic processes and features, that either the frequency of occurrence or magnitude of earthquakes may increase.

(11) Evidence of igneous activity since the start of the Quaternary Period.

(12) Potential for changes in hydrologic conditions that would significantly affect the migration of radionuclides to the accessible environment including but not limited to changes in hydraulic gradient, average interstitial velocity, storage coefficient, hydraulic conductivity, natural recharge, potentiometric levels, and discharge points.

(13) Conditions in the host rock that are not reducing conditions.

(14) Groundwater conditions in the host rock, including but not limited to high ionic strength or ranges of Eh-pH, that could affect the solubility and chemical reactivity of the engineered systems.

(15) Processes that would reduce sorption, result in degradation of the rock strength, or adversely affect the performance of the engineered system.

(16) Rock or groundwater conditions that would require complex engineering measures in the design and construction of the underground facility or in the sealing of boreholes and shafts.

(17) Geomechanical properties that do not permit deisign of stable underground openings during construction, waste emplacement, or retrieval operations.

§ 60.124 Assessment of potentially adverse conditions.

In order to show that a potentially adverse condition or combination of conditions cited in § 60.123 does not impair significantly the ability of the geologic repository to isolate the radioactive waste, the following must be demonstrated:

(a) The potentially adverse human activity or natural condition has been adequately characterized, including the extent to which the condition may be present and still be undetected taking into account the degree of resolution achieved by the investigations; and

(b) The effect of the potentially adverse human activity or natural condition on the geologic setting has been adequately evaluated using conservative analyses and assumptions, and the evaluation used is sensitive to the adverse human activity or natural condition; and

(c)(1) The potentially adverse human activity or natural condition is shown by analysis in paragraph (b) of this section not to affect significantly the ability of the geologic setting to isolate waste, or

(2) The effect of the potentially adverse human activity or natural condition is compensated by the presence of a combination of the favorable characteristics cited in § 60.122, or

(3) The potentially adverse human activity or natural condition can be remedied.

Design and Construction Requirements

§ 60.130 General design requirements for the geologic repository operations area.

(a) Sections 60.130 through 60.134 specify minimum requirements for the design of, and construction specifications for, the geologic repository operations area. Requirements for design contained in §§ 60.131 through 60.133 must be considered in conjunction with the requirements for construction in § 60.134. Sections 60.130 through 60.134 are not intended to contain an exhaustive list of design and construction requirements. Omissions in §§ 60.130 through 60.134 do not relieve DOE from providing safety features in a specific facility needed to achieve the performance objectives contained in § 60.111. All design and construction criteria must be consistent with the results of site characterization activities.

(b) Systems, structures, and components of the geologic repository operations area shall satisfy the following:

(1) *Radiological protection.* The structures, systems, and components located within restricted areas shall be designed to maintain radiation doses, levels, and concentrations of radioactive material in air in those restricted areas within the limits specified in Part 20 of this chapter. These structures, systems, and components shall be designed to include—

(i) Means to limit concentrations of radioactive material in air;

(ii) Means to limit the time required to perform work in the vicinity of radioactive materials, including, as appropriate, designing equipment for ease of repair and replacement and providing adequate space for ease of operation;

(iii) Suitable shielding;

(iv) Means to monitor and control the dispersal of radioactive contamination;

(v) Means to control access to high radiation areas or airborne radioactivity areas; and

(vi) A radiation alarm system to warn of increases in radiation levels, concentrations of radioactive material in air, and of increased radioactivity released in effluents. The alarm system shall be designed with redundancy and in situ testing capability.

(2) *Protection against natural phenomena and environmental conditions.*

(i) The structures, systems, and components important to safety shall be designed to be compatible with anticipated site characteristics and to accommodate the effects of environmental conditions, so as to prevent interference with normal operation, maintainence and testing during the entire period of construction and operations.

(ii) The structures, systems, and components important to safety shall be designed so that natural phenomena and environmental conditions anticipated at the site will not result, in any relevant time period, in failure to achieve the performance objectives.

(3) *Protection against dynamic effects of equipment failure and similar events.* The structures, systems and components important to safety shall be designed to withstand dynamic effects that could result from equipment failure, such as missle impacts, and similar events and conditions that could lead to loss of their safety functions.

(4) *Protection against fires and explosions.*

(i) The structures, systems, and components important to safety shall be designed to perform their safety functions during and after fires or explosions in the geologic repository operations area.

(ii) To the extent practicable, the geologic repository operations area shall be designed to incorporate the use of noncombustible and heat resistant materials.

(iii) The geologic repository operations area shall be designed to include explosion and fire detection alarm systems and appropriate suppression systems with sufficient capacity and capability to reduce the adverse effects of fires and explosions on structures, systems, and components important to safety.

(iv) The geologic repository operations area shall be designed to include means to protect systems, structures, and components important to safety against the adverse effects of either the operation or failure of the fire suppression systems.

(5) *Emergency capability.*

(i) The structures, systems, and components important to safety shall be designed to maintain control of radioactive waste, and permit prompt termination of operations and

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evacuation of personnel during an emergency.

(ii) The geologic repository operations area shall be designed to include onsite facilities and services that ensure a safe and timely response to emergency conditions and that facilitate the use of available offsite services (such as fire, police, medical and ambulance service) that may aid in recovery from emergencies.

(6) *Utility services.*

(i) Each utility service system shall be designed so that essential safety functions can be performed under both normal and emergency conditions.

(ii) The utility services important to safety shall include redundant systems to the extent necessary to maintain, with adequate capacity, the ability to perform their safety functions.

(iii) The emergency utility services shall be designed to permit testing of their functional operability and capacity. This will include the full operational sequence of each system when transferring between normal and emergency supply sources, as well as the operation of associated safety systems.

(iv) Provisions shall be made so that, if there is a loss of the primary electric power source or circuit, reliable and continued emergency power is provided to instruments, utility service systems, and operating systems, including alarm systems. This emergency power shall be sufficient to allow safe conditions to be maintained. All systems important to safety shall be designed to permit them to be maintained at all times in a functional mode.

(7) *Inspection, testing, and maintenance.* The structures, systems, and components important to safety shall be designed to permit periodic inspection, testing, and maintenance, as necessary, to ensure their continued functioning and readiness.

(8) *Criticality control.* All systems for processing, transporting, handling, storage, retrieval, emplacement, and isolation of radioactive waste shall be designed to ensure that a nuclear criticality accident is not possible unless at least two unlikely, independent, and concurrent or sequential changes have occurred in the conditions essential to nuclear criticality safety. Each system shall be designed for criticality safety under normal and accident conditions. The calculated effective multiplication factor (k_{eff}) must be sufficiently below unity to show at least a 5% margin, after allowance for the bias in the method of calculation and the uncertainty in the experiments used to validate the method of calculation.

(9) *Instrumentation and control systems.* Instrumentation and control systems shall be designed to monitor and control the behavior of engineered systems important to safety over anticipated ranges for normal operation and for accident conditions. The systems shall be designed with sufficient redundancy to ensure that adequate margins of safety are maintained.

(10) *Compliance with mining regulations.* To the extent that DOE is not subject to the Federal Mine Safety and Health Act of 1977, as to the construction and operation of the geologic repository operations area, the design of the geologic repository operations area shall nevertheless include such provisions for worker protection as may be necessary to provide reasonable assurance that all structures, systems, and components important to safety can perform their intended functions. Any deviation from relevant design requirements in 30 CFR, Chapter I, Subchapters D, E, and N will give rise to a rebuttable presumption that this requirement has not been met.

§ 60.131 Additional design requirements for surface facilities in the geologic repository operations area.

(a) *Facilities for receipt and retrieval of waste.* Surface facilities in the geologic repository operations area shall be designed to allow safe handling and storage of wastes at the site, whether these wastes are on the surface before emplacement or as a result of retrieval from the underground facility. The surface facilities shall be designed so as to permit inspection, repair, and decontamination of such wastes and their containers. Surface storage capacity is not required for all emplaced waste.

(b) *Surface facility ventilation.* Surface facility ventilation systems supporting waste transfer, inspection, decontamination, processing, or packaging shall be designed to provide protection against radiation exposures and offsite releases as provided in § 60.111.

(c) *Radiation control and monitoring.*—(1) *Effluent control.* The surface facilities shall be designed to control the release of radioactive materials in effluents during normal and emergency operations. The facilities shall be designed to provide protection against radiation exposures and offsite releases as provided in § 60.111.

(2) *Effluent monitoring.* The effluent monitoring systems shall be designed to measure the amount and concentration of radionuclides in any effluent with sufficient precision to determine whether releases conform to the design requirement for effluent control. The monitoring systems shall be designed to include alarms that can be periodically tested.

(d) *Waste treatment.* Radioactive waste treatment facilities shall be designed to process any radioactive wastes generated at the geologic repository operations area into a form suitable to permit safe disposal at the geologic repository operations area or to permit safe transportation and conversion to a form suitable for disposal at an alternative site in accordance with any regulations that are applicable.

(e) *Consideration of decommissioning.* The surface facility shall be designed to facilitate decommissioning.

§ 60.132 Additional design requirements for the underground facility.

(a) General criteria for the underground facility.

(1) The underground facility shall be designed so as to perform its safety functions assuming interactions among the geologic setting, the underground facility, and the waste package.

(2) The underground facility shall be designed to provide for structural stability, control of groundwater movement and control of radionuclide releases, as necessary to comply with the performance objectives of § 60.111.

(3) The orientation, geometry, layout, and depth of the underground facility, and the design of any engineered barriers that are part of the underground facility shall enhance containment and isolation of radionuclides to the extent practicable at the site.

(4) The underground facility shall be designed so that the effects of disruptive events such as intrusions of gas, or water, or explosions, will not spread through the facility.

(b) *Flexibility of design.* The underground facility shall be designed with sufficient flexibility to allow adjustments, where necessary to accommodate specific site conditions identified through in situ monitoring, testing, or excavation.

(c) *Separation of excavation and waste emplacement (modular concept).* If concurrent excavation and emplacement of wastes are planned, then:

(1) The design shall provide for such separation of activities into discrete areas (modules) as may be necessary to assure that excavation does not impair waste emplacement or retrieval operations.

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(2) Each module shall be designed to permit insulation from other modules if an accident occurs.

(d) *Design for retrieval of waste.* The underground facility shall be designed to—

(1) Permit retrieval of waste in accordance with the performance objectives (§ 60.111);

(2) Ensure sufficient structural stability of openings and control of groundwater to permit the safe conduct of waste retrieval operations; and

(3) Allow removal of any waste packages that may be damaged or require inspection without compromising the ability of the geologic repository to meet the performance objectives (§ 60.111).

(e) *Design of subsurface openings.*

(1) Subsurface openings shall be designed to maintain stability throughout the construction and operation periods. If structural support is required for stability, it shall be designed to be compatible with long-term deformation, hydrologic, geochemical, and thermomechanical characteristics of the rock and to allow subsequent placement of backfill.

(2) Structures required for temporary support of zones of weak or highly fractured rock shall be designed so as not to impair the placement of permanent structures or the capability to seal excavated areas used for the containment of wastes.

(3) Subsurface openings shall be designed to reduce the potential for deleterious rock movement or fracturing of overlying or surrounding rock over the long term. The size, shape, orientation, and spacing of openings and the design of engineered support systems shall take the following conditions into considerations—

(i) natural stress conditions;

(ii) deformation characteristics of the host rock under normal conditions and thermal loading;

(iii) The kinds of weaknesses or structural discontinuities found at various locations in the geologic repository;

(iv) Equipment requirements; and

(v) The ability to construct the underground facility as designed so that stability of the rock is enhanced.

(f) *Rock excavation.* The design of the underground facility shall incorporate excavation methods that will limit damage to and fracturing of rock.

(g) *Control of water and gas.*

(1) Water and gas control systems shall be designed to be of sufficient capability and capacity to reduce the potentially adverse effects of groundwater intrusion, service water intrusion, or gas inflow into the underground facility.

(2) Water and gas control systems shall be designed to control the quantity of water or gas flowing into or from the underground facility, monitor the composition of gases, and permit sampling of liquids.

(3) Systems shall be designed to provide control of water and gas in both waste emplacement areas and excavation areas.

(4) Water control systems shall be designed to include storage capability and modular layouts that ensure that unexpected inrush or flooding can be controlled and contained.

(5) If the intersection of aquifers or water-bearing geologic structures is anticipated during construction, the design of the underground facility shall include plans for cutoff or control of water in advance of the excavation.

(6) If linings are required, the contact between the lining and the rock surrounding subsurface excavations shall be designed so as to avoid the creation of any preferential pathway for groundwater or radionuclide migration.

(h) *Subsurface ventilation.* The ventilation system shall be designed to—

(1) Control the transport of radioactive particulates and gases within and releases from the subsurface facility in accordance with the performance objectives (§ 60.111);

(2) Permit continuous occupancy of all excavated areas during normal operations through the time of permanent closure;

(3) Accommodate changes in operating conditions such as variations in temperature and humidity in the underground facility;

(4) Include redundant equipment and fail safe control systems as may be needed to assure continued function under normal and emergency conditions; and

(5) Separate the ventilation of excavation and waste emplacement areas.

(i) *Engineered barriers.*

(1) Barriers shall be located where shafts could allow access for groundwater to enter or leave the underground facility.

(2) Barriers shall create a waste package environment which favorably controls chemical reactions affecting the performance of the waste package.

(3) Backfill placed in the underground facility shall be designed as a barrier.

(i) Backfill placed in the underground facility shall perform its functions assuming anticipated changes in the geologic setting.

(ii) Backfill placed in the underground facility shall serve the following functions:

(A) It shall provide a barrier to groundwater movement into and from the underground facility.

(B) It shall reduce creep deformation of the host rock that may adversely affect (*1*) waste package performance or (*2*) the local hydrological system.

(C) It shall reduce and control groundwater movement within the underground facility.

(D) It shall retard radionuclide migration.

(iii) Backfill placed in the underground facility shall be selected to allow for adequate placement and compaction in underground openings.

(j) *Waste handling and emplacement.*

(1) The systems used for handling, transporting, and emplacing radioactive wastes shall be designed to have positive, fail-safe designs to protect workers and to prevent damage to waste packages.

(2) The handling systems for emplacement and retrieval operations shall be designed to minimize the potential for operator error.

(k) *Design for thermal loads.*

(1) The underground facility shall be designed so that the predicted thermal and thermomechanical response of the rock will not degrade significantly the performance of the repository or the ability of the natural or engineered barriers to retard radionuclide migration.

(2) The design of waste loading and waste spacings shall take into consideration—

(i) Effects of the design of the underground facility on the thermal and thermomechanical response of the host rock and the groundwater system;

(ii) Features of the host rock and geologic setting that affect the thermomechanical response of the underground facility and barriers, including but not limited to, behavior and deformational characteristics of the host rock, the presence of insulating layers, aquifers, faults, orientation of bedding planes, and the presence of discontinuities in the host rock; and

(iii) The extent to which fracturing of the host rock is influenced by cycles of temperature increase and decrease.

§ 60.133 Design of shafts and seals for shafts and boreholes.

(a) *Shaft design.* Shafts shall be designed so as not to create a preferential pathway for migration of groundwater and so as not to increase the potential for migration through existing pathways.

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(b) *Shaft and borehole seals.* Shaft and borehole seals shall be designed so that:

(1) Shafts and boreholes will be sealed as soon as possible after they have served their operational purpose.

(2) At the time of permanent closure sealed shafts and boreholes will inhibit transport of radionclides to at least the same degree as the undisturbed units of rock through which the shafts or boreholes pass. In the case of soluble rocks, the borehole and shaft seals shall also be designed to prevent groundwater circulation that would result in dissolution.

(3) Contact between shaft and borehole seals and the adjacent rock does not become a preferential pathway for water.

(4) Shaft and borehole seals can accommodate potential variations of stress, temperature, and moisture.

(5) The materials used to construct the seals are appropriate in view of the geochemistry of the rock and groundwater system, anticipated deformations of the rock, and other in situ conditions.

(c) *Shaft conveyances used in radioactive waste handling.*

(1) Shaft conveyances used to transport radioactive materials shall be designed to satisfy the requirements as set forth in § 60.130 for systems, structures, and components important to safety.

(2) Hoists important to safety shall be designed to preclude cage free fall.

(3) Hoists important to safety shall be designed with a reliable cage location system.

(4) Hoist loading and unloading systems shall be designed with a reliable system of interlocks that will fail safely upon malfunction.

(5) Hoists important to safety shall be designed to include two independent indicators to indicate when waste packages are in place, grappled, and ready for transfer.

§ 60.134 Construction specifications for surface and subsurface facilities.

(a) *General requirement.* Specifications for construction shall conform to the objectives and technical requirements of §§ 60.130 through 60.133.

(b) *Construction management program.* The construction specifications shall facilitate the conduct of a construction management program that will ensure that construction activities do not adversely affect the suitability of the site to isolate the waste or jeopardize the isolation capabilities of the underground facility, boreholes, shaft, and seals, and that the underground facility is constructed as designed.

(c) *Construction records.* The construction specifications shall include requirements for the development of a complete documented history of repository construction. This documented history shall include at least the following—

(1) Surveys of underground excavations and shafts located via readily identifiable surface features or monuments;

(2) Materials encountered;

(3) Geologic maps and geologic cross sections;

(4) Locations and amount of seepage;

(5) Details of equipment, methods, progress, and sequence of work;

(6) Construction problems;

(7) Anomalous conditions encountered;

(8) Instrument locations, readings, and analysis;

(9) Location and description of structural support systems;

(10) Location and description of dewatering systems; and

(11) Details, methods of emplacement, and location of seals used.

[(d) *Rock excavation.* The methods used for excavation shall be selected to reduce to the extent practicable the potential to create a preferential pathway for groundwater or radioactive waste migration or increase migration through existing pathways.

(e) *Control of explosives.* If explosives are used, the provisions of 30 CFR 57.6 (Explosives) issued by the Mine Safety and Health Administration, Department of Labor, shall be met, as minimum safety requirements for storage, use and transport at the geologic repository operations area.

(f) *Water control.* The construction specifications shall provide that water encountered in excavat___ shall be removed to the surface and controlled in accordance with design requirements for radiation control and monitoring (§ 60.131(c)).

(g) *Waste handling and emplacement.* The construction specifications shall provide for demonstration of the effectiveness of handling equipment and systems for emplacement and retrieval operations, under operating conditions.

Waste Package Requirements

§ 60.135 Requirements for the waste package and its components.

(a) *General requirements of design.* The design of the waste package shall include the following elements:

(1) *Effect of the site on the waste package.* The waste package shall be designed so that the in situ chemical, physical, and nuclear properties of the waste package and its interactions with the emplacement environment do not compromise the function of the waste packages. The design shall include but not be limited to consideration of the following factors: solubility, oxidation/reduction reactions, corrosion, hydriding, gas generation, thermal effects, mechanical strength, mechanical stress, radiolysis, radiation damage, radionuclide retardation, leaching, fire and explosion hazards, thermal loads, and synergistic interactions.

(2) *Effect of the waste package on the underground facility and the natural barriers of the geologic setting.* The waste package shall be designed so that the in situ chemical, physical, and nuclear properties of the waste package and its interactions with the emplacement environment do not compromise the performance of the underground facility or the geologic setting. The design shall include but not be limited to consideration of the following factors: solubility, oxidation/reduction reactions, corrosion, hydriding, gas generation, thermal effects, mechanical strength, mechanical stress, radiolysis, radiation damage, radionuclide retardation, leaching, fire and explosion hazards, thermal loads, and synergistic interactions.

(b) *Waste form requirements.* Radioactive waste that is emplaced in the underground facility shall meet the following requirements:

(1) *Solidification.* All such radioactive wastes shall be in solid form and placed in sealed containers.

(2) *Consolidation.* Particulate waste forms shall have been consolidated (for example, by incorporation into an encapsulating matrix) to limit the availability and generation of particulates.

(3) *Combustibles.* All combustible radioactive wastes must have been reduced to a noncombustible form unless it can be demonstrated that a fire involving a single package will neither compromise the integrity of other packages, nor adversely affect any safety-related structures, systems, or components.

(c) *Waste package requirements.* The waste package design shall meet the following requirements:

(1) *Explosive, pyrophoric, and chemically reactive materials.* The waste package shall not contain explosive or pyrophoric materials or chemically reactive materials that could interfere with operations in the underground facility or compromise the ability of the geologic repository to satisfy the performance objectives.

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(2) *Free liquids.* The waste package shall not contain free liquids in an amount that could impair the structural integrity of waste package components (because of chemical interactions or formation of pressurized vapor) or result in spillage and spread of contamination in the event of package perforation.

(3) *Handling.* Waste packages shall be designed to maintain waste containment during transportation, emplacement, and retrieval.

(4) *Unique identification.* A label or other means of identification shall be provided for each package. The identification shall not impair the integrity of the package and shall be applied in such a way that the information shall be legible at least to the end of the retrievable storage period. Each package identification shall be consistent with the package's permanent written records.

Performance Confirmation Requirements

§ 60.137 General requirements for performance confirmation.

The geologic repository operations area shall be designed so as to permit implementation of a performance confirmation program that meets the requirements of Subpart F of this part.

Subpart F—Performance Confirmation

§ 60.140 General requirements.

(a) The performance confirmation program shall ascertain whether—

(1) Actual subsurface conditions encountered and changes in those conditions during construction and waste emplacement operations are within the limits assumed in the licensing review; and

(2) Natural and engineered systems and components required for repository operation, or which are designed or assumed to operate as barriers after permanent closure are functioning as intended and anticipated.

(b) The program shall have been started during site characterization and it will continue until permanent closure.

(c) The program will include in situ monitoring, laboratory and field testing, and in situ experiments, as may be appropriate to accomplish the objective as stated above.

(d) The confirmation program shall be implemented so that:

(1) It does not adversely affect the natural and engineered elements of the geologic repository.

(2) It provides baseline information and analysis of that information on those parameters and natural processes pertaining to the geologic setting that may be changed by site characterization, construction, and operational activities.

(3) It monitors and analyzes changes from the baseline condition of parameters that could affect the performance of a geologic repository.

(4) It provides an established plan for feedback and analysis of data, and implementation of appropriate action.

§ 60.141 Confirmation of geotechnical and design parameters.

(a) During repository construction and operation, a continuing program of surveillance, measurement, testing, and geologic mapping shall be conducted to ensure that geotechnical and design parameters are confirmed and to ensure that appropriate action is taken to inform the Commission of changes needed in design to accommodate actual field conditions encountered.

(b) Subsurface conditions shall be monitored and evaluated against design assumptions.

(c) As a minimum, measurements shall be made of rock deformations and displacement, changes in rock stress and strain, rate and location of water inflow into subsurface areas, changes in groundwater conditions, rock pore water pressures including those along fractures and joints, and the thermal and thermomechanical response of the rock mass as a result of development and operations of the geologic repository.

(d) These measurements and observations shall be compared with the original design bases and assumptions. If significant differences exist between the measurements and observations and the original design bases and assumptions, the need for modifications to the design or in construction methods shall be determined and these differences and the recommended changes reported to the Commission.

(e) In situ monitoring of the thermomechanical response of the underground facility shall be conducted until permanent closure to ensure that the performance of the natural and engineering features are within design limits.

§ 60.142 Design testing.

(a) During the early or developmental stages of construction, a program for in situ testing of such features as borehole and shaft seals, backfill, and the thermal interaction effects of the waste packages, backfill, rock, and groundwater shall be conducted.

(b) The testing shall be initiated as early as is practicable.

(c) A backfill test section shall be constructed to test the effectiveness of backfill placement and compaction procedures against design requirements before permanent backfill placement is begun.

(d) Test sections shall be established to test the effectiveness of borehole and shaft seals before full-scale operation proceeds to seal boreholes and shafts.

§ 60.143 Monitoring and testing waste packages.

(a) A program shall be established at the repository for monitoring the condition of the waste packages. Packages chosen for the program shall be representative of those to be emplaced in the repository.

(b) Consistent with safe operation of the repository, the environment of the waste packages selected for the waste package monitoring program shall be representative of the emplaced wastes.

(c) The waste package monitoring program shall include laboratory experiments which focus on the internal condition of the waste packages. To the extent practical, the environment experienced by the emplaced waste packages within the repository during the waste package monitoring program shall be duplicated in the laboratory experiments.

(d) The waste package monitoring program shall continue as long as practical up to the time of permanent closure.

Subpart G—Quality Assurance

§ 60.150 Scope.

(a) As used in this part, "quality assurance" comprises all those planned and systematic actions necessary to provide adequate confidence that the repository and its subsystems or components will perform satisfactorily in service.

(b) Quality assurance is a multidisciplinary system of management controls which address safety, reliability, maintainability, performance, and other technical disciplines.

§ 60.151 Applicability.

The quality assurance program applies to all systems, structures and components important to safety and to activities which would prevent or mitigate events that could cause an undue risk to the health and safety of the public. These activities include: exploring, site selecting, designing, fabricating, purchasing, handling, shipping, storing, cleaning, erecting, installing, emplacing, inspecting, testing,

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ENCLOSURE C

[COMPARATIVE TEXT]

10 CFR PART 60 - DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTES IN GEOLOGIC REPOSITORIES

1. The Table of Contents for Part 60 is revised to read as follows:

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SUBPART B--LICENSES

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60.23 Elimination of repetition.

60.24 Updating of application and environmental report.

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60.33 Amendment of construction authorization.

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60.41 Standards for issuance of a license.

60.42 Conditions of license.

60.43 License specifications.

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PERMANENT CLOSURE [DECOMMISSIONING]

60.51 License amendment [to-decommission] for permanent closure.

60.52 Termination of license.

SUBPART C--PARTICIPATION BY STATE GOVERNMENTS AND INDIAN TRIBES

60.61 Site review.

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60.63 Approval of proposals.

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SUBPART D--RECORDS, REPORTS, TESTS, AND INSPECTIONS

60.71 General recordkeeping and reporting requirements. [Records and-reports]

60.72 Construction records. [Tests]

60.73 Reports of deficiencies. [Inspections]

60.74 Tests.

60.75 Inspections.

SUBPART E--TECHNICAL CRITERIA

[Sec.]

60.101 Purpose and nature of findings.

60.102 Concepts.

PERFORMANCE OBJECTIVES

60.111 Performance of the geologic repository operations area through permanent closure. [Performance objectives.]

60.112 Overall system performance objective for the geologic repository after permanent closure. [Required-characteristics-of-the geologic-setting.]

60.113 Performance of particular barriers after permanent closure.

LAND OWNERSHIP AND CONTROL [OF-THE-GEOLOGIC-REPOSITORY-OPERATIONS-AREA]

[Sec.]

60.121 Requirements for ownership and control of the geologic repository operations area.

SITING CRITERIA [ADDITIONAL-REQUIREMENTS-FOR-THE-GEOLOGIC-SETTING]

60.122 Siting criteria [Favorable-conditions.]

[60.123---Potentially-adverse-conditions.]

[60.124---Assessment-of-potentially-adverse-conditions.]

DESIGN [AND-CONSTRUCTION-REQUIREMENTS] CRITERIA FOR THE GEOLOGIC REPOSITORY OPERATIONS AREA

60.130 Scope of design criteria for the geologic repository operations area.

[60.130] 60.131 General design [requirements] criteria for the geologic repository operations area.

[60.131] 60.132 Additional design [requirements] criteria for surface facilities in the geologic repository operations area.

[60.132] 60.133 Additional design [requirements] criteria for the underground facility.

[60.133] 60.134 Design of [shafts-and] seals for shafts and boreholes.

[60.134---Construction-specifications-for-surface-and-subsurface facilities.]

DESIGN CRITERIA FOR THE WASTE PACKAGE [REQUIREMENTS]

60.135 [Requirements] Criteria for the waste package and its components.

PERFORMANCE CONFIRMATION REQUIREMENTS

60.137 General requirements for performance confirmation.

SUBPART F - PERFORMANCE CONFIRMATION PROGRAM

60.140 General requirements.

60.141 Confirmation of geotechnical and design parameters.

60.142 Design testing.

60.143 Monitoring and testing waste packages.

SUBPART G - QUALITY ASSURANCE

60.150 Scope.

60.151 Applicability.

60.152 Implementation.

[60.153 Quality assurance for performance confirmation.]

SUBPART H - TRAINING AND CERTIFICATION OF PERSONNEL

60.160 General requirements.

60.161 Training and certification program.

60.162 Physical requirements.

SUBPART I - EMERGENCY PLANNING CRITERIA

[RESERVED]

2. The authority citation for Part 60 is revised to read[s] as follows: Authority: Secs. 51, 53, 62, 63, 65, 81, 161[b.,-f.,-i.,-o.,-p.], 182, 183, [Pub.-L.-83-703,-as-amended,] 68 Stat. 929, 930, 932, 933, 935, 948, 953, 954, as amended (42 U.S.C. 2071, 2073, 2092, 2093, 2095, 2111, 2201, 2232, 2233); [S]secs. 202, 206, [Pub.-L.-93-438,] 88 Stat. 1244, 1246 (42 U.S.C. 5842, 5846); [S]sec. 14, Pub. L. 95-601, 92 Stat. 2591 (42 U.S.C. 2021a); [S]sec. 102[(2)(c),] Pub. L. 91-190, 83 Stat. 853 (42 U.S.C. 4332)[.]; sec. 121, Pub. L. 97-425, 96 Stat. 2228.

For the purposes of sec. 223, 68 Stat. 958, as amended (42 U.S.C. 2273); §§ 60.71-60.75 are issued under sec. 161o, 68 Stat. 950, as amended (42 U.S.C. 2201(o)).

3. Section 60.2 is revised to read as follows:

§ 60.2 Definitions.

[For-the-purposes-of] As used in this Part--

"Accessible environment" means (1) the atmosphere, (2) the land surface, (3) surface water, (4) oceans, and (5) the portion of the lithosphere that is outside the controlled area. [those-portions-of-the environment-directly-in-contact-with-or-readily-available-for-use-by human-beings.]

"Anticipated processes and events" means those natural processes and events that are reasonably likely to occur during the period the intended performance objective must be achieved. [and-from-which-the design-bases-for-the-engineered-system-are-derived.] To the extent reasonable in the light of the geologic record, it shall be assumed that those processes operating in the geologic setting during the Quaternary Period continue to operate but with the perturbations caused by the presence of emplaced radioactive waste superimposed thereon.

"Barrier" means any material or structure that prevents or substantially delays movement of water or radionuclides.

"Candidate area" means a geologic and hydrologic system within which a geologic repository may be located.

"Commencement of construction" means clearing of land, surface or subsurface excavation, or other substantial action that would adversely affect the environment of a site, but does not include changes desirable for the temporary use of the land for public recreational uses, site characterization activities, other preconstruction monitoring and investigation necessary to establish background information related to the suitability of a site or to the protection of environmental values, or procurement or manufacture of components of the geologic repository operations area.

"Commission" means the Nuclear Regulatory Commission or its duly authorized representatives.

"Containment" means the confinement of radioactive waste within a designated boundary.

"Controlled area" means a surface location, to be marked by suitable monuments, extending horizontally no more than 10 kilometers in any direction from the underground facility, and the underlying subsurface, which area has been committed to use as a geologic repository and from which incompatible activities would be restricted following permanent closure.

["Decommissioning;"-or-"permanent-closure;"-means-final-back filling--of-subsurface-facilities;-sealing-of-shafts;-and-decontamination and-dismantlement-of-surface-facilities.]

"Director" means the Director of the Nuclear Regulatory Commission's Office of Nuclear Material Safety and Safeguards.

"Disposal" means the isolation of radioactive wastes from the accessible environment. [biosphere.]

"Disturbed zone" means that portion of the [geologic-setting-that is-significantly-affected-by-construction-of-the-subsurface-facility-or by-the-heat-generated-by-the-emplacement-of-radioactive-waste.] controlled area the physical or chemical properties of which have changed as a result of underground facility construction or as a result of heat generated by the emplaced radioactive wastes such that the resultant change of properties may have a significant effect on the performance of the geologic repository.

"DOE" means the U.S. Department of Energy or its duly authorized representatives.

"Engineered barrier system" means the waste packages and the underground facility.

["Far-field"-means-the-portion-of-the-geologic-setting-that-lies beyond-the-disturbed-zone.]

["Floodplain"-means-the-lowland-and-relatively-flat-areas-adjoining inland-and-coastal-waters-including-flood-prone-areas-of-offshore-islands and-including-at-a-minimum-that-area-subject-to-a-one-percent-or-greater chance-of-flooding-in-any-given-year.]

"Geologic repository" means a system [which-is-intended-to-be-used for;-or-may-be-used] for the disposal of radioactive wastes in excavated geologic media. A geologic repository includes (1) the geologic repository operations area, and (2) the portion of the geologic setting that provides isolation of the radioactive waste.

"Geologic repository operations area" means [an-HLW] a high-level radioactive waste facility that is part of a geologic repository, including both surface and subsurface areas, where waste handling activities are conducted.

"Geologic setting" [or-"site"] means the [is-the-spatially-distributed] geologic, hydrologic, and geochemical systems of the region in which a geologic repository operations area is or may be located. [that-provide isolation-of-the-radioactive-waste.]

"High-level radioactive waste" or "HLW" means (1) irradiated reactor fuel, (2) liquid wastes resulting from the operation of the first cycle solvent extraction system, or equivalent, and the concentrated wastes from subsequent extraction cycles, or equivalent, in a facility for reprocessing irradiated reactor fuel, and (3) solids into which such liquid wastes have been converted.

"HLW facility" means a facility subject to the licensing and related regulatory authority of the Commission pursuant to Sections 202(3) and 202(4) of the Energy Reorganization Act of 1974 (88 Stat 1244).[1]

"Host rock" means the geologic medium in which the waste is emplaced.

[1]These are DOE "facilities used primarily for the receipt and storage of high-level radioactive wastes resulting from activities licensed under such Act [the Atomic Energy Act]" and "Retrievable Surface Storage Facilities and other facilities authorized for the express purpose of subsequent long-term storage of high-level radioactive wastes generated by [DOE], which are not used for, or are part of, research and development activities."

"Important to safety," with reference to structures, systems, and components, means those engineered structures, systems, and components [that-provide-reasonable-assurance-that-radioactive-waste-can-be-received;-handled;-and-stored-without-undue-risk-to-the-health-and-safety-of-the public.] essential to the prevention or mitigation of an accident that could result in a radiation dose to the whole body, or any organ, of 0.5 rem or greater at or beyond the nearest boundary of the unrestricted area at any time until the completion of permanent closure.

"Indian tribe" means an Indian tribe as defined in the Indian Self-Determination and Education Assistance Act (Public Law 93-638).

"Isolation" means inhibiting the transport of radioactive material so that amounts and concentrations of this material entering the accessible environment will be kept within prescribed limits.

["Medium"-or-"geologic-medium"-is-a-body-of-rock-characterized-by lithologic-homogeneity.

"Overpack"-means-any-buffer-material;-receptacle;-wrapper;-box-or other-structure;-that-is-both-within-and-an-integral-part-of-a-waste package.--It-encloses-and-protects-the-waste-form-so-as-to-meet-the performance-objectives.]

"Permanent closure" means final backfilling of the underground facility and the sealing of shafts and boreholes.

"Performance confirmation" means the program of tests, experiments, and analyses which is conducted to evaluate the accuracy and adequacy of the information used to determine with reasonable assurance that the performance objectives for the period after permanent closure will be met.

"Public Document Room" means the place at 1717 H Street N.W., Washington, D.C., at which records of the Commission will ordinarily be made available for public inspection and any other place, the location of which has been published in the Federal Register, at which public records of the Commission pertaining to a particular geologic repository are made available for public inspection.

"Radioactive waste" or "waste" means HLW and any other radioactive materials other than HLW that are received for emplacement in a geologic repository.

"Restricted area" means any area access to which is controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials. "Restricted area" shall not include any areas used as residential quarters, although a separate room or rooms in a residential building may be set apart as a restricted area.

"Retrieval" means the act of intentionally removing radioactive waste from the underground location at which the waste had been previously emplaced for disposal.

"Saturated zone" means that part of the earth's crust beneath the deepest water table in which all voids, large and small, are ideally filled with water under pressure greater than atmospheric.

"Site" means [the geologic setting.] the location of the controlled area.

"Site characterization" means the program of exploration and research, both in the laboratory and in the field, undertaken to establish the geologic conditions and the ranges of those parameters of a particular site relevant to the procedures under this part. Site characterization includes borings, surface excavations, excavation of exploratory shafts, limited subsurface lateral excavations and borings, and in situ testing at depth needed to determine the suitability of the site for a geologic repository, but does not include preliminary borings and geophysical testing needed to decide whether site characterization should be undertaken.

["Stability"-means-that-the-nature-and-rates-of-natural-processes such-as-erosion-and-faulting-have-been-and-are-projected-to-be-such-that their-effects-will-not-jeopardize-isolation-of-the-radioactive-waste.

-"Subsurface-facility"-means-the-underground-portions-of-the-geo logic-repository-operations-area-including-openings,-backfill-materials, shafts-and-boreholes-as-well-as-shaft-and-borehole-seals.

"Transuranic-wastes"-or-TRU-wastes"-means-radioactive-waste-containing-alpha-emitting-transuranic-elements,-with-radioactive-half-lives greater-than-five-years,-in-excess-of-10-nanocuries-per-gram.]

"Tribal organization" means a tribal organization as defined in the Indian Self-Determination and Education Assistance Act (Public Law 93-638).

"Unanticipated processes and events" means those processes and events affecting the geologic setting that are judged not to be reasonably likely to occur during the period the intended performance objective must be achieved, but which are nevertheless sufficiently credible to warrant consideration. Unanticipated processes and events may be either natural processes or events, or processes and events initiated by human activities other than those activities licensed under this part. Processes and events initiated by human activities may only be found to be sufficiently credible to warrant consideration if it is assumed that: (1) the monuments provided for by this part are sufficiently permanent to serve their intended purpose; (2) the value to future generations of potential resources within the site can be assessed adequately under the applicable provisions of this part; (3) an understanding of the nature of radioactivity, and an appreciation of its hazards, have been retained in some functioning institutions; (4) institutions are able to assess risk and to take remedial action at a level of social organization and technological competence equivalent to, or superior to, that which was applied in initiating the processes or events concerned; and (5) relevant records are preserved, and remain accessible, for several hundred years after permanent closure.

"Underground facility" means the underground structure, including openings and backfill materials, but excluding shafts, boreholes, and their seals.

"Unrestricted area" means any area, access to which is not controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials, and any area used for residential quarters.

"Waste form" means the radioactive waste materials and any encapsulating or stabilizing matrix. [materials,-exclusive-of-containers.]

"Waste package" means the waste form and any containers, shielding, packing and other absorbent materials immediately surrounding an individual waste container. [airtight,-watertight,-sealed-container which-includes-the-waste-form-and-any-ancillary-enclosures,-including shielding,-discrete-backfill-and-overpacks.]

"Water table" means that surface in a groundwater body at which the water pressure is atmospheric.

4. Section 60.10 is amended by revising paragraphs (a) and (d) to read as follows:

§ 60.10 Site characterization.

(a) Prior to submittal of an application for a license to be issued under this part [the] DOE shall conduct a program of site characterization with respect to the site to be described in such application.

(b) Unless the Commission determines with respect to the site described in the application that it is not necessary, site characterization shall include a program of in situ exploration and testing at the depths that wastes would be emplaced.

(c) As provided in § 51.40 of this chapter, DOE is also required to conduct a program of site characterization, including in situ testing at depth, with respect to alternative sites.

(d) The program of site characterization shall be conducted in accordance with the following:

(1) Investigations to obtain the required information shall be conducted in such a manner as to limit adverse effects on the long-term performance of the geologic repository to the extent practical.

(2) [As-a-minimum-the-location] The number of exploratory boreholes and shafts shall be limited to the extent practical [selected-so-as-to limit-the-total-number-of-subsurface-penetrations-above-and-around-the underground-facility] consistent with obtaining the information needed for site characterization.

(3) To the extent practical, exploratory boreholes and shafts in the geologic repository operations area shall be located where shafts are planned for [repository] underground facility construction and operation or where large unexcavated pillars are planned.

(4) Subsurface exploratory drilling, excavation, and in situ testing before and during construction shall be planned and coordinated with geologic repository operations area design and construction.

5. Section 60.11 is amended by revising paragraphs (a) and (b) to read as follows:

§ 60.11 Site characterization report.

(a) As early as possible after commencement of planning for a particular geologic repository operations area, and prior to site characterization, [the] DOE shall submit to the Director a Site Characterization Report. The report shall include[2] (1) a description of the site to be characterized; (2) the criteria used to arrive at the candidate area; (3) the method by which the site was selected for site characterization; (4) identification and location of alternative media and sites at which DOE intends to conduct site characterization and for which DOE anticipates submitting subsequent Site Characterization Reports; (5) a description of the decision process by which the site was selected for characterization, including the means used to obtain public, Indian tribal and State views during selection; (6) a description of the site characterization program including (i) the extent of planned excavation and plans for in situ testing, (ii) a conceptual design of a geologic repository operations area appropriate to the named site in sufficient detail to allow assessment of the site characterization program, with respect to investigation activities which address the ability of the

[2]To the extent that the information indicated in items 2 through 5 appears in an Environmental Impact Statement prepared by DOE for site characterization at the named site, it may be incorporated into DOE's Site Characterization Report by reference.

site to host a geologic repository and isolate radioactive waste, or which may affect such ability, and (iii) provisions to control any adverse, safety-related effects from site characterization, including appropriate quality assurance programs; (7) a description of the quality assurance program to be applied to data collection; and (8) any issues related to site selection, alternative candidate areas or other sites, or design of the geologic repository operations area which the DOE wishes the Commission to review. Also included shall be a description of the research and development activities being conducted by DOE which deal with the waste form and packaging which may be considered appropriate for the site to be characterized, including research planned or underway to evaluate the performance of such waste forms and packaging.

* * * * *

6. § 60.21 is amended by revising paragraphs (c)(1), (c)(3), (c)(4), (c)(8), (c)(9), (c)(11), (c)(13), (c)(14), and (c)(15) to read as follows:

§ 60.21 Content of application.

* * * * *

(c) The Safety Analysis Report shall include:

(1) A description and assessment of the site at which the proposed geologic repository operations area is to be located with appropriate attention to those features of the site that might affect geologic repository operations area [facility] design and performance. The description of the site shall identify the [limits-of-the-accessible-environment with-respect-to-the] location of the geologic repository operations area with respect to the boundary of the accessible environment.

(i) The description of the site shall also include the following information regarding subsurface conditions. This description shall, in all cases, include such information with respect to the controlled area. In addition, where subsurface conditions outside the controlled area may affect isolation within the controlled area, the description shall include such information with respect to subsurface conditions outside the controlled area to the extent such information is relevant and material. The detailed information referred to in this paragraph shall include--[in-the-vicinity-of-the-proposed-underground-facility]

(A) The orientation, distribution, aperture in-filling and origin of fractures, discontinuities, and heterogeneities;

(B) The presence and characteristics of other potential pathways such as solution features, breccia pipes, or other potentially permeable [anomalies] features;

(C) The [bulk] geomechanical properties and conditions, including pore pressure and ambient stress conditions;

(D) The [bulk] hydrogeologic properties and conditions;

(E) The [bulk] geochemical properties; and

(F) The anticipated response of the [bulk] geomechanical, hydrogeologic, and geochemical systems to the maximum design thermal loading, given the pattern of fractures and other discontinuities and the heat transfer properties of the rock mass and groundwater.

(ii) The assessment shall contain--

(A) An analysis of the geology, geophysics, hydrogeology, geochemistry, climatology, and meteorology of the site,

(B) Analyses to determine the degree to which each of the favorable and potentially adverse conditions, if present, has been characterized, and the extent to which it contributes to or detracts from isolation. For the purpose of determining the presence of the potentially adverse conditions, investigations shall extend from the surface to a depth sufficient to determine critical pathways for radionuclide migration from the underground facility to the accessible environment. Potentially adverse conditions shall be investigated outside of the controlled area if they affect isolation within the controlled area.

(C) An evaluation of the [expected] performance of the proposed geologic repository for the period after permanent closure, [noting] assuming [the] anticipated processes and events, giving the rates and quantities of [expected] releases of radionuclides to the accessible environment as a function of time; and a similar evaluation which assumes the occurrence of unanticipated processes and events. [In-executing-this evaluation-DOE-shall-assume-that-those-processes-operating-on-the-site-are those-which-have-been-operating-on-it-during-the-Quaternary-Period-and superpose-the-perturbations-caused-by-the-presence-ofemplaced-radioactive waste-on-the-natural-processes].

(D) The effectiveness of engineered and natural barriers, including barriers that may not be themselves a part of the geologic repository operations area, against the release of radioactive material to the environment. The analysis shall also include a comparative evaluation of alternatives to the major design features that are important to waste isolation, with particular attention to the alternatives that would provide longer radionuclide containment and isolation.

(E)[(D)] An analysis of the [expected] performance of the major design structures, systems, and components, both surface and subsurface, to identify those that are important to safety. [bear-significantly on-the-suitability-of-the-geologic-repository-for-disposal-of-radioactive waste-assuming-the-anticipated-processes-and-events-and-natural-phenomena from-which-the-design-bases-are-derived.] For the purposes of this analysis, it shall be assumed that operations at the geologic repository operations area will be carried out at the maximum capacity and rate of receipt of radioactive waste stated in the application.

(F)[(E)] An explanation of measures used to support [confirm] the models used to perform the assessments required in paragraphs (A) through (D). Analyses and models that will be used to predict future conditions and changes in the geologic setting shall be supported [confirmed] by using an appropriate combination of such methods as field tests, in situ tests, [field-verified] laboratory tests which are representative of field conditions, monitoring data, and [or] natural analog studies.

* * * * *

(3) A description and analysis of the design and performance requirements for structures, systems, and components of the geologic repositiory which are important to safety. This analysis shall consider-- (i) the margins of safety under normal conditions and under conditions that may result from anticipated operational occurrences, including those of natural origin; and (ii) the adequacy of structures, systems, and components provided for the prevention of accidents and mitigation of the consequences of accidents, including those caused by natural phenomena. [;and-(iii)-the-effectivenessof-engineered-and-natural-barriers;-including barriers-that-may-not-be-themselves-a-part-of-the-geologic-repository operations-area;-against-the-release-of-radioactive-material-to-the environment.--The-analysis-shall-also-include-a-comparative-evaluation of-alternatives-to-the-major-design-features-that-are-important-to

radionuclide-containment-and-isolation;-with-particular-attention-to-the-alternatives-that-would-provide-longer-radionuclide-containment-and isolation.]

(4) A description of the quality assurance program to be applied to the [design-fabrication;-inspection;-construction;-testing;-and operation-of-the] structures, systems, and components important to safety [of-the-geologic-repository-operations-area[7]] and to the engineered and natural barriers important to waste isolation.

[[7]The-criteria-in-Appendix-B-of-Part-50-of-this-chapter-will-be-used-by the-Commission-in-determining-the-adequacy-of-the-quality-assurance program]

* * * * *

(8) A description of the controls that the applicant will apply to restrict access and to regulate land use at the [geologic-repository operations-area] site and adjacent areas, including a conceptual design of monuments which would be used to identify the controlled area after permanent closure.

(9) Plans for coping with radiological emergencies at any time prior to [completion-of-decommissioning-the-geologic-respository operations-area] permanent closure and decontamination or dismantlement of surface facilities.

* * * * *

(11) A description of design considerations that are intended to facilitate [decommissioning-of-the-facility] permanent closure and decontamination or dismantlement of surface facilities.

* * * * *

(13) An identification and evaluation of the natural resources [at the-site;] of the geologic setting, including estimates as to undiscovered deposits, the exploitation of which could affect the ability of the geologic repository [site] to isolate radioactive wastes. Undiscovered deposits of resources characteristic of the area shall be estimated by reasonable inference based on geological and geophysical evidence. This evaluation of resources, including undiscovered deposits, shall be conducted for the site [disturbed-zone] and for areas of similar size that are representative of and are within the geologic setting. For natural resources with current markets the resources shall be assessed, with estimates provided of both gross and net value. The estimate of net value shall take into account current development, extraction and marketing costs. For natural resources without current markets, but which would be marketable given credible projected changes in economic or technological factors, the resources shall be described by physical factors such as tonnage or other amount, grade, and quality.

(14) An identification of those structures, systems, and components of the geologic repository, both surface and subsurface, which require research and development to confirm the adequacy of design. For [systems] structures, systems, and components important to safety, and for the engineered and natural barriers important to waste isolation, [the] DOE shall provide a detailed description of the programs designed to resolve safety questions, including a schedule indicating when these questions would be resolved.

(15) The following information concerning activities at the geologic repository operations area:

(i) The organizational structure of DOE as it pertains to construction and operation of the geologic repository operations area [offsite-and onsite] including a description of any delegations of authority and assignments of responsibilities, whether in the form of regulations, administrative directives, contract provisions, or otherwise.

(ii) The quality assurance [program] organization to be used to ensure safety.

(iii) * * *

(vii) Plans for [decommissioning] permanent closure and plans for the decontamination or dismantlement of surface facilities.

(viii) Plans for any uses of the geologic repository operations area for purposes other than disposal of radioactive wastes, with an analysis of the effects, if any, that such uses may have upon the operation of the structures, systems, and components important to safety and the engineered and natural barriers important to waste isolation.

7. Section 60.22 is amended by revising paragraphs (a) and (d) to read as follows:

§ 60.22 Filing and distribution of application.

(a) An application for a license to receive and possess source, special nuclear, or byproduct material [in] at a geologic repository operations area at a site which has been characterized, and an accompanying environmental report, and any amendments thereto, shall be filed in triplicate with the Director and shall be signed by the Secretary of Energy or [his] the Secretary's authorized representative.

* * * * *

(d) At the time of filing of an application and environmental report, and any amendments thereto, one copy shall be made available in an appropriate location near the [site-of-the] proposed geologic repository operations area (which shall be a public document room, if one has been established) for inspection by the public and updated as amendments to the application or environmental report are made. An updated copy shall be produced at any public hearing on the application for use by any parties to the proceedings.

* * * * *

8. Section 60.31 is amended by revising paragraphs (a)(1) and (a)(2) to read as follows:

§ 60.31 Construction authorization.

* * * * *

(a) Safety. That there is reasonable assurance that the types and amounts of radioactive materials described in the application can be received, possessed, and disposed of in a geologic repository operations area of the design proposed without unreasonable risk to the health and safety of the public. In arriving at this determination, the Commission shall consider whether:

(1) [The] DOE has described the proposed geologic repository including but not limited to (i) the geologic, geophysical, geochemical and hydrologic characteristics of the site; (ii) the kinds and quantities of radioactive waste to be received, possessed, stored, and disposed of in the geologic repository operations area; (iii) the principal architectural and engineering criteria for the design of the geologic repository operations area; (iv) construction procedures which may affect the capability of the geologic repository to serve its intended function; and (v) features or components incorporated in the design for the protection of the health and safety of the public.

(2) The site and design comply with the performance objectives and criteria contained in Subpart E of this part.

* * * * *

9. Section 60.32 is amended by revising paragraphs (b) and (c) to read as follows:

§ 60.32 Conditions of construction authorization.

(a) * * * *

(b) The Commission will incorporate in the construction authorization provisions requiring [the] DOE to furnish periodic or special reports regarding: (1) progress of construction, (2) any [site] data about the site obtained during construction which are not within the predicted limits upon which the facility design was based, (3) any deficiencies in design and construction which, if uncorrected, could adversely affect safety at any future time, and (4) results of research and development programs being conducted to resolve safety questions.

(c) The construction authorization will include restrictions on subsequent changes to the features of the geologic repository and the procedures authorized. The restrictions that may be imposed under this paragraph can include measures to prevent adverse effects on the geologic setting as well as measures related to the design and construction of the geologic repository operations area. These restrictions will fall into three categories of descending importance to public health and safety as follows: (1) those features and procedures which may not be changed without (i) 60 days prior notice to the Commission, (ii) 30 days notice of opportunity for a prior hearing, and (iii) prior Commission approval; (2) those features and procedures which may not be changed without (i) 60 days prior notice to the Commission, and (ii) prior Commission approval; and (3) those features and procedures which may not be changed without 60 days prior notice to the Commission. Features and procedures falling in paragraph (c)(3) of this section may not be changed without prior Commission approval if the Commission, after having received the required notice, so orders.

*　　　*　　　*　　　*　　　*

10. Section 60.43 is amended by revising paragraphs (b)(3) and (b)(5) to read as follows:

§ 60.43 License specifications.

(a)　　*　　*　　*　　*

(b) License conditions shall include items in the following categories--

(1) * * *

(3) Restrictions as to the amount of waste permitted per unit volume of storage space considering the physical characteristics of both the waste and the host rock [storage-medium].

(4) * * *

(5) Controls to be applied to restrict access and to avoid disturbance to the [geologic-repository-operations-area-and-adjacent areas] controlled area and to areas outside the controlled area where conditions may affect isolation within the controlled area.

*　　　*　　　*　　　*　　　*

11. Section 60.46 is amended by revising paragraphs (a)(3) and (a)(6), and adding (a)(7) to read as follows:

§ 60.46 Particular activities requiring license amendment.

(a) Unless expressly authorized in the license, an amendment of the license shall be required with respect to any of the following activities--

(1) * * *

(3) Removal or reduction of controls applied to restrict access to or to avoid disturbance of the [geologic-repositoryoperations-area-or adjacent-areas] controlled area and to areas outside the controlled area where conditions may affect isolation within the controlled area.

(4) * * *

(6) Permanent closure. [Decommissioning].

(7) Any other activity involving an unreviewed safety question.

12. Section 60.51 is amended by changing the undesignated center heading immediately preceding the section from DECOMMISSIONING to PERMANENT CLOSURE and by revising paragraphs (a)(1), (2), (4), (5) and (6), and paragraph (b).

§ 60.51 License amendment [to-decommission] for permanent closure.

(a) [The] DOE shall submit an application to amend the license prior to permanent closure [decommissioning-]. The application shall consist of an update of the license application and environmental report submitted under §§60.21 and 60.22, including:

(1) A description of the program for [post-decommissioning] post-permanent closure monitoring of the geologic repository.

(2) A detailed description of the measures to be employed--such as land use controls, construction of monuments, and preservation of records--to regulate or prevent activities that could impair the long-term isolation of emplaced waste within the geologic repository and to

assure that relevant information will be preserved for the use of future generations. As a minimum, such measures shall include--

(i) Identification of the controlled area and geologic repository operations area by monuments that have been designed, fabricated, and emplaced to be as permanent as is practicable; and

(ii) Placement of records [of-the-location-of-the-geologic-repository operations-area-and-the-nature-and-hazard-of-the-waste] in the archives and land record systems of local, State, and Federal government agencies, and archives elsewhere in the world, that would be likely to be consulted by potential human intruders--such records to identify the location of the geologic repository operations area, including the underground facility, boreholes and shafts, and the boundaries of the controlled area, and the nature and hazard of the waste.

(3) * * *

(4) The results of tests, experiments, and any other analyses relating to backfill of excavated areas, shaft sealing, waste interaction with the host rock, [emplacement-media] and any other tests, experiments, or analyses pertinent to the long-term isolation of emplaced wastes within the geologic repository.

(5) Any substantial revision of plans for [decommissioning] permanent closure.

(6) Other information bearing upon [decommissioning] permanent closure that was not available at the time a license was issued.

(b) [The] DOE shall update its environmental report in a timely manner so as to permit the Commission to review, prior to issuance of an amendment, substantial changes in the [decommissioning] permanent closure activities proposed to be carried out or significant new information regarding the environmental impacts of such [decommissioning] permanent closure.

13. Section 60.52 is amended by revising paragraphs (a) and (c)(2) to read as follows:

§ 60.52 Termination of license.

(a) Following permanent closure [decommissioning] and the decontamination or dismantlement of surface facilities, DOE may apply for an amendment to terminate the license.

*   *   *   *   *

(c) A license shall be terminated only when the Commission finds with respect to the geologic repository--

(1) * * *

(2) That the final state of the geologic repository operations area [site] conforms to [the] DOE's plans for permanent closure [decommissioning] and DOE's plans for the decontamination or dismantlement of surface facilities, as amended and approved as part of the license.

*   *   *   *   *

14. Subpart D is revised to read as follows:

SUBPART D -- RECORDS, REPORTS, TESTS AND INSPECTIONS

[Records-and-reports]

§ 60.71 General recordkeeping and reporting requirements.

(a) [The] DOE shall maintain such records and make such reports in connection with the licensed activity as may be required by the conditions of the license or by rules, regulations, and orders of the Commission as authorized by the Atomic Energy Act and the Energy Reorganization Act.

(b) Records of the receipt, handling, and disposition of radioactive waste at a geologic repository operations area shall contain sufficient information to provide a complete history of the movement of the waste from the shipper through all phases of storage and disposal.

[§-60.134(c)] § 60.72 Construction records.

[The-construction-specifications-shall-include-requirements-for-the development-of-a-complete-documented-history-of-repository-construction. This-documented-history-shall-include-at-least-the-following:]

(a) DOE shall maintain records of construction of the geologic repository operations area.

(b) The records required under paragraph (a) shall include at least the following --

(1) Surveys of the underground facility excavations, [and] shafts, and boreholes referenced to [located-via] readily identifiable surface features or monuments;

(2) A description of the [M] materials encountered;

(3) Geologic maps and geologic cross sections;

(4) Locations and amount of seepage;

(5) Details of equipment, methods, progress, and sequence of work;

(6) Construction problems;

(7) Anomalous conditions encountered;

(8) Instrument locations, readings, and analysis;

(9) Location and description of structural support systems;

(10) Location and description of dewatering systems; and

(11) Details, methods of emplacement, and location of seals used.

§ 60.73 Reports of deficiencies.

[The] DOE shall promptly notify the Commission of each deficiency found in the characteristics of the site, and design and construction of the geologic repository operations area which, were it to remain uncorrected, could (a) be a substantial safety hazard, (b) represent a significant deviation from the design criteria and design bases stated in the application, or (c) represent a deviation from the conditions stated in the terms of a construction authorization or the license, including license specifications. The notification shall be in the form of a written report, copies of which shall be sent to the Director and to the appropriate Nuclear Regulatory Commission [Inspection-and-Enforcement] Regional Office listed in Appendix D of Part 20 of this chapter.

[§-60.72] § 60.74 Tests.

(a)[The] DOE shall perform, or permit the Commission to perform, such tests as the Commission deems appropriate or necessary for the administration of the regulations in this part. These may include tests of (1) [(a)] radioactive waste, (2) [(b)] the geologic repository including its structures, systems, and components, (3) [(c)] radiation detection and monitoring instruments, and (4) [(d)] other equipment and devices used in connection with the receipt, handling, or storage of radioactive waste.

(b) The tests required under this section shall include a performance confirmation program carried out in accordance with Subpart F of this part.

[§-60.73] § 60.75 Inspections.

(a) [The] DOE shall allow the Commission to inspect the premises of the geologic repository operations area and adjacent areas to which [the] DOE has rights of access.

(b) [The] DOE shall make available to the Commission for inspection, upon reasonable notice, records kept by [the] DOE pertaining to activities under this part.

(c)(1) [The] DOE shall upon request by the Director, Office of Inspection and Enforcement, provide rent-free office space for the exclusive use of the Commission inspection personnel. Heat, air-conditioning, light, electrical outlets and janitorial services shall be furnished by DOE. The office shall be convenient to and have full access to the facility and shall provide the inspector both visual and acoustic privacy.

(2) The space provided shall be adequate to accommodate a full-time inspector, a part-time secretary and transient NRC personnel and will be generally commensurate with other office facilities at the geologic repository operations area [site]. A space of 250 square feet either within the geologic repository operations area's [site's] office complex or in an office trailer or other onsite space at the geologic repository operations area is suggested as a guide. For [sites] locations at which activities are carried out under licenses issued under other parts of this chapter, [containing-multiple-facilities,] additional space may be requested to accommodate additional full time [inspector(s)] inspectors. The office space that is provided shall be subject to the approval of the Director, Office of Inspection and Enforcement. All furniture, supplies and communication equipment will be furnished by the Commission.

(3) DOE shall afford any NRC resident inspector assigned to that [site] location, or other NRC inspectors identified by the Regional [Director] Administrator as likely to inspect the facility, immediate unfettered access, equivalent to access provided regular employees, following proper identification and compliance with applicable access control measures for security, radiological protection and personal safety.

15. Subparts E, F, G, H, and I are added to read as follows:

SUBPART E - TECHNICAL CRITERIA

§60.101 Purpose and nature of findings.

(a)(1) Subpart B of this part prescribes the standards for issuance of a license to receive and possess source, special nuclear, or byproduct material at a geologic repository operations area. In particular, § 60.41(c) requires a finding that the issuance of a license will not constitute an unreasonable risk to the health and safety of the public. The purpose of this subpart is to set out performance objectives and site and design criteria which, if satisfied, will support such a finding of no unreasonable risk.

(2) 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 § [60.111,] 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 [media] setting over time periods of [a thousand] 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, [and] 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 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.

(b) Subpart B of this part also lists findings that must be made in support of an authorization to construct a geologic repository operations area. In particular, § 60.31(a) requires a finding that there is reasonable assurance that the types and amounts of radioactive materials described in the application can be received, possessed, and disposed of in a geologic repository operations area of the design proposed without unreasonable risk to the health and safety of the public. As stated in that paragraph, in arriving at this determination, the Commission will consider whether the site and design comply with the criteria contained in this subpart. Once again, while the criteria may be written in unqualified terms, the demonstration of compliance may take uncertainties and gaps in knowledge into account, provided that the Commission can make the specified finding of reasonable assurance as specified in paragraph (a) of this section.

§ 60.102 Concepts.

This section provides a functional overview of Subpart E. In the event of any inconsistency with definitions found in § 60.2, those definitions shall prevail.

(a) The HLW facility.

NRC exercises licensing and related regulatory authority over those facilities described in section 202(3) and (4) of the Energy Reorganization Act of 1974. Any of these facilities is designated a HLW facility.

(b) The geologic repository operations area.

(1) This part deals with the exercise of authority with respect to a particular class of HLW facility -- namely a geologic repository operations area.

(2) A geologic repository operations area consists of those surface and subsurface areas that are part of a geologic repository where radioactive waste handling activities are conducted. The underground structure, including openings and backfill materials, but excluding shafts, boreholes, and their seals, is designated the underground facility.

(3) The exercise of Commission authority requires that the geologic repository operations area be used for storage (which includes disposal) of high-level radioactive wastes (HLW).

(4) HLW includes irradiated reactor fuel as well as reprocessing wastes. However, if DOE proposes to use the geologic repository operations area for storage of radioactive waste other than HLW, the storage of this radioactive waste is subject to the requirements of this part. [~~Thus, the storage of transuranic contaminated waste (TRU), though not itself a form of HLW, must conform to the requirements of this part if it is stored in a geologic repository operations area.~~]

(c) Areas related to isolation. [adjacent-to-the-geologic-repository-operations-area.]

Although the activities subject to regulation under this part are those to be carried out at the geologic repository operations area, the licensing process also considers characteristics of adjacent areas that are defined in other ways. [First,] There is to be an area surrounding the underground facility referred to above, which is designated the controlled area, within which DOE is to exercise specified controls to prevent adverse human actions following permanent closure. [Second,] The location of the controlled area is the site. The accessible environment is the atmosphere, land surface, surface water, oceans, and the portion of the lithosphere that is outside the controlled area. There is an [a-larger] area, designated the geologic setting, [or-site] which includes the [spatially-distributed] geologic, hydrologic, and geochemical systems of the region in which a geologic repository operations area is or may be located [that-provide-isolation-of-the-radioactive-waste-from-the accessible-environment.] The geologic repository operations area plus the portion of the geologic setting that provides isolation of the radioactive waste make up the geologic repository. [Within-the-geologic setting,-particular-attention-must-be-given-to-thecharacteristics-of-the host-rock-as-well-as-any-rock-units-surrounding-the-host-rock.]

(d) Stages in the licensing process.

There are several stages in the licensing process. The site characterization stage, though begun before submission of a license application, may result in consequences requiring evaluation in the license review. The construction stage would follow, after issuance of a construction authorization. A period of operations follows the issuance of a license by the Commission. The period of operations includes the time during which emplacement of wastes occurs; any subsequent period before permanent closure during which the emplaced wastes are retrievable; and permanent closure, which includes [final-backfilling-of-subsurface facilities] sealing of shafts. [and-decontaminating-and-dismantling-of surface-facilities. Permanent closure represents the end of active human intervention with respect to the [activities-with-the-geologic-repository operations-area-and] engineered barrier system[s].

(e) Isolation of waste. [Containment-.]

[Early] During the first several hundred years following permanent closure [repository-life] of a geologic repository, when radiation and thermal levels are high and the uncertainties in assessing repository performance are large, [consequences-of-events-are-especially-difficult to-predict-rigorously;] special emphasis is placed upon the ability to contain the wastes by waste packages within an engineered barrier system. This is known as the containment period. The engineered barrier system includes the waste packages [as-well-as] and the underground facility. A waste package [includes:] is composed of the waste form and any containers, shielding, packing, and absorbent materials immediately surrounding an individual waste container. The underground facility means the underground structure, including openings and backfill materials, but excluding, shafts, boreholes, and their seals.

[(1)-The-waste-form-which-consists-of-the-radioactive-waste-materials-and-any-associated-encapsulating-or-stabilizing-materials;]

[(2)--The-container-which-is-the-first-major-sealed-enclosure-that holds-the-waste-form;]

[(3)--Overpacks-which-consist-of-any-buffer-material;-receptacle; wrapper;-box-or-other-structure;-that-is-both-within-and-an-integral partof-a-waste-package:--It-encloses-and-protects-the-waste-form-so-as-to-meet-the-performance-objectives:]

[(f)--Isolation:]

Following the containment period special emphasis is placed upon the ability to achieve isolation of the wastes by virtue of the characteristics of the geologic repository. The engineered barrier system works to control the release of radioactive material to the geologic setting and the geologic setting works to control the release of radioactive material to the accessible environment. Isolation means [the-act-of] inhibiting the transport of radioactive material [to] so that amounts and concentrations of the material entering the accessible environment [in-amounts-and concentrations] will be kept within prescribed limits. [The-accessible environment-means-those-portions-of-the-environment-directly-in-contact with-or-readily-available-for-use-by-human-beings:]

PERFORMANCE OBJECTIVES

[§60:111--Performance-objectives:]

§ 60.111 (a) Performance of the geologic repository operations area through permanent closure.

(a) (1) Protection against radiation exposures and releases of radioactive material. The geologic repository operations area shall be designed so that until permanent closure has been completed, radiation exposures and radiation levels, and releases of radioactive materials to unrestricted areas, will at all times be maintained within the limits specified in Part 20 of this chapter and such [any] generally applicable environmental standards for radioactivity as may have been established by the Environmental Protection Agency.

[(2)--Retrievability-of-waste.--The-geologic-repository-operations-area-shall-be-designed-so-that-the-entire-inventory-of-waste-could-be-retrieved-on-a-reasonable-schedule;-starting-at-any-time-up-to-50-years-after-waste-emplacement-operations-are-complete.--A-reasonable-schedule-for-retrieval-is-one-that-requires-no-longer-than-about-the-same-overall-period-of-time-than-was-devoted-to-the-construction-of-the-geologic-repository-operations-area-and-the-emplacement-of-wastes.]

(b) Retrievability of waste.

(1) The geologic repository operations area shall be designed to preserve the option of waste retrieval throughout the period during which wastes are being emplaced and, thereafter, until the completion of a performance confirmation program and Commission review of the information obtained from such a program. To satisfy this objective, the geologic repository operations area shall be designed so that any or all of the emplaced waste could be retrieved on a reasonable schedule starting at any time up to 50 years after waste emplacement operations are initiated, unless a different time period is approved or specified by the Commission. This different time period may be established on a case-by-case basis consistent with the emplacement schedule and the planned performance confirmation program.

(2) This requirement shall not preclude decisions by the Commission to allow backfilling part or all of, or permanent closure of, the geologic repository operations area prior to the end of the period of design for retrievability.

(3) For purposes of this paragraph, a reasonable schedule for retrieval is one that would permit retrieval in about the same time as that devoted to construction of the geologic repository operations area and the emplacement of wastes.

[(b)--Performance-of-the-geologic-repository-after-permanent-closure.

(1)-Overall-system-performance.]

§ 60.112 Overall system performance objectives for the geologic repository after permanent closure.

The geologic setting shall be selected and the engineered barrier system [subsurface-facility] and the shafts, boreholes and their seals shall be designed [so-as] to assure that [assuming-anticipated-processes-and events,] releases of radioactive materials [from-the-geologic-repository] to the accessible environment following permanent closure conform to such generally applicable environmental standards for radioactivity as may have been established by the Environmental Protection Agency with respect to both anticipated processes and events and unanticipated processes and events.

[(2)-Performance-of-the-engineered-system.

(i)--Containment-of-wastes.*--The-engineered-system-shall-be designed-so-that-even-if-full-or-partial-saturation-of-the-underground facility-were-to-occur,-and-assuming-anticipated-processes-and-events,-the waste-packages-will-contain-all-radionuclides-for-at-least-the-first-1,000 years-after-permanent-closure.--This-requirement-does-not-apply-to-TRU waste-unless-TRU-waste-is-emplaced-close-enough-to-HLW-that-the-TRU-release-rate-can-be-significantly-affected-by-the-heat-generated-by-the-HLW.]

~~(ii)-Control-of-releases~~.

[~~(A)--For-HLW,-the-engineered-system-shall-be-designed-so-that, after-the-first-1,000-years-following-permanent-closure,-the-annual release-rate-of-any-radionuclide-from-the-engineered-system-into-the geologic-setting,-assuming-anticipated-processes-and-events,-is-at-most one-part-in-100,000-of-the-maximum-amount-of-that-radionuclide-calculated-to-be-present-in-the-underground-facility-(assuming-no-release from-the-underground-facility)-at-any-time-after-1,000-years-following permanent-closure.--This-requirement-does-not-apply-to-radionuclides whose-contribution-is-less-than-0.1%-of-the-total-annual-curie-release as-prescribed-by-this-paragraph.~~

~~(B)--For-TRU-waste,-the-engineered-system-shall-be-designed-so-that following-permanent-closure-the-annual-release-rate-of-any-radionuclide from-the-underground-facility-into-the-geologic-setting,-assuming anticipated-processes-and-events,-is-at-most-one-part-in-100,000-of-the maximum-amount-calculated-to-be-present-in-the-underground-facility (assuming-no-release-from-the-underground-facility)-at-any-time following-permanent-closure.--This-requirement-does-not-apply-to radionuclides-whose-contribution-is-less-than-0.1%-of-the-annual curie-release-as-prescribed-by-this-paragraph.~~]

§ 60.113 Performance of particular barriers after permanent closure.

(a) General provisions.

(1) Engineered barrier system.

(i) The engineered barrier system shall be designed so that assuming anticipated processes and events (A) containment of HLW will be substantially complete during the period when radiation and thermal conditions in the engineered barrier system are dominated by fission product decay; and (B) any release of radionuclides from the engineered barrier system shall be a gradual process which results in small fractional releases to the geologic setting over long times. For disposal in the saturated zone, both the partial and complete filling with groundwater of available void spaces in the underground facility shall be appropriately considered and analysed among the anticipated processes and events in designing the engineered barrier system.

(ii) In satisfying the preceding requirement, the engineered barrier system shall be designed, assuming anticipated processes and events, so that:

(A) Containment of HLW within the waste packages will be substantially complete for a period to be determined by the Commission taking into account the factors specified in subsection 60.113(b) provided, that such period shall be not less than 300 years nor more than 1,000 years after permanent closure of the geologic repository; and

(B) The release rate of any radionuclide from the engineered barrier system following the containment period shall not exceed one part in 100,000 per year of the inventory of that radionuclide calculated to be present at 1,000 years following permanent closure, or such other fraction of the inventory as may be approved or specified by the Commission; provided, that this requirement does not apply to any radionuclide which is released at a rate less than 0.1% of the calculated total release rate limit. The calculated total release rate limit shall be taken to be one part in 100,000 per year of the inventory of radioactive waste, originally emplaced in the underground facility, that remains after 1,000 years of radioactive decay.

[(3)--Performance-of-the-geologic-setting.

(i)--Containment-period.--During-the-containment-period,-the-geologic-setting-shall-mitigate-the-impacts-of-premature-failure-of-the-engineered-system.--The-ability-of-the-geologic-setting-to-isolate-wastes-during-the-isolation-period,-in-accordance-with-paragraph-(b)(3)(ii)-of-this-section,-shall-be-deemed-to-satisfy-this-requirement.]

[(ii)---Isolation-period.--Following-the-containment-period,-the-geologic-setting,-in-conjunction-with-the-engineered-system-as-long-as-that-system-is-expected-to-function,-and-alone-thereafter,-shall-be-capable-of-isolating-radioactive-waste-so-that-transport-of-radionuclides-to-the-accessible-environment-shall-be-in-amounts-and-concentrations-that-conform-to-such-generally-applicable-environmental-standards-as-may-have-been-established-by-the-Environmental-Protection-Agency.--For-the-purpose-of-this-paragraph,-the-evaluation-of-the-site-shall-be-based-upon-the-assumption-that-those-processes-operating-on-the-site-are-those-which-have-been-operating-on-it-during-the-Quaternary-Period,-with-perturbations-caused-by-the-presence-of-emplaced-radioactive-wastes-superimposed-thereon.-]

[§60.112--Required-characteristics-of-the-geologic-setting.

(a)--The-geologic-setting-shall-have-exhibited-structural-and-tectonic-stability-since-the-start-of-the-Quaternary-Period.

(b)--The-geologic-setting-shall-have-exhibited-hydrogeologic,-geochemical,-and-geomorphic-stability-since-the-start-of-the-Quaternary-Period.]

[(c)] (2) Geologic setting. The geologic repository shall be located so that pre-waste-emplacement groundwater travel time[s-through-the-far-field] along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment [are] shall be at least

1,000 years or such other travel time as may be approved or specified by the Commission.

(b) 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. Among the factors that the Commission may take into account are--

(1) Any generally applicable environmental standard for radioactivity established by the Environmental Protection Agency;

(2) The age and nature of the waste, and the design of the underground facility, particularly as these factors bear upon the time during which the thermal pulse is dominated by the decay heat from the fission products;

(3) The geochemical characteristics of the host rock, surrounding strata and groundwater; and

(4) Particular sources of uncertainty in predicting the performance of the geologic repository.

(c) Additional requirements may be found to be necessary to satisfy the overall system performance objective as it relates to unanticipated processes and events.

LAND OWNERSHIP AND CONTROL [OF-THE-GEOLOGIC-REPOSITORY-OPERATIONS-AREA-]

§ 60.121 Requirements for ownership and control of interests in land. [the-geologic-repository-operations-area.]

(a) Ownership of land. [the-geologic-repository-operations-area.]

(1) Both the geologic repository operations area and the controlled area shall be located in and on lands that are either acquired lands under

the jurisdiction and control of DOE, or lands permanently withdrawn and reserved for its use.

(2) These lands shall be held free and clear of all encumbrances, if significant, such as: (i) [(1)] rights arising under the general mining laws; (ii)[(2)] easements for right-of-way; and (iii)[(3)] all other rights arising under lease, rights of entry, deed, patent, mortgage, appropriation, prescription, or otherwise.

(b) [Establishment-of] Additional controls.

Appropriate controls shall be established outside of the [geologic repository-operations] controlled area. DOE shall exercise any jurisdiction and control over surface and subsurface estates necessary to prevent adverse human actions that could significantly reduce the geologic repository's [site-or-engineered-system's] ability to achieve isolation. The rights of DOE may take the form of appropriate possessory interests, servitudes, or withdrawals from location or patent under the general mining laws.

(c) Water rights.

(1) DOE shall also have obtained such water rights as may be needed to accomplish the purpose of the geologic repository operations area.

(2) Water rights are included in the additional controls to be established under paragraph (b) of this section.

[ADDITIONAL-REQUIREMENTS-FOR-THE-GEOLOGIC-SETTING]

SITING CRITERIA

§ 60.122 Siting criteria [Favorable-conditions.]

(a)(1) [Each-of-the-following-conditions-may-contribute-to-the ability-of-the-geologic-setting-to-meet-the-performance-objectives relating-to-isolation-of-the-waste.] [In-addition-to-meeting-the mandatory-requirements-of-§-60.112,-a] A geologic setting shall exhibit an appropriate combination of [these] the conditions specified in paragraph (b) so that, together with the engineered barrier system, the favorable conditions present are sufficient to provide reasonable assurance that [such] the performance objectives relating to isolation of the waste will be met.

(2) If any of the potentially adverse conditions specified in paragraph (c) of this section is present, it may compromise the ability of the geologic repository to meet the performance objectives relating to isolation of the waste. In order to show that a potentially adverse condition does not so compromise the performance of the geologic repository, the following must be demonstrated:

[60.124--Assessment-of-potentially-adverse-conditions.

In-order-to-show-that-a-potentially-adverse-condition-or-combination of-conditions-cited-in-§-60.123-does-not-impair-significantly-the-ability of-the-geologic-repository-to-isolate-the-radioactive-waste,-the-following-must-be-demonstrated:]

[(a)](i) The potentially adverse human activity or natural condition has been adequately investigated [characterized], including the extent to which the condition may be present and still be undetected taking into account the degree of resolution achieved by the investigations; and

[(b)](ii) The effect of the potentially adverse human activity or natural condition on the site [geologic-setting] has been adequately evaluated using [conservative] analyses which are [and-assumptions,-and the-evaluation-used-is] sensitive to the potentially adverse human activity or natural condition and assumptions which are not likely to underestimate its effect; and

[(c)(1)](iii)(A) The potentially adverse human activity or natural condition is shown by analysis pursuant to [in] paragraph [b](2)(ii) of this section not to affect significantly the ability of the geologic repository [setting-to-isolate-waste;] to meet the performance objectives relating to isolation of the waste, or

[(c)(2)] (B) The effect of the potentially adverse human activity or natural condition is compensated by the presence of a combination of the favorable characteristics [cited-in-§-60.122;] so that the performance objectives relating to isolation of the waste are met, or

[(c)(3)] (C) The potentially adverse human activity or natural condition can be remedied.

[60.122(a)--The-nature-and-rates-of-tectonic-processes-that-have occurred-since-the-start-of-the-Quaternary-Period-are-such-that;-when projected;-they-would-not-affect-or-would-favorably-affect-the-ability of-the-geologic-repository-to-isolate-the-waste.

(b)--The-nature-and-rates-of-structural-processes-that-have-occurred since-the-start-of-the-Quaternary-Period-are-such-that;-when-projected; they-would-not-affect-or-would-favorably-affect-the-ability-of-the-geologic-repository-to-isolate-the-waste.

(c)--The-nature-and-rates-of-hydrogeological-processes-that-have occurred-since-the-start-of-the-Quaternary-Period-are-such-that;-when projected;-they-would-not-affect-or-would-favorably-affect-the-ability of-the-geologic-repository-to-isolate-the-waste.

~~(d)---The-nature-and-rates-of-geochemical-processes-that-have-occurred-since-the-start-of-the-Quaternary-Period-are-such-that;-when-projected;-they-would-not-affect-or-would-favorably-affect-the-ability-of the-geologic-repository-to-isolate-the-waste.~~

~~(e)--The-nature-and-rates-of-geomorphic-processes-that-have-occurred-since-the-start-of-the-Quaternary-Period-are-such-that;-when-projected;-they-would-not-affect-or-would-favorably-affect-the-ability-of the-geologic-repository-to-isolate-the-waste.~~

~~(f)--A-host-rock-that-provides-the-following-ground-water characteristics--(1)-low-groundwater-content;-(2)-inhibition-of-groundwater-circulation-in-the-host-rock;-(3)-inhibition-of-groundwater-flow between-hydrogeologic-units-or-along-shafts;-drifts;-and-boreholes;-and (4)-groundwater-travel-times;-under-pre-waste-emplacement-conditions; between-the-underground-facility-and-the-accessible-environment-that substantially-exceed-1;000-years.~~]

(b) Favorable conditions.

(1) The nature and rates of tectonic, hydrogeologic, geochemical, and geomorphic processes (or any of such processes) operating within the geologic setting during the Quaternary Period, when projected, would not affect or would favorably affect the ability of the geologic repository to isolate the waste.

(2) For disposal in the saturated zone, hydrogeologic conditions that provide --

(i) A host rock with low horizontal and vertical permeability;

(ii) Downward or dominantly horizontal hydraulic gradient in the host rock and in immediately surrounding hydrologeologic units; and

(iii) Low vertical permeability and low hydraulic potential between the host rock and surrounding hydrogeologic units; or

(iv) Pre-waste emplacement groundwater travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment that substantially exceeds 1,000 years.

(3)[60.122(g)] Geochemical conditions that--(i)[(1)] Promote precipitation or sorption of radionuclides; (ii)[(2)] Inhibit the formation of particulates, colloids, and inorganic and organic complexes that increase the mobility of radionuclides; or [and] (iii)[(3)] Inhibit the transport of radionuclides by particulates, colloids, and complexes.

(4) [60.122(h)] Mineral assemblages that, when subjected to anticipated thermal loading, will remain unaltered or alter to mineral assemblages having equal or increased capacity to inhibit radionuclide migration.

[(6)] (5) [60.122(i)] Conditions that permit the emplacement of waste at a minimum depth of 300 meters from the ground surface. (The ground surface shall be deemed to be the elevation of the lowest point on the surface above the disturbed zone.)

[60.122(j)Any-local-condition-of-the-disturbed-zone-that-contributes to-isolation.]

(6) A low population density within the geologic setting and a controlled area that is remote from population centers.

[60.123] (c) Potentially adverse conditions.

The following conditions are potentially adverse conditions [The presence-of-any-such-conditions-may-compromise-site-suitability-and-will require-careful-analysis-and-such-measures-as-are-necessary-to-compensate-for-them-adequately-pursuant-to-§-60.124.] if they are characteristic of the controlled area or may affect isolation within the controlled area.

(a)-Adverse-conditions-in-the-geologic-setting:]

(1)[60.123(a)(1)] Potential for flooding of the underground facility, whether resulting from the occupancy and modification of floodplains or from the failure of existing or planned man-made surface water impoundments. [that-could-cause-flooding-of-the-geologic-repository operations-area:]

[(2)-Potential;-based-on-existing-geologic-and-hydrologic-conditions;-that-planned-construction-of-large-scale-surface-water-impoundments-may-significantly-affect-the-geologic-repository-through-changes in-the-regional-groundwater-flow-system:]

(2)[(3)] Potential for foreseeable human activity to adversely affect [significantly-the-geologic-repository-through-changes-in-the hydrogeology:--This-activity-includes;-but-is-not-limited-to-planned] the groundwater flow system such as, groundwater withdrawal, extensive irrigation, subsurface injection of fluids, underground pumped storage, [facilities;-or--underground] military activity or construction of large scale surface water impoundments.

[(5)-A-fault-in-the-geologic-setting-that-has-been-active-since-the start-of-the-Quaternary-Period-and-which-is-within-a-distance-of-the disturbed-zone-that-is-less-than-the-smallest-dimension-of-the-fault rupture-surface:].

[(6)--Potential-for-adverse-impacts-on-the-geologic-repository resulting-from-the-occupancy-and-modification-of-floodplains:]

(3)[(7)] Potential for natural phenomena such as landslides, subsidence, or volcanic activity of such a magnitude that large-scale surface water impoundments could be created that could [affect-the-performance-of-the-geologic-repository-through-changes-in] change the regional groundwater flow system and thereby adversely affect the performance of the geologic repository.

(4)[60.123(b)(8)] Structural deformation, such as uplift, subsidence, folding, or faulting, [and-fracturing-during-the-Quaternary-Period] that may adversely affect the regional groundwater flow system.

(5)[60.123(b)(12)] Potential for changes in hydrologic conditions that would [significantly] affect the migration of radionuclides to the accessible environment, such as [including-but-not-limited-to] changes in hydraulic gradient, average interstitial velocity, storage coefficient, hydraulic conductivity, natural recharge, potentiometric levels, and discharge points.

(6)[60.123(a)(8)-Expected-climatic-changes-that-would-have-an adverse-effect-on-the-geologic,-geochemical,-or-hydrologic-characteristics] Potential for changes in hydrologic conditions resulting from reasonably foreseeable climatic changes.

(7)[60.123(b)(14)] Groundwater conditions in the host rock, including chemical composition, [but-not-limited-to] high ionic strength or ranges of Eh-pH, that could [affect] increase the solubility or [and] chemical reactivity of the engineered barrier system[s].

[60.123(b)--Adverse-conditions-in-the-disturbed-zone

For-the-purpose-of-determining-the-presence-of-the-following-conditions-within-the-investigations-should-extend-to-the-greater-of-either its-calculated-extent-or-a-horizontal-distance-of-2-km-from-the-limits of-the-underground-facility,-and-from-the-surface-to-a-depth-pathways for-radionuclide-of-500-meters-below-the-limits-of-the-repository excavation.]

[60.123(b)(6)--The-existence-of-a-fault-that-has-been-active-during the-Quaternary-Period.

(7)--Potential-for-creating-new-pathways-for-radionuclide-migration due-to-presence-of-a-fault-or-fracture-zone-irrespective-of-the-age-of last-movement.]

[60.123(9)-More-frequent-occurrence-of-earthquakes-or-earthquakes-of higher-magnitude-than-is-typical-of-the-area-in-which-the-geologic-setting-is-located.]

(8)[60.123(b)(15)] Geochemical [P] processes that would reduce sorption of radionuclides, result in degradation of the rock strength, or adversely affect the performance of the engineered barrier system.

(9)[60.123(b)(13)] For disposal in the saturated zone, groundwater [C] conditions in the host rock that are not reducing [conditions].

(10)[60.123(b)(5)] Evidence of dissolutioning [of-soluble-rocks.] such as breccia pipes, dissolution cavities, or brine pockets.

(11)[60.123(b)(8)] Structural deformation such as uplift, subsidence, folding, and faulting [and-fracturing] during the Quaternary Period.

(12)[60.123(a)(4)] Earthquakes which have occurred historically that if they were to be repeated could affect the [geologic-repository] site significantly.

(13)[60.123(b)(10)] Indications, based on correlations of earthquakes with tectonic processes and features, that either the frequency of occurrence or magnitude of earthquakes may increase.

(14)[60.123(b)(9)] More frequent occurrence of earthquakes or earthquakes of higher magnitude than is typical of the area in which the geologic setting is located.

(15)[60.123(b)(11)] Evidence of igneous activity since the start of the Quaternary Period.

(16)[60.123(b)(4)] Evidence of extreme erosion during the Quaternary Period.

(17)[60.123(b)(3)] [Resources-that-have-either] The presence of naturally occurring materials, whether identified or undiscovered, within the site, in such form that:

(i) economic extraction is currently feasible or potentially feasible during the foreseeable future; or

(ii) such materials have greater gross value or net value[;-or commercial-potential] than the average for other [representative] areas of similar size that are representative of and located in the geologic setting.

(18)[60.123(b)(1)] Evidence of subsurface mining for resources within the site.

(19)[60.123(b)(2)] Evidence of drilling for any purpose within the site.

(20)[60.123(b)(16)] Rock or groundwater conditions that would require complex engineering measures in the design and construction of the underground facility or in the sealing of boreholes and shafts.

(21)[60.123(b)(17)] Geomechanical properties that do not permit design of [stable] underground openings [during-construction;-waste emplacement;-or-retrieval-operations.] that will remain stable through permanent closure.

DESIGN [AND-CONSTRUCTION-REQUIREMENTS] CRITERIA FOR THE GEOLOGIC REPOSITORY OPERATIONS AREAS

§60.130 Scope of [General] design criteria [requirements] for the geologic repository operations area.

[(a)] Sections [60.130] 60.131 through 60.134 specify minimum [requirements] criteria for the design of[;-and-construction-specifications-for;] the geologic repository operations area. [Requirements-for design-contained-in-§§60.131-through-60.133-must-be-considered-in-conjunction-with-the-requirements-for-construction-in-§60.134.--Sections-60.130 through-60.134-are-not-intended-to-contain-an-exhaustive-list-of] These design [and-construction-requirements] criteria are not intended to be exhaustive, however. Omissions in §§ [60.130] 60.131 through 60.134 do not relieve DOE from [providing] any obligation to provide such safety features in a specific facility needed to achieve the performance objectives. [contained-in-§§-60.111.] All design [and-construction-criteria-] bases must be consistent with the results of site characterization activities.

[(b)-Systems;-structures;-and-components-of-the-geologic-repository operations-area-shall-satisfy-the-following:]

§ 60.131 General design criteria for the geologic repository operations area.

(a)[60.130(b)(1)] Radiological protection.

The geologic respository operations area [structures;-systems;-and components-located-within-restricted-areas] shall be designed to maintain radiation doses, levels, and concentrations of radioactive material in air in [those] restricted areas within the limits specified in Part 20 of this chapter. [These-structures,-systems,-and-components] Design shall [be-designed-to] include--

(1)[(i)] Means to limit concentrations of radioactive material in air;

(2)[(ii)] Means to limit the time required to perform work in the vicinity of radioactive materials, including, as appropriate, designing equipment for ease of repair and replacement and providing adequate space for ease of operation;

(3)[(iii)] Suitable shielding;

(4)[(iv)] Means to monitor and control the dispersal of radioactive contamination;

(5)[(v)] Means to control access to high radiation areas or airborne radioactivity areas; and

(6)[(vi)] A radiation alarm system to warn of significant increases in radiation levels, concentrations of radioactive material in air, and of increased radioactivity released in effluents. The alarm system shall be designed with provisions for calibration and for testing its operability. [redundancy-and-in-situ-testing-capability.]

(b) Structures, systems, and components important to safety.

(1)[60.130(b)(2)] Protection against natural phenomena and environmental conditions.

[(i)-The-structures,-systems,-and-components-important-to-safety shall-be-designed-to-be-compatible-with-anticipated-site-characteristics and-to-accommodate-the-effects-of-environmental-conditions,-so-as-to prevent-interference-with-normal-operation,-maintenance-and-testing during-the-entire-period-of-construction-and-operations.]

[(ii)] The structures, systems, and components important to safety shall be designed so that natural phenomena and environmental conditions anticipated at the [site] geologic repository operations area will not [result-in-any-relevant-time-period-in-failure-to-achieve-the-performance-objectives] interfere with necessary safety functions.

(2) [(3)] Protection against dynamic effects of equipment failure and similar events.

The structures, systems, and components important to safety shall be designed to withstand dynamic effects such as missile impacts that could result from equipment failure[;-such-as-missile-impacts], and similar events and conditions that could lead to loss of their safety functions.

(3) [(4)] Protection against fires and explosions.

(i) The structures, systems, and components important to safety shall be designed to perform their safety functions during and after credible fires or explosions in the geologic repository operations area.

(ii) To the extent practicable, the geologic repository operations area shall be designed to incorporate the use of noncombustible and heat resistant materials.

(iii) The geologic repository operations area shall be designed to include explosion and fire detection alarm systems and appropriate suppression systems with sufficient capacity and capability to reduce the adverse effects of fires and explosions on structures, systems, and components important to safety.

(iv) The geologic repository operations area shall be designed to include means to protect systems, structures, and components important to safety against the adverse effects of either the operation or failure of the fire suppression systems.

(4)[(5)] Emergency capability.

(i) The structures, systems, and components important to safety shall be designed to maintain control of radioactive waste and radioactive effluents, and permit prompt termination of operations and evacuation of personnel during an emergency.

(ii) The geologic repository operations area shall be designed to include onsite facilities and services that ensure a safe and timely response to emergency conditions and that facilitate the use of available offsite services (such as fire, police, medical and ambulance service) that may aid in recovery from emergencies.

(5)[(6)] Utility services.

(i) Each utility service system that is important to safety shall be designed so that essential safety functions can be performed under both normal and [emergency] accident conditions.

(ii) The utility services important to safety shall include redundant systems to the extent necessary to maintain, with adequate capacity, the ability to perform their safety functions.

[(iii)-The-emergency-utility-services-shall-be-designed-to-permit testing-of-their-functional-operability-and-capacity.--This-will-include the-full-operational-sequence-of-each-system-when-transferring-between normal-and-emergency-supply-sources,-as-well-as-the-operation-of associated-safety-systems.]

(iii)[(iv)] Provisions shall be made so that, if there is a loss of the primary electric power source or circuit, reliable and timely [continued] emergency power can be [is] provided to instruments, utility service systems, and operating systems, including alarm systems, important to safety. [This-emergency-power-shall-be-sufficient-to-allow-safe-conditions-to-be-maintained:--All-systems-important-to-safety-shall-be-designed to-permit-them-to-be-maintained-at-all-times-in-a-functional-mode.]

(6)[(7)] Inspection, testing, and maintenance. The structures, systems, and components important to safety shall be designed to permit periodic inspection, testing, and maintenance, as necessary, to ensure their continued functioning and readiness.

(7)[(8)] Criticality control. All systems for processing, transporting, handling, storage, retrieval, emplacement, and isolation of radioactive waste shall be designed to ensure that a nuclear criticality accident is not possible unless at least two unlikely, independent, and concurrent or sequential changes have occurred in the conditions essential to nuclear criticality safety. Each system shall be designed for criticality safety under normal and accident conditions. The calculated effective multiplication factor (k_{eff}) must be sufficiently below unity to show at least a 5% margin, after allowance for the bias in the method of calculation and the uncertainty in the experiments used to validate the method of calculation.

(8)[(9)] Instrumentation and control systems. The design shall include provisions for [I] instrumentation and control systems [shall be-designed] to monitor and control the behavior of engineered systems important to safety over anticipated ranges for normal operation and for accident conditions. [The-systems-shall-be-designed-with-sufficient redundancy-to-ensure-that-adequate-margins-of-safety-are-maintained]

(9)[(10)] Compliance with mining regulations. To the extent that DOE is not subject to the Federal Mine Safety and Health Act of 1977, as to the construction and operation of the geologic repository operations area, the design of the geologic repository operations area shall nevertheless include such provisions for worker protection as may be necessary to provide reasonable assurance that all structures, systems, and components important to safety can perform their intended functions. Any deviation from relevant design requirements in 30 CFR, Chapter I, Subchapters D, E, and N will give rise to a rebuttable presumption that this requirement has not been met.

(10)[60.133(c)] Shaft conveyances used in radioactive waste handling.

[(1)--Shaft-conveyances-used-to-transport-radioactive-materials-shall be-designed-to-satisfy-the-requirements-as-set-forth-in-§-60.130-for systems,-structures,-and-components-important-to-safety.]

(i)[2.] Hoists important to safety shall be designed to preclude cage free fall.

(ii)[3.] Hoists important to safety shall be designed with a reliable cage location system.

(iii)[4.] [Hoist] Loading and unloading systems for hoists important to safety shall be designed with a reliable system of interlocks that will fail safely upon malfunction.

(iv)[5.] Hoists important to safety shall be designed to include two independent indicators to indicate when waste packages are in place [,-grappled,] and ready for transfer.

§ 60.132 [60.131] Additional design [requirements] criteria for surface facilities in the geologic repository operations area.

(a) Facilities for receipt and retrieval of waste. Surface facilities in the geologic repository operations area shall be designed to allow safe handling and storage of wastes at the [site] geologic repository operations area, whether these wastes are on the surface before emplacement or as a result of retrieval from the underground facility. [The-surface-facilities-shall-be-designed-so-as-to-permit inspection,-repair,-and-decontamination-of-such-wastes-and-their containers.--Surface-storage-capacity-is-not-required-for-all-emplaced waste.]

(b) Surface facility ventilation. Surface facility ventilation systems supporting waste transfer, inspection, decontamination, processing, or packaging shall be designed to provide protection against radiation exposures and offsite releases as provided in §60.111(a).

(c) Radiation control and monitoring.

(1) Effluent control. The surface facilities shall be designed to control the release of radioactive materials in effluents during normal [and-emergency] operations so as to meet the performance objectives of § 60.111(a). [The-facilities-shall-be-designed-to-provide-protection against-radiation-exposures-and-offsite-releases-as-provided-in-§60.111.]

(2) Effluent monitoring. The effluent monitoring systems shall be designed to measure the amount and concentration of radionuclides in any effluent with sufficient precision to determine whether releases conform to the design requirement for effluent control. The monitoring systems shall be designed to include alarms that can be periodically tested.

(d) Waste treatment. Radioactive waste treatment facilities shall be designed to process any radioactive wastes generated at the geologic repository operations area into a form suitable to permit safe disposal at the geologic repository operations area or to permit safe transportation and conversion to a form suitable for disposal at an alternative site in accordance with any regulations that are applicable.

(e) Consideration of decommissioning. The surface facility shall be designed to facilitate [decommissioning] decontamination or dismantlement to the same extent as would be required, under other parts of this chapter, with respect to equivalent activities licensed thereunder.

§ 60.133 [†-60.132] Additional subsurface design [requirements] criteria for the underground facility.

(a) General criteria for the underground facility.

[(1)--The-underground-facility-shall-be-designed-so-as-to-perform its-safety-functions-assuming-interactions-among-the-geologic-setting, the-underground-facility,-and-the-waste-package.]

[(2)--The-underground-facility-shall-be-designed-to-provide-for structural-stability,-control-of-groundwater-movement-and-control-of radionuclide-releases,-as-necessary-to-comply-with-the-performance objectives-of-§§60.111.]

(1) [(3)] The orientation, geometry, layout, and depth of the underground facility, and the design of any engineered barriers that are part of the underground facility shall contribute to the [enhance] containment and isolation of radionuclides [to-the-extent-practicable-at the-site].

(2) [(4)] The underground facility shall be designed so that the effects of credible disruptive events during the period of operations, such as [intrusions-of-gas,-or-water,-or] flooding, fires, and explosions, will not spread through the facility.

(b) Flexibility of design. The underground facility shall be designed with sufficient flexibility to allow adjustments where necessary to accommodate specific site conditions identified through in situ monitoring, testing, or excavation.

[(c)--Separation-of-excavation-and-waste-emplacement-(modular-concept): If-concurrent-excavation-and-emplacement-of-wastes-are-planned;-then:

(1)--The-design-shall-provide-for-such-separation-of-activities into-discrete-areas-(modules)-as-may-be-necessary-to-assure-that excavation-does-not-impair-waste-emplacement-or-retrieval-operations.

(2)--Each-module-shall-be-designed-to-permit-insulation-from-other modules-if-an-accident-occurs.]

(c) [(d)] [Design-for] Retrieval of waste. The underground facility shall be designed to [(1)P-] permit retrieval of waste in accordance with the performance objectives of §60.111.

[(2)--Ensure-sufficient-structural-stability-of-openings-and-control of-groundwater-to-permit-the-safe-conduct-of-waste-retrieval-operations; and]

[(3)--Allow-removal-of-any-waste-packages-that-may-be-damaged-or require-inspection-without-compromising-the-ability-of-the-geologic repository-to-meet-the-performance-objectives-(§60.111).]

(d) [60.132(g)] Control of water and gas. [(1)--Water-and-gas control-systems-shall-be-designed-to-be-of-sufficient-capability-and capacity-to-reduce-the-potentially-adverse-effects-of-groundwater intrusion;-service-water-intrusion;-or-gas-inflow-into-the-underground-facility.] The design of the underground facility shall provide for control of water or gas intrusion.

[(2)-Water-and-gas-control-systems-shall-be-designed-to-control-the quantity-of-water-or-gas-flowing-into-or-from-the-underground-facility; monitor-the-composition-of-gases;-and-permit-sampling-of-liquids.

(3)--Systems-shall-be-designed-to-provide-control-of-water-and-gas in-both-waste-emplacement-areas-and-excavation-areas.

(4)--Water-control-systems-shall-be-designed-to-include-storage capability-and-modular-layouts-that-ensure-that-unexpected-inrush-or flooding-can-be-controlled-and-contained.

(5)--If-the-intersection-of-aquifers-or-water-bearing-geologic structures-is-anticipated-during-construction,-the-design-of-the-underground-facility-shall-include-plans-for-cutoff-or-control-of-water-in advance-of-the-excavation.

(6)--If-linings-are-required,-the-contact-between-the-lining-and the-rock-surrounding-subsurface-excavations-shall-be-designed-so-as-to avoid-the-creation-of-any-preferential-pathway-for-groundwater-or radionuclide-migration.]

(e) [Design-of-subsurface] Underground openings.

(1) [Subsurface] Openings in the underground facility shall be designed so that operations can be carried out safely and the retrievability option maintained. [to-maintain-stability-throughout-the-construction and-operation-periods.--If-structural-support-is-required-for-stability, it-shall-be-designed-to-be-compatible-with-long-term-deformation, hydrologic,-geochemical,-and-thermomechanical-characteristics-of-the rock-and-to-allow-subsequent-placement-of-backfill.]

(2)--Structures-required-for-temporary-support-of-zones-of-weak-or highly-fractured-rock-shall-be-designed-so-as-not-to-impair-the-placement-of-permanent-structures-or-the-capability-to-seal-excavated-areas used-for-the-containment-of-wastes.

(2)[(3)] [Subsurface-o]Openings in the underground facility shall be designed to reduce the potential for deleterious rock movement or fracturing of overlying or surrounding rock. [over-the-long-term.--The size,-shape,-orientation,-and-spacing-of-openings-and-the-design-of engineered-support-systems-shall-take-the-following-conditions-into considerations--

(i)--natural-stress-conditions;

(ii)--deformation-characteristics-of-the-host-rock-under-normal conditions-and-thermal-loading;

(iii)--the-kinds-of-weaknesses-or-structural-discontinuities-found-at various-locations-in-the-geologic-repository;

(iv)--equipment-requirements;-and:

(v)--the-ability-to-construct-the-underground-facility-as-designed so-that-stability-of-the-rock-is-enhanced.

(f) Rock excavation. The design of the underground facility shall incorporate excavation methods that will limit the potential for creating a preferential pathway for groundwater or radioactive waste migration to the accessible environment. [damage-to-and-fracturing-of-rock:] (NOTE: The modified text for 60.132(g) Control of water and gas is now found at § 60.133(d)).

(g) [60.132(h)] [Subsurface] Underground facility ventilation. The ventilation system shall be designed to--

(1) Control the transport of radioactive particulates and gases within and releases from the underground [subsurface-] facility in accordance with the performance objectives of [(]§60.111(a)[)].

[(2)-Permit-continuous-occupancy-of-all-excavated-areas-during normal-operations-through-the-time-of-permanent-closure;

(3)--Accommodate-changes-in-operating-conditions-such-as-variations in-temperature-and-humidity-in-the-underground-facility;

(4)--include-redundant-equipment-and-fail-safe-control-systems-as may-be-needed-to]

(2) [a] Assure continued function during [under] normal operations and under accident conditions; and

(3)[(5)] Separate the ventilation of excavation and waste emplacement areas.

(h)[(i)] Engineered barriers.

Engineered barriers shall be designed to assist the geologic setting in meeting the performance objectives for the period following permanent closure.

[(1)--Barriers-shall-be-located-where-shafts-could-allow-access-for groundwater-to-enter-or-leave-the-underground-facility.

(2)--Barriers-shall-create-a-waste-package-environment-which favorably-controls-chemical-reactions-affecting-the-performance-of-the waste-package.

(3)--Backfill-placed-in-the-underground-facility-shall-be-designed as-a-barrier.

(i)--Backfill-placed-in-the-underground-facility-shall-perform-its functions-assuming-anticipated-changes-in-the-geologic-setting.

(ii)-Backfill-placed-in-the-underground-facility-shall-serve the following-functions:

(A)--It-shall-provide-a-barrier-to-groundwater-movement-into-and from-the-underground-facility.

(B)--It-shall-reduce-creep-deformation-of-the-host-rock-that-may adversely-affect-(1)-waste-package-performance-or-(2)-the-local hydrological-system.

(C)--It-shall-reduce-and-control-groundwater-movement-within-the underground-facility.

(B)--It-shall-retard-radionuclide-migration.

(iii)--Backfill-placed-in-the-underground-facility-shall-be-selected to-allow-for-adequate-placement-and-compaction-in-underground-openings.

(j)--Waste-handling-and-emplacement.

(1)--The-systems-used-for-handling,-transporting,-and-emplacing radioactive-wastes-shall-be-designed-to-have-positive,-fail-safe-designs to-protect-workers-and-to-prevent-damage-to-waste-packages.

(2)--The-handling-systems-for-emplacement-and-retrieval-operations shall-be-designed-to-minimize-the-potential-for-operator-error.]

(i) [60.132(k)] [Design-for] Thermal loads. [(1)] The underground facility shall be designed so that the performance objectives will be met taking into account the predicted thermal and thermomechanical response of the host rock, surrounding strata, and groundwater system. [will-not degrade-significantly-the-performance-of-the-repository-or-the-ability of-the-natural-or-engineered-barriers-to-retard-radionuclide-migration.

[(2)-The-design-of-waste-loading-and-waste-spacings-shall-take-into consideration--

(i)--Effects-of-the-design-of-the-underground-facility-on-the thermal-and-thermomechanical-response-of-the-host-rock-and-the-groundwater-system;

(ii)--Features-of-the-host-rock-and-geologic-setting-that-affect-the thermomechanical-response-of-the-underground-facility-and-barriers, including-but-not-limited-to,-behavior-and-deformational-characteristics of-the-host-rock,-the-presence-of-insulating-layers,-aquifers,-faults, orientation-of-bedding-planes,-and-the-presence-of-discontinuities-in the-host-rock,-and (iii)--The-extent-to-which-fracturing-of-the-host-rock-is-influenced by-cycles-of-temperature-increase-and-decrease.]

§ 60.134[60.133] Design of [shafts-and] seals for shafts and boreholes.

(a) General design criterion. [Shaft-design] Seals for [S] shafts and boreholes shall be designed so that they do not become pathways that compromise the geologic repository's ability to meet the performance objectives for the period following permanent closure. [as-not-to-create-a-preferential-pathway-for-migration-of-groundwater and-so-as-not-to-increase-the-potential-for-migration-through-existing pathways.]

(b) Selection of materials and placement methods. Materials and placement methods for seals shall be selected to reduce, to the extent practicable, (1) the potential for creating a preferential pathway for groundwater or (2) radioactive waste migration through existing pathways.

[60.133(b)--Shaft-and-borehole-seals.

Shaft-and-borehole-seals-shall-be-designed-so-that.

(1)--Shafts-and-boreholes-will-be-sealed-as-soon-as-possible-after they-have-served-their-operational-purpose.

(2)--At-the-time-of-permanent-closure-sealed-shafts-and-boreholes will-inhibit-transport-of-radionuclides-to-at-least-the-same-degree-as the-undisturbed-units-of-rock-through-which-the-shafts-or-boreholes-pass. In-the-case-of-soluble-rocks,-the-borehole-and-shaft-seals-shall-also-be designed-to-prevent-groundwater-circulation-that-would-result-in dissolution.

(3)--Contact-between-shaft-and-borehole-seals-and-the-adjacent-rock does-not-become-a-preferential-pathway-for-water.

(4)--Shaft-and-borehole-seals-can-accommodate-potential-variations of-stress;-temperature;-and-moisture.

(5)--The-materials-used-to-construct-the-seals-are-appropriate-in view-of-the-geochemistry-of-the-rock-and-groundwater-system;-anticipated deformations-of-the-rock;-and-other-in-situ-conditions.

[§60.134--Construction-specifications-for-surface-and-subsurface-facilities.

(a)--General-requirement.--Specifications-for-construction-shall conform-to-the-objectives-and-technical-requirements-of-§§60.130-through 60.133.

(b)--Construction-management-program.--The-construction-specifications-shall-facilitate-the-conduct-of-a-construction-management-program that-will-ensure-that-construction-activities-do-not-adversely-affect the-suitability-of-the-site-to-isolate-the-waste-or-jeopardize-the-isolation-capabilities-of-the-underground-facility;-boreholes;-shaft;-and seals;-and-that-the-underground-facility-is-constructed-as-designed.

(NOTE: What was 60.134(c) is now found in modified form at § 60.72.)

(d)--[60.134(d)]--Rock-excavation.--The-methods-used-for-excavation shall-be-selected-to-reduce-to-the-extent-practicable-the-potential-to create-a-preferential-pathway-for-groundwater-or-radioactive-waste-migration-or-increase-migration-through-existing-pathways.

(e)--Control-of-explosives.--If-explosives-are-used;-the-provisions of-30-CFR-57.6-(Explosives)-issued-by-the-Mine-Safety-and-Health-Administration;-Department-of-Labor;-shall-be-met;-as-minimum-safety-requirements-for-storage;-use-and-transport-at-the-geologic-repository-operations-area.

(f)--Water-control.--The-construction-specifications-shall-provide that-water-encountered-in-excavations-shall-be-removed-to-the-surface and-controlled-in-accordance-with-design-requirements-for-radiation-control-and-monitoring-(§60.131(c)).

(g)--Waste-handling-and-emplacement.--The-construction-specifications shall-provide-for-demonstration-of-the-effectiveness-of-handling-equipment and-systems-for-emplacement-and-retrieval-operations,-under-operating conditions.].

DESIGN CRITERIA FOR THE WASTE PACKAGE [REQUIREMENTS]

§ 60.135 [Requirements] Criteria for the waste package and its components.

(a) [General-requirements-of-design] High-level-waste package design in general.

[The-design-of-the-waste-package-shall-include-the-following elements.

(1) [Effect-of-the-site-on-the-waste-package.--The-waste] [p] Packages for HLW shall be designed so that the in situ chemical, physical, and nuclear properties of the waste package and its interactions with the emplacement environment do not compromise the function of the waste packages or the performance of the underground facility or the geologic setting.

(2) The design shall include but not be limited to consideration of the following factors: solubility, oxidation/reduction reactions, corrosion, hydriding, gas generation, thermal effects, mechanical strength, mechanical stress, radiolysis, radiation damage, radionuclide retardation, leaching, fire and explosion hazards, thermal loads, and synergistic interactions.

[(2)--Effect-of-the-waste-package-on-the-underground-facility-and the-natural-barriers-of-the-geologic-setting.--The-waste-package-shall-be designed-so-that-the-in-situ-chemical;-physical;-and-nuclear-properties of-the-waste-package-and-its-interactions-with-the-emplacement-environment-do-not-compromise-the-performance-of-the-underground-facility-or-the geologic-setting.--The-design-shall-include-but-not-be-limited-to-consideration-of-the-following-factors:--solubility;-oxidation/reduction reactions;-corrosion;-hydriding;-gas-generation;-thermal-effects;-mechanical-strength;-mechanical-stress;-radiolysis;-radiation-damage;-radionuclide-retardation;-leaching;-fire-and-explosion-hazards;-thermal-loads; and-synergistic-interactions.]

(b) [(c)] Specific criteria for HLW package design.

[The-HLW-waste-package-design-shall-meet-the-following-requirements:]

(1) Explosive, pyrophoric, and chemically reactive materials. The waste package shall not contain explosive or pyrophoric materials or chemically reactive materials in an amount that could [interfere-with operations-in] compromise the ability of the underground facility [or compromise] to contribute to waste isolation or the ability of the geologic repository to satisfy the performance objectives.

(2) Free liquids. The waste package shall not contain free liquids in an amount that could compromise the ability [impair-the-structural integrity] of the waste packages [components] to achieve the performance objectives relating to containment of HLW (because of chemical interactions or formation of pressurized vapor) or result in spillage and spread of contamination in the event of waste package perforation during the period through permanent closure.

(3) Handling. Waste packages shall be designed to maintain waste containment during transportation, emplacement, and retrieval.

(4) Unique identification. A label or other means of identification shall be provided for each waste package. The identification shall not impair the integrity of the waste package and shall be applied in such a way that the information shall be legible at least to the end of the [retrievable-storage] period of retrievability. Each waste package identification shall be consistent with the waste package's permanent written records.

(c)[60.135(b)] Waste form [requirements] criteria for HLW.

High-level [R]radioactive waste that is emplaced in the underground facility shall be designed to meet the following [requirements] criteria:

(1) Solidification. All such radioactive wastes shall be in solid form and placed in sealed containers.

(2) Consolidation. Particulate waste forms shall be [have-been] consolidated (for example, by incorporation into an encapsulating matrix) to limit the availability and generation of particulates.

(3) Combustibles. All combustible radioactive wastes shall be [must-have-been] reduced to a noncombustible form unless it can be demonstrated that a fire involving [a-single] the waste packages containing combustibles will not [neither] compromise the integrity of other waste packages, [nor] adversely affect any [safety-related] structures, systems, or components important to safety, or compromise the ability of the underground facility to contribute to waste isolation.

(d) Design criteria for other radioactive wastes.

Design criteria for waste types other than HLW will be addressed on an individual basis if and when they are proposed for disposal in a geologic repository.

PERFORMANCE CONFIRMATION REQUIREMENTS

§ 60.137 General requirements for performance confirmation.

The geologic repository operations area shall be designed so as to permit implementation of a performance confirmation program that meets the requirements of Subpart F of this part.

SUBPART F - PERFORMANCE CONFIRMATION PROGRAM

§ 60.140 General requirements.

(a) The performance confirmation program shall provide data which indicates, where practicable [ascertain] whether--

(1) Actual subsurface conditions encountered and changes in those conditions during construction and waste emplacement operations are within the limits assumed in the licensing review; and

(2) Natural and engineered systems and components required for repository operation, or which are designed or assumed to operate as barriers after permanent closure, are functioning as intended and anticipated.

(b) The program shall have been started during site characterization and it will continue until permanent closure.

(c) The program [will] shall include in situ monitoring, laboratory and field testing, and in situ experiments, as may be appropriate to accomplish the objective as stated above.

(d) The [confirmation] program shall be implemented so that:

(1) It does not adversely affect the ability of the natural and engineered elements of the geologic repository to meet the performance objectives.

(2) It provides baseline information and analysis of that information on those parameters and natural processes pertaining to the geologic setting that may be changed by site characterization, construction, and operational activities.

(3) It monitors and analyzes changes from the baseline condition of parameters that could affect the performance of a geologic repository.

(4) It provides an established plan for feedback and analysis of data, and implementation of appropriate action.

§ 60.141 Confirmation of geotechnical and design parameters.

(a) During repository construction and operation, a continuing program of surveillance, measurement, testing, and geologic mapping shall be conducted to ensure that geotechnical and design parameters are confirmed and to ensure that appropriate action is taken to inform the Commission of changes needed in design to accommodate actual field conditions encountered.

(b) Subsurface conditions shall be monitored and evaluated against design assumptions.

(c) As a minimum, measurements shall be made of rock deformations and displacement, changes in rock stress and strain, rate and location of water inflow into subsurface areas, changes in groundwater conditions, rock pore water pressures including those along fractures and joints, and the thermal and thermomechanical response of the rock mass as a result of development and operations of the geologic repository.

(d) These measurements and observations shall be compared with the original design bases and assumptions. If significant differences exist between the measurements and observations and the original design bases and assumptions, the need for modifications to the design or in con- struction methods shall be determined and these differences and the recommended changes reported to the Commission.

(e) In situ monitoring of the thermomechanical response of the underground facility shall be conducted until permanent closure to ensure that the performance of the natural and engineering features are within design limits.

§ 60.142 Design testing.

(a) During the early or developmental stages of construction, a program for in situ testing of such features as borehole and shaft seals, backfill, and the thermal interaction effects of the waste packages, backfill, rock, and groundwater shall be conducted.

(b) The testing shall be initiated as early as is practicable.

(c) A backfill test section shall be constructed to test the effectiveness of backfill placement and compaction procedures against design requirements before permanent backfill placement is begun.

(d) Test sections shall be established to test the effectiveness of borehole and shaft seals before full-scale operation proceeds to seal boreholes and shafts.

§ 60.143 Monitoring and testing waste packages.

(a) A program shall be established at the geologic repository operations area for monitoring the condition of the waste packages. Waste [P] packages chosen for the program shall be representative of those to be emplaced in the [repository.] underground facility.

(b) Consistent with safe operation [of] at the geologic repository operations area, the environment of the waste packages selected for the waste package monitoring program shall be representative of the [emplaced] environment in which the wastes are to be emplaced.

(c) The waste package monitoring program shall include laboratory experiments which focus on the internal condition of the waste packages. To the extent practical, the environment experienced by the emplaced waste packages within the [repository] underground facility during the waste package monitoring program shall be duplicated in the laboratory experiments.

(d) The waste package monitoring program shall continue as long as practical up to the time of permanent closure.

SUBPART G - QUALITY ASSURANCE

§ 60.150 Scope.

[(a)] As used in this part, "quality assurance" comprises all those planned and systematic actions necessary to provide adequate confidence that the geologic repository and its subsystems or components will perform satisfactorily in service. [b] Quality assurance includes quality control, which comprises those quality assurance actions related to the physical characteristics of a material, structure, component, or system which provide a means to control the quality of the material, structure, component, or system to predetermined requirements. [is-a-multi-disciplinary-system-of-management-controls-which-address-safety;-reliability;-maintainability;-performance;-and-other-technical-disciplines.]

§ 60.151 Applicability.

The quality assurance program applies to all systems, structures and components important to safety, to design and characterization of barriers important to waste isolation, and to activities related thereto. [which would-prevent-or-mitigate-events-that-could-cause-an-undue-risk-to-the health-and-safety-of-the-public.] These activities include: site characterization, facility and equipment construction, facility operation, [exploring,-selecting,-designing,-fabricating,-purchasing,-handling, storing,-cleaning,-erecting,-installing,-emplacing,-inspecting,-testing operating,-maintaining,-monitoring,-repairing,-modifying,-and decommissioning] performance confirmation, permanent closure, and decontamination and dismantling of surface facilities.

§ 60.152 Implementation.

DOE shall implement a quality assurance program based on the criteria of Appendix B of 10 CFR Part 50 as applicable, and appropriately supplemented by additional criteria as required by § 60.151.

[§-60.153--Quality-assurance-for-performance-confirmation.

The-quality-assurance-program-shall-include-the-program-of-tests, experiments-and-analyses-essential-to-achieving-adequate-confidence that-the-emplaced-wastes-will-remain-isolated-from-the-accessible environment.]

SUBPART H - TRAINING AND CERTIFICATION OF PERSONNEL

§ 60.160 General requirements.

Operations of systems and components that have been identified as important to safety in the Safety Analysis Report and in the license shall be performed only by trained and certified personnel or by personnel under the direct visual supervision of an individual with training and certification in such operation. Supervisory personnel who direct operations that are important to safety must also be certified in such operations.

§ 60.161 Training and certification program.

[The] DOE shall establish a program for training, proficiency testing, certification and requalification of operating and supervisory personnel.

§ 60.162 Physical requirements.

The physical condition and the general health of personnel certified for operations that are important to safety shall not be such as might cause operational errors that could endanger the public health and safety. Any condition which might cause impaired judgment or motor coordination must be considered in the selection of personnel for activities that are important to safety. These conditions need not categorically disqualify a person, so long as appropriate provisions are made to accommodate such [defect] conditions.

SUBPART I - EMERGENCY PLANNING CRITERIA

[RESERVED]

Dated at Washington, D.C. this ______________ day of _____, 1983.

For the U.S. Nuclear Regulatory Commission.

Samuel J. Chilk
Secretary of the Commission

ENCLOSURE D