EARLY EVALUATION OF THE SUITABILITY OF THE POTENTIAL REPOSITORY SITE AT YUCCA MOUNTAIN, NEVADA

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ABSTRACT

The overall process to be followed in siting and licensing a geologic repository was established in the Nuclear Waste Policy Act of 1982, (1) and the amendment to this Act in 1987. (2) The siting process was set forth in the U.S. Department of Energy's (DOE) General Siting Guidelines at Title 10, Part 960 of the Code of Federal Regulations (10 CFR Part 960). (3,4) The Siting Guidelines establish criteria for selecting and evaluating the suitability of potential repository sites. The siting process involves characterization of the site and development and evaluation of repository and waste package designs to support site suitability evaluations. If the DOE determines that the site is suitable, a license application would then be prepared and submitted to the U.S. Nuclear Regulatory commission.

A preliminary site suitability evaluation was completed as part of the site selection process, and its findings are reported in the Environmental Assessment (EA) (DOE, 1986). (5) The DOE requested that a second site suitability evaluation be conducted early in the site characterization phase for the Yucca Mountain site. The purpose of the evaluation was to determine if there is evidence of features or conditions that would render the Yucca Mountain site unsuitable for repository development.

To ensure that the conclusions of the evaluation were technically sound and logically consistent, the report of the Early Site Suitability Evaluation (ESSE) (6) underwent two formal reviews. The first review was performed by technical personnel within the Yucca Mountain Site Characterization Project who were not involved in the evaluation. The second review was conducted by a panel of experts (university faculty members and private consultants) who had minimal previous involvement with the geologic repository program. The report was then revised based on the comments and recommendations received from reviewers, and these revisions were subsequently reviewed and accepted by the reviewers. The comments of the outside peer review and the associated responses are available in a companion document to the final ESSE report. (7)

The conclusion of the evaluation is that the presently available evidence continues to support the findings of the EA that the site is suitable for site characterization. This evaluation, however, found that additional information is needed in specific areas before a final recommendation can be made regarding the suitability of the site for repository development.

OVERVIEW OF DOE GENERAL SITING GUIDELINES

This evaluation was based on the DOE's Siting Guidelines, which establish criteria to be considered when judging the suitability or unsuitability of sites for site characterization or repository development. The guidelines form a multilayered hierarchy, as depicted in Fig. 1. The first level of the hierarchy consists of two categories:

- Postclosure guidelines, which relate to the ability of the site to contain and isolate wastes after the repository is permanently closed
- Preclosure guidelines, which relate to characteristics that could affect the public, the environment, or workers during siting, construction, and operation of the repository before closure.

There is only one postclosure guideline group, whereas the preclosure guidelines are grouped in decreasing order of importance for repository siting as follows:

1. Preclosure radiological safety,
2. Environmental quality, socioeconomic impacts, and transportation,
3. Ease and cost of siting, construction, operation, and closure.

Each postclosure and preclosure guideline is divided into system and technical guidelines. System guidelines address the expected performance of the total repository system with respect to the topic of the guideline. Each system guideline includes a set of technical guidelines that concern those specific features and conditions of the site that could affect repository performance.

The technical guidelines are subdivided into qualifying and disqualifying conditions. Although each technical guideline specifies at least one qualifying condition, not all technical guidelines identify disqualifying conditions. For a site to be considered suitable for repository development, it must satisfy

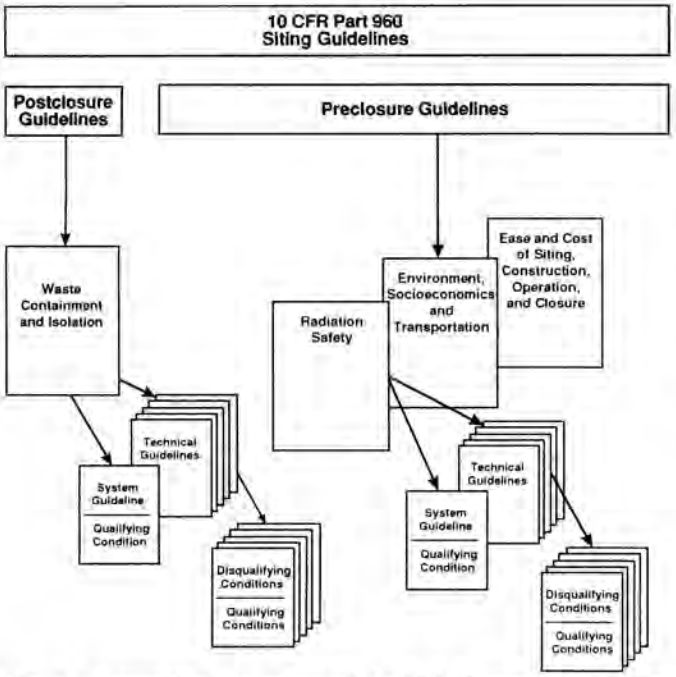

Fig. 1. Hierarchical structure of the U.S. Department of Energy siting guidelines, 10 CFR Part 960.

all of the qualifying conditions and no disqualifying conditions can be present.

EVALUATION

The site suitability evaluation described in this report was based on the structure of the Siting Guidelines. The evaluations began at the lowest level of the guideline hierarchy. Using presently available site information and data, the site was evaluated against each qualifying and disqualifying condition and conclusions were developed for each technical guideline. The conclusions were then integrated to form a conclusion for each system guideline and, finally, combined to develop an overall conclusion for the site.

In accordance with the Siting Guidelines, conclusions about the site can be either that current information supports an unsuitability finding or that current information supports a suitability finding. An unsuitability finding means that 1) a disqualifying condition is present, or 2) a qualifying condition is not present. A suitability finding means that 1) a disqualifying condition is not present, or 2) a qualifying condition is present.

The Siting Guidelines specify two levels of suitability findings, depending on the likelihood that new information could change current conclusions about the site. These levels are designated "lower-level" and "higher-level" suitability findings in the report and are defined as follows:

> Lower-Level Suitability Finding - A lower-level suitability finding can be supported when 1) a disqualifying condition does not appear to be present, but additional information could change the conclusion; or 2) a qualifying condition appears to be present, but additional information could change the conclusion, and thus, the site could subsequently be found to be unsuitable.

Higher-Level Suitability Finding - A higher-level suitability finding can be supported when 1) a disqualifying condition is not present and additional information is unlikely to change the conclusion; or 2) a qualifying condition is present and additional information is unlikely to change the conclusion. This finding would be supported if there is high confidence in the conclusion based on current information.

A higher-level suitability finding for a particular disqualifying or qualifying condition does not necessarily mean that all remaining uncertainties regarding the condition have been resolved. Rather, a higher-level suitability finding means that gaining additional information to resolve the remaining uncertainties is unlikely to change the present conclusion about the suitability of the site.

The terms "likely" and "unlikely" are used in the DOE Siting Guidelines in a qualitative sense in relation to making lower-level and higher-level suitability findings. Consequently, an integral part of the deliberative process used to achieve consensus was to develop appropriate meanings for these terms in the context of each qualifying and disqualifying condition. "Likely" was generally interpreted in the quantitative sense of probability or likelihood. The likelihood that a condition would be present at the site was estimated, and, additionally, the likelihood necessary to support the suitability findings specified by 10 CFR Part 960. Team members also factored in their opinions on the relative importance of the particular condition in relation to site performance. Thus, each judgment considered the nature of the condition, the likelihood of its being present, and the confidence required in order to reach a suitability finding. The individual judgments were then consolidated into a consensus position.

For purposes of this evaluation, if each team member judged, at a minimum, that current information does not indicate that the site is unsuitable, then the consensus position was that at least a lower-level suitability finding could be supported. If, in addition, each team member judged that future information will be unlikely to change the current conclusion regarding site suitability, then a higher-level suitability finding could be supported. If, on the other hand, a single team member favored a lower-level finding, then only a lower-level finding could be supported. This method of reaching consensus ensured that higher-level suitability findings could be supported only by unanimous agreement. These consensus positions about whether available evidence was sufficient to support a particular level of finding for each disqualifying and qualifying condition and for each system and technical guideline were provided to the DOE for their consideration.

SUMMARY OF EVALUATION RESULTS

Considerable data and analyses have become available since the EA for the Yucca Mountain site was issued in 1986. New information has been obtained from surface-based studies, ongoing monitoring activities, and laboratory studies, as well as from reanalysis of data gathered before the EA using new analysis techniques. The consensus of the team members is that the new information corroborates the findings of the EA that the site is suitable for characterization. In some cases, the evidence supports stronger findings regarding suitability for repository development. The consensus findings for each of the guidelines are summarized in Tables I-IV.

A review of the four tables shows that 13 of 17 disqualifying conditions are not present and new information is unlikely to change these conclusions. As described previously, this conclusion is referred to as a higher-level suitability finding. The remaining four disqualifying conditions are considered

not likely to be present, but further information is needed, which constitutes a lower-level suitability finding. These conclusions were not challenged by the peer reviewers.

For the qualifying conditions, the final report concludes that 13 of 32 are present and new information is unlikely to change this conclusion (higher-level suitability finding). Prior to the peer review, the team conducting this evaluation concluded that three additional qualifying conditions (a total of 16 of 32) could be supported at the higher-level of suitability. However, issues raised by the peer reviewers lead the team to revise the conclusions to reflect a more conservative philosophy. The conclusions that were questioned by the peer review were those that relied on preliminary assumptions about expected radiological releases during normal and accidental operations, and those pertaining to underground rock properties, which will be confirmed during excavation of the Exploratory Study Facilities.

A review of Tables I through IV shows that the primary areas where additional information is needed to determine if higher-level suitability conclusions can be supported for the Yucca Mountain Site are: effects of climate change over the next 10,000 years; effects of tectonic disturbance over the next 10,000 years; source term for gaseous radionuclide releases; potential for and consequences of fast flow paths; potential for natural resources to attract human interference; potential for unacceptable environmental quality, socioeconomic and transportation-related impacts; adequacy of vertical and lateral extent of potential host rock; and, the consequences of seismic activity at the site.

REFERENCES

1. NWPA (Nuclear Waste Policy Act), 1983. "Nuclear Waste Policy Act of 1982," Public Law 97-425, 42 USC 10101-10226, Washington, D.C.
2. NWPAA (Nuclear Waste Policy Act Amendments), 1987. Amendments to the Nuclear Waste Policy Act of 1982 - Public Law 100-203 - December 22, 1987, 100th Congress, Title V, pp 236-266, Washington, DC.
3. 10 CFR Part 960 (Code of Federal Regulations), 1984. Title 10, "Energy," Part 960, "General Guidelines for the Recommendation of Sites for Nuclear Waste Repositories;

TABLE I

Conclusions of Early Site Suitability Evaluation: Postclosure Guidelines

DOE Siting Guideline	Conclusion
Postclosure system: EPA & NRC standards can be met	*Condition is likely to be present
Geohydrology	
QC: Compatible with waste containment & isolation	*Condition is likely to be present
DC: < 1000 year ground-water travel time	*Condition is not likely to be present
Geochemistry	
QC: Compatible with waste containment and isolation	* Condition is likely to be present
Rock Characteristics	
QC: Accommodate thermal, chemical, mechanical stresses	*Condition is likely to be present
Climate Changes	
QC: No unacceptable releases due to climate change	*Condition is likely to be present
Erosion	
QC: No unacceptable releases due to erosion DC: Burial cannot be >200m	Condition present: new information unlikely to change conclusion Condition not present: new information unlikely to change conclusion
Dissolution	
QC: No unacceptable releases due to dissolution DC: Loss of isolation due to dissolution expected	Condition present: new information unlikely to change conclusion Condition not present: new information unlikely to change conclusion
Tectonics	
QC: No unacceptable releases due to tectonics	*Condition is likely to be present
DC: Fault movement expected to cause loss of waste isolation	Condition not present: new information unlikely to change conclusion
Human Interference: Natural Resources	
QC: Interference due to resources will not lead to unacceptable releases	*Condition is likely to be present
DC1: Significant pathways exist from previous mining	Condition not present: new information unlikely to change conclusion
DC2: Mining activities expected to lead to loss of waste isolation	Condition not present: new information unlikely to change conclusion
Human Interference: Site Ownership and Control	
QC: DOE can obtain land ownership and rights	Condition present: new information unlikely to change conclusion

* Higher-level finding not recommended

Final Siting Guidelines," 49 FR 47714, Vol. 49, No. 236, December 6, 1984, pp. 47714-47769.

4. 10 CFR Part 960 (Code of Federal Regulations), 1987. Title 10, "Energy," Part 960, "General Guidelines for the Recommendation of Sites for Nuclear Waste Repositories," U.S. Government Printing Office, Washington, D.C., pp. 518-551.
5. DOE (U.S. Department of Energy), 1986. Final Environmental Assessment: Yucca Mountain Site, Nevada Research and Development Area, Nevada, 3 volumes, DOE/RW-0073, Office of Civilian Radioactive Waste Management, Washington, DC.
6. J.L. YOUNKER, et al., "Report of Early Site Suitability Evaluation of the Potential Repository Site at Yucca Mountain, Nevada," SAIC-91/8000, Technical & Management Support Services, Science Applications International Corporation (January 1992).
7. J.L. YOUNKER, et al., "Report of the Peer Review Panel on the Early Site Suitability Evaluation of the Potential Repository Site at Yucca Mountain, Nevada," SAIC-91-8001, Technical & Management Support Services, Science Applications International Corporation (January 1992).

TABLE II
Conclusions of Early Site Suitability Evaluation - Preclosure Guidelines: Radiological Safety

DOE Siting Guideline	Conclusion
System: Radiological safety standards can be met	*Condition is likely to be present
Population Density	
QC1: Doses to highly populated areas meet limits	Condition present: new information unlikely to change conclusion
QC2: Doses to public in unrestricted areas meet limits	Condition present: new information unlikely to change conclusion
DC1: Population density too high	Condition not present: new information unlikely to change conclusion
DC2: Adjacent area with > 1,000 population	Condition not present: new information unlikely to change conclusion
DC3: DOE cannot develop emergency preparedness program	Condition not present: new information unlikely to change conclusion
Site Ownership and Control	
QC: DOE can obtain land ownership and rights	Condition present: new information unlikely to change conclusion
Meteorology	
QC: Conditions will not lead to unacceptable release	Condition present: new information unlikely to change conclusion
Offsite Installations and Operations	
QC: Offsite facilities will not lead to unacceptable releases	*Condition is likely to be present
DC: Irreconcilable conflicts expected with atomic energy defense activities	Condition not present: new information unlikely to change conclusion

* Higher-level finding not recommended

TABLE III
Conclusions of Early Site Suitability Evaluation - Preclosure Guidelines: Environment-Socioeconomic Impacts-Transportation

DOE Siting Guideline	Conclusion
System Guideline: Public and environment can be protected	*Condition is likely to be present
Environmental Quality	
QC: Environmental quality adequately protected	*Condition is likely to be present
DC1: Environment cannot be protected and impacts cannot be mitigated	*Condition is not likely to be present
DC2: Facilities located in federally protected areas	Condition not present: new information unlikely to change conclusion
DC3: Irreconcilable conflicts with protected areas expected	*Condition is not likely to be present
Socioeconomic Impacts	
QC: Impacts can be offset by reasonable mitigation or compensation	*Condition is likely to be present
DC: Water quality/quantity expected to be significantly impacted	*Condition is not likely to be present
Transportation	
QC1: No conflicts due to location of access routes	*Condition is likely to be present
QC2: Technology adequate to develop system	*Condition is likely to be present
QC3: Extreme performance standards not required	*Condition is likely to be present
QC4: No unacceptable risks or environmental impacts	*Condition is likely to be present

* Higher-level finding not recommended

TABLE IV
Conclusions of Early Site Suitability Evaluation: Ease and Cost of Siting, Construction, Operation, and Closure

DOE Siting Guideline	Conclusion
System Guideline: Technology available to accommodate site conditions	*Condition is likely to be present
Surface Characteristics	
QC: Technology available for terrain & flood control	Condition present: new information unlikely to change conclusion
Rock Characteristics	
QC1: Adequate rock thickness and lateral extent	*Condition is likely to be present
QC2: Conditions will not cause undue hazards to personnel	Condition present: new information unlikely to change conclusion
QC3: Technology available to accommodate conditions	Condition present: new information unlikely to change conclusion
DC: Significant risk to health and safety expected	Condition not present: new information unlikely to change conclusion
Hydrology	
QC1: Conditions allow repository development	Condition present: new information unlikely to change conclusion
QC2: Liners and seals will function as intended	Condition present: new information unlikely to change conclusion
QC3: Technology available to accommodate hydrology	Condition present: new information unlikely to change conclusion
DC: Technology not available for ground-water conditions expected	Condition not present: new information unlikely to change conclusion
Tectonics	
QC: Technology adequate for expected conditions	*Condition is likely to be present
DC: Technology not available to accommodate expected fault movement or ground motion	Condition not present: new information unlikely to change conclusion

* Higher-level finding not recommended