

ROLE OF SITE-SUITABILITY EVALUATIONS IN THE SITING PROCESS

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ABSTRACT

A methodology has been developed for site-suitability evaluations that is compatible with decisions that must be made in the siting process for radioactive waste disposal facilities. The method specifically addresses decisions about future testing or facility design to address uncertainties in site characteristics. This method was verified in part in an early evaluation of the suitability of the Yucca Mountain site for a geologic high-level waste repository. The method can be generalized to address the full range of conditions that must be considered in the siting process.

INTRODUCTION

Siting decisions associated with radioactive waste disposal facilities involve considerations of a wide variety of complex factors. These factors include (1) the results of technical site-suitability evaluations to determine if the facility will meet its performance objectives; (2) additional site information that must be acquired; (3) possible design alternatives for the facility; (4) costs and time needed to conduct testing, to design and construct the facility, and to operate and close it; (4) the level of information and interaction with regulatory bodies needed to obtain necessary licenses and permits; (5) other requirements that must be met under existing and pending legislation; and (6) necessary interactions with the public, for example under the NEPA process. The considerations are particularly difficult because there are important uncertainties associated with each of the factors that must be taken into account. Those responsible for the siting process must make decisions in the face of uncertainties in site information and in potential processes and events that could affect the facility, in the performance of engineered systems far into the future, in the costs and time needed, in the regulatory and legal environment, and in other matters affecting decisions. As a result there is uncertainty about when to proceed, how much information is sufficient to proceed, and what the consequences are in proceeding prematurely.

Recently the Department of Energy (DOE) initiated an Early Site-Suitability Evaluation (ESSE) of the Yucca Mountain site, the site that is currently the sole candidate for a high-level waste repository. The ESSE was a technical evaluation of the site that focused on whether current information indicates the presence of potentially disqualifying features or conditions at the site and whether site characterization should proceed. The ESSE was not a decision-making process; nevertheless, it considered how siting decisions might be made in order to ensure that the technical evaluations would be consistent with that process. The ESSE explicitly considered the role that uncertainties play in those decisions and structured the evaluation to provide information that could be helpful in addressing many of these uncertainties.

The complete methodology and results of the ESSE technical evaluation are discussed elsewhere (1, 2). In this paper we discuss the general considerations made in the ESSE

regarding the siting process and the methodology that was developed as a consequence of these considerations. In particular, we discuss the ways the technical and other uncertainties can be addressed in making the siting decisions. The ESSE focused on those questions associated with the testing program: whether current information is adequate to answer technical questions about the suitability of the site; whether additional information should be obtained to address outstanding issues; whether testing is capable of providing that information; whether conservative designs can compensate for uncertainties in the site; what the trade-off between testing and design is; and whether additional work is justified in terms of the cost and time needed. This paper is limited to these same considerations. This discussion provides an example of the broad range of considerations that might be made in the siting process. First the general approach to the technical evaluation of a site is discussed. Then the approach to siting decisions, in the context of those considerations addressed in the ESSE, is described.

APPROACH TO SITE-SUITABILITY EVALUATIONS

In general, site-suitability evaluations begin with a set of siting criteria that reflect the purposes of the facility and the geologic factors affecting those purposes. For example, the ESSE focused on DOE's general siting guidelines for a geologic repository specified in the regulations of 10 CFR Part 960 (3). In general, whether established by regulation or by judgement of the facility developer, such criteria are needed to define the hydrologic, tectonic, and other geologic conditions that qualify or disqualify a site for development of a radioactive waste disposal facility. Uncertainties in site characteristics will, in general, affect the ability to determine if the siting criteria are met. As a consequence, a principal focus of the site-suitability evaluations is to analyze the uncertainties in the site information and determine (quantitatively or qualitatively) the probability that the siting criteria are met.

Figure 1 illustrates the role of the uncertainties. This figure shows a possible probability distribution for the occurrence of values for a particular site-suitability parameter and also shows the siting criterion for that factor. If all of the values expected for the system were to lie well above or well below the criterion, then the conclusion about the technical

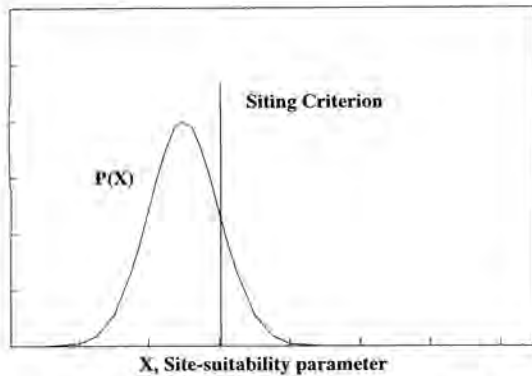


Fig. 1. Effect of uncertainties on site-suitability determination.

suitability of the site with regard to that criterion is straightforward. However, this figure illustrates that uncertainties about site characteristics may result in the possibility of some values occurring above the criterion and some below the criterion. In general there will be a probability that the criterion is met determined from the area under the probability distribution on the "suitability" side of the criterion. This probability is a measure of the level of confidence that the criterion is met. In this case, the site-suitability evaluation must include not only assessment of the site-suitability factors, but analysis of the uncertainties in site characteristics that affect the probability of meeting the siting criteria.

Figure 2 shows how the probability of meeting the siting criteria depends on the information about the site and how this probability can change as additional information is obtained. The figure shows on the left side the probability that results from an evaluation of the information available at early in the siting process. This level of information is labeled "current information" in Fig. 2 and the corresponding probability is labeled "current probability." The figure shows that this probability could change as information changes due to additional work (e.g. additional testing at the site or changes to design of the waste facility to mitigate potentially adverse conditions). The probability changes because we determine with greater accuracy where within the original range of uncertainty site characteristics fall. The probability could also change as we discover new things about the site not considered before. Figure 2 shows that work to provide additional site and design information could increase the probability to a sufficiently high value that the site could be determined to be suitable or decrease it to a low enough value that the site could

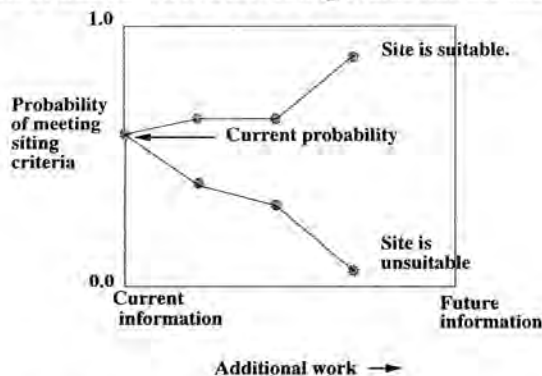


Fig. 2. Conducting site-suitability evaluations.

be determined to be unsuitable. Therefore, there are three possible results of a site-suitability evaluation: (1) an unsuitability finding; (2) a lower-level suitability finding; or (3) a higher-level suitability finding. An unsuitability finding is made if current information indicates that it unlikely that all of the siting criteria are met. A higher-level suitability finding is made if there is confidence that all the siting criteria are met. A lower-level suitability finding is made if it appears that the siting criteria are met, but there are uncertainties that are sufficiently important that future information could indicate a criterion is, in fact, not met.

APPROACH TO SITING DECISIONS

The siting decisions determine, for example, if the site is to be abandoned, recommended for facility development, or subjected to additional investigation. These decisions can be made by comparing the probability of meeting the siting criteria with appropriate "suitability thresholds." Figure 3 illustrates the nature of this comparison. This figure defines three ranges of the probability of meeting the criteria, each corresponding to one of the three different kinds of suitability findings that can be made. These ranges are defined such that, if the probability estimate falls into the lowest region, the site is unsuitable and the decision should be to abandon the site. If the probability estimate falls into the highest region, the site is suitable and the decision should be to recommend the site for facility development. If the probability estimate falls into the middle region, the site appears to be suitable, but confidence is not high enough for a higher-level finding; in this case the siting decision should be to perform additional site characterization or design work to address these uncertainties.

Figure 4 shows how the additional work could affect the siting decision. If the additional work results in the probability of meeting the siting criteria descending below the lower threshold, the site should be abandoned. Likewise, if additional work increases the probability sufficiently to exceed the upper threshold, the site should be recommended for development.

The key to these siting decisions is therefore the choice of the suitability thresholds. These thresholds are established by the decision-makers, and are based upon the various decision options available to them, the relative consequences of those decisions, and the factors they want to take into account in the decision. For example, the lower suitability threshold can be determined by identifying the probability level at which the costs of additional testing of a potentially suitable site or

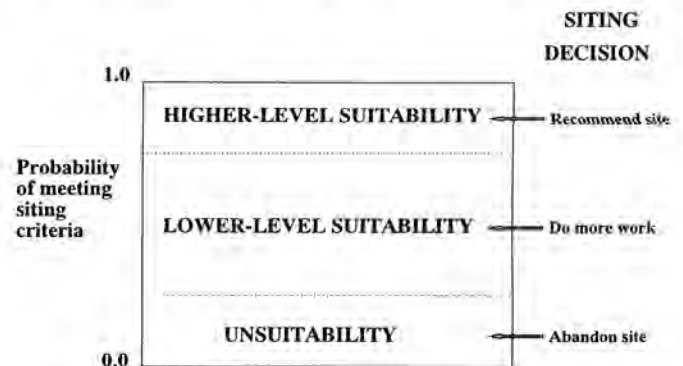


Fig. 3. Using site-suitability findings for siting decisions.

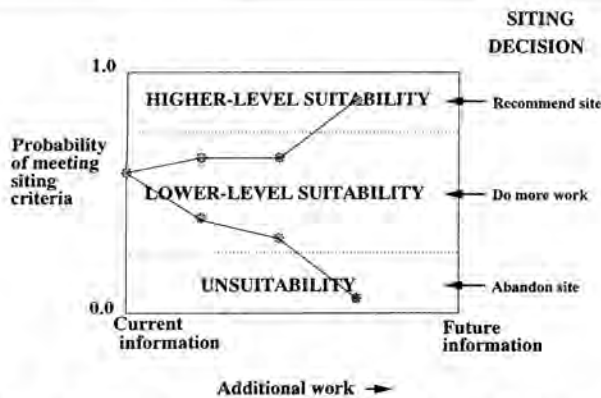


Fig. 4. Role of additional testing or design work in siting decisions.

of utilizing particular engineering options in the design is equal to the benefits of abandoning a potentially unsuitable site. Likewise, the upper suitability threshold can be determined by estimating the probability level at which it is unlikely that additional work will result in the probability moving below the lower suitability threshold. If all the tests that are available are unlikely to reduce existing uncertainties very much, then the upper suitability threshold may not be very far from the lower one. Likewise, if institutional concerns are very important in the siting decision, the decision-maker may be risk-averse and set a much higher threshold than if those concerns were not taken into account. Systematic techniques exist to assist the decision-maker in specifying the factors that are important and to estimate the suitability thresholds explicitly taking them into account. Such decision analysis techniques are well-established and have been successfully applied in areas where, like radioactive waste management, decisions are difficult and subject to a large number of factors internal and external to the program. For example, such techniques were used to evaluate testing priorities for the Yucca Mountain site characterization program (4).

RESULTS AND CONCLUSIONS

The approach described above was considered in setting up the early evaluation of the suitability of the Yucca Mountain site in the ESSE. Suitability thresholds were not established since these are the responsibility of the decision-makers. Nevertheless, it was clear in most cases what the nature of those thresholds was likely to be. For example the siting criteria that were considered, DOE's general siting guidelines, specify that the system performance measures of the applicable regulatory criteria (5) should be met. These criteria specify that a 90 percent probability of meeting the release limits specified in the applicable EPA environmental standards (6) should be obtained and it is likely that the upper suitability threshold established by the DOE decision-makers

for cumulative releases will be consistent with this requirement.

The ESSE focused on whether the current information indicates the likelihood of the presence of disqualifying features or conditions at the Yucca Mountain site, that is on the unsuitability of the site. In general the ESSE made its judgements using a qualitative notion of the lower thresholds; that is, the judgement was based on whether the evaluation concluded the feature or condition was "likely" to be present or not. On this basis it was concluded in the ESSE that the available information supports an overall lower-level suitability finding for the site. The ESSE identified specific areas where higher-level findings can be made now and noted a finite set of critical issues that must be resolved before an overall higher-level suitability finding can be made. The ESSE showed that the method developed can be conducted from a qualitative basis as well as a quantitative basis. Because it is early in the site characterization program, application of the approach to the decision process was fairly primitive. For example, not all factors important to determination of the suitability of the site for repository development were taken into account. Nevertheless, the approach addressed many of those factors and the early evaluation provides a partial verification of the utility of the approach.

REFERENCES

1. YOUNKER, JEAN L, et al., "Report of the Early Site-Suitability Evaluation of the Potential Repository Site at Yucca Mountain, Nevada," SAIC-91/8000, Science Applications International Corporation, Las Vegas, Nevada (1992).
2. YOUNKER, J.L., L.D. RICKERTSEN, and B.R. JUDD, "Early Evaluation of the Suitability of the Yucca Mountain Site," Proceedings of the International High-Level Radioactive Waste Meeting, Las Vegas, Nevada (1992).
3. 10 CFR Part 960, "General Guidelines for the Recommendation of Sites for Nuclear Waste Repositories," Code of Federal Regulations, Title 10, Part 960, Washington, DC (1984).
4. MATTSON, S.R. et al., "Testing Priorities at Yucca Mountain: Recommended Early Tests to Select Potentially Unsuitable Conditions for a Nuclear Waste Repository," YMP/91-25, Yucca Mountain Site Characterization Project, Las Vegas Nevada (1991).
5. 10 CFR Part 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories," Code of Federal Regulations, Title 10, Part 60, Washington, DC (1983).
6. 40 CFR Part 191, "Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Waste," Code of Federal Regulations, Title 40, Part 191, Washington, DC (1985).