

**Perspectives on NRC Staff's Review of a License Application for a
Deep Geologic Repository at Yucca Mountain, U.S.A.
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Background

Yucca Mountain, Nevada was identified by the U.S. Congress in 1987 as the sole candidate site for constructing a deep geologic repository for the nation's spent nuclear fuel and high-level waste. By 2002, the U.S. Department of Energy (DOE) had completed sufficient characterization and analysis of the site to support a required Site Recommendation, which provided DOE perspectives on the safety case. Although formally opposed by the State of Nevada, this Site Recommendation was approved by the U.S. Congress and the President, which authorized DOE to prepare and submit a license application for the repository. In June of 2008, DOE submitted this application (DOE, 2008) to the U.S. Nuclear Regulatory Commission (NRC) for its review and formal adjudication of contested issues during a 3-4 year period. Although subsequent actions by the Administration and Congress have changed the direction for geologic disposal in the U.S., the NRC staff was able to conduct a thorough technical review of the DOE license application and issue technical evaluation reports before the review and hearings were suspended in September 2011. This paper provides the author's perspective on how the NRC prepared for, and conducted, this first-of-a-kind licensing review.

Planning Framework

As mandated in the Nuclear Waste Policy Act of 1982 (Public Law 97-425), NRC had 3-to-4 years to complete its review of the DOE license application, conduct hearings on contested issues of fact and law, and reach a decision on granting or denying a license to construct the Yucca Mountain deep geologic repository. A general framework was apparent in planning for this task:

- The engineering and geologic characteristics of the Yucca Mountain site were not duplicated in other national programs, and innovative science and technology was being used by DOE. Thus, NRC had to establish a high level of staff and contractor expertise, which was free from conflict of interest, in order to conduct a fair and thorough review.
- DOE and other stakeholders had conducted a wide variety of scientific and technical investigations during an approximately 20-year-long site characterization program, and all of this information would need to be available for the review and hearings. Thus, a dedicated information management system would be required.
- A mandated 3-4 year schedule for completion of the review and hearings represented unprecedented constraints on NRC's licensing framework. Interveners had conducted many technical investigations and had indicated that many contentions would be filed for the hearings. Thus, successful completion of all needed activities would require advanced project management skills and detailed planning.
- NRC would use a risk-informed, performance-based regulation to judge the safety of the proposed facility for the next one million years. Thus, implementation of this regulation would require development of unique review plans and guidance to provide a transparent and traceable basis for the ensuing licensing decisions.

Key Preparations for Staff

NRC made use of staff experience in licensing to help prepare for the Yucca Mountain license application review. NRC staff conducted reviews and monitored proceedings of license applications for other nuclear installations. Although regulations for these installations were significantly different from those for a deep geologic repository, participation in these reviews provided several important benefits to staff. These reviews familiarized staff with the levels of information needed to support compliance with different regulatory requirements, and on effective interactions with applicants and interveners. Staff also was able to bring risk-informed perspectives to these reviews, which often were helpful in resolving technical issues. Staff learned how to effectively document the results of their reviews in safety evaluation reports and how to ensure that the basis for their regulatory decisions was clearly communicated.

Many of the staff had the opportunity to participate in developing site-specific regulations for Yucca Mountain (i.e., Title 10 of the US Code of Federal Regulations, Part 63). One important benefit was that staff had to interact collaboratively with the NRC's legal staff in developing regulatory language that was both technically and legally correct. For many staff members, this was the first time they had the opportunity to work extensively with legal counsel and to better understand legal concerns and perspectives that would be important during the review and hearings. Developing regulations also gave staff important perspectives on the types of information that would be needed to demonstrate regulatory compliance, and how to ensure that those information needs were clearly communicated to the applicant and stakeholders.

The Nuclear Waste Policy Act of 1982 (Public Law 97-425) envisioned pre-licensing interactions with DOE. Staff conducted many public meetings with DOE, primarily at or near the Yucca Mountain site, to discuss the ongoing DOE program. Although these meetings focused on the DOE investigations, they also provided a forum to discuss alternative models and data that were developed by the NRC staff and other interested parties. Technical issues discussed during the meetings did not commit any organization to a position during licensing, which facilitated an open exchange of information. As a result of these meetings, staff had a much more complete understanding of the complex information presented in the license application and of alternative information that was available.

Recognizing that sustained technical support was going to be needed throughout the pre-licensing and licensing process, NRC established the Center for Nuclear Waste Regulatory Analyses (CNWRA). Beginning in 1987, CNWRA worked with NRC to develop the independent technical information that would be needed to review the DOE license application. The CNWRA staff primarily conducted laboratory and field investigations in geoscience and engineering disciplines, developed a broad range of numerical process models, and analyzed the significance of different features, events and processes using performance assessment codes. Close collaboration between NRC and CNWRA staffs (herein simply referred to as NRC staff) ensured that appropriate knowledge and skills were developed and shared.

Key Preparations for Processes

NRC staff anticipated that the DOE license application would be complex and supported by a large volume of information that might need to be reviewed. Many staff members would need to participate in concurrent reviews of pre-closure, post-closure, and administrative sections of the application, along with an additional review of the Environmental Impact Statement. For the hearings to be completed within 3-4 years, staff would have approximately 18 months to complete their technical reviews and document the results in Safety Evaluation Reports. A

dedicated project management team was established to organize the staff into appropriate review teams, and develop a work structure that allowed the teams to meet critical milestones and move on to ensuing tasks. The editing, review, concurrence, and publication of the Safety Evaluation Reports also had to be planned carefully to ensure completion within the allotted time. The team devoted several years to developing a computerized project plan with a detailed work breakdown structure, which could adapt to unplanned changes in staff availability or deadlines.

By 1987, NRC recognized that an extraordinary amount of information would likely be available for the Yucca Mountain hearings and that an electronic document management system would be needed (NRC, 1987). Under NRC's regulations for conducting the hearing (i.e., 10 CFR Part 2), all of this information had to be available to all participants in the hearings. Although the design of this document management system evolved significantly over 20 years, the implemented system (called the Licensing Support Network, or LSN) used a centralized search engine that queried indexed databases containing each participant's document collection. The LSN cost about \$16M USD to develop over approximately 5 years, which did not include the considerable amount of resources needed to organize, digitize, and index the documents or develop ancillary support systems (Graser, 2010). Following submittal of the license application, the LSN could access, search, and retrieve more than 84,000,000 pages of images, text, HTML and bibliographic components of documentary material (Graser, 2009).

NRC staff also had to develop a standard review plan that addressed the unique risk-informed, performance-based requirements in Part 63. This review plan had to be developed well before DOE submitted the license application, so that the applicant and other stakeholders would have a clear understanding of the criteria NRC would use to judge regulatory compliance. After receiving considerable stakeholder input on a draft, NRC published the Yucca Mountain Review Plan (YMRP) in 2003. Most importantly, the YMRP (NRC, 2003) had to provide review criteria for all topics that might be relevant to demonstrating pre-closure and post-closure repository safety. This is because NRC staff could not predetermine which topics the applicant would rely on as significant to safety. Nevertheless, NRC staff expected the review to take a risk-informed approach and focus on topics that were significant to safety (e.g., NRC, 2003, Section 2.2.1). Developing the YMRP took more than 3 years and involved significant effort by tens of staff members.

Events After Receipt of License Application

The DOE license application of June 2008 was over 8,000 pages in length and was supported by approximately 3,000,000 pages of additional information. More than 80,000,000 pages of supporting documents, data, and other information were available through the LSN. Interveners submitted 319 contentions by 22 December 2008, which required NRC staff review and input to the legal team for timely response. Nevertheless, the NRC appropriation for conducting the licensing review declined substantially in subsequent fiscal years, which led to significant reductions in staffing, underfunding of infrastructure, and delays in completion of key milestones. DOE also experienced reduced funding in this timeframe, and in March 2010 petitioned the NRC's Atomic Safety and Licensing Board to withdraw its license application. Although the Licensing Board denied the DOE's motion to withdraw the license in June 2010, it suspended the hearings in September 2011. The legal issues surrounding these events are being determined in the U.S. Court of Appeals (Case #11-1271).

In spite of these challenges, NRC staff issued the first of five expected volumes of its Safety Evaluation Report in August 2010 (NRC, 2010). Subsequently, the NRC staff was directed to

document the results of their remaining reviews in technical evaluation reports before the end of September 2011. These reports provide a detailed evaluation of the technical basis used by DOE in its license application, using review methods and acceptance criteria in the YMRP.

Retrospective on Staff Preparations

First and foremost, decades of preparation formed a cadre of dedicated, professional staff who had world-class expertise in their subjects. Coupling that expertise with extensive pre-licensing interactions with the applicant and stakeholders gave the staff an unprecedented knowledge of the technical issues surrounding the DOE's safety case for Yucca Mountain. That knowledge base, and the dedicated efforts of a professional project management team, was critical for staff's resolving all significant technical issues and completing its technical review of the complex DOE license application within 3 years.

One particular challenge that resulted from a long pre-licensing period was that staff needed additional awareness and training on the distinctions between academic or scientific reviews and regulatory reviews. In NRC regulatory reviews for Part 63, for example, the use of risk insights is an acceptable approach to determine that technical uncertainties would not significantly affect the acceptability of a safety analysis. In contrast, a purely scientific review would need to address, and resolve, all relevant sources of uncertainty before a result could be accepted. Both types of reviews must be technically rigorous, and the logic for review conclusions must be transparent. Nevertheless, the review process should allow for resolution of technical uncertainties that do not significantly affect the safety case.

Staff understood that the basis for the safety case must be demonstrated in the information presented by the applicant in license application and in formal responses to staff's questions. Throughout the pre-licensing period, NRC staff conducted a broad range of investigations on important technical issues. The results of these investigations provided an independent perspective on the risk significance of key issues and associated uncertainties, and were valuable in guiding staff's review and probing the applicant's safety case. Nevertheless, attention was needed to ensure that these independent investigations were used to confirm the acceptability of information in the license application and were not substituted as the technical basis for approving or disapproving the safety case.

Close and successful collaboration occurred between NRC's technical and legal staffs during the review and hearings. Staff's technical input often was needed to support NRC responses to various legal issues, and the Safety Evaluation Reports would establish NRC positions on the license application in the hearings. However, the technical focus for legal arguments often had to have a different emphasis and presentation than was used for the technical review. More extensive pre-licensing interaction between the technical and legal staffs would likely have increased the efficiency in communication between the staffs, and likely resulted in a better understanding of how to harmonize the approach for addressing legal and technical issues throughout the review.

Retrospective on Processes

Not surprisingly, differing interpretations occurred amongst the staff on the significance of technical issues that appeared important to safety. Although many of these differences were resolved at the team level, several mechanisms were in place that worked effectively to resolve such technical disagreements. First, NRC had developed a strong safety culture that fostered an environment where alternative views could be expressed and discussed without fear of

retribution. This environment allowed team members to raise concerns about technical issues and discuss those concerns openly with their colleagues and immediate supervisors. Additionally, several Senior Technical Advisors (STAs) were embedded in the program. The STAs served as expert resources for staff and supervisors, and often mediated technical disagreements by probing the different interpretations and building a consensus on issue resolution that was acceptable to all team members. Remaining disagreements were elevated to a Safety Integration Review (SIR) team, which consisted of all supervisors and STAs. Staff presented alternative views to the SIR team, which evaluated the issue and recommended a path forward on resolving the issue. The SIR team often used risk insights in conjunction with technical information to develop a consensus on issue resolution. Most issues were resolved with the SIR team approach, however, discussions with division senior executives was necessary to resolve a few contentious issues. A formal process for resolving any remaining contentious issues was available at NRC, but was not needed for this licensing review.

Project management was a resource-intensive process that required training and dedication comparable to the technical review. Approximately one third of the staff was engaged in project management, as project managers, supervisors, or technical support. In addition to near-daily challenges in adapting to evolving budgets, hearing schedules and deliverable dates, project managers had to issue approximately 600 formal requests to the applicant for additional information and ensure the teams received timely responses to these information needs.

Although the YMRP addressed all topics that might be in the safety case, staff focused the review on topics that were significant to safety. This led to different interpretations over the level of detail that should be presented in the safety evaluation reports, with a view that all topics appearing in the YMRP needed to be addressed, not just the topics that were significant to safety. These differences might have been avoided if there was less specificity in the YMRP on what aspects of specific scenarios or features, events, and processes might need to be reviewed for each possible topic. A relatively generalized approach might have aligned the YMRP more closely with the flexibility given to the applicant in demonstrating compliance with regulatory requirements (i.e., Part 63).

Final Remarks

By the end of September 2011, the NRC staff had issued three Technical Evaluation Reports using a risk-informed, performance-based approach to review the DOE license application for a deep geologic repository at Yucca Mountain, Nevada, U.S.A. These reports augment the Introductory Volume I of the Safety Evaluation Report for the proposed Yucca Mountain repository, which was issued in 2010, and the many reports and documents generated over the NRC's multi-decade high-level-waste program. The review of this first-of-a-kind license application was successful, in large part, due to the dedication of the project staff in overcoming many external and internal challenges and in diligently preparing for an efficient and rigorous technical review. The staff demonstrated that risk-informed, performance-based regulatory concepts can be implemented transparently in a regulatory review, and that a complex performance assessment can be thoroughly reviewed and used to assess the safety case for a one-million-year period of performance. Although professional disagreements occurred during the review, having objective technical advisors outside of the review teams was critical to implementing a process that achieved consensus on issue resolution. Staff's independent

technical investigations during pre-licensing were extremely useful in developing risk insights and confirming the acceptability of the applicant's methods and results, but care was needed to ensure that this information was not substituted for the applicant's safety case. More information about NRC staff's review of the DOE license application, including links to the technical evaluation reports, is available at [http:// www.nrc.gov/waste/hlw-disposal/yucca-lic-app.html](http://www.nrc.gov/waste/hlw-disposal/yucca-lic-app.html)

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