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1 July 2011

Blue Ribbon Commission on America's Nuclear Future
c/o U.S. Department of Energy
1000 Independence Avenue SW
Washington, DC 20585

Subject: EPRI comments on the Blue Ribbon Commission on America's Nuclear Future (BRC) Disposal Subcommittee Draft Report to the Full Commission dated June 1, 2011

Dear BRC Disposal Subcommittee members:

EPRI is pleased to have the opportunity to provide comments on the Subcommittee's draft report. As an independent research organization, EPRI will only comment on technical aspects of the draft report. In general, the findings and recommendations made by the BRC Disposal Subcommittee are consistent with EPRI's view. While the details of EPRI's comments are found in the attachment to this letter, a short summary of EPRI's comments are provided here:

EPRI Comment 1: Site screening and selection under the NWPA

The BRC disposal report provides an insightful, concise history of the U.S. geologic disposal program, which is critical for understanding and applying lessons learned from the site selection process established under the Nuclear Waste Policy Act (NWPA). However, the report omits useful information describing the technical underpinning of the NWPA site screening and selection process, which included a technical site evaluation process conducted by DOE that resulted in Yucca Mountain being ranked highest overall among multiple sites. EPRI recommends that the Commission include this relevant history in its full report.

EPRI Comment 2: "Reasonable assurance" versus "reasonable expectation"

The BRC disposal report suggests that the EPA's standard of proof for demonstrating regulatory compliance known as "reasonable expectation" was "...ultimately adopted by the NRC for its Yucca Mountain regulations" in place of its own more stringent "reasonable assurance" standard for the post-closure period. In short, the EPA "reasonable expectation" concept requests the applicant use "best estimate" assumptions, data, models to evaluate the disposal facility, whereas the NRC "reasonable assurance" approach often results in the applicant using technically "conservative" assumptions, data, and models.[1] EPRI would like to point out there is a significant technical difference between the two concepts. In practice, DOE did not always use EPA's "reasonable expectation" concept in its technical assumptions,

[1] "Best estimate" can roughly be described as using the ranges of assumptions, data, and models that the applicant feels best represents the disposal system. In practice, "conservative" means the applicant chooses "bounding" assumptions, data, and models in order to avoid understating the assessed health risk to humans living downstream of the facility.

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data, and models. EPRI's independent technical analyses shows, in some cases, DOE's approach resulted in misleading analysis results that caused DOE to fundamentally "over engineer" the Yucca Mountain repository design (EPRI 2008b). Therefore, EPRI agrees with BRC's preference for EPA's "reasonable expectation" concept over that of "reasonable assurance".

EPRI Comment 3: The Safety Case

The BRC disposal report emphasizes the utility of and recommends the use of a "Safety Case" that "goes beyond the traditional performance assessment" approach. However, numerous observers and reviewers – including the National Academy of Sciences – have recognized that the U.S. regulatory system, considered in total, is fully equivalent to the "safety case" concept, including the National Academy of Sciences, and EPRI concurs with this view. EPRI has two comments on the issue of the "safety case". EPRI first notes that the report provides no clarification of what is meant by going "beyond" the traditional performance assessment approach. Secondly, EPRI's view is there is no technical or licensing benefit of going "beyond" the traditional performance assessment approach.

EPRI Comment 4: Radioactive decay and decrease of hazard with time

In framing the rationale for disposal, the BRC disposal report characterizes the decrease in radioactivity of used fuel and HLW due to radioactive decay as occurring "only very gradually." However, this subjective statement does not accurately reflect the important and substantial decay of shorter-lived constituents over periods that could be considered "short", i.e., 100's to 1000's of years, especially when compared with the timeframes over which performance of geologic disposal systems is assessed, i.e., 10,000's to 100,000's of years. This distinction is important in determining the appropriate timeframe for the regulatory compliance period as discussed in EPRI Comment 5. Therefore, EPRI requests the BRC reconsider its view that radioactivity decreases "only very gradually".

EPRI Comment 5: Timeframe for regulatory compliance

The BRC disposal report questions the scientific merits of a million-year quantitative compliance period. EPRI concurs with the BRC's argument for appropriate timeframes for demonstrating repository performance. The decay characteristics of the disposal inventory, along with the WIPP experience in the U.S. and examples from international regulations for geologic disposal, suggest that future U.S. regulations should consider a tiered approach. Such an approach may include a shorter quantitative compliance period than the one million-year standard in effect for Yucca Mountain (e.g., 1000's to 10,000 years), with a second qualitative compliance period extending out to a longer period of concern, e.g., 100,000's to one million years (EPRI 2005).

EPRI Comment 6: Maintaining a systems perspective in future regulations

Many organizations have commented on the inappropriateness of the use of sub-system performance standards for determining regulatory compliance of repository performance as their use often leads to a sub-optimal repository design. The Commission should emphasize the importance of maintaining a system level, rather than a sub-system level, perspective in future regulations for demonstrating repository performance and regulatory compliance. Specifically, the Commission should provide more substantial discussion of the drawbacks of sub-system performance standards and separate pathway standards with

respect to protection and system optimization.

EPRI Comment 7: Current regulations as a basis for future U.S. regulations
The U.S. has two sets of standards and regulations for geologic disposal of used fuel and HLW, one generic set that is generally viewed as obsolete, 40 CFR 191 and 10 CFR 60, and a much more evolved set that is only applicable to a repository at Yucca Mountain, 40 CFR 197 and 10 CFR 63. While some components of NRC's 10 CFR 63 are specific to Yucca Mountain, the overall regulatory approach used in NRC's regulation for Yucca Mountain could be used generically.[2] EPRI recommends the Commission thoroughly examine the components of 10 CFR 63 for their potential, generic use.

EPRI Comment 8: "Engineering" versus "science" as basis for repository program
There are fundamental differences between science-based and engineering-based approaches that have significant implications in the overall organization, management, and execution of a repository disposal program. The construction of a repository is ultimately an engineering endeavor that will involve some degree of uncertainty and risk to proceed toward the defined goal of building and operating an engineered facility within a natural environment. These science versus engineering differences are not acknowledged or addressed in the BRC disposal report. In light of the impact that this science versus engineering basis may have played in the previous U.S. repository program and may play in a future program, the Commission should explicitly examine the issue of science-based and engineering-based programs.

EPRI Comment 9: Uncertainties and "predictions" in performance assessment
The BRC has correctly identified the importance of uncertainty in compliance demonstration. The performance assessment community has long recognized the central and unavoidable role uncertainly plays in evaluating long-term performance of geologic repositories. Such recognition has motivated and guided the development of performance assessment tools for evaluating geologic disposal systems.
In discussing the application of performance assessment models, the Commission should avoid use of the term "prediction" as it does not accurately represent the appropriate role of performance assessment.

I would be happy to clarify these comments or provide additional information. I can be reached by e-mail (asowder@epri.com) or phone (704-595-2647).

Sincerely,

[*signed*]

Andrew G. Sowder
Senior Project Manager, Used Fuel and HLW Management Program

Attachment

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[2] One exception is the use of a separate groundwater standard in 10 CFR 63. As discussed in EPRI's Comment 6, use of sub-system performance standards should be avoided.

Attachment

Detailed EPRI comments on the BRC Disposal Subcommittee draft report dated May 31, 2011

This attachment provides the technical basis for the high-level comments on the BRC draft disposal report provided in the body of this letter including reference citations.

EPRI Comment 1: Site screening and selection under the NWPA

In Section 3.2 (page 15), the BRC disposal report describes the historical context for and process leading to enactment of the 1987 Nuclear Waste Policy Amendments Act (NWPAA), which designated Yucca Mountain as the only site for further characterization. The report includes an important clarification in Footnote 25 stating that "Yucca Mountain had been the highest ranked site based upon the scientific and technical siting guidelines." This detail warrants greater visibility in the text to provide adequate context for drawing lessons from the U.S. site selection process. A recent EPRI study of the U.S. geologic disposal program prior to the NWPAA (EPRI, 2010a. Sections 2.2 – 2.4) reviews the technical work underpinning DOE's site screening and selection process, which included draft environmental assessment reports applicable to nine early candidate sites out of which the list of five sites was drawn for additional characterization and formal technical ranking. Of particular relevance is DOE's 1986 publication of its Multi-attribute Utility Analysis (MUA), which evaluated and ranked five candidate sites against many key programmatic attributes including compliance with prevailing regulations (DOE, 1986). It is from this technical analysis that the Yucca Mountain site received the overall top ranking.

EPRI Comment 2: Reasonable assurance and reasonable expectation

EPRI agrees with the BRC's recommendation (page 73) that the EPA's "reasonable expectation" approach be carried over into new U.S. disposal regulations that might be developed. However, the BRC report underemphasizes important differences between and implications of the EPA's approach from the NRC's "reasonable expectation" approach, which are more than semantic in nature (EPRI, 2010b). Independent analyses by EPRI have shown many orders of magnitude difference in margin of safety between using EPA's reasonable expectation approach versus a more conservative reasonable assurance approach (e.g., EPRI, 2004; 2008b). EPRI's independent technical analyses shows, in some cases, DOE's use of conservatism resulted in misleading analysis results that caused DOE to fundamentally "over engineer" the Yucca Mountain repository design (EPRI, 2008a).

In developing its standards in 40 CRF 197, EPA called attention to the difference between the two approaches (EPA, 2001):

> "The EPA standards call for use of "reasonable expectation," rather than "reasonable assurance," as a basis for assuring compliance with the EPA standards. … In brief, the intent of reasonable expectation is to recognize the inherent uncertainties involved in repository safety performance evaluations, and to encourage realistic treatment of the uncertainties in performance assessments and evaluations of compliance with the disposal standards. Reasonable expectation takes what might be termed a realistic or best-value approach [emphasis added]

> to dealing with uncertainty in performance projections when compliance issues are complicated by uncertainties imposed by extrapolations of data and projections of performance over long time periods."

The reasonable expectation concept was used by EPA to establish the type of analysis that would constitute an acceptable analysis for comparison with the individual protection requirements. Accordingly, the EPA limits were intended to relate to a "best estimate" analysis, whereas the NRC "reasonable assurance" standard by which regulatory determinations are made is an approach for resolving site-specific uncertainties, often through the use of conservatively biased assessments (NCRP, 2005) rather than a best-value approach. The NRC has stated that it considers that there is no meaningful difference between the two concepts (NEI vs. EPA, 373 F3 1251, DC Circuit), and the BRC disposal report simply states in Section 8.1.4 "...the NRC dropped the 'reasonable assurance' standard of proof in favor of 'reasonable expectation' with respect to the post-closure period." Neither of these positions recognizes the substantive differences between the two interpretations, which effectively introduces additional conservatism in the licensing process.

EPRI Comment 3: The Safety Case

In Section 8.1.3 (pages 70 – 71) and Section 8.1.6 (Recommendation #3, page 74), the BRC disposal report recommends the use of a "Safety Case" approach, which "goes beyond the traditional performance assessment." However, numerous observers have noted that the U.S. program already uses a safety case approach (e.g., NAS, 2003), although the U.S. does not use the safety case terminology and does not require the arguments to be collected in a single safety case document. Given this acknowledged equivalence of NRC's 10 Parts 60 and 63 to a safety case, it is not clear why BRC disposal report emphasizes the need for a safety case approach that has already been effectively implemented in the U.S. program.

As noted by the BRC disposal report, there is not a standard definition of the safety case, but a definition of the NEA (2004) is often used: "A safety case is the synthesis of evidence, analyses and arguments that quantify and substantiate a claim that the repository will be safe after closure and beyond the time when active control of the facility can be relied on." The elements of the safety case described by NEA (2004) were limited in scope to the technical, and to a lesser extent the managerial, elements that contribute to confidence in the safety of a disposal system. The primary broadening element proposed by NEA (2004) was to take account of qualitative technical arguments in addition to quantitative ones. However, IAEA has clearly identified a number of other elements that contribute to confidence in the disposal system (IAEA, 2000; 2008). These additional elements may be broadly categorized as legal, managerial, and financial elements of the safety case (Kozak, 2010). It is the combination of these elements that leads to confidence in the safety of the facility.

In taking this broader view of the safety case as the synthesis of <u>all</u> arguments for safety of a repository, it can be seen that the U.S. program currently implements the safety case, but in a distributed manner. Many of the qualitative technical arguments for safety of the repository are embedded in justification documents

for the regulations (e.g. EPA, 2001), in the regulations themselves, in requirements for reporting and in the regulatory process. The organization of the safety case in the U.S. is different than in European programs, mainly because the concepts in the safety case have long been integral to the U.S. program, whereas these ideas have been introduced to the European programs more recently and therefore appear in a more explicit fashion.

Thus, EPRI has two comments that directly relate to the issue of the "safety case". EPRI first notes that the report provides no clarification of what is meant by going "beyond" the traditional performance assessment approach. Secondly, EPRI's view is there is no technical or licensing benefit of going "beyond" the performance assessment approach as implemented in the U.S. program.

EPRI Comment 4: Radioactive decay and decrease of hazard with time

Section 4.1 (page 18) of the BRC disposal report states the radiation hazard associated with used fuel and HLW "...diminishes over time, but only very gradually..." This statement is subjective and could be interpreted as a clear justification for quantitative regulatory compliance standards for timescales on the order hundreds of thousands of years or more – contrary to recommendations presented later in the report, e.g., Section 8.1.6, Recommendation 2 (page 72). One might consider the decrease in radioactivity to be rapid within the timeframe of interest for geologic isolation of used fuel and HLW in a repository, i.e., on the order of 10,000's to 100,000's of years. To this point, Figure 4 in the BRC disposal report (page 8), indicates a factor of 10 decrease for the period from 10 years to 100 years following discharge from the reactor, and a factor of 1000 decrease for the period from 10 years to 1000 years following discharge. The appearance of a gradual decrease in radioactivity may be an artifact of the log-log scales typically employed to capture and display the large time spans (up to millions of years) and many orders of magnitude of radioactivity. If one changes to a linear representation over relevant timescales, which could be argued as being more in line with human perception of time and temporal relationships, the relative radioactivity of used fuel and HLW decreases significantly (see Figure A below) in the first several 100's of years.

This distinction is important in determining the appropriate timeframe for the regulatory compliance period as discussed in EPRI Comment 5. Therefore, EPRI recommends the BRC clarify or rephrase its statement that radioactivity decreases "only very gradually".

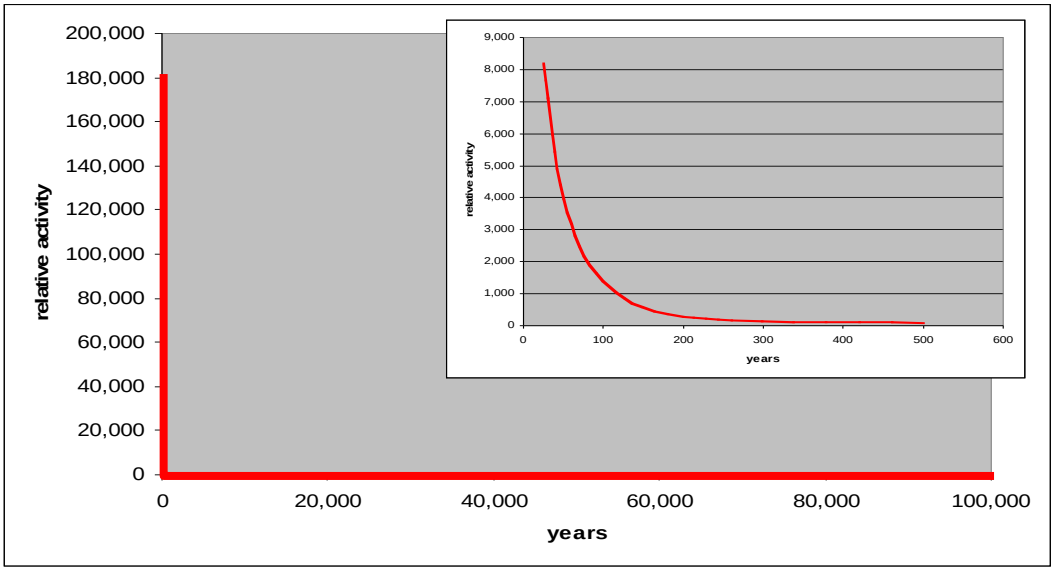

Figure A. Relative radioactivity of spent nuclear fuel as a function of time for two timescales, i.e., 100's and 10,000's of years, presented on a linear-linear plot for illustration.

EPRI Comment 5: Timeframe for regulatory compliance

EPRI supports BRC's views on development of appropriate timeframes for any future U.S. regulations, and has previously published extensive analyses on this topic (EPRI, 2005; 2010b). Sections 8.1.2 and 8.1.6 of the BRC disposal report discuss regulatory timeframes, noting how many countries have developed different kinds of criteria for different timeframes. In addition, as noted in previous comment on the characteristic radioactive decay of used fuel and HLW, there is a significant decrease of a repository's radioactive inventory within the first 100's to a few 1000's of years (Figure A). The inherent bifurcation of used fuel and HLW into short- and long-lived radioactive inventories suggest a logical division between quantitative and qualitative compliance periods for U.S. HLW disposal regulations, similar to tiered regulatory approaches adopted in Finland, Sweden, and France (as noted in Section 8.1.2 of the BRC disposal report and in EPRI, 2010c). The quantitative compliance timeframe could apply for a period on the order of 1000 to 10,000 years, corresponding to the period of greatest radioactive inventory and greatest confidence in engineered systems. A second qualitative period of compliance analysis and demonstration would apply beyond 10,000 years to provide regulatory confidence needed for repository performance over such longer timeframes. Such qualitative analyses would include arguments based on geologic evidence and natural analog studies and would comprise a complete safety argument similar to that of the Swedish program as cited in Section 8.1.2 of the BRC report and IAEA guidance (page 73) on not using quantitative criteria beyond the time where the uncertainties become so large that the criteria may no longer serve as a reasonable basis for decision making.

The BRC disposal report recognizes in footnote 115 (page 70) the origins of the extension of the regulatory compliance period for the EPA Yucca Mountain standards from 10,000 to 1 million years as being from a

legal finding that the EPA was required to follow the recommendations of the NAS, i.e., "...compliance should be measured at the time of peak dose within the period of geologic stability for Yucca Mountain, which the NAS found to be on the order of 1 million years." In light of the site specific applicability of the 1 million year compliance standard, examples from international regulatory approaches, and the successful application in the U.S. of 40 CFR 191 to WIPP certification, a 10,000-year quantitative compliance period could be retained for future geologic disposal regulations for a site other than Yucca Mountain.

EPRI Comment 6: Maintaining a systems perspective in future regulations

On page 69, the BRC touches upon the important point that generic 10 CFR 60 NRC regulations imposed sub-system performance targets on individual barriers. The site-specific 10 CFR 63 NRC regulations, however, omitted such sub-system requirements. It might be useful for the BRC to discuss the rationale behind this decision when considering future U.S. regulations in Section 8.1.6. The 1995 NAS "TYMS" report specifically concluded (NAS, 1995):

> "...because it is the performance of the total system in light of the risk-based standard that is crucial, imposing subsystem performance requirements might result in suboptimal design..."

This conclusion was directed specifically to NRC, in the context of revisions that USNRC needed to make to its new 10 CFR 63 regulations to be consistent with a new EPA standard for Yucca Mountain. Following these observations from NAS, the NRC made the following comment in promulgating its revised 10 CFR 63 (NRC, 1999):

> "NRC was not able to demonstrate, however, that compliance with the subsystem criteria alone was sufficient to meet the assumed EPA standards, nor that compliance with the assumed EPA standards would suffice to assure compliance with the subsystem criteria."

EPRI believes that future U.S. regulations for geologic disposal of HLW should adopt a system, rather than sub-system, perspective both in guiding research priorities and in conducting safety analyses. A similar view was expressed in Chapter 7 of a recent NAS report (NAS, 2011) on the performance of waste forms in disposal systems.

The BRC disposal report observes in Section 8.1.5 (page 72) that "...EPA's standards for the disposal of high-level radioactive waste and TRU include a separate groundwater standard designed to protect groundwater as a resource" without discussing the shortcomings of including a separate standard. EPRI views the inclusion of a separate groundwater pathway standard to be redundant and inconsistent with a risk-based, all-pathways approach.

EPRI Comment 7: Current regulations as a basis for future U.S. regulations

EPRI supports the technical merits of the general principles presented in Section 8.1.6 of the BRC disposal report for development of new geologic disposal standards and regulations. EPRI also concurs with the observation in the report that the Yucca Mountain regulations in 10 Part 63 are more contemporary and in line with "current thinking". However, the BRC report lacks a substantive discussion and analysis of the relative merits of the approaches embodied in the two sets of U.S. repository regulations, other than a high-level summary provided in the boxed text in Section 8.1.1 (page 69).

EPRI views the NRC Yucca Mountain regulation (10 CFR 63) as a useful starting point for a new or revised generic set of geologic disposal regulations, albeit one that should lead to a simpler, risk-based, all pathways approach (EPRI, 2010b,d).The BRC disposal report also appears to support the use of Yucca Mountain specific regulations as a basis for moving forward with the development of new regulations in the U.S. in the following observation (Section 8.1; page 68):

> "Since there was a substantial evolution in regulatory philosophy during the development of the Yucca Mountain regulations, it is to be expected that the regulations for other repositories, finalized nearly 20 years ago, would be revisited to support the development of repositories at new sites in the future...therefore, we will focus on relevant aspects of the Yucca Mountain regulation as being most representative of current thinking."

Given the BRC disposal report's implicit recognition of the more modern but site specific standards and regulations of 40 CFR 197 and 10 CFR 63, the Commission should clarify whether the Yucca Mountain standards would serve as a useful starting point for establishing new standards and regulations in the U.S.

Comment 8: Engineering versus science as basis for repository program

Science and engineering play fundamentally different roles in the organization, management, and execution of a repository disposal program. Accordingly, the use of the term "science-based" or similar references should be done with proper clarification of science versus engineering as the underpinning of the activity. Given that the objective of a repository program is to ultimately construct and operate a disposal facility, there needs to be a clear delineation of how much information and understanding of features, events, and processes are needed in order to progress toward a tangible goal (*c.f.*, NWTRB, 2010, pages 58 - 60).

Scientific inquiry is fundamentally a continuing quest for closer approximations to understanding natural phenomena. Its methodology relies on making predictions and devising methods to test such predictions. Full, scientific understanding is never obtainable, and advocating for a pure "science-based" approach is not conducive to developing a program that can successfully complete and construct a repository.

Engineering practice, on the other hand, is concerned with the design, construction, and operation of a facility, in this case a repository system composed of an engineered barrier system containing radioactive waste located within deep, passive geological formations. The engineering approach is directed at the

development of adequate safety margins, using stringently applied, managed and quality assured technical approaches. Therefore, it is fully compatible with the recommendations on risk informed decision-making by the NAS (1996). This type of engineering safety analysis ("safety function analysis") lies at the very heart of the recently submitted SR-Site report by the Swedish organization SKB in support of a repository construction license application.

Comment 9: Uncertainties and "predictions" in performance assessment

The BRC has correctly identified the importance of uncertainty in compliance demonstration. The performance assessment community has long recognized the central and unavoidable role uncertainly plays in evaluating long-term performance of geologic repositories, and such recognition has motivated and guided the development of performance assessment tools for evaluating geologic disposal systems. However, Section 8.1.2 (page 70) of the BRC report mentions "difficulties of making very long-term predictions about human and natural systems..." The term "prediction" is generally avoided by performance assessors because the calculations they make are not "predictions" in the sense commonly understood either by scientists or the general public. As the BRC report mentions repeatedly, the uncertainties of many (but not all) future conditions affecting a repository can increase with time, so that performance assessment analyses are perhaps better understood as illustrations of repository system behavior for postulated "what if" sets of future conditions. Consideration of uncertainties about conditions in the far future, and even concerns about "unknown unknowns" and their potential effect on performance assessment calculations, are comprehensively addressed by scenario analysis, as noted in the recent Swedish repository construction licensing report by SKB (SKB, 2011, pages 564 and 570). Thus, in discussing the application of performance assessment models, the Commission should avoid use of the term "prediction", as this term does not accurately represent the appropriate role or intent of performance assessment.

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