



Department of Energy  
Washington, DC 20585

MAY 16 1994

Mr. Joseph J. Holonich, Director  
Repository Licensing & Quality  
Assurance Project Directorate  
Division of High-Level  
Waste Management  
Office of Nuclear Material  
Safety and Safeguards  
U.S. Nuclear Regulatory Commission  
Washington, D.C. 20555

Dear Mr. Holonich:

References: (1) Ltr, Bernero to Dreyfus, dtd 2/6/94  
(2) Ltr, Roberts to Holonich, dtd 1/26/93

On February 16, 1994, the U.S. Department of Energy (DOE) received the results of the U.S. Nuclear Regulatory Commission (NRC) staff's review of the DOE's Site Characterization Semi-Annual Progress Report 8. The review resulted in one comment and four questions. The enclosure provides the DOE's response to the comment and questions. The DOE believes the responses are sufficient to resolve the comment and questions on Progress Report 8.

If you have any questions regarding the enclosure, contact Corinne Macaluso of my staff at (202) 586-2837.

Sincerely,

Dwight E. Shelor  
Associate Director  
Office of Systems and Compliance

Enclosure:  
Responses to NRC's Comment  
and Questions on Progress  
Report 8

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cc:

R. Nelson, YMPO  
R. Loux, State of Nevada  
D. Bechtel, Las Vegas, NV  
Eureka County, NV  
Lander County, Battle Mountain, NV  
P. Niedzielski-Eichner, Nye County, NV  
W. Offutt, Nye County, NV  
L. Bradshaw, Nye County, NV  
C. Schank, Churchill County, NV  
F. Mariani, White Pine County, NV  
V. Poe, Mineral County, NV  
J. Pitts, Lincoln County, NV  
J. Hayes, Esmeralda County, NV  
B. Mettam, Inyo County, CA

**Enclosure**

**Summary of NRC Comment and Questions on PR8**

**COMMENT 1**

The definition and use of natural analogs as given in this subsection are not consistent with the staff's position on the meaning of the term as used in 10 CFR Part 60 and the range of topics to which natural analog studies can apply appears to be too restrictive.

**QUESTION 1**

How will DOE ensure that a comprehensive set of alternative conceptual models will be considered during site characterization?

**QUESTION 2**

How was the replacement of the Expected Partial Performance Measure (EPPM) with the Complementary Cumulative Distribution Function (CCDF) in the Site Characterization Program Baseline (SCPB) accomplished?

**QUESTION 3**

What is DOE's overall approach to validation and verification of models?

**QUESTION 4**

How effective will the zeolites be in retarding radionuclides if they are 2 to 10 million years old and have not experienced significant ion exchange for that period of time? Also, if the zeolites were samples from the rock matrix, how effectively can matrix diffusion retard radionuclides, given the apparent closed system behavior of the zeolites?

**NRC Comment 1 and  
DOE Response to Comment 1  
on Progress Report 8**

## NRC Comment 1

The definition and use of natural analogs as given in this subsection are not consistent with the staff's position on the meaning of the term as used in 10 CFR Part 60 and the range of topics to which natural analog studies can apply appears to be too restrictive.

## DOE Response to Comment 1

The Yucca Mountain Site Characterization Office (YMSCO) provided a response in a letter from Roberts to Holonich, dated January 26, 1993 (Reference 2, Enclosure 1). The essence of this reply was presented to the Natural Analogue Review Group (NARG) (Enclosure 1, copy of viewgraph) by John W. Bradbury, U.S. Nuclear Regulatory Commission (NRC).

On March 22, 1994, the Advisory Committee on Nuclear Waste (ACNW) met in Bethesda, Maryland, to discuss NRC support work on natural analogues. The question of definition of the term occupied a significant portion of the meeting. Several NRC and Center for Nuclear Waste Regulatory Analysis (CNWRA) staff expressed the view that the differences between what the NRC and YMSCO consider natural analogues and what constitutes ordinary geologic field work is largely semantic. The main concern of the NRC is that the definition may in some way result in the U.S. Department of Energy (DOE) not conducting some of the appropriate research. In this connection, please see viewgraph (Enclosure 1) of the summary section of the presentation by Dr. Linda Kovach. The letter from Roberts to Holonich is not intended to imply that the site characterization studies will be any less comprehensive in covering the geological sciences, nor that natural analogue studies are inappropriate for investigating future conditions and changes. Title 10, Part 60.21(c)(1)(ii) includes both field and natural analogue studies. When Dr. Paul Cloke was called upon by Dr. Scheindler (Chairman of the ACNW) at a meeting on March 22, 1994, the ACNW, NRC, and CNWRA staff were assured that the DOE in no way intended to reduce or limit the scope of work as a consequence of the use of a particular definition. Rather, the DOE simply classifies some work as field work and the NRC prefers to call the work a natural analogue study. At the end of the discussion following John Bradbury's presentations, Dr. Scheindler was unable to understand why so much effort and attention was being devoted to an issue that seemed to have such minor importance. This explanation addresses what is believed to be a misunderstanding, and therefore, the DOE considers this comment resolved.

**Enclosure 1 to Comment 1**

- **Limited definitions should not be used as reasons to avoid studying systems that may yield important information about processes important to repository performance (e.g. don't study analogous volcanic systems because they don't fit a specific definition of natural analogs.)**

## **Background (continued)**

- **DOE Response to NRC Letter on NARG Report - January 26, 1993**

**(The DOE sees no inconsistency between the NARG report and 10 CFR Part 60.)**

- **DOE Progress Report #8 - September 22, 1993**

**(The DOE adopts the recommendations of the NARG report.)**

- **NRC Staff Comments on DOE Progress Report #8 - February 6, 1994**

**(The NRC recommends that the DOE adopt a broader definition of natural analog studies to ensure the full benefit of this information, in guiding site characterization, validating conceptual models, and estimating repository performance. The NRC is concerned that a restricted definition of natural analog**

**studies might be used as a reason for not doing important work.)**

**NRC Question 1 and  
DOE Response to Question 1  
on Progress Report 8**

NRC Question 1

How will DOE ensure that a comprehensive set of alternative conceptual models will be considered during site characterization?

DOE Response to Question 1

The NRC is correct in stating that alternative conceptual models are currently under active consideration in the site characterization program. The alternative models presented in the SCP and other hypothesis are tested in the normal course of the scientific investigation program. The hypothesis testing tables were, however, removed from the SCPB because they do not belong in the Yucca Mountain Site Characterization Project's technical baseline. The SCPB is part of this baseline and is controlled by a procedural process with a Change Control Board. Because the hypothesis testing tables in the Site Characterization Plan were preliminary in nature and will evolve throughout site characterization, the tables could require continued review and approval from the Change Control Board. The DOE decided that this level of change control is not necessary to track modifications to alternative conceptual models.

The DOE agrees with the recommended need for revisiting the hypothesis testing tables. Recent experience in performance assessment model development and progress in scenario development suggests that there is a need for reordering the relative importance of the items listed in the hypothesis tables. The results of this assessment will be summarized in project reports or Site Characterization Plan (SCP) Progress Reports. The DOE also suggests that this question be closed by the NRC as the same concern is being tracked by SCA Comment 6. It is unnecessary to create multiple open items to track the same concern. Therefore, DOE believes future questions from Progress Report 8 are resolved.

**NRC Question 2 and  
DOE Response to Question 2  
on Progress Report 8**

## NRC Question 2

How was the replacement of the Expected Partial Performance Measure (EPPM) with the Complementary Cumulative Distribution Function (CCDF) in the Site Characterization Program Baseline (SCPB) accomplished?

## DOE Response to Question 2

A change from the use of "EPPM" to "CCDF" was made for the following reason:

EPPMs are defined in the SCP as the conditional expectations of the performance measure for each scenario class (SCP page 8.3.5.13-18). The performance measure for each scenario class is the normalized release from the total system (SCP page 8.3.5.13-14). Normalized total system releases are now calculated probabilistically and shown as Complementary Cumulative Distribution Functions (CCDFs) in either subsystem or total system performance analyses. The use of CCDF for EPPM in the referenced tables calls into question the performance allocations in the SCP, which were based on EPPMs and not CCDFs. The language of the SCP's explanation of the EPPM and its relation to the CCDF on page 8.3.5.13-92 of the SCP explains the EPPM was a stopgap measure prior to the program's demonstration of an ability to construct CCDFs. The SCP explains the EPPM is a "surrogate measure suitable for individual scenario classes" and "ideally, the value of the entire CCDF could be used as the performance measure." The SCP concluded that: "The final resolution of this issue (Issue 1.1) will be made in terms of the full CCDF and not EPPMs." This clearly demonstrates the program's transition from the EPPM to the CCDF was planned from the start.

The program has moved to the use of the CCDF because recent experience gained in evaluating scenario classes in the Total System Performance Assessment 1991 and 1993 exercises. These exercises are a part of a continuing iterative system assessment effort that evaluates the state of engineering and site knowledge periodically to provide feedback to these activity areas. As these exercises progress, subsystem performance measures will also be addressed, representing intermediate results that become input to the CCDF. This effort, in effect, has replaced the detailed performance allocation approach, for which EPPMs were used in the SCP. Because many parameters are now known to have little influence on total system performance, the value of performance allocation is substantially reduced. Sensitivity studies identify those parameters more important to system performance, and allow the site and design programs to be focused on describing the spatial distribution and ranges for these parameters. This in turn requires the site and design programs to properly capture the conditions and ancillary parameters controlling the values of the parameter of interest.

In terms of scenario evaluation, the SCP suggest CCDFs were not appropriate: ". . . would not be useful or practical in guiding the site characterization program toward acquiring the information needed for evaluating a single scenario class," because the calculation of the CCDF performance measure requires "that information for all the scenario classes be available at the same time." This judgement reflects the fact that the CCDF is a comprehensive roll-up for all of total system performance, and EPPMs should be used for looking at the performance influences of parts of the system.

The new approach, however, is based on more experience with the CCDF approach. In the iterative performance assessment program, series of conditional CCDFs are produced to reflect the importance of one or more selected scenarios, in addition to the final CCDFs reflecting the impact of new information on all scenario classes. Thus, conditional CCDFs are now used as a tool for evaluating scenario classes, a possibility that had not been developed at the time of the SCP. The DOE considers this question resolved.

**NRC Question 3 and  
DOE Response to Question 3  
on Progress Report 8**

### NRC Question 3

What is DOE's overall approach to validation and verification of models?

### DOE Response to Question 3

On page 2-173, Lawrence Livermore National Laboratory (LLNL) makes the statement that they "agree with scientists who believe that the terms 'model validation' and 'verification' are misleading in ground-water science and should be replaced with the following process: (1) using models to obtain a better fundamental understanding of the system, (2) asking what it is about the system that needs to be predicted, (3) utilizing this understanding to formulate fundamental hypotheses that are the basis of the conceptual model and performance attributes of the system, and (4) performing analyses and experiments in an attempt to test or invalidate the conceptual models (or hypotheses)."

The meaning of this statement is admittedly unclear, as it proposes replacing technical terms with a process. The subject of validation of ground-water flow and transport models has indeed been controversial, and LLNL's statement results from their evaluation of the especially controversial area of hydrothermal processes in the repository near-field. They have raised issues with respect to the relevant processes which must be modeled in order to provide a valid assessment of repository system performance. These issues include questions about the validation of hydrologic models. It is not apparent yet whether the process which is proposed reflects a significant and useful change in the process of validation. LLNL does not have responsibility for the development of validation strategies for the YMP. DOE has long considered the term "validation" to refer to an open-ended process, the completion of which requires informed judgment about adequacy. Validity of models is, and always has been, a matter of degree, and the opinion that the term is misleading may be a matter of misconstrual of the concept as referring to mathematical proof.

The reference to verification is also confusing, as it appears to be applied to models. In the YMSCO Work Breakdown Structure, the term "verification" has been restricted in application to computer codes, which may implement one or more models of various processes or systems. "Verification" is used to refer to the determination that a computer code does, in fact, implement the mathematical model it purports to implement. This concept has not generally been controversial, except when misapplied to models, where it suggests the same unachievable absoluteness that appears to lead to misunderstanding of the meaning of "validation."

The comment on model validation is currently being evaluated by DOE, and is reported for information purposes. The DOE evaluation will consider the applicability of the proposed approach to areas beyond the limited focus of the LLNL work scope in which this comment was made. It will also consider compatibility with other validation strategies, such as those cited by NRC. The DOE recognizes the NRC's concern about the need for comprehensive approaches to verification of codes and validation of models used to evaluate the repository system. Such approaches may require different strategies for different disciplines. Given the controversial nature of the subject, care is required in the development of these approaches. DOE would appreciate the opportunity to discuss verification and validation, and our current thinking on these subjects.

**NRC Question 4 and  
DOE Response to Question 4  
on Progress Report 8**

#### NRC Question 4

How effective will the zeolites be in retarding radionuclides if they are 2 to 10 million years old and have not experienced significant ion exchange for that period of time? Also, if the zeolites were sampled from the rock matrix, how effectively can matrix diffusion retard radionuclides, given the apparent closed system behavior of the zeolites?

#### DOE Response to Question 4

First, DOE reemphasized the statement in Study Plan 8.3.1.3.2.2, "History of Mineralogic and Geochemical Alterations of Yucca Mountain," that the K/Ar "technique may be applicable to the studies of smectites and zeolites with low potassium contents, and part of this test will be conducted to assess the possibility of dating such materials." The use of K/Ar as an absolute dating technique does rely on an assumption of closed-system behavior with respect to potassium and argon, but we have made no assumptions and consequently we distinguish between "dates" that are simply analytical results and "ages" that are geologically meaningful. The statement by WoldeGabriel and others, 1992, that "the precision of preliminary clinoptilolite K/Ar dates are acceptable and similar results suggest some sensible meaning to the dates obtained," means, first, that analyses of sample splits prepared the same way are repeatable and, second, that the ranges and vertical distributions of dates are similar for all borehole sample suites. The technical information product, "Preliminary Assessment of Clinoptilolite K/Ar Results from Yucca Mountain, Nevada USA: A Potential High-Level Radioactive Waste Repository Site," cited in Progress Report 8, has been published (LA-12652-MS, WoldeGabriel and others, 1993) and contains a detailed discussion of factors that might affect the "dates" or apparent ages obtained for zeolites. The interpretation in the technical report is that the zeolites at Yucca Mountain formed about 10 million years ago, and the younger apparent ages are generally due to loss of radiogenic argon from the clinoptilolites in the unsaturated zone.

At the time Study Plan 8.3.1.3.2.2, Mineralogic and Geochemical Alterations of Yucca Mountain, was written, potassium exchange was thought to be the most significant problem in obtaining meaningful ages for zeolites. However, it now appears that argon loss is the more important factor. A milestone report for this fiscal year will describe experimental results for argon retention and loss in clinoptilolite. The presence of abundant water seems to inhibit argon loss from the zeolites, whereas loss of argon can be caused by heating or dehydration; this may explain why older apparent ages are obtained for zeolites from below the water table. As noted in Progress Report 8, the preliminary results suggest that K/Ar data may be useful for assessing zeolite-ground-water interactions at Yucca Mountain. WoldeGabriel and others (1993) discuss the possibility of post-crystallization changes in potassium and treat the issue of

closed-system and other preliminary data suggest that zeolites in the unsaturated zone may have gained contents of the dated clinoptilolites from the saturated zone, it seems that zeolites there have not gained much potassium from the ground water by cation exchange since their formation.

Because argon loss is thought to be responsible for zeolite age variations in the unsaturated zone, there are no adverse implications for radionuclide retardation by cation exchange with zeolites in the rock matrix or anywhere else. DOE believes this item is resolved.

References:

WoldeGabriel, G., 1993. "K/Ar Dating of Clinoptilolites: Methods and Preliminary Results," in Proceedings and Abstracts of the 4th International Conference on the Occurrence, Properties, and Utilization of Natural Zeolites (Zeolite '93), June 20-28, 1993, Boise, ID, pp. 216-218. (pg. 2.2-38) (LANL)

WoldeGabriel, G., Broxton, D.E., Bish, D.L., and Chipera, S. J., 1992, Preliminary assessment of clinoptilolite K/Ar results from Yucca Mountain, Nevada, USA: A potential high-level radioactive waste repository site, Water-Rock Interaction, Kharaka & Maest (eds.), Balkema, Rotterdam.