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Office of Civilian Radioactive Waste Management
Yucca Mountain Site Characterization Office
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JUL 17 1996

Overnight

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U.S. Nuclear Regulatory Commission
Washington, DC 20555

RESPONSE TO U.S. NUCLEAR REGULATORY COMMISSION (NRC) STAFF COMMENTS ON SEMIANNUAL PROGRESS REPORT 11 (SCPB: N/A)

Reference: Ltr, Holonich to Milner, dtd 7/18/95

The NRC staff provided three comments and five questions on Site Characterization Plan Progress Report 11 (reference). In addition, in your letter, you identified a general concern which related to the timeliness of the Progress Report.

Your concern referred to discrepancies between the Progress Report and information available from other U.S. Department of Energy documents. We value the importance of updating the Progress Report as soon as possible and ensuring that the information provided in the report is current and timely. We will continue to use the Progress Report as a primary method for communicating the status of the program; however, due to the schedule for preparation of the report, and as noted in your cover letter with comments on PR 11, information may be available to the NRC from other sources that are more current.

We continue to work to make the Progress Report as useful as possible and the information contained in it as current as practicable. We agree with the NRC's emphasis on the Progress Report as the statutory document updating progress on site characterization activities at Yucca Mountain, Nevada.

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Our detailed responses to your specific comments and questions are provided in the enclosure. If you have any questions, please contact Carol L. Hanlon at (702) 794-1324.

Stephan J. Brocoum
Assistant Manager for
Suitability and Licensing

AMSL:CLH-1427

Enclosure:
Comments, Questions,
Recommendations, and Responses

cc w/encl:
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ENCLOSURE

COMMENT 1:
The Perry and Crowe (1987) document which purports to contain analyses sufficient to address this topic does not fully justify its conclusions. Although the staff agrees with some of the conclusions for the ash fall potential at the site during preclosure, in its present form the report is not suitable as the sole input to design of repository surface facilities. Furthermore, the additional discussion of this topic which DOE states is included in the Los Alamos Volcanism Status Report could not be found by the staff in its review of that report.

NRC RECOMMENDATION
Characterize the potential hazards to the repository and surface facilities from ash fall during the preclosure period (i.e., effects on HEPA filters, radiation safety structures, systems and components).

DOE RESPONSE
Preclosure analyses that are underway in FY96 will define design basis events and will include consideration of the probability of an ash fall during the operational period that would be sufficient to interfere with filter operation or to endanger other operations.

NRC RECOMMENDATION
Specify the exact page or section in the Volcanism Status Report where additional information on preclosure ash fall may be found.

DOE RESPONSE
The issue of preclosure ash fall is not addressed in the Volcanism Status Report. The reference to additional discussion of preclosure ash fall in the Los Alamos Volcanism Status Report was incorrect. The Volcanism Status Report contains information and analyses relevant to postclosure conditions, but the document contains no information specifically relevant to preclosure conditions. The DOE regrets the incorrect reference.

NRC RECOMMENDATION
Address and resolve discrepancies between ash fall estimates in Perry and Crowe (1987) and Mullineaux (1975), or a more recent volcanic hazards map if one exits.

DOE RESPONSE
The DOE finds no discrepancy between the conclusions of Perry and Crowe (1987) and Mullineaux (1975) concerning ash fall potential at the repository site during the preclosure period. Perry and Crowe (1987) conclude that a maximum of 2-3 cm of ash could be deposited at the repository site, given an eruption volume of 1 km^3 at the Coso volcanic field ($\sim$ 150 km distance), the nearest "active" silicic center in the region. Note that the likelihood of an eruption volume of 1 km^3 is extremely remote during the

short preclosure period, since no single eruption in the Coso or Mono/Inyo fields has produced this volume of eruptive products during the entire Holocene.

The NRC bases their "discrepancies" of ash fall estimates on the map of Mullineaux (1975), which indicates an ash fall thickness of ~5 cm at the repository site from a "large" or "very large" eruption. First, the DOE does not consider estimates of 2-3 centimeters versus ~5 cm to be discrepant, given the uncertainties inherent in both estimates. More importantly, basing estimates of ash fall at the repository site on "large" and "very large" eruptions is inappropriate given the recent volcanic history of the western United States. The "very large" eruption of Mullineaux (1975) is equivalent to the Mt. Mazama eruption that formed Crater Lake approximately 7000 years ago. This eruption had an estimated volume of 50-60 km^3, an order of magnitude larger than *any other eruption* in the western United States during the Holocene. There is no reason to expect an eruption of this magnitude from any volcanic field in the western U.S. (or from any volcano on the earth, for that matter) during the preclosure period. The "large" eruption of Mullineaux (1975) is equivalent to the Mt. St. Helens eruption of ~3400 years ago, which had an eruption volume of >1 km^3 and produced the second most voluminous Holocene tephra in the Cascade range (after the Mt. Mazama ash). Another eruption of this magnitude in the Cascade range would produce <1 cm of ash fall at the repository site, based on estimates in Mullineaux (1975). As stated earlier, an eruption of this magnitude has not occurred in the Coso or Mono/Inyo fields during the entire Holocene; the DOE does not consider a "large" eruption at the Coso or Mono/Inyo field as a credible concern during the preclosure period.

In summary, there is no discrepancy between ash fall estimates of Perry and Crowe (1987) and Mullineaux (1975). The "discrepancy" brought up by the NRC is based on inappropriate application of the volcanic hazards map of Mullineaux (1975). A more appropriate comparison of ash fall estimates from Perry and Crowe (1987) and Mullineaux (1975) would use Mullineaux's estimate of ash fall from a "moderate" eruption. In this case, ash fall thickness at the repository site from an eruption in the Coso volcanic field (150 km distance) would be ~1 cm, which is consistent with Perry and Crowe's "worst-case" estimate of 2-3 cm.

NRC RECOMMENDATION

Justify the assumption that a 1 meter scoria accumulation will not cause structural damage to surface facilities, and specify how such a deposit is assumed to cause unacceptable effects.

DOE RESPONSE

This assumption was chosen somewhat arbitrarily and was intended to be a conservative assumption that would (1) allow calculation of the area of a surface volcanic effect and that (2) convert that area to a probability estimate for a preclosure event. The point of the calculation was to determine sensitivity through probabilistic analyses of the analyses of the importance of a preclosure volcanic event. The only assumption concerning such a deposit was "thickness of scoria would *most likely not* cause structural damage but could increase the difficulty of operating a repository during the retrievability period" [emphasis added]. There was no intent to make an engineering judgment concerning the nature or extent of structural damage or non-structural damage to a surface facility, nor is such an interpretation important to the preclosure probabilistic analyses. A thickness assumption of 0.5 or 2.0 meters could just as easily have been used. The important point of the calculations in Perry and Crowe (1987) is that the probabilistic analyses and sensitivity of the analyses indicate the probability of preclosure volcanic events is very low and, therefore, it should not be a priority issue in site characterization studies. The issue of structural damage to surface facilities and descriptions of the basis for such assessments, if required, will be considered in other parts of the DOE program.

NRC RECOMMENDATION
Explain why the study which was inadequate in 1988 is considered sufficient for design inputs in 1995.

DOE RESPONSE
In 1988, only a preliminary conceptual repository design had been developed and there was limited information available to determine what information would be needed for further design work. Broad plans for site characterization (in 1988) covered topics that were fully expected to be found unnecessary to support further design development. Because of the very low probabilities of significant ash fall thickness at the site during the operational period and the technology that is available for air filtration, existing information is now viewed as adequate for proceeding with design work.

COMMENT 2:
DOE considerations on long-term subsidence are insufficient, which may actually overlook the potential long-term deformation.

RECOMMENDATION
Systematic monitoring of ground movement, including closure measurement, should be conducted during construction and operation of the repository. Also, numerical modeling should be conducted to study long-term ground behavior around the openings, taking into account both the openings and major geological structural profiles.

DOE should address these concerns on long-term deformation around the openings in subsequent progress reports.

DOE RESPONSE
Section 3.3.7 of Progress Report 13 provides an update of rock characteristics modeling that addresses rock quality in the ESF. Sections 3.11.5 through 3.11.10 cover various aspects of current excavation investigations. Deformation of ESF

openings is being monitored, and ground support systems are being compared. Geotechnical instruments installed along the ESF are being used to monitor drift stability, including estensometers and cross-drift convergence pins.

The current plan calls for an extensive monitoring program for all underground openings during MGDS construction and performance confirmation phases. Numerical modeling has recently started that will provide estimates of the probability and size distributions for possible rock falls in the various underground openings.

The DOE agrees that systematic monitoring of ground movement, including closure measurements, should be conducted during construction and operation of the repository. In addition, numerical modeling will be conducted, in conjunction with other studies, to examine long-term ground behavior around openings, taking into account the opening geometry and site-specific geology. Since Progress Report 11 was issued, numerical analyses have been used to examine repository opening designs to better define thermal and thermomechanical responses. Some of these analyses have implications for interpreting long-term repository behavior.

In particular, numerical analyses, using continuum and jointed rock thermomechanical models have been presented in the Mined Geologic Disposal System, Advanced Conceptual Design Report (CRWMS M&O, 1996) and provide a basis for evaluating the potential for subsidence. The problems of ground and subsidence control depend primarily on the extent to which the rock around an opening becomes fractured and yields. [Repository thermal loading is expected to induce relatively high lateral loads that persist for centuries.] The effects of this thermomechanical loading condition are being examined with continuum and discontinuum models.

Numerical modeling has been used to examine the distribution of strength-to-stress ratios for the pillar between typical 5-meter diameter emplacement drifts at a center-to-center spacing of 22.5 meters. This case gives an extraction ratio of about 22 percent. For initial excavation (*in situ* stress only), the zone of potential rock yield extends to a depth of less than one meter from the perimeter of the opening for the lowest limit of rock stiffness. This depth of excavation-induced damage is less than 10 percent of the pillar width and will not significantly influence behavior of the pillar, which in this case remains mostly in the elastic state.

For a combined *in situ* load and a thermal load of 83 metric tons of uranium/acre, the maximum depth of potential yield in the pillar between emplacement drifts is about one meter. Thus, potential rock fracturing is shown to be limited to zones adjacent to the opening. In addition, more than three quarters of the pillar thickness has a strength-to-stress ratio greater than 6.0. The extent and location of possible yield zones and strength-to-stress ratios is such that much of the pillar region is expected to behave elastically for long periods of time after waste emplacement. In addition, thermomechanical modeling indicates that the ground surface will, in fact, rise during preclosure at a rate of about 2.7 mm/year, resulting in a heat-induced heave of about 400 mm at 150 years, increasing only gradually for at least 1000 years.

These analyses indicate a low potential for long-term subsidence. Additional evaluations of postclosure thermomechanical behavior and rock mass strength will confirm the postclosure behavior of the rock mass.

COMMENT 3:
The staff has the following concerns on DOE's sealing strategy based on the details provided in the Sandia report by Fernandez, et al. referenced in Sections 4.5.3 and 4.5.4 (1994):

- *Lack of a field testing plan aimed at assessing long-term seal performance.*

- *Lack of consideration of previous NRC guidance and NRC-sponsored research relevant to sealing.*

- *Lack of integration of analyses supporting the development of borehole seal strategy and other relevant aspects of the DOE HLW Program, such as Total-System Performance Assessment and Site Characterization Activities.*

- *Lack of justification for selection of specific seal performance measures/goals for restricting vertical flow through boreholes.*

- *Superficial treatment of potentially important issues in the development of the seal strategy.*

RECOMMENDATION
In the next progress report, DOE should provide an integrated sealing strategy which provides details of long-term testing and justification for performance goals/measures.

DOE RESPONSE
The sealing program is developing an integrated strategy for the development of a sealing system. The report by Fernandez, et al. (1994) details a strategy for sealing of boreholes. A similar report (Finley, et al., in preparation) is being prepared that discusses a strategy for sealing of the repository openings. In the context of these reports, the term "strategy" refers to answering the basic questions of where to seal, when to seal, and how to seal. As outlined in the following discussion, the details of developing seal materials and a comprehensive test program integrated into the sealing strategy are the subjects of later documents.

In the sealing strategy reports, performance measures are provided. These measures are intended to be goals for the development of a seal system. The strategy, as defined, meets those goals.

The development of performance criteria for the sealing system is tied to other parts of the program, especially repository design, site characterization, and performance assessment. The performance goals of the seal system were specifically developed to meet regulatory requirements and, thus, have a minimal, but quantifiable, impact on the total system performance.

The implementation of the sealing strategy requires both laboratory and field testing. A comprehensive field testing program, tied closely to meeting performance and regulatory requirements was outlined in Fernandez, et. al. (1993). This report was the initial basis for developing Study Plan 8.3.3.2.2.3 for In Situ Seals Testing. This study plan is currently in the DOE review process and focuses on plans for evaluating long-term performance of seals and other issues. The companion Study Plan 8.3.3.2.2.1 describes a laboratory test process and should be released this fiscal year. The DOE is aware of NRC-sponsored research relevant to sealing being done by Professor Damon (University of Nevada, Reno). The project has used Professor Damon's expertise to improve several sectors of the sealing program, including development of the laboratory testing study plan.

The collection of strategy reports, field and laboratory testing plans, and performance assessments to evaluate required seal performance form the complete basis for the sealing system.

REFERENCES:

Fernandez, et al., 1987. Technical Basis for Performance Goals, Design Requirements, and Material Recommendations for the NNWSI Repository Sealing Program, SAND84-1895.

Fernandez, et al., 1993. Initial Field Testing Definition of Subsurface Sealing and Backfilling Tests in Unsaturated Tuff, SAND92-0960.

Fernandez, et al., 1994. A Strategy to Seal Exploratory Boreholes in Unsaturated Tuff, SAND93-1184.

Finley, et al. (In preparation). A Sealing and Backfilling Strategy for the Proposed High Level Repository, SAND94-0645.

QUESTION 1:
Since the creep testing program is still ongoing the conclusive statement by DOE on the creep behavior of tuff seems premature. Is there a report that presents the details of tests presented here?

RECOMMENDATION
DOE should provide more supporting information in a future progress report or refer to a published report.

DOE RESPONSE

Two sets of creep tests have been conducted on Tsw2, the repository horizon welded tuff. Results of the first set have been published in Martin et al. (1995). In the first set, cylindrical samples of rock from Busted Butte were axially loaded under 5 MPa confining pressure and 4.5 MPa pore pressure at temperatures up to 250°C. The loading started at approximately 50 percent of the estimated unconfined compressive strength and was increased in steps, holding the load constant at each step over a period of time ranging from few days to many weeks. In most of these tests little creep strain was observed at each load level (plateau) until the stress approached the failure stress.

In the second set of tests, results of which are to be published in SAND95-1759 (in review) triaxial creep tests were conducted at 10MPa confining pressure and 225°C Constant differential stress of 40, 70, 100 and 130 MPa for approximately 30 or 60 days were applied. The test at 40MPa did not show any creep strain. Small but detectable creep strain were observed in the tests at the higher stress level tests, although one sample at 130 MPa did not exhibit any creep strain.

REFERENCES:

Martin, R.J. III, R.H. Price, P.J. Boyd, J.S. Noel, 1995. "Creep in Topopah Spring Member Welded Tuff", Sandia National Laboratory report SAND 94-2585.

QUESTION 2:

DOE has conducted a preliminary probabilistic risk assessment study for accidental radionuclide releases initiated by either a rock fall or waste transporter accident. However, no details are provided related to this study. Was this study conducted on the Multi Purpose Canister (MPC)?

RECOMMENDATION

To better evaluate the DOE study, more detailed information about the probabilistic risk assessment study to predict performance of the waste containers under different conditions should be provided.

DOE RESPONSE

The preliminary probabilistic risk assessment study for accidental radionuclide releases initiated by either a rock fall or waste transporter accident did not evaluate a specific respository design and as such did not specifically evaluate a MPC, but looked at several different disposal containers. Also, the study was a non-Q draft with preliminary data and results. The results are being rolled into the ongoing overall Design Basis Event Integrated Product Team efforts. In addition, work has continued on the evaluation of waste package performance. This work is described in Chapter 5 of Progress Report 13. Previously, Progress Report 12 described structural evaluations of the results of rock fall and waste package drop for waste packages with multi-purpose canisters. Section 5.1.3 in Progress Report 13 provides additional fuel basket assemblies was also analyzed and is described in this section.

The recently published Advanced Conceptual Design Report provides the results of detailed calculation of waste package response to large rock falls. The calculations indicate that the current design of the waste package affords protection to the waste form from all but a very large and improbable rock fall. Effort is ongoing to quantify the probability of experiencing such a fall.

QUESTION 3:
This section states that 2-m drop of a "canister" has been adopted to simulate handling accidents. The simulation will evaluate the effects of the 2-m drops and will focus on end drops, corner drops, and slap down drops onto an essentially unyielding surface. The 2-m drop tests are different from current Waste Acceptance Preliminary Specification in which 7-m drop of a HLW "glass canister" is adopted to simulate handling accidents [Plodinec and Marra, 1991]. Does the 2-m drop "canister" refer to a 2-m drop of multi-purpose canister (MPC)? What is the basis of the 2-m drop test and the relation to the 7-m drop test?

RECOMMENDATION
In future PR studies, include bases for taking the 2-m drop test.

DOE RESPONSE
The DOE agrees that the description of the waste package modeling in Progress Report 11 was ambiguous. This ambiguity was removed in Progress Report 12 by the following wording: "The waste packages modeled are (a) a multi-purpose canister with 21 pressurized water reactor assemblies in a disposal container and (b) a multi-purpose canister with 24 boiling water reactor assemblies in a disposal container."

A more recent version of the DWPF Waste Form Compliance Plan (1993) concurs that a 7-m drop test is required for high-level waste glass pour canisters, but no statement was found that the drop height was based on considerations of repository operations.

A drop height of 2 m is based on the height required for moving one waste package over another waste package that is lying on its side. The largest waste package currently under consideration (Initial Summary Report for Repository/Waste Package Advanced Conceptual Design, 1994) has a diameter of 1.8016 m .

REFERENCES:
DWPF Waste Form Compliance Plan, Revision 2, June 1993, WSRC-IM-91-116-0, Part 5, Item 750.

Initial Summary Report for Repository/Waste Package Advanced Conceptual Design, Rev. 00, August 29, 1994, Volume 3, B00000000-01717-5705-00015.

QUESTION 4:
This section summarizes DOE's models developed to assess the oxidation and the atmospheric corrosion container. NRC reviews of the PR reference by McCoy [McCoy, 1994] show that corrosion rate increases exponentially with relative humidity. Is this correlation valid at all temperatures above room temperature?

RECOMMENDATION
In future PR studies, explain how the correlation of atmospheric corrosion rate to relative humidity has been validated for higher than ambient temperatures.

DOE RESPONSE
The exponential relationship between corrosion rate and relative humidity has not been validated for higher-than-ambient temperatures. Validation of the model will be necessary before the model can be applied to final design work.

QUESTION 5:
DOE has been studying bimetallic metal systems for container design. Bimetallic metal systems have been considered to have many advantages over single metal systems. One of the advantages is offered by the outer layer which is sacrificed galvanically to protect the inner cathodic layer. Is this protection achievable over a very long period?

RECOMMENDATION
Future PRs should include discussions on the advantages and the expected lifetime, as computed for repository conditions, of bimetallic metal systems.

DOE RESPONSE
The DOE agrees that cathodic protection of the inner barrier might be defeated for some waste package designs and fabrication methods. However, the currently preferred fabrication method is to produce the inner barrier as a welded cladding on the inner surface of the outer barrier. This method leaves no gap between the two barriers, so water cannot flow between them. If a pit should penetrate the outer barrier, the exposed part of the inner barrier will be limited to the area of the bottom of the pit. This gives a very favorable (large) anode-to-cathode area ratio. Because of the metallurgical bond between the two barriers, cathodic protection is expected to be effective until almost all of the outer barrier has corroded away.