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09 May 1986
Ref. No. 1148-07-02

WM-RES
WM Record File D1004
EI

WM Project 10,11,16
Docket No.
PDR ✓
LPDR B,N,S

Distribution:
Buckley
(Return to WM, 623-SS)

Mr. John T. Buckley
U.S. Nuclear Regulatory Commission
7915 Eastern Avenue
Silver Spring, MD 20910

Subject: Review of NNWSI Documents Under Subtask 1 of Task Order 007 of Contract No. NRC-02-84-002.

Dear John,

Enclosed please find document reviews on the following

- "Critical Parameters for a High-Level Waste Repository, Vol. 2: Tuff", Binnall et al., LLL, 1985.
- "Rock Mass Classification of Candidate Repository Units at Yucca Mountain, Nye County, Nevada", Langkopf and Gnirk, Sandia, 1986.

We regret the delay caused by misinterpretation on task order authorization. Copies of the reviews are being sent to Dr. Dinesh Gupta and Mr. David Tiktinsky. Please call me if you have any questions.

Sincerely,

ENGINEERS INTERNATIONAL, INC.

Swapan Bhattacharya
Project Engineer

SB/bt

Enclosure: 2

cc: D. Gupta
D. Tiktinsky

3054

EI DOCUMENT REVIEW SHEET

FILE NO. 1148-07

DOCUMENT Binnall, E.P., H.A. Wollenberg, S.M. Benson, and L. Tsao, "Critical Parameters for a High-Level Waste Repository Vol. 2: Tuff", Publ. by Lawrence Livermore Laboratory, Draft, December 1985.

REVIEWER Engineers International, Inc.

DATE REVIEW COMPLETED 11 April 1986

SIGNIFICANCE TO NRC WASTE MANAGEMENT PROGRAM

The document provides a list of parameters that are considered critical for the design, construction, operation, and closure of a high-level waste (HLW) repository in tuff. The identification and prioritization of these parameters should aid in the development of the site characterization and in situ testing plan, and hence is significant to the NRC Waste Management program.

BRIEF SUMMARY OF DOCUMENT

The document provides a list of geomechanical, geological, hydrological, and geochemical parameters critical to the emplacement of nuclear waste in tuff. The criticality of a parameter is based on the premise that its mismeasurement could lead to incorrect conclusions regarding repository adequacy.

In addition, the relative importance of these critical parameters are presented for each phase of repository activity, viz., site characterization, construction, operation, and closure. Finally, brief discussion is provided on the current state of knowledge of each parameter and the manner in which the parameter values will be measured and applied to repository design.

PROBLEMS, DEFICIENCIES OR LIMITATIONS OF DOCUMENT

1. The list of parameters included is quite comprehensive, however, the relative importance of the individual variables provided are subjective. The methodology used to assign these ranks is not presented in detail, nor is there any discussion regarding the implications of the ranking on site characterization and in situ testing.

2. The different variables are so intimately interrelated that the relative importance ratings are rather spurious. For example, during site characterization, permeability is given a rank of 1 while its primary determinants, viz., fracture properties, induced fractures, rock strength, and fault properties are rated lower.

3. Although not explicitly mentioned, the "canister and support system corrosion" parameter should also include corrosion of "borehole liners."

4. Several past DOE documents (Johnstone et al.[1], 1984; DOE[2], 1986) have provided estimates of rock matrix and fracture deformations through model studies, and important conclusions regarding repository support requirements have been drawn. However, the expected values of this parameter during normal site operation is not provided in Section 3.1.1.3. Furthermore, the normal parameter range for permeability of tuff is presented in Section 3.3.2.1, however, it is stated in Section 3.1.2.1 that "virtually no data are available on properties of individual fractures or the effect of fractures". In the absence of data on fractures and faults, the range of tuff permeabilities presented cannot be meaningful.

5. The rule-of-thumb proposed by Goodman (1980) in Section 3.1.3.4 is inapplicable to the Yucca Mountain site since the rock mass behavior is dictated by the nature of discontinuities rather than the rock material itself.

6. The rock strength parameters presented in Section 3.1.4.1 should include "lithophysal content" of the tuff. In the absence of this parameter, the rock mass strength will be inaccurate.

7. It has been stated at several places, for example in Section 3.1.4.6, that "parameters should be measured at numerous locations to account for spatial variability and anisotrophy." However, the manner in which these highly variable rock properties are to be dealt with in design is not explicitly addressed, e.g. use of sensitivity analysis or geostatistics, etc.

8. The data on drift floor temperatures provided in Section 3.1.6.3 do not agree with those presented in Flores, 1986 (SAND 84-2242 on Retrievability). The discrepancy should be explained.

9. The discussions on several geological parameters such as faulting, folding, erosion, and potential igneous activity (Section 3.2.4) are extremely sketchy. More information should be provided on the impact of these parameters on design, their normal ranges, site sensitivity, and the manner in which these parameters will be monitored and quantified. In particular, past DOE documents have deemphasized the potential problems arising from widespread faulting at the Yucca Mountain site.

RECOMMENDED ACTION

In this document review, only the geomechanical parameters are examined in detail. A complete review should examine the geological, hydrological, and geochemical parameters closely. This document should be kept on hand during review of the NNWSI Site Characterization Plan to ensure that appropriate tests are proposed to measure these parameters.

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[1] SAND 83-0372, "Unit Evaluation at Yucca Mountain, NTS: Summary Report and Recommendation"

[2] Draft Environmental Assessment, Yucca Mountain Site, Nevada

EI DOCUMENT REVIEW SHEET

FILE NO. 1148-07

DOCUMENT SAND 82-2034, "Rock Mass Classification of Candidate Repository Units at Yucca Mountain, Nye County, Nevada", by B.S. Langkopf and P.R. Gnirk, Sandia National Laboratories, Albuquerque, NM, February 1986.

REVIEWER Engineers International, Inc.

DATE REVIEW COMPLETED 01 May 1986

SIGNIFICANCE TO NRC WASTE MANAGEMENT PROGRAM

The document provides methodologies and preliminary data for the classification of the rock masses at the Yucca Mountain site. Based on these methodologies, preliminary ground support estimates are made for the proposed repository openings. This information is required by 10CFR-60.133(e) and is significant to the NRC in the evaluation of the DOE's plans.

BRIEF SUMMARY OF DOCUMENT

The document provides results of the application of two rock-mass classification systems to the four tuff units at Yucca Mountain - the Topopah Spring, Calico Hills, Bullfrog and Tram - and two other tuff units located at Rainier Mesa on the Nevada Test Site (NTS) - the Grouse Canyon and Belted Range tuffs. The two rock classification systems employed are the South African Council for Scientific and Industrial Research Classification System (CSIR) developed by Bieniawski, and the Norwegian Geotechnical Institute Classification System (Q-system) developed by Barton. The data for input into the classification systems were obtained from on-site drill cores and rock exposures. Results showed that the Topopah Spring Member and the Grouse Canyon Member ranked highest in stability, while the Bullfrog and Tram units ranked lowest. Based on these results, it is concluded that support requirements for repository openings in the Topopah Spring will be minimal.

PROBLEMS, DEFICIENCIES OR LIMITATIONS OF DOCUMENT

1. The validity or usefulness of deriving an overall rock mass classification number (or range) for the highly variable rock units at Yucca Mountain is questionable. Also, given the lack of data on fractures and discontinuities (which have been acknowledged in the text as having the greatest influence on the rock mass ratings), the derived range of rock mass ratings may only be slightly better than outright guesses.

In addition, the Topopah Spring member is contended to have the best stability characteristics based on the premise that its upper range is better than Bullfrog or Tram (p. 87). However, the more realistic comparison should be between expected values, and not upper and lower ends of the ranges. For example, if more than 90% of the Topopah Spring unit has rock quality near the lower end of the range, and the 90% of Calico Hills is closer to the upper range, in terms of expected value the Calico Hills is superior. Therefore, what is needed is a sensitivity analysis that will adequately address the variability of the rock masses and assign likelihoods for a certain quality of rock mass to occur over a greater area.

It should also be realized that rock mass quality in an actual repository is expected to vary significantly over relatively short distances. The principal usefulness of rock classification systems lies in recording those variations and adopting appropriate support measures to overcome zones of lower quality rock. Hence, to use these systems to compare and contrast entire rock units may be overstretching their capabilities.

2. Although the concern on whether tuff has unique qualities unlike those rocks whose case histories were used to develop the CSIR and NGI classification systems has been addressed (p. 103), no mention has been made about the abundance of lithophysal cavities in the Topopah Spring and their impact of rock mass quality. Experience at the G-Tunnel is not sufficient to conclude that lithophysal will not affect stability.

Another concern that has not been adequately addressed involves the inability of the classification systems to take thermal stresses into account. It is claimed that the rock mass ratings will not change significantly (p. 106). However, the contention is based on a preliminary computer model by Johnstone et al. (which has been commented upon in past NRC publications), and few small-scale non-representative heater tests. In this light, it is perhaps advisable for the DOE to use a discount factor on the final ratings to accommodate thermal stresses, and stress concentrations due to multiple openings.

3. The input data used to develop the rock mass ratings, in most instances, appear to be extremely uncertain and discrepancies were noted in some cases. These are summarized below.

a. Based on data presented in the draft Environmental Assessment (EA) for Yucca Mountain (p. 6-274), Tillerson and Nimick, 1984 (p. 99), and Johnstone et al., 1984 (p. 9), the unconfined compressive strength of the Topopah Spring was reported to vary between 91 to 95 MPa. However, the 95% confidence interval used here is 140 to 185 MPa. In the CSIR technique, this translates to a five-point discrepancy in the overall rating. Similarly, the stress reduction factor (SRF) falls on the borderline between two ranges in the Q-system.

b. According to Dravo Engineers, 1984 (p. 19) and Sprengler et al., 1984 (Appendix), the indirectly computed RQD using Core Index of the Topopah Spring Member for USW G-4 between the depths of 1,100 ft to 1,300 ft varies from 0 to 35. In this document, an average of 79.7 was used using core index data. The discrepancy is too large to be attributed simply to the different methods of translating core index to RQD values.

c. The sensitivity of joint data to the final rock quality rating for both CSIR and Q-System is very high. However, data on rock joint properties are by far the least reliable of all input data used in this study. In fact, data from the G-Tunnel appears to be the predominant source of data for the Topopah Spring Member (as noted in p. 40 and 71)!

Although Schmidt Equal Area Nets are presented for each unit, these were not directly used in the models. The Topopah Spring Schmidt plot (p. 41) appears to indicate the presence of at least five separate joint sets, including bedding, while the input to the models were only 2-3 joint sets.

Quite surprisingly, although little or no information appeared to be available on the number of joint sets, the document provides 22 pages of information on joint spacings. The point being made here is that if uncertainty regarding the number of joint sets present is high, chances are good that joint spacing data are not accurate either.

d. The maximum water inflow rate used in the analysis has been derived using the average flux of <u>0.2 mm/yr</u>. Based on estimates used in the draft EA, the average flux in the unsaturated zone was taken to be <u>1 mm/yr</u> (p. 6-137). In addition, this method of estimating inflow does <u>not</u> provide the <u>maximum</u> inflow as has been claimed, rather it provides an <u>average</u> estimate. Maximum water inflows will probably occur at various parts of the repository where either perched water zones or water-bearing fault zones are encountered. Hence, the value used in this report is far from conservative.

e. The excavation support ratio (ESR) value used for repository drifts is 1 (p. 97). A more appropriate value may have been 0.8 since this value pertain to such sensitive structures as nuclear power stations, railroad stations and factories. Due to the hazardous nature of the material to be stored in the repository, the factor of safety required should be higher than that for general roadway and railway tunnels.

4. It is not surprising that the Topopah Spring and Grouse Canyon units fell into the same rock class group considering that most of the joint information for Topopah Spring were obtained from the G-Tunnel. It does not necessarily follow that since the G-Tunnel is generally stable that a repository in Topopah Spring will be similarly stable (as claimed on p. 99). Furthermore, to prove this point the document provides one example of an intersection in the G-Tunnel where the rock shows no signs of distress. It is extremely ambitious on the part of the DOE to conclude on the basis of one observation that support requirements prescribed for the entire repository are conservative.

5. This comment has no direct bearing on the conclusions of the report. However, it may be significant to the performance objectives of a repository in tuff. As noted on p. 9-10 of the document, the borehole USW G-3/GU-3 did not contain the Calico Hills unit. Since Calico Hills is claimed to be the most significant hydrologic barrier between a repository at Yucca Mountain and the water table, its absence may raise questions on the minimum ground water travel time estimates provided in the draft EA.

RECOMMENDED ACTION

The document in its present form provides little additional information over what is already fairly well known. The Topopah Spring Member has long been chosen as the target unit, and hence comparisons with other tuffs is somewhat academic at this time. The derived RMR and Q values are also of limited usefulness due to their wide ranges and inadequate input data. The only recommended course of action may be to perform parametric and sensitivity studies in order to get a feel for which rock properties of the Topopah Spring are most critical with regard to stability and which properties appear to be of greatest concern. Sensitivity studies may also establish the expected spatial variability of rock properties of the Topopah Spring Member.