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Dr. Gary K. Jacobs
Environmental Sciences Division
Building 1505/Room 312
P.O. Box X
Oak Ridge National Laboratory
Oak Ridge, TN 37831

Dear Dr. Jacobs:

SUBJECT: CONTRACT NO. NRC-50-19-03-01, FIN B-0287, ORNL NO. 41-37-54-92-4, "TECHNICAL ASSISTANCE IN GEOCHEMISTRY" MAY (1986) MONTHLY PROGRESS REPORT

I have reviewed the May monthly progress report dated June 13, 1986. Based on my review, I have the following comments.

Task 1 - BWIP Geochemical Technical Assistance

- Progress to date is satisfactory.
- An appendix 7 meeting is being planned for the week of 21 July. The meeting will address waste package testing and geochemical conditions near waste packages (see Attachment 1).
- BWIP FEA draft comments will be sent to you for review by 14 July. Please be prepared to provide your feedback by 22 July.

Task 2 - Yucca Mountain Geochemical Technical Assistance

- Progress to date is satisfactory.
- Draft comments on the FEA for NNWSI will be sent to you for review by 14 July. Please be prepared to provide your feedback by 22 July.

Task 3 - Salt Site Geochemical Technical Assistance

- Progress to date is satisfactory.
- Draft comments on the FEA for the Deaf Smith site are enclosed for review (Attachment 2). Our draft comments on the FEA's for Richton Dome, and Davis Canyon will be sent before 21 July. Please be prepared to provide us with your comments by 6 August.

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Task 4 - Short Term Technical Assistance

- Progress to date is satisfactory.

- I have reviewed the draft report of the proceedings of the sorption workshop held May 13-15, 1985. My comments are as follows:

  1) The preliminary draft report provides a good review summarizing the conclusions of the workshop. However, even though it was generally agreed at the workshop that it was important to understand the geochemical processes that may affect radionuclide transport, little consensus was reached on the required level of detail, understanding, or the priorities for the work that needs to be done. Consideration should be given to discussing this aspect of the workshop.

  2) As discussed during the workshop, the report should include references and some discussion to support the uncertainties caused by the lack of detail/understanding of specific geochemical processes. The report lacks this discussion and detail. It is suggested that when the draft is sent to the rest of the workshop participants, they be asked to contribute these details.

Task 5 - Project Management

- Progress to date is satisfactory.

The action taken by this letter is considered to be within the scope of the current contract (FIN B-2482). No changes to cost or delivery of contracted services and products are authorized. Please notify me immediately if you believe that this letter would result in changes to cost or delivery of contracted products.

Original Signed By

David J. Brooks
Geochemistry Section
Geotechnical Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

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Comment 1

Host Rock Clay Content and Dehydration - (Draft EA Major Comment 4)

Guidelines on Geochemistry 10 CFR 960.4-2-2(b)(3),(b)(4),(c)(1), and Rock Characteristics 960.4-2-3(c)(2)

In NRC staff major comment 4 on the draft EA for Deaf Smith County, the concern was raised that not all of the data or uncertainties in the data were used in evaluating the amount of clay impurities within the San Andres Unit 4 salt. One of the reasons this is of concern is because an underestimation of the clay content leads to an underestimation of brine content in the salt, thus affecting performance assessment calculations. In the draft EA, it was stated that the Unit 4 salt contains 3 volume percent clay. The final EA (Section 3.2.7.1, page 3-104) is amended to state that clay averages between 3.5 and 4.5 volume percent in the Unit 4 salt. This average is based on mudstone (7 to 9 volume percent) containing approximately one-half clay minerals (Hovorka et al., 1985). For predictions of brine content in the Unit 4 salt, 8 volume percent mudstone containing 15.0 weight percent water is assumed. Using these and other assumptions, what is believed to be a conservative brine content of 4.14 volume percent is calculated, leading to the conclusion that the 5.0 volume percent used in performance assessment calculations is conservative.

The NRC staff believes that assumptions made in the final EA may be incorrect, leading to nonconservative estimates of brine content. The value of 8 percent mudstone used to calculate the amount of water in mudstone is based on limited

data; it is an average of mean contents found in 3 wells between 3 and 16 miles from the site. The well closest to the site, J. Friemel No. 1, which is stated to be lithologically "a good representation of site conditions" in the final EA (Section 3.2.3.2, page 3-27, paragraph 5), has a mudstone content of 9 percent. Other wells in the Palo Duro Basin further from the site are reported to have mudstone contents up to 10 percent (Hovorka et al., 1985). Although 9 or 10 percent mudstone appears to be a trivial difference compared to 8 percent, significantly higher brine contents are calculated using the larger mudstone estimates.

In addition, some incorrect statements are made in the final EA in calculating the amount of water in halite (p. 3-105, paragraph 1, #1). Fisher (1984) reports water contents for only 16 lower San Andres Unit 4 "clean" salt (greater than 90% halite) cores, not over 150 as reported in the final EA (the remainder are from Unit 4 "clay" salts or other salt-bearing units). Also, the 0.4 weight percent water reported by Fisher (1984) is for the total San Andres Formation; the average water content for Unit 4 salt is reported to be 0.48 weight precent (p. 10). The final EA uses a value of 0.5 weight percent in calculating brine contents, an amount stated to be conservative. The analytical error associated with the value reported by Fisher (1984) implies that, based on the data collected to date, the average amount of water in Unit 4 salt can be in excess of 0.5 weight percent. Due to the small number of samples analyzed and the analytical uncertainties, it appears that 0.5 weight percent water in halite is not defensibly conservative at present.

Using more defensibly conservative values of, for example, 0.7 weight percent water in clay-free halite and 10 percent mudstone leads to a calculated maximum amount of brine available in Unit 4 salt in excess of 5 volume percent (5.32 volume percent), the value used in performance assessments and stated to be conservative. Therefore, based on the amount and uncertainties of the data collected to date, it does not appear that 5.0 volume percent brine is conservative, as claimed in the final EA. For guideline 960.4-2-2(c)(1), concerning groundwater conditions that affect the stability or chemical reactivity of the engineered barrier system, a favorable finding is made based solely on performance assessment calculations, including analyses of the migration of brine. Nonconservative volumes of brine used in the calculations weakens the evidence used in evaluating this condition. In addition, brine migration calculations are used to support favorable findings for guidelines 960.4-2-2(b)(3), concerning mineral stability, and 960.4-2-2(b)(4), concerning radionuclide solubility. For guideline 960-4-2-3(c)(2), concerning changes in rock properties due to repository conditions, the value of clay content from the draft EA (3%) is used instead of the recalculated values presented in the final EA.

REFERENCES

Fisher, R.S., 1984. Amount and Nature of Occluded Water in Bedded Salt, Palo Duro Basin, Texas, OF-WTWI-1984-50, prepared for U.S Department of Energy by the Bureau of Economic Geology, The University of Texas at Austin, Austin, TX.

Hovorka, S.D., B.A. Luneau, and S. Thomas, 1985. Stratigraphy of Bedded Halite in the Permian San Andres Formation, Units 4 and 5, Palo Duro Basin, Texas (draft), OF-WTWI-1985-9, prepared for U.S Department of Energy by the Bureau of Economic Geology, The University of Texas at Austin, Austin, TX.

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Comment 2

Radionuclide Mobility - (Draft EA Major Comment 5)

Guidelines on Geochemistry 10 CFR 960.4-2-2(b)(2),(c)(3)

In the NRC staff major comment 5 of the draft EA for Deaf Smith County, concerns were raised that evidence regarding processes that affect radionuclide migration was limited and, in some cases, evaluations were incomplete. Examination of the final EA indicates that discussions of some processes of concern have been modified to include references to uncertainties in the data (Section 6.3.1.2.2, pages 6-100 to 6-102, items 3 through 6); however, concerns with redox conditions have not been factored into discussions and evaluations presented in the final EA related to the Geochemistry Guideline (Section 6.3.1.2.2, pages 6-100 to 6-101, items 1 and 2).

The NRC staff is concerned that kinetic effects may prevent the establishment of redox equilibria and inhibit the transformation of actinide species which may be in the oxidized state when dissolving from the waste to reduced species, which are less mobile. In fact, it is admitted in the final EA that the oxidized species $UO_2(CO_3)_3^{4-}$ "can be thermodynamically stable under reducing conditions" (Section 6.3.1.2.2, page 6-101, item 5). However, in more detailed discussions on redox conditions, it is stated that reducing conditions expected in the host salt and deep basin aquifers "will promote the precipitation of many redox sensitive radionuclides" (page 6-100, item 1) and "redox-sensitive

radionuclides are expected to be present in their lower oxidation states" (page 6-101, item 2).

The NRC staff considers that there is a lack of recognition in the final EA that kinetic effects may allow redox-sensitive radionuclides to remain in more soluble oxidized phases, resulting in an unsupported finding for favorable condition 960.4-2-2(b)(2). It is in the discussion of items 1 and 2 of this condition, precipitation of radionuclides in the host salt and in the deep basin aquifers, that the bulk of the evidence supporting a favorable finding is presented. If uncertainties regarding redox conditions are factored into the analysis, then the evidence supporting a favorable finding for this condition is not substantial. For guideline 960.4-2-2(c)(3), concerning pre-waste-emplacement redox conditions, although considerable indirect evidence is presented supporting reducing conditions, it is not certain that oxidized species of radionuclides will be reduced.

Comment 3

Modeling of Brine Migration - (Draft EA Detailed Comment 6-27)

Guidelines on Geochemistry 10 CFR 960.4-2-2(b)(3),(b)(4),(c)(1)

In NRC staff detailed comment 6-27 on the draft EA for Deaf Smith County, the concern was raised that the model used to simulate brine migration in salt, BRINEMIG, was inappropriate for that task. In the final EA (Section C.5.11, pages C.5-49 to C.5-50), it is admitted that the BRINEMIG code was developed using unrealistic assumptions concerning brine movement in salt. Nevertheless, BRINEMIG is still used in the final EA to predict the movement of brine in salt. The NRC staff remains convinced that BRINEMIG is inappropriate in this context and should not be used to model brine movement in a salt repository.

BRINEMIG has a number of limitations, including: (1) the assumption that Unit 4 salt is a homogeneous and isotropic medium; (2) the use of an empirical equation derived from intracrystalline brine migration studies (Jenks and Claiborne, 1981) to model intercrystalline brine migration, which will probably be a more significant process concerning brine movement; (3) data used to validate the code that are probably not applicable to HLW disposal applications; and (4) only flow in a radial direction is modeled. These limitations are discussed more fully in NRC staff detailed comment 6-27 on the draft EA. In addition, the Jenks-Claiborne equation is dimensionally inconsistent. The use of this equation has led to underpredictions of brine flow rates in in-situ heater experiments at the Waste Isolation Pilot Plant

(WIPP) facility (Nowak, 1986). The justification given in the final EA for continuing to use BRINEMIG is that predictions of waste package lifetimes are insensitive to brine migration rates (Section C.5.11, page C.5-49, paragraph 4). The NRC staff believes that this is a specious justification that de-emphasizes the need to obtain a mechanistic understanding of this process.

Results from BRINEMIG are used to support findings for favorable conditions (b)(3) and (b)(4) and potentially adverse condition (c)(1) of Guideline 960.4-2-2. The NRC staff considers that the use of BRINEMIG has produced results which are inappropriate for use in supporting these findings.

REFERENCE

Jenks, G.H., and H.C. Claiborne, "Brine Migration in Salt and its Implications in Geologic Disposal of Nuclear Waste," Oak Ridge National Laboratory, Oak Ridge, TN, ORNL-5815, 1981.

Nowak, E.J., "Brine Migration Studies in the Waste Isolation Pilot Plant (WIPP)," abstract, Waste Management '86 Meeting, Tucson, AZ, March 2-6, 1986.