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MEMORANDUM

DATE: December 22, 2000
TO: Mal Murphy [malmurphy@home.com]
CC: Danielle Fife **[**dfife@nrff.com]
RE: **BIOSPHERE MODEL AMR Reviews**
Unsaturated Zone Flow Models and Submodels
MDL-NBS-HS-000006

This AMR is one of the most comprehensive AMRs I have reviewed, and it appears to have numerous critical factors. Key Items are:

1. p. 23, Section 4. Notes that "Uncalibrated fracture and matrix properties" have been used. This is *uncalibrated*, not *unqualified*. Calibrated in this AMR basically means they have run the values through a model.

2. p. 31, Section 5, Assumption 2. "The bottom model boundary representing the water table is subject to fixed gas pressure." What, if anything, does this imply regarding potential transport of radionuclides from the gas phase above the water table, into the water phase below the water table. Although such transport may be small, this topic does not appear to be addressed in this AMR.

3. p. 32, Section 5, **Assumption 8. "Water flow through the UZ is assumed to occur under steady-state conditions. Transient, "fast pathway" flow, such as has conveyed ^{36}Cl to the ESF horizon, is assumed not to contribute significantly to the total flow through the UZ." No rationale is presented on this page for this astonishing**

assumption, and one wonders whether the "assumption" drives the conclusion later in this AMR.

4. p. 41, Section 6.1.2, Paragraph 3. States "the interflow between fractures and matrix has to be handled using some quasi-steady-state flow assumption". Not so. Petroleum models have tested steady state, quasi-steady-state, and fully transient modes. They just didn't write their code to allow it. It probably has little or no effect, but they could easily test that by computing the time constant for reaching quasi-steady state flow in the matrix blocks to see whether it is a problem or not.

5. p. 51, Section 6.2.3, Paragraph 2. What they call "calibrated" is seen here to be really just bounded by looking at parameter ranges.

6. p. 52, Section 6.2.4, Top Paragraph. "**In general, it takes simulation times of thousands to millions of years for the system to equilibrate** [emphasis added]. Rapid flow through fractures, plus the slow response in the matrix, makes it very difficult to obtain steady-state solutions numerically." **THIS STATEMENT IS VERY IMPORTANT, AS IT MAY INDICATE A PROBLEM WITH THE UZ FLOW MODEL – PROBABLY IN THE DATA SETS USED**. It is not clear from the statements made whether this refers to a computing problem, or to an actual equilibration time when the steady-state boundary conditions are changed. If it is a problem with the data sets or computation scheme, that should be brought to light of day. If it is an actual equilibration time question, it would imply that the system has never been in steady state, and is not now, but rather has all the transients since the mountain began! That could explain a lot of discrepancies, and lead to many more, between observations at different levels. It also would be extremely interesting given the observed daily effects of atmospheric pulsing.

7. p. 55, Section 6.2.5, 1st full paragraph on the page. This paragraph cites minimal global mass errors of inflow and outflow as implying steady-state solutions were obtained. That

statement is true only if the pressures and rates satisfied the relevant flow and conservation equations at all gridblocks in the final time step, and that those values were not changing from time step to time step.

8. p. 61, Section 6.2.5, 1st full paragraph on the page. States "because percolation fluxes of unsaturated flow cannot be readily measured in the field, indirect data and model results are used to estimate these fluxes." This is true, but is a limitation.

9. p. 65, table 6-11. The computed fraction of flow passing through the matrix seems large – up to 29.96% in one run – which may indicate too much fracture-matrix interaction.

10. p. 79, Figure 6-21. The UZ#16 Cl concentrations were very poorly matched. Their calibrated model on p. 83, Figure 6-27, does a much better job. What were the main data changes causing this improved match on this well? Why were they so far off to begin with?

11. p. 86, Section 6.5.1, last full paragraph on page. Throughout the rest of this report, it refers to an active fracture model of Liu et al. Has anyone reviewed that model? I will get a copy of that paper. Later in the same paragraph, it states "Many UZ pore waters are oversaturated with calcite, possibly indicating kinetic inhibition or possibly measurement errors." I presume that Don Shettel can comment on this.

12. p. 123, Section 6.7.1, Paragraph 2. For transport calculations from the potential repository to the water table, they used a single constant molecular diffusion coefficient for matrix diffusion of the conservative component, and a different one for reactive component. Do all layers between the potential repository and the water table have the same matrix properties otherwise (i.e., permeability, porosity, etc.)? If not, why should they have the same diffusion constant?

13. p. 129, Paragraph 1. **Inconsistency in computed travel times for different cases**. "The predominant factors in groundwater travel times or tracer transport [from the potential repository to the water table], as indicated by Figures 6-54, 6-55 and 6-56, are (1) surface-infiltration rates or net water recharge and (2) adsorption effects, whether the tracer is conservative or reactive." This is so obviously true. Note that a considerable number of cases have as much as 30% fractional mass breakthrough within 10 years. Contrast this now with the ^{36}Cl runs from the land surface to the repository level on p. 139 and Figure 6-60 on p. 140, which indicate "there is about 1% mass breakthrough during 10 to 100 years after tracer release on the ground." Their model shows time scales of 1000+ years to get 10% fractional mass breakthrough at the repository level from the ground surface. The Alcove 1 results as shown in Figure 6-65, p. 148 show in essence 100% of the tracer passing through there in 1000 days or 3 years, with 10% in approximately 100 days. **Although these are different calculations for different cases, the wide divergence in travel times should be a cause for concern**.

14. p. 159, Section 7.5, Paragraph 3. All 18 simulated percolation flux cases indicated little lateral diversion by the PTn unit. In Conceptual Model #2, there was "significant lateral flow at perched or zeolitic layers", while in Conceptual Model #1 (preferred by the authors), there was much less lateral diversion.

15. p. 161, Section 7.8, Paragraph 2. "Even though considerable progress has been made in this area, uncertainty associated with the UZ Model input parameters will continue to be a key issue for future studies." Five major areas of uncertainty are listed, including net infiltration rates; quantitative descriptions of heterogeneity if welded and non-welded units, "especially below the proposed repository"; fracture properties in zeolitic units and faults; lateral diversion by zeolites in the CHn units; and transport properties. **How can they ever expect to adequately characterize the rock below the repository if they never drill it?**