August 27, 2001

MEMORANDUM TO: C. William Reamer, Chief
High-Level Waste and Performance Assessment Branch
Division of Waste Management, NMSS

FROM: Neil M. Coleman and Hans Arlt, Hydrologists /RA/
High-Level Waste and Performance Assessment Branch
Division of Waste Management, NMSS

SUBJECT: TRIP REPORT: WORKSHOP ON YUCCA MOUNTAIN SATURATED ZONE FLOW AND TRANSPORT (KEY TECHNICAL ISSUE: UNSATURATED AND SATURATED FLOW UNDER ISOTHERMAL CONDITIONS)

During August 1-3, 2001, the Center for Nuclear Waste Regulatory Analyses (CNWRA) in San Antonio, TX, hosted a workshop on Yucca Mountain saturated zone flow and transport. The work is being done under the Key Technical Issue: Unsaturated and Saturated Flow Under Isothermal Conditions (USFIC). Attendees from the NRC staff were Hans Arlt, Neil Coleman, and Latif Hamdan. Hamdan attended on behalf of NRC's Advisory Committee on Nuclear Waste. CNWRA attendees included Jim Winterle, David Farrell, English Pearcy, Paul Bertetti, Scott Painter, Melissa Hill, and John Stamatakos. The workshop consisted of interactive presentations and discussions about saturated zone issues at Yucca Mountain that remain to be closed. One topic of discussion was the need to update NRC's hydrogeologic framework model (HFM) for the Yucca Mountain region. This HFM, developed using the Earth Vision code, covers a large portion of the Amargosa Desert including Crater Flat, Jackass Flats, and the Amargosa Farm region. The HFM integrates data from the DOE geologic framework model (GFM 3.0), borehole data, and surface geophysical data.

As a group the attendees agreed that the HFM needs to be updated to incorporate the new drilling data from Nye County's program. However, some of the tuff units encountered in the Nye wells have yet to be firmly identified. Until that work is complete, the HFM update should be limited and focus on the stratigraphy that has been well established. This meeting helped to finalize the list of milestone products to be completed under USFIC during FY02. Overall, the CNWRA saturated zone work discussed at this workshop will effectively support future issue resolution interactions with DOE.

Details of the meeting are provided in the attachment. If you would like additional information on any aspect of the trip, please contact us.

TRIP REPORT ATTACHMENT

During August 1-3, 2001, the Center for Nuclear Waste Regulatory Analyses (CNWRA) in San Antonio, TX, hosted a workshop on Yucca Mountain saturated zone flow and transport. Attendees from the NRC staff were Hans Arlt, Neil Coleman, and Latif Hamdan. Hamdan attended on behalf of NRC's Advisory Committee on Nuclear Waste. CNWRA attendees included Jim Winterle, David Farrell, English Pearcy, Paul Bertetti, Scott Painter, Melissa Hill, and John Stamatakos. Other attendees were consultants to the CNWRA, including Chen Zhu of the University of Pittsburgh and Alan Woodbury of the University of Manitoba, Canada. Zhu is a specialist in the use of radioisotopes to study groundwater flow systems. Woodbury specializes in the modeling of complex groundwater and contaminant systems. Another attendee, a student at Purdue named Danielle Murray, is developing a thesis on Yucca Mountain stratigraphy.

The workshop consisted of interactive presentations and discussions about saturated zone issues at Yucca Mountain that remain to be closed. The work is being done under the Key Technical Issue: Unsaturated and Saturated Flow Under Isothermal Conditions (USFIC). Darrell Sims led the discussion of the CNWRA hydrogeologic framework model (HFM) for the Yucca Mountain region (Sims et al., 1999). This HFM, developed using the Earth Vision code, covers a large portion of the Amargosa Desert including Crater Flat, Jackass Flats, and the Amargosa Farm region. The HFM integrates data from the DOE geologic framework model (GFM 3.0), borehole data, and surface geophysical data. Areas of greatest hydrogeologic uncertainty in the HFM include the Paleozoic rocks that underlie the region (it was stressed that the Paleozoic rocks are not all carbonates as is sometimes assumed), and a caldera complex to the north. The purpose of the HFM is to provide a consistent foundation to develop independent groundwater flow models for the region. Independent flow models are useful for several reasons. These include (1) providing a basis for the abstraction of flow and transport for NRC's Total-System Performance Assessment (TPA) code; (2) providing a means to explore alternative conceptual models for site-scale hydrogeology and structural controls on flow; and (3) providing boundary conditions for smaller models to evaluate potentially important processes such as heterogeneity and preferential flow channels in alluvium.

Scott Painter provided an overview and discussion of the first saturated zone model to be based on the HFM, a limited-scale 3-D water and heat flow model for the saturated volcanic tuffs east of Yucca Mountain. Results from this model indicate that the observed variability of temperature at the water table can be explained by both the variability in thickness of the overlying unsaturated zone, and by vertical movement of water within permeable tuffs as it flows across a layer offset at the Paintbrush Canyon Fault. This result suggests earlier conceptual models of preferential flow paths or upward flow from the Paleozoic aquifer are not needed to explain the water-table temperature patterns.

Jim Winterle led the discussion of the 3-D site-scale isothermal model of saturated zone flow that is being developed at CNWRA using the GMS/MODFLOW software package. This model is in the early development stage and much of the discussion focused on appropriate boundary conditions, possible hydrologic properties of faults and other structural features. Results from preliminary flow model runs showed that it is not possible to obtain a reasonable match to observed hydraulic heads by simply assigning constant hydrologic properties to the various HMF units. It was agreed that zones of differing hydrologic properties should be added to account for structural controls on flow along Solitario Canyon Fault, Highway 95, and in the

area of the caldera complex to the north. A goal of the model is to achieve the best match to observed heads with a minimum level of complexity because complexity becomes increasingly difficult to justify with available data. This will help assess whether the high level of complexity in the layering of the DOE saturated zone model results in any undue benefit to performance assessment that is not adequately justified by data. In addition, once the CNWRA model is reasonably calibrated, alternative conceptual models for flow can be evaluated to provide risk-informed insights. For example, the model will allow NRC to evaluate the potential significance of unmapped fault zones; if such zones act as preferential flow paths, streamtubes can be extracted from the flow model for input to NRC's TPA code to evaluate risk significance. The development of this model will be documented in an USFIC milestone on concepts of saturated zone flow in early FY02.

Ron Green discussed a proposal to develop a saturated zone heat and water flow model that would be calibrated to match temperature data as well as water levels. Alan Woodbury (University of Manitoba) added to the discussion a presentation of how a Bayesian approach can be used to calibrate such a model using multiple calibration parameters. The purpose of this effort would be to evaluate potential hydraulic communication between the deep regional Paleozoic aquifer system and the upper Tertiary volcanic and alluvial aquifer systems. Hydraulic communication between these two aquifer systems could be especially important south of Yucca Mountain near the 18-km compliance boundary, where the older tuffs that act as a confining unit thin and pinch out. This model is in the early stage of development where the feasibility of the approach is being assessed.

Paul Bertetti discussed the groundwater chemistry database that was recently compiled at CNWRA and provided to NRC as a Milestone for the Radionuclide Transport KTI. Chen Zhu (University of Pittsburgh) discussed potential uses for geochemical data in saturated zone. He presented some of the work he has done for CNWRA to estimate differences in Pleistocene and Holocene recharge at Yucca Mountain based on chloride data from perched water. Dr. Zhu also discussed the usefulness of obtaining organic carbon-14 age estimates for groundwater samples from saturated zone wells. Groundwater age estimates would be useful to validate flow model results. Dr. Zhu has access to laboratories that can perform such analyses and can advise CNWRA or NRC staff on appropriate sampling protocols.

John Stamatakos and Danielle Murray discussed the stratigraphy and paleoenvironmental history of the Rocks of Pavits Spring and the Horse Spring Formation. These units pre-date the thick tuff deposits, and can apparently be correlated over large areas of the Amargosa Desert. One preliminary finding is the presence of relatively unfractured siltstones, about two hundred meters thick, that occur directly above the Paleozoic rocks. This siltstone unit can potentially serve as a confining unit to restrict groundwater flow between the Paleozoic aquifer system and the overlying rocks and sediments. This confining unit could be important to the long-term performance of a potential repository at Yucca Mountain.

Reference: Sims, D.W., J.A. Stamatakos, D.A. Ferrill, H.L. McKague, D.A. Farrell, A. Armstrong. *Three Dimensional Structural Model of the Amargosa Desert, Version 1.0: Report to Accompany Model Transfer to the Nuclear Regulatory Commission*. CNWRA Letter Report. San Antonio, TX: Center for Nuclear Waste Regulatory Analyses. 1999.

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