United States Nuclear Regulatory Commission
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(Friday, February 28, 1997)

NOTE TO EDITORS:

The Nuclear Regulatory Commission has received the attached report from its Advisory Committee on Nuclear Waste. The report, in the form of a letter, provides comments on flow and radionuclide transport at Yucca Mountain.

Attachments:
As stated

February 13, 1997

The Honorable Shirley Ann Jackson
Chairman
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Dear Chairman Jackson:

SUBJECT: COMMENTS ON FLOW AND RADIONUCLIDE TRANSPORT AT YUCCA MOUNTAIN

Evaluation of the strategy for dealing with disposal of high-level radioactive wastes will require a license applicant to demonstrate convincingly that a site has hydrogeological characteristics that are appropriate for mitigating releases of radionuclides to the biosphere. Consequently, the Advisory Committee on Nuclear Waste (ACNW) continues to hold as a high priority the evaluation of NRC Key Technical Issues that relate to flow of water and the transport of radionuclides at Yucca Mountain. The ACNW held a working group on flow and radionuclide transport on September 26, 1996. The Committee heard from representatives of the Los Alamos National Laboratory, the Lawrence Livermore National Laboratory, the Lawrence Berkeley Laboratory, the Electric Power Research Institute, the Department of Energy (DOE) Yucca Mountain Project Office, and the University of Arizona.

Following the presentations at the working group, and on the basis of other experience as well, the ACNW has several recommendations that reflect our continuing interest in the important issue of transport of radionuclides at the site.

- Because of the importance of radionuclide transport and the effects of sorptive processes on radionuclide concentrations in groundwater, as recognized in the DOE Waste Containment and Isolation Strategy, the NRC should maintain a critical level of expertise within its staff and at the Center for Nuclear Waste Regulatory Analyses (CNWRA) related to flow and radionuclide transport.

- The NRC staff should examine available information from DOE to ensure that the abstraction from detailed models to the total system performance assessment (TSPA) models are valid and transparent and that the details of individual models are clear. As part of this examination, the NRC should follow closely the appropriate DOE expert elicitations and TSPA abstraction workshops.

- It is not clear that DOE is developing a comprehensive chemistry model for the site for analyzing transport processes. Accordingly, the staff should ensure that the CNWRA continues to develop coupled chemical and hydrologic transport models to determine whether these coupled processes are important to demonstrating compliance with a risk- (or dose-) based standard. As part of this model development, the staff should continue to support the work at the CNWRA to determine the potential importance of “foreign” materials (such as concrete and steel) in the performance of the repository.

- The Apache Leap Research Site (ALRS) could be used as a location to collect important data on colloid migration through a fractured unsaturated tuff. The NRC should consider supporting work to observe naturally occurring colloids and possibly to introduce colloidal “tracers” at the ALRS to generate data useful for bounding calculations at Yucca Mountain.

DETAILED COMMENTS

Total System Performance Assessment Issues

Radionuclide transport by subsurface water at the Yucca Mountain site is thought to be the most significant pathway in terms of risk to the critical group. The evaluation of risk will be accomplished through TSPA. It is necessary to establish the important processes and mechanisms for retaining and retarding the release and transport of radionuclides from the repository. These processes attenuate radionuclide concentrations in the ground water and thus reduce the calculated dose to a member of the critical group. To be effective in evaluating of the expected license application for Yucca Mountain, the NRC staff will have to be able to understand and critically evaluate the work of DOE and its contractors on transport phenomena. The ACNW is concerned that the NRC staff had to eliminate radionuclide transport work at the CNWRA. The issue remains critical to assessment of the repository, and we encourage reinstatement of CNWRA activities in this area.

An evaluation of the Yucca Mountain site with respect to standards will require the framework of a risk assessment. The ACNW is not convinced that the DOE program is strongly integrated. We are concerned that the transition from models developed in somewhat isolated "science" programs of DOE contractors to those required for practical, "engineering" system-level performance assessment may be opaque. It is essential that the NRC staff fully understand the abstraction process. Currently, DOE is planning and conducting a series of expert elicitations related to the performance assessment resource base. The NRC staff needs to continue evaluating these activities, as well as the DOE abstraction workshops.

Flow and Transport in the Vadose Zone and the Saturated Zone

Samples recovered from the Yucca Mountain Exploratory Studies Facility (ESF) show apparent "bomb-pulse" ^{36}Cl on or near some faults that are mapped at the surface[1]. The isotopic data, which provide important insights into transport processes, reinforce the notion that an interconnected set of fractures forms a transport pathway for radionuclides at Yucca Mountain. DOE models for flow and transport in the vadose zone must employ flow along faults and fractures and diffusion from the fractures into the matrix as important processes. There appears to be a paucity of critical information on hydrological characteristics of fractures and faults and their impact on the transport of radionuclides.

Models for the vadose zone employed by DOE necessarily rely on integrated average values of percolation fluxes of water through the repository horizon. The generally accepted average flux values have crept upward over the past years, covering a range between 1 and 20 mm/yr. In the saturated zone, models use “dual continuum” methods to approximate flow in fractures and diffusion into the surrounding rock matrix. The available data related to hydrological characteristics of rocks in the saturated zone may not be adequate to constrain models in a credible way. The NRC and CNWRA staffs need to maintain their efforts in flow and transport modeling in the vadose zone and the saturated zone, and on the use of data to determine parameters in the models, to ensure that they will have the capability to conduct an assessment at the time of license application.

The Role of Chemistry in Evaluating Risk

In February 1995, a group of DOE and contractor scientists prepared a “white paper” outlining the needs for quantifying chemical reactions at Yucca Mountain.[2] The report notes that “the key performance issue for the Yucca Mountain site is radionuclide transport. Transport, in turn, consists of the coupling of flow (hydrology) and retardation (geochemistry).” This report describes how chemical studies involving concrete, waste canisters, and other “foreign” materials in the near field are essential ingredients of a program. In such a program, solubility, speciation, and sorption must all be adequately quantified in the near and far fields. We could not determine from material presented to us at the working group the extent to which DOE is taking into account the effect that these “foreign” materials have on reactions and speciation of important nuclides (e.g., Np, Tc, U, Pu, I, and perhaps Se). The chemical state of the repository needs to be evaluated to determine whether these materials exercise a significant buffering effect on the chemical

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[1.] Fabryka-Martin, J.T., Dixon, P.R., Levy, S., Liu, B., Turin, H.J., and A.V. Wolfsberg. 1996. Systematic sampling for chlorine-36 in the Exploratory Studies Facility. Draft material presented to the ACNW.
[2] Simmons, A.M., Nelson, S.T., Cloke, P.L., Crump, T.R., Duffy, C.J., Glassley, W.E., Peterman, Z.E., Siegel, M.D., Stahl, D., Steinkampf, W.C., and B.E. Viani. 1995. The Critical Role of Geochemistry in the Program Approach. Unpublished paper.

environment in terms of the calculated consequences.

The role of geochemistry in radionuclide transport has become crucial to demonstrating compliance. The understanding of the hydrologic system at Yucca Mountain has evolved from a model based primarily upon fluid flow through the rock matrix, with very slow transport pathways, to a model that includes, and may be dominated by, fluid flow through an interconnected network of fractures, with relatively fast pathways. What is needed is a comprehensive chemical model for the site. The NRC staff should evaluate DOE's efforts in this area and determine the advisability of DOE's developing a site chemistry model. We are concerned that DOE may be relying too much on laboratory-scale experiments. We urge the NRC staff to investigate the appropriate use of data from intermediate-scale field tests and from natural analogs to build confidence in modeling results.

Colloids and Radionuclide Transport

The transport of colloids through unsaturated rocks is a poorly understood phenomenon. We received no information at our working group to counter the 1995 conclusion of Manaktala, et al[3]: “Based on reports in the available literature, it may be possible for colloids to form in the Yucca Mountain environment, but the extent to which they could contribute to overall radionuclide transport remains unclear.” We do not know whether colloid migration could be an important consideration in either enhancing or inhibiting radionuclide transport at Yucca Mountain. We believe that it is important to deal with the colloid issue in a direct fashion. The importance of colloid transport may be negligible, but an initiative must be taken to assess whether this is true.

The ALRS is in a fractured tuff but has an annual rainfall of more than twice that at Yucca Mountain. In a sense, the ALRS is an "analog" for Yucca Mountain under pluvial conditions, which are anticipated to occur within the time frame of a few tens of thousands of years. Because the ALRS is wetter than Yucca Mountain, it should be possible to collect water samples of flow through fractures in the vadose zone and determine colloid concentrations. Because there is a known connection along a fracture to a surface expression in a stream channel, it should also be possible to introduce colloidal "tracers" at the surface and monitor samples at depth to quantify transport. Data from the ALRS should prove to be very valuable in performing bounding calculations for Yucca Mountain that may resolve the colloid issue.

We trust that our comments and suggestions will be helpful in assessing the potential risks associated with the proposed high-level waste repository at Yucca Mountain.

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[3] Manaktala, H., Turner, D.,Ahn, T. Colten-Bradley, V., and E. Bonano. 1995. Potential Implications of Colloids on the Long-Term Performance of a High-Level Radioactive Waste Repository, CNWRA 95-015.

Sincerely,

/s/

Paul W. Pomeroy,
Chairman