UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON NUCLEAR WASTE
WASHINGTON, DC 20555 - 0001

ACNW R-0230

December 9, 2005

The Honorable Nils J. Diaz
Chairman
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: REVIEW OF THE NRC PROGRAM ON THE RISK FROM IGNEOUS ACTIVITY AT THE PROPOSED YUCCA MOUNTAIN REPOSITORY

Dear Chairman Diaz:

The Advisory Committee on Nuclear Waste (the Committee) has met several times to discuss the risk from igneous activity at the proposed Yucca Mountain repository. In September 2004, the ACNW held a Working Group Meeting on this topic, and summarized its conclusions and recommendations in a November 4, 2004 letter report. The Center for Nuclear Waste Regulatory Analyses (CNWRA) staff updated members of the Committee on NRC's current studies on volcanism in April 2005.

Subsequent meetings, review, and analysis of recently published documents of the NRC and its contractors, and discussions with the NRC and CNWRA staffs have resulted in the following observations and recommendations regarding potential igneous activity at the repository. Several of the ACNW's observations and recommendations are related to the NRC staff's use of assumptions in their analysis that appear to be conservative rather than realistic. Excessive conservatism can foster misperceptions of the performance of the proposed Yucca Mountain repository and conceal attributes of processes that should receive the attention of the NRC staff. The Committee believes continued investigation of potential scenarios will better prepare the staff to evaluate assumptions and approaches in a potential license application. The Committee looks forward to understanding how the staff has used risk-informed thinking throughout the analysis of igneous activity at the proposed Yucca Mountain repository.

INTERACTION BETWEEN INTRUDING MAGMA AND REPOSITORY DRIFT AND WASTE PACKAGES

The Committee believes that resolution of questions about the interaction between intruding magma and the repository drift and waste packages could be better risk informed by considering alternative interaction scenarios and their potential influence on consequences. Specifically, the effects on repository performance of rapid magma cooling with attendant increases in viscosity and solidification of magma should be considered in analyzing the magma/drift/waste package interactions in scenarios in which the intruding dike vents to the surface as a volcano. The alternative scenarios and their implications include the following:

1. Magma characteristics influence production of different materials when an igneous intrusion intersects a repository drift. If the volatile content of magma is relatively large, as anticipated from available evidence, volcanic ash could erupt into the drift at the point of dike/drift intersection. Only after the entrained gases have escaped from the magma due to eruption processes would magma enter the repository drift as a lava flow rather than as ash. The Committee has been provided information that either ash or lava will likely solidify near the entry point into the repository drift.

2. Key factors in the rate of solidification of the magma and self-sealing of the drift are the delivery rate of magma, latent heat of crystallization, volatile content of the magma, and thermal conductivity of drift walls and waste packages. As a result, the magma would likely interact with a few waste packages near the point of entry. Rapid solidification would likely prevent the formation of secondary (flank) vents from the rising magma flowing into repository drifts and subsequently venting to the surface.

3. Solidification of magma entering a repository drift is an important topic to consider regarding the integrity of waste packages. At present, both the Department of Energy (DOE) and the NRC staff assume that the contents of a relatively small number of waste packages directly involved in the dike intrusion are completely destroyed by interaction with invading magma and that all the included waste is entrained in the magma and becomes airborne after eruption. In contrast, Electric Power Research Institute (EPRI) modeling indicates that waste packages are sufficiently robust that invading magma will not destroy the packages (EPRI, 2004). Information presented to the Committee suggests that quenching of magma on an intact canister could provide a protective barrier, thereby isolating and protecting the waste from the intruding magma. Thus, even if a few waste packages are entrained within a cone-forming volcanic conduit, the NRC staff's alternative approach that assumes complete destruction of the waste canisters may lead to incorrect assumptions and parameterization in performance assessment. Undue conservatism also may lead to a distorted view of the risks posed by the repository.

4. Waste packages will be most resistant to degradation and therefore to igneous thermal/physical effects during the first few thousand years of repository life. This is the time interval over which peak doses may occur from igneous activity, because beyond that period potential doses will diminish significantly due to the decay of shorter-lived radionuclides in the few waste packages involved in the volcanic activity (Mohanty et al., 2004). Even if the waste is directly exposed to magma because of package degradation after a long time period, quenching of the magma can produce a protective rind on the waste particles.

By not including the effects of magma solidification and quenching in the extrusive event scenario, important processes may not be adequately understood (e.g., those involved in entrainment and eruption of waste), and both the overall consequences and the risk of the package disruption process may be evaluated incorrectly. DOE's choice to use a conservative scenario to describe magma/waste package interactions does not justify overlooking insights gained by using a more realistic scenario.

Recommendation 1. Analysis of the consequences of an igneous dike intersection with a repository drift would be better risk informed by assessing the effects of

magma solidifying upon entering a drift and quenching on the waste packages and any waste released from them. These studies could have an impact on conclusions regarding the number of waste packages that could be affected by a dike intrusion and the occurrence of secondary (flank) eruptions. This in turn would impact the amount of waste distributed in a resulting ash plume, the reasonably maximally exposed individual (RMEI) dose, and understanding of processes important to the total igneous activity effects.

EXPOSURE SCENARIO FROM CONTAMINATED EXTRUSIVE VOLCANIC MATERIALS

The NRC staff has updated the exposure scenario model incorporating particle size measurements from analogous volcanic eruptions. The revised and updated performance assessment model assumes a particle size distribution of dispersed contaminated ash with a median aerodynamic diameter of 10 microns and a minimum aerodynamic diameter of about 0.1 microns, thus including particulate matter that is not only inhalable but respirable.

The NRC staff's view, as presented to the Committee, is that long-term resuspension of contaminated fluvially dispersed ash and ash deposited on the surface can contribute to an inhalation dose to the RMEI. Consistent with this view, the NRC staff has selected parameter values for particle size distribution, dispersion, and long-term resuspension based on direct observation of volcanic ash at sites of recent volcanic activity. The Committee notes that these assumptions seem reasonable. Nonetheless, the Committee believes a more fully integrated analysis of the processes, parameters, and assumptions used in modeling this scenario would be helpful in making the staff's approaches transparent.

Recommendation 2. The parameters and assumptions presented to date regarding the exposure scenario associated with igneous activity appear reasonable. However, in order to be adequately prepared for the license application review, the NRC staff should integrate all risk-significant aspects of the scenario by clearly justifying the processes, parameters and their values, and assumptions. The Committee believes the staff should use risk-informed approaches, including sensitivity studies, and other techniques to study and justify its choices.

PROBABILITY OF AN IGNEOUS DIKE INTERSECTING THE REPOSITORY

The NRC staff's single-valued estimate of the probability of an igneous intrusion, 10^{-7}/yr over the next 10,000 years, is at the higher end of the range of published estimates for dike intrusion on the order of 10^{-8}/yr to 10^{-7}/yr, authored by the NRC staff, their contractors, and the ACNW staff (Connor et al., 2000, Coleman et al., 2004).

Recommendation 3. The NRC staff should reevaluate the use of a single value for probability of a volcanic intersection of the proposed Yucca Mountain repository, and should consider a range of estimates on the order of 10^{-7}/yr to 10^{-8}/yr based on studies published by NRC and previous ACNW views. If the staff decides to use a single-point value approach, the staff should document how this decision will support a risk-informed review of the consequences of an igneous event in a potential license application. Further evaluation of this range of probabilities should include consideration of new information being assembled for, and the results of, DOE's ongoing expert elicitation on Probabilistic Volcanic Hazard Assessment.

The Committee recognizes that some differences in views on volcanism between the ACNW and the NRC staff are a matter of professional judgment. The Committee appreciates the ongoing dialogue and offers its views as complementary to the staff's views. Consideration of these views may help the staff better risk inform their analyses of an igneous event during the potential Yucca Mountain license application review and related decisionmaking.

Work in progress by the NRC, which is unavailable to the Committee, may at least in part respond to the concerns addressed in this letter. Accordingly, the Committee plans to continue its dialogue with the NRC staff to better understand the bases of the staff's positions and to assess issues as additional information becomes available.

Sincerely,

/RA/

Michael T. Ryan
Chairman

References:

1. Coleman, N.M., B.D. Marsh, and L. Abramson. Testing Claims about Volcanic Disruption of a Potential Geologic Repository at Yucca Mountain, Nevada, Geophys. Res. Lett., doi:10.1029/2004GL021032, 2004.

2. Connor, C.B., J. Stamatakos, D. Ferrill, B. Hill, G. Ofoegbu, F. Conway, B. Sagar, and J. Trapp. Geologic Factors Controlling Patterns of Small-volume Basaltic Volcanism: Application to a Volcanic Hazards Assessment at Yucca Mountain, NV, J. Geophys. Res., 105, 417–432, 2000.

3. EPRI. Potential Igneous Processes Relevant to the Yucca Mountain Repository: Extrusive Release Scenario: Analysis and Implications. EPRI Report 1008169. Electric Power Research Institute: Palo Alto. 2004.

4. Mohanty, S., et al. System-level Performance Assessment of the Proposed Repository at Yucca Mountain Using the Tpa Version 4.1 Code. NRC accession no. ML041350316. 2004.

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* See previous concurrence.
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