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November 25, 2003

Dr. Michael L. Corradini
Chairman
U.S. Nuclear Waste Technical Review Board
2300 Clarendon Boulevard
Suite 1300
Arlington, VA 22201

RE: Internal Criticality Risk at Yucca Mountain

Dear Dr. Corradini:

I am writing to request that the Nuclear Waste Technical Review Board ("TRB") conduct a careful review of the previously withheld, but recognized potential for internal criticality of nuclear waste residues at the proposed Yucca Mountain nuclear waste repository. We were amazed to learn, after finally obtaining some of the pertinent documents from the Department of Energy ("DOE") through the Freedom of Information Act ("FOIA"), that DOE's own studies anticipate that, if the repository operates as is now planned, *up to 60 nuclear criticalities* may plausibly occur inside the mountain, and that the conditional probability of occurrence may be greater than one in one thousand per year.

That conclusion is sharply at odds with what DOE publicly represented in its Final Environmental Impact Statement (FEIS) on the proposed facility, which assigns such events an extremely low probability of occurrence. In particular, in FEIS Volume 1 at page 5-39, DOE concluded:

> The potential for criticality of commercial spent nuclear fuel would be maximized when the internal basket was fully degraded, but with the assemblies remaining intact and no breach of the bottom of the waste package. Under these circumstances, the calculated probability of a critical event within the total inventory of the 21-PWR Absorber Plate

waste packages would be less than 2×10^{-7} in 10,000 years (after closure of the repository).

However, DOE's actual criticality studies, which were omitted (improperly, we believe) from the FEIS administrative record, tell a markedly different story. Once Nevada determined that such documents existed, we filed a series of FOIA requests, which produced some, but not yet all, of the pertinent documents. One document we did receive recently is DOE's *Criticality Potential Curve Draft Report* for the proposed Yucca Mountain repository. Nevada engaged Dr. Michael C. Thorne, an independent expert in criticality safety and probabilistic risk assessment, to study that report. He has not been able to undertake a full review at this time because DOE has withheld some of the supporting documentation, calculations and analyses performed for the preparation of this report.

However, Dr. Thorne was able to make some clear and startling conclusions. He noted that the DOE report identifies three types of potential criticality events at Yucca Mountain – "Light Bulb," "SL-1," and "Waste Package." He concluded, based on his review of previous criticality accidents worldwide, that these potential criticality events and their projected fission yields were indeed plausible occurrences in the proposed repository. The DOE report estimated the conditional probability of each of these events per cask as 5.1×10^{-3}, 2.6×10^{-4} and 2.6×10^{-4} for Light Bulb, SL-1 and Waste Package criticality events, respectively. The calculated probabilities are conditional in that they assume perforation of the cask and introduction of water to the waste, but for the long term, of course, DOE's Total System Performance Assessment assumes that all packages eventually do degrade.

Moreover, Dr. Thorne observed several non-conservative deficiencies in the probabilistic arguments used in the DOE studies, implying that higher frequencies (which he assessed as 4.1×10^{-2}, 2.1×10^{-2} and 2.1×10^{-2} for Light Bulb, SL-1 and Waste Package events, respectively) cannot be ruled out. Nevertheless, even using the conditional probability estimates given in the DOE report, because the Yucca Mountain repository would contain about 11,770 waste packages (Supplemental Science and Performance Analyses, 2001, page 7-62), and because all packages will eventually degrade, the expected numbers of criticality events over the long term are 60, 3, and 3 for Light Bulb, SL-1 and Waste Package events, respectively.

These astonishing numbers raise grave concerns about the proposed repository's safety and environmental impacts, further calling into question the legal and technical adequacy and veracity of the Yucca Mountain FEIS. A criticality occurring in the repository could severely compromise the entire facility, vastly increasing radionuclide releases and making waste packages irretrievable.

DOE's *Criticality Potential Curve Draft Report* does not discuss the timescale over which these presumed criticality events would occur. However, Dr. Thorne believes the report suggests they occur uniformly over a period beginning when a package first perforates and admits water and ends when the presumed "bathtub" wall has corroded

sufficiently to release the water. (The potential long-term integrity of the canisters is a matter to which the TRB and we are also very concerned.) According to Dr. Thorne, the period from penetration of the first package to loss of the bathtub configuration in the last is likely to extend from some point within the 10,000 years following repository closure and for some tens of thousands of years thereafter. Based on more than 60 critical events over that interval, the probability of a critical event within the whole proposed repository is thus – using DOE's own numbers – *on the order of 1 x 10^{-3} per year or higher*, with that probability applying to at least part of the interval within the 10,000-year regulatory compliance period. This value differs radically from the value of 2 x 10^{-7} per year cited in DOE's FEIS. The criticality numbers also further underscore the absurdity of limiting Yucca Mountain's safety analysis to 10,000 years.

We recognize that the values given in the *Criticality Potential Curve Draft Report* are based on a simplified analysis, though we see no reason why they should not have been prominently dealt with in the FEIS. This issue has become all the more important given recent determinations by the TRB and Nevada's experts that corrosion of the Yucca Mountain waste containers and water infiltration are serious possibilities during the regulatory compliance period, and are certain to occur over longer periods.

Finally, this month we received through the FOIA process several backup documents for the *Criticality Potential Curve Draft Report* that appear only to confirm our concerns. These 1998 documents reveal that DOE's Senior Technical Review Panel for the FEIS was likewise worried about criticality in the event of water entering a ruptured or corroded spent fuel canister, and it recommended on several occasions that DOE "quantify the consequences" if such an event "is conceivable." The documents show that DOE's own criticality analysts had "assumed that ingress of water into a storage cask, without any change in geometry of the spent fuel and/or movement of the neutron poison, *would result in a critical event,*" and that the probability of criticality was so high that DOE should not waste time analyzing it, but should proceed directly to analysis of the consequences. Unfortunately, DOE performed no such analysis. This same document concluded that "[a] criticality event could affect radionuclide release to the environment by damaging uranium and fuel matrix and cladding, so that the slow dissolution process which would normally occur is accelerated, and radionuclides are released in a short time period. Such a release would be more concentrated and the air release pathway would become significant, so an evaluation of the effects of potential criticality events is in order."

We and Dr. Thorne have also examined more recent criticality reports, in particular:

> Configuration Generator Model for In-Package Criticality, MDL-EBS-NU-000001 REV 01 ICN 01; and
>
> U.S. Nuclear Regulatory Commission, Safety Evaluation Report for Disposal Criticality Analysis Methodology Topical Report, Revision 0, June 2000.

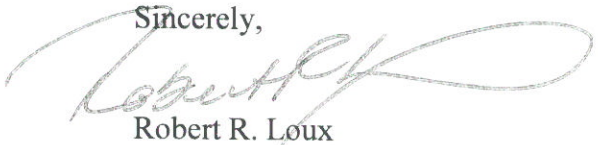
The June 2000 NRC report describes the methodology then proposed by DOE for evaluating criticality events. This methodology involved application of detailed geochemical modeling to define potentially critical configurations of fissile material both within and outside waste packages. But according to Nevada's experts, it is not clear that such geochemical modeling is feasible given the complexities of the proposed repository, the limitations of existing computer codes and the lack of appropriate data for use with those codes under proposed repository conditions. This seems to have been recognized by DOE itself, which subsequently adopted a fault tree/event tree based approach. Nevertheless, the fundamental problem remains of determining from the generalized descriptions of configuration classes used in the fault tree/event tree approach whether they can give rise to criticality events. This issue does not appear to have been addressed in DOE's proposed methodology, and it was certainly ignored in the FEIS.

In short, the documentation available to DOE at the time the FEIS was written was nowhere near sufficient for DOE to have summarily ruled out substantial numbers of criticality events occurring in the proposed Yucca Mountain repository. Indeed, the available documentation suggests internal criticality may be one of the most, if not the most, significant safety issues in repository licensing. Although subsequent work provided two alternative methodologies that, at first blush, have the potential to demonstrate lower probabilities of criticality events, more detailed examination by Nevada's experts suggests that limitations of scientific understanding, computational tools and relevant data will make it impossible to effectively deploy those alternative methodologies.

In view of the above, the potential occurrence and significance of criticality events, deliberately obscured in the FEIS, must be thoroughly analyzed and reviewed. I am requesting that the Board initiate such a review and begin by requesting from DOE a clear and comprehensive demonstration that the methodology, models and data identify the range of criticality events that could occur, quantify their probabilities of occurrence, and evaluate their potential consequences and the implications for repository operability, closure and post-closure performance.

I would be happy to share any of our documents with you, and we can put you in contact with Dr. Thorne so you can discuss this matter with him directly if you wish.

Sincerely,



Robert R. Loux
Executive Director

cc: Dr. Margaret S. Y. Chu, DOE
Dr. William D. Travers, NRC