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subject: Commentary on Report by High Bridge Associates, Inc. date January 29, 2016

On January 29, 2016, High Bridge Associates, Inc. published a report entitled, "Impact of Surplus Weapons Plutonium on Disposition on WIPP." The report was prepared for the MOX Services Board of Governors. What follows is an initial assessment by Sandia National Laboratories of assertions made in the High Bridge report.

The High Bridge reports present numbers representing Pu-239 permitted for WIPP, surplus Pu that would be dispositioned in Criticality Control Overpacks (CCOs), Pu-239 critical mass, and so on. The manner in which these numbers are used may be misleading. For example, the report compares the Pu-239 *density* in CCOs (29.2 kg/m^3) with a limit of 7.3 kg/m^3 set by the American National Standards Institute, but fails to note that each CCO would contain only 0.3 kg, much less than a critical mass, and that the overall density of Pu-239 would be only about 1.4 kg/m^3.

While surplus, weapons grade Pu disposal would increase the amount of Pu-239 (and possibly other Pu isotopes) in WIPP several fold, and increase the average density of Pu-239, criticality of downblended and packaged Pu-239 cannot result. The salt formation will squeeze the disposal rooms and consolidate the waste, but this process cannot *separate* Pu from the diluting materials to form an undiluted critical mass. The fact of dilution means that the actual mass of Pu-239 required for criticality could be greater, or that criticality may not be possible at all. Post-closure criticality would be a key part of the disposal safety case for surplus Pu. In the unlikely event that extra margins of safety to prevent criticality were necessary, modifications to the CCO/drum configuration could be made based on analysis of consolidation at repository conditions. Over the past decades workers at Sandia and elsewhere have developed a thorough understanding of WIPP evolution that includes the nature of waste consolidation. While many critical masses of surplus Pu-239 would be dispositioned at WIPP, the High Bridge scenario (21 CCOs crushed by 30%, somehow aggregating 8 kg of Pu-239 into a critical configuration) is simplistic and not credible. Further, as stated by High Bridge, additional downblending could provide any needed level of additional assurance (along with fillers and neutron poisons as discussed below).

The density of Pu-239 in WIPP, and the potential for TRU waste in solid form to achieve criticality, was analyzed previously (SAND99-2898). A limit of 3 kg PuO_2 per m^3 was adopted in that study to ensure subcriticality, and the average density of Pu in WIPP (0.034 kg/m^3) is about 90 times less. At 300 g of Pu-239 per CCO, the average density (about 1.4 kg/m^3) would still be less than this limit (and the ANSI limit), and downblending would ensure that the Pu is well mixed. This volume calculation does not account for Pu packaging materials, MgO backfill in the WIPP repository, salt debris, void space, etc., which would decrease the density of fissile material even further.

Further, in the presence of NaCl salt, whether as solid or brine, criticality would be virtually impossible. The WIPP disposal panels are constructed in nearly pure NaCl salt. The chlorine in natural salt is about 75% Cl-35, an excellent neutron absorber. Few isotopes found in nature have better absorption properties. None of the claims made in the High Bridge report regarding criticality, take Cl-35 into account.

The maximum heat output of a CCO containing 0.3 kg of Pu-239 would be approximately 0.6 W, amounting to moderate thermal loading for a salt repository. Salt is the best of all possible geologic media for dissipation of heat. Based on extensive testing and modeling of salt thermal responses, there would be insignificant effects from heating by surplus Pu.

For comparison, the Department of Energy has analyzed the interaction of spent nuclear fuel (SNF) with generic salt, such as exists across broad regions of the U.S. and might host a repository for commercial SNF. Each SNF package could contain 50 kg or more of Pu-239. The average density of Pu-239 and other fissiles in each waste package would be on the order of 10 kg/m^3. Detailed simulations show that criticality would be unlikely because of the salt, even if the packages were flooded with brine, and eventually crushed. A similar situation would exist with surplus Pu, especially if the final packaging and emplacement arrangement includes fillers and neutron poisons such as salt or engineered materials.

Cost estimates for WIPP disposal operations with TRU wastes are a matter of public record. The overall project cost for the TRU mission will come to approximately \$50k per m^3 of packaged waste. Adding 35 T of surplus Pu to the TRU waste inventory emplaced at WIPP would add on the order of \$2B in disposal cost (not including blending and packaging).

While DOE has not completed a scientific study of the evolution of WIPP (or any salt repository) loaded with downblended Pu, that completely considers effects from repository consolidation, neutron absorption by salt, waste packaging, and other relevant processes, the general properties and behavior of a salt repository support a reasoned prediction that none of the affects alleged in the High Bridge report would be of any significance. A scientific study to account for all physical, chemical and radiological processes still must be performed in the context of the scenarios important to WIPP performance. Before the surplus Pu in question is shipped to WIPP for disposal, a thorough evaluation of potential impact on long term repository performance will be performed.

REFERENCE

Rechard, Rob P., et al, 2000. Consideration of Nuclear Criticality When Disposing of Transuranic Waste at the Waste Isolation Pilot Plant. SAND99-2898. Sandia National Laboratories, Albuquerque, New Mexico.