CONF-960421--42

TOTAL SYSTEM PERFORMANCE PREDICTIONS (TSPA-1995) FOR THE POTENTIAL HIGH-LEVEL WASTE REPOSITORY AT YUCCA MOUNTAIN

S. David Sevougian
CRWMS M&O/INTERA, Inc.
1261 Town Center Drive
Las Vegas, Nevada 89134
(702) 295-4634

Robert W. Andrews
CRWMS M&O/INTERA, Inc.
1261 Town Center Drive
Las Vegas, Nevada 89134
(702) 295-5549

Jerry A. McNeish
CRWMS M&O/INTERA, Inc.
1261 Town Center Drive
Las Vegas, Nevada 89134
(702) 295-4630

RECEIVED
JUN 10 1996
OSTI

ABSTRACT

The management and operating contractor for the potential high-level nuclear waste repository at Yucca Mountain, Nevada, has recently completed a new performance assessment of the ability of the repository to isolate and contain nuclear waste for long time periods (up to 1,000,000 years). Sensitivity analyses determine the most important physical parameters and processes, using the most current information and models.

I. INTRODUCTION

The evaluation of the ability of the overall repository system to meet the performance and safety objectives specified in the applicable regulatory standards is termed total system performance assessment (TSPA). Besides providing a quantitative basis for evaluating the suitability of the site, such assessments are useful in defining the most significant processes and the information gaps and uncertainties regarding these processes and their corresponding parameters. TSPAs explicitly acknowledge the uncertainty in the process models and parameters and predict the impact of this uncertainty on the overall performance. The aim of any TSPA is to be as complete and reasonably conservative as possible.

TSPAs evolve with time. As additional site and design information is generated, assessments can be revised to become more representative of expected conditions and less conservative. Previous TSPAs of the Yucca Mountain site have been conducted in 1991 and 1993 (Barnard et al., 1992; Eslinger et al., 1993; Wilson et al., 1994; Andrews et al, 1994). The current analyses (M&O, 1995) build on these previous ones, using more recent information.

II. WORK DESCRIPTION

The specific goals of TSPA-1995 were to develop and apply more representative models of (1) the drift-scale thermohydrologic environment, including more reasonable estimates of relative humidity and temperature adjacent to the waste packages; (2) waste-package degradation, including improved corrosion models of the mild-steel corrosion-allowance material and the effects of cathodic protection on the corrosion-resistant material; (3) the engineered barrier system (EBS) design, including possible alternative backfills and barriers; (4) near-field unsaturated-zone aqueous flux (i.e., dripping water in the emplacement drifts); and (5) unsaturated-zone flow and transport, including the potential effects of fracture-matrix interaction.

III. RESULTS

The effect of model and parameter uncertainty on predicted results is evaluated by a number of sensitivity analyses. Alternative repository designs and alternative scenarios for natural-system behavior are considered, including (1) low and high water-infiltration rates through the unsaturated zone (0.01 - 0.05 mm/yr and 0.5 - 2.0 mm/yr); (2) low and high thermal load (25 MTU/acre and 83 MTU/acre); (3) alternative thermohydrologic models for the near-field environment; (4) three assumptions for the initiation of waste-package corrosion (relative-humidity controlled, temperature and relative-humidity controlled, and temperature and relative-humidity controlled with cathodic protection); (5) five conceptual models of EBS transport and water movement (drips directly on the waste form, drips on the waste container but not on the waste form, no drips or capillary-barrier effect, no drips and aqueous EBS transport of ^{129}I and ^{36}Cl, and no drips and aqueous EBS transport of ^{129}I and ^{36}Cl plus ^{14}C transport directly to atmosphere—the "diffusion-only" model); (6) fracture/matrix interaction in the

MASTER

geosphere; and (7) climate change (with and without water table rise).

As one example of these analyses, Figure 1 shows the effect of the alternative EBS transport models on predicted total peak dose over 1,000,000 years to an individual 5 km downgradient from the repository (at the accessible environment), drinking 2 liters of water a day from the tuff aquifer, assuming an initial (and minimum) percolation rate through the unsaturated zone of 1.25 mm/yr. The effect can be very large as the transport mechanism in the EBS changes from advection to diffusion.

IV. CONCLUSIONS AND DISCUSSION

A. 10,000-year Predicted Performance

(1) 10,000-year total peak dose, due mainly to ^{99}Tc and ^{129}I, is most sensitive to: (i) matrix velocity in the CHnv, and (ii) percolation flux in the unsaturated zone;

(2) Over 10,000 years there are no releases to the accessible environment for the following cases: (i) low infiltration range (0.01 - 0.05 mm/yr), (ii) cathodic protection of the waste-package, (iii) Buscheck 80 MTU/acre thermohydrologic model with and without backfill, and (iv) matrix-flow-only (zero fracture flow) in the unsaturated zone;

(3) Depending on the conceptual model of intra-unit fracture connectivity, fracture/matrix interaction can significantly affect peak dose and cumulative release during the first 10,000 years after repository closure.

B. 1,000,000-year Predicted Performance

(1) 1,000,000-year total peak dose, due mainly to ^{129}I over the low infiltration range (q_{inf} = 0.01 -0.05 mm/yr) and to ^{237}Np over the high infiltration range (q_{inf} = 0.5 -2.0 mm/yr), is most sensitive to: (i) dilution in the saturated zone (or equivalently, the saturated-zone bulk Darcy flux, q_{SZ}), and (ii) percolation flux in the unsaturated zone;

(2) 1,000,000-year total peak dose may be greatly reduced by a barrier that intercepts and diverts water dripping on the waste packages (the capillary-barrier effect), i.e., for aqueous-phase radionuclides, pure diffusion (no advection) through the EBS produces extremely low doses at the accessible environment;

(3) Low intra-unit fracture connectivity in the unsaturated zone can significantly delay the breakthrough of peak doses to the accessible environment but only slightly reduces the ultimate peak dose (a similar conclusion applies to matrix diffusion);

(4) Alternative thermal loads, alternative thermohydrologic models for the near-field, and alternative corrosion-initiation models (including cathodic protection) do not individually have a very large effect on the total peak dose that occurs during the 1,000,000-year time span (a factor of about three is the largest effect).

Throughout the TSPA-1995 analyses, an over-arching theme recurs as the driving factor impacting the predicted results: the amount of water present in the natural and engineered systems and the magnitude of aqueous flux through these systems. Therefore, information on the distribution of the amount and rate of water movement, through the various scales relevant to the prediction of post-closure performance, remains the key need to enhance the representativeness of future iterations of TSPA.

REFERENCES

1. Andrews, R. W., T. F. Dale, and J. A. McNeish, 1994. "Total System Performance Assessment-1993: An Evaluation of the Potential Yucca Mountain Repository," B00000000-01717-2200-00099-Rev. 01, Civilian Radioactive Waste Management System, Management and Operating Contractor, Las Vegas, Nevada.

2. Barnard, R. W., M. L. Wilson, H. A. Dockery, J. H. Gauthier, P. G. Kaplan, R. R. Eaton, F. W. Bingham, and T. H. Robey, 1992. "TSPA 1991: An Initial Total-System Performance Assessment for Yucca Mountain," SAND91-2795, Sandia National Laboratories, Albuquerque, New Mexico, September.

3. Eslinger, P. W., L. A. Doremus, D. W. Engel, T. B. Miley, M. T. Murphy, W. E. Nichols, M. D. White, D. W. Langford, and S. J. Ouderkirk, 1993. "Preliminary Total-System Analysis of a Potential High-Level Nuclear Waste Repository at Yucca Mountain," PNL-8444, Pacific Northwest Laboratory, Richland, Washington.

4. M&O (Civilian Radioactive Waste Management System, Management and Operating Contractor [CRWMS M&O]), 1995. "Total System Performance Assessment-1995: An Evaluation of the Potential Yucca Mountain Repository," B00000000-01717-2200-00136, Rev. 01, Las Vegas, Nevada.

5. Wilson, M. L., J. H. Gauthier, R. W. Barnard, G. E. Barr, H. A. Dockery, E. Dunn, R. R. Eaton, D. C. Guerin, N. Lu, M. J. Martinez, R. Nilson, C. A. Rautman, T. H. Robey, B. Ross, E. E. Ryder, A. R. Schenker, S. A. Shannon, L. H. Skinner, W. G. Halsey, J. Gansemer, L. C. Lewis, A. D. Lamont, I. R. Triay, A. Meijer, and D. E. Morris, 1994. "Total System Performance Assessment for Yucca Mountain - SNL Second Iteration (TSPA-1993)," SAND93-2675, Sandia National Laboratories, Albuquerque, New Mexico.

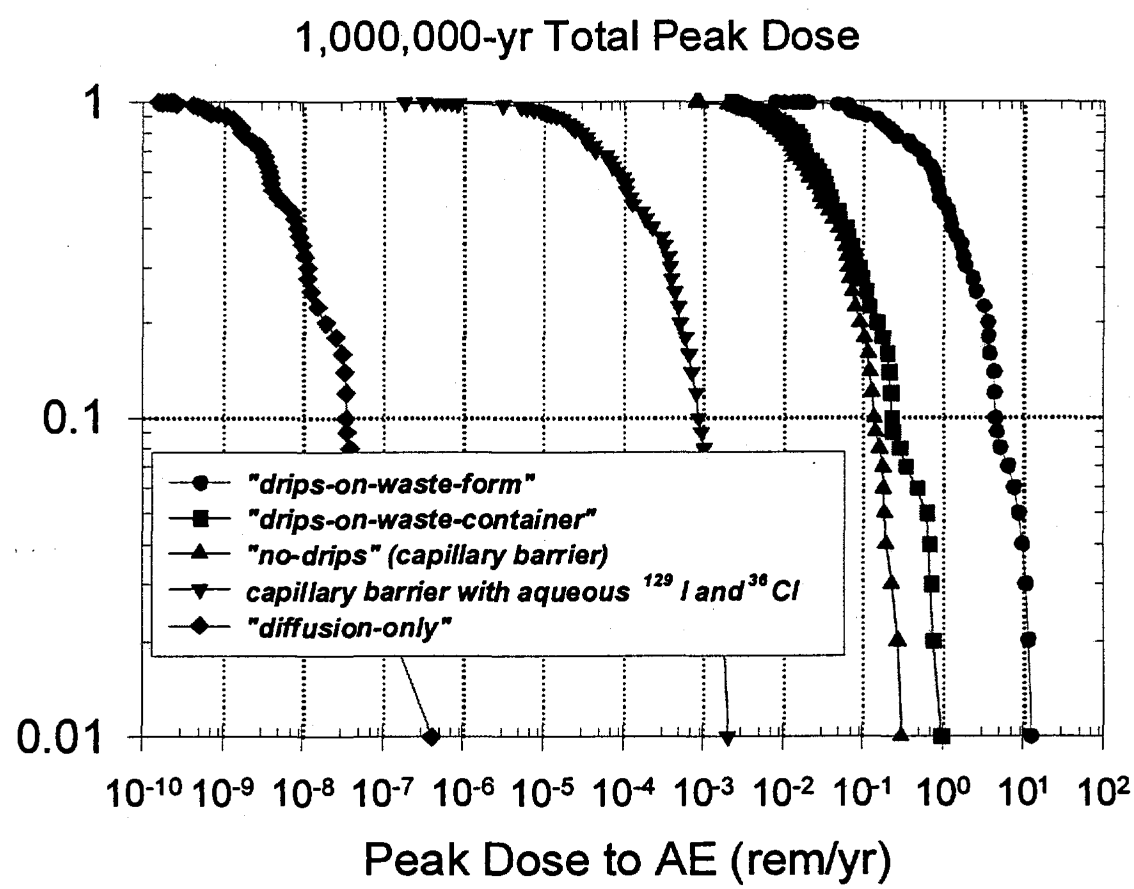

Figure 1 Comparison of EBS transport models. CCDF of Total Peak Dose at the Accessible Environment (AE): 1,000,000 years, 83 MTU/acre, backfill, high infiltration range, cyclical-q_{inf} climate model.