Analyzing Drift Seepage at Yucca Mountain in a Performance-Assessment Framework

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RESEARCH OBJECTIVES

In relation to the proposed geologic repository for high-level radioactive wastes at Yucca Mountain, seepage is defined as the amount of water that drips into the waste emplacement tunnels (drifts), potentially contacting waste packages and dissolving the waste form. Predicting the amount of seepage into drifts is thus essential in assessing the long-term performance of the proposed repository. The Total System Performance Assessment Model (TSPA Model) for Yucca Mountain therefore evaluates the amount and spatial distribution of drift seepage. In support of TSPA, we have developed an integrated probabilistic–deterministic seepage module for the TSPA Model, a module that accounts for the spatial and temporal variability and inherent uncertainty of all seepage-relevant properties and processes. This module calculates the seepage rate (amount of seepage per time) and the seepage fraction (the fraction of waste packages affected by seepage) as a function of time and location in the repository.

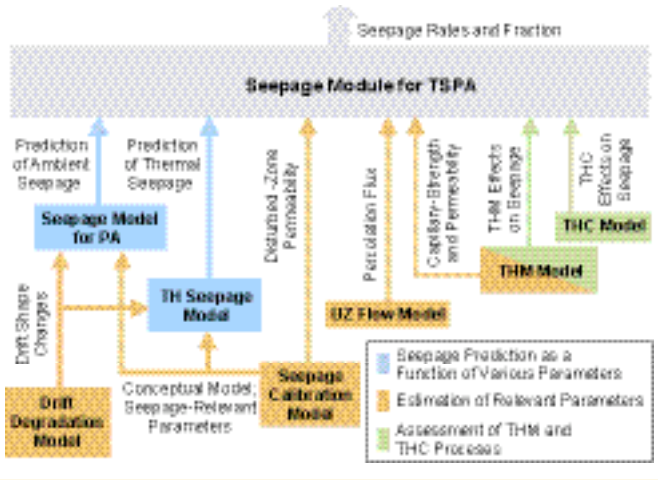

Figure 1. Schematic showing information flow between various predictive process models and the seepage module for TSPA

APPROACH

The basic processes involved in seepage phenomena in unsaturated fractured tuff have been presented elsewhere (e.g., BSC, 2004). In short, experimental and modeling studies have demonstrated that seepage at ambient, idealized conditions can be described as a function of a few key hydrological properties. Using various data sources from site characterization, *in situ* testing, and predictive modeling, we developed appropriate spatial variability and uncertainty distributions for these key properties. Additional factors important for seepage are, for example, flux perturbations as a result of increased temperatures near heat-producing waste packages, changes in hydrological properties caused by mechanical and chemical effects, changes in the drift shape caused by drift degradation, and the presence of rock bolts used for ground support (see Figure 1). Information on these factors was available from various experimental and modeling studies, but not enough to allow for a probabilistic treatment. Our seepage module therefore involves two steps: First, ambient seepage at idealized conditions is calculated based on a probabilistic approach that accounts for the variability and uncertainty of seepage-relevant properties at ambient conditions. Second, the impact of additional factors affecting seepage is evaluated by adjusting the probabilistic seepage rates in a simplified, deterministic manner, based on input provided from various experimental and modeling studies (e.g., studies evaluating geomechanical and geochemical processes at Yucca Mountain). To incorporate uncertainty, the simplifications made in this second step realistically bound the expected seepage behavior.

ACCOMPLISHMENTS

A seepage module was developed that incorporates processes and properties relevant for seepage estimation, yet is sufficiently simple, efficient, and transparent such that it can be incorporated into the overall performance assessment of the proposed geological repository at Yucca Mountain. The new seepage module is a key element of the TSPA Model supporting the license application of the proposed Yucca Mountain repository.

SIGNIFICANCE OF FINDINGS

Results from the integrated probabilistic–deterministic seepage model show that the fraction of waste canisters affected by seepage will be rather small over the lifespan of the repository. The seepage rates are usually much smaller than the local percolation fluxes arriving at drift sections. These findings illustrate the importance of the natural barrier formed by the unsaturated rock at and above the repository horizon.

RELATED PUBLICATION

Bechtel SAIC Company, Abstraction of drift seepage. Yucca Mountain Project Report, MDL-NBS-HS-000019 REV 01, Bechtel SAIC Company, Las Vegas, NV, 2004.

ACKNOWLEDGMENTS

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