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U.S. Nuclear Regulatory Commission
ATTN: Mrs. Deborah A. DeMarco
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Subject: Programmatic Review of Abstract

Dear Mrs. DeMarco:

The enclosed abstract is being submitted for programmatic review. This extended abstract will be published in the conference Proceedings of Groundwater 2000: International Conference on Groundwater Research to be held in Copenhagen, Denmark, June 6–8, 2000, The title of the abstract is:

> "Radionuclide Transport and Retardation in the Alluvial Aquifer Near Yucca Mountain, Nevada" by Scott Painter and David Turner

This abstract is a product of CNWRA and it does not necessarily reflect the view(s) or regulatory position of the NRC.

Please advise me of the results of your programmatic review. Your cooperation in this matter is appreciated.

Sincerely,

Budhi Sagar
Technical Director

/ar
Enclosure

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Radionuclide Transport and Retardation in the Alluvial Aquifer near Yucca Mountain, Nevada

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ABSTRACT: Effects of heterogeneity on transport in the alluvial aquifer near Yucca Mountain, Nevada USA are evaluated using the stochastic Lagrangian method and a two-site sorption model. Radionuclide transport is sensitive to physical heterogeneity and to mass transfer rates between mobile (non-sorbing) and immobile (sorbing) zones, but is insensitive to chemical heterogeneities.

1 INTRODUCTION

The U.S. Department of Energy is currently studying Yucca Mountain (YM), Nevada as a potential site for a geologic repository for high-level radioactive waste. Analyses have identified interactions of radionuclides with minerals in the alluvial aquifer near YM as important to repository performance (U.S. Department of Energy, 1998). We evaluate the effects of spatial variability in hydraulic conductivity K and distribution coefficient K_d on the efficacy of the YM alluvium as a transport barrier. Rate-limited transfer between mobile and immobile zones, a process driven by small-scale heterogeneity, is also addressed. Further details can be found in Painter et al. (2000).

2 MODEL FOR TRANSPORT WITH NON-IDEAL SORPTION

An idealized scenario involving a Dirac δ function (in space and time) release of Np^{237} at the upstream side of the alluvial aquifer is considered as an example. We consider advective transport in a spatially variable velocity field resulting from spatially variable K. Downstream movement is slowed by sorption, but sorption sites are not necessarily available instantaneously. We use the Lagrangian stochastic framework (Cvetkovic et al. 1998) and a two-site mobile-immobile mass transfer model (e.g., Nkedi-Kizza et al. 1984) to model advective transport and sorption with rate-limited transfer between mobile and immobile zones. Sorption in the mobile zones and porosity in the immobile zones are neglected, a simplification that allows the effect of spatial varability and rate-limited transfer to be addressed in a generic manner. After transforming from the Eulerian framework onto a single streamtube (Lagrangian representation), the radionuclide discharge (normalized by the total mass released) at a specified boundary is obtained as $\gamma(t;\tau,\mu) = e^{-\alpha'\mu}\,\delta(t-\tau) + \alpha'^2\mu\exp\{-\alpha'[\mu + (t-\tau)]\}\,\widehat{I}_1[\alpha'^2\mu(t-\tau)]$ where $\widehat{I}_1(z) \equiv I_1(2z^{1/2})/z^{1/2}$ and I_1 is the modified Bessel function of the first kind of order one. The parameter α' is a mass transfer rate coefficient: $\alpha' \to \infty$ implies the equilibrium sorption model and $\alpha' = 0$ corresponds to no sorption. The Lagrangian quantities $\tau(x_1)$ and $\mu(x_1)$ are defined as integrals of $1/v$ and $K_d\rho_b/v\theta$ along the streamline, where v,θ and ρ_b are velocity, porosity and bulk density, respectively. The quantities τ and μ are random variables, which also makes γ a random variable. To compute its expected value, we approximate the pdf of τ,μ as log-normal and compute its moments from the available data using first-order approximations relating velocity statistics to τ and μ statistics.

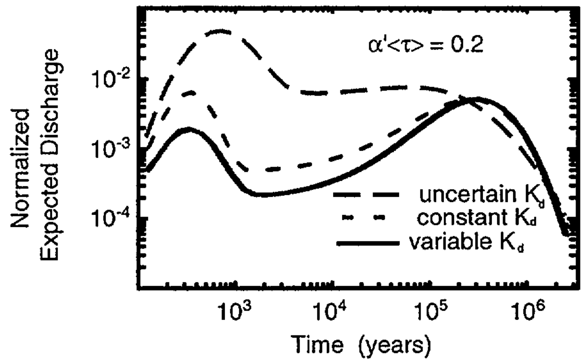

Figure 1: Normalized breakthrough curves $\langle\gamma\rangle\langle\tau\rangle$ versus time. The curves are for spatially variable K_d, constant effective K_d, and an uncertain parameter model, in which the K_d is treated as spatially constant but uncertain. The mass transfer rate is $\alpha'\langle\tau\rangle = 0.2$ and physical heterogeneity is included.

We use the log-normal model for K, and write $K = K_G e^Y$ where $K_G = 0.290$ km/y is the geometric mean and Y is a normally distributed random field with variance $\sigma_Y^2 = 1.56$ and exponentially decaying covariance. $I_Y = 2$ km is the integral scale. The mean travel time is $\langle\tau\rangle = 4000$ y based on $\theta = 0.25$. A log-normal model is also used for K_d for neptunium $K_d = K_d^G e^Z$. Parameters are estimated from a database of K_d compiled from groundwater chemistry measurements and a calibrated modeling approach (Turner & Pabalan, 1999): $K_d^G = 0.0144$ m^3/kg, $I_Z = 0.4$ km, and $\sigma_Z^2 = 0.82$. The geometric mean of the dimensionless sorption coefficient is $\rho_b K_d^G/\theta = 108$.

3 RESULTS

Normalized expected breakthrough curves $\langle\gamma(t)\rangle\langle\tau\rangle$ are shown versus time in Figure 1. The different curves represent different treatments of K_d variability. Neglecting chemical heterogeneity introduces a modest error at early times. The uncertain parameter model, which is used in performance assessment studies, greatly overestimates the expected discharge. The expected discharge was also found to be sensitive to the rate of mass transfer between mobile and immobile zones and to spatial variability in K.

Acknowledgments

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