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Representative Pathway Length for Contaminant Transport in Performance Assessment Models

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Abstract

Performance assessment models, in the context of high-level waste management, commonly incorporate a “representative” element concept as a simplification approach. For example, on the basis of a representative waste package, radionuclide release away from a single waste package is computed and scaled up to derive an estimate of the total release from an ensemble of waste packages. This computation is an approximation as each waste package may release radionuclides at different rates controlled by local conditions in or around the waste package. This paper considers whether it is feasible to define a representative property, length of transport pathway, so that scaled up releases are consistent with releases that would be computed by individually simulating each waste package. In the hypothetical radioactive waste disposal system considered in this analysis, it was assumed that a buffer material, a diffusive barrier, surrounds the waste packages. The waste packages are placed in a tunnel and distributed along its axis. The tunnel could be backfilled with crushed host rock or other natural or engineered material. The host rock is considered sparsely fractured (e.g., granite rock), and each waste package is assumed to be located between two fracture planes intercepting the tunnel. This system is assumed to be fully saturated with slowly moving or stagnant groundwater (in the fractures, water could move at faster rates). Radionuclides diffusing away from the buffer material are transported toward these two closest fractures (the region from the buffer material to a fracture is referred to as the transition region), in which radionuclides are held at low or zero concentration. Radionuclide release rates into these fractures are used as input for far-field computations of contaminant transport through geological formations. The distance from a particular waste package to a fracture and the fracture spacing were considered random. An approach was devised to select a single representative or equivalent length of the transition region so that the total, scaled-up release rate was consistent with release rates computed by individually simulating each waste package. Approximations were derived to compute the equivalent length for steady-state cases where radionuclide releases away from the waste form are controlled by solubility constraints in the waste package internals. For other cases, the radionuclide residence time in the system is short, and accurate estimation of the representative length

parameter has a less effect on performance calculations. This example showed that although approaches to defining features of representative elements can be developed in some cases, general approaches may not be available. In general, additional analyses should be performed to verify that detrimental consequences are not underestimated by the use of representative element concepts.

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