9.6.6.1 Mechanical Dispersion

Mechanical dispersion (D_m) is the mixing of water through aquifer material. Dispersion spreads out the concentration of a constituent and is proportional to the rate of groundwater flow and travel distance. Diffusion results from the random motion of molecules in solution and tends to move a constituent from a region of high concentration to a region of low concentration.

The mechanical dispersion (D_m) is frequently estimated as a linear function of velocity (Rowe, 1988), as shown in thé equation below.

$$D_m = \frac{\alpha V_w}{n_w}$$

where α, V_w, n, and corresponding baseline model values are:

α = longitudinal dispersivity (0.09 m)
V_w = vertical Darcy velocity within aquitard (m/yr)
n_w = aquitard porosity (0.4)

A longitudinal dispersivity of 0.3 ft (0.09 m) is used to calculate the mechanical dispersion coefficient. This value is based on the 50-foot length of vertical groundwater flow through the aquitard and reported dispersivity values for this length by Gelhar et al. (1992). Gelhar summarized longitudinal dispersivity values reported for field studies and showed that longitudinal dispersivity is scale dependent and a function of flow/transport distance.

The equation above was used to calculate a mechanical dispersion coefficient (D_m) of 4.4×10^{-6} ft²/day (1.5×10^{-4} m²/yr). This mechanical dispersion coefficient was used to calculate the hydrodynamic dispersion input parameters used in the model. The input value for hydrodynamic dispersion is presented in Table 9-3.

9.6.6.2 Diffusion

A value of 4.4×10^{-4} ft²/day (1.5×10^{-2} m²/yr) was used for the baseline model. Diffusion coefficients (D_e) in fine-grained sediments typically range from 6.0×10^{-10} m²/sec (1.9×10^{-2} m²/yr) for mobile ions to 1.1×10^{-11} m²/sec (3.5×10^{-4} m²/yr) for ions adsorbed by soil surfaces (Freeze and Cherry, 1979; Johnson et al., 1989; Shackelford, 1990; Nye, 1979). Diffusion coefficients for non-ionic organic compounds are reported to be approximately 2×10^{-10} m²/sec (6.3×10^{-3} m²/yr) (Subramanian and Fitch, 1992; Mott and Weber, 1992).

Diffusion through a geomembrane is considerably less than diffusion through clay. Rowe & Booker (1990) suggests using a diffusion coefficient of 3.0×10^{-5} m²/yr based on Lord et al. (1988) and Hughes and Monteleone (1987) which is 500 times lower than the clay diffusion rate. As a conservative approach to accounting for the lower diffusion rates through a synthetic liner, a value of 4.4×10^{-4} ft²/day (1.5×10^{-2} m²/yr) was used for the diffusion coefficient. This value is the geometric mean value calculated from the three clay diffusion values referenced above and is still 60 times higher than the value used in Rowe & Booker (1990).

9.6.7 Bulk Density and Distribution Coefficient

The soil bulk density and constituent distribution coefficient are parameters that characterize constituent adsorption on the soil and retard the transport of constituents. The baseline model assumes no constituent adsorption. As recommended in the POLLUTE documentation, when there is no adsorption, values of

CERTIFICATION BY PROFESSIONAL ENGINEER AND HYDROGEOLOGIST

I hereby affirm that all information contained in this Permit Application is true and accurate to the best of my knowledge and belief in accordance with good engineering practice.

Signature of Engineer

6-15-99

Date

062-044806

Illinois Reg. No.

CHRISTOPHER G. RUBAK
062-044806
REGISTERED
PROFESSIONAL
ENGINEER
OF
ILLINOIS

I hereby affirm that all information contained in this Permit Application is true and accurate to the best of my knowledge and belief.

Joan E. Underwood

Signature of Groundwater Professional

6-18-99

Date

Professional Geologist 196-000286

Title