Determining the Plume Source Discharge, Trailing Edge, and Natural Attenuation Timeframe: the F-Area Savannah River Site

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At the Savannah River Site (SRS) and many other contaminated facilities, understanding residual drainage from the source zone is essential for predicting attenuation of plumes. Lacking this understanding, the dynamics of a plume's trailing edge remain unknown, and remediation timeframes cannot be predicted. The challenging nature of these problems is reflected in large uncertainties in remediation timeframes at many sites, even after decades of monitoring and research. At the SRS F-Area, large contaminant plumes resulted from decades of radioactive waste disposal into seepage basins. The objective of this work was to predict groundwater plume attenuation through characterizing its current status and developing a mass balance model for source zone drainage and dilution. Here, we combined data from recently acquired field borehole sediment samples with historical waste disposal records, and long-term groundwater and plume monitoring data. Analyses of the sediments reveal the trailing plume edges for tritium and nitrate (Wan et al., in press). We developed a mixing model to predict source zone recharge rates and contaminant concentrations within the plume as functions of time and distance. Our calculations for the plume in F-Area SRS indicate that early stages of post-closure waste drainage occurred with high water fluxes (≈ 0.5 m y^{-1}), and declined over the 20 years since basin closure to low rates of a few cm y^{-1} (Tokunaga et al., in press). While the magnitude of late stage vadose zone drainage is low, its impact is large because of the high concentrations of contaminants it continues to supply to groundwater. The model predictions compared well with measured tritium and nitrate concentrations from monitoring wells 220 and 375 m downstream of the seepage basin. The methodology presented here requires only groundwater monitoring data and a few well-constrained input quantities. Thus, this approach can be useful for gaining better understanding of contaminant dissipation at other sites as well.

We also conducted isotopic studies of U, Sr and nitrate to understand the plume's history. The nitrate isotopic analyses give no indication of biotic denitrification within the plume, although a surface water sample suggests denitrification occurs between the seep line and the stream. Both chemical and systematic isotopic vertical variations of U and Sr isotopes were identified within the upper aquifer. The data suggest that the lower zone represents the effect of the original contaminant fluids, while the upper zone mainly represents recharge of water contaminated by infiltration post-closure through the contaminated vadose zone beneath the basins. The U isotopic compositions of groundwaters collected at the same wells two years apart suggest the migration rate of U from up-gradient portions of the plume of 100 m y^{-1}, below the estimated velocity (123 m y^{-1}) used in our models of basin drainage and plume attenuation.

Tetsu K. Tokunaga, Jiamin Wan, and Miles E. Denham, Estimates of Vadose Zone Drainage From a Capped Seepage Basin, F Area, Savannah River Site. Vadose Zone Journal, in press.

Jiamin Wan, Tetsu K. Tokunaga, Wenming Dong, Miles Denham, and Susan S. Hubbard, Persistent Source Influences on the Trailing Edge of a Groundwater Plume, and Natural Attenuation Timeframes: the F-Area Savannah River Site, ES&T, in press.