Evaluation of Soil Vapor Extraction Data to Characterize Mass Flux to the Vapor Intrusion Boundary

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Background/Objectives. Methods for assessing contaminant mass flux for vapor intrusion consist primarily of two approaches. In the first, mass removal is measured during the operation of mitigation systems, either in basement areas or for subslab depressurization. Variability in measuring mass removal is reduced over measures of vapor concentrations alone; however, climate variables (e.g., barometric pressure, precipitation) as well as building usage generate significant transients. The mitigation itself introduces a non-native condition. The second approach evaluates the upward diffusion rate of vapors from persistent sources in the vadose zone and/or from contaminated groundwater. Consistent measures of concentration can usually be attained from probes at depths roughly 5 or more feet below surface. These locations are relatively impervious to climate variations and lie within native soils. Vertical vapor concentration profiles are often measured at sites; however, the measures are usually made under ambient (steady) conditions that require specification of a vertically-averaged, unmeasured diffusion coefficient that varies vastly in native soils. For contaminated groundwater the lower boundary requires assumptions about mass transfer across the capillary fringe. An objective of this project was to demonstrate the utility of classic soil vapor extraction (SVE) rebound techniques to assess more directly the location of and mass flux from contaminant sources. The technique is based upon transient measures of vapor concentration in a vertical soil profile.

Approach/Activities. The assessment of the contaminant sources and fluxes is based on periodic operation of SVE followed by measures of transient concentration rebound. Results are presented for two periods of rebound between active SVE operations over a two-year period at an industrial site in Southern California with modestly stratified soil and with sources of PCE and TCE in the vadose zone and groundwater. The SVE data yielded estimates of diffusion-limited mass transfer along with a volume-averaged maximal mass flux and its decay with mass removal. Concurrent with the SVE data evaluation, a field effort employed pneumatic logging to provide high resolution measures of vapor permeability and vapor concentrations along SVE screens including a groundwater monitoring well with exposed screen. With these profiles, a layered model of the vadose zone was readily constructed and measures of transient vapor concentrations were used for calibration of diffusion coefficients. The modeling was performed with EPA’s VLEACH code modified to include variable soil layering.

Results/Lessons Learned. The diffusion coefficients estimated from the transient vapor concentrations and the layered soil model were consistent with those estimated from the SVE operational data. The estimated mass flux of PCE and TCE before SVE was found to be reduced by roughly two orders-of-magnitude at the end of SVE. The results provide a relationship for assessing acceptable source vapor concentrations at the close of SVE that are sufficient to obviate future active mitigation of vapor intrusion. A comparison calculation assuming a uniform vadose zone revealed that diffusion coefficient averaging eliminated the dominant transport features at the site and rendered such results invalid. Soil vapor extraction proximate to the sources of contaminant vapors, particularly contaminated groundwater, is an effective method of VI mitigation, though costs must be considered.