Evaluation of Multiple Lines of Evidence for Quantitfying Natural Source Zone Depletion Rates Overlying a Shallow LNAPL Source Zone

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Management of sites impacted with light non-aqueous phase liquids (LNAPLs) using passive approaches such as monitored natural source zone depletion (NSZD) is increasingly being implemented in remediation of petroleum hydrocarbon (PHC) source zones. Estimated NSZD rates may be used to support transitioning of active remediation systems when active rates are less than NSZD rates support passive remediation as a standalone strategy. Quantitative tools for estimating NSZD rates are necessary to understand source zone longevity for site management decisions. In order to evaluate NSZD monitoring tools, multiple approaches for quantifying NSZD rates were implemented over a 4-year period at a former refinery overlying a shallow (4 m depth) light non-aqueous phase liquid LNAPL contaminated aquifer. Comparison of discrete CO_2 efflux measurements from dynamic closed chambers to estimates obtained using integrated CO_2 efflux data from static traps and continuous hourly CO_2 efflux monitoring measurements using forced diffusion (FD) technology was completed over four monitoring programs. Thermistor strings along a transect were installed to monitor continuous (hourly) thermal gradients and assess NSZD rates using the temperature gradient method. Evaluation of available soil gas data using the concentration gradient method (CGM) was used to quantify the vertical oxygen gradient to estimate NSZD rates. Estimates of NSZD rates for a decane ($C_{10}H_{22}$) equivalent for fall and summer respectively, ranged from 80 to 1,300 US gal/acre/yr using radiocarbon corrected CO_2 efflux methods, 120 to 1,600 US gal/acre/yr using oxygen soil gas gradients and 400 to 2,000 US gal/acre/yr using a background corrected temperature gradient method. Temporal variability was analysed in respect to seasonal temperature changes and increased precipitation characteristic of a wet regional climate setting. The range estimates quantified using concentration gradient method indicated importance of considering soil moisture data in NSZD estimates. Continuous measurement methods provided improved temporal data resolution as compared to discrete sampling programs. This study addressed consideration in spatial and temporal data collection for designing field programs for predicting quantitative annual NSZD rates.

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Anne Wozney, is an environmental consultant with Golder Associates (a member of WSP). She has worked in the contaminated sites group for the past 5 years, working on a diverse range of projects from contaminant transport to source zone longevity evaluation. Prior to working in consulting, Anne obtained her MSc from the University of Ottawa under the co-supervision of Dr. Ulrich Mayer (UBC) and Dr. Ian Clark (Uottawa). Her thesis work investigated radiocarbon methods for differentiating contaminant and natural derived carbon when monitoring LNAPL biodegradation at hydrocarbon contaminated sites.