Estimates of Engineered and Natural Source Zone Depletion by Wireline Temperature Measurement

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Background/Objectives. Engineered air sparging and bioventing systems have been implemented at a former refinery to enhance the aerobic biodegradation of residual and dissolved phase petroleum hydrocarbons (PHCs) in the subsurface. The relative rate of biodegradation through natural and engineered processes is an active area of research at many similar PHC sites. The objective of this work is to compare rates of ‘engineered’ and natural source zone depletion (E/NSZD) while the engineered systems are in operation, and after the systems are shutdown.

Approach/Activities. Biodegradation of PHCs releases heat which was detected by measurement of a temperature profile versus depth in soil. Four existing groundwater monitoring wells and one reference well were used to measure temperature in the subsurface by wireline measurement to depths ranging up to 400 feet below ground surface. To facilitate this approach, a blank PVC casing was placed within the existing wells, filled with water, and allowed to equilibrate. Commonly used in the petroleum industry, wireline measurements were performed by lowering a temperature probe down the blank casing to read a continuous profile. The temperature profiles were converted to heat fluxes and then E/NSZD biodegradation rates. An initial profile was taken with the engineered systems running and then periodically over a year cycle once the systems were shut off. Oxygen, carbon dioxide and methane concentrations were monitored in nearby wells to better understand degradation processes.

Results/Lessons Learned. Each well had initial E/NSZD rates of 450 to 1,300 gallons per acre per year (gal/ac/yr) while the engineered systems were in operation. Two of the wells had two distinct zones of biodegradation: a shallow zone resulting from diffusion of atmospheric oxygen into the subsurface, and a deep zone created by the engineered addition of oxygen through bioventing and air sparging. A well far from the engineered oxygen addition, but in a PHC-impacted area, showed only a shallow biodegradation zone, and the reference well outside the impacted area showed no indication of biodegradation. After system shutdown, the deep zone ESZD rate decreased by about 70% over 7 months in a specific well. Data show that, in all but one well, the shallow NSZD rate was greater than the deep ESZD rate, indicating that natural biodegradation exceeds the rate of engineered biodegradation at this site. Results also demonstrate that the relatively straightforward wireline temperature method can be used to temporarily convert existing wells to NSZD measurement points. This can be a valuable approach for temperature measurements, especially in deep aquifer systems. ESZD estimates provide an independent measure of the effectiveness of air sparging and bioventing systems relative to NSZD.