

Finding LNAPL Natural Source Zone Depletion in a Fractured Rock Environment

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Spurred by relatively recent research and several years of field trials of different measurement techniques, the assessment of LNAPL natural source zone depletion (NSZD) is becoming a more standard consideration in LNAPL conceptual site model development and remedial decision-making. Assessing NSZD can serve a number of purposes including: quantifying NSZD as the baseline remedy consideration, scrutinizing the costs and benefits of engineered remedies over NSZD alone, and as a supporting line of evidence of the appropriateness of risk-based LNAPL management strategies (to name a few). Due to a growing recognition of the significance of NSZD in LNAPL site management, it is expected that the incorporation of NSZD as a critical part of LCSM development and LNAPL site management will become progressively more common in the future. As evidence, the measurement and use of NSZD data is promoted in recent guidance from the American Petroleum Institute (API) and the Interstate Technology & Regulatory Council (ITRC) in the U.S., and is the focus of guidance currently under development by CRC-CARE in Australia. However, relatively little information is found in the literature regarding NSZD at fractured rock sites specifically. This presentation will detail efforts to quantify NSZD and incorporate results into the site management process at such a site.

Efforts to quantify NSZD have in recent years focused on two techniques: (1) near surface carbon dioxide (CO₂) efflux; and (2) biogenic heat. As CO₂ will represent the final product of LNAPL mineralization, the CO₂-based technique involves measuring surface CO₂ efflux at LNAPL sites and using different ways of isolating the fraction of the measured CO₂ efflux that is derived from LNAPL degradation (as opposed to modern carbon sources such as plant respiration). The CO₂-based method can be applied using both active and/or passive techniques. Conversely, the biogenic heat method focuses on identifying temperature gradients/anomalies in the vadose zone within an LNAPL-impacted area that are associated with exothermic biodegradation reactions. The associated heat flux and heat of reaction form the basis for the estimation of the LNAPL degradation/NSZD rate. This presentation will discuss the implementation of both the CO₂ method (initial screening via dynamic flux chamber followed by the use of CO₂ Traps) and the biogenic heat technique at a fractured rock site in New South Wales, Australia, where NSZD is being evaluated as a potential fundamental component of the LNAPL remedial/management strategy. Discussion will include the importance of the LCSM and initial site work to determine where NSZD-related CO₂ was likely to be found near surface. In addition, the estimates developed via the different techniques will be compared and contrasted and pros and cons of the implementation of each technique in a fractured rock environment discussed.

The results lend themselves to the growing body of evidence that NSZD rates can be significant under a wide-range of conditions including complex fractured rock environments. As with the now widely accepted use of monitored natural attenuation (MNA) to remediate dissolved phase petroleum hydrocarbons, the data presented here support the increasing inclusion of NSZD as a fundamental/baseline consideration for the remediation or management of LNAPL.