

## **Advances in Monitoring Petroleum Contaminated Sites**

Charles J. Newell, Poonam Kulkarni, John Connor (GSI Environmental Inc.)

Tom Sale (Colorado State University)

The conceptual model for hydrocarbon source zones at contaminated groundwater sites has been revolutionized by a new focus on natural anaerobic processes that act directly on the Light Non-Aqueous Phase Liquids (LNAPL) present in these sources. As the understanding of this important process has gained acceptance, there have been several new developments in measuring and enhancing this attenuation, now referred to as Natural Source Zone Depletion (NSZD). Since 2006, two methods are now being routinely applied to measure and quantify NSZD rates, including: 1) the gradient method and 2) surface carbon dioxide efflux measurements using carbon dioxide traps or dynamic closed chambers. A third method, temperature based NSZD monitoring, is now being explored by several research groups. The USGS has applied this concept at the National Crude Oil Spill Research Site in Bemidji, Minnesota with both detailed and simple methodologies (Warren and Bekins, 2015). Sweeny and Ririe (2014) presented the energy balance equations for a temperature-based methodology and compared NSZD vs. soil vapor extraction. Finally, Colorado State University/GSI Environmental Inc. have developed an integrated measurement and data processing system where temperature is used with an “internet of things” approach to continuously monitor NSZD and potentially replace active monitoring at LNAPL sites (Sale et al., 2014; ThermalNSZD.com).