

## **Applied groundwater tracers: an invaluable practitioners tool for remediation system design and operation**

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**Abstract.** Although applied groundwater tracers have been used extensively for many decades to study solute transport phenomena in both the laboratory and field studies, they have only recently become widely used by some practitioners to support groundwater remediation system design and operation. For example, conservative and reactive tracers can greatly aid in the design and evaluation of enhanced bioremediation strategies by providing a reliable way to quantify remedial fluid delivery and distribution, in-situ contaminant decay, electron acceptor/donor utilization rates, mobile and immobile porosity, mass transfer rate coefficients, and contaminant sorption. Appropriate test design and interpretation methods are dependent upon the test objectives; they may be limited to simple qualitative observations using dyes, or they may involve the use of more exotic tracer such as dissolved gases and quantitative interpretation with numerical flow and transport models. ARCADIS has reaped such benefit from tracer testing that we now include tracers in almost all of our pilot tests for in situ remediation systems, and are initiating new tracer tests on a nearly weekly frequency. This large number of tracer tests has provided a unique opportunity to effectively manage the knowledge gained from experiences and lessons learned to develop and refine practical design and implementation guidance. Furthermore, the collective observations from several hundred tests have lead to deeper understanding of characteristic behaviors of various system and aquifer types. For example, non-ideal “dual-domain-like” transport behavior is observed at the 10-m scale in essentially all alluvial systems, and that mobile porosity (the porosity that controls initial solute breakthrough) is typically 2 to 10% (and never exceeds ~15%) even for very “homogeneous” aquifers. In this paper we present some general guidance and specific examples of tracer testing for the design and operation of in situ remediation systems.

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