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Delineating Groundwater Discharge Inputs to Surface Waters Using Thermal Methods

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Background/Objectives. Groundwater discharge inputs to surface waters may serve as point sources of contaminants from groundwater plumes. On environmental remediation sites, evaluation of these inputs should be incorporated into human health and ecological risk assessments, and the need to incorporate groundwater discharge locations into monitored natural attenuation programs is gaining prominence. Traditional methods of identifying groundwater-surface water exchange do not have the ability to delineate point sources of groundwater discharge, as these methods typically rely on net gains/losses integrated over a portion of a surface water body. We demonstrate that heat-tracing techniques offer cost effective alternatives that can identify discrete areas of groundwater input without the need for active tracers or expensive laboratory analyses. These thermal methods enable site managers to confirm the presence/absence of point source discharge to streams, as well as to enable the site investigator to sample the discharge itself. Directly sampling the groundwater discharge input is advantageous, as the results indicate the concentrations entering the surface water body, and as contaminated groundwater migrates through the hyporheic zone, there is an increased potential for contaminant degradation through biological and redox-based mechanisms.

Approach/Activities. We compare increasingly common heat tracing methods that rely on either direct-contact measurements or remote sensing. Direct-contact methods include discrete point measurements and fiber-optic distributed temperature sensing (FO-DTS) measurements. FO-DTS collect high spatial resolution thermal measurements through time within the water column using temperature-sensitive cables, which can span kilometers. The data collected provides temporal evaluation of thermal anomalies; however, the method can be laborious and time-intensive. Remote sensing methods, such as thermal infrared (TIR) imagery, either from handheld, airborne, or satellite platforms, can quickly identify groundwater seepage zones across large scales. TIR imagery measurements are adversely influenced by many environmental and physical factors, and the measurements are limited to the surface temperature of water bodies.

Results/Lessons Learned. We present case studies from various aquatic systems to evaluate the effectiveness of various thermal methods for evaluating groundwater discharge. We will illustrate the types of data produced using these thermal methods, and will discuss the pros and cons of each of the methods. We will also present appropriate and inappropriate use cases for remediation site managers.