Mapping Complex Pollution Scenarios: Charting Water Flow Along Lenses of Materials with Differing Permeability

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In the Great Basin desert of the western United States lies an airfield that has been in continuous operation for almost a century. The owners of the airfield had dumped fuel, oil, and other liquid waste into chemical disposal pits. When evidence recently emerged that one of these pits—which had been in use1973-75—was linked to local groundwater contamination, the airfield operators began an intensive remediation investigation.

The starting assumption of the investigation was that the waste contaminants flowed directly downward from the pit into the water table. Before developing remediation strategies based on that assumption, however, the investigative team decided to test its validity with a relatively new groundwater-mapping method. The results of the investigation showed that the assumption was fundamentally flawed. Rather than flowing directly downward from the pit, the contaminants appeared to flow along preferential paths where surface water concentrated as it seeped into the water table. The investigation suggested that these paths of least resistance consisted of lenses of higher or lower permeable materials (silts, sands and/or gravels). As surface water seeped through and along these lenses of varying earthen materials, the groundwater flowed outward from the pit in all directions.

The intricate flow pattern revealed in this investigation would have been extremely difficult to comprehend through traditional subsurface mapping methods. Such methods have typically relied on the drilling of investigative wells in the hope of a fortuitous intersection of the borehole with a contaminant flow path. This sort of approach may have been suitable for relatively simple flow patterns, with one or two major channels, but a fractured, complex and counterintuitive pattern like the one in this study would require a prohibitively large amount of exploratory drilling, with all of the financial expense and ecological trauma entailed in such an invasive technique.

Detailing the method used in the above case study, this paper presents an alternative to traditional mapping methods, one much better suited to the demands of such complex groundwater scenarios. This procedure, which uses Audio Frequency Domain Magnetics (AFDM), begins by charging the groundwater site with a low voltage, low amperage, high frequency electrical current. As the current moves through the groundwater, it emits a magnetic field whose size, shape, magnitude and direction are characteristic of the surrounding aqueous system (Biot-Savart Law). This field is then read at the surface by a specially tuned receiver. The data thus generated—after being run through a series of filters detailed in this paper—can be used to create both two-dimensional maps and three-dimensional models which indicate the attributes of the subsurface water network, including potential flow paths. Because this method uses the

broad diffusion of electrical current rather than targeted boreholes, it can capture the character of large and complicated groundwater systems much more effectively.

Drawing primarily from the above case study, this paper will examine the promise and the limitations of this approach.

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