Evaluation of Geophysical Methods for the Detection of Subsurface Tetrachloroethylene in Controlled Spill Experiments

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Why?

Tetrachloroethylene (PCE), a dense non-aqueous phase liquid (DNAPL), is a predominant contaminant of drinking water aquifers. Effective remediation requires the location of the non-aqueous phase PCE in the subsurface.

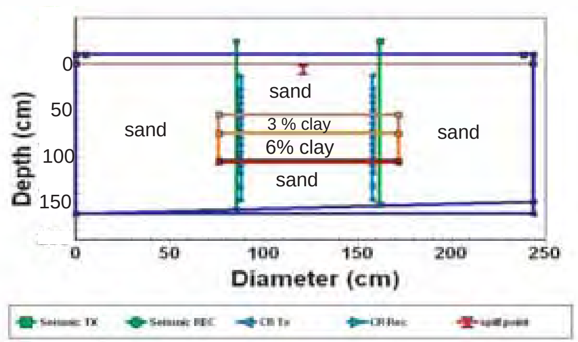
How?

Geophysical methods have the potential to detect subsurface DNAPLs in a safe, non-invasive, cost-effective manner. A number of controlled spill experiments were conducted in which measurements with 10 different geophysical methods were made before, during, and after the injection of PCE into the subsurface. This approach clearly identifies any geophysical anomaly associated with the PCE.

The Experiment

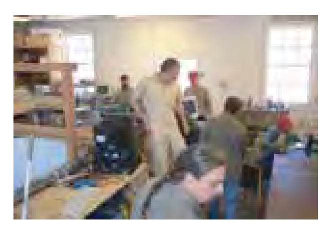
A number of sand and clay/sand layers were constructed in a fiberglass tank at LBNL.

Geological formation cross-section.



In May 2004, 85 liters of PCE was injected into the subsurface over a period of 26 hours.

Eleven scientists from the U.S. EPA, LBNL and the U.S. Geological Survey (USGS) obtained measurements with 10 different geophysical methods.

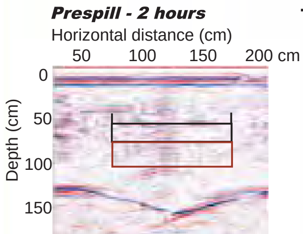


The geophysical methods evaluated were surface ground penetrating radar (GPR), cross borehole GPR, directional borehole GPR, borehole dielectric tool, high frequency and very early time electromagnetic systems, cross borehole seismic, complex resistivity, self potential and borehole video.

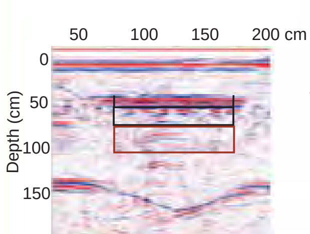
Results

Preliminary results indicate that most of the methods observed some anomaly associated with the PCE. Partial data from the surface GPR, seismic and complex resistivity methods are shown below taken at prespill, spill and post spill periods. These three methods respond to different intrinsic physical properties of the formations.

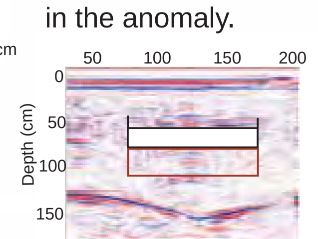
Prespill - 2 hours



GPR data show a large anomaly during spill at 50 cm depth, post spill data show reduction in the anomaly.



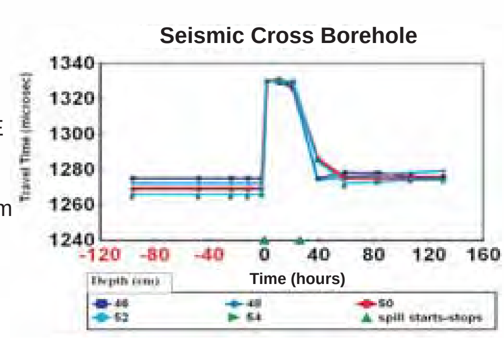
+9 hours after spill started

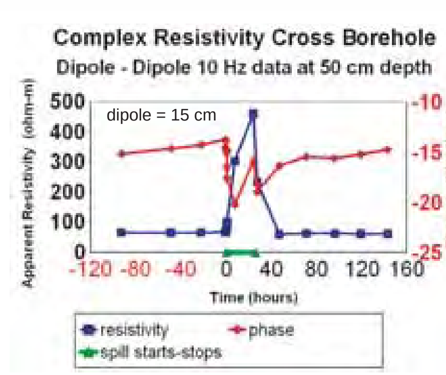


+68 hours after spill started (+42 hours after spill stopped)

The seismic and complex resistivity data shown below were taken at the top of the 3% clay/sand layer, 50 cm depth. Both methods show a large anomaly during the spill period, returning almost to background after the spill stopped.

Borehole video indicated that 4 hours after the spill started, a 4 cm thick layer of PCE had accumulated and spread across the 3% clay/sand layer at 50 cm depth





Summary

Anomalies were observed with multiple geophysical methods indicating changes occurred in different physical properties of the formations with the presence of the PCE. A monitoring approach utilizing multiple, different geophysical methods and scientific expertise could provide unique detection and identification of subsurface PCE.

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