Sandia National Laboratories

Environmental Field Geophysics

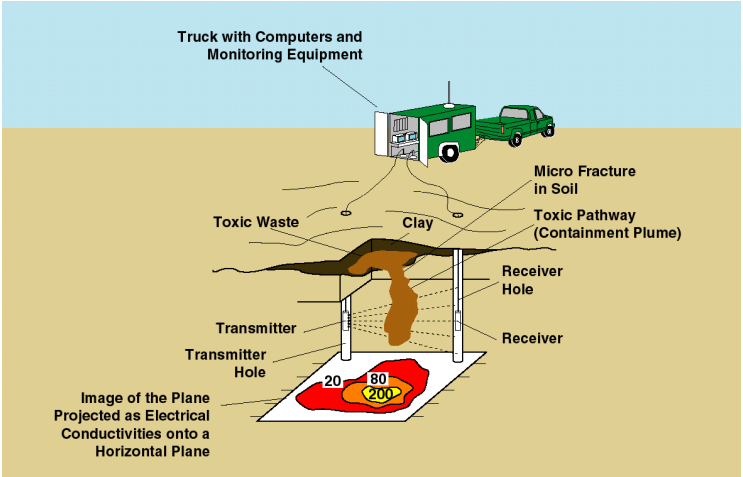
Subsurface Imaging using Crossborehole Electromagnetics

Need

Environmental site characterization and monitoring are essential elements in developing and implementing remediation strategies. Electrical and electromagnetic (EM) methods can be particularly effective for monitoring and characterization because some waste forms, such as metals, have significant contrasts in electrical properties compared with typical soils. One approach to electromagnetic monitoring is to place an active EM source on the surface or in a borehole and record signals either on the surface or in a nearby borehole; the data are then inverted for EM images of the subsurface. Sandia National Laboratories has worked with industrial partners to demonstrate the feasibility of EM imaging for landfills with continuous wave and pulsed radar systems. The continuous wave system has been used in several demonstration projects at Sandia and on Kirtland Air Force Base in Albuquerque. Commercial firms have provided contract services to Department of Energy remediation projects at several different sites based on these EM imaging techniques.

Description

Continuous wave radio imaging uses the measured amplitude and phase of a signal transmitted between two boreholes or borehole-to-surface to provide tomographic images of the 2-D electrical properties between the transmitter and the receiver. Typical frequencies of operation are in the 15MHz range. The instruments are 2 inches in diameter and 6-12 feet in length, and employ fiber optic cables. A typical survey between two boreholes would be collected in a series of ray path fans, where the transmitter is stationary and the receiver is moved to a number of locations until a fan of measurements is completed. Typical resolution is 1/20 of the distance between the transmitter and the receiver, thus the system can image reasonably small objects or EM anomalies with borehole separations on the order of tens of meters. For demonstration surveys at the Sandia Chemical Waste Landfill, for example, resolution was approximately 1.5 ft. From repeated and overlapping measurements of amplitude and phase between boreholes, the distribution of electrical conductivity



Schematic showing crosswell experiment for imaging contaminants using electromagnetic methods

between boreholes can be reconstructed using tomographic algorithms. Conductivity is sensitive to changes in moisture content, permeability, and water chemistry. Repeated experiments over time can be used to monitor plume movements and remediation efforts. In addition, using EM imaging provides a means to image in between boreholes where no direct sampling is available; it is minimally invasive.

Example Applications

Sandia was involved in several demonstrations of this technology including imaging of the Chemical Waste Landfill at Sandia and Kirtland AFB's RB-11 site. Additional demonstrations of the EM imaging method have been provided at numerous DOE sites, such as Fernald, Rocky Flats, and the Idaho National Engineering and Environmental Laboratory by commercial partners. The patent rights to the EM imaging system are now held by Raton Technology Research, in Raton, New Mexico.

Radio-imaging method borehole electromagnetic tool

Reference

Borns, D. J., G. Newman, L. Stolarczyk, and W. Mondt, 1993., Cross Borehole Electromagnetic Imaging of Chemical and Mixed Waste Landfills, Proceedings of the Symposium on the Application of Geophysics to Engineering and Environmental Problems, Environmental and Engineering Geophysical Society, 91-105.

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