Waste Pit Imaging at the Idaho National Engineering and Environmental Laboratory using the Very Early Time Electromagnetic (VETEM) System

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Abstract: The Very Early Time Electromagnetic (VETEM) system, developed with support from the Department of Energy Environmental Management Science Program, was deployed at Pits 4, 9, and 10 in the Subsurface Disposal Area (SDA) of the Radioactive Waste Management Complex (RWMC) at the Idaho National Engineering and Environmental Laboratory (INEEL). VETEM was used to provide geophysical images of the location and estimated depths of some of the waste in Pit 9. The images are being used to assist remediation activities. VETEM is designed to produce high-resolution images of the shallow subsurface when the electrical conductivity is too high for ground-penetrating radar (GPR) to be effective, such as in the clay capping material over waste pits like Pits 4, 9, and 10. The University of Illinois developed an inversion algorithm, appropriate to VETEM data, that was used to provide depth estimates to highly conducting objects in Pit 9. Subsequent to the successful results at Pit 9, data were collected over the approximately 41,000 m² of Pits 4 and 10. The data from Pits 4 and 10 are of high quality and were the first to be produced using a new all-terrain-vehicle (ATV)-towed version of VETEM with an integrated real-time kinematic global positioning system that can provide decimeter level positional accuracy. The high-resolution time-slice images of Pits 4 and 10 reveal lateral location of buried waste and of conductivity variations in the subsurface. Inversion of these data for depth using the University of Illinois code is planned.

The VETEM system was developed to address a need for high-resolution electromagnetic imaging of the shallow (0 to ~5 m) subsurface in cases where the electrical conductivity of the earth is too high for ground-penetrating radar (GPR) to achieve the required depth of investigation. Relatively high electrical conductivities are common in clay capping materials covering waste pits. VETEM was supported, in part, by the Department of Energy, Environmental Management Science Program (EMSP). The VETEM EMSP final report is available on-line at http://www.osti.gov/em52/final_reports/60162.pdf. Many of the details of the system, numerical modeling, and applications, both at the INEEL and at the Denver Federal Center, are contained in that final report.

During VETEM development we carried out system tests at the Cold Test Pit, outside the RWMC at INEEL. In addition, we used the system to gather data over Pit 9 and, later, Pits 4 and 10 inside the RWMC. Figure 1 shows a time-slice view of VETEM data recorded over Pit 9. The hotter colors map higher amplitudes in the VETEM recorded signal. Higher amplitudes indicate higher electrical conductivities. In most cases high conductivity is due to buried metal objects, although the VETEM signal also responds to changes in earth conductivity. Earth responses and buried metal responses can be distinguished because they have different characteristic decay times (Smith and others, 2000). Figure 2 shows a conductivity isosurface created from data inverted using the University of Illinois 1D Distorted Born Iterative Method (DBIM) inversion algorithm (Aydiner and others, 2001). Most of the volume within the isosurface probably contains buried metal objects. An exception is the “arm” sticking out from

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the lower right of the isosurface in Figure 2. Note that no corresponding high conductivity indication is seen in Figure 1, although one can be seen in early time slices.

Figure 1 – A time-slice amplitude map of Pit 9. Figure 2 – A conductivity isosurface of Pit 9.

VETEM images, such as shown in Figures 1 and 2, as well as more detailed images of a subarea of particular interest, were used as a guide for placement of stainless steel tubes that were subsequently used for nuclear logging of Pit 9. When the primary area of interest is remediated, it should be possible to determine the accuracy of the VETEM location and calculated depths. Plans are also underway to have the University of Illinois develop an advanced 3D-inversion algorithm and use that new algorithm to reprocess the Pit 9 VETEM data.

We performed a VETEM survey of Pits 4 and 10 at the RWMC during the summer of 2000. Since the area of Pits 4 and 10 combined, about 41,000 m², is much larger than the area of Pit 9, it was necessary to reconfigure the VETEM system to be towed by an ATV or other vehicle, as shown in Figure 3, to increase the achievable survey speed. In addition to the ATV-conversion, greater electronic dynamic range was achieved using a new linear/logarithmic receiver. The system dynamic range and stability were increased in comparison to the results that had been achieved during the Pit 9 survey. A real-time kinematic global positioning system (RTK-GPS) was first integrated into the VETEM system for the survey of Pits 4 and 10. Position data, to decimeter or better accuracy, are now automatically included in the headers prefixed to each VETEM data record. Thus maps referenced to the Universal Transverse Mercator system, or other universally accepted systems, can be produced, thus avoiding any local grid uncertainties.
Figure 3 – The VETEM system in operation on Pit 4 in the RWMC, INEEL. Note the roving GPS antenna mounted on the front of the VETEM cart. Use of an independent towing vehicle makes surveys of large areas practical.

Figure 4 - This time-slice amplitude map of VETEM data over Pits 4 and 10 at the RWMC shows the location of buried metal waste. These data were recorded over several days and no attempt to level the data has been made. The high data quality reflects good system stability.

The VETEM system produces high quality electromagnetic data useful for waste pit and other Department of Energy shallow subsurface imaging needs. Inversion adds the depth dimension.

References