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Innovative Technology Verification Report

Rapid Optical Screen Tool (ROST™)

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Executive Summary

Recent changes in environmental site characterization have resulted in the application of cone penetrometer technologies to site characterization. With a variety of in situ physical and chemical sensors, this technology is seeing an increased frequency of use in environmental site characterization. Cone penetrometer technologies employ a wide array of sampling tools and produce limited investigation-derived waste.

The Environmental Protection Agency's (EPA) Monitoring and Measurement Technologies Program (MMTP) at the National Exposure Research Laboratory, Las Vegas, Nevada, selected cone penetrometer sensors as a technology class to be evaluated under the Superfund Innovative Technology Evaluation (SITE) Program. In August 1994, a demonstration of cone penetrometer-mounted sensor technologies took place to evaluate how effective they were in analyzing the physical and chemical characteristics of subsurface soil at hazardous waste sites. Prior to this demonstration, two separate predemonstration sampling efforts were conducted to provide the developers with site-specific samples. These samples were intended to provide data for site-specific calibration of the technologies and matrix interferences.

The main objective of this demonstration was to examine technology performance by comparing each technology's results relative to physical and chemical characterization techniques obtained using conventional reference methods. The primary focus of the demonstration was to evaluate the ability of the technologies to detect the relative magnitude of fluorescing subsurface contaminants. This evaluation is described in this report as the qualitative evaluation. A subordinate focus was to evaluate the possible correlations or comparability of the technologies chemical data with reference method data. This evaluation is described in this report as the quantitative evaluation. All of the technologies were designed and marketed to produce only qualitative screening data. The reference methods for evaluating the physical characterization capabilities were stratigraphic logs created by a geologist from soil samples collected by a drill rig equipped with hollow stem augers, and soil samples analyzed by a geotechnical laboratory. The reference methods for evaluating the chemical characterization capabilities were EPA Method 418.1 and SW-846 Methods 8310 and 8020, and University of Iowa Hygienics Laboratory Method OA-1. In addition, the effect of total organic carbon (TOC) on technology performance was evaluated.

Three technologies were evaluated: the rapid optical screening tool (ROST™) developed by Loral Corporation and Dakota Technologies, Inc. (DTI), the site characterization and analysis penetrometer system (SCAPS) developed by the Tri-Services (Army, Navy, and Air Force), and the conductivity sensor developed by Geoprobe@ Systems. Results of the demonstration are summarized by technology and by data type (chemical or physical) in individual innovative technology evaluation reports (ITER). In addition to the three technology-specific ITERs, a general ITER that examines cone penetrometry, hydraulic probe samplers, and hollow stem auger drilling in greater detail has been prepared.

The purpose of this ITER is to chronicle the development of the ROST™, its capabilities, associated equipment, and accessories. The report concludes with an evaluation of how closely the results obtained using the technology compare to the results obtained using the reference methods.

The ROST™ evolved from U.S. Government Department of Defense funded research performed at North Dakota State University (NDSU). The funding was sponsored by the U.S. Department of Defense Tri-Services SCAPS committee. The technology is being commercialized and marketed by a consortium of

government and industry led by the Loral Corporation. Loral Corporation owns the marketing rights to ROST” with development assistance provided by DTI, TriServices, and the U.S. Advanced Research Projects Agency. The technology was generally designed to provide rapid sampling and real-time, relatively low cost screening level analysis of the physical and chemical characteristics (primarily petroleum fuels and coal tars) of subsurface soil to quickly distinguish contaminated areas from noncontaminated areas. The ROSY” measures fluorescence and is attached to a standard cone penetrometer tool, which provides a continuous reading of subsurface physical characteristics. This is translated by software into various soil classifications. This capability will allow investigation and remediation decisions to be made more efficiently on site and will reduce the number of samples that need to be submitted for costly confirmatory analyses.

One hazardous waste site each was selected in Iowa, Nebraska, and Kansas to demonstrate the technologies. The sites were selected because of their varying concentrations of coal tar waste and petroleum fuels, and because of their ranges in soil textures.

This demonstration found that the ROST™ produces screening level data. Specifically, the qualitative assessment showed that the stratigraphic and the chemical cross sections were comparable to the reference methods. The ROST™ showed advantages relative to the reference methods in that the technology does not require the collection of samples for analysis because analysis occurs in situ. This capability helps the technology avoid the problems with sample recovery encountered with the reference methods during this demonstration. The relatively continuous data output from the ROST™ eliminated the data interpolation required for the reference methods, and it provided greater resolution. The ROST™ can also be used to identify changes in waste type during a site characterization. Through the use of a wavelength-time-matrix (WTM), the ROST™ can identify classes of contaminants, such as gasoline, diesel, jet petroleum (JP-4), and coal tar. The qualitative assessment showed that relative to the degree of contamination; for example, low, medium, and high, the technology’s data and the reference data were well correlated. Changes in TOC concentration did not appear to affect the technology’s performance.

The in situ nature of the ROST™ minimized the altering of soil samples, a possibility inherent with conventional sampling, transport, and analysis. Furthermore, the cone penetrometer rods are steam cleaned directly upon removal from the ground, reducing potential contamination hazards to field personnel. In addition, the continuous data output for both the chemical and physical properties of soil produced by the ROST” appears to be a valuable tool for qualitative site characterization.

The quantitative assessment found that the ROST™ data exhibited little correlation to any of the reference data concentrations of the target analytes. The lack of correlation for the quantitative evaluation cannot be solely attributed to the technology. Rather, it is likely due to the combined effect of matrix heterogeneity, lack of technology calibration, uncertainties regarding the exact contaminants being measured, and the age and constituents in the waste. Based on the data from this demonstration, it is not possible to conclude that the technology can or cannot be quantitative in its current configuration. Based on the effects listed above, a high degree of correlation should not be expected in comparisons with conventional technologies.

Verification of this technology’s performance should be done only on a qualitative level. Even though it cannot quantify levels of contamination or identify individual compounds, it can produce qualitative contaminant distribution data very similar to corresponding data produced by conventional reference methods, such as drilling and laboratory sample analysis. The general magnitude of the technology’s data is directly correlated to the general magnitude of contamination detected by the reference methods. The performance of the ROW’” during this demonstration showed that it could generate site characterization data faster than the reference methods and with little to no waste generation relative to the reference methods. The cost associated with using this technology to produce the qualitative data used in this demonstration was approximately $41,000 which included the cone penetrometer truck and cone penetrometer sensor, and the ROST™. Due to the increased quality control and visitor distractions, it is likely that the actual “production mode” cost of the ROST operation would be less than that exhibited during this demonstration. This can be compared to the approximate $55,000 used to produce the reference method cross sections, which were not available until 30 days after the demonstration. The ROSY cost less than the reference methods, it produced almost 1,200 more data points (continuously), and provided data in a real-time fashion.

The question that this demonstration can not answer is whether or not it is better to have fewer data points at the highest data quality level or more data points at a lower data quality level. Issues such as matrix heterogeneity may greatly reduce the need for definitive level data in an initial site characterization. Sampling and analysis must always be done to effectively use the ROST™ and critical samples will always require definitive analysis.