## Data Collection Options for *In Situ* Soil Segregation and Closure

The Ashtabula site has well-defined contaminant activity concentration guidelines for free releasing soils on site. These include:

- 30 pCi/g of total uranium averaged over 100 square meters;
- 65 pCi/g of technetium-99 averaged over 100 square meters.

For the bulk of the site already remediated, contamination has been near surface. For the balance of contaminated soils in Area B, much of this contamination is subsurface under foundations and slabs, and associated with buried drain lines. In this instance, clean soils will have to be removed to reach soils that are contaminated. Given the relatively high cost of remediating soils deemed contaminated, there is a need to keep the volume of soils identified as such limited to those that truly are. Consequently there is a need to differentiate between soils that meet cleanup criteria and those that do not. Characterization data collected to date are insufficient to accurately differentiate between soils that meet free release criteria and soils that do not across all of Area B. Consequently there is a need to be able to differentiate between these soils *in situ* as excavation work proceeds. This paper summarizes real-time data collection technology options for performing this work. The emphasis is on uranium. Recent GeoProbe characterization work indicates that within Area B, remediating uranium to its guidelines also addresses technetium-99 concerns.

The desired operational characteristics of an appropriate data collection system include:

- real-time results to support excavation decision-making/*in situ* soil segregation;
- 100% coverage capabilities, and
- detection limits sufficiently low to meet soil closure requirements for uranium.

There are several options that satisfy these operational characteristics.

<u>Hand-Held NaI Systems</u>

Sodium iodide (NaI) sensors are scintillation sensors sensitive to gamma rays. Hand-held NaI systems are typically used in a gross activity mode, identifying contamination by sensing gross gamma activity above background levels. NaI sensors are highly efficient, meaning that excellent counting statistics can be achieved with relatively short count times. When used in a scanning mode, typical count times are on the order of a few seconds. In a scanning mode, a technician walks swinging the sensor a few inches off the ground. When coupled with a data logger and positional control system, these data can be recorded and mapped after collection. In this fashion, complete coverage of exposed soil surfaces can be obtained. NaI systems have relatively poor energy resolution, meaning that when multiple radionuclides of concern are present at elevated levels, the system may not provide any information regarding their relative or absolute concentrations. In the case of Ashtabula, where the only measurable radionuclide of concern is uranium-238 and its daughter products, this is not an issue.

An important characteristic of these systems is their detection limit. Detection limits are a function of the level of background activity present, the radionuclide(s) of concern, and measurement times. Examples of hand-held NaI systems are 1x1, 2x2, FIDLER and miniFIDLER NaI sensors. Under ideal conditions, detection limits for a 2x2 detector are approximately 40 pCi/g for depleted uranium with a 2 second acquisition time (MARSSIM, 1997). These detection limits can be further reduced for uranium by controlling background through judicious use of shielding on the detector, by using a thin crystal detector such as a FIDLER or mini-FIDLER system, and/or by post-processing data through spatial averaging (equivalent to increasing effective count times). Subcontracting costs for these types of surveys typically run several hundred dollars per acre surveyed. These types of surveys have been used to effectively perform *in situ* soil segregation and support soil closure decision-making at a number of FUSRAP sites. On of their advantages is the ability to be used in almost any kind of terrain or slope that might be generated by a selective excavation operation.

Because gross activity NaI systems do not provide activity concentration estimates, trigger levels are typically defined that provide a pre-specified level of confidence that cleanup goals have been achieved (e.g., if a measurement is below a particular counts per second value, one can be 95% confident that total uranium concentrations are below 30 pCi/g).

Motorized NaI Systems with Gamma Spectroscopy Capabilities

More sophisticated NaI-based systems are capable of providing 100% coverage of exposed soil surfaces and limited gamma spectroscopy capabilities, typically through the use of multi-channel analyzers and larger crystals or crystal arrays.

Examples of these types of systems are the real-time NaI platforms deployed with ASTD support at the FEMP. These rely on 4x4x16 NaI cyrstals connected to a multi-channel analyzer, data logger and position tracking system. At the FEMP site, these systems have been deployed on hand-propelled jogging carts, GATOR four wheel personal recreational vehicles, and a tractor. With four second acquisition times, and only uranium present in surficial soils, these systems have been capable of detection limits less than 30 pCi/g for total uranium for individual measurements. They can cover large areas quickly, but have more limited mobility in challenging terrain than a walk-over does. The FEMP systems include real-time data reduction and mapping as well, allowing system operators to track their locations and electronically flag suspect areas. The FEMP has estimated their survey costs at approximately $500 per acre surveyed with these systems.

*In Situ* Gamma Spectroscopy

*In situ* gamma spectroscopy systems typically rely on High Purity Germanium (HPGe) crystals to provide quantitative analysis of activity concentrations in *in situ* soils. While *in situ* HPGe systems use equipment similar to that used to perform gamma spectroscopy in the laboratory, these systems provide several distinct advantages over traditional sampling and *ex situ* analysis techniques. These advantages include immediate availability of results, reduced data collection costs, elimination of investigation derived wastes, and results that are typically more directly comparable to cleanup criteria. As an example of the latter, an un-collimated HPGe system set at a height of 1 m has a field of view approximately equal to 100 square meters, providing a direct estimate of average activity concentrations for that area.

The advantage of HPGe systems over NaI scanning systems is the ability to obtain radionuclide-specific activity concentrations *in situ*. The disadvantage of HPGe systems is that measurement times are on the order of minutes, as compared to seconds for a NaI scanning system, meaning HPGe systems are typically deployed for stationary direct readings, not scans. In the case of total uranium, detection limits well below 30 pCi/g can be achieved with measurement times of 15 minutes. HPGe systems have been deployed at the FEMP under ASTD auspices, and used effectively for measuring total uranium concentrations in soils as a substitute for sampling and laboratory analyses. The cost for an HPGe measurement is on the order of $100 per measurement. HPGe systems require a higher level of technical expertise to operate than do NaI scanning systems.

All of the above systems are most effective when coupled with data logger and positional equipment. Positional equipment options are discussed in a separate technology fact sheet.