# A GPS-Based System for Radium/Uranium Contamination Gamma Scanning

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**Abstract.** MFG Inc. in 2001 developed a Global Positioning System (GPS)-based gamma scanning technique for use during site surveys at a large (16 km2) in-situ-leach uranium mine being developed in Kazakhstan. Since that time, the system has been improved and used at a total of eight radium/uranium-contaminated sites in the western U.S. At one former uranium mill site in Texas, data acquisition occurred at a rate of seven acres/hour on the 600 acre site. High-speed scanning allows 100% coverage of a site in a short period, providing color-coded output defining gamma exposure rates over the entire site.

## The GPS/Gamma Scan System

With the deployment of the Global Positioning System (GPS) satellite constellation, a number of new data collection methods became possible. Development of handheld GPS receivers has made such approaches feasible and cost-efficient. MFG staff have been involved in radiation measurements work for years. We decided in the late 1990's to link gamma detection units with GPS and computer systems to allow the development of very high density mapped data sets. Such data are useful to identify contamination at sites including uranium mills and mines, other metal mine facilities (for example, copper, vanadium and rare earth) with secondary radioactive contamination, and facilities with other contamination, including accidental. The GPS-based detection systems may also be used to direct remedial action at such sites, and become especially valuable when providing a record of the final radiation status of a remediated site.

Each system used to collect gamma exposure rate data includes the following:

- Ludlum 2350-1 radiation detection datalogger
- Ludlum 44-10 2x2 inch NaI gamma detector
- Garmin iQue 3600 GPS/Personal Digital Assistant (PDA)

- MFG code to capture data on iQue memory, and to sort and view data.

The Ludlum 2350-1 datalogger includes a bidirectional RS-232 port, allowing communication with PC and PDA devices. The iQue GPS data can be captured internally with appropriate programming, and an RS-232-capable port on the iQue allows communication with the 2350-1 for data transfer initialization and capture. Fig. 1 presents views of the system in use in a "backpack" configuration.

The system may be deployed in a single-detector configuration, with the gamma detector carried 1 meter above the ground, either lead-shielded or unshielded. The single detector system scans an effective width of two meters. It may also be deployed, using a portable computer, a USB hub, and individual WAAS-enabled GPS units to replace the iQue 3600, with multiple detectors carried on a truck or all-terrain vehicle. The latter configuration increases data collection speed, with two or more gamma detectors each providing data once per second to the PC. Fig. 2 provides a view of a three detector system, with detectors spaced on 2 meter centers at 1 meter height. The three detector system scans an effective width of 6 meters.

Developing a correlation between soil radionuclide concentrations and gamma exposure rates requires careful attention to sample and gamma data collection. Relatively uniform areas of contamination (typically 10 m squares) must be selected prior to sampling. Ten to twenty aliquots of soil, taken to 15 cm depth, are composited from each square, and sent to a qualified laboratory for Ra-226 con-

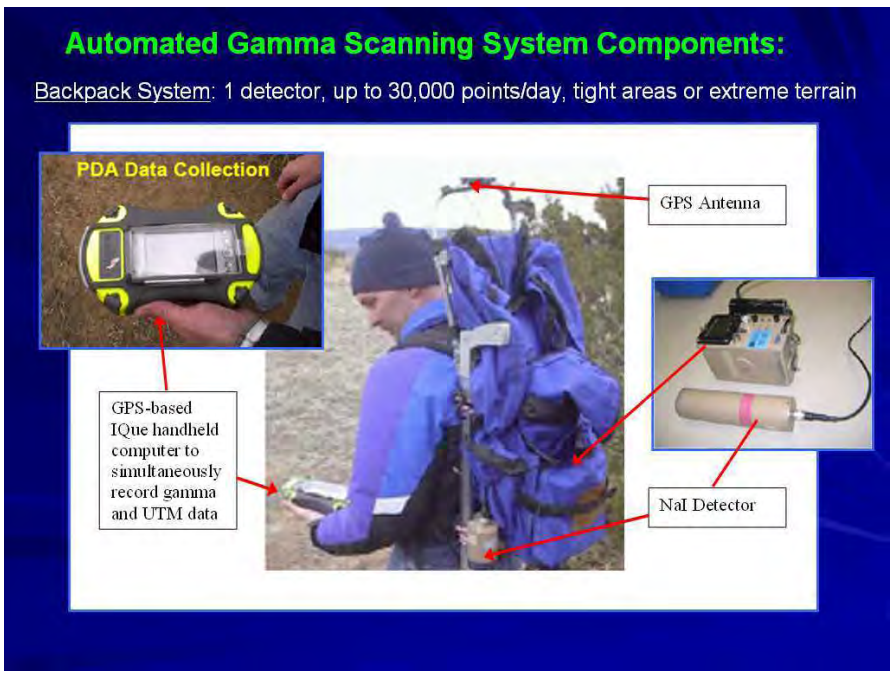


**Fig. 1.** System in Backpack Configuration.

centration analysis (after drying, grinding and homogenization). The sampled area is carefully scanned using either a backpack or truck-mounted GPS/gamma scan setup, to develop a useful correlation. Fig. 3 presents the results of such a correlation analysis, utilizing data collected at another client site in the western U.S.

**Fig. 2.** System in Three Detector Configuration.

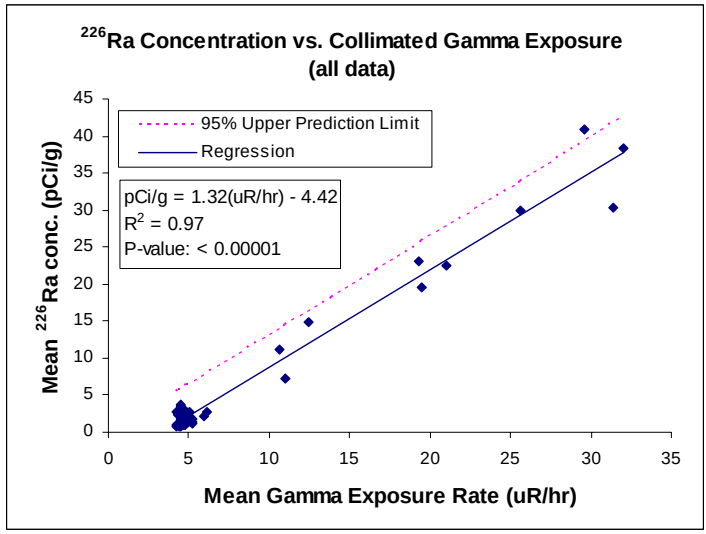


**Fig. 3.** Soil Analysis vs. GPS/Gamma Scan Exposure Data.

## Using the GPS/Gamma Scan System

Figs. 4 and 5 show characterization data developed at a client facility currently being remediated Initially, a base drawing of the plant was evaluated using computer automated design (CAD) systems. Such a drawing, developed earlier using available information, may not accurately present the locations of the site's features. The base map for this site was therefore "ground-truthed" by collecting GPS data at several dozen points throughout the site. This information was used to "warp" the original CAD drawing to fit the GPS findings. Fig. 4 presents such a corrected drawing, ready for gamma data display.

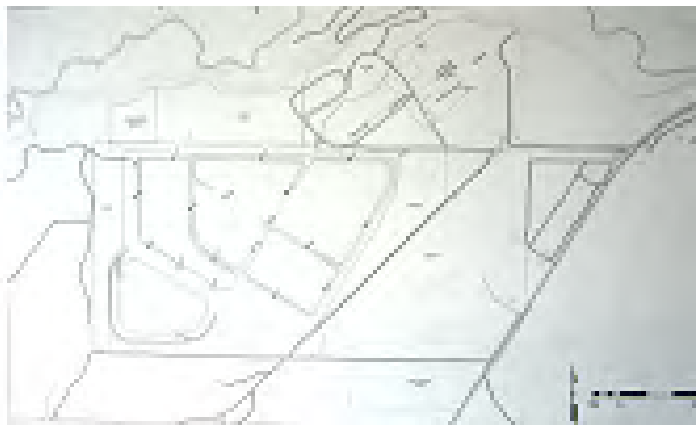

**Fig. 4.** Initial base map of a facility, corrected using on-site GPS data.

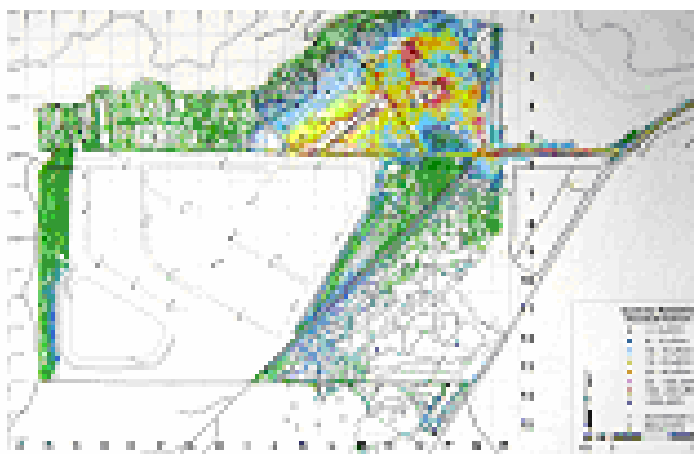

**Fig. 5.** Full Data Set Prior to Initiation of Remedial Action

Fig. 5 displays gamma exposure rate data collected using the MFG systems detailed above. The figure displays the facility's gamma status, as it exists prior to remedial action. Initial data were used to characterize site exposure rates, to identify areas from which soil samples could be taken to establish a site-specific correlation between gamma levels and actual soil Ra-226 concentrations. Note that such correlations are approximate only. Remedial action (cleanup) criteria, specified as allowable residual soil concentrations, may then be compared to color-coded data as shown, to allow quick identification of areas in which remedial action will be required. As excavation of contaminated soil proceeds during cleanup, new will be layered over this plot, providing a nearly real-time display of site remedial action status. Hand-held gamma detectors, of the same type used to develop the plot data, are used for excavation control.

Fig. 6 presents the status of another client site in the western U.S. This project is currently moving toward completion of remedial action. Given that a large number of soil samples have established a good correlation with gamma exposure rate for this site, the Geographical Information System (GIS) display has been modified to show green areas highly likely to meet the soil standard (6 pCi/g Ra-226 at this facility), or red areas requiring additional soil removal. Modification of the data presentation to this two-color format allows for quick identification of areas requiring additional work. All plots that we produce using the GPS/gamma system display high-resolution latitude/longitude (lat/lon) coordinates, allowing re-location of such contaminated areas easily, using "walk-back" features common to hand-held GPS units.

Fig. 7 presents the results of a "current status" check of another client's site in the southwestern U.S. The purpose of the survey was to check for potential con-

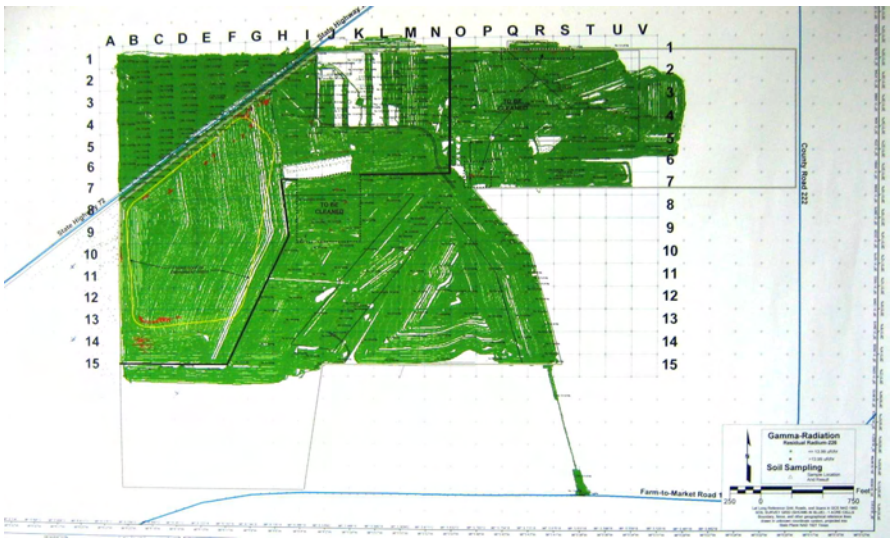


**Fig. 6.** Data Filtered to View Areas of Potential Remediation.

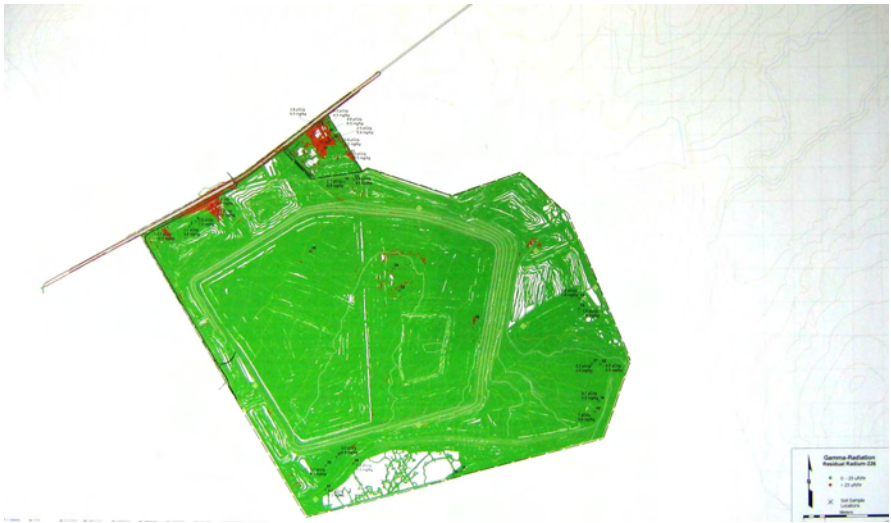

**Fig. 7.** Contamination Status Check Using GPS/Gamma Scan Data

taminated material left behind after completion of earlier remedial actions. Earlier survey techniques were unable to provide data at this resolution (the plot displays some two million data locations). Detailed soil sampling was used to establish a correlation between the GPS/gamma exposure rate and actual soil Ra-226 concentrations. Areas exceeding the allowable residual concentration, based on gamma levels, will be easy to find if additional remediation is determined by the client to be appropriate.

## Summary

The MFG GPS/Gamma Scan system has been refined since 2001 for use on a variety of radioactive contamination sites. The current configuration allows for very rapid data collection, development of useful correlations between soil concentration and gamma exposure rate, and display of very large data sets in a flexible and easily reviewed format. The system is currently in use at several U.S. remedial action sites.