WORKS IN PROGRESS

ELIPGRID-PC and INRADS®: Tools for Reducing Costs and Optimizing Data Collection on Sites Contaminated with NORM

Philip V. Egidi
Oak Ridge National Laboratory/Health Sciences Research Division
Environmental Technology Section*
Grand Junction, Colorado

ABSTRACT

Oak Ridge National Laboratory (ORNL), Environmental Technology Section (ETS), located in Grand Junction, Colorado has more than ten years experience in radiological surveying and more than twenty years as part of the ongoing Formerly Utilized Sites Remedial Action Project surveys conducted by ORNL Health Sciences Research Division. As part of our mission, ETS researches, develops, and applies innovative technologies to share with private industry. The ELIPGRID-PC software and INRADS® multi-detector radiologic survey instrument are works in progress discussed. ELIPGRID-PC is a tool that aids in survey design, and the INRADS system automates and increases the amount of data collected.

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INTRODUCTION

The purpose of this paper is to discuss two tools being developed by Oak Ridge National Laboratory (ORNL) Environmental Technology Section (ETS) located in Grand Junction, Colorado. ORNL/ETS has been conducting radiological surveys for more than ten years in conjunction with numerous U.S. Department of Energy (DOE) Projects, including the Uranium Mill Tailings Remedial Action Program (UMTRAP), the Monticello Remedial Action Project, the Formerly Utilized Sites Remedial Action Program, and the Decontamination and Decommissioning (D&D) Program. Much of its work in these programs involves investigating uranium and radium contamination from the uranium mining and milling part of the fuel cycle. In the course of investigating these mill-related tailings and debris, we often encounter naturally occurring radioactive material (NORM) in many forms and places. We encounter elevated levels of NORM in many forms: dinosaur bone, decorative rock, building materials, old radium dial watches, contaminated piping and steel that have been released from the old mill sites (Wilson 1993). Our experience has led us to develop methodologies that are applicable to some NORM projects. Two tools we are developing are the ELIPGRID-PC software and the INRADS system. ELIPGRID-PC is a tool that aids in survey design, and the INRADS system automates and increases the amount of data collected.

ELIPGRID-PC

One important factor to determine when designing a radiological survey is the amount of samples to collect in order to satisfy data quality objectives (DQOs) for the project. Some items to consider in this process are:

- The sensitivity of the instrumentation,
- the average contaminant concentration compared to background,
- the smallest size and shape of pockets of residual contamination to be detected,
- the level of confidence that an area of residual contamination will be detected, and
- the cost involved in detecting these pockets (called hot-spots).

If the minimum detectable activity (MDA) of the instrumentation is not low enough to detect residual contamination at guideline levels with confidence, scanning alone may not be sufficient to release the items or area of interest from radiological control to the public. Formulas for determining MDA can be found in the literature (U.S. NRC 1992). In addition, some projects require static measurements or samples regardless of MDA. The ELIPGRID-PC software is used to aid in the design of these surveys.

The standard approach for calculating the probability of detecting elliptical hot spots is based on ELIPGRID, a FORTRAN IV program developed by Singer (1972) and based on a mathematical procedure for determining the probability of success in locating elliptical geologic deposits (Singer and Wickman 1969). Designed to calculate the probability of success in locating elliptical targets

with square, rectangular, and hexagonal (triangular) grids, ELIPGRID employs data input and code designed for the then-standard punch-card computer.

In 1984, J. Zirschky and R.O. Gilbert developed a nomographic procedure based on ELIPGRID to aid detection of highly contaminated areas at chemical- or nuclear-waste disposal sites (Zirschky and Gilbert 1984). Gilbert used these nomographs as the basis for the chapter "Locating Hot Spots" in his widely referenced book on environmental statistical methods (Gilbert 1987). Subsequently, these nomographs were used in 1989 by the U.S. Environmental Protection Agency (EPA) to develop tables for calculating the probability of missing various hot spots when using triangular and square sampling grids (U.S. EPA 1989). Both Gilbert's nomographs and EPA's tables have some inherent limitations not found in the original ELIPGRID program. They include the following:

- Gilbert's nomographs give probabilities for only one rectangular sampling grid size; no data for rectangular grids are given in the EPA tables.
- Neither approach allows specific orientation angles for suspected hot spots. For example, the tables and nomographs cannot provide the probability of detecting a given target with a given grid for a specific orientation angle.
- Data extracted from a graph are less likely to be accurate than computer program output resulting from the same input data.

ELIPGRID-PC removes these limitations by allowing a large number of rectangular grids, allowing specification of orientation angles for suspected hot spots, and calculating the results with a computer algorithm. ELIPGRID-PC was designed as a DOS utility by James R. Davidson of ORNL/ETS (Davidson 1995). It is user friendly and simple to operate. A Windows 3.x version of the program is now in development.

Some capabilities of ELIPGRID-PC are:

- Calculates grid size, given the desired probability of detecting a specified hot spot,
- calculates approximate grid size, given desired cost and hot spot specifications,
- calculates the smallest hot spot detectable with a given probability and size, and
- provides capability for graphing the probability of detection versus cost for various scenarios of interest to stakeholders.

The program assumes:

- The target is elliptical or circular,
- measurements or samples are taken on a square, rectangular, or triangular grid,
- the distance between points is much larger than the size of the sample being measured,
- the definition of a hot spot is clear and unambiguous, and
- there are no measurement misclassification errors; that is, no errors are made in deciding when a hot spot has been detected.

The recently published *ELIPGRID-PC: Upgraded Version* (Davidson 1995) provides step-by-step examples, with color illustrations, of ELIPGRID-PC being used to solve the sample problems in Gilbert's chapter on hot spots (Gilbert 1987).

ELIPGRID-PC can be downloaded from the World Wide Web at the following URL:

<http://terrassa.pnl.gov:2080/DQO/software/elipgrid.html>

INRADS

The INRADS system is being developed as an indoor version of the Ultrasonic Ranging and Data System (USRADS[®]) system. As part of the UMTRA Program, ORNL was requested to survey thousands of public, residential, and commercial properties where the presence of uranium mill tailings was suspected. USRADS was developed at ORNL to automate much of the gamma radiation survey process and provide tabular and graphical data display in the field or in the office for report generation. Tests and use of USRADS by ORNL/ETS showed that the system is effective in locating radiation hot spots. The USRADS system and its use is described in detail elsewhere (Berven et al. 1991).

USRADS uses an ultrasonic signal to locate the position of the surveyor and FM radio to transmit data to a receiver module. The surveyor position and instrument measurements are recorded and stored once each second in a computer. As the surveyor progresses, the past and present positions are displayed on the screen to denote the completeness of coverage by the surveyor. During the survey, the software checks incoming information and provides a prompt if errors are detected in either the survey data or the position data. Over 3,500 data points can be collected in an hour. The data can be then interpreted and displayed with the software. Data can be exported by the USRADS software to a variety of formats, including AutoCAD. USRADS has been adapted to numerous uses including geophysical instruments, X-ray fluorescence detectors, alpha-beta gas proportional detectors, tissue-equivalent dose rate meters, and organic vapor detectors. CHEMRAD Tennessee, Inc., of Oak Ridge, Tennessee is the licensee of the USRADS and INRADS technologies.

INRADS takes the USRADS concept and technology and adapts it for indoor use. Instead of locating the surveyor's position over a large outdoor area with many stationary receivers (SRs), the position of the multiple detectors are tracked as they are moved along a wall surface using between one and three SRs. Depending on the array of the detectors, a 2-m high scan can be performed in two to four passes. The first prototype of the INRADS system used sodium iodide detectors for gamma radiation detection and gas flow proportional detectors for alpha and beta detection. Individual instruments were used for each detector and they were mounted on a cart. The current prototype detector array consists of five dual-phosphor scintillation detectors mounted on a pole. The ultrasonic crystal is also located on the detector array. The detectors are

coupled to high-voltage and dual-pulse discriminator circuits housed in a central unit located on a backpack. The backpack unit can be controlled by the surveyor with a hand-held terminal. The location of the detector array and the data from the detectors are then transmitted to the host computer.

The software normalizes the data from each detector. Color-coded track maps are generated showing data points for each detector. The graphical display of the results of this initial qualitative scan identifies areas of high activity using color-coded dots correlated to the range of the detector's output. Areas of high activity are sequentially resurveyed, and a stationary 1-minute count is obtained at each elevated area for quantitative interpretation.

CHEMRAD Tennessee has successfully used the first prototype for indoor radiation scans. The INRADS system eliminates uncertainties in data recording, and provides excellent permanent documentation. In most cases, it reduces the cost of the survey, especially when data processing and the risk of contingent liabilities are included. A detailed characterization of interior surfaces can be formulated by directly sending survey data from multiple detectors to a PC that performs statistical treatment of the data. INRADS ensures complete survey coverage and increased data reliability through the elimination of transcription errors and conversion of direct instrument readout to appropriate radiological units.

PROPOSED PROJECTS

ORNL/ETS is currently planning to use the INRADS system on independent verification surveys at two sites this fiscal year. The Grand Junction Projects Office Remedial Action Project is a D&D project that has in its current scope the release of metal buildings. INRADS is being considered for a survey of metal building panels. The survey results will be used to independently verify the status of the panels. The National Conversion Pilot Program at the Rocky Flats Environmental Technology Center is currently in the process of remediating former uranium stamping and forming facilities and transferring them to the private sector for use in radioactive scrap metal recycling. As part of this effort, ORNL/ETS is proposing to perform an independent verification of the baseline survey being conducted to document the condition of the facilities prior to transfer. ELIPGRID-PC and INRADS are planned for use in designing and conducting these surveys.

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