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DISCLAIMER

Radiological Survey Tool Set for

ArcGIS 8.3 and ArcPad 6.0

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Abstract

The Radiological Control Operations (RCO) group at the Savannah River Site (SRS) is tasked with conducting routine surveys for the detection of radiological contaminants in the environment. The Radiological Survey Tool Set (RSTS) was developed by the Environmental & Geographic Information Systems (EGIS) group of SRS to assist RCO personnel in this survey process. The tool set consists of two major components. The first component is a custom extension for ArcGIS 8.3 that allows the user to interactively create a sampling plan prior to entering the field. Additionally, the extension allows the user to upload field-collected data to the GIS with post-processing functionality. The second component is a custom ArcPad 6.0 applet. This applet provides the user with navigational capabilities to a selected origin point with the help of Global Positioning Systems (GPS) technology, and the recording of the sample data results into a hand-held field computer via ArcPad 6.0 software.

1.0 Introduction

The Savannah River Site is a 310 square mile Department of Energy (DOE) complex tasked with missions in national defense, technological development and transfer, and environmental restoration. All work at the SRS is accomplished while providing a safe and healthy work environment for all SRS employees, subcontractors, and visitors. This includes regular monitoring of the environment for radiological contaminants.

The RCO group at SRS is an organization comprised of professionals whose mission is to evaluate the inside and outside environment for radiological hazards using various radiological detection instruments. This group routinely performs radiological surveys around the SRS for construction, site clearance, and environmental compliance. Once a radiological survey is complete, the Radiological Control Inspector (RCI) is responsible for generating a report of their findings. This report is stored in paper format for no less than seventy-five years after the original report is submitted. These documents are used for environmental compliance with state and federal agencies and become legal documents. The typical report contains a column containing sampling values in units that conform to the radiological collection device and a site map representing the sampled area and sample point locations. These maps are usually generated using non-standard graphical software packages that are not equipped to generate quality, cartographically correct maps. Moreover, there are no established standards for creating these maps; therefore, there is a large variation in map scale and symbology, which can cause difficulties in interpreting the sampled area.

The Environmental & Geographic Information Systems group at the Savannah River Site is responsible for providing Geographic Information Systems (GIS) data and services to other SRS organizations. EGIS is comprised of approximately twenty GIS, Computer Aided Drafting and Design (CADD), and Information Technology (IT) professionals. In the spring of 2003, EGIS was approached by the RCO group to evaluate their current field data collection techniques, post-processing, and map generation processes. This evaluation resulted in the recommendation that the RCO group adopt a new, more automated process for planning, collecting, and evaluating field-collected data. Also, the recommendation included the need to create map standardization with respect to symbology, scale, and other critical map elements. EGIS was awarded the contract to produce a logical solution for the RCO group’s radiological survey activities and report generation activities with respect to map generation.

The EGIS group developed the Radiological Survey Tool Set to aid Radiological Control Inspectors with planning, navigating, sampling, and post-processing of radiological survey data. The RSTS provides the RCI with tools to create a sampling plan map, export this map and spatial layers to a hand-held data collection device,

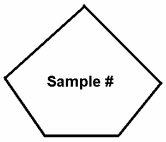
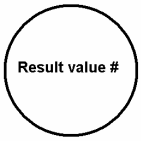
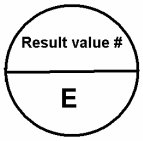
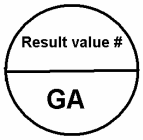
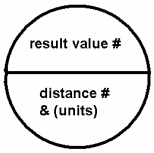
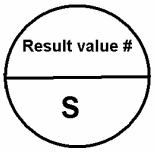
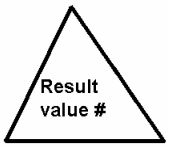
collect sampling data including attributes, navigate in the field, and post-process this data for creation of a cartographically correct map. The resulting map can be exported from ArcMap into a graphic file for insertion into SRS procedural documents and reports. This paper describes and illustrates the development of the Radiological Survey Tool Set using ArcGIS 8.3 and ArcPad 6.0.

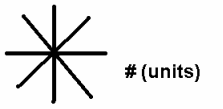
2.0 Tool Development Methodology

The Savannah River Site developed specific procedures for developing custom software applications. These procedures were based upon standards developed by the Institute of Electrical and Electronics Engineers, (IEEE) Inc. The chosen model of development was the Waterfall Model, which included the following phases: requirements, specification, design, implementation, testing, integration, maintenance, and retirement (Schach, 2002). EGIS used this model to develop the Radiological Survey Tool Set because it supported not only the process, but the required SRS documentation.

A team of professionals was assembled to develop the Radiological Survey Tool Set, which included a project manager, three programmers, a GIS Analyst, a GPS expert, a Quality Assurance (QA) professional and an RCI. The team spent approximately one hundred man-hours developing solid tool requirements and specifications with the assistance of the RCI. Specific requirements included the following:

- The tool shall allow the user to create a radiological sampling plan map in ArcGIS 8.3 and export all shapefiles representing the map to ArcPad 6.0 for loading onto a field computer.
- The tool shall allow the user to navigate, using GPS, to a predetermined origin/starting point. The user shall have the option to navigate to each sample grid point using GPS or by laying out the grid using bearing and distance with a compass and tape measure.
- The tool shall allow the user to enter multiple attributes into the sample point grid using predefined dropdown lists, text boxes, and stylus keyboard entry on the file computer. The attributes entered are dependent upon the media being sampled.
- The tool shall allow the user to download shapefiles to a desktop personal computer for post-processing in ArcGIS 8.3.
- The tool shall allow the user to display result and point ID values in the data view or layout view map for each shapefile for creation of final map products for report forms. The following table illustrates all symbology that will be used to represent sampled data:

Symbol (icon)	Symbol Name	Symbol Description
	***Soil Sample or Direct Probe - Soil***	Pentagon with sample number in the center of the symbol
	Radiation Dose Rate (whole body)	Circle with result value number in the center of the symbol
	Radiation Dose Rate (Extremity)	Circle divided in half with result value number in top half and large “E” in bottom half
	Radiation Dose Rate (General Area)	Circle divided in half with result value number in top half and large “GA” in bottom half
	Radiation Dose Rate (distance)	Circle divided in half with result value number in top half and distance value and units in bottom half
	Radiation Dose Rate (Skin)	Circle divided in half with result value number in top half and large “S” in bottom half
	Neutron – Surface	Triangle with result value number in center of symbol
	Direct Probe – Animal	Diamond with adjacent number value
“12”	Detail Smear	Number only

	Location Airborne Radiation Monitored - Air	Square with sample number in center of symbol
	Direct Probe – Vegetation	Cross with adjacent number value
	Direct Probe – Air	Square with sample number in center of symbol with value indicated on survey log sheet
	Direct Probe – Total Surface Contamination	Capital “T” with direct smear location number adjacent to symbol
	Direct Probe – Water	Star with adjacent value as number
	Fixed Contamination	Asterisk with the units number on the right side of symbol (integer > 1)
	Unsampled	Capital “U”.
	Non-detect	Capital “ND”.

- The tool will allow the user to produce an Environmental Systems Research Institute (ESRI) shapefile that contains their sample locations and collected data from all analog and digital radiological detection devices.

After the assemblage and approval of the application requirements, the project team formulated a design and specification document from which to develop the product. This document contained several logical flowcharts and object diagrams detailing the specifications required for the implementation and integration phases. Each step in the process required review from the Soil and Groundwater Closure Project's Quality Assurance division, which included the assigned project RCI, a QA professional, and an independent reviewer.

The implementation and integration phases were accomplished by dividing the development team into two groups classified as either the desktop application group, or the mobile application group. The desktop application group developed all the necessary interfaces, coding and configuration for the ArcGIS 8.3 extension, while the mobile application group developed the necessary interfaces, coding and configuration for the ArcPad applet. Although the groups operated independent of each other, it was necessary to understand how the two components worked together. This was easily accomplished because the applications only shared ESRI shapefiles, which are native to both applications. The two components were regularly tested with one another to ensure compatibility in functionality.

Prior to going into production, the project team conducted numerous internal testing procedures, which were followed by internal and external beta testing procedures. Testing was followed by the release of the software into production and maintenance status. The software was released on time, under budget, and to customer specifications.

3.0 GIS Software Platforms

Environmental Systems Research Institute's ArcGIS 8.3 software was the chosen GIS software because it is the GIS software choice by the EGIS group and the Savannah River Site. EGIS decided to develop a tool set to cover all aspects of planning, field-collection and post-processing using ArcGIS and ArcPad software packages, which would allow the user to create quality sampling plan layers, navigate to features contained in this layer in the field, and collect attribute information on these layers based upon instrument requirements. Moreover, this application would allow the user to download the sampled data layer to ArcMap and post-process the data for creation of high-quality maps to be inserted into the procedural report documents.

As mentioned earlier, the most efficient way to create the Radiological Survey Tool Set was to develop a two-component system; one for the desktop GIS to create the sampling plan map and post-process sampled data, and one for the mobile field-collection of radiological data. The first component was developed as an extension to ArcGIS 8.3 using an ArcView license configuration. The ArcView license

configuration was chosen because EGIS already had numerous floating ArcView licenses available for the SRS GIS user community. Moreover, the ArcView license configuration allowed for considerable cost avoidance, and was sufficient for the application's functionality. The second component was developed as an ArcPad 6.0 applet designed to run on a Windows™ CE device, which was the Compaq Ipaq hand-held computer already used extensively by EGIS. This hand-held computer was equipped with a durable, weather-proof case for use in the field. The Compaq Ipaq provided the ports necessary to incorporate GPS receivers for navigation and data collection purposes in the field (Figures 1 and 2).

Figure 1.
Use of Trimble Pocket GPS™ receiver in the field.

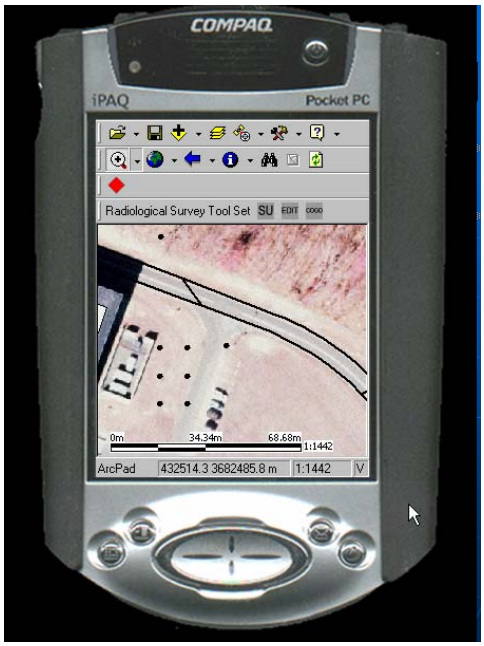


Figure 2.
Compaq Ipaq hand-held Windows™ CE device running the Radiological Survey Tool Set applet

4.0 Tool Functionality

The Radiological Survey Tool Set provides the user with a unique set of GIS tools for sampling plan construction, field data collection, field navigation, and post-processing all within the realm of a Geographic Information System. This allows for the creation of accurate, geo-referenced data sets that provide the user with the ability to reproduce sampling events if necessary. This is important for projects where the RCI is required to revisit and reproduce data located in remote areas at the Savannah River Site. For example, RCIs are often asked to resample remote, swampy areas to gather additional information. The Radiological Survey Tool Set allows the user to navigate back to sample points within the accuracy of the GPS receiver attached to the hand-held. The Radiological Survey Tool Set was tested using the Trimble Pocket GPS™ Receiver, which has an average precision of no more that one meter. Since RCIs usually place flags at sample locations, one meter precision is more than sufficient.

The creation of a sampling plan map was somewhat cumbersome and non-standard prior to the introduction of the Radiological Survey Tool Set. The RCIs often used non-spatially oriented, graphic software packages to create their maps. The RCI would simply draw a rectangle representing a building or other landmark feature and approximate the location of the sampling grid. This map product did not provide the reader with enough information. Furthermore, this process did not allow another user to re-create the exact location of the sampling event because these maps were not to scale, used non-standard symbology, and were devoid of north arrows and other valuable map elements. The use of a GIS eliminated this shortfall in the sampling map creation because it provided the user with a geo-referenced, scaled map product and grid shapefile that could be printed for use in the field, or more importantly, exported for use in ArcPad on a hand-held computer (Figure 3). Printed maps could be created with all of the proper map elements such as north arrows, scale bars, legends, coordinate grid tics, and textual map scale readings.

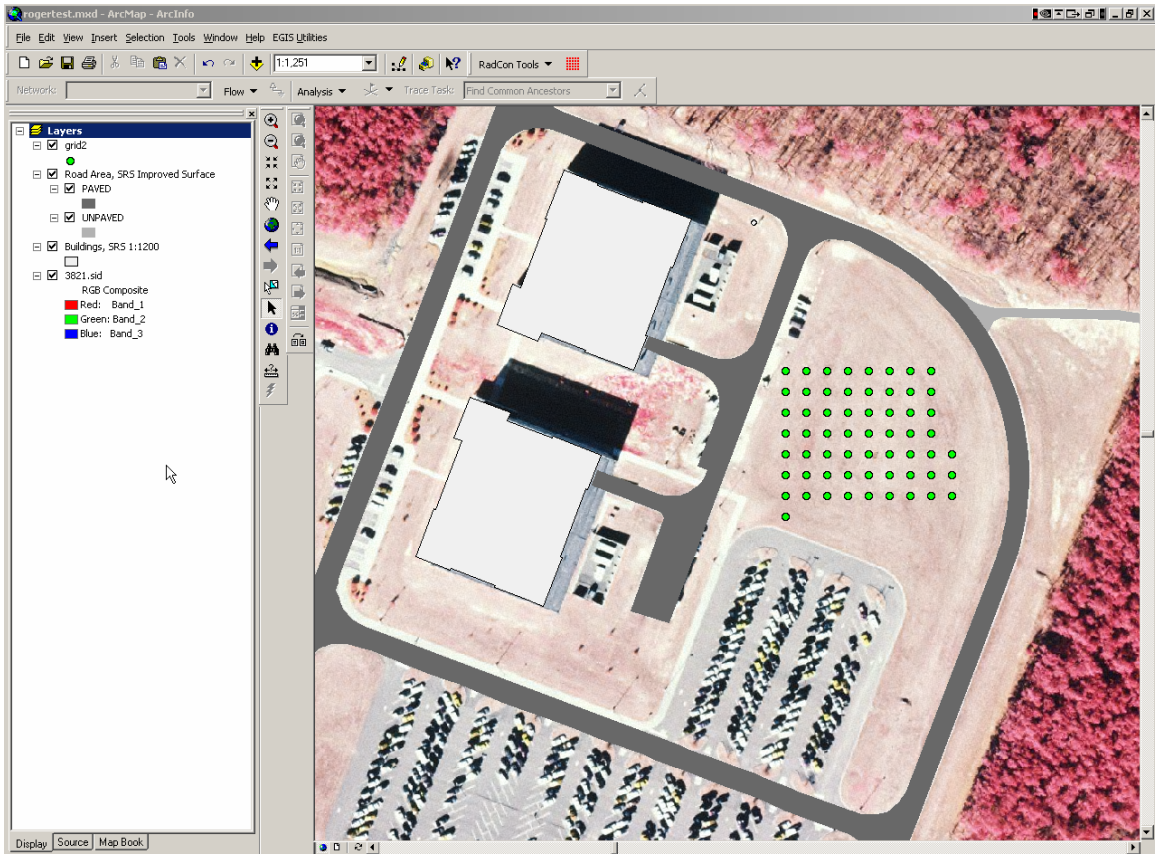


Figure 3.
Sample grid (green circles) created in ArcMap prior to beginning field collection activities

Prior to the development of the Radiological Survey Tool Set, Radiological Control Inspector field-collection methods consisted of the use of analog and digital detection instruments whose readings had to be transcribed on to a notepad in the field. This created numerous problems such as ink and lead smudging of figures due to inclement weather or perspiration, less-than-perfect handwritten transcription errors, or loss of data because of the loss of a page from the notepad. Problems such as these caused a re-work of sampling events, which caused the loss of valuable time and increased costs to the project. The Radiological Survey Tool Set eliminates the need for manual transcription by allowing the user to enter sample attributes directly into the hand-held computer. Attribute values are stored within the shapefile dbase file in tabular format, which can be downloaded to the desktop GIS at the completion of field collection activities via Microsoft's ActiveSync™ software.

In addition to the introduction of cartographically correct maps, navigation capabilities and the elimination of transcription errors, the Radiological Survey Tool Set allows the user relate digital data file collected using the Electra radiological detection device to the data stored in the field-collection shapefile dbase file. These two files are related to each other during the post-processing of data on the desktop. This tabular relate is accomplished by relating the unique reading number column in

the Electra text file with the reading number entered by the RCI in the field, which is stored in the shapefile dBase table. The ArcGIS extension component requires that the user download the Electra text file and export the file into a Microsoft Access database prior to post-processing the data in ArcMap. The extension then requires that the user select the Access database prior to the database relate with the field data shapefile. The result of this relational join between the Electra text file and the shapefile is a topologically correct sample point that is symbolized in ArcMap using the required radiological symbology. Analog radiological detection devices require that the RCI enter the device reading values into the hand-held computer because they do not store a text file.

There are several other attribute values collected by the RCI in the field. The Radiological Survey Tool Set allows the RCI to quickly enter these values by providing a domain field and dropdown form control (Figure 4). This minimizes the field data entry using a keyboard, thus reducing transcription errors. The only field values that require the user to use the keyboard are the reading numbers for the Electra device and the comment field. The comment fields allow the user to type in field notes on the

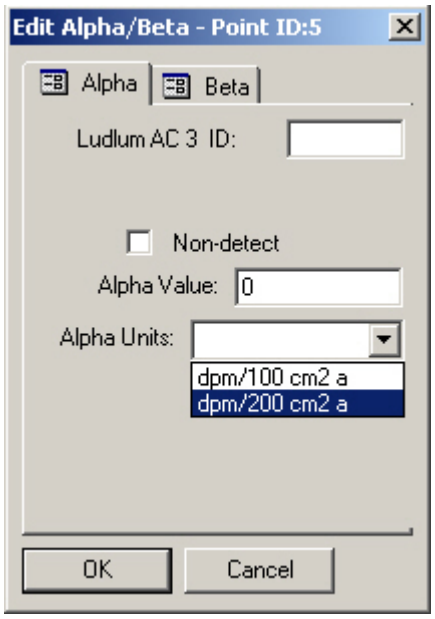


Figure 4
Example of form containing domain fields within dropdown boxes for easy data entry

sampling point. Comments often include special circumstances related to the sampling point such as obstructions, field collection methods, or name of the RCI conducting the sample. All of the field-collected attribute data entered by the RCI becomes a digital record of the sampling event. This data can be kept in shapefile format, transferred to a relational database, or stored in spreadsheet format. Whatever the digital format, the Radiological Survey Tool Set allows the RCI to reproduce their sampling event if required.

Navigation and the ability to add other sampling points in the field require the use of GPS receivers and custom functionality. ArcPad out-of-the-box functionality provides the user with GPS capability for waypoint navigation and sampling point creation. The RCI has the ability to add a sampling point to the shapefile using the GPS by using built-in ArcPad functionality. Additionally, the Radiological Survey Tool Set provides the RCI with a basic type of coordinate geometry (cogo) functionality. There are circumstances in the field that prevent the user from adding a point using GPS such as inside of a building or under heavy forest canopy. In these situations, the GPS signal is severely degraded and the receiver is unable to generate a good fix on the user's position. Therefore, the Radiological Survey Tool Set is equipped with cogo functionality whereby the user is directed to provide a starting point in the field by clicking on the ArcPad view screen. The user is then asked to provide a bearing and distance to their new point (Figure 5). The cogo utility adds a point based upon the user's input and adds this point to the field collection shapefile. This tool requires that the RCI carry a magnetic compass and tape measure to provide the cogo utility with an accurate bearing and distance.

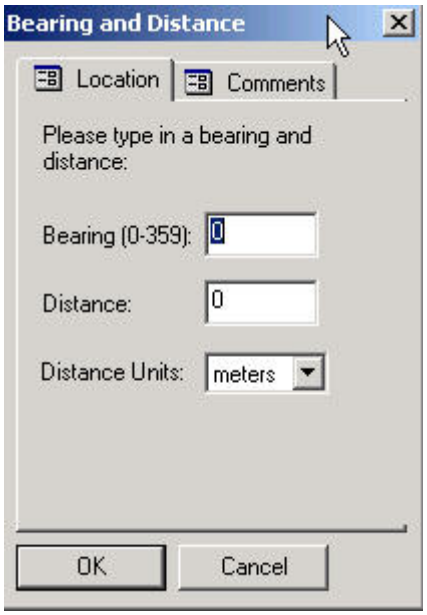


Figure 5.
Cogo utility Bearing and Distance form

Whether using the Electra radiological detection device or another analog device, the Radiological Survey Tool Set provides the RCI with the necessary tools to create a sampling map for project work, collect field sampling data, and process this data to create high-quality, cartographically correct map products for standard reports (Figure 6).

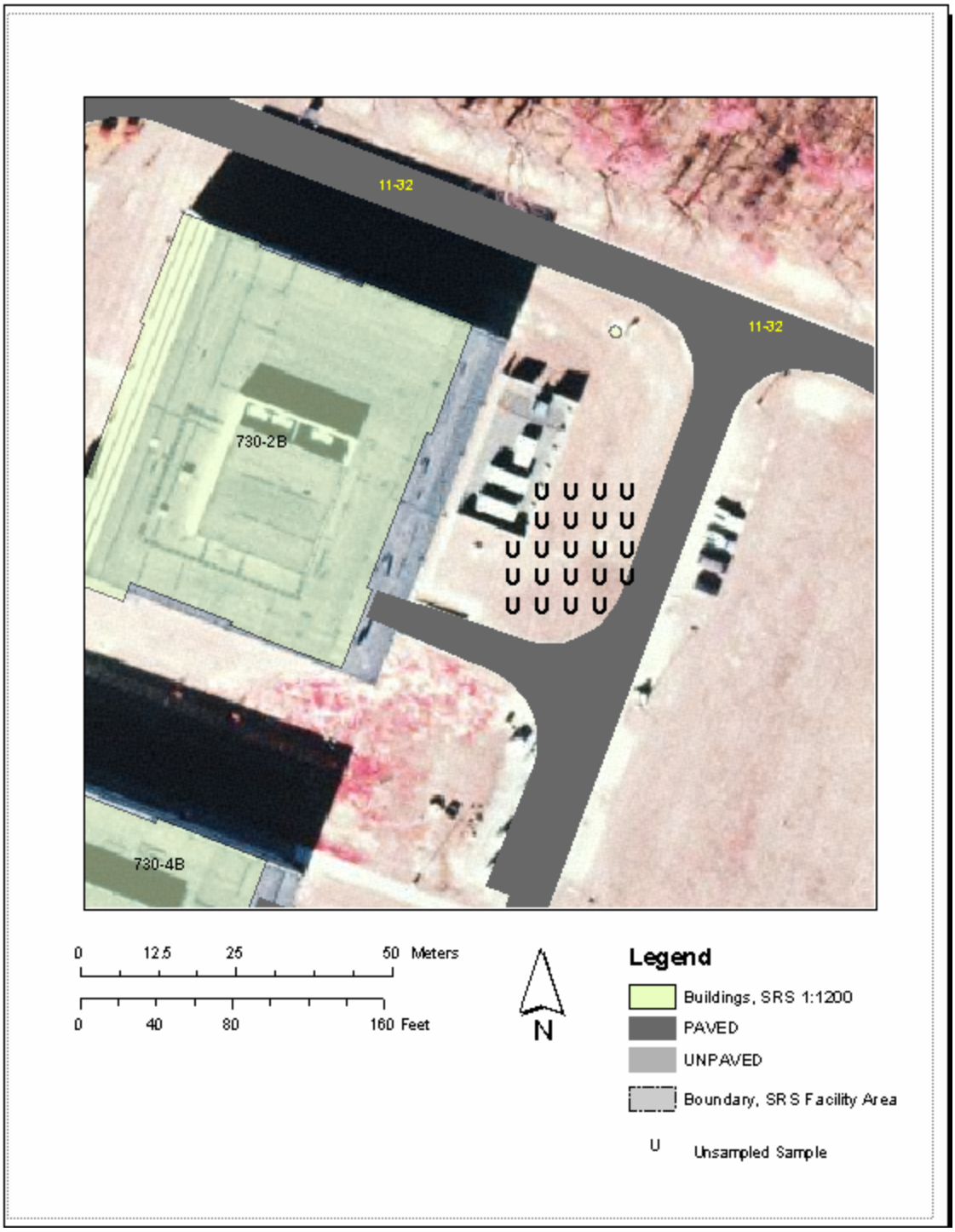


Figure 6
Cartographically correct, scaled output map

5.0 Conclusion

The Radiological Survey Tool Set provides the user with the ability to use GIS to plan, collect, and post-process field-sampled data. The result of this process is a cartographically correct, scaled, reproducible map product that can be inserted into a standard report. The Radiological Survey Tool Set provides location accuracy and navigational functionality by combining GIS with GPS capabilities. Moreover, the tool provides the user with easy-to-use graphical user interfaces to input their attribute data into the hand-held computer. This ability eliminates much of the errors that occur when using manual transcription methods. Finally, the Radiological Survey Tool Set provides a digital copy of the field-collected data that can be used to reproduce the radiological survey event.

6.0 Acknowledgements

The development of the Radiological Survey Tool Set was achieved by a highly-skilled professional project team. The following are the names and project roles of the Radiological Survey Tool Set project team members:

Roger K. Cottrell, Jr., Project Manager and ArcPad Developer
Devlin Fung, Ph.D., ArcGIS Extension Developer
Matthew Bafford, ArcGIS Extension Developer
Jason Ramirez, ArcPad Developer
David Isiminger, GPS/Mobile GIS Development
Erik Fallman, Radiological Control Inspection
Keith Dykes, Quality Assurance
James Poorbaugh, Soil and Groundwater Closure Projects Design Authority
Matthew Maryak, EGIS Manager and Design Agency

7.0 Reference

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