January 31, 2011

Mr. Jason Darby, EM-91
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U.S. Department of Energy
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**SUBJECT: DOE CONTRACT NO. DE-AC0506OR23100
CHARACTERIZATION REPORT FOR THE DAVID WITHERSPOON
SCREEN ARTS SITE, KNOXVILLE, TENNESSEE
DCN: 5096-SR-01-0**

Dear Mr. Darby,

Enclosed is the Characterization Report for the David Witherspoon Screen Arts Site located in Knoxville, Tennessee. Field activities began June 8, 2010, and were completed by July 9, 2010. Activities included site clearing, gamma radiation surface scans, and sampling of surface and subsurface soil.

You may contact me at my information listed below or Tim Vitkus at 865.576.5073 should you have any questions or require additional information.

Sincerely,

Phyllis C. Weaver
Health Physics Project Manager
Oak Ridge Institute for Science and Education
Independent Environmental Assessment and Verification

PCW:jc

Enclosure

c: T. Vitkus, ORISE
S. Roberts, ORISE
File/5096

CHARACTERIZATION REPORT FOR THE DAVID WITHERSPOON SCREEN ARTS SITE, KNOXVILLE, TENNESSEE

P. C. Weaver

Prepared for the
U.S. Department of Energy

ORISE

Oak Ridge Institute for Science and Education

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**CHARACTERIZATION REPORT
FOR THE DAVID WITHERSPOON SCREEN ARTS SITE,
KNOXVILLE, TENNESSEE**

Prepared by

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Prepared for the

U.S. Department of Energy

FINAL REPORT

JANUARY 2011

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**CHARACTERIZATION REPORT
FOR THE DAVID WITHERSPOON SCREEN ARTS SITE,
KNOXVILLE, TENNESSEE**

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ABBREVIATIONS AND ACRONYMS

BH	borehole
BKG	background
cm	centimeter
cm ²	square centimeter
cpm	counts per minute
Cs-137	cesium-137
DCGLs	Derived Concentration Guideline Levels
DOE	U.S. Department of Energy
DQA	Data Quality Assessment
DQO	Data Quality Objective
DWI	David Witherspoon, Incorporated
EM	Environmental Management
EPA	U.S. Environmental Protection Agency
FIDLER	Field Instrument for the Detection of Low Energy Radiation
ft	foot
g	gram
GPS	Global Positioning System
ISM	Integrated Safety Management
in	inch
ITP	Intercomparison Testing Program
IEAV	Independent Environmental Assessment and Verification
JHA	Job Hazard Analysis
keV	kiloelectron volts
kg	kilogram
MAPEP	Mixed Analyte Performance Evaluation Program
MDC	minimum detectable concentration
NaI	sodium iodide
NIST	National Institute of Standards and Technology
NRIP	NIST Radiochemistry Intercomparison Program
ORAU	Oak Ridge Associated Universities
ORISE	Oak Ridge Institute for Science and Education
ORO	Oak Ridge Office
pCi/g	picocuries per gram
PEMS	Project Environmental Measurement System

ABBREVIATIONS AND ACRONYMS

QAPP	Quality Assurance Project Plan
Ra-226	radium-226
SAP	Sampling and Analysis Plan
sec	second
SPCS	State Plane Coordinate System
TAP	total absorption peak
Ra-226	radium-226
RLs	Remediation Levels
TEDE	total effective dose equivalent
Th-228/232	thorium-228/232
U-233/234	uranium-233/234
U-235/238	uranium-235/238
VESC	Volunteer Equipment and Supply Company
VSP	Visual Sampling Plan

CHARACTERIZATION REPORT FOR THE DAVID WITHERSPOON SCREEN ARTS SITE, KNOXVILLE, TENNESSEE

1.0 INTRODUCTION AND SITE HISTORY

The U.S. Department of Energy (DOE) Oak Ridge Office (ORO) of Environmental Management (EM) requested the technical assistance of Oak Ridge Institute for Science and Education (ORISE) to characterize a tract of land associated with the David Witherspoon, Incorporated (DWI) Volunteer Equipment and Supply Company (VESC). This tract of land (hereinafter referred to as Screen Arts) is located in the Vestal Community in the 2000-block of Maryville Pike in south Knoxville, Tennessee, as shown in Figure A-1. This tract of land has been used primarily to store salvaged equipment and materials for resale, recycle, or for disposal in the former landfill once operated by DWI. The DWI Site industrial landfill and metal recycling business had been permitted by the Tennessee Division of Radiological Health to accept low-level radiologically contaminated metals. DWI received materials and equipment associated with operations from DOE sites, including those in Oak Ridge, Tennessee; Paducah, Kentucky; and Portsmouth, Ohio. It is likely that items stored at Screen Arts may have contained some residual radiological materials.

In 2009, ORISE was tasked to conduct a scoping survey of the site to provide radiological information to determine the need for additional characterization (ORISE 2009). Gamma scan results identified elevated radiation levels at numerous locations. The preliminary investigation defined the need for an in-depth characterization that would lead to the development of a decontamination scope of work to identify areas with excess residual radioactivity levels. This report combines the results of both surveys.

2.0 SITE DESCRIPTION

The Screen Arts Site is situated in an urban setting in the Vestal Community between the Kingsley Station and Mt. Olive communities in Knox County, Tennessee, approximately three miles south of downtown Knoxville just outside of the city limits (Figure A-1). The area of concern is a 1.4 acre tract adjacent to the VESC warehouse facility and parking area owned by DWI (Figure A-2). The Site is bounded by the warehouse and current material storage area to the east, the CSX Railroad to the south, a private residence to the west, and Maryville Pike to the north.

Heavy vegetation undergrowth and trees once covered much of the area (Figure A-3). A gravel road was used for access into the heart of the site. Several large pieces of equipment including a large track hoe, dump truck, and other small vehicles were stored among the various forms of scrap material and equipment. Prior to survey activities, the site owner removed all equipment and scrap material previously observed and staged it on the VESC property just beyond the fence and adjacent to the CSX railroad. ORISE contracted to have only the heavy vegetation cleared from the site before characterization activities began (Figure A-3). A number of large trees and tree stumps were removed to improve access throughout the property, with the exception of the far west corner and along the property fence lines. Removal of the trees along the fence line could have resulted in damage to the adjoining property as well as compromise control of the site. Vegetation was chipped and used for erosion control purposes.

3.0 OBJECTIVES

The objectives of the radiological characterization survey were twofold. The initial data gathering through scans and sample collection determined the identity and potential distribution of radiological contaminants of concern, throughout the site. Additionally, this data will be used to identify the potential radiation dose and health risk impacts. A limited scoping survey of the site conducted in 2009 determined that the presence of contamination warranted further evaluation (ORISE 2009).

Characterization survey field and analytical results provide data for the development of site-specific derived dose modeling. The site specific dose model(s) can be used to determine the permissible annual total effective dose equivalent (TEDE) based on site-specific conditions for current and future land use. The generated data can be used to estimate the level of effort for the developing a decontamination scope of work, should it be necessary to reduce or remove residual contamination from the site.

4.0 SURVEY PROCEDURES

Site evaluation activities were conducted in accordance with an ORISE Sampling and Analysis Plan (SAP)/Quality Assurance Project Plan (QAPP), with the exception of the scanning and sampling of equipment and scrap materials (ORISE 2010a). Prior to the start of characterization activities by ORISE, all items previously stored on the site were moved to the adjacent warehouse property

(Figure A-3). ORISE surveys adhered to the Independent Environmental Assessment and Verification (IEAV) Survey Procedures Manual and Quality Program Manual (ORISE 2008, and ORAU 2009).

The data quality objective (DQO) process was implemented as described in the SAP to improve the decision process for further required actions at the site. As a part of the data quality assessment (DQA) process, the data were evaluated to determine if the results would support using present site knowledge to develop the sampling design. DQAs were performed in accordance with EPA QA/G-9R and EPA QA/G-9S (EPA 2006a, EPA 2006b).

4.1 SCOPING SURVEY

On May 26, 2009, ORISE conducted a scoping survey of the Screen Arts Site accessible soils, scrap metal, and other stored materials. Gamma radiation scans of accessible ground areas were performed; however, beta-gamma scans of equipment and material surfaces were included where soil activity was highest (ORISE 2009). The resulting data justified the need for an expanded evaluation of the site conditions.

4.2 CHARACTERIZATION SURVEY

During the period between June 8 and July 9, 2010, ORISE conducted characterization activities to determine the potential area and depth of radiological contamination at the site. Survey activities included gamma surface scans, borehole sampling, and surface soil static measurements and samples.

4.3 REFERENCE SYSTEM

ORISE used a Global Positioning System (GPS) for documenting survey area boundaries, tracking survey data and identifying measurement and sampling locations. Physical observations at the site identified a state surveyors' marker that allowed the site boundaries to be accurately drawn. The specific geographic coordinate system required for documentation was the Tennessee State Plane Coordinate System (SPCS). GPS coordinates were typically accurate to within one meter of any given position data point.

4.4 GAMMA SURFACE SCANS

High-density scans for gamma radiation were performed in accessible areas at the site. A small portion of the site, over an active sewer drain (east corner) and the property boundary fenceline (overgrown with heavy vegetation and large entangled trees roots), was not cleared thereby limiting scanning and sampling efforts. Removing the vegetation could have damaged or destroyed the drain or fence and also the property owner would not allow clearing to be performed.

Surface scans were performed using a 2-in $\times$ 2-in model 44-10 and 5-in diameter Field Instrument for the Detection of Low Energy Radiation (FIDLER) NaI scintillation detectors coupled to ratemeters with audible indicators. Gamma count rates were monitored via audio output by the surveyor and detectors were coupled to GPS systems that enabled real-time gamma count rate and position data capture. The electronic data captures, together with the locations identified in real-time by the audio output, were reviewed for areas of elevated direct radiation that suggested the presence of residual contamination. The gamma surface scans were established such that surficial locations of natural processed uranium contamination would be identified such that false negative errors do not exceed 0.05 for a 0.25 m² or larger contaminated area containing more than 80 pCi/g. Areas of elevated direct gamma radiation were identified for further investigation (Figures A-4 and A-5).

4.5 SOIL SAMPLING

The SAP specified a statistical design to gather subsurface data to characterize the depth of potential contamination. The total number of planned random-start/systematic boreholes was 20, which would be sufficient for establishing statistical-based mean concentration estimates, exposure point concentrations for future human-health exposure analyses, if required, and also provided a 95% probability of detecting a circular sub-surface hot spot with a radius of 9.3 m in the absence of gamma walkover survey data. Visual Sampling Plan (VSP) software (version 6.0) was used to establish the 20 random-start/systematic borehole (BH) locations on a triangular pattern (Figure A-6) (PNNL 2007). Table B-1 represents VSP-generated borehole coordinate locations. Two of the 20 borehole locations (BH004 and BH008) could not be collected where originally planned due to an active sewer drain line in the area. Five additional judgmental borehole locations were selected based on professional judgment and/or gamma walkover survey results (Figure A-7). Additional characterization design details are defined in Section 5 of the SAP/QAPP (ORISE 2010a).

At each borehole, efforts were made to obtain two discrete 4-ft soil sample cores. However, there were a few locations where the core bit either encountered refusal before completion of the initial 4-ft probe or the bit encountered a void space or gravel. These included BH003, BH021, B022, and BH024. Each core sample was scanned using hand-held scanning instruments and pre- and post-static gamma measurements were collected during the core sampling process.

Twenty-two judgmental surface soil samples (0 to 15 cm) were collected based on a review of gamma walkover survey results (Figure A-8). Three surface/subsurface (0 to 30 cm) soil samples were collected over the sewer drainage to replace sampling at BH004 and BH008. Pre- and post-static gamma measurements were collected at each sample location to observe if radiation levels increased, thereby indicating that contamination was not limited to just the surface.

4.6 SAMPLE ANALYSIS AND DATA INTERPRETATION

Samples were returned to the ORISE/IEAV radiological laboratory in Oak Ridge, Tennessee for analyses and interpretation. Sample analyses were performed in accordance with the ORISE Laboratory Procedures Manual (ORISE 2010b). Soil samples were analyzed by gamma spectroscopy for uranium, thorium, and cesium-137, and reviewed for other gamma-emitting contaminants. Radionuclide concentrations were reported in units of picocuries per gram (pCi/g), including background. Analytical sample results were directly downloaded from the laboratory into the Project Environmental Measurement System (PEMS) database. All field records and electronic data deliverables will be loaded into PEMS for internal tracking and downloaded as needed for statistical analysis. Additional information concerning major instrumentation, sampling equipment, calculation variables, and analytical procedures has been provided in Appendices C and D.

5.0 FINDINGS AND RESULTS

The initial scoping survey of the site identified various soil locations with increased gamma radiation levels. The scoping effort deemed it necessary during characterization of the site to bound contamination areas for the purpose of future decontamination actions. The results of the Screen Arts characterization survey effort are discussed below.

5.1 SURFACE SCANS

Gamma scan patterns and count rates are provided in Figures A-4 and A-5 for the 2-in $\times$ 2-in NaI and FIDLER, respectively. The data logged by the GPS units for each detector type are charted in the histograms provided in Figures A-9 and A-10 showing a frequency distribution of the count-rates. These histograms identify three distinct populations; gamma radiation at background levels, areas of gamma radiation greater than two to three times background, and hot spots or concentrated areas of high gamma radiation. The counts represent an asymmetrical distribution about the mean positively skewed to the right with no significant variation in the median and mode. This graphical depiction of the data indicates that the largest contamination population is within the two to three times background level. Both histograms support the representation of a multi-modal distribution of contamination about the site.

Scans identified elevated gamma radiation levels at numerous locations about the site; however, contamination was concentrated primarily towards the site center in the northwest and southwest quadrants of the site. The distribution of gross gamma radiation ranged from 4,000 cpm to 170,000 cpm with a mean of about 13,100 cpm for the 2 $\times$ 2 NaI and 5,000 cpm to 250,000 cpm with a mean of 15,900 cpm for the FIDLER. Generally, background count rates for both detectors were in the range of 5,600 cpm and 6,900 cpm.

In locating one of the judgmental boreholes near the western corner of the property, a technician observed an increase in the gamma count rate near the base of a tree. Upon further investigation, the high count rate contribution was determined to be a piece of metal gear chain link lying on the ground. It did not show on the GPS scan because of interference of the signal due to the tree canopy. Additionally, due to the position of the trees in this area and the neighboring house, aggressive removal of trees and shrubs in this area could not be performed. Further investigation revealed a yellow powdered substance packed into the void spaces of the chain (Figure A-11).

5.2 RADIONUCLIDE CONCENTRATIONS IN SOILS

Each core sample tube was cut into one foot sections in order to be counted as individual samples. All soil samples (borehole and surface grab soils) were homogenized and sieved to remove large stone and rock prior to performing any analysis. The rocklike material removed from four samples turned out to be particles with elevated concentrations of Th-232 and the associated decay chain

progeny (Figures A-12). These included sample 0048A from BH025 and surface grab samples 0058, 0059, and 0064. Post sample gamma radiation measurements at these locations showed a significant decrease in the gamma radiation count rates once the sample had been collected.

Radionuclide concentrations for systematic and judgmental borehole samples are summarized in Table B-2. The predominantly detected radionuclides were Th-228, Th-232, U-235, and U-238. The maximum concentrations were 569 pCi/g for Th-232 and 209 pCi/g for U-238. Uranium concentrations were found to be highest in BH007, BH010, BH018, BH022, BH023, BH024, and BH025 with the maximum thorium concentrations found in boreholes BH004 and BH025. Other identifiable photopeaks included Ra-226 and Cs-137. Concentrations ranged from 0.48 pCi/g to 24.7 pCi/g for Ra-226, with the highest concentrations noted in BH022, and -1.06 pCi/g to 0.50 pCi/g for Cs-137.

Figures A-13 and A-14 represent a cross-section of the radionuclide concentration at depth for each borehole. Concentrations were generally higher in a span from the ground surface to one foot and tapering around the 3 ft to 4 ft depth below ground surface. However, there were two locations noted to have contamination at the five foot and six foot depths. Approximately a foot to slightly over a foot of sample was collected from BH024.

The projected area distribution of contamination, for both uranium and thorium, are represented in Figures A-15 and A-16. Figure A-17 includes all systematic and judgmental, surface and subsurface sample locations to illustrate the projected involvement of contaminated soils throughout the site. The distribution is generated by interpolation of the nearest neighbor to that of the highest radionuclide concentration sample location.

The radionuclide concentrations in individual judgmental soil samples are provided in Table B-3. Radionuclide concentrations for Th-228 and Th-232 ranged from 0.50 pCi/g to 201 pCi/g and 0.51 pCi/g to 220 pCi/g, respectively. The maximum thorium concentration was identified in a sample collected from the zero to one foot depth in BH025. U-235 concentrations ranged from -0.3 pCi/g to 180 pCi/g and U-238 concentrations ranged from 0.61 pCi/g to 3550 pCi/g. The highest U-235 and U-238 concentrations were 180 pCi/g and 3550 pCi/g, respectively, and were detected in judgmental surface soil sample 0068. Ra-226 concentrations ranged from 0.29 pCi/g to

11.27 pCi/g and -0.18 pCi/g to 2.84 pCi/g for Cs-137, considerably lower than potential action levels.

6.0 DISCUSSION OF RESULTS

Scans suggest the larger area of surface contamination is in the western quadrant of the site. Overall the site has generally low levels of contamination with some localized areas of higher concentrations. A gravel-paved road provides access to most portions of the site. Visual inspection of the ground surface identified several mounds of debris and soil, assumed to have been disturbed during previous usage of the site. The site topography slopes gently toward the south and southeastern portion of the property. The southeastern border of the property is bound by a shallow ditch intended to move drainage water away from the site. Assessment of the ditch was not in the scope of the characterization effort and therefore, no surveys were performed. However, ORISE did perform scans along the fence line, noting that the gamma count rates were at least twice background, and that samples were collected in this general area.

Evaluation of scan data was used to develop an additional sampling approach for collecting both surface and subsurface judgmental samples. Clearly, the largest area of land with elevated radionuclide concentration levels were identified by the gamma radiation scans. Judgmental surface soils and borehole soils were specifically selected to target a few locations of the highest gamma radiation levels observed. For judgmental soil locations the typical depth of soil in which contamination was encountered was primarily at the two to three foot level (Figures A-13 and A-14). The greatest depth of soil contamination appears to be around the five foot level (BH023).

Analytical results determined the predominant contaminants of concern to be the Th-232 and U-238 decay series. The concentration levels observed for Ra-226 were well below 5 pCi/g with the exception of the sample collected from borehole BH022, which was co-located with the highest uranium concentration. Similarly, Cs-137 concentrations were less than 0.5 pCi/g with the exception of three surface soil samples greater than 1 pCi/g collected from judgmental locations; 0032B, 0054, and 0055. Neither Ra-226 nor Cs-137 were considered contaminants of concern.

7.0 SUMMARY AND RECOMMENDATIONS

At the request of the DOE/ORO/EM, ORISE conducted radiological scoping and characterization surveys of the DWI/VESC property referred to as the Screen Arts Site. During the period between June 8 and July 9, 2010, ORISE conducted characterization activities to determine the potential size of the area involved and depth of radiological contamination at the 1.4 acre Screen Arts Site located in Knoxville, Tennessee. The site could have potentially been used by DWI as a holding area when the nearby 1630 landfill was in operation prior to transferring materials for disposal or held to recycle parts. Some of the equipment and materials may have contributed to soil contamination. The results of this survey effort validated the initial findings reported in the scoping assessment performed by ORISE in 2009. Contamination in the soil was confirmed throughout the area; the heaviest concentration of contamination was identified in the western and southern quadrants of the site. The predominant contaminants identified were thorium and uranium.

Additionally, items that may be closely related to DOE site operations were previously identified on the site. However, most of the items stored onsite during the scoping phase had been removed and relocated outside the site boundary. The survey included visual inspections and radiological surveys performed in accordance with the SAP which included surface scans, and surface and subsurface soil sampling.

Recommendations for further site activities include consequence modeling of the current contamination levels, development of site-specific derived concentration guideline levels (DCGLs), consideration of remediation levels (RLs) of the identified areas of concern, and performance of final status surveys as applicable. The applicable data can be further evaluated and a more accurate estimate of the impacted soil volume determined once site-specific DCGLs are developed.

8.0 REFERENCES

- Oak Ridge Associated Universities (ORAU). *Quality Program Manual for the Independent Environmental Assessment and Verification Program*. Oak Ridge, Tennessee; June 30, 2009.
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APPENDIX A FIGURES

Figure A-1: Map of Knoxville, Tennessee Screen Arts Site

Figure A-2: Screen Arts Site Plot Plan

Photographs of Screen Arts Site Prior to Clearing (2009)

Photographs of Cleared Screen Arts Site (2011)

Figure A-3: Before and After Photographs of the Screen Arts Site

Figure A-4: 44-10 Sodium Iodide Gamma Walk-over Scans

Figure A-5: FIDLER Gamma Walk-over Scans

Figure A-6: Screen Arts Site Systematic Borehole Sample Locations

Figure A-7: Screen Arts Site Judgmental Borehole Sample Locations

Figure A-8: Screen Arts Site Judgmental Surface Soil Locations

Figure A-9: Sodium Iodide Count Rate Distribution at the Screen Arts Site

FIDLER Detector Low Energy Gamma Scan Range

Figure A-11: Gear Chain Link with High Gamma Activity near Judgmental Borehole Location

Figure A-12: Thorium Hot Particles found in Judgmental Surface Soil Locations

Figure A-13: Depth of Total Thorium Concentration in Systematic and Judgmental Boreholes

Figure A-14: Depth of Total Uranium Concentration in Systematic and Judgmental Boreholes

Figure A-15: Area Probability of Uranium Concentration in Boreholes

Figure A-16. Area Probability of Thorium Concentration in Boreholes

Figure A-17: Area Probability of Uranium Concentration in Judgmental and Systematic Soil Samples

APPENDIX B

TABLES

**TABLE B-1:
SYSTEMATIC BOREHOLE SAMPLE LOCATIONS
SCREEN ARTS SITE
KNOXVILLE, TN**

Sample Type	Borehole No.	Easting (feet)^a	Northing (feet)^a	Borehole No.	Easting (feet)^a	Northing (feet)^a
Systematic	5096BH01	2580972.46	582690.95	5096BH11	2580943.07	582843.66
Systematic	5096BH02	2580943.07	582741.85	5096BH12	2581001.85	582843.66
Systematic	5096BH03	2581001.85	582741.85	5096BH13	2580854.90	582894.57
Systematic	5096BH04 ^b	2581060.63	582741.85	5096BH14	2580913.68	582894.57
Systematic	5096BH05	2580854.90	582792.76	5096BH15	2580972.46	582894.57
Systematic	5096BH06	2580913.68	582792.76	5096BH16	2580884.29	582945.48
Systematic	5096BH07	2580972.46	582792.76	5096BH17	2580943.07	582945.48
Systematic	5096BH08 ^c	2581031.24	582792.76	5096BH18	2581001.85	582945.48
Systematic	5096BH09	2580825.51	582843.66	5096BH19	2580913.68	582996.38
Systematic	5096BH10	2580884.29	582843.66	5096BH20	2580972.46	582996.38
Judgmental	5096BH21	2581004	582893	5096BH24	2580887	582764
Judgmental	5096BH22	2580930	582893	5096BH25	2580916	582844
Judgmental	5096BH23	2580825	582893			

^aTennessee State Plane in survey feet; actual measured coordinates can be $\pm$ 3-15 feet depending on location accessibility and GPS accuracy (e.g., as impacted by physical obstructions).

^bRelocated because of active sewer line.

^cLocation not selected because of active sewer line.

TABLE B-2
RADIONUCLIDE CONCENTRATION RANGES IN SOIL SAMPLES SUMMARY RESULTS OF BOREHOLES
SCREEN ARTS SITE
KNOXVILLE, TN

Location/Sample number ^a	Depth (ft)	Th-228 (pCi/g)	Th-232 (pCi/g)	U-238 (pCi/g)	U-235 (pCi/g)	Total U (pCi/g) ^b	Ra-226 (pCi/g)	Cs-137 (pCi/g)
BH001								
5096S0025A	0 to 1	1.31 ± 0.16 ^c	1.48 ± 0.32	5.29 ± 0.89	0.60 ± 0.20	11.2 ± 1.8	0.69 ± 0.13	0.49 ± 0.09
5096S0025B	1 to 2	1.47 ± 0.12	1.58 ± 0.20	2.07 ± 0.66	0.13 ± 0.07	4.3 ± 1.3	0.93 ± 0.08	0.23 ± 0.03
5096S0025C	2 to 3	1.18 ± 0.10	1.29 ± 0.16	1.36 ± 0.27	0.05 ± 0.16	2.77 ± 0.56	0.85 ± 0.07	0.02 ± 0.03
5096S0025D	3 to 4	1.26 ± 0.10	1.23 ± 0.17	1.10 ± 0.59	0.12 ± 0.06	2.3 ± 1.2	0.82 ± 0.07	-0.02 ± 0.03
5096S0026A	0 to 1	0.99 ± 0.09	1.02 ± 0.16	1.01 ± 0.28	-0.09 ± 0.13	1.93 ± 0.57	0.83 ± 0.07	0.02 ± 0.03
5096S0026B	1 to 2	1.02 ± 0.09	1.09 ± 0.15	1.31 ± 0.33	0.11 ± 0.19	2.73 ± 0.69	0.80 ± 0.07	-0.02 ± 0.04
5096S0026C	2 to 3	1.01 ± 0.08	0.95 ± 0.13	0.78 ± 0.22	0.13 ± 0.05	1.69 ± 0.44	0.72 ± 0.06	0.02 ± 0.03
5096S0026D	3 to 4	0.90 ± 0.08	0.87 ± 0.13	0.93 ± 0.32	0.11 ± 0.10	1.97 ± 0.65	0.56 ± 0.05	-0.02 ± 0.03
BH002								
5096S0027A	0 to 1	1.36 ± 0.14	1.56 ± 0.28	3.48 ± 0.56	0.19 ± 0.13	7.2 ± 1.1	0.83 ± 0.11	0.38 ± 0.07
5096S0027B	1 to 2	1.41 ± 0.12	1.46 ± 0.20	2.15 ± 0.43	0.15 ± 0.08	4.45 ± 0.86	0.95 ± 0.09	0.05 ± 0.05
5096S0027C	2 to 3	1.26 ± 0.10	1.21 ± 0.16	1.03 ± 0.25	0.14 ± 0.16	2.20 ± 0.52	0.58 ± 0.05	0.02 ± 0.03
5096S0027D	3 to 4	1.54 ± 0.15	1.42 ± 0.27	1.47 ± 0.47	0.29 ± 0.25	3.23 ± 0.97	0.60 ± 0.10	0.00 ± 0.08 ^d
5096S0028A	0 to 1	1.50 ± 0.18	1.64 ± 0.36	1.66 ± 0.69	0.29 ± 0.17	3.6 ± 1.4	0.71 ± 0.13	-0.07 ± 0.14
5096S0028B	1 to 2	1.47 ± 0.12	1.52 ± 0.19	0.68 ± 0.26	0.02 ± 0.18	1.38 ± 0.55	0.72 ± 0.06	0.02 ± 0.04
5096S0028C	2 to 3	1.51 ± 0.13	1.44 ± 0.20	1.16 ± 0.69	0.02 ± 0.16	2.3 ± 1.4	0.84 ± 0.08	-0.01 ± 0.04
BH003								
5096S0023A	0 to 1	1.23 ± 0.11	1.12 ± 0.18	7.53 ± 0.72	0.49 ± 0.11	15.6 ± 1.4	0.83 ± 0.09	0.41 ± 0.05
5096S0024A	0 to 1	1.39 ± 0.16	1.67 ± 0.33	2.98 ± 0.70	0.32 ± 0.17	6.3 ± 1.4	0.98 ± 0.14	0.09 ± 0.05
5096S0024B	1 to 2	1.41 ± 0.11	1.42 ± 0.19	1.79 ± 0.31	0.17 ± 0.07	3.75 ± 0.62	1.10 ± 0.09	0.04 ± 0.01
5096S0024C	2 to 3	1.57 ± 0.13	1.52 ± 0.21	2.26 ± 0.69	0.11 ± 0.06	4.6 ± 1.4	1.10 ± 0.10	0.01 ± 0.02
BH005								
5096S0009A	0 to 1	1.38 ± 0.12	1.47 ± 0.21	1.57 ± 0.35	0.05 ± 0.15	3.19 ± 0.72	0.76 ± 0.07	0.00 ± 0.04
5096S0009B	1 to 2	1.28 ± 0.11	1.40 ± 0.19	1.48 ± 0.35	-0.07 ± 0.21	2.89 ± 0.73	0.59 ± 0.06	0.03 ± 0.04

TABLE B-2
RADIONUCLIDE CONCENTRATION RANGES IN SOIL SAMPLES SUMMARY RESULTS OF BOREHOLES
SCREEN ARTS SITE
KNOXVILLE, TN

Location/Sample number ^a	Depth (ft)	Th-228 (pCi/g)	Th-232 (pCi/g)	U-238 (pCi/g)	U-235 (pCi/g)	Total U (pCi/g) ^b	Ra-226 (pCi/g)	Cs-137 (pCi/g)
5096S0009C	2 to 3	1.18 ± 0.09	1.23 ± 0.16	1.19 ± 0.25	-0.03 ± 0.15	2.35 ± 0.52	0.55 ± 0.05	0.00 ± 0.03
5096S0009D	3 to 4	1.49 ± 0.12	1.43 ± 0.19	1.08 ± 0.61	-0.04 ± 0.15	2.1 ± 1.2	0.72 ± 0.07	-0.07 ± 0.04
5096S0010A	0 to 1	1.66 ± 0.18	1.44 ± 0.57	2.08 ± 0.86	0.13 ± 0.37	4.3 ± 1.8	0.63 ± 0.13	0.07 ± 0.11
BH006								
5096S0007A	0 to 1	1.19 ± 0.10	1.32 ± 0.18	1.60 ± 0.37	0.20 ± 0.09	3.40 ± 0.75	0.78 ± 0.08	0.04 ± 0.05
5096S0007B	1 to 2	1.23 ± 0.10	1.22 ± 0.16	1.29 ± 0.28	0.08 ± 0.17	2.66 ± 0.59	0.76 ± 0.07	0.00 ± 0.04
5096S0007C	2 to 3	1.99 ± 0.18	1.85 ± 0.32	11.7 ± 1.3	0.43 ± 0.14	23.8 ± 2.6	0.76 ± 0.10	-0.01 ± 0.08
5096S0008A	0 to 1	1.51 ± 0.13	1.61 ± 0.22	3.56 ± 0.45	0.23 ± 0.02	7.35 ± 0.90	0.84 ± 0.08	0.01 ± 0.04
5096S0008B	1 to 2	1.56 ± 0.13	1.57 ± 0.21	3.57 ± 0.51	0.37 ± 0.25	7.5 ± 1.1	0.86 ± 0.09	0.00 ± 0.06
5096S0008C	2 to 3	1.49 ± 0.12	1.53 ± 0.19	1.76 ± 0.31	0.01 ± 0.18	3.53 ± 0.65	0.86 ± 0.07	-0.02 ± 0.04
5096S0008D	3 to 4	1.61 ± 0.13	1.48 ± 0.19	2.08 ± 0.64	0.10 ± 0.15	4.3 ± 1.3	0.95 ± 0.08	-0.04 ± 0.04
BH007								
5096S0017A	0 to 1	1.15 ± 0.12	1.35 ± 0.25	7.06 ± 0.76	0.44 ± 0.14	14.6 ± 1.5	0.62 ± 0.10	0.50 ± 0.07
5096S0017B	1 to 2	1.43 ± 0.12	1.60 ± 0.23	1.71 ± 0.35	0.02 ± 0.15	3.44 ± 0.72	0.75 ± 0.07	0.00 ± 0.04
5096S0017C	2 to 3	1.28 ± 0.11	1.44 ± 0.19	1.27 ± 0.33	0.30 ± 0.21	2.84 ± 0.69	0.84 ± 0.08	0.19 ± 0.03
5096S0017D	3 to 4	1.50 ± 0.14	1.55 ± 0.28	1.25 ± 0.48	0.11 ± 0.23	2.61 ± 0.99	0.82 ± 0.12	0.29 ± 0.06
5096S0018A	0 to 1	1.43 ± 0.18	1.60 ± 0.38	2.02 ± 0.69	0.23 ± 0.38	4.3 ± 1.4	0.87 ± 0.15	0.39 ± 0.09
5096S0018B	1 to 2	1.41 ± 0.12	1.48 ± 0.21	53.4 ± 3.7	3.59 ± 0.30	110.4 ± 7.4	1.28 ± 0.11	0.11 ± 0.03
5096S0018C	2 to 3	1.43 ± 0.11	1.52 ± 0.19	15.5 ± 1.1	1.14 ± 0.12	32.1 ± 2.2	1.03 ± 0.08	0.01 ± 0.03
BH009								
5096S0011A	0 to 1	1.34 ± 0.12	1.34 ± 0.20	1.71 ± 0.36	0.06 ± 0.16	3.48 ± 0.74	0.84 ± 0.08	0.07 ± 0.02
5096S0011B	1 to 2	1.46 ± 0.12	1.60 ± 0.22	1.19 ± 0.41	0.16 ± 0.09	2.54 ± 0.82	0.82 ± 0.08	-0.04 ± 0.06
5096S0011C	2 to 3	1.33 ± 0.11	1.34 ± 0.18	1.12 ± 0.28	0.18 ± 0.18	2.42 ± 0.59	0.76 ± 0.07	0.00 ± 0.04
5096S0011D	3 to 4	1.50 ± 0.12	1.62 ± 0.21	1.71 ± 0.60	0.02 ± 0.14	3.4 ± 1.2	0.79 ± 0.07	-0.01 ± 0.04
5096S0012A	0 to 1	1.37 ± 0.16	1.45 ± 0.34	0.80 ± 0.54	-0.02 ± 0.33	1.6 ± 1.1	0.71 ± 0.13	0.09 ± 0.11

TABLE B-2
RADIONUCLIDE CONCENTRATION RANGES IN SOIL SAMPLES SUMMARY RESULTS OF BOREHOLES
SCREEN ARTS SITE
KNOXVILLE, TN

Location/Sample number ^a	Depth (ft)	Th-228 (pCi/g)	Th-232 (pCi/g)	U-238 (pCi/g)	U-235 (pCi/g)	Total U (pCi/g) ^b	Ra-226 (pCi/g)	Cs-137 (pCi/g)
BH010								
5096S0013A	0 to 1	1.53 ± 0.13	1.56 ± 0.24	2.17 ± 0.43	0.07 ± 0.19	4.41 ± 0.88	0.85 ± 0.09	0.01 ± 0.05
5096S0013B	1 to 2	1.45 ± 0.12	1.48 ± 0.20	1.43 ± 0.37	0.12 ± 0.25	2.98 ± 0.78	0.85 ± 0.08	0.04 ± 0.06
5096S0013C	2 to 3	2.75 ± 0.21	2.31 ± 0.27	44.3 ± 3.0	3.18 ± 0.24	91.8 ± 6.0	1.00 ± 0.08	0.13 ± 0.02
5096S0013D	3 to 4	1.70 ± 0.14	1.74 ± 0.26	2.6 ± 0.41	0.20 ± 0.07	5.40 ± 0.82	0.65 ± 0.07	-0.01 ± 0.04
5096S0014A	0 to 1	1.60 ± 0.14	1.71 ± 0.24	10.47 ± 0.90	0.64 ± 0.11	21.6 ± 1.8	1.18 ± 0.10	0.05 ± 0.02
5096S0014B	1 to 2	1.40 ± 0.12	1.43 ± 0.20	1.27 ± 0.37	0.07 ± 0.25	2.61 ± 0.78	0.67 ± 0.07	0.01 ± 0.05
5096S0014C	2 to 3	1.41 ± 0.11	1.52 ± 0.20	1.49 ± 0.31	-0.03 ± 0.19	2.95 ± 0.65	0.73 ± 0.07	0.00 ± 0.04
5096S0014D	3 to 4	1.57 ± 0.13	1.48 ± 0.20	0.97 ± 0.35	0.15 ± 0.14	2.09 ± 0.71	0.73 ± 0.07	-0.05 ± 0.04
BH011								
5096S0005A	0 to 1	1.74 ± 0.15	1.77 ± 0.25	5.42 ± 0.57	0.38 ± 0.09	11.2 ± 1.1	0.68 ± 0.07	0.05 ± 0.02
5096S0005B	1 to 2	1.20 ± 0.11	1.29 ± 0.18	0.61 ± 0.35	0.01 ± 0.23	1.23 ± 0.74	0.78 ± 0.08	-0.03 ± 0.05
5096S0005C	2 to 3	1.33 ± 0.11	1.46 ± 0.18	1.21 ± 0.27	-0.03 ± 0.18	2.39 ± 0.57	0.95 ± 0.07	0.03 ± 0.03
5096S0005D	3 to 4	1.53 ± 0.12	1.29 ± 0.17	4.23 ± 0.72	0.28 ± 0.07	8.7 ± 1.4	0.94 ± 0.08	-0.01 ± 0.04
5096S0006A	0 to 1	1.44 ± 0.12	1.49 ± 0.21	2.33 ± 0.37	0.10 ± 0.15	4.76 ± 0.76	1.01 ± 0.09	-0.01 ± 0.04
5096S0006B	1 to 2	1.24 ± 0.11	1.35 ± 0.18	1.35 ± 0.33	0.06 ± 0.21	2.76 ± 0.69	1.04 ± 0.09	0.02 ± 0.04
5096S0006C	2 to 3	1.42 ± 0.11	1.41 ± 0.17	1.66 ± 0.28	0.19 ± 0.17	3.51 ± 0.59	1.11 ± 0.08	-0.02 ± 0.03
5096S0006D	3 to 4	1.48 ± 0.12	1.48 ± 0.19	1.22 ± 0.29	0.14 ± 0.07	2.58 ± 0.58	0.96 ± 0.08	-0.05 ± 0.04
BH012								
5096S0021A	0 to 1	0.66 ± 0.10	0.61 ± 0.21	2.03 ± 0.53	0.16 ± 0.13	4.2 ± 1.1	0.48 ± 0.10	0.03 ± 0.03
5096S0021B	1 to 2	0.73 ± 0.11	0.75 ± 0.22	2.73 ± 0.60	0.26 ± 0.15	5.7 ± 1.2	0.47 ± 0.10	0.04 ± 0.10
5096S0021C	2 to 3	1.14 ± 0.09	1.22 ± 0.16	1.50 ± 0.28	0.13 ± 0.06	3.13 ± 0.56	0.72 ± 0.06	0.17 ± 0.03
5096S0021D	3 to 4	1.11 ± 0.09	1.18 ± 0.16	1.43 ± 0.29	0.15 ± 0.02	3.01 ± 0.58	0.55 ± 0.06	0.05 ± 0.02
5096S0022A	0 to 1	1.11 ± 0.14	1.09 ± 0.27	8.8 ± 1.0	0.75 ± 0.22	18.4 ± 2.0	0.85 ± 0.14	0.08 ± 0.04
5096S0022B	1 to 2	1.25 ± 0.11	1.42 ± 0.19	6.47 ± 0.63	0.32 ± 0.08	13.3 ± 1.3	1.07 ± 0.09	0.01 ± 0.05

TABLE B-2
RADIONUCLIDE CONCENTRATION RANGES IN SOIL SAMPLES SUMMARY RESULTS OF BOREHOLES
SCREEN ARTS SITE
KNOXVILLE, TN

Location/Sample number ^a	Depth (ft)	Th-228 (pCi/g)	Th-232 (pCi/g)	U-238 (pCi/g)	U-235 (pCi/g)	Total U (pCi/g) ^b	Ra-226 (pCi/g)	Cs-137 (pCi/g)
BH013								
5096S0034A	0 to 1	1.45 ± 0.18	1.24 ± 0.34	1.11 ± 0.63	0.34 ± 0.34	2.6 ± 1.3	0.76 ± 0.15	0.09 ± 0.12
5096S0034B	1 to 2	1.48 ± 0.13	1.63 ± 0.22	1.41 ± 0.40	-0.07 ± 0.26	2.75 ± 0.84	0.73 ± 0.08	0.04 ± 0.05
5096S0034C	2 to 3	1.55 ± 0.12	1.63 ± 0.21	1.42 ± 0.33	0.13 ± 0.20	2.97 ± 0.69	0.82 ± 0.07	0.05 ± 0.04
5096S0035A	0 to 1	1.40 ± 0.12	1.43 ± 0.20	1.14 ± 0.32	0.11 ± 0.15	2.39 ± 0.66	0.68 ± 0.07	0.02 ± 0.04
5096S0035B	1 to 2	1.49 ± 0.13	1.55 ± 0.21	1.40 ± 0.35	0.20 ± 0.24	3.00 ± 0.74	0.73 ± 0.08	0.03 ± 0.05
5096S0035C	2 to 3	1.47 ± 0.12	1.51 ± 0.19	1.23 ± 0.30	-0.11 ± 0.18	2.35 ± 0.63	0.65 ± 0.06	0.02 ± 0.04
5096S0035D	3 to 4	1.52 ± 0.12	1.51 ± 0.20	1.04 ± 0.30	0.00 ± 0.14	2.08 ± 0.62	0.59 ± 0.06	-0.01 ± 0.04
BH014								
5096S0015A	0 to 1	1.42 ± 0.16	1.56 ± 0.35	3.62 ± 0.72	0.61 ± 0.33	7.8 ± 1.5	0.66 ± 0.12	0.10 ± 0.10
5096S0015B	1 to 2	1.11 ± 0.10	1.35 ± 0.18	0.69 ± 0.30	0.10 ± 0.22	1.48 ± 0.64	0.59 ± 0.06	0.00 ± 0.05
5096S0015C	2 to 3	1.01 ± 0.09	1.06 ± 0.16	0.98 ± 0.27	0.06 ± 0.13	2.02 ± 0.56	0.62 ± 0.06	0.03 ± 0.03
5096S0015D	3 to 4	1.04 ± 0.09	1.07 ± 0.16	1.53 ± 0.35	0.15 ± 0.08	3.21 ± 0.70	0.67 ± 0.07	0.05 ± 0.04
5096S0016A	0 to 1	1.35 ± 0.17	1.12 ± 0.30	10.8 ± 1.3	0.60 ± 0.26	22.2 ± 2.6	0.87 ± 0.26	0.15 ± 0.16
5096S0016B	1 to 2	1.10 ± 0.09	1.15 ± 0.15	1.23 ± 0.26	-0.04 ± 0.17	2.42 ± 0.55	0.77 ± 0.06	-0.01 ± 0.03
5096S0016C	2 to 3	1.43 ± 0.12	1.41 ± 0.19	1.11 ± 0.33	-0.03 ± 0.14	2.19 ± 0.67	0.80 ± 0.07	-0.01 ± 0.03
BH015								
5096S0003A	0 to 1	0.80 ± 0.07	0.78 ± 0.13	1.37 ± 0.28	0.13 ± 0.12	2.87 ± 0.57	0.54 ± 0.06	0.00 ± 0.03
5096S0003B	1 to 2	1.35 ± 0.12	1.62 ± 0.22	1.53 ± 0.40	0.23 ± 0.24	3.29 ± 0.84	1.01 ± 0.09	-0.03 ± 0.06
5096S0003C	2 to 3	1.36 ± 0.11	1.40 ± 0.18	1.10 ± 0.27	0.16 ± 0.07	2.36 ± 0.54	0.92 ± 0.07	0.00 ± 0.04
5096S0003D	3 to 4	1.01 ± 0.09	0.92 ± 0.14	0.97 ± 0.26	0.02 ± 0.13	1.96 ± 0.54	0.62 ± 0.06	-0.03 ± 0.04
5096S0004A	0 to 1	1.19 ± 0.10	1.31 ± 0.19	8.43 ± 0.72	0.59 ± 0.09	17.4 ± 1.4	0.79 ± 0.07	0.02 ± 0.04
5096S0004B	1 to 2	1.36 ± 0.11	1.28 ± 0.17	1.69 ± 0.36	0.03 ± 0.21	3.41 ± 0.75	1.08 ± 0.09	0.04 ± 0.04
5096S0004C	2 to 3	1.48 ± 0.11	1.56 ± 0.19	2.42 ± 0.32	0.15 ± 0.06	4.99 ± 0.64	1.02 ± 0.08	-0.02 ± 0.03
5096S0004D	3 to 4	1.30 ± 0.11	1.40 ± 0.18	1.45 ± 0.30	0.04 ± 0.13	2.94 ± 0.61	0.81 ± 0.07	0.00 ± 0.03

TABLE B-2
RADIONUCLIDE CONCENTRATION RANGES IN SOIL SAMPLES SUMMARY RESULTS OF BOREHOLES
SCREEN ARTS SITE
KNOXVILLE, TN

Location/Sample number ^a	Depth (ft)	Th-228 (pCi/g)	Th-232 (pCi/g)	U-238 (pCi/g)	U-235 (pCi/g)	Total U (pCi/g) ^b	Ra-226 (pCi/g)	Cs-137 (pCi/g)
BH016								
5096S0036A	0 to 1	1.14 ± 0.10	1.27 ± 0.18	1.00 ± 0.29	-0.06 ± 0.13	1.94 ± 0.59	0.76 ± 0.07	0.01 ± 0.04
5096S0036B	1 to 2	1.28 ± 0.11	1.45 ± 0.20	1.23 ± 0.37	-0.14 ± 0.24	2.32 ± 0.78	0.70 ± 0.07	0.07 ± 0.02
5096S0036C	2 to 3	1.40 ± 0.11	1.40 ± 0.18	1.12 ± 0.28	0.11 ± 0.19	2.35 ± 0.59	0.62 ± 0.06	0.00 ± 0.04
5096S0036D	3 to 4	1.62 ± 0.13	1.48 ± 0.20	1.29 ± 0.65	0.07 ± 0.15	2.6 ± 1.3	0.58 ± 0.06	-0.02 ± 0.04
5096S0037A	0 to 1	1.35 ± 0.11	1.39 ± 0.18	1.01 ± 0.25	0.14 ± 0.17	2.16 ± 0.53	0.65 ± 0.06	0.01 ± 0.04
5096S0037B	1 to 2	1.56 ± 0.13	1.62 ± 0.21	0.77 ± 0.39	-0.05 ± 0.15	1.49 ± 0.79	0.75 ± 0.07	-0.01 ± 0.04
5096S0037C	2 to 3	1.45 ± 0.12	1.43 ± 0.21	1.32 ± 0.34	0.03 ± 0.15	2.67 ± 0.70	0.70 ± 0.07	0.05 ± 0.04
5096S0037D	3 to 4	1.46 ± 0.12	1.49 ± 0.20	1.11 ± 0.37	0.02 ± 0.26	2.24 ± 0.78	0.79 ± 0.08	0.05 ± 0.05
BH017								
5096S0001A	0 to 1	1.12 ± 0.10	1.30 ± 0.19	1.40 ± 0.32	0.14 ± 0.14	2.94 ± 0.66	0.60 ± 0.06	0.02 ± 0.04
5096S0001B	1 to 2	1.13 ± 0.10	1.35 ± 0.19	1.21 ± 0.35	0.34 ± 0.22	2.76 ± 0.73	0.69 ± 0.07	-0.03 ± 0.05
5096S0001C	2 to 3	1.41 ± 0.11	1.62 ± 0.20	3.55 ± 0.41	0.22 ± 0.07	7.32 ± 0.82	0.70 ± 0.06	0.02 ± 0.01
5096S0001D	3 to 4	1.47 ± 0.12	1.51 ± 0.20	1.00 ± 0.31	0.16 ± 0.14	2.16 ± 0.64	0.67 ± 0.06	-0.05 ± 0.04
5096S0002A	0 to 1	1.33 ± 0.11	1.34 ± 0.17	1.66 ± 0.30	0.18 ± 0.18	3.50 ± 0.63	0.79 ± 0.07	0.01 ± 0.04
5096S0002B	1 to 2	1.07 ± 0.09	1.13 ± 0.18	0.65 ± 0.24	0.02 ± 0.12	1.32 ± 0.49	0.61 ± 0.06	-0.02 ± 0.03
BH018								
5096S0019A	0 to 1	1.07 ± 0.10	1.14 ± 0.17	1.50 ± 0.31	0.09 ± 0.13	3.09 ± 0.63	0.64 ± 0.06	0.02 ± 0.04
5096S0019B	1 to 2	1.40 ± 0.12	1.48 ± 0.20	1.73 ± 0.40	0.23 ± 0.24	3.69 ± 0.84	0.76 ± 0.08	0.03 ± 0.05
5096S0019C	2 to 3	1.38 ± 0.11	1.33 ± 0.17	1.33 ± 0.29	0.13 ± 0.18	2.79 ± 0.61	0.77 ± 0.07	0.06 ± 0.03
5096S0019D	3 to 4	1.55 ± 0.13	1.56 ± 0.20	2.54 ± 0.39	0.14 ± 0.08	5.22 ± 0.78	0.85 ± 0.08	-0.03 ± 0.04
5096S0020A	0 to 1	3.46 ± 0.28	4.01 ± 0.48	45.2 ± 3.1	2.70 ± 0.25	93.1 ± 6.2	2.52 ± 0.18	0.24 ± 0.04
5096S0020B	1 to 2	1.27 ± 0.11	1.55 ± 0.20	1.37 ± 0.35	0.16 ± 0.08	2.90 ± 0.70	0.86 ± 0.08	0.03 ± 0.04
5096S0020C	2 to 3	1.43 ± 0.11	1.47 ± 0.19	1.68 ± 0.30	0.16 ± 0.18	3.52 ± 0.63	0.79 ± 0.07	-0.01 ± 0.04
5096S0020D	3 to 4	1.54 ± 0.13	1.64 ± 0.21	1.36 ± 0.62	0.10 ± 0.14	2.8 ± 1.2	0.71 ± 0.07	-0.06 ± 0.04

TABLE B-2
RADIONUCLIDE CONCENTRATION RANGES IN SOIL SAMPLES SUMMARY RESULTS OF BOREHOLES
SCREEN ARTS SITE
KNOXVILLE, TN

Location/Sample number ^a	Depth (ft)	Th-228 (pCi/g)	Th-232 (pCi/g)	U-238 (pCi/g)	U-235 (pCi/g)	Total U (pCi/g) ^b	Ra-226 (pCi/g)	Cs-137 (pCi/g)
BH019								
5096S0038A	0 to 1	1.18 ± 0.14	1.39 ± 0.30	1.23 ± 0.51	0.09 ± 0.30	2.6 ± 1.1	0.58 ± 0.11	0.00 ± 0.09
5096S0038B	1 to 2	0.71 ± 0.07	0.79 ± 0.13	0.89 ± 0.29	0.06 ± 0.19	1.84 ± 0.61	0.59 ± 0.06	0.02 ± 0.04
5096S0038C	2 to 3	1.21 ± 0.10	1.24 ± 0.16	1.13 ± 0.26	-0.11 ± 0.17	2.15 ± 0.55	0.69 ± 0.06	-0.02 ± 0.04
5096S0038D	3 to 4	1.40 ± 0.12	1.33 ± 0.18	1.16 ± 0.32	0.12 ± 0.14	2.44 ± 0.66	0.68 ± 0.07	-0.02 ± 0.04
5096S0039A	0 to 1	1.27 ± 0.10	1.26 ± 0.17	0.87 ± 0.25	0.18 ± 0.17	1.92 ± 0.53	0.64 ± 0.06	0.00 ± 0.03
5096S0039B	1 to 2	1.33 ± 0.11	1.23 ± 0.17	1.25 ± 0.30	0.13 ± 0.13	2.63 ± 0.61	0.65 ± 0.06	-0.01 ± 0.04
5096S0039C	2 to 3	1.38 ± 0.12	1.50 ± 0.21	1.09 ± 0.33	0.05 ± 0.15	2.23 ± 0.68	0.66 ± 0.07	0.02 ± 0.04
5096S0039D	3 to 4	1.42 ± 0.12	1.55 ± 0.21	0.91 ± 0.35	0.06 ± 0.24	1.88 ± 0.74	0.75 ± 0.08	0.03 ± 0.05
BH020								
5096S0029A	0 to 1	0.87 ± 0.08	0.90 ± 0.14	2.19 ± 0.37	0.14 ± 0.07	4.52 ± 0.74	0.57 ± 0.06	0.03 ± 0.04
5096S0029B	1 to 2	1.31 ± 0.10	1.35 ± 0.17	1.47 ± 0.28	-0.03 ± 0.18	2.91 ± 0.59	0.74 ± 0.06	0.10 ± 0.02
5096S0029C	2 to 3	1.49 ± 0.12	1.50 ± 0.20	1.05 ± 0.32	0.11 ± 0.14	2.21 ± 0.66	0.80 ± 0.07	-0.02 ± 0.04
5096S0030A	0 to 1	1.31 ± 0.11	1.26 ± 0.19	1.28 ± 0.32	0.12 ± 0.06	2.68 ± 0.64	0.65 ± 0.06	0.02 ± 0.01
5096S0030B	1 to 2	1.38 ± 0.12	1.48 ± 0.20	1.19 ± 0.37	0.15 ± 0.24	2.53 ± 0.78	0.61 ± 0.07	0.03 ± 0.05
5096S0030C	2 to 3	1.33 ± 0.11	1.41 ± 0.18	0.97 ± 0.26	-0.15 ± 0.18	1.79 ± 0.55	0.59 ± 0.06	0.00 ± 0.04
5096S0030D	3 to 4	1.44 ± 0.12	1.41 ± 0.19	0.90 ± 0.31	0.00 ± 0.14	1.80 ± 0.64	0.68 ± 0.07	0.00 ± 0.04
BH021^c								
5096S0040A	0 to 1	2.05 ± 0.22	1.86 ± 0.38	1.38 ± 0.59	0.33 ± 0.33	3.1 ± 1.2	0.50 ± 0.11	0.04 ± 0.11
5096S0040B	1 to 2	1.19 ± 0.11	1.34 ± 0.19	1.48 ± 0.38	0.04 ± 0.25	3.00 ± 0.80	0.76 ± 0.08	0.01 ± 0.05
5096S0040C	2 to 3	1.67 ± 0.13	1.74 ± 0.21	1.58 ± 0.30	0.12 ± 0.18	3.28 ± 0.63	0.72 ± 0.06	0.00 ± 0.04
5096S0040D	3 to 4	1.57 ± 0.13	1.41 ± 0.19	1.49 ± 0.32	0.13 ± 0.06	3.11 ± 0.64	0.70 ± 0.06	0.02 ± 0.03
5096S0041A	0 to 1	1.94 ± 0.15	1.91 ± 0.24	1.83 ± 0.37	-0.02 ± 0.22	3.64 ± 0.77	0.94 ± 0.08	0.02 ± 0.04
5096S0041B	1 to 2	2.55 ± 0.20	2.53 ± 0.29	13.3 ± 1.0	0.84 ± 0.12	27.4 ± 2.0	1.50 ± 0.11	0.16 ± 0.03
5096S0041C	2 to 3	2.41 ± 0.19	2.15 ± 0.25	3.38 ± 0.71	0.25 ± 0.08	7.0 ± 1.4	1.07 ± 0.08	0.04 ± 0.02

TABLE B-2
RADIONUCLIDE CONCENTRATION RANGES IN SOIL SAMPLES SUMMARY RESULTS OF BOREHOLES
SCREEN ARTS SITE
KNOXVILLE, TN

Location/Sample number ^a	Depth (ft)	Th-228 (pCi/g)	Th-232 (pCi/g)	U-238 (pCi/g)	U-235 (pCi/g)	Total U (pCi/g) ^b	Ra-226 (pCi/g)	Cs-137 (pCi/g)
BH022^c								
5096S0042A	0 to 1	2.77 ± 0.30	3.05 ± 0.59	209 ± 14	20.2 ± 1.7	438 ± 28	24.7 ± 1.5	-0.17 ± 0.22
5096S0042B	1 to 2	1.57 ± 0.14	1.59 ± 0.24	163 ± 11	7.71 ± 0.58	334 ± 22	2.03 ± 0.16	0.06 ± 0.03
5096S0042C	2 to 3	1.49 ± 0.13	1.65 ± 0.23	22.4 ± 1.7	1.64 ± 0.19	46.4 ± 3.4	2.48 ± 0.19	0.03 ± 0.07
5096S0043A	0 to 1	1.45 ± 0.12	1.63 ± 0.21	13.3 ± 1.0	1.29 ± 0.14	27.9 ± 2.0	2.75 ± 0.18	-0.02 ± 0.04
5096S0043B	1 to 2	1.55 ± 0.13	1.49 ± 0.20	1.21 ± 0.35	0.00 ± 0.15	2.42 ± 0.72	0.75 ± 0.07	-0.02 ± 0.04
BH023^c								
5096S0044A	0 to 1	1.39 ± 0.17	1.04 ± 0.35	107.7 ± 7.4	5.54 ± 0.60	221 ± 15	0.62 ± 0.14	0.02 ± 0.18
5096S0044B	1 to 2	1.52 ± 0.13	1.65 ± 0.22	34.0 ± 2.4	1.49 ± 0.17	69.5 ± 4.8	0.71 ± 0.08	-0.02 ± 0.07
5096S0044C	2 to 3	1.54 ± 0.12	1.39 ± 0.18	34.5 ± 2.4	1.74 ± 0.17	70.7 ± 4.8	0.69 ± 0.06	0.02 ± 0.04
5096S0044D	3 to 4	1.68 ± 0.14	1.71 ± 0.23	9.3 ± 1.0	0.49 ± 0.10	19.1 ± 2.0	0.71 ± 0.07	-0.03 ± 0.05
5096S0045A	0 to 1	1.54 ± 0.14	1.47 ± 0.23	63.1 ± 4.3	3.23 ± 0.29	129.4 ± 8.6	0.76 ± 0.08	0.03 ± 0.08
5096S0045B	1 to 2	1.48 ± 0.13	1.54 ± 0.21	22.1 ± 1.7	1.09 ± 0.14	45.3 ± 3.4	0.72 ± 0.08	-0.03 ± 0.06
5096S0045C	2 to 3	1.53 ± 0.12	1.46 ± 0.19	2.54 ± 0.36	0.19 ± 0.07	5.27 ± 0.72	0.70 ± 0.06	0.00 ± 0.04
5096S0045D	3 to 4	1.48 ± 0.12	1.38 ± 0.20	1.79 ± 0.37	0.18 ± 0.15	3.76 ± 0.76	0.66 ± 0.07	-0.01 ± 0.04
BH024^c								
5096S0046A	0 to 1	1.46 ± 0.12	1.49 ± 0.20	43.9 ± 3.1	3.54 ± 0.27	91.3 ± 6.2	0.84 ± 0.08	0.29 ± 0.04
BH025^c								
5096S0048A	0 to 1	539 ± 41	569 ± 61	33.4 ± 4.4	-2.9 ± 1.3	63.9 ± 8.9	1.03 ± 0.31	-1.06 ± 0.47
5096S0048B	1 to 2	1.35 ± 0.12	1.41 ± 0.20	1.35 ± 0.39	0.03 ± 0.26	2.73 ± 0.82	0.88 ± 0.09	-0.03 ± 0.06
5096S0048C	2 to 3	1.52 ± 0.12	1.57 ± 0.20	6.64 ± 0.61	0.54 ± 0.09	13.8 ± 1.2	0.94 ± 0.08	0.06 ± 0.02
5096S0048D	3 to 4	1.73 ± 0.14	-0.94 ± 0.36	2.35 ± 0.40	0.17 ± 0.07	4.87 ± 0.80	1.11 ± 0.09	0.04 ± 0.04
5096S0049A	0 to 1	1.42 ± 0.12	1.46 ± 0.21	1.70 ± 0.35	0.08 ± 0.16	3.48 ± 0.72	0.83 ± 0.08	0.00 ± 0.04
5096S0049B	1 to 2	1.54 ± 0.13	1.61 ± 0.22	1.35 ± 0.39	0.22 ± 0.26	2.92 ± 0.82	0.85 ± 0.09	-0.02 ± 0.05
5096S0049C	2 to 3	1.55 ± 0.12	1.61 ± 0.20	1.4 ± 0.3	0.02 ± 0.18	2.82 ± 0.63	0.86 ± 0.07	0.00 ± 0.04

TABLE B-2
RADIONUCLIDE CONCENTRATION RANGES IN SOIL SAMPLES SUMMARY RESULTS OF BOREHOLES
SCREEN ARTS SITE
KNOXVILLE, TN

Location/Sample number^a	Depth (ft)	Th-228 (pCi/g)^c	Th-232 (pCi/g)	U-238 (pCi/g)	U-235 (pCi/g)	Total U (pCi/g)^b	Ra-226 (pCi/g)	Cs-137 (pCi/g)
5096S0049D	3 to 4	1.52 ± 0.12	1.48 ± 0.19	1.23 ± 0.31	0.02 ± 0.14	2.48 ± 0.64	0.69 ± 0.07	0.01 ± 0.04

^aRefer to figures A-6 and A-7 for position.

^bTotal U is calculated by U-234 + U-235 + U-238.

^cUncertainties are at the 95% confidence level based on total propagated uncertainties.

^dZero values for sample results are due to rounding.

^eBoreholes BH021, BH022, BH023, BH024, and BH025 are judgmental locations.

TABLE B-3
RADIONUCLIDE CONCENTRATIONS IN JUDGMENTAL SOIL SAMPLES
SCREEN ARTS SITE
KNOXVILLE, TN

Sample Number ^a	Th-228 (pCi/g)	Th-232 (pCi/g)	U-238 (pCi/g)	U-235 (pCi/g)	Total U (pCi/g) ^b	Ra-226 (pCi/g)	Cs-137 (pCi/g)
5096S0031A ^c	78.9 ± 0.09 ^d	80.7 ± 0.17	5.9 ± 0.01	0.39 ± 0.00	12.2 ± 0.02	0.35 ± 0.00	0.66 ± 0.00
5096S0032B ^c	0.83 ± 0.07	0.78 ± 0.12	7.43 ± 0.65	0.74 ± 0.09	15.6 ± 1.3	11.27 ± 0.81	1.71 ± 0.14
5096S0033C ^c	1.10 ± 0.10	1.07 ± 0.17	12.37 ± 0.98	0.85 ± 0.11	25.6 ± 2.0	13.7 ± 1.0	0.33 ± 0.04
5096S0050	1.00 ± 0.09	1.12 ± 0.17	4.73 ± 0.57	0.34 ± 0.10	9.8 ± 1.1	0.45 ± 0.06	0.21 ± 0.04
5096S0051	1.43 ± 0.13	1.62 ± 0.24	17.4 ± 1.4	0.92 ± 0.15	35.7 ± 2.8	0.95 ± 0.10	0.62 ± 0.08
5096S0052	1.25 ± 0.10	1.32 ± 0.19	4.07 ± 0.49	0.17 ± 0.06	8.31 ± 0.98	0.78 ± 0.07	0.26 ± 0.04
5096S0053	1.87 ± 0.15	2.00 ± 0.28	19.7 ± 1.9	1.25 ± 0.17	40.6 ± 3.8	1.89 ± 0.16	0.72 ± 0.09
5096S0054	77.2 ± 5.4	81.0 ± 8.1	8.9 ± 1.8	0.26 ± 0.85	18.1 ± 3.7	0.70 ± 0.25	1.28 ± 0.15
5096S0055	201 ± 14	220 ± 23	21.9 ± 2.9	1.1 ± 1.1	44.9 ± 5.9	1.01 ± 0.48	2.84 ± 0.30
5096S0056	1.06 ± 0.10	1.03 ± 0.17	5.42 ± 0.63	0.33 ± 0.10	11.2 ± 1.3	0.56 ± 0.07	0.16 ± 0.03
5096S0057	1.40 ± 0.12	1.27 ± 0.20	82.9 ± 5.5	34.9 ± 2.1	201 ± 11	0.93 ± 0.09	0.48 ± 0.06
5096S0058	1.51 ± 0.13	1.55 ± 0.23	48.7 ± 3.4	9.97 ± 0.65	107.4 ± 6.8	1.01 ± 0.10	0.36 ± 0.05
5096S0059	88.7 ± 6.3	96.7 ± 9.9	12.9 ± 2.4	1.3 ± 1.5	27.1 ± 5.0	2.46 ± 0.23	0.10 ± 0.31
5096S0060	1.72 ± 0.13	1.82 ± 0.24	4.40 ± 0.52	0.26 ± 0.08	9.1 ± 1.0	0.80 ± 0.07	0.04 ± 0.04
5096S0061	1.60 ± 0.13	1.49 ± 0.22	6.00 ± 0.97	0.37 ± 0.09	12.4 ± 1.9	0.87 ± 0.09	0.04 ± 0.02
5096S0062	3.40 ± 0.26	3.60 ± 0.40	12.3 ± 1.0	1.12 ± 0.14	25.7 ± 2.0	0.63 ± 0.07	0.18 ± 0.03
5096S0063	19.1 ± 1.4	19.7 ± 2.1	31.7 ± 2.5	3.65 ± 0.37	67.0 ± 5.0	1.24 ± 0.13	0.11 ± 0.05
5096S0064	8.72 ± 0.62	9.18 ± 0.97	11.6 ± 1.6	0.75 ± 0.15	24.0 ± 3.2	0.83 ± 0.08	0.08 ± 0.03
5096S0065	14.7 ± 1.1	17.3 ± 1.7	11.4 ± 1.3	0.72 ± 0.20	23.5 ± 2.6	0.86 ± 0.10	0.08 ± 0.04
5096S0066	7.22 ± 0.55	7.56 ± 0.87	24.1 ± 2.1	2.23 ± 0.30	50.4 ± 4.2	1.07 ± 0.13	0.2 ± 0.06
5096S0067	0.63 ± 0.06	0.63 ± 0.11	0.61 ± 0.28	0.01 ± 0.13	1.26 ± 0.57	0.48 ± 0.06	0.06 ± 0.02
5096S0068	1.03 ± 0.18	1.08 ± 0.88	3550 ± 220	180 ± 10	7280 ± 440	1.30 ± 0.22	0.35 ± 0.11
5096S0069	3.82 ± 0.28	3.79 ± 0.44	20.4 ± 1.5	1.60 ± 0.16	42.4 ± 3.0	0.89 ± 0.08	0.13 ± 0.03

TABLE B-3
RADIONUCLIDE CONCENTRATIONS IN JUDGMENTAL SOIL SAMPLES
SCREEN ARTS SITE
KNOXVILLE, TN

Sample Number^a	Th-228 (pCi/g)	Th-232 (pCi/g)	U-238 (pCi/g)	U-235 (pCi/g)	Total U (pCi/g)^b	Ra-226 (pCi/g)	Cs-137 (pCi/g)
5096S0070	4.68 ± 0.34	4.90 ± 0.54	50.2 ± 3.6	3.78 ± 0.28	104.2 ± 7.2	1.36 ± 0.11	0.30 ± 0.04
5096S0071	64.9 ± 4.6	129 ± 13	4.4 ± 5.6	-0.3 ± 1.5	8 ± 11	4.84 ± 0.40	-0.18 ± 0.40
5096S0072	116.3 ± 9.5	131 ± 15	20.9 ± 3.3	4.1 ± 2.4	45.9 ± 7.0	0.29 ± 0.70	0.33 ± 0.44
5096S0073	0.50 ± 0.05	0.51 ± 0.08	1.59 ± 0.25	0.09 ± 0.04	3.27 ± 0.50	0.43 ± 0.04	0.01 ± 0.02
5096S0074	1.49 ± 0.14	1.39 ± 0.27	97.2 ± 6.9	4.02 ± 0.38	198 ± 14	0.90 ± 0.12	0.09 ± 0.04
Range	0.50 to 201	0.51 to 220	0.61 to 3550	-0.3 to 180	1.26 to 7280	0.29 to 4.84	-0.18 to 2.84

^aRefer to Figure A-7.

^bFor total U the assumption is made that U-234 is present in equilibrium with U-238. This is calculated by U-234 + U-235 + U-238.

^cBorehole BH004 includes samples 0031A, 0032B, and 0033C

^dUncertainties are at the 95% confidence level based on total propagated uncertainties.

APPENDIX C

MAJOR INSTRUMENTATION

MAJOR INSTRUMENTATION

The display of a specific product is not to be construed as an endorsement of the product or its manufacturer by the author or her employer.

C.1 Scanning Instrument/Detector Combinations

Ludlum Scintillation Detector Model 44-10, Crystal: 5 cm x 5 cm (Ludlum Measurements, Inc., Sweetwater, TX)

Coupled to:

Ludlum Ratemeter-Scaler Model 2221 (Ludlum Measurements, Inc., Sweetwater, TX)

Coupled to:

Trimble GeoXH Receiver and Data Logger (Trimble Navigation Limited, Sunnyvale, CA)

Bicron Field Instrument Detector for Low Energy Radiation (FIDLER) Model G5 (Bicron Corporation, Newburg, OH)

Coupled to Ludlum Ratemeter-Scaler Model 2221 (Ludlum Measurements, Inc., Sweetwater, TX)

Coupled to:

Trimble GeoXH Receiver and Data Logger (Trimble Navigation Limited, Sunnyvale, CA)

C.2 Laboratory Analytical Instrumentation

High Purity Extended Range Intrinsic Detector CANBERRA/Tennelec Model No: ERVDS30-25195 (Canberra, Meriden, CT)

Used in conjunction with:

Lead Shield Model G-11 (Nuclear Lead, Oak Ridge, TN) and Multichannel Analyzer; Dell Workstation and Apex Gamma Software (Canberra, Meriden, CT)

High Purity Extended Range Intrinsic Detector Model No. GMX-45200-5 (AMETEK/ORTEC, Oak Ridge, TN)

Used in conjunction with:

Lead Shield Model SPG-16-K8 (Nuclear Data) and Multichannel Analyzer; Dell Workstation and Apex Gamma Software (Canberra, Meriden, CT)

High-Purity Germanium Detector Model GMX-30-P4, 30% Eff. (AMETEK/ORTEC, Oak Ridge, TN)

Used in conjunction with:

Lead Shield Model G-16 (Gamma Products, Palos Hills, IL) and Multichannel Analyzer; Dell Workstation and Apex Gamma Software (Canberra, Meriden, CT)

APPENDIX D
SURVEY AND ANALYTICAL PROCEDURES

SURVEY AND ANALYTICAL PROCEDURES

D.1 Project Health and Safety

The survey and sampling procedures were evaluated to ensure that any hazards inherent to the procedures themselves were addressed in current Job Hazard Analyses (JHAs). All survey and laboratory activities were conducted in accordance with ORISE health and safety and radiation protection procedures. Pre-survey activities included an overview of potential health and safety issues. Characterization surveys were performed according to the ORISE generic health and safety plan, site-specific integrated safety management (ISM) pre-job hazard checklist, and safety procedures discussed during the on-site training.

D.2 Calibration and Quality Assurance

Calibration of all field and laboratory instrumentation was based on standards/sources, traceable to the National Institute of Standards and Technology (NIST).

Analytical and field survey activities were conducted in accordance with procedures from the following ORAU and ORISE documents:

- Survey Procedures Manual (May 2008)
- Laboratory Procedures Manual (March 2010)
- Quality Program Manual (June 2009)

The procedures contained in these manuals were developed to meet the requirements of 10 CFR 830 Subpart A, *Quality Assurance Requirements*, Department of Energy Order 414.1C *Quality Assurance*, and the U.S. Nuclear Regulatory Commission *Quality Assurance Manual for the Office of Nuclear Material Safety and Safeguards* and contain measures to assess processes during their performance.

Quality control procedures include:

- Daily instrument background and check-source measurements to confirm that equipment operation is within acceptable statistical fluctuations.

- Participation in Mixed-Analyte Performance Evaluation Program (MAPEP), NIST Radiochemistry Intercomparison Testing Program (NRIP), and Intercomparison Testing Program (ITP) Laboratory Quality Assurance Programs.
- Training and certification of all individuals performing procedures.
- Periodic internal and external audits.

D.3 Survey Procedures

D.3.1 Surface Scans

NaI scintillation detectors (2 x 2) and FIDLER scintillation detector, with a detector area 127 cm², were coupled to GPS units that enabled real-time recording of position in one-second intervals. Surface soils scanned for elevated gamma radiation were performed by passing the detector slowly over the surface. The distance between the detector and surface was maintained at a nominal distance of about 1 to 5 cm. Identification of elevated radiation levels was based on increases in the audible signal from the instrument. Positioning data files were downloaded from field data loggers for plotting using commercially available software:

http://trl.trimble.com/docushare/dsweb/Get/Document-261826/GeoExpl2005_100A_GSG_ENG.pdf.

The scan minimum detectable concentrations (MDCs) for the NaI scintillation detector for the contaminants of concern in surface soil were obtained directly from NUREG-1507 when available or estimated using the approach described in NUREG-1507¹. A typical NaI detector (2 × 2) MDC is 2.8 pCi/g for Ra-226, 1.8 pCi/g for Th-232, 56 pCi/g for U-238, and 3 pCi/g for U-235 and 6.4 pCi/g for Cs-137. ORISE used the FIDLER for qualitative measurements. An audible increase in the activity rate was investigated by ORISE. It is standard procedure for the ORISE staff to pause and investigate any locations where gamma radiation is distinguishable from background levels.

D.3.2 Soil Sampling

Approximately 0.5 to 1 kg of soil was collected at each sample location. Collected samples were placed in plastic bags, sealed, and labeled in accordance with ORISE survey procedures.

¹NUREG-1507. Minimum Detectable Concentrations With Typical Radiation Survey Instruments for Various Contaminants and Field Conditions. U.S. Nuclear Regulatory Commission. Washington, DC; June 1998.

D.4 Radiological Analysis

D.4.1 Gamma Spectroscopy

Samples of soil were dried, mixed, crushed, and/or homogenized as necessary, and a portion sealed in a 0.5-liter Marinelli beaker or other appropriate container. The quantity placed in the beaker was chosen to reproduce the calibrated counting geometry. Net material weights were determined and the samples counted using intrinsic germanium detectors coupled to a pulse height analyzer system. Background and Compton stripping, peak search, peak identification, and concentration calculations were performed using the computer capabilities inherent in the analyzer system. All total absorption peaks (TAP) associated with the primary radionuclides of concern were reviewed for consistency of activity. Total absorption peaks used for determining the activities of radionuclides of concern and the typical associated MDCs for a one-hour count time were:

Radionuclide	TAP (MeV) ^a	MDC (pCi/g)
U-238 (from Th-234)	0.063	0.75
U-235	0.143	0.24
Ra-226 (from Pb-214)	0.351	0.08
Th-232 (from Ac-228)	0.911	0.14
Cs-137	0.662	0.05

^aSpectra were also reviewed for other identifiable TAPs.

D.4.2 Uncertainties

The uncertainties associated with the analytical data presented in the tables of this report represent the total propagated uncertainties for those data. These uncertainties were calculated based on both the gross sample count levels and the associated background count level.

D.5 Detection Limits

Detection limits, referred to as MDC, were based on 3 plus 4.65 times the standard deviation of the background count [$3 + (4.65 (\text{BKG})^{1/2})$]. Because of variations in background levels, measurement efficiencies, and contributions from other radionuclides in samples, the detection limits differ from sample to sample and instrument to instrument.