ORISE
OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION
Managed by ORAU for the U.S. Department of Energy

September 20, 2012

Mr. David Queen
U.S. Department of Energy
Oak Ridge Office
P.O. Box 2001
Oak Ridge, TN 37831-0117

**SUBJECT: DOE CONTRACT NO. DE-AC05-06OR23100
INDEPENDENT VERIFICATION SURVEY SUMMARY AND RESULTS FOR SUB-SLAB SOILS ASSOCIATED WITH THE FORMER BUILDING K-33, OAK RIDGE, TENNESSEE
DCN 5105-SR-01-1**

Dear Mr. Queen:

Oak Ridge Associated Universities (ORAU), under the Oak Ridge Institute for Science and Education (ORISE) contract, is pleased to provide the enclosed final report that details the independent verification activities that were performed during the period of August 2011 through May 2012, at the former Building K-33 site in Oak Ridge, Tennessee. The survey activities were conducted in accordance with ORAU independent verification and inspection plans provided to the U.S. Department of Energy. Comments on the draft report (DCN 5105-SR-01-0) have been incorporated into this final version.

Please feel free to contact me via my information below or Erika Bailey at 865.576.6659 if you have any questions or comments.

Sincerely,

Nick A. Altic
Health Physicist,
Assistant Project Manager
Independent Environmental Assessment
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NAA:fr

Enclosure

cc: M. Travaglini, DOE
File/5105

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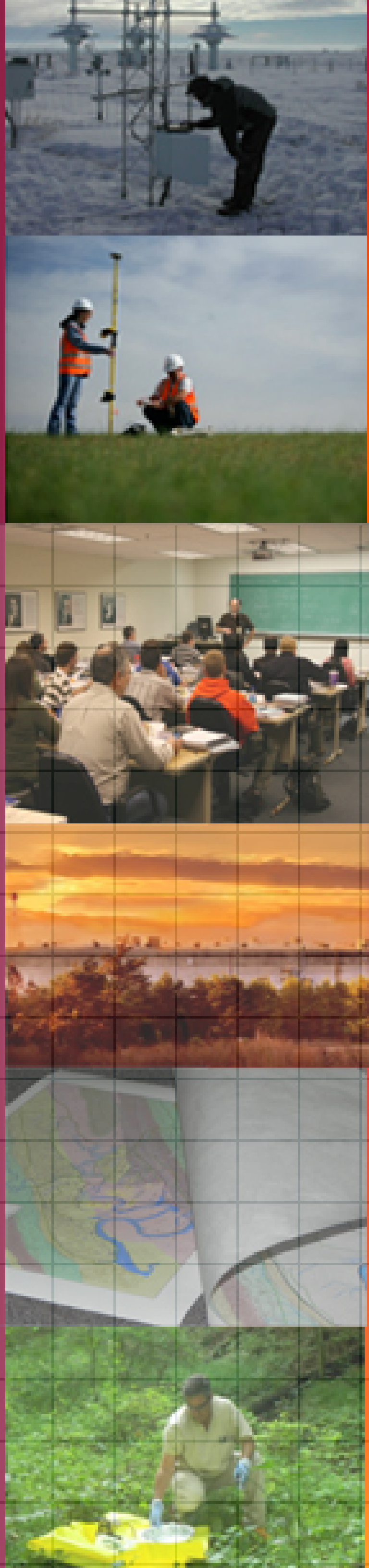
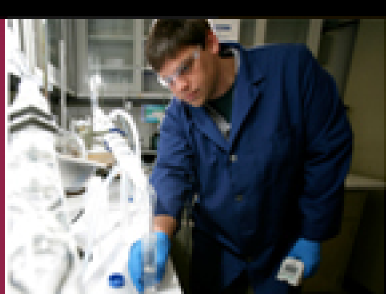


INDEPENDENT VERIFICATION SURVEY SUMMARY AND RESULTS FOR SUB-SLAB SOILS ASSOCIATED WITH THE FORMER BUILDING K-33, OAK RIDGE, TENNESSEE

N. A. Altic

Prepared for the U.S. Department of Energy

ORISE



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INDEPENDENT VERIFICATION SURVEY SUMMARY AND RESULTS FOR SUB-SLAB SOILS ASSOCIATED WITH THE FORMER BUILDING K-33, OAK RIDGE, TENNESSEE

Prepared by

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Prepared for the
U.S. Department of Energy

FINAL REPORT

September 2012

Prepared by Oak Ridge Associated Universities under the Oak Ridge Institute for Science and Education contract, number DE-AC05-06OR23100, with the U.S. Department of Energy.

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Managed by ORAU for the U.S. Department of Energy

INDEPENDENT VERIFICATION SURVEY SUMMARY AND RESULTS FOR SUB-SLAB SOILS ASSOCIATED WITH THE FORMER BUILDING K-33, OAK RIDGE, TENNESSEE

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FINAL REPORT

SEPTEMBER 2012

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ACRONYMS

BNFL	British Nuclear Fuels Limited
cpm	counts per minute
D&D	decontamination and decommissioning
DOE	U.S. Department of Energy
ETTP	East Tennessee Technology Park
EU	exposure unit
FSS	final status survey
GPS	global positioning system
IV	independent verification
LSRS	LATA-Sharp Remediation Services, LLC
LEU	low-enriched uranium
NaI	sodium iodide
ORAU	Oak Ridge Associated Universities
ORISE	Oak Ridge Institute for Science and Education
PCCR	phased construction completion report
pCi/g	picocuries per gram
ROC	radionuclide of concern
ROD	record of decision

INDEPENDENT VERIFICATION SURVEY SUMMARY AND RESULTS FOR SUB-SLAB SOILS ASSOCIATED WITH THE FORMER BUILDING K-33, OAK RIDGE, TENNESSEE

1. INTRODUCTION

Building K-33 was one of three low-enriched uranium (LEU) process buildings at the East Tennessee Technology Park (ETTP) in Oak Ridge, Tennessee. It was added to the Oak Ridge Gaseous Diffusion Plant in the early 1950s to produce LEU for use as nuclear power plant fuel (ORISE 2010). The LEU process buildings were taken offline in 1985 after the anticipated demands for LEU failed to materialize. After the process buildings were shut down, the uranium hexafluoride inventory was removed and the process equipment was purged. Building K-33 and its process equipment were maintained in a shutdown state from 1987 to 1997.

In 1997 the U.S. Department of Energy (DOE) contracted British Nuclear Fuels Limited (BNFL) to perform decontamination and decommissioning (D&D) of Building K-33. The original project objective was to remediate Building K-33 to conditions that would permit its reuse as an industrial site. However, by 2005 it became apparent that reindustrialization of Building K-33 was not feasible due to the inability to remediate all areas of the building to the end point criteria. In late 2009, DOE decided to demolish Building K-33 and contracted LATA-Sharp Remediation Services, LLC (LSRS) to perform the demolition. The building was demolished down to the concrete slab and the debris shipped off site. Removal of the basement began in late August 2011, followed by the slab in September 2011.

LSRS is not required by their contract to perform a final status survey (FSS) of the sub-slab soil because soil areas are managed under the Zone 2 record of decision (ROD) (BJC 2005). However, LSRS committed to conducting gamma walkover surveys as the slab was being removed. LSRS collected biased samples to confirm survey results and to determine waste disposition paths for excavations identified as part of the survey. Gamma walkover survey results are presented in LSRS 2012 and have been reviewed as part of this independent verification (IV) report. LSRS also collected the required statistical sample set across the former K-33 footprint for comparison to ROD criteria per the dynamic verification strategy. Those data are being used in the data analysis for Zone 2 Exposure Units (EUs) Z2-04 and Z2-05, and the associated Phased Construction

Completion Report (PCCR) for EUs 4 and 5 is scheduled for publication in October 2012 (Hensley 2012).

At DOE's request, Oak Ridge Associated Universities (ORAU), under the Oak Ridge Institute for Science and Education (ORISE) contract, performed IV of LSRS's gamma survey results and reviewed, to the extent possible, preliminary analytical data from the aforementioned soil samples. ORAU assumes the soil sample results and gamma walkover data will be incorporated into a future PCCR to conclusively demonstrate compliance or non-compliance with the Zone 2 ROD. However, no version of the PCCR is currently available for review and will not be available until well after ORAU's period of performance for IV work, which ends with the 2012 fiscal year.

2. SITE DESCRIPTION

The footprint of Building K-33 is located in Zone 2 at the ETTP, approximately 6 miles southwest of downtown Oak Ridge, Tennessee. The Building K-33 footprint spans two exposure units in Zone 2; Z2-04 and Z2-05 (BJC 2005). The Building K-33 concrete slab was approximately 32 acres in size and approximately 6 inches thick.

The applicable radionuclides of concern (ROCs) are uranium, thorium, cesium, neptunium, and radium. Table 1 lists the ROCs and their respective remediation concentration (BJC 2005).

Table 1. Applicable Radiological Soil Cleanup Criteria

Radionuclides of Concern	Remediation Concentration (pCi/g)
U-234	700
U-235 + Progeny	8
U-238 + Progeny	50
Ra-226 + Progeny	5
Cs-137 + Progeny	2
Np-237 + Progeny	5
Th-232 + Progeny	5
Th-230	5

3. OBJECTIVES

The objectives of IV activities were to provide independent contractor field data reviews and to generate independent radiological data for use by DOE in evaluating the adequacy and accuracy of the contractor's procedures and survey results.

4. PROCEDURES

During the period August 26, 2011 through May 8, 2012, ORAU performed a verification survey of the soils underneath the K-33 slab during 17 separate site visits. The survey was performed and judgmental soil samples collected in accordance with a plan dated August 31, 2011, submitted to and approved by DOE (ORAU 2011).

ORAU used global positioning system (GPS) technology with data loggers to collect coordinates for gamma walkover survey and soil sampling position data using the Tennessee State Plane Coordinate System – North American Datum 1983 meters.

Soil samples were returned to the ORAU/ORISE radiochemistry laboratory in Oak Ridge, Tennessee for analysis and interpretation. Sample analyses were performed in accordance with the ORAU/ORISE Laboratory Procedures Manual (ORAU/ORISE 2012a).

A description of instrumentation and a summary of procedures used for IV surveys and ORAU/ORISE analytical laboratory analysis efforts are presented in Appendices B and C, respectively.

5. FINDINGS AND RESULTS

The results for each of the verification activities are discussed below, considering both qualitative gamma walkover survey results and quantitative soil sampling results. LSRS data are also evaluated, when available.

5.1 SURFACE SCANS

5.1.1 ORAU Scans

Medium-density surface scans for gamma radiation were performed over the entire 32 acre soil area, including the soil directly beneath the excavated basement. Locations with former drains were also scanned separately from the soil. Scans were performed using Ludlum Model 44-10 2-inch × 2-inch sodium iodide (NaI) scintillation detectors coupled to Ludlum Model 2221 ratemeter-scalers with audible indicators. Ratemeter-scalers were coupled to GPS equipment that enabled real-time gamma count rate and position data capture. Locations of elevated direct gamma radiation were marked for further investigation. Figure A-1 presents gamma walkover survey data collected over the K-33 footprint and Fig. A-2 presents survey data collected from the former basement footprint. Figure A-3 presents a histogram of gamma walkover survey data with a range set from 2,500 counts per minute (cpm) to the maximum detector response of almost 15,000 cpm.

Gamma walkover surveys identified several small areas of elevated activity and two relatively large areas of contamination: the former loading dock at the northern study boundary and an area containing in-ground pipes located near the center of the K-33 footprint. Judgmental soil samples were collected as a result of gamma walkover survey results. Figure A-1 shows the gamma scan coverage and the gamma radiation count rates for the sub-slab soil. Instrument responses generally ranged from 3,000 to 15,000 cpm, though Fig. A-3 suggests an approximate background detector response for surface soils ranging from 3,000 to 7,000 cpm.

The maximum ORAU cpm results were collected after the pipes and some soils were excavated but still appear to represent elevated soil concentrations. However, the remediation contractor excavated soils that ORAU suspected were contaminated based on real-time detector responses. The final survey was performed by lowering the detector into the excavation, thus creating a well (rather than planar) geometry that often increases the background detector response. ORAU surveyors considered final detector responses to be consistent with background soil concentration for the well geometry, and no additional judgmental samples were collected.

As scans progressed toward the edge of the former slab located in the northwest corner, the gamma scan count rates increased to approximately 10,000 cpm. It was determined that the observed elevated direct gamma radiation was the result of "shine" (gamma radiation from a source not intentionally measured) from the radioactive waste-transporting railcars. This is supported by the fact that NaI responses increased as surveyors approached the edge of the former slab with detectors held in the air. Responses in the subject area were also noted to vary by day as stored materials were moved.

Scans of the soil below the former basement did not produce direct gamma radiation levels distinguishable from background. Scan results from the basement area are depicted in Fig. A-2. The response range is approximately 5,600 to 9,700 cpm and does not suggest the presence of contamination. No judgmental samples were collected as a result of basement scans.

Five individual locations where drains were previously located were also investigated. The location and scan range of each drain location is presented in Fig. A-4. Scans did not identify any areas in excess of background. Instrument response ranged from 4,600 to 7,700 cpm for all five drains and did not suggest the presence of contamination. No judgmental samples were collected as a result of drain scans.

5.1.2 LSRS Scans

ORAU and LSRS surveyors used the same detector model and generated comparable results. ORAU identified no significant deficiencies in LSRS survey procedures or results and concludes the survey data presented in LSRS 2012 generally represents gross gamma radiation levels across the face of the K-33 footprint. However, the LSRS technicians failed to identify several areas of elevated direct gamma radiation. The contractor was quick to perform additional remediation of areas identified or suspected (sometimes by ORAU) to have contamination above the ROD limits, noting further investigation by ORAU was not requested by DOE after additional remediation was completed.

LSRS 2012 includes scan results for soils after the slab was removed and, when applicable, after contaminated soils discovered by LSRS or ORAU were removed. Of particular note are the pre-and-post excavation presentations for the former loading dock and in-ground pipe locations. In both cases, pre-excavation surveys show significant gross activity/contamination (supported by judgmental sample results) and post-survey results show a significant drop in radiation levels.

5.2 RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES

5.2.1 ORAU Soil Samples

A total of nine surface soil samples were collected from judgmental locations (see Fig. A-1 for locations) where elevated direct gamma radiation levels suggest the presence of contamination. However, and as presented in LSRS 2012, soils associated with samples S0001 and S0002 (in the loading dock area) and samples S0008 and S0009 (from the former contaminated pipe run) were excavated and do not represent current conditions. Additionally, samples S0003 and S0004 are associated with a former waste line that was removed by LSRS, meaning only samples S0005, S0006, and S0007 represent current residual concentrations.

Individual sample results for the gamma-emitting ROCs are presented in Table 2. The far right column indicates whether the sampled materials were remediated by LSRS. As shown in Table 2, concentrations in samples S0005, S0006, and S0007 are small compared to the ROD criteria with maximum U-235 and U-238 concentrations of 0.17 ± 0.17 pCi/g and 1.99 ± 0.56 pCi/g, respectively; thus a direct computational comparison is not required. Table 3 presents the activity range of site-specific ROCs in all samples regardless of excavation status.

5.2.2 LSRS Soil Samples

ORAU conducted a limited review of preliminary analytical data provided by LSRS, some or all of which may be presented in a future PCCR and compared to applicable ROD criteria. Of particular interest here were Tc-99 and uranium results, two of the most prominent K-33 radiological contaminants. Results for 21 statistical and 33 judgmental sample stations were provided for review. However, it is currently unclear which judgmental soil sample results represent excavated soils or as-left conditions; therefore, ORAU defers to the future PCCR for evaluation of LSRS judgmental sample data. The maximum Tc-99 result is 0.53 pCi/g and the maximum total uranium concentration is 4.2 mg/kg (by inductively coupled plasma mass spectrometry analysis) for statistical samples. When reporting uranium via gamma or alpha spectroscopy analysis, the maximum total uranium result is less than 5 pCi/g. These results suggest the sub-slab soils satisfy ROD criteria, though stakeholder decisions should rely upon the findings presented in the future PCCR. It is also noted ORAU made no observation that would question the quality or integrity of LSRS soil samples.

Table 2. Radionuclide of Concern Concentration via Gamma Spectroscopy

Sample Location[a]	Sample Date	Radionuclide Concentration (pCi/g)						Excavated (Yes/No)
		Cs-137	Np-237	Ra-226	Th-232	U-235	U-238	
S0001[b]	1/19/2012	0.05 ± 0.07[c]	0.07 ± 0.09	0.49 ± 0.08	0.58 ± 0.14	43.8 ± 2.4	563 ± 36	Yes
S0001B[d]	1/19/2012	0.09 ± 0.12	-0.07 ± 0.20	0.54 ± 0.12	0.58 ± 0.21	61.2 ± 3.3	711 ± 46	Yes
S0001C[e]	1/19/2012	0.06 ± 0.07	-0.02 ± 0.13	0.37 ± 0.08	0.49 ± 0.15	13.57 ± 0.88	185 ± 12	Yes
S0002	1/19/2012	0.03 ± 0.05	0.01 ± 0.06	0.17 ± 0.05	0.30 ± 0.11	15.94 ± 0.95	207 ± 14	Yes
S0002B	1/19/2012	0.07 ± 0.09	-0.07 ± 0.16	0.33 ± 0.10	0.34 ± 0.13	33.3 ± 1.9	460 ± 30	Yes
S0002C	1/19/2012	0.04 ± 0.04	0.02 ± 0.08	0.27 ± 0.05	0.21 ± 0.09	8.81 ± 0.54	133.3 ± 8.6	Yes
S0003	2/15/2012	0.59 ± 0.06	-0.03 ± 0.06	0.83 ± 0.08	1.02 ± 0.16	0.10 ± 0.09	2.19 ± 0.45	Yes
S0004	2/15/2012	-0.26 ± 0.07	-0.01 ± 0.10	27.9 ± 1.5	0.18 ± 0.14	0.83 ± 0.25	5.17 ± 0.96	Yes
S0005	3/16/2012	-0.01± 0.02	-0.02 ± 0.06	0.82 ± 0.07	1.33 ± 0.17	0.17 ± 0.17	1.55 ± 0.35	No
S0006	3/16/2012	0.02 ± 0.02	0.04 ± 0.05	0.85 ± 0.09	1.74 ± 0.24	0.13 ± 0.12	1.99 ± 0.56	No
S0007	4/19/2012	-0.01 ± 0.02	0.01 ± 0.02	0.81 ± 0.07	1.10 ± 0.16	0.02 ± 0.13	1.09 ± 0.40	No
S0008	4/24/2012	0.02 ± 0.04	0.03 ± 0.05	0.51 ± 0.06	0.70 ± 0.13	7.47 ± 0.47	113.8 ± 7 .4	Yes
S0009	4/24/2012	0.01 ± 0.05	-0.03 ± 0.07	0.72 ± 0.08	0.93 ± 0.15	7.74 ± 0.50	74.2 ± 5.0	Yes

[a]Refer to Fig. A-1 for sample locations.
[b]Sample location without suffix is the entire, non-sieved, sample.
[c]Uncertainties represent the 95 % confidence level, based on total propagated uncertainties.
[d]Sample location with suffix "B" is the material that passes through a 1/4" sieve.
[e]Sample location with suffix "C" is the material that does not pass through a 1/4" sieve.

Table 3. ROC Concentration Summary for all Samples

Radionuclide of Concern	Activity Range for all Samples (pCi/g)		
Cs-137	-0.26	to	0.59
Np-237	-0.07	to	0.07
Ra-226	0.17	to	27.9
Th-232	0.18	to	1.74
U-235	0.02	to	61.2
U-238	1.09	to	711

6. SUMMARY

At DOE's request, ORAU conducted confirmatory surveys of the K-33 sub-slab soil during the period of August 2011 through May 2012. The survey activities included visual inspections and measurement and sampling activities.

LSRS was forthcoming with information relating to surface scan results. Scans performed by the contractor were of adequate coverage and overall data appear to represent actual site conditions. However, the LSRS technicians failed to identify several areas of elevated direct gamma radiation. Most of the samples taken by ORAU at locations of elevated instrument response were above the remediation concentration for one or more ROC. The contractor was, however, quick to perform additional remediation of areas identified to have contamination above the guidelines. Further investigation by ORAU was not requested once additional remediation was completed. It is presumed the remediation contractor's future PCCR will present detailed and conclusive evidence that K-33 sub-slab soils either comply or do not comply with ROD criteria. However, ORAU concludes, based on both IV data and data provided by LSRS, that the remediation contractor followed appropriate and applicable procedures and that the associated data adequately represent site conditions.

7. REFERENCES

BJC 2005. *Record of Decision for Soil, Buried Waste, and Subsurface Structure Actions in Zone 2, East Tennessee Technology Park, Oak Ridge, Tennessee.* Bechtel Jacobs Company, LLC. Oak Ridge, Tennessee. March.

Hensley, Janice 2012. Email from Janice Hensley/LATA-Sharp Remediation Services to David A. King/Oak Ridge Associated Universities discussing the remediation contractor's scope; re: subslab soils and schedule for results publication, September 18.

LSRS 2012. *Final Report of Radiological Surveys and Soil Sampling for the K-33 Demolition and Disposition/Removal Project at East Tennessee Technology Park.* LSRS-K33-FSR-RP-001. LATA-Sharp Remediation Services, LLC, prepared for the U.S. Department of Energy, Oak Ridge, Tennessee, June.

ORAU 2011. *Independent Verification Survey Plan for Soils Underneath the Building K-33 Concrete Slab Oak Ridge, Tennessee.* Oak Ridge Associated Universities. Oak Ridge, Tennessee. August 31.

ORAU 2012. *Quality Program Manual for the Independent Environmental Assessment and Verification Program.* Oak Ridge Associated Universities. Oak Ridge, Tennessee. June 28.

ORAU/ORISE 2012a. *Laboratory Procedures Manual for the Independent Environmental Assessment and Verification Program.* Oak Ridge Institute for Science and Education, managed by Oak Ridge Associated Universities. Oak Ridge, Tennessee. August 15.

ORAU/ORISE 2012b. *Survey Procedures Manual for the Independent Environmental Assessment and Verification Program.* Oak Ridge Associated Universities. Oak Ridge, Tennessee. May 11.

ORISE 2010. *Environmental Management Waste Management Facility Waste Lot Profile 401.1 for the K-33 Building Debris and Miscellaneous Material, East Tennessee Technology Park, Oak Ridge, Tennessee.* Oak Ridge Institute for Science and Education, managed by Oak Ridge Associated Universities. Oak Ridge, Tennessee. October 7.

APPENDIX A
FIGURES

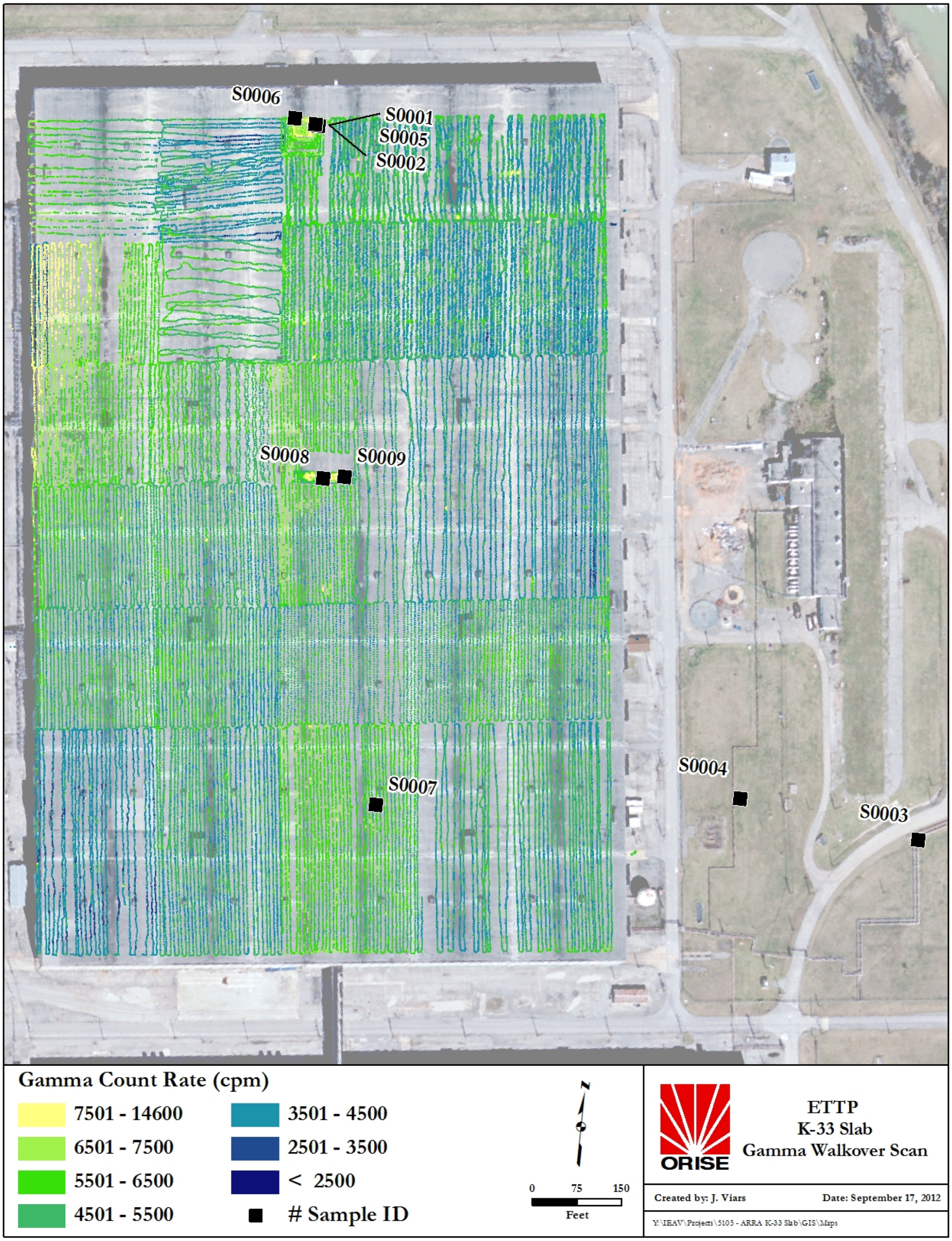

Fig. A-1. Gamma Scan Coverage of the Sub-Slab Soil and Sample Locations

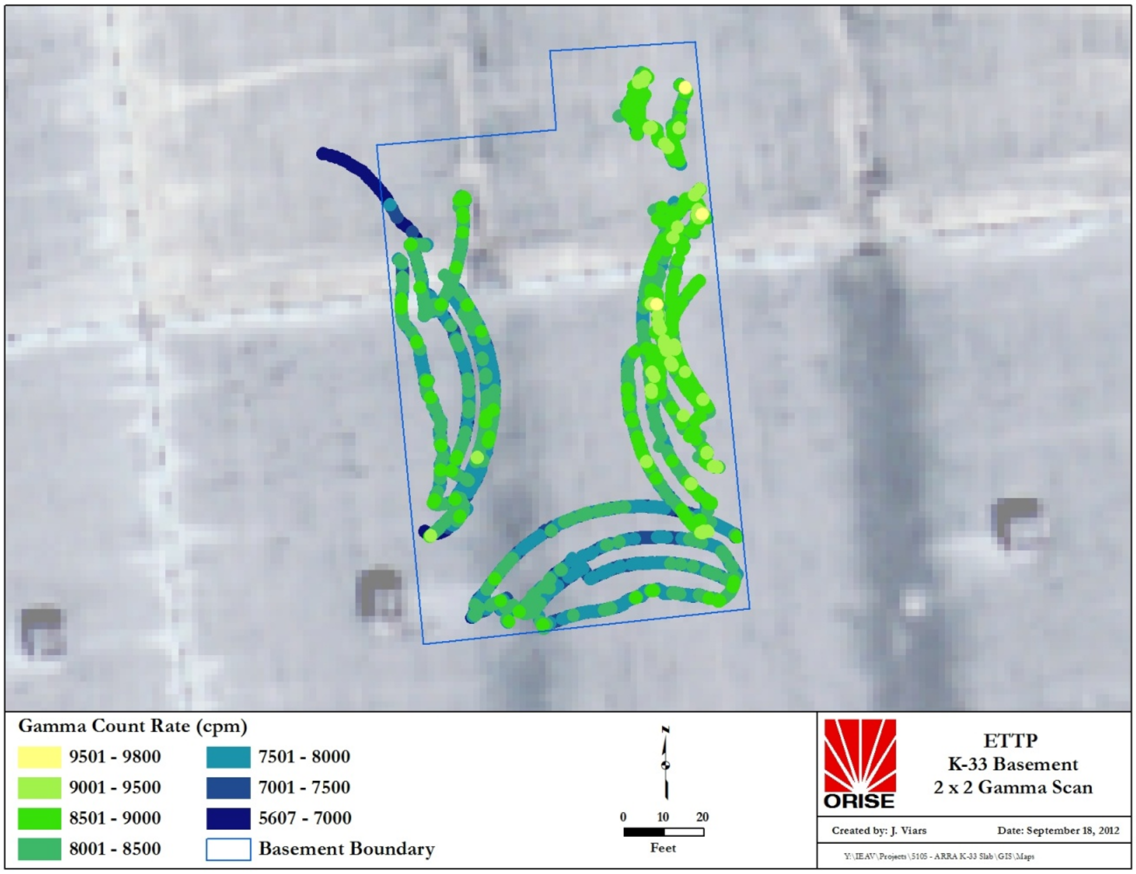

Fig. A-2. Gamma Scan of Soil below the Former Basement

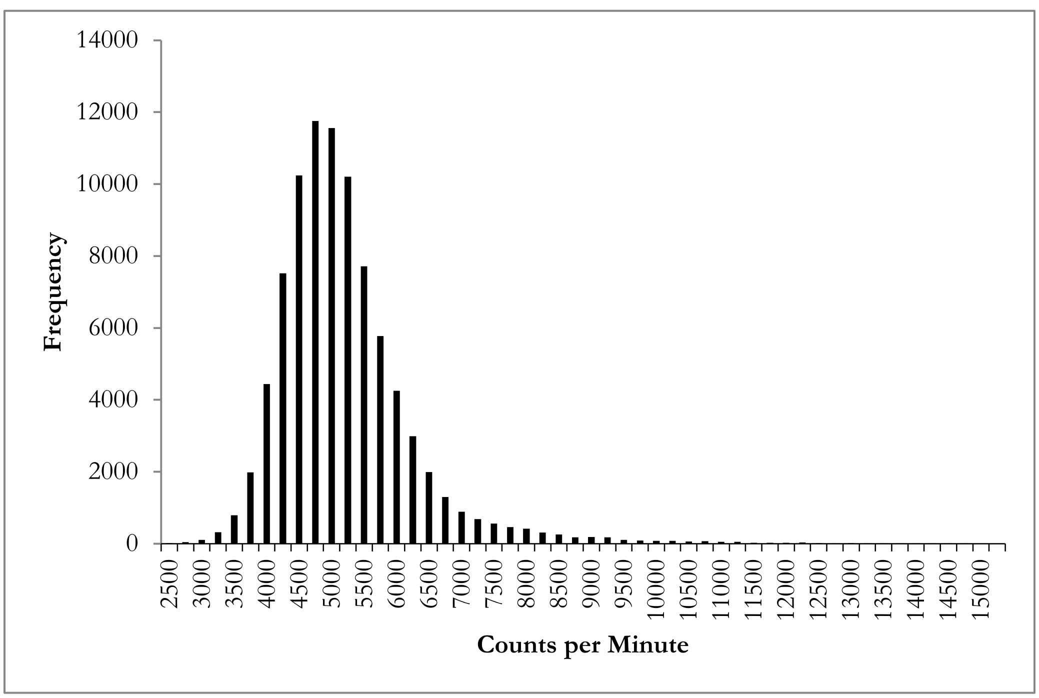

Fig. A-3. Histogram of Gamma Scan Data

Fig. A-4. Gamma Scan of Former Drain Locations

APPENDIX B
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 his employer.

B.1 SCANNING AND MEASUREMENT INSTRUMENT/DETECTOR COMBINATIONS

B.1.1 GAMMA

Ludlum NaI Scintillation Detector Model 44-10, Crystal: 5.1 cm × 5.1 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)

B.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
Canberra's Apex Gamma Software
Dell Workstation
(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)
Multichannel Analyzer
Canberra's Apex Gamma Software
Dell Workstation
(Canberra, Meriden, CT)

Laboratory Analytical Instrumentation (continued)

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
Canberra's Apex Gamma Software
Dell Workstation
(Canberra, Meriden, CT)

APPENDIX C
SURVEY AND ANALYTICAL PROCEDURES

C.1 PROJECT HEALTH AND SAFETY

The proposed survey and sampling procedures were evaluated to ensure that any hazards inherent to the procedures themselves were addressed in current job hazard analyses. Additionally, upon arrival to the site, a walkdown was performed to identify hazards present and a prejob integrated safety management checklist was completed and discussed with field personnel. All survey and laboratory activities were conducted in accordance with ORAU and ORISE health and safety and radiation protection procedures.

C.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 Independent Environmental Assessment and Verification (IEAV) Program documents:

- Survey Procedures Manual (ORAU/ORISE 2012b)
- Laboratory Procedures Manual (ORAU/ORISE 2012a)
- Quality Program Manual (ORAU 2012)

The procedures contained in these manuals were developed to meet the requirements of U.S. Department of Energy (DOE) Order 414.1D and contains 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 Program (NRIP), and Intercomparison Testing Program (ITP) Laboratory Quality Assurance Programs.
- Training and certification of all individuals performing procedures.
- Periodic internal and external audits.

C.3 SURVEY PROCEDURES

C.3.1 SURFACE SCANS

A sodium iodide (NaI) scintillation detector was used to scan for elevated gamma radiation. Identification of elevated radiation levels was based on increases in the audible signal from the recording and/or indicating instrument. Additionally, the detectors were coupled to global positioning system (GPS) units with data loggers enabling real-time recording in 1- or 2-s intervals of both geographic position and the gamma count rate. Position and gamma count rate data files were transferred to a computer system, positions differentially corrected, and the results plotted on geo-referenced aerial photographs. Positional accuracy was within 0.5 meters at the 95th percentile.

C.3.2 SOIL SAMPLING

Approximately 0.5 to 1 kilogram (kg) of soil and gravel was collected at each sample location. Collected samples were placed in a plastic bag, sealed, and labeled in accordance with ORAU/ORISE survey procedures.

C.4 RADIOLOGICAL ANALYSIS

Soil samples were analyzed by solid-state gamma spectroscopy for selected gamma-emitting ROCs. Samples S0001 and S0002 contained large rocks/concrete. These two samples were analyzed and then sieved using a 1/4 inch screen. The portions that passed through the sieve were analyzed separately from the portions larger than 0.25 inch. Analytical results were reported in units of picocuries per gram (pCi/g).

C.4.1 GAMMA SPECTROSCOPY

Samples were dried, mixed, sieved, 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 (TAPs) associated with the ROCs were reviewed for consistency of activity. TAPs used for determining the activities of ROCs and the typical associated minimum detection concentrations

(MDCs) for a one-hour count time are shown in Table C-1.

Table C-1. MDC Derived from Total Absorption Peak		
Radionuclide	**TAP (MeV)**	**MDC (pCi/g)**
Cs-137	0.662	0.05
Np-237 from Pa-233	0.312	0.20
Ra-226 from Pb-214	0.352	0.08
Th-232 from Ac-228	0.911	0.14
U-235	0.144	0.24
U-238 from Th-234	0.063	0.75

Spectra were also reviewed for other identifiable TAPs. The determination of MDCs, as well as sample activity, was derived from the progeny of neptunium-237, radium-226, thorium-232, and uranium-238, as listed in Table C-1. Soil concentration calculations were based on the assumption that progeny of the parent nuclide was in secular equilibrium with the parent nuclide.