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June 6, 2012

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DOE CONTRACT NO. DE-AC05-06OR23100
SUBJECT: FINAL REPORT—INDEPENDENT VERIFICATION SURVEY OF THE SPRU LOWER LEVEL HILLSIDE AREA AT THE KNOLLS ATOMIC POWER LABORATORY, NISKAYUNA, NEW YORK
DCN 5146-SR-02-0

Dear Mr. Feinberg:

Oak Ridge Associated Universities, under the Oak Ridge Institute for Science and Education contract, is pleased to provide the enclosed final report for the independent verification survey activities conducted in Survey Units A, B, and C at the Separations Process Research Unit Lower Level Hillside Area. Comments received on the draft report have been addressed in this final report. A matrix addressing all comments has been provided under a separate cover.

You may contact me via my information provided below or Phyllis Weaver at 865.576.5321 if you require additional information.

Sincerely,

Evan M. Harpenau
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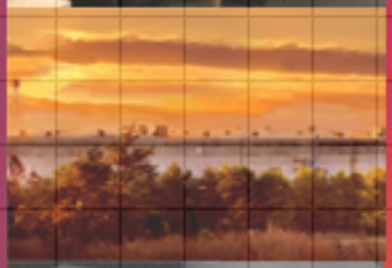

INDEPENDENT VERIFICATION SURVEY OF THE SPRU LOWER LEVEL HILLSIDE AREA AT THE KNOLLS ATOMIC POWER LABORATORY NISKAYUNA, NEW YORK

E. M. Harpenau
and
P. C. Weaver

Prepared for the
U.S. Department of Energy

ORISE

Approved for public release; further dissemination unlimited.

The Oak Ridge Institute for Science and Education (ORISE) is a U.S. Department of Energy institute focusing on scientific initiatives to research health risks from occupational hazards, assess environmental cleanup, respond to radiation medical emergencies, support national security and emergency preparedness, and educate the next generation of scientists. ORISE is managed by Oak Ridge Associated Universities.

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FINAL REPORT

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INDEPENDENT VERIFICATION SURVEY OF THE SPRU LOWER LEVEL HILLSIDE AREA AT THE KNOLLS ATOMIC POWER LABORATORY, NISKAYUNA, NEW YORK

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ACRONYMS

ALARA	as low as reasonably achievable
aRc	Accelerated Remediation Company
BKG	background
cpm	counts per minute
$DCGL_W$	derived concentration guideline level
DOE	U.S. Department of Energy
dpm	disintegrations per minute
EM	Environmental Management
FSS	final status survey
FSSR	final status survey report
GPS	global positioning system
IV	independent verification
KAPL	Knolls Atomic Power Laboratory
LLHA	Lower Level Hillside Area
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	minimum detectable concentration
NaI	sodium iodide
ORAU	Oak Ridge Associated Universities
ORISE	Oak Ridge Institute for Science and Education
pCi/g	picocuries per gram
PSP	project-specific plan
QAPP	Quality Assurance Project Plan
ROC	radionuclide of concern
RSS	ranked set sampling
SCO	soil cleanup objective
SOF	sum-of-fractions
SPRU	Separations Process Research Unit
VSP	Visual Sample Plan

INDEPENDENT VERIFICATION SURVEY OF THE SPRU LOWER LEVEL HILLSIDE AREA AT THE KNOLLS ATOMIC POWER LABORATORY, NISKAYUNA, NEW YORK

1. INTRODUCTION AND SITE HISTORY

The former Separations Process Research Unit (SPRU) is located within the boundary of Knolls Atomic Power Laboratory (KAPL) at 2425 River Road, Niskayuna, Schenectady County, New York (Figure A-1). SPRU was designed and developed to research an efficient process to chemically separate plutonium and uranium from processed fuel. Buildings H2 and G2 were the primary research and process facilities. SPRU operated between February 1950 and October 1953, at which time the research successfully developed useable reduction/oxidation and plutonium-uranium extraction processes. These processes were subsequently moved to the Hanford and the Savannah River sites for full-scale operations. KAPL used Building H2 for radioactive wastewater processing and Building G2 for offices from the time SPRU process ceased until the late 1990s. Process areas and equipment were maintained in a safe condition under a surveillance and maintenance program.

The H2 and G2 Building complex is currently undergoing decommissioning. An airborne release of radioactive material occurred during demolition activities at Building H2 on September 29, 2010. This event could have potentially contaminated portions of a nearby hillside, located to the east and slightly north of the SPRU site. To determine if the release radiologically impacted hillside surface soils or vegetation, a characterization survey was performed.

The characterization data for strontium-90 (Sr-90) in soil showed an average concentration of 0.24 pCi/g and a maximum value of 0.94 pCi/g. The maximum cesium-137 (Cs-137) concentration was 1.31 pCi/g (ORISE 2011a). These results are statistically equal to background concentration levels. However, because the characterization did not require identifying and sampling a background reference area for comparative evaluation, the conservative assumption was that the hillside could have been impacted by the release. The initial decommissioning plan had designated the hillside land area as Class 3 in accordance with the *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)* (NRC 2000). Per the MARSSIM definition, Class 3 areas are either not expected to contain any contamination or the concentrations are at a small fraction of the cleanup criteria. However, as a result of the release, the 2011 characterization considered the area as a Class 1. The

resulting data supported the initial categorization of a Class 3 designation and no remediation was necessary. The Accelerated Remediation Company (aRc) elected to upgrade the area to a Class 2 final status survey (FSS) area because of the additional potential for contamination. .MARSSIM defines Class 2 survey areas as those areas that could have residual contaminant concentrations ranging from a small fraction to the entirety of the cleanup criteria. aRc performed FSS on the Lower Level Hillside Area (LLHA) based on MARSSIM requirements for demonstrating compliance with the cleanup criteria. At the request of the U.S. Department of Energy Office of Environmental Management (DOE-EM) SPRU Project Office, the Oak Ridge Associated Universities (ORAU), via the Oak Ridge Institute for Science and Education (ORISE) contract, then conducted independent verification (IV) surveys of the LLHA.

2. SITE DESCRIPTION

The LLHA is bounded by the H2 and G2 Building complex and KAPL facilities to the south, and by the Lower Level Rail Bed to the east. Although the area of the LLHA is approximately 7 acres, the primary area of concern consists of approximately 2.9 acres. This narrow band of the LLHA adjacent to the H2/G2 demolition area has moderate timber growth and dense ground cover vegetation, and has been divided into three survey units (Figure A-2). This portion of the hillside area was previously considered a Class 3 area during the decontamination and remediation efforts in 2009. This determination was based on contamination potential definitions provided in MARSSIM. However, as a result of the September 2010 event, the LLHA was reclassified as a Class 1. The LLHA was eventually determined to be a Class 2 area after aRc reviewed the characterization survey results from June 2011 (aRc 2011a).

3. OBJECTIVES

There were multiple objectives for ORAU's verification activities. These included independent confirmation of the LLHA radiological classification decision following the release event that occurred during the Building H2/G2 demolition project, providing independent reviews of the site contractor's FSS data, and generating independent radiological survey and sampling data for DOE's use in evaluating the contractor's FSS results relative to the site's overall clean up radiological end points.

4. PROCEDURES

ORAU site verification activities were performed during the period of October 25, 2011 through October 31, 2011. Survey activities were conducted in accordance with the project-specific plan (PSP), ORAU/ORISE Survey Procedures Manual, and Quality Program Manual (ORISE 2011b, ORAU 2012a, and ORAU 2011). ORAU activities included in-process inspections; data reviews; gamma walkover scans; beta activity scans and static measurements; and systematic and judgmental soil sampling within Survey Units A, B, and C.

4.1 DOCUMENT REVIEW

ORAU reviewed aRc's *Survey and Sampling Analyses Plan for the SPRU Lower Level Hillside Investigation* (aRc 2011b) for compliance with MARSSIM guidance; the associated Quality Assurance Project Plan (QAPP) documents were also reviewed for technical content. ORAU also reviewed aRc's *Separations Process Research Unit Radiological Survey and Sampling Report for the Lower Level Hillside Investigation* (aRc 2011a).

4.2 REFERENCE SYSTEM

ORAU used a global positioning system (GPS) to track survey data and identify measurement and sampling locations. GPS units were integrated with the ratemeter-scaler and detector to collect position and count rate data. The specific geographic coordinate system used for documentation was the New York State Plane Coordinate System. GPS coordinates were typically accurate to within one meter of any given position data point. Updated survey unit boundaries as defined by aRc were loaded into the GPS units and used by ORAU so survey data could be accurately delineated.

4.3 SURFACE SCANS

ORAU performed medium- to high-density gamma scans using a 2 inch × 2 inch (2×2) sodium iodide (NaI) scintillation detector in the accessible areas of the LLHA (Figures A-3 and A-4). Locations of elevated direct gamma radiation levels were identified in real-time via audio output and after reviewing the electronic data for anomalies. The GPS signal was occasionally intermittent in certain areas as a result of the tree canopy and dense vegetation; therefore, the position accuracy of these data was degraded. Areas that were relatively clear of vegetation and with a moderate terrain received higher density scans.

The steep terrain and heavy vegetation in the wooded areas greatly impeded the movement of the detector and survey technician access. This impedance was primarily observed when surveying the steep gradient just beyond the 20 foot buffer along the KAPL perimeter fence. In addition, the area in close proximity to the eastern fence of the LLHA within Survey Unit A was determined to be unstable and identified as off-limits due to a landslide event in early September 2011. The restrictions implemented by DOE for this area prevented ORAU personnel from collecting verification survey data for the eastern-most border of Survey Unit A.

Beta scans were performed of the ground surface after the removal of vegetation. At each random sampling point, the beta scans were performed within a contiguous one square meter ($1m^2$) area from the specified sample point. Measurements were collected using a beta scintillation detector coupled to a ratemeter-scaler with audible output. The gamma scan data were specific for the detection of Cs-137 and the beta soil investigations were designed to detect Sr-90.

4.4 STATISTICAL SAMPLING DESIGN

Visual Sample Plan (VSP) software was used to generate random coordinates for direct measurements and soil sampling. These measurement sample points were downloaded to the GPS and were based upon the reference grid system established by aRc. These predetermined random field assessment and resultant soil sample locations were designed and generated based on the ranked set sampling (RSS) approach (EPA 2006).

The statistically-based RSS design was used to determine the number of random samples that would be required to estimate the mean concentration of the radionuclides of concern (ROCs) and verify that it does not exceed the soil cleanup objectives (SCOs) for a given population. The survey unit average residual ROC soil concentration results from these random samples is then compared to the site's FSS results. RSS does not require the assumption of a normal distribution. The process combines random sampling with the use of professional judgment to select sampling locations. Professional judgment relies upon the ability to assess the relative magnitude of beta and gamma radiation levels between randomly selected locations. In this case, both the beta and gamma count rate data collected at randomly selected locations provided the measurable field screening method that correlated with the relative ROC concentrations. The beta and gamma count rate data for each location were then used to select a specific sampling location.

The RSS systematic planning process uses a replication method on a larger random population from which the locations for the resulting samples can be selected. Replication refers to the number of cycles (r) for performing a set size (m) of field measurements. The number of field assessment locations per cycle is a function of the set size and is simply m^2. The number of field assessment locations will vary but is defined as $m^2 \times r$, or for example, $3^2 \times 2 = 18$ for a particular survey unit. These measurements are grouped into cycle sets and distributed in the survey area. The first set identification location is cycle 1 of set 1 at measurement location 1, designated as 1-1-1. Mapping the population of assessment locations uses color coding with a specific geometric shape to correspond to each RSS cycle.

One-minute static beta and gamma count rate measurements were performed at each of the random assessment locations per the survey unit requirement. A weighted calculation using the beta and gamma count rate data for each location was evaluated with the RSS assessment process and then used to select a specific sampling location. Eighteen randomly generated locations were created in Survey Units A, B, and C. RSS locations are shown on Figures A-5 through A-7.

4.5 STATIC RADIATION MEASUREMENTS OF SOIL

Once the specific soil sampling locations were determined, one-minute static beta and gamma measurements, in counts per minute (cpm), were recorded prior to and after the collection of a sample from the soil surface (Table B-1). The judgmentally selected assessment locations were evaluated for gamma-emitting isotopes per the review of FSS sample results. Gamma static measurements were obtained using the NaI detector, and beta static measurements were obtained using the beta scintillation detector.

4.6 SOIL SAMPLING

Surface soil samples were collected at two depths for each assessment location and are shown in Figure A-8. In all, 18 random and 2 judgmental locations were sampled. The first sample collected at each location was at a depth of 0–5 cm and the second from 5–15 cm, for a total of 40 verification soil samples. The 4 judgmental samples, 5146S0073 through 5146S0076, were collected based on the elevated Cs-137 concentrations observed in the final status survey report (FSSR).

5. SOIL CLEANUP OBJECTIVES

The previously established SCOs for all of the site's ROCs for the SPRU project are provided in Table 1 (aRc 2008). DOE-EM identified Sr-90 as the predominant ROC from the release event (DOE 2010). Cs-137 is the other predominant ROC that could potentially impact the LLHA. The initial SCO approved as the SPRU project cleanup goal for Sr-90 is 4,654 pCi/g; however, DOE-EM at SPRU has implemented an as low as reasonably achievable (ALARA) cleanup goal for Sr-90 at 30 pCi/g (DOE 2011). The ALARA cleanup goal is the volumetric activity within the first 15 cm of soil. The SCO for Cs-137 is 30 pCi/g.

Table 1. Soil Cleanup Objectives for the Radionuclides of Concern
Separations Process Research Unit
Niskayuna, New York

ROC	SCO (pCi/g)	ROC	SCO (pCi/g)
Am-241	574	Pu-241	19,120
Cs-137	30 [a]	Pm-147	1.59E+06
Co-60	9.78	Sm-151	6.59E+06
Eu-152	21.8	Sr-90	4,654 [b]
Eu-154	20.1	Tc-99	1.43E+06
Eu-155	852	Th-232	9.05
H-3	1.04E+06	U-234	1,162
Ni-63	5.1E+06	U-235	188
Pu-238	792	U-238	851
Pu-239	714	Zr-93	1.34E+06
Pu-240	715		

[a]The survey level of concern for Cs-137 is not based on the derived concentration guideline level model, but rather on an ALARA agreement between DOE-EM and Naval Reactors (NR) at the request of NR.
[b]DOE-EM implemented an ALARA cleanup goal of 30 pCi/g for Sr-90.

6. SAMPLE ANALYSIS AND DATA INTERPRETATION

Samples were returned to the ORAU/ORISE laboratory in Oak Ridge, Tennessee for radiological analysis and interpretation. Sample analyses were performed in accordance with the ORAU/ORISE Laboratory Procedures Manual (ORISE 2012b). The samples were analyzed by gamma spectroscopy and reviewed for Cs-137, as well as any other gamma-emitting radionuclides. Gamma spectroscopy

spectra were specifically reviewed for americium-241 (Am-241) as it is a decay product of plutonium-241 (Pu-241). A high concentration of Am-241 would be indicative that alpha spectroscopy was warranted to quantify plutonium levels. The primary LLHA ROC, Sr-90, was quantified by radiochemical separation and counted on a low background proportional counter. Analytical results were reported in units of picocuries per gram (pCi/g). These results were then compared to the SCOs or ALARA goals provided in Table 1.

7. FINDINGS AND RESULTS

The results of the characterization surveys for the LLHA are discussed in the following sections. Direct measurement and radionuclide concentration data for all samples are provided in Tables B-1 through B-4.

7.1 DOCUMENT REVIEWS

The aRc *Survey and Sampling Analyses Plan for the SPRU Lower Level Hillside Investigation* (aRc 2011b), and DOE's incorporation of an ALARA goal for Sr-90 of 30 pCi/g (DOE 2011) provided soil cleanup levels for the ROCs expected to be encountered during the characterization of the hillside. aRc recognized and incorporated DOE's ALARA goal for Sr-90 into their Survey and Sampling Analyses Plan. As a result, Sr-90 and Cs-137, each with a SCO of 30 pCi/g, were identified as the limiting ROCs for the LLHA. ORAU had reviewed aRc's radiological survey procedures during previous site verification phases, and these efforts were therefore not duplicated.

aRc prepared a radiological survey and sampling effort based on ORAU's initial characterization investigation of the LLHA (ORISE 2011a). ORAU had previously evaluated aRc's sampling and analysis procedures during the Lower Level Railroad Bed remediation and sampling analysis project (aRc 2008). aRc utilized the ORAU data from the investigation and radioanalysis of vegetation and soils, to establish a Cs-137 to Sr-90 ratio of 2.15:1. This ratio was then used to define an investigation level for gamma scanning (14,200 cpm) using Cs-137 as a surrogate for Sr-90 (aRc 2011b).

The aRc survey effort consisted of both systematic and biased soil samples. Particular emphasis was given to the hillside area closest to the H2/G2 release area. aRc applied MARSSIM-based principles that ORAU could replicate during independent verification.

7.2 SURFACE SCANS

Gamma walkover surveys identified a few isolated areas with radioactivity near twice background. The areas identified as exhibiting elevated direct radiation received additional high-density investigative scans. A majority of the hillside had an observed gamma scan range of approximately 6,300 to 14,000 gross cpm, with an average ambient background of 8,100 cpm. Figure A-9 represents the gamma scan data of the LLHA using a histogram. The three elevated sample locations identified during the review of aRc's report were also evaluated, and resultant scan ranges were approximately 23,000 to 66,000 gross cpm. Two of the three locations had significantly higher count rates and prompted the collection of judgmental samples at each of those locations (Figure A-8).

The *a priori* scan minimum detectable concentration (MDC) for a 2×2 detector is approximately 6.4 pCi/g for the secondary ROC Cs-137 (estimated from Table 6.4 of NUREG-1507)(NRC 1997). Therefore, the detector was capable of determining Cs-137 concentrations lower than the site-specific SCO of 30 pCi/g.

A beta scintillation detector was used to perform scans within the immediate area around the measurement location. Beta scans at each 1 m^2 random soil assessment location typically ranged from approximately 280 to 580 gross cpm. The average ambient beta background was determined to be 411 cpm within a non-impacted area west of the LLHA fence.

7.3 SURFACE ACTIVITY MEASUREMENTS

The results of static surface activity measurements of the random sample locations are provided in Table B-1. Sample 5146S0054 had the highest reported gross beta count rate at 579 cpm per 100 cm^2. Sample 5146S0060 exhibited the highest recorded gross gamma count rate for the random samples at 12,908 cpm. Gross beta count rates for the random samples ranged from 306 cpm per 100 cm^2 to 579 cpm per 100 cm^2; gross gamma count rates ranged from 7,394 to 12,908 cpm.

The two judgmental locations selected for further investigation and soil sampling are identified in Figure A-8. Beta measurements were not conducted at these locations because analytical data from the FSSR identified Cs-137 as the primary radioactive contaminant. Static surface activity measurements for the judgmental locations are provided in Table B-2. All post-sample gamma static

measurements collected at the judgmental locations with a NaI detector were in excess of 34,000 cpm, with the highest recorded post-sample gross count rate of 66,505 cpm for sample 5146S0074.

7.4 RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES

The soil concentration ranges for the primary ROCs have been summarized in Table 2. Individual results for the random soil samples 5146S0037 through 5146S0072 and judgmental samples 5146S0073 through 5146S0076 are provided in Tables B-3 and B-4 respectively. Specific concentrations for Sr-90 are represented with the corresponding sample location in Figure A-10. Gamma spectra review did not identify any additional gamma-emitting ROCs. The sum-of-fractions (SOF) calculations for random samples 5146S0037 through 5146S0072 ranged from -0.01 to 0.13. The SOF calculation was not necessary for the judgmental samples because the Cs-137 concentrations exceeded 30 pCi/g.

Table 2. Soil Concentration Ranges on the Lower Level Hillside for the Primary Radionuclides of Concern

ROC	Soil Concentrations (pCi/g)
Random Sample Locations	
Sr-90	-0.27 to 0.93
Am-241	-0.06 to 0.11
Cs-137	0.04 to 3.13
Co-60	-0.05 to 0.05
U-235	-0.10 to 0.28
U-238	0.43 to 1.58
Total U	1.0 to 3.27
Judgmental Sample Locations	
Sr-90	0.65 to 2.49
Am-241	-0.14 to 0.45
Cs-137	58.2 to 74.1
Co-60	-0.02 to 0.00
U-235	-0.27 to 0.25
U-238	0.72 to 1.9
Total U	1.7 to 3.8

8. COMPARISION OF RESULTS WITH GUIDELINES

The random soil sample concentrations for the ROCs at SPRU's LLHA were determined to be well below established site SCOs. However, the Cs-137 concentrations in judgmental samples 5146S0073 through 5146S0076 exceeded the SCO of 30 pCi/g. Sample 5146S0074 had the highest concentration of Cs-137 at 74.1 pCi/g, with a Sr-90 concentration of 0.65 pCi/g. The highest Sr-90 concentration was observed in sample 5146S0076 at 2.49 pCi/g, with a Cs-137 concentration of 66.1 pCi/g. Furthermore, judgmental samples collected from the two locations with the highest gamma count rates indicated that Cs-137 concentrations increased with depth. This correlation can be seen in Table B-4 where samples 5146S0073 and 5146S0075 were collected from a 0–5 cm depth, and samples 5146S0074 and 5146S0076 were obtained from a depth of 5–15 cm at their respective locations.

The identification of these isolated locations along with the third elevated gamma area (Figure A-4), resulted in further discussions with DOE personnel. Details of those discussions indicated that the former Laundry Waste Line was included in a decommissioning and removal effort on the hillside during the 1980s. ORAU and DOE personnel concluded that the path of the Laundry Waste Line and position of two decommissioned buildings (K-5 and K-6) appeared to be consistent with the locations of the elevated gamma count rates (AEC 1972) (Figure A-11) and this waste line was the likely source of the observed Cs-137 contamination.

ORAU reviewed the aRc analytical results to determine if the survey results agreed. The review determined comparable results for the minimum and maximum concentrations for each FSS unit (Table 3). The direct comparison of the mean concentrations were also in general agreement with the mean concentrations of both ROCs being below 1 pCi/g. aRc scans and sample results confirmed Cs-137 contamination in the area of the Laundry Waste Line. The highest concentration of Cs-137 determined by aRc was 31.5 pCi/g.

Table 3. Comparison Summary of Final Status Survey Statistics of Soil Samples Collected From Each Survey Unit
Lower Level Hillside Area
Separations Process Research Unit
Niskayuna, New York

Random Samples per Survey Unit	Sr-90 Radionuclide Concentrations (pCi/g)							
	aRc				ORAU			
	Min	Max	Mean	SD	Min	Max	Mean	SD
A	-0.130	0.720	0.101	0.170	0.15	0.93	0.392	0.215
B	-0.046	0.310	0.071	0.077	-0.27	0.38	0.004	0.195
C	-0.010	0.340	0.138	0.087	0.24	0.80	0.464	0.170
	Cs-137 Radionuclide Concentrations (pCi/g)							
A	-0.040	3.270	0.393	0.659	0.18	3.13	0.873	1.07
B	0.00	1.4	0.354	0.321	0.04	0.64	0.350	0.219
C	0.120	0.930	0.416	0.182	0.26	0.62	0.375	0.115
Judgmental Samples per Survey Unit	**Sr-90 Radionuclide Concentrations (pCi/g)**							
	aRc				ORAU			
	Min	Max	Mean	SD	Min	Max	Mean	SD
A	0.050	1.270	0.52	0.554	2.43	2.49	2.46	0.042
B	0.050	0.220	0.17	0.065	0.65	1.34	0.995	0.488
C	0.017	0.38	0.20	0.144	—[a]	—	—	—
	Cs-137 Radionuclide Concentrations (pCi/g)							
A	0.380	31.5	9.57	14.3	58.2	66.1	62.2	5.59
B	0.022	28.0	8.49	10.5	70.3	74.1	72.2	2.69
C	0.228	0.55	0.45	0.123	—[a]	—	—	—

[a]Sample not collected from survey unit

9. CONCLUSION

During August 10, 2011 through August 19, 2011, and October 23, 2011 through November 4, 2011, ORAU/ORISE conducted verification survey activities at the SPRU site that included in-process inspections, surface scans, and soil sampling of the LLHA. According to the Type-B Investigation Report, Sr-90 was the primary contributor to the majority of the activity (60 times greater than the Cs-137 activity) (DOE 2010). The evaluation of the scan data and sample results obtained during verification activities determined that the primary ROC, Sr-90, was well below the agreed upon SCO of 30 pCi/g for the site. However, the concentration of Cs-137 in the four judgmental samples collected in FSS Units A and B was greater than the SCO. Both ORAU and aRc surveys identified higher Cs-137 concentrations in FSS Units A and B; the greatest concentrations were indentified in FSS Unit A.

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APPENDIX A
FIGURES

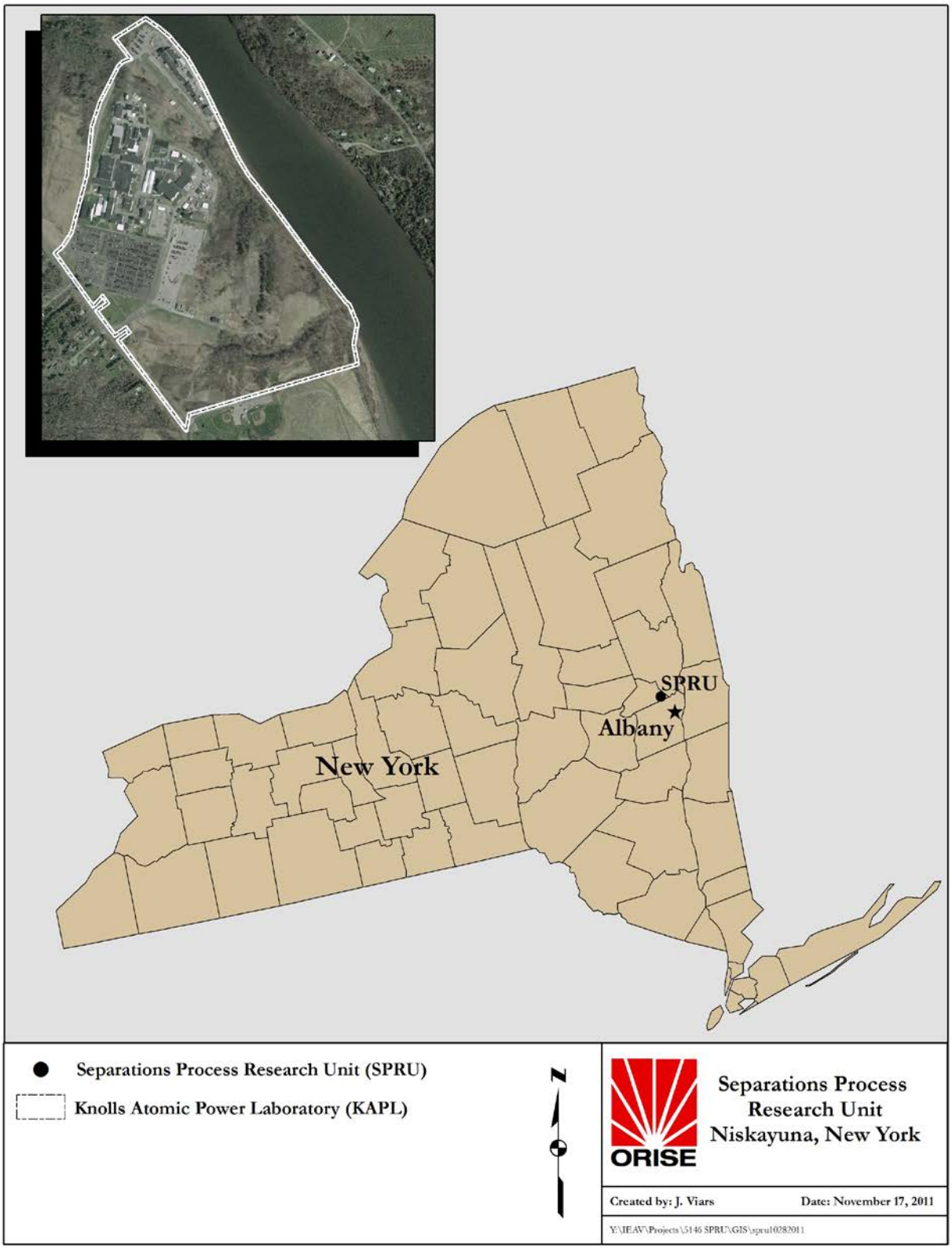

Figure A-1. Separations Process Research Unit (SPRU) at the Knolls Atomic Power Laboratory

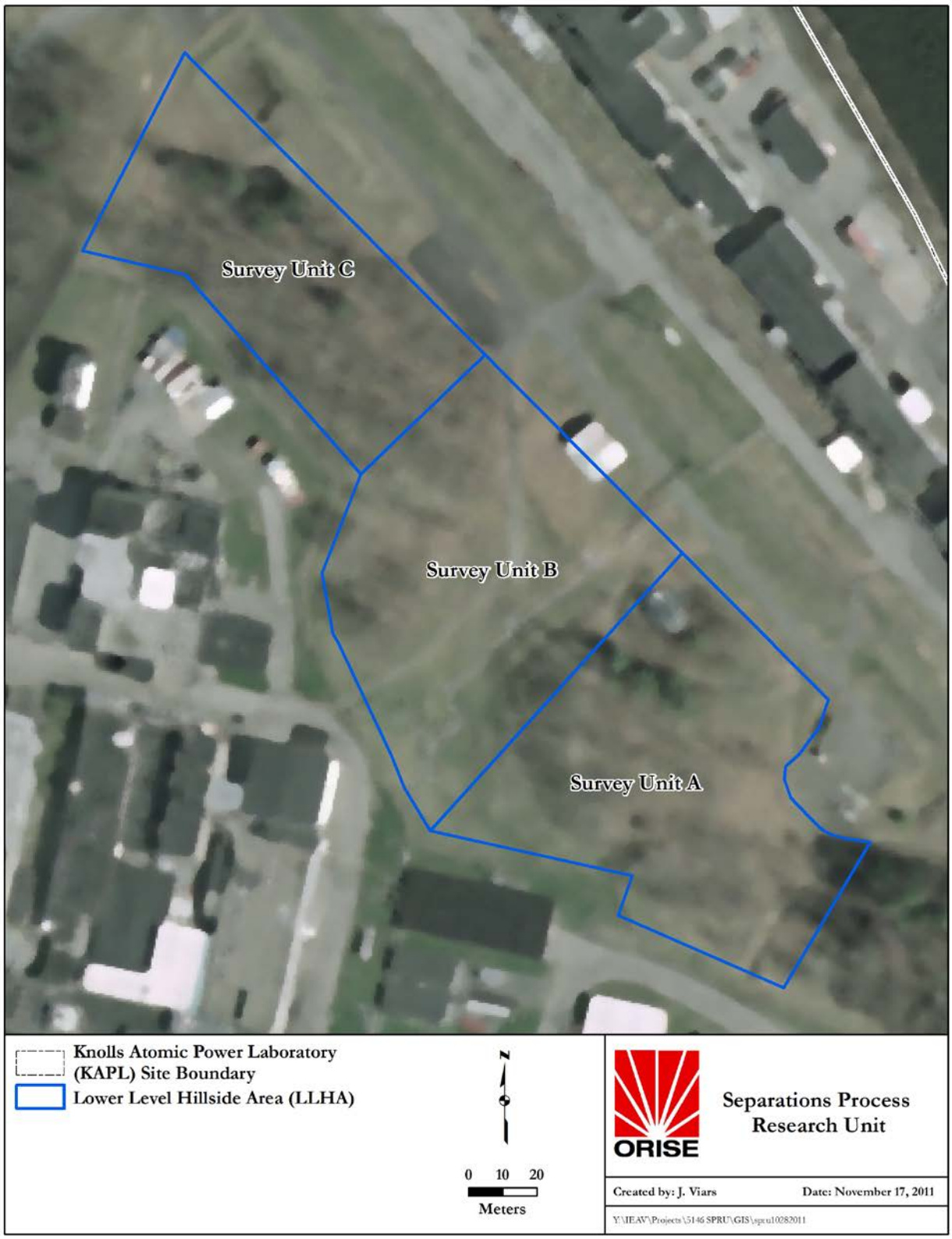

Figure A-2. SPRU Plot Plans for the Lower Level Hillside Area

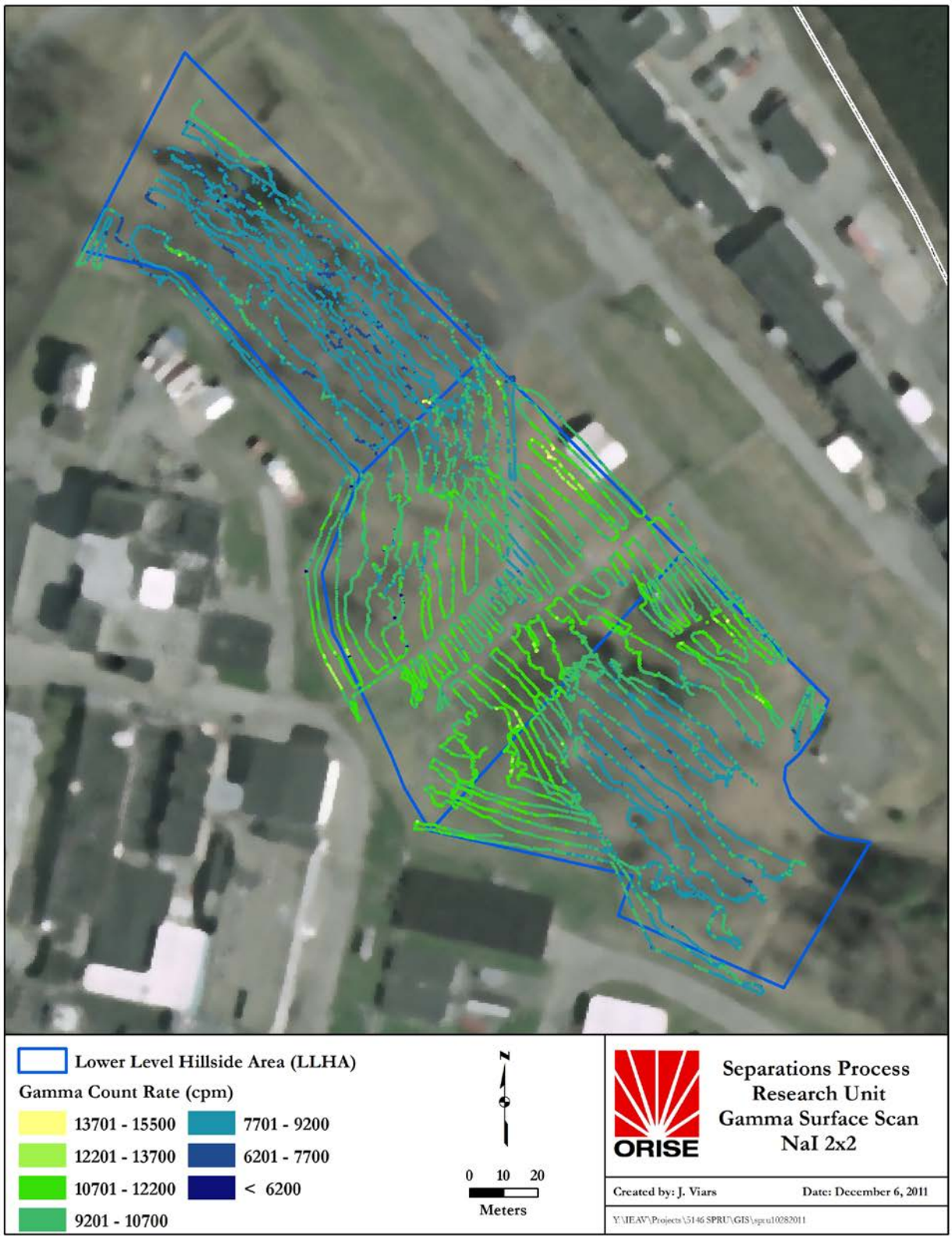

Figure A-3. SPRU Lower Level Hillside Area Gamma Surface Scans with 2×2 Detector

Figure A-4. Lower Level Hillside Area Elevated Activity Investigation Gamma Scans with 2×2 Detector

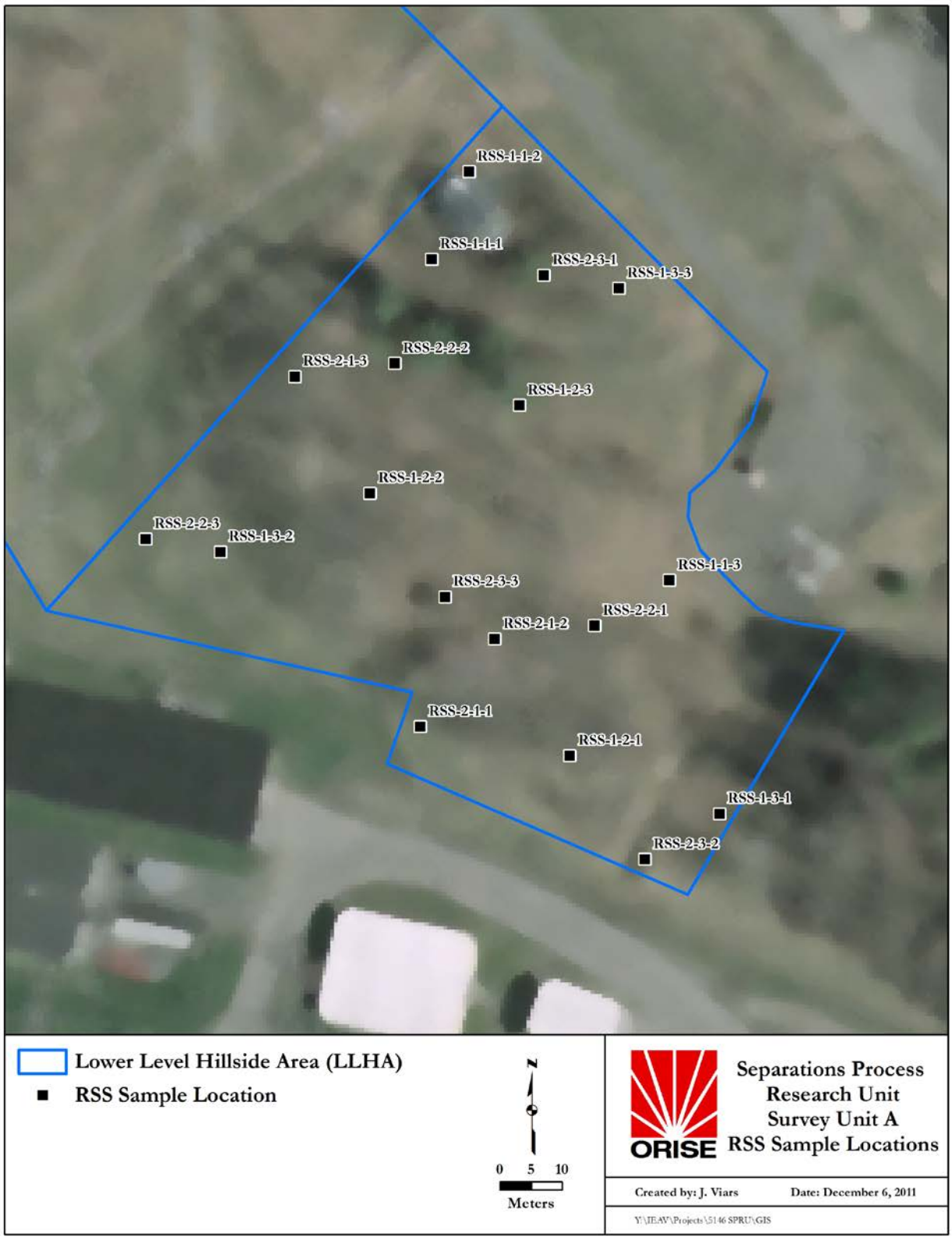

Figure A-5. Lower Level Hillside Area Ranked Set Sample Locations Survey Unit A

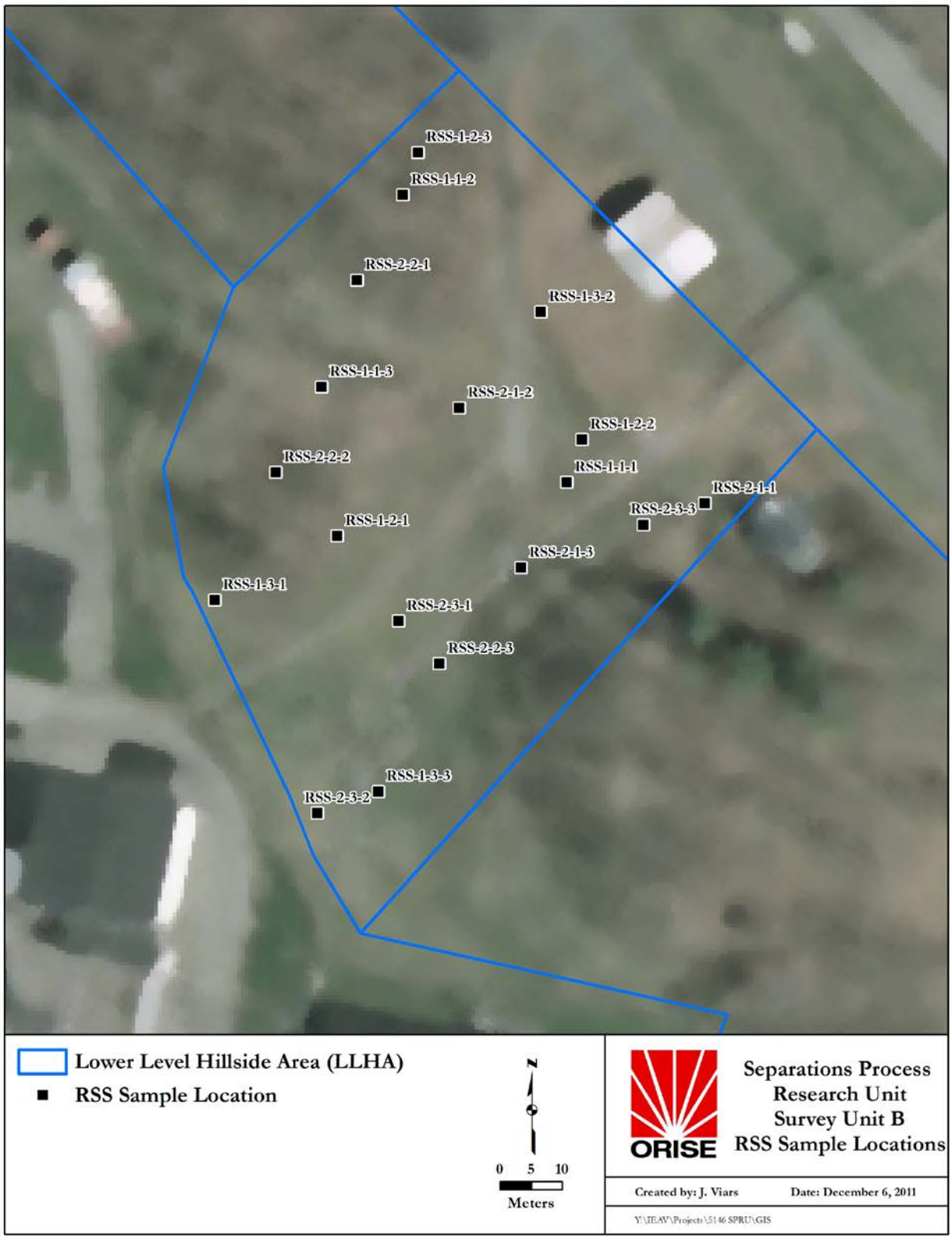

Figure A-6. Lower Level Hillside Area Ranked Set Sample Locations Survey Unit B

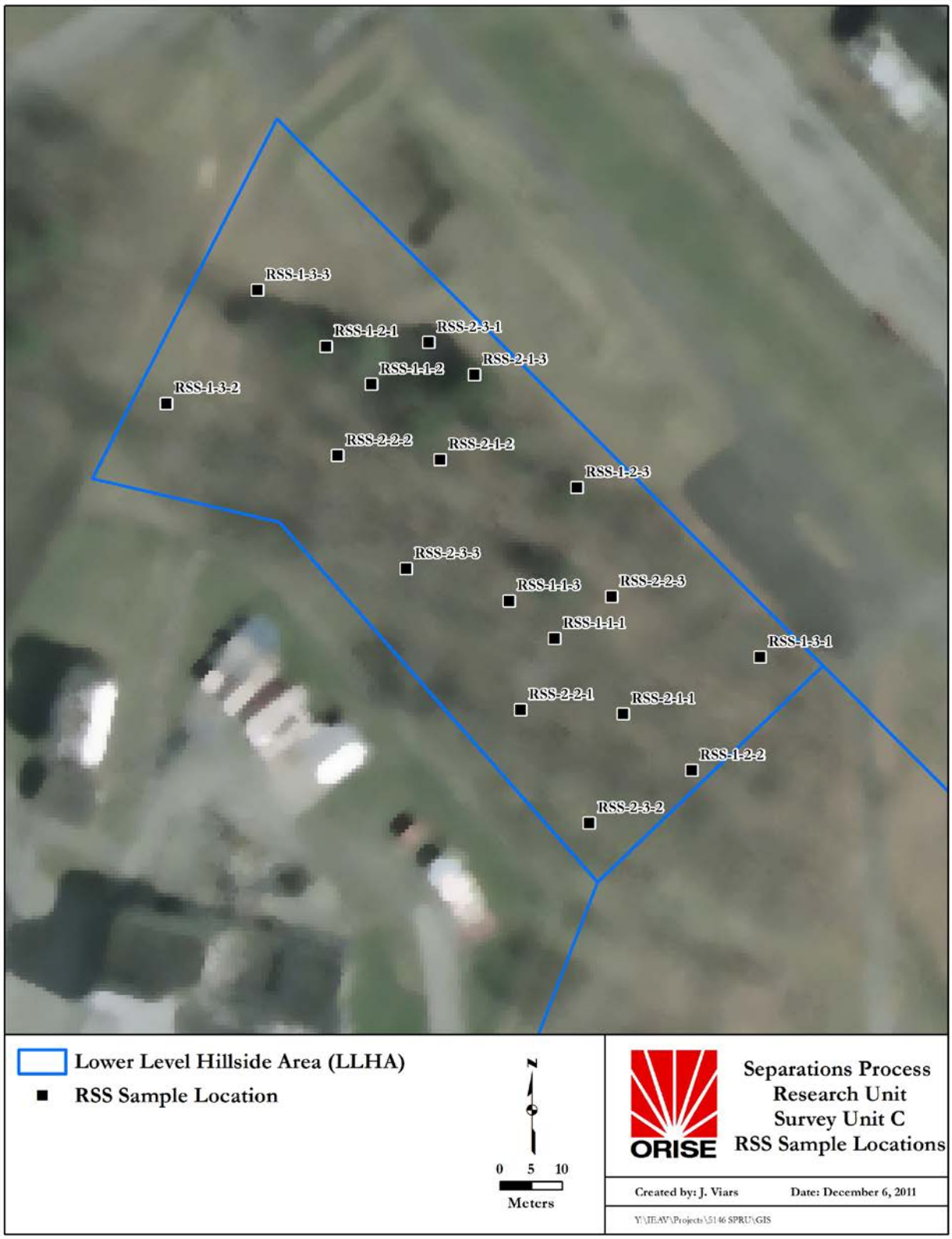

Figure A-7. Lower Level Hillside Area Ranked Set Sample Locations Survey Unit C

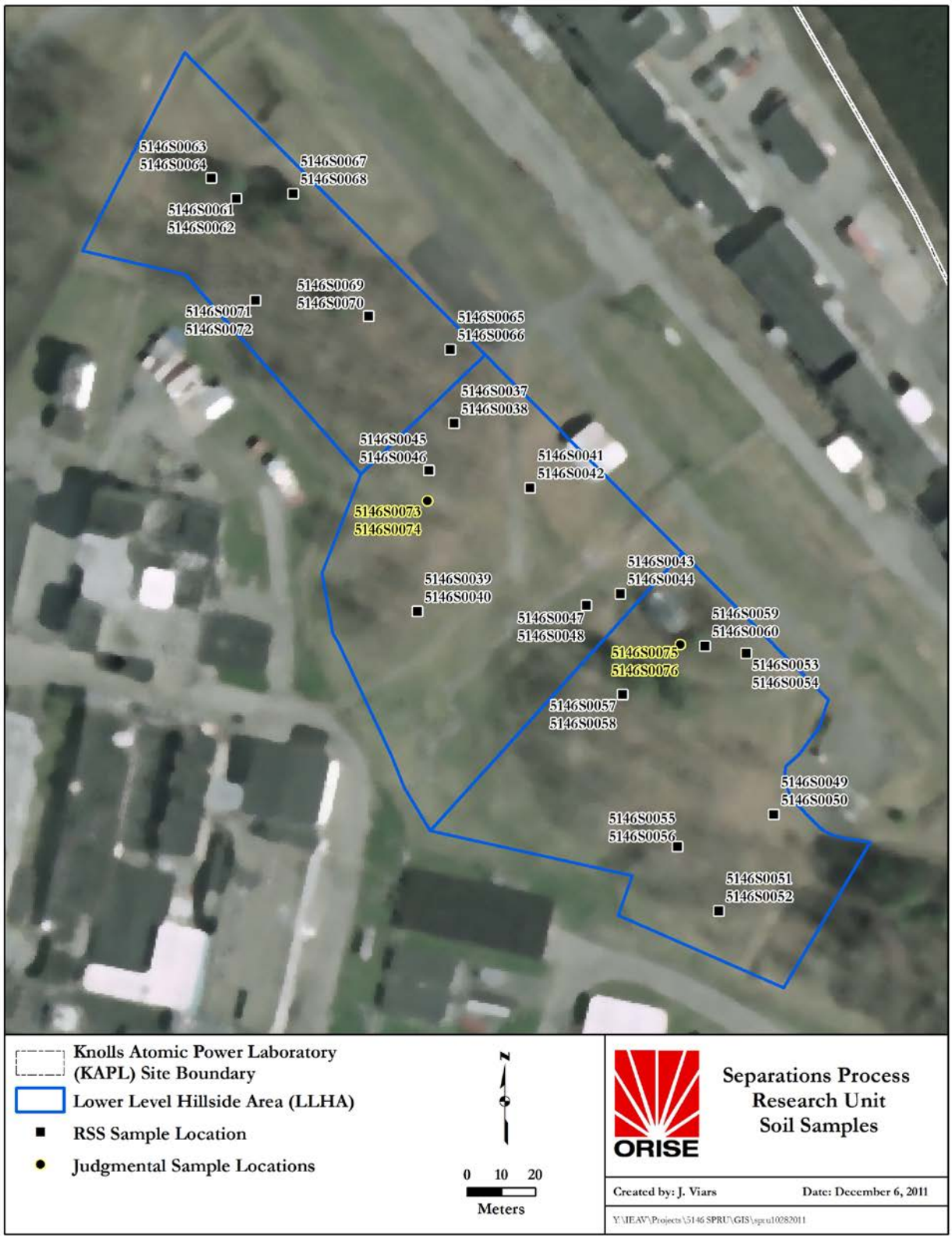

Figure A-8. Soil Sample Locations for the Lower Level Hillside Area

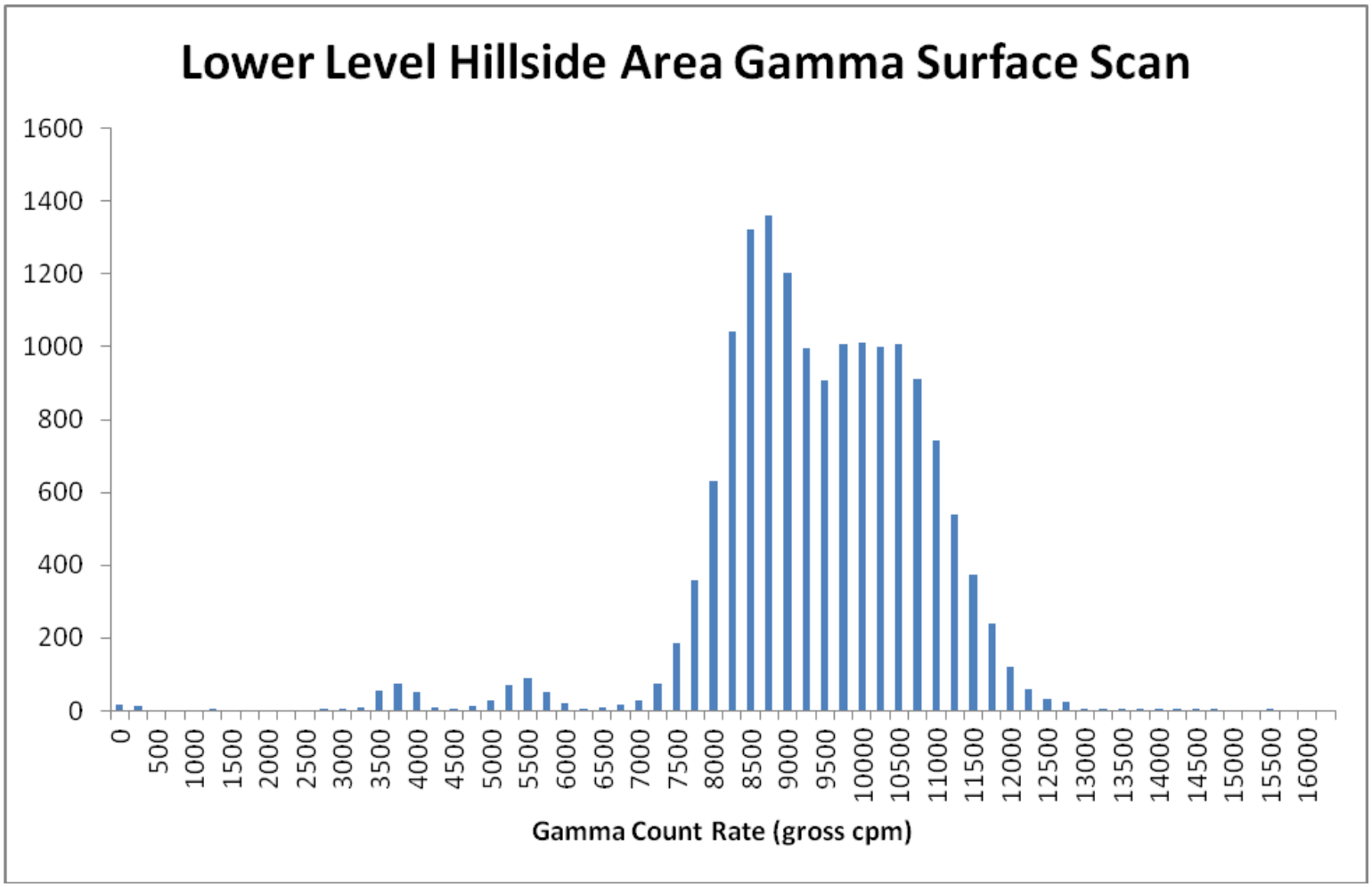

Figure A-9. Histogram for the Lower Level Hillside Area Gamma Surface Scans

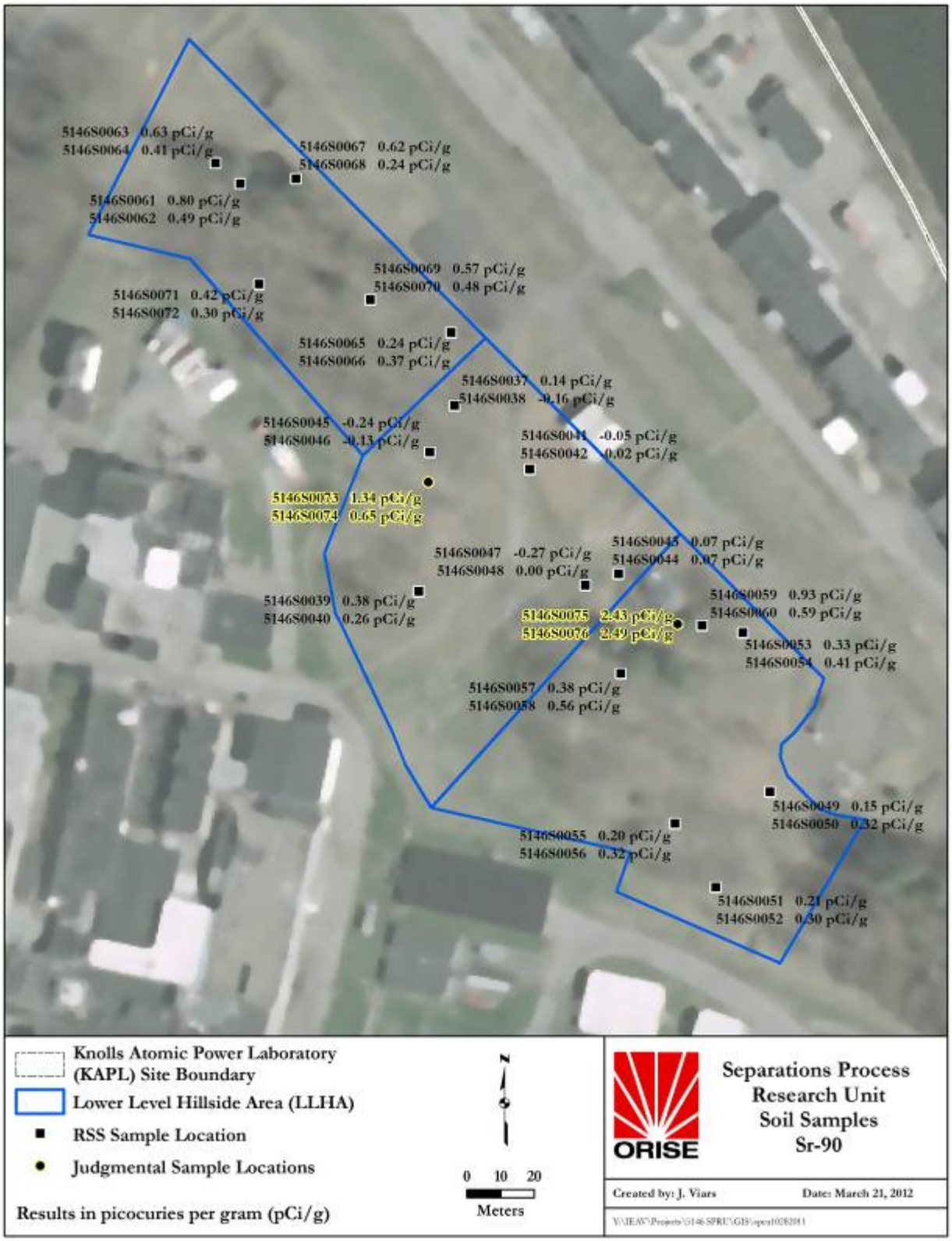

Figure A-10. Sr-90 Concentrations for Soil Samples on the Lower Level Hillside Area

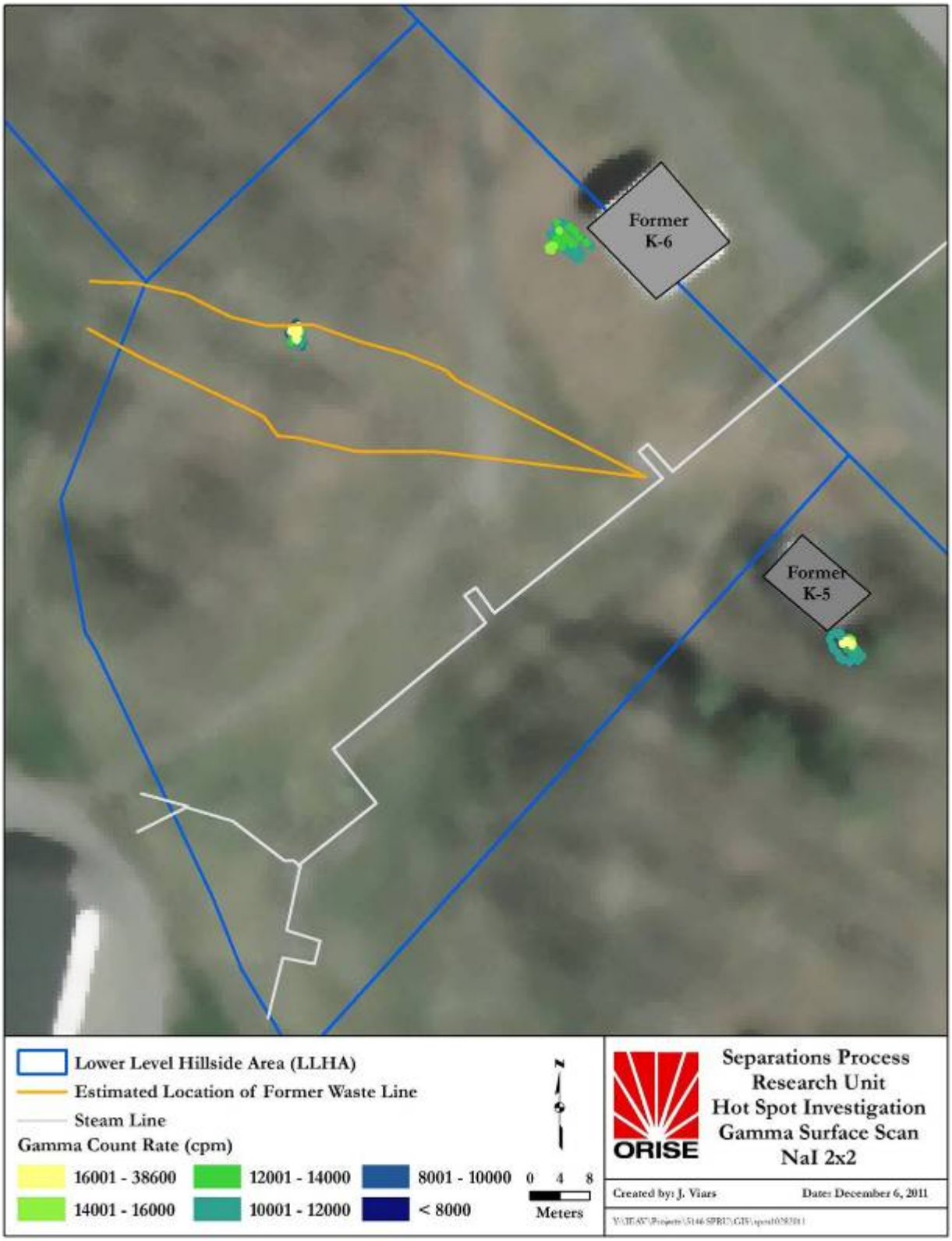

Figure A-11. Elevated Activity Investigation Gamma Scans Compared Locations of Former Waste Lines and Facilities

APPENDIX B
TABLES

Table B-1. Surface Activity Measurements on the Lower Level Hillside Area Separations Process Research Unit Niskayuna, New York						
Location[a]	Direct Measurements					
	GPS Coordinates		Beta Count Rate		Gamma Count Rate	
	Easting[b]	Northing[b]	Pre-Sample[c] (cpm)	Post-Sample[c] (cpm)	Pre-Sample[c] (cpm)	Post-Sample[c] (cpm)
5146S0037	625074	1029698	386	367	8,532	9,618
5146S0038	625074	1029698	504	483	9,120	10,417
5146S0039	625039	1029517	385	429	9,596	10,642
5146S0040	625039	1029517	475	440	10,611	12,031
5146S0041	625147	1029636	489	387	9,221	8,434
5146S0042	625147	1029636	363	368	9,797	7,821
5146S0043	625233	1029534	407	395	7,394	9,317
5146S0044	625233	1029534	327	538	10,146	12,113
5146S0045	625049	1029652	431	518	9,372	10,613
5146S0046	625049	1029652	502	518	10,124	11,338
5146S0047	625201	1029523	516	364	9,392	10,896
5146S0048	625201	1029523	494	532	10,630	11,726
5146S0049	625381	1029322	396	323	8,084	8,673
5146S0050	625381	1029322	466	501	8,265	9,740
5146S0051	625328	1029229	401	336	8,504	8,713
5146S0052	625328	1029229	471	459	9,370	9,775
5146S0053	625354	1029477	441	405	9,683	10,598

Table B-1. Surface Activity Measurements on the Lower Level Hillside Area Separations Process Research Unit Niskayuna, New York						
Location[a]	Direct Measurements					
	GPS Coordinates		Beta Count Rate		Gamma Count Rate	
	Easting[b]	Northing[b]	Pre-Sample[c] (cpm)	Post-Sample[c] (cpm)	Pre-Sample[c] (cpm)	Post-Sample[c] (cpm)
5146S0054	625354	1029477	492	579	10,426	12,310
5146S0055	625288	1029291	411	306	8,189	8,632
5146S0056	625288	1029291	475	448	8,460	10,617
5146S0057	625235	1029437	433	337	8,688	8,840
5146S0058	625235	1029437	482	450	8,967	10,332
5146S0059	625315	1029484	486	349	10,137	10,638
5146S0060	625315	1029484	538	376	10,812	12,908
5146S0061	624865	1029913	402	324	8,417	9,498
5146S0062	624865	1029913	479	502	9,677	11,018
5146S0063	624841	1029933	428	318	8,111	9,479
5146S0064	624841	1029933	437	477	9,385	10,697
5146S0065	625070	1029768	485	334	9,254	9,819
5146S0066	625070	1029768	479	549	10,416	11,799
5146S0067	624919	1029918	410	370	8,940	10,745
5146S0068	624919	1029918	483	412	11,145	12,255
5146S0069	624992	1029801	425	307	8,357	9,009

Table B-1. Surface Activity Measurements on the Lower Level Hillside Area Separations Process Research Unit Niskayuna, New York						
Location[a]	Direct Measurements					
	GPS Coordinates		Beta Count Rate		Gamma Count Rate	
	Easting[b]	Northing[b]	Pre-Sample[c] (cpm)	Post-Sample[c] (cpm)	Pre-Sample[c] (cpm)	Post-Sample[c] (cpm)
5146S0070	624992	1029801	444	424	8,810	9,884
5146S0071	624883	1029816	420	331	9,336	10,252
5146S0072	624883	1029816	482	548	10,341	12,664

[a]Refer to Figure A-8.
[b]New York State Plane Coordinate System East 3101 NAD 1927 US Foot.
[c]Background has not been subtracted from reported values.

Table B-2. Surface Activity Measurements for Judgmental Samples on the Lower Level Hillside Area Separations Process Research Unit Niskayuna, New York				
Location[a]	Direct Measurements			
	GPS Coordinates		Gamma Count Rate[c]	
	Easting[b]	Northing[b]	Pre-Sample[d] (cpm)	Post-Sample[d] (cpm)
5146S0073	625048	1029623	36,895	51,973
5146S0074	625048	1029623	51,973	66,505
5146S0075	625291	1029485	23,907	34,300
5146S0076	625291	1029485	34,300	38,359

[a]Refer to Figure A-8.
[b]New York State Plane Coordinate System East 3101 NAD 1927 US Foot.
[c]Cs-137 was identified as predominant contaminant in the Final Status Survey Report, beta activity measurements were not collected.
[d]Background has not been subtracted from reported values.

Table B-3. Radionuclide Concentrations in Soil on the Lower Level Hillside Area Separations Process Research Unit Niskayuna, New York								
Sample ID[a]	Radionuclide Concentration in Soil Samples (pCi/g)							
	Sr-90[b]	Am-241	Cs-137	Co-60	U-235	U-238[c]	Total U[d]	SOF[e,f]
5146S0037	0.14 ± 0.48[g]	0.02 ± 0.08	0.48 ± 0.06	0.00[h] ± 0.07	-0.10 ± 0.17	0.81 ± 0.36	1.52 ± 0.74	0.02
5146S0038	-0.16 ± 0.37	-0.06 ± 0.07	0.50 ± 0.06	0.01 ± 0.05	0.04 ± 0.18	0.99 ± 0.30	2.02 ± 0.63	0.01
5146S0039	0.38 ± 0.46	0.00[h] ± 0.08	0.42 ± 0.06	-0.02 ± 0.06	0.11 ± 0.16	1.58 ± 0.40	3.27 ± 0.82	0.03
5146S0040	0.26 ± 0.42	0.05 ± 0.08	0.26 ± 0.04	-0.01 ± 0.06	0.11 ± 0.16	0.9 0± 0.37	1.91 ± 0.76	0.02
5146S0041	-0.05 ± 0.39	-0.01 ± 0.07	0.50 ± 0.06	-0.01 ± 0.05	-0.02 ± 0.18	0.92 ± 0.30	1.82 ± 0.63	0.02
5146S0042	-0.02 ± 0.41	0.04 ± 0.07	0.49 ± 0.06	-0.02 ± 0.05	0.04 ± 0.14	0.99 ± 0.31	2.02 ± 0.64	0.02
5146S0043	0.07 ± 0.39	-0.04 ± 0.08	0.04 ± 0.02	-0.01 ± 0.07	0.12 ± 0.15	0.43 ± 0.52	1.0 ± 1.1	0.00
5146S0044	0.07 ± 0.40	-0.02 ± 0.07	0.04 ± 0.02	-0.05 ± 0.06	0.15 ± 0.18	1.41 ± 0.32	2.97 ± 0.66	0.00
5146S0045	-0.24 ± 0.37	0.02 ± 0.07	0.58 ± 0.07	0.02 ± 0.05	-0.03 ± 0.15	1.54 ± 0.34	3.05 ± 0.70	0.02
5146S0046	-0.13 ± 0.37	-0.03 ± 0.07	0.64 ± 0.07	-0.03 ± 0.07	0.28 ± 0.15	0.94 ± 0.35	2.16 ± 0.72	0.02
5146S0047	-0.27 ± 0.37	-0.02 ± 0.06	0.11 ± 0.02	-0.02 ± 0.05	0.14 ± 0.06	1.27 ± 0.29	2.68 ± 0.58	-0.01
5146S0048	0.00 ± 0.39	0.07 ± 0.06	0.14 ± 0.03	-0.04 ± 0.05	-0.04 ± 0.14	1.41 ± 0.63	2.8 ± 1.3	0.00
5146S0049	0.15 ± 0.33	0.08 ± 0.06	0.25 ± 0.04	-0.01 ± 0.06	0.14 ± 0.14	1.42 ± 0.34	2.98 ± 0.69	0.01
5146S0050	0.32 ± 0.34	0.01 ± 0.08	0.29 ± 0.05	-0.02 ± 0.06	-0.04 ± 0.16	1.38 ± 0.38	2.72 ± 0.78	0.02
5146S0051	0.21 ± 0.32	0.05 ± 0.07	0.18 ± 0.03	-0.02 ± 0.07	0.08 ± 0.16	1.15 ± 0.38	2.38 ± 0.78	0.01
5146S0052	0.30 ± 0.34	0.00 ± 0.07	0.20 ± 0.03	-0.01 ± 0.06	0.07 ± 0.15	0.93 ± 0.32	1.93 ± 0.66	0.02
5146S0053	0.33 ± 0.33	0.05 ± 0.08	1.27 ± 0.13	-0.01 ± 0.06	0.16 ± 0.07	1.28 ± 0.36	2.72 ± 0.72	0.05
5146S0054	0.41 ± 0.35	0.00 ± 0.06	0.97 ± 0.10	0.00 ± 0.05	-0.02 ± 0.18	1.29 ± 0.30	2.56 ± 0.63	0.05
5146S0055	0.20 ± 0.34	0.00 ± 0.05	0.29 ± 0.04	-0.01 ± 0.05	0.05 ± 0.17	1.17 ± 0.29	2.39 ± 0.60	0.02
5146S0056	0.32 ± 0.35	0.00 ± 0.07	0.21 ± 0.03	0.01 ± 0.06	0.04 ± 0.15	0.87 ± 0.33	1.78 ± 0.68	0.02
5146S0057	0.38 ± 0.35	0.11 ± 0.08	0.38 ± 0.05	0.02 ± 0.06	0.05 ± 0.17	0.83 ± 0.38	1.71 ± 0.78	0.03
5146S0058	0.56 ± 0.38	0.02 ± 0.06	0.34 ± 0.05	0.00± 0.05	-0.02 ± 0.18	1.29 ± 0.30	2.56 ± 0.63	0.03

Table B-3. Radionuclide Concentrations in Soil, Lower Level Hillside Area Separations Process Research Unit Niskayuna, New York								
Sample ID[a]	**Radionuclide Concentration in Soil Samples (pCi/g)**							
	Sr-90[b]	**Am-241**	**Cs-137**	**Co-60**	**U-235**	**U-238[c]**	**Total U[d]**	**SOF[e,f]**
5146S0059	0.93 ± 0.42[g]	0.09 ± 0.03	2.96 ± 0.23	0.02 ± 0.04	0.15 ± 0.15	1.03 ± 0.33	2.21 ± 0.68	0.13
5146S0060	0.59 ± 0.39	0.03 ± 0.03	3.13 ± 0.30	0.01 ± 0.05	0.09 ± 0.16	0.73 ± 0.36	1.55 ± 0.74	0.13
5146S0061	0.80 ± 0.44	0.03 ± 0.06	0.26 ± 0.03	0.01 ± 0.05	0.19 ± 0.17	1.32 ± 0.28	2.83 ± 0.59	0.04
5146S0062	0.49 ± 0.43	0.02 ± 0.06	0.27 ± 0.04	0.02 ± 0.05	0.01 ± 0.19	1.25 ± 0.30	2.51 ± 0.63	0.03
5146S0063	0.63 ± 0.43	-0.02 ± 0.07	0.28 ± 0.04	0.01 ± 0.04	0.05 ± 0.13	1.37 ± 0.59	2.8 ± 1.2	0.03
5146S0064	0.41 ± 0.39	0.00[h] ± 0.07	0.28 ± 0.04	-0.02 ± 0.06	0.09 ± 0.14	0.80 ± 0.30	1.69 ± 0.62	0.02
5146S0065	0.24 ± 0.39	-0.02 ± 0.09	0.62 ± 0.07	0.04 ± 0.07	0.13 ± 0.18	1.14 ± 0.42	2.41 ± 0.86	0.03
5146S0066	0.37 ± 0.38	0.01 ± 0.06	0.50 ± 0.06	0.01 ± 0.05	0.02 ± 0.19	1.11 ± 0.31	2.24 ± 0.65	0.03
5146S0067	0.62 ± 0.41	0.00 ± 0.08	0.49 ± 0.07	0.01 ± 0.05	0.16 ± 0.16	0.93 ± 0.41	2.02 ± 0.84	0.04
5146S0068	0.24 ± 0.38	0.00 ± 0.06	0.30 ± 0.04	0.00 ± 0.05	0.00 ± 0.18	0.93 ± 0.28	1.86 ± 0.59	0.02
5146S0069	0.57 ± 0.41	-0.07 ± 0.08	0.39 ± 0.06	-0.02 ± 0.05	0.05 ± 0.15	0.83 ± 0.34	1.71 ± 0.70	0.03
5146S0070	0.48 ± 0.46	-0.03 ± 0.08	0.30 ± 0.04	0.05 ± 0.06	0.00 ± 0.16	1.34 ± 0.38	2.68 ± 0.78	0.03
5146S0071	0.42 ± 0.39	0.04 ± 0.07	0.4 0± 0.05	-0.01 ± 0.06	0.06 ± 0.20	0.99 ± 0.34	2.04 ± 0.71	0.03
5146S0072	0.30 ± 0.35	0.00 ± 0.08	0.41 ± 0.06	0.01 ± 0.05	0.03 ± 0.16	0.74 ± 0.36	1.51 ± 0.74	0.03

[a]Refer to Figures A-8.
[b]Sr-90 concentration determination by analytical preparation and counted via low background proportional counter.
[c]U-238 was derived from and considered to be in equilibrium with Th-234.
[d]Total U is calculated by U-235 +2*(U-238).
[e]Sum of Fractions (SOF) account for the contributions from each individual radionuclide listed. Total U was not incorporated into the calculations.
[f]Individual radionuclide concentrations were compared against their respective site cleanup objective in Table 1.
[g]Uncertainties are at the 95% confidence level based on total propagated uncertainties.
[h]Zero values for sample results are due to rounding.

Table B-4. Radionuclide Concentrations for Judgmental Samples on the Lower Level Hillside Area Separations Process Research Unit Niskayuna, New York

Sample ID[a]	Radionuclide Concentration in Soil Samples (pCi/g)							
	Sr-90[b]	Am-241	Cs-137	Co-60	U-235	U-238[c]	Total U[d]	SOF[e,f]
5146S0073	1.34 ± 0.52[g]	-0.14 ± 0.13	70.3 ± 6.5	0.00[h] ± 0.05	0.17 ± 0.46	1.8 ± 1.1	3.8 ± 2.2	2.39
5146S0074	0.65 ± 0.44	-0.08 ± 0.13	74.1 ± 6.8	-0.02 ± 0.05	-0.27 ± 0.49	1.9 ± 1.2	3.5 ± 2.4	2.49
5146S0075	2.43 ± 0.53	0.17 ± 0.11	58.2 ± 4.2	-0.01 ± 0.04	0.25 ± 0.28	0.72 ± 0.94	1.7 ± 1.9	2.02
5146S0076	2.49 ± 0.55	0.45 ± 0.11	66.1 ± 5.3	-0.02 ± 0.05	0.08 ± 0.39	1.38 ± 0.94	2.8 ± 1.9	2.29

[a]Refer to Figure A-8.
[b]Sr-90 concentration determination by analytical preparation and counted via low background proportional counter.
[c]U-238 was derived from and considered to be in equilibrium with Th-234.
[d]Total U is calculated by U-235 +2*(U-238).
[e]Sum of Fractions (SOF) account for the contributions from each individual radionuclide listed. Total U was not incorporated into the calculations.
[f]Individual radionuclide concentrations were compared against their respective site cleanup objective in Table 1.
[g]Uncertainties are at the 95% confidence level based on total propagated uncertainties.
[h]Zero values for sample results are due to rounding.

APPENDIX C
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.

C.1 SCANNING AND MEASUREMENT INSTRUMENT/DETECTOR COMBINATIONS

Ludlum Scintillation Detector Model SPA-3, Crystal: 2-in. × 2-in. (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)

Ludlum Scintillation Detector Model 44-10, Crystal: 2-in. × 2-in. (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)

Ludlum Beta Scintillation Detector Model 44-142, 1.125-in. diameter magnetically shielded photomultiplier. (Ludlum Measurements, Inc., Sweetwater, TX)
Coupled to:
Ludlum Ratemeter-Scaler Model 2221 (Ludlum Measurements, Inc., Sweetwater, TX)

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), Apex Gamma Software (Canberra, Meriden, CT) and Multichannel Analyzer with Dell Workstation

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), Apex Gamma Software (Canberra, Meriden, CT) and Multichannel Analyzer with Dell Workstation

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), Apex Gamma Software (Canberra, Meriden, CT) and Multichannel Analyzer with Dell Workstation

Low background alpha/beta counting system
Canberra/Tennelec LB5100W
Eclipse Software
(Canberra, Inc., Meriden, CT)

APPENDIX D
SURVEY AND ANALYTICAL PROCEDURES

D.1 PROJECT HEALTH AND SAFETY

URS-SPRU representatives provided site-specific safety awareness training for personnel working on the project to ensure that appropriate safety precautions were implemented. Pre-survey activities included an overview of potential health and safety issues. Survey activities were conducted in accordance with the ORAU/ORISE overall health and safety program (HASP) and radiological protection program manuals. Potential health and safety issues were appropriately addressed by the ORISE HASP, site-specific Integrated Safety Management (ISM) pre-job hazard checklist, and an activity hazard analysis (AHA) prior to beginning site work.

D.2 QUALITY ASSURANCE

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

- Survey Procedures Manual (ORISE 2012a)
- Laboratory Procedures Manual (ORISE 2012b)
- Quality Program Manual (ORAU 2011)

The procedures contained in these manuals were developed to meet the requirements of 10 CFR 830 Subpart A, *Quality Assurance Requirements*, U.S. 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), National Institute for Standards and Technology (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.

D.3 CALIBRATION

Calibration of all field and laboratory instrumentation was based on standards/sources, traceable to NIST, when such standards/sources were available. In cases where they were not available, standards of an industry-recognized organization were used.

D.4 SURVEY PROCEDURES

D.4.1 SURFACE SCANS

Scans 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 of about 1 to 5 centimeters (cm). NaI scintillation detectors were coupled to GPS units that enabled real-time recording of position in one-second intervals. 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[1] when available or estimated using the calculation approach described in NUREG-1507. A typical NaI 2-inch × 2-inch detector MDC is 6.4 pCi/g for cesium-137. Audible increases in the activity rate are investigated by ORISE. It is standard procedure for ORISE staff to pause and investigate any locations where gamma radiation is distinguishable from background levels.

D.4.2 SURFACE ACTIVITY MEASUREMENTS

Measurements of total beta surface activity levels were performed using hand-held scintillation detectors coupled to portable ratemeter-scalers. The instrument count rates were reported in cpm per 100 cm^2.

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

The *a priori* MDC for surface activity measurements was calculated using the following equation:

$$MDC = \frac{3 + (4.65\sqrt{B})}{Tx\varepsilon_{Tot}xG}$$

Where:

B	=	background (total counts) in time interval, T
T	=	count time (min) used for field instruments
ε_{Tot}	=	total efficiency = ε_i x ε_s
ε_i	=	instrument efficiency
ε_s	=	source efficiency
G	=	geometry (physical detector area $cm^2/100$)

The physical surface area assessed by the scintillation detector used was 100 cm^2. The *a priori* beta static MDC was approximately 281 dpm/100 cm^2 using the total efficiency of 0.32 and the site redetermined instrument background of 411 cpm.

D.4.3 SOIL SAMPLING

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

D.5 RADIOLOGICAL ANALYSIS

D.5.1 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 $(BKG)^{1/2}$)]. 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.

D.5.2 STRONTIUM-90

Soil and vegetation samples were dissolved by a combination of potassium hydrogen fluoride and pyrosultfate fusions. The fusion cake was dissolved and strontium was coprecipitated on lead sulfate. The strontium was separated from residual calcium and lead by precipitating strontium sulfate from ethylenediaminetetraacetic acid at a pH of 4.0. Strontium was separated from barium by complexing the strontium in diethylenetriaminepentaacetic acid while precipitating barium as barium chromate.

The strontium was ultimately converted to strontium carbonate and counted on a low-background gas proportional counter. The typical MDC of the procedure is 0.4 pCi/g for a one hour count time.

D.5.3 GAMMA SPECTROSCOPY

Samples 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)s associated with the 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[a]	TAP (MeV)	MDC (pCi/g)
Cs-137	0.662	0.05
Am-241	0.059	0.11
U-235[b]	0.144	0.24
U-238[c]	0.063	0.75

[a]Spectra were also reviewed for other identifiable TAPs.
[b]The 143.76 keV peak is used for the quantification of U-235 in the presence of Ra.
[c]The 63.29 keV peak is from Th-234, the first progeny of U-238 and is used to quantify U-238.

D.5.4 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.