ORISE
OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION

July 7, 2011

Mr. Theodore Smith
U.S. Nuclear Regulatory Commission
Office of Federal and State Materials and Environmental Management Programs
11545 Rockville Pike
Mail Stop T-7F27
Rockville, MD 20852

SUBJECT: FINAL–REPORT NO. 2: INDEPENDENT CONFIRMATORY SURVEY SUMMARY AND RESULTS FOR THE ENRICO FERMI ATOMIC POWER PLANT, UNIT 1, NEWPORT, MICHIGAN (DOCKET NO. 50-16; RFTA 10-004) DCN 2018-SR-02-0

Dear Mr. Smith:

The Oak Ridge Institute for Science and Education (ORISE) is pleased to provide the enclosed report that details the confirmatory survey activities performed during the second ORISE site visit to the Enrico Fermi Atomic Power Plant, Unit 1 (Fermi 1) in Newport, Michigan during the period of November 1 through 4, 2010. The survey activities were conducted in accordance with the ORISE confirmatory plan provided to and approved by the U.S. Nuclear Regulatory Commission. Comments provided on the draft report have been addressed.

Please direct any questions you may have to me via my information below or to Tim Vitkus at 865.576.5073.

Sincerely,

Erika N. Bailey

Erika N. Bailey
Deputy Survey Projects Manager
Independent Environmental
Assessment and Verification

ENB:bf

Enclosure

c: S. Giebel, NRC/TWFN 8F5   B. Snell, NRC/Region III
File/2018

electronic distribution: S. Roberts, ORISE   T. Vitkus, ORISE

Voice: 865.576.6659   Fax: 865.241.3497   E-mail: Erika.Bailey@orau.org

P.O. Box 117 | Oak Ridge, TN 37831 | www.orise.orau.gov

FINAL – REPORT NO. 2: INDEPENDENT CONFIRMATORY SURVEY SUMMARY AND RESULTS FOR THE ENRICO FERMI ATOMIC POWER PLANT, UNIT 1, NEWPORT, MICHIGAN

E. N. Bailey

Prepared for the
U.S. Nuclear Regulatory Commission

ORISE

Oak Ridge Institute for Science and Education

ORISE
OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION

FINAL – REPORT NO. 2: INDEPENDENT CONFIRMATORY SURVEY SUMMARY AND RESULTS FOR THE ENRICO FERMI ATOMIC POWER PLANT, UNIT 1, NEWPORT, MICHIGAN

Prepared by: Erika N. Bailey Date: 7/7/11
E. N. Bailey, Deputy Survey Projects Manager
Independent Environmental Assessment and Verification Program

Reviewed by: [signature] Date: 7/7/2011
T. J. Vitkus, IEAV Associate Director,
Director Survey Operations
Independent Environmental Assessment and Verification Program

Reviewed by: Wade P. Ivey Date: 7/7/11
W. P. Ivey, Laboratory Group Manager
Independent Environmental Assessment and Verification Program

Reviewed by: Paige H. Benton Date: 7/7/11
P. H. Benton, Quality Assurance Specialst
Independent Environmental Assessment and Verification Program

FINAL – REPORT NO. 2:
INDEPENDENT CONFIRMATORY SURVEY SUMMARY AND RESULTS FOR THE ENRICO FERMI ATOMIC POWER PLANT, UNIT 1 NEWPORT, MICHIGAN

Prepared by

E. Bailey

Independent Environmental Assessment and Verification Program
Oak Ridge Institute for Science and Education
Oak Ridge, Tennessee 37831-0017

Prepared for the
U.S. Nuclear Regulatory Commission

FINAL REPORT

July 2011

Prepared by the Oak Ridge Institute for Science and Education, under interagency agreement (NRC FIN No. F1008) between the U.S. Nuclear Regulatory Commission and the U.S. Department of Energy. The Oak Ridge Institute for Science and Education performs complementary work under contract number DE-AC05-06OR23100 with the U.S. Department of Energy.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS AND ACRONYMS

AEC	Atomic Energy Commission
cm	centimeter
cpm	counts per minute
$DCGL_W$	derived concentration guideline level
$DCGL_{GA}$	gross activity derived concentration guideline level
DOE	U.S. Department of Energy
DTE	Detroit Edison Company
dpm	disintegrations per minute
E_s	Source Efficiency
E_i	2π instrument efficiency
ESG	East Sodium Gallery
Fermi 1	Enrico Fermi Atomic Power Plant, Unit 1
Fermi 2	Enrico Fermi Atomic Power Plant, Unit 2
FRB	Fuel and Reactor Building
FSS	final status survey
FSSP	Final Status Survey Package
gal	gallon
GPS	global positioning system
HSA	Historical Site Assessment
IEAV	Independent Environmental Assessment and Verification Program
ITP	Intercomparison Testing Program
kg	kilogram
LTP	License Termination Plan
MAPEP	Mixed Analyte Performance Evaluation Program
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	Minimum Detectable Concentration
m^2	square meter
MW	megawatt
mrem	millirem
NAD	North American Datum
NaI	sodium iodide
NIST	National Institute of Standards and Technology
NRIP	NIST Radiochemistry Intercomparison Program
NRC	U.S. Nuclear Regulatory Commission
ORAU	Oak Ridge Associated Universities

ABBREVIATIONS AND ACRONYMS (CONT.)

ORISE	Oak Ridge Institute for Science and Education
pCi/g	picocuries per gram
PRDC	Power Reactor Development Company
ROC	Radionuclide of Concern
SU	Survey Unit
yr	year

FINAL – REPORT NO. 2: INDEPENDENT CONFIRMATORY SURVEY SUMMARY AND RESULTS FOR THE ENRICO FERMI ATOMIC POWER PLANT, UNIT 1 NEWPORT, MICHIGAN

1.0 INTRODUCTION

The Enrico Fermi Atomic Power Plant, Unit 1 (Fermi 1) was a fast breeder reactor design that was cooled by sodium and operated at essentially atmospheric pressure. On May 10, 1963, the Atomic Energy Commission (AEC) granted an operating license, DPR-9, to the Power Reactor Development Company (PRDC), a consortium specifically formed to own and operate a nuclear reactor at the Fermi 1 site. The reactor was designed for a maximum capability of 430 megawatts (MW); however, the maximum reactor power with the first core loading (Core A) was 200 MW. The primary system was filled with sodium in December 1960 and criticality was achieved in August 1963.

The reactor was tested at low power during the first couple years of operation. Power ascension testing above 1 MW commenced in December 1965 immediately following the receipt of a high-power operating license. In October 1966 during power ascension, zirconium plates at the bottom of the reactor vessel became loose and blocked sodium coolant flow to some fuel subassemblies. Two subassemblies started to melt and the reactor was manually shut down. No abnormal releases to the environment occurred. Forty-two months later after the cause had been determined, cleanup completed, and the fuel replaced, Fermi 1 was restarted. However, in November 1972, PRDC made the decision to decommission Fermi 1 as the core was approaching its burn-up limit. The fuel and blanket subassemblies were shipped off-site in 1973. Following that, the secondary sodium system was drained and sent off-site. The radioactive primary sodium was stored on-site in storage tanks and 55 gallon (gal) drums until it was shipped off-site in 1984. The initial decommissioning of Fermi 1 was completed in 1975. Effective January 23, 1976, DPR-9 was transferred to the Detroit Edison Company (DTE) as a "possession only" license (DTE 2010a).

This report details the confirmatory activities performed during the second Oak Ridge Institute for Science and Education (ORISE) site visit to Fermi 1 in November 2010. The survey was strategically planned during a Unit 2 (Fermi 2) outage to take advantage of decreased radiation levels that were observed and attributed to Fermi 2 from the operating unit during the first site visit. However, during the second visit there were elevated radiation levels observed and attributed to the partially dismantled Fermi 1 reactor vessel and a waste storage box located on the 3rd floor of the Fermi 1 Turbine Building. Confirmatory surveys (unshielded) performed directly in the line of sight of these areas were affected.

2.0 SITE DESCRIPTION

Fermi 1 is located in Monroe County near the town of Newport, Michigan on the western bank of Lake Erie (Figure A-1). Fermi 1 and Fermi 2 are located in the same controlled area on the same site. Fermi 1, however, stands beyond the protected operational area of Fermi 2. The Fermi 1 License Termination boundary is made up of 27, 200 square meters (m^2) including roads, a railroad spur, buildings and land areas; a portion of which is occupied by an oily waste bin (DTE 2010a). Figure A-2 shows the Fermi 1 plot plan and associated building identifications.

3.0 OBJECTIVES

The objective of the confirmatory survey was to verify that the final radiological conditions were accurately and adequately described in Final Status Survey (FSS) documentation, relative to the established release criteria. This objective was achieved by performing document reviews, as well as independent measurements and sampling. Specifically, documentation of the planning, implementation, and results of the FSS were evaluated; side-by-side FSS measurement and source comparisons were performed; site areas were evaluated relative to appropriate FSS classification; and areas were assessed for residual, undocumented contamination.

4.0 DOCUMENT REVIEW

Prior to on-site activities, ORISE was tasked with reviewing the Enrico Fermi Atomic Power Plant, Unit No. 1 License Termination Plan (LTP) which includes the Final Status Survey Plan as Chapter 5 (DTE 2010a). ORISE also reviewed any Final Status Survey Packages (FSSPs) and results for the survey units (SUs) of interest that were available prior to the site visit. The FSSPs were specifically reviewed to identify the SU's Radionuclides of Concern (ROCs), associated nuclide fractions, and the applicable derived concentration guideline levels ($DCGL_W$). ORISE also reviewed DTE's survey measurement methods used during the FSS and instrument calibration information used for the side-by-side source comparison measurements. All documents and data were reviewed for adequacy and appropriateness taking into account the LTP and Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) guidance (DTE 2010a and NRC 2000).

5.0 PROCEDURES

The ORISE survey team visited the Fermi 1 site from November 1 through 4, 2010 during a Fermi 2 outage, to perform visual inspections, confirmatory measurements, and sample collection of the ongoing decommissioning activities. ORISE also performed side-by-side measurement comparisons on the exterior south wall of the Sodium Building as well as side-by-side measurements on several sources for comparison. The confirmatory survey activities were conducted in accordance with a project-specific plan, the ORISE/Independent Environmental Assessment and Verification (IEAV) Survey Procedures Manual and Quality Program Manual (ORISE 2010a, ORISE 2008, and ORAU 2010). Questions and concerns were brought to the immediate attention of the U. S. Nuclear Regulatory Commission (NRC) representatives and are also noted in the Findings and Results section of this report.

The SUs were classified based on contamination potential, as either Class 1, 2, or 3 in accordance with MARSSIM (NRC 2000). A description of each is as follows:

> Class 1: Buildings or land areas that have a significant potential for radioactive contamination (based on site operating history) or known contamination (based on previous radiological surveys) that exceeds the expected $DCGL_W$ value.
>
> Class 2: Buildings or land areas, often contiguous to Class 1 areas that have a potential for radioactive contamination, but at levels less than the expected $DCGL_W$.
>
> Class 3: Remaining impacted buildings and land areas that are not expected to contain residual contamination or are expected to contain levels of residual contamination at a small fraction of the $DCGL_W$.

Confirmatory survey activities were conducted in the SUs as shown in Table 1.

**TABLE 1:
CONFIRMATORY SURVEY SUMMARY**

SURVEY UNIT	Class	SCAN COVERAGE[a]		
		Surface	Alpha + Beta	Gamma
East Sodium Gallery	1	Floor	High Density[b]	High Density[b]
	1	Lower Walls	Medium Density[b]	N/A
Fuel and Repair Building (Decay Pool)	1	Floor	High Density[b]	High Density[b]
	1	Lower Walls	Medium Density[b]	N/A
	1	Upper Walls	Medium Density[b]	N/A
Fuel and Repair Building (Upper Roof)	3	Roof	High Density	High Density
Fuel and Repair Building (Middle Roof over Fan Room)	3	Roof	High Density	High Density
Fuel and Repair Building (Lower Roof over Decay Pool)	3	Roof	High Density[b]	High Density
Sodium Building	3	Roof	High Density	High Density
		South Wall	3 side-by-side Direct Measurements Only	N/A
Waste Gas Building	3	Roof	High Density	High Density[c]
Inert Gas Building	3	Roof	High Density	High Density
Steam Generator Building	3	Roof	High Density	High Density[c]
North Exterior Wall of FRB	3	North Wall	Medium Density[b]	N/A
NOL – Open Land Area Inside Controlled Area	2	Concrete Pad	High Density	High Density[c]
Land Area Perimeter	3	Soil and/or concrete	N/A	Low Density[d]

[a]Due to safety concerns, scans were not performed within 6 feet of any roof edge.
[b]A scan map was not generated for this survey. Scan ranges were hand recorded on a field map.
[c]Only shielded gamma scans were performed.
[d]Follow-up shielded gamma scans were performed south of the Turbine Building due to elevated readings coming from a waste storage box stored in the Turbine Building.

5.1 REFERENCE SYSTEM

Indoor measurement locations were referenced to prominent site features or FSS locations and documented on site drawings provided by DTE. Exterior survey scans and direct measurement locations were referenced to prominent site features and/or Global Positioning System (GPS) coordinates and also documented on site drawings provided by DTE. The coordinate reference system used for the confirmatory survey was: North American Datum (NAD) 1983 UTM Zone 17N with units represented in meters.

5.2 Surface Scans

Confirmatory survey activities were strategically planned to take advantage of reduced radiation levels as a result of the Fermi 2 outage. Elevated radiation levels attributed to the operational Fermi 2 unit were observed while performing exterior scans during the first ORISE site visit in July 2010. Confirmatory survey activities preceded DTE's FSS activities in several exterior SUs to maximize ORISE's time on site during the outage. DTE also planned to complete their FSS activities in these SUs prior to the restart of Fermi 2. FSS results were considered (if available) to determine the level of confirmatory survey effort required to adequately represent each SU or to identify specific areas to focus scans within the SU. Interior building scans covered floors, lower walls, and accessible upper surfaces while exterior scans focused on roofs, exterior building walls, the land area surrounding Fermi 1, and the soil and concrete pad inside the controlled area. The surface scan coverage of the areas selected for confirmatory surveys varied based on the size and accessibility of the areas. Medium to high density scans were performed and focused in areas with the highest potential for contamination (i.e., cracks and joints in the floor and walls, other horizontal surfaces, surface run-off pathways, etc.). Refer to Table 1 for the list of SUs in which confirmatory survey activities were performed.

5.2.1 Interior Survey Units

Interior SU surfaces including floors, lower walls, and other accessible surfaces of the Decay Pool (FRB01-02) and East Sodium Gallery (ESG01-02) were scanned using large-area (floor monitor) and/or hand-held gas proportional detectors for direct alpha plus beta radiation and for gamma radiation using sodium iodide (NaI) detectors. All detectors were coupled to ratemeter-scalers with audible indicators.

5.2.2 Exterior Survey Units

Exterior SU surfaces were scanned using NaI scintillation detectors for direct gamma radiation (with the exception of vertical wall scans). After observing elevated radiation levels attributed to the partially dismantled Fermi 1 reactor vessel and a waste storage box on the 3rd floor of the Fermi 1 Turbine Building, ORISE opted to used DTE's gamma shield to perform surveys on the roofs of the Waste Gas and Steam Generator Buildings, the NOL (open land area and concrete pad inside the controlled area), as well as follow-up shielded gamma scans of the soil/slab area south of the

Turbine Building. DTE's gamma shield was constructed out of a carbon steel pipe having ¼ inch wall thickness and inner diameter of 3 inches.

Large-area or hand-held gas proportional detectors were also used to scan the building roofs, NOL concrete pad, and the north wall of the Fuel and Reactor (FRB) building for alpha plus beta radiation. All detectors were coupled to ratemeter-scalers with audible indicators and were also coupled to a GPS unit that enabled real-time recording of both position and count rates in one-second intervals (with the exception of GPS being used to document scans on the north wall of the FRB). Figures A-5 through A-21 show the exterior alpha plus beta and gamma scan results for rooftops, NOL pad, and soil areas. Due to safety concerns, scans were not performed within six feet of any roof edge. Additionally on the building rooftops, limited scans were also performed of roof vents and other structures. These additional scan results were not collected with detectors coupled to GPS units, therefore the scan results are not included in the figures; however, no elevated radiation levels were observed on these items.

5.3 SURFACE ACTIVITY MEASUREMENTS

Direct measurements to quantify total alpha plus beta activities were performed at select FSS (side-by-side) locations and other judgmental locations. ORISE performed two direct measurements on the north wall of the decay pool at FSS locations (see Figure A-3). Smears were also collected from the decay pool direct measurement locations to determine if there was removable gross alpha and/or gross beta activity. Additionally, one direct measurement was collected on the upper roof of the FRB; however, no smear was collected due to the tar and gravel roof make-up (see Figure A-5).

During the ORISE site visit, DTE was performing FSS measurements on the exterior of the Sodium Building. ORISE performed side-by-side alpha plus beta measurements at three FSS locations on the south exterior wall of the Sodium Building (see Figure A-4).

Direct measurements were collected using hand-held gas proportional detectors coupled to ratemeter-scalers.

5.4 SOURCE MEASUREMENT COMPARISON

As a follow-up to the surface activity data comparison performed during the first site visit in July 2010, ORISE provided three National Institute of Standards and Technology (NIST) traceable calibration sources for a side-by-side source measurement comparison. The sources included SrY-90, Tc-99, and Tl-204. DTE also provided a Tc-99 source for comparison. ORISE performed alpha plus beta measurements on the sources using ORISE instrumentation alongside DTE personnel using their FSS instrumentation. Both ORISE and DTE used comparable gas proportional detectors (Ludlum Model 43-68) coupled to ratemeter-scalers. Each source was measured separately and then all three were placed under the same detector. DTE's procedure requires the use of an acrylic jig with an approximate ¼ inch standoff for all measurements. ORISE collected measurements on contact with the sources (per ORISE procedure) and also used DTE's ¼ inch standoff jig for comparison of the counts per minute (cpm) values. The values for both the ORISE and DTE measurements were recorded by ORISE. DTE committed to forward their conversions from cpm to surface activity in disintegrations per minute (dpm)/100 cm^2 at a later date after the appropriate FSS Engineer had performed the calculations and the data were approved for release.

6.0 SAMPLE ANALYSIS AND DATA INTERPRETATION

Smear samples and data were returned to the ORISE facilities in Oak Ridge, Tennessee for analysis and interpretation. Analyses of the two smears collected in the decay pool were performed in accordance with the ORISE Laboratory Procedures Manual (ORISE 2010b). Smear samples collected for the quantification of gross alpha/beta activity were analyzed using a low-background proportional counter. Analytical smear results were reported in units of dpm. Direct measurement data were converted from cpm to units of dpm/100 cm^2. The data generated were compared with the approved $DCGL_W$s established for the Fermi 1 site.

7.0 APPLICABLE SITE GUIDELINES

The primary ROCs at the Fermi 1 site are beta-gamma emitters—fission and activation products—resulting from reactor operation. Table B-1 provides both the surface activity and soil concentration DCGLs. The $DCGL_W$ values were compared with the FSS measurements to determine compliance with the 25 millirem per year (mrem/yr) unrestricted use criterion. The average residual radioactivity above background must be less than or equal to the $DCGL_W$. For mixtures of radionuclides, the sum of the ratios of the contaminant's concentration over the contaminant's $DCGL_W$ must be less or equal to one (DTE 2010b).

During site characterization activities the licensee determined the specific ROCs for the site. The presence of multiple radionuclides was determined by analyzing concrete cores, smears, and other sample media. These data were used in developing gross activity $DCGL_{GA}$ values for all Fermi 1 SUs (DTE 2010b).

The gross activity $DCGL_{GA}$ values were calculated using the following equation:

$$DCGL_{GA} = \frac{1}{\frac{f_1}{DCGL_1} + \frac{f_2}{DCGL_2} + \cdots \frac{f_n}{DCGL_n}}$$

Where: $DCGL_{GA}$ = gross activity DCGL

f_n = fraction of the total activity contributed by radionuclide n, and

$DCGL_n$ = DCGL for radionuclide n.

The final, conservative $DCGL_{GA}$ of 28,000 dpm/100 cm^2 is being applied to all SUs with the exception of the FRB Hot Sump SU in which the DCGL is 11,000 dpm/100 cm^2. The lower Co-60 DCGL was selected for the FRB Hot Sump due to Co-60 comprising a larger fraction of the radionuclide mix in this SU in comparison to all other SUs.

8.0 FINDINGS AND RESULTS

The results for each of the verification activities are discussed on the proceeding pages.

8.1 DOCUMENT REVIEW

The ORISE reviews of DTE's stand-alone FSS packages initially indicated that the FSS methods were appropriate and that the resultant data were acceptable. However, after receiving DTE's calculations for the side-by-side source measurement comparison and reviewing the instrument calibration sheets, issues with the DTE procedures were identified. Section 8.4 describes these issues in further detail.

8.2 SURFACE SCANS

Surface scan results for the interior and exterior SUs are discussed below.

8.2.1 Interior Survey Units

Surface scans of the accessible surfaces of the Decay Pool (FRB01-02) and East Sodium Gallery (ESG01-02) did not identify elevated radiation levels of concern. ORISE calculated action levels based on the specific ORISE instrumentation used for surveys and the corresponding $DCGL_{GA}$ for the SUs. The maximum scan results for each SU were above background levels but, far below the action level determined for the SUs and the associated $DCGL_{GA}$.

8.2.2 Exterior Survey Units

Figures A-5 through A-21 show the exterior alpha plus beta and gamma scan results for the building roofs and soil/slab areas. The maximum radiation levels are attributed to either the partially dismantled reactor vessel or the waste storage box on the 3rd floor of the Turbine Building. Radiation levels greatly increased when in direct line-of-sight of these items (for both the gamma detectors and directionally for the gas proportional detectors). ORISE used DTE's gamma detector shield while performing gamma scans on the roofs of the Waste Gas and Steam Generator Buildings, the NOL Open Land Area (inside the controlled area), and during follow-up scans of the soil/slab area south of the Turbine Building which reduced the radiation levels observed. As depicted in the comparison of gamma scans in Figures A-20 and A-21 for the area south of the Turbine Building, the highest unshielded radiation levels of +20,000 cpm south of the Turbine Building were reduced to 10,000 cpm to 12,000 cpm using the detector shield. Refer to Table B-2 for the minimum detectable concentration (MDC) calculations performed by ORISE during site activities to determine the approximate Co-60 and Cs-137 concentrations that could be identified with the elevated background levels observed. The calculations demonstrated that the Cs-137 $DCGL_W$ of 17.0 picocuries per gram (pCi/g) was detectable at a background of 12,000 cpm (with an MDC_{SCAN} of 11.8 pCi/g) while the calculated Co-60 MDC_{SCAN} was 6.3 pCi/g which is slightly higher than the Co-60 $DCGL_W$ of 5.1 pCi/g. For comparison, the NUREG-1507 Table 6.4 "default" values for 2×2 NaI scintillation detectors are listed as 3.4 pCi/g for Co-60 and 6.4 pCi/g for Cs-137, based on a background of 10,000 cpm and a d'=1.38. The standard ORISE confirmatory survey MDC_{SCAN} calculation is based on a d' value of 2.32 which results in an increased MDC_{SCAN} but with the benefit a reduced false positive rate. ORISE was confident the elevated radiation levels could be attributed to the waste storage box in the Turbine Building and not indicative of contamination in soil.

8.3 Surface Activity Measurements

Table 2 provides surface activity measurements and represents gross levels that have not had background contributions subtracted, per the DTE FSS data reporting procedure.

TABLE 2: SURFACE ACTIVITY SUMMARY					
Measurement Location	ORISE (dpm/100 cm²)		DTE (dpm/100 cm²)		DTE: ORISE Ratio
	(cpm)	(dpm/100 cm²)	(cpm)	(dpm/100 cm²)	
Sodium Building – South Exterior Wall[a]					
FSS-NAB01-04-002-F-M	413	1,561	344	2,195[a]	1.4
FSS-NAB01-04-017-F-M	420	1,587	332	2,119[a]	1.3
FSS-NAB01-04-020-F-M	370	1,398	324	2,068[a]	1.5
Decay Pool					
FSS-FRB01-02-013-F-M	353	1,273	405	2,446[a]	1.9
FSS-FRB01-02-019-F-M	323	1,165	459	2,772[a]	2.4
Fuel and Reactor Building – Upper Roof					
4647886.8 N, 312893 E	637	2,407	NA[b]	NA[b]	--

[a]DTE's surface activity values reflect revised values following resolution of issues described in Section 8.4.
[b]ORISE judgmental location. DTE did not perform a measurement.

8.4 Source Measurement Comparison

The side-by-side source comparison measurements ORISE collected in conjunction with DTE were a follow-up evaluation to the surface activity data comparison performed during the first site visit in July 2010. The initial results of the July 2010 surface activity data comparison first identified that DTE's reported 1-minute counts were much lower than the expected levels and potentially was the cause of the observed systematic non-conservative bias—DTE's results were consistently reported an average of 40% below the ORISE result. After this original observation was provided to the NRC and DTE, DTE issued NSEF-10-0027 *Fermi 1 Final Status Survey DCGL Selection for Survey Units*, which describes how a weighted surface efficiency factor was applied to the calculations to correct the observed bias (DTE 2010b). The results were reevaluated and the final DTE results were reported 20 percent higher on average than the ORISE values and at that time determined to be an acceptable and conservative systematic bias. For the second site visit, ORISE provided three known activity calibration sources to perform another side-by-side comparison (and of higher activity) to ensure the issue was resolved. DTE also provided a source for comparison. The cpm values measured by DTE and ORISE were very comparable, as shown in Table 3. However, DTE's reported dpm/100 cm^2 activity levels again exhibited a non-conservative bias (also shown in Table 3). After reviewing DTE's calibration sheet for the instrument used for the source comparison measurements, one of the major issues identified was DTE's use of the 4π emission information from the calibration sheet as opposed to ORISE using the 2π emission rate. Additionally, DTE applied a source efficiency (ε_s) of one in each calculation.

DTE's project documentation indicates the guidance and recommendations of MARSSIM are being followed. However, MARSSIM recommends using the 2π instrument efficiency (ε_i) and then applying the appropriate ε_s based on radiation type and energy (see ISO 7503-1 for recommendations). On January 13, 2011, the NRC forwarded the ORISE findings to DTE and requested they reevaluate their calculations and respond as appropriate. On February 14, 2011, DTE issued NSEF-11-004 *Issues with Beta Surface Measurements* in response (DTE 2011). In this document DTE concurred that the activity should have been calculated using the 2π ε_i from the calibration sheet and applying the appropriate ε_s based on the recommendations of ISO 7503-1. Additionally, DTE opted to apply a 10% correction to the calculations to account for the source-geometry. Refer to Table 3 for the source comparison information originally submitted by DTE and then to Table 4 for the revised DTE calculations.

TABLE 3: SOURCE COMPARISON DIRECT MEASUREMENT RESULTS						
Source	DTE Data using ¼ in standoff		ORISE Data on contact		ORISE Data using ¼ in standoff	DTE: ORISE Ratio
	cpm	(dpm/100cm²)[a] ε_{total}[b]	cpm	(dpm/100cm²)[c] ε_{total}[d]	cpm	
ORISE SrY-90 #425	15,255	35,777	15,514	44,724	14,370	0.80
ORISE Tc-99 #92TC3202962	31,380	110,289	31,886	227,900	28,034	0.48
ORISE Tl-204 #501	2,232	--[e]	2,379	5,692	2,096	--
Fermi Tc-99 #5774-07	1,379	3,973	1,394	7,900	NA[f]	0.50
All 3 ORISE sources together	45,817	--	47,121	168,911	NA	--

[a]DTE calculation from cpm to dpm/100cm² = (cpm value – 258 instrument background)/(0.803 * ε_{total}* 1.26); where 0.803 = correction factor applied for standoff, 1.26 = probe geometry correction factor
[b]$\varepsilon_{total} = \varepsilon_i * \varepsilon_s$; where ε_s = 1 (used for each source); ε_i = 4π value from calibration sheet (Tc-99 = 0.28, SrY-90 = 0.41)
[c]ORISE calculation from cpm to dpm/100cm² = (cpm value – 299 instrument background)/(ε_{total}* 1.26); where 1.26 = probe geometry correction factor
[d]$\varepsilon_{total} = \varepsilon_i * \varepsilon_s$; where ε_s = 0.25 for Tc-99 and 0.5 for SrY-90 and Tl-204; ε_i = 2π value from calibration sheet (Tc-99 = 0.45, SrY-90 = 0.54, Tl-204= 0.57)
[e]Not reported
[f]Not collected

TABLE 4: REVISED SOURCE COMPARISON DIRECT MEASUREMENT RESULTS						
Source	DTE Data using ¼ inch standoff		ORISE Data on contact		ORISE Data using ¼ inch standoff	DTE: ORISE Ratio
	cpm	(dpm/100cm²)[a] ε_{total}[b]	cpm	(dpm/100cm²)[c] ε_{total}[d]	cpm	
ORISE SrY-90 #425	15,255	63,048	15,514	44,724	14,370	1.4
ORISE Tc-99 #92TC3202962	31,380	347,155	31,886	227,900	28,034	1.5
ORISE Tl-204 #501	2,232	--[e]	2,379	5,692	2,096	--
Fermi Tc-99 #5774-07	1,379	12,504	1,394	7,900	n/a[f]	1.6
All 3 ORISE sources together	45,817	--	47,121	168,911	n/a	--

[a]DTE calculation from cpm to dpm/100cm² = [(cpm value – 258 instrument background)/(0.701 * ε_{total}* 1.26)]*1.10; where 0.701 = correction factor applied for standoff, 1.26 = probe geometry correction factor, and 1.10 is to account for a 10% correction applied for source geometry corrections
[b]$\varepsilon_{total} = \varepsilon_i * \varepsilon_s$; where ε_s = 1 (used for each source); ε_i = 2π value from calibration sheet (Tc-99 = 0.45, SrY-90 = 0.59)
[c]ORISE calculation from cpm to dpm/100cm² = (cpm value – 299 instrument background)/(ε_{total}* 1.26); where 1.26 = probe geometry correction factor
[d]$\varepsilon_{total} = \varepsilon_i * \varepsilon_s$; where ε_s = 0.25 for Tc-99 and 0.5 for SrY-90 and Tl-204; ε_i = 2π value from calibration sheet (Tc-99 = 0.45, SrY-90 = 0.54, Tl-204= 0.57)
[e]Not reported
[f]Not collected

The final DTE:ORISE ratio averaged 1.5, an acceptable and conservative systematic bias considering the correction factors applied in the DTE calculations.

The instrument/detector combinations used for the source comparison measurements were:

- ORISE—Ludlum Model 2221 ratemeter-scaler coupled to a Ludlum Model 43-68 gas proportional detector
- DTE—Ludlum Model 2350-1 data-logger coupled to a Ludlum Model 43-68 detector. DTE also used an acrylic spacer that provided an approximate ¼ inch stand-off from the surface being surveyed

8.5 SURFACE ACTIVITY DATA COMPARISON

ORISE collected three "side-by-side" measurements in conjunction with DTE's FSS activities on the south exterior wall of the Sodium Building (SU NAB01-04). The in-process measurements were collected at the same location immediately following DTE's measurement. Table 2 presents the comparison of the ORISE field measurements and calculated surface activity values to DTE's values. ORISE surface activity values represent gross activity that has not been corrected for background contributions for consistency with the DTE FSS data reporting procedure. The instrument/detector combinations used were the same as described above for the source comparison measurements.

The final DTE:ORISE ratios for the measurements collected from the Sodium Building and the Decay Pool averaged 1.7, an acceptable and conservative systematic bias considering the correction factors applied in the DTE calculations.

9.0 COMPARISON OF RESULTS WITH GUIDELINES

There were no direct measurements collected as a result of ORISE identifying elevated radiation levels of concern. The total surface activity values of the six direct measurements collected were directly compared with the licensee's survey unit-specific gross activity $DCGL_{GA}$. All surface activity levels were well below the corresponding $DCGL_{GA}$. Laboratory analysis of the two smears collected from the Decay Pool did not identify removable contamination.

10.0 SUMMARY

At the request of the NRC, ORISE conducted confirmatory surveys of the Fermi 1 facility during the period of November 1 through 4, 2010. The survey activities included visual inspections and measurement and sampling activities. Confirmatory activities also included the review and assessment of the licensee's project documentation and methodologies.

ORISE's survey data verifies that the radiological conditions of the confirmatory SUs are below the $DCGL_{GA}$ value requirements as stated in the DTE's FSS Plan (DTE 2010b). Confirmatory survey activities validated the SU classifications, radiological status and, satisfaction of the guidelines.

Although several calculational issues were identified as a result of the side-by-side source comparison measurements, DTE corrected the issues appropriately as described in Section 8.4.

It is also important to note when DTE issued NSEF-11-004 *Issues with Beta Surface Measurements* in response to the discrepancies identified in the source comparison measurements, their investigation also identified other calculational errors in their LTP characterization data, Historical Site Assessment (HSA) data, and the draft FSS Plans. In the case of the LTP characterization data calculations, the 2π ε_i, the appropriate ε_s, and the actual probe area of 126 cm^2 (verses the 100 cm^2 nominal area) should have been applied. When each of these items was corrected, an increase of approximately 62% (correcting a significant nonconservative bias) was observed (DTE 2011). DTE reviewed all the corrected data and determined the increase in activity did not affect any of the original SU classification decisions. The HSA data were calculated in a similar manner and DTE determined the data does not need updating since it was used as input into Section 2 of the LTP and does not enter into other aspects of the FSS program (DTE 2011).

The calculations in the draft FSS packages applied an appropriate weighted source efficiency, but similarly the 2π ε_i, the appropriate ε_s, and the actual probe area of 126 cm^2 (verses the 100 cm^2 nominal area) were not applied. When each of these items was corrected, a decrease of approximately 30% was observed (DTE 2011).

DTE was forthcoming with information regarding the side-by-side source comparison measurement discrepancies identified during the confirmatory survey. DTE resolved the non conservative bias in the surface activity values between the ORISE and DTE calculations and also identified and corrected other calculational issues as summarized above and in NSEF-11-004 *Issues with Beta Surface Measurements* (DTE 2011).

DTE's FSS data packages were revised to correct the calculations. The packages reviewed by ORISE accurately and adequately described the radiological conditions at the site and followed MARSSIM recommendations.

11.0 REFERENCES

Detroit Edison Energy (DTE). *Enrico Fermi Atomic Power Plant, Unit 1 License Termination Plan, Revision 2*. Newport, MI; March 23, 2010a.

DTE. *NSEF-10-0027 Fermi 1 Final Status Survey DCGL Selection for Survey Units*. Newport, MI; July 29, 2010b.

DTE. *NSEF-11-0004 Issues with Beta Surface Measurements*. Newport, MI; February 14, 2011.

Oak Ridge Associated Universities (ORAU). *Quality Program Manual for the Independent Environmental Assessment and Verification Program*. Oak Ridge, TN; October 29, 2010.

Oak Ridge Institute for Science and Education (ORISE). *Survey Procedures Manual for the Independent Environmental Assessment and Verification Program*. Oak Ridge, TN; May 1, 2008.

ORISE. *Survey Project-Specific Plan for the Decommissioning of the Enrico Fermi Atomic Power Plant, Unit 1*. Oak Ridge, TN; May 28, 2010a.

ORISE. *Laboratory Procedures Manual for the Independent Environmental Assessment and Verification Program*. Oak Ridge, TN; December 31, 2010b.

U.S. Nuclear Regulatory Commission (NRC). *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), NUREG-1575; Revision 1*. Washington, DC; August 2000.

APPENDIX A
FIGURES

Figure A-1: Location of the Detroit Edison Enrico Fermi Atomic Power Plant, Units 1 and 2

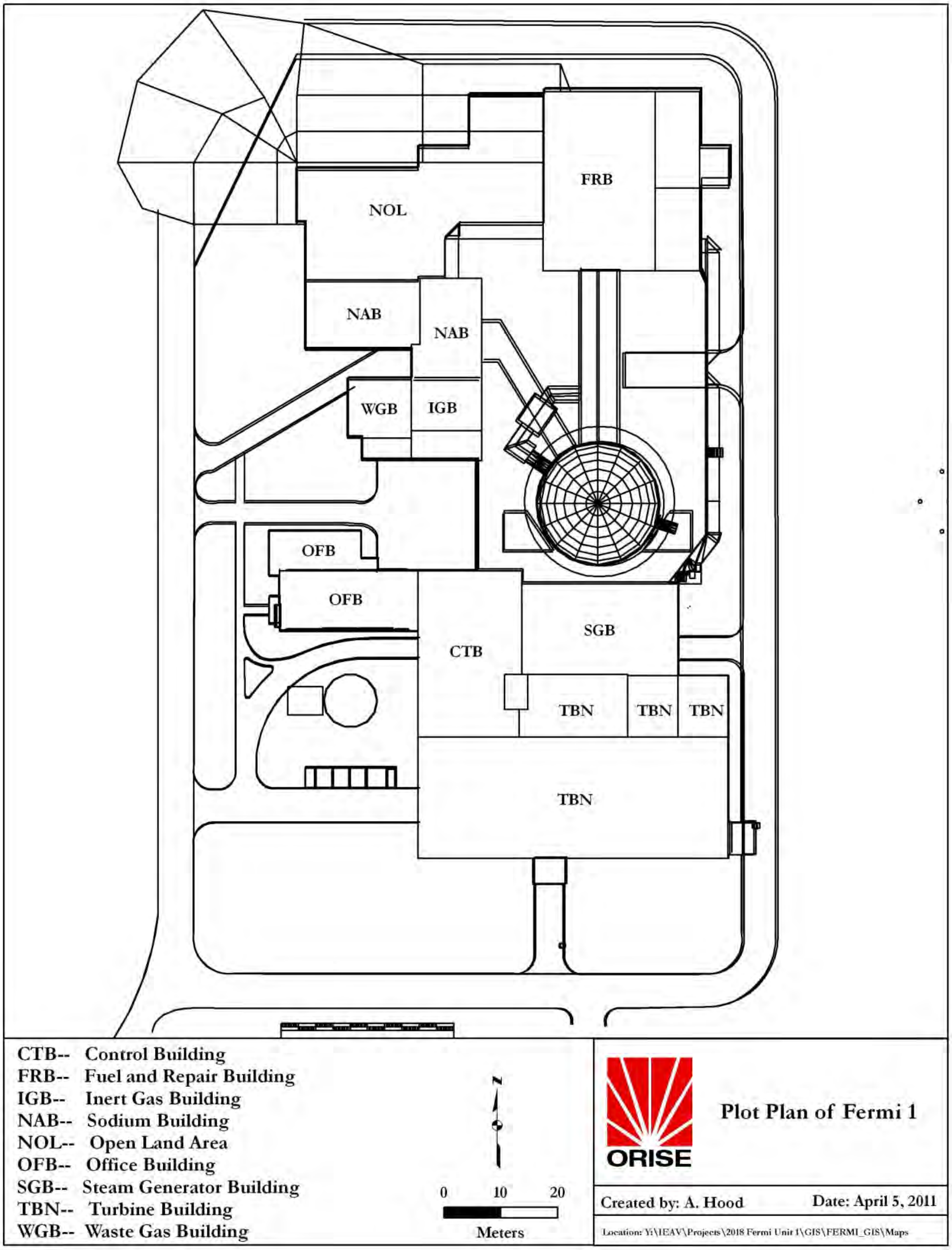

Figure A-2: Enrico Fermi Atomic Power Plant, Unit 1 Plot Plan

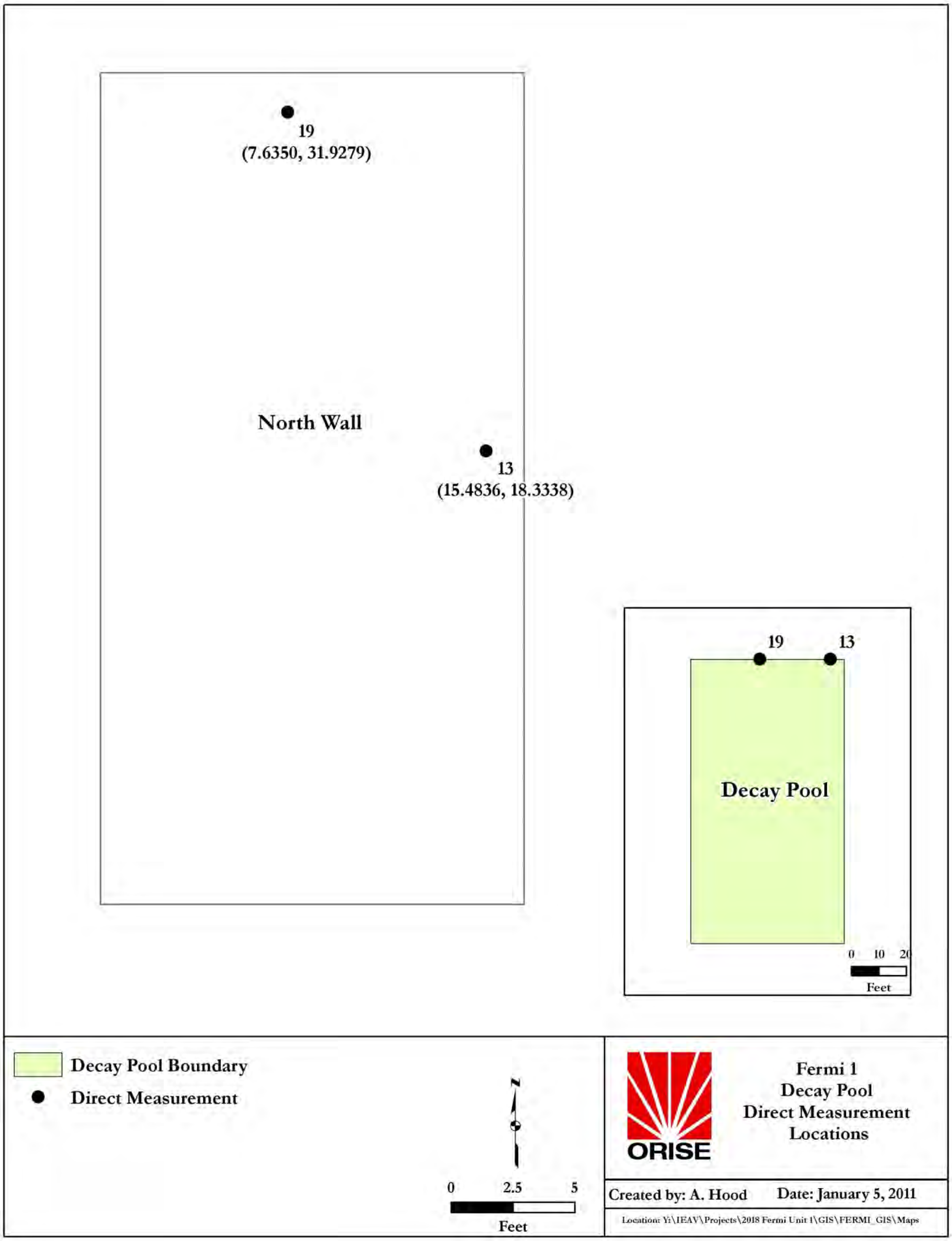

Figure A-3: Decay Pool Direct Measurement Locations

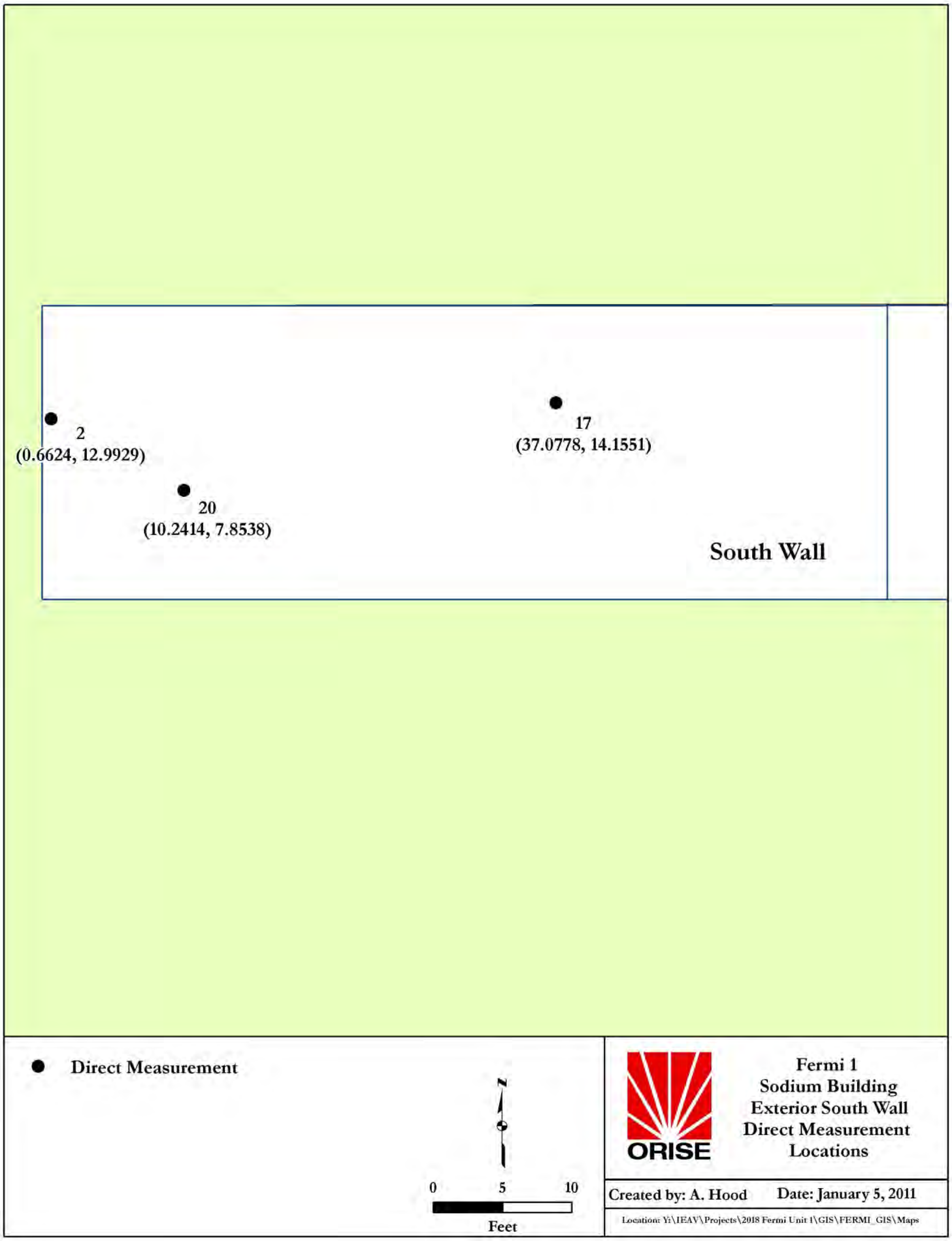

Figure A-4: Sodium Building, Exterior South Wall—Direct Measurement Locations

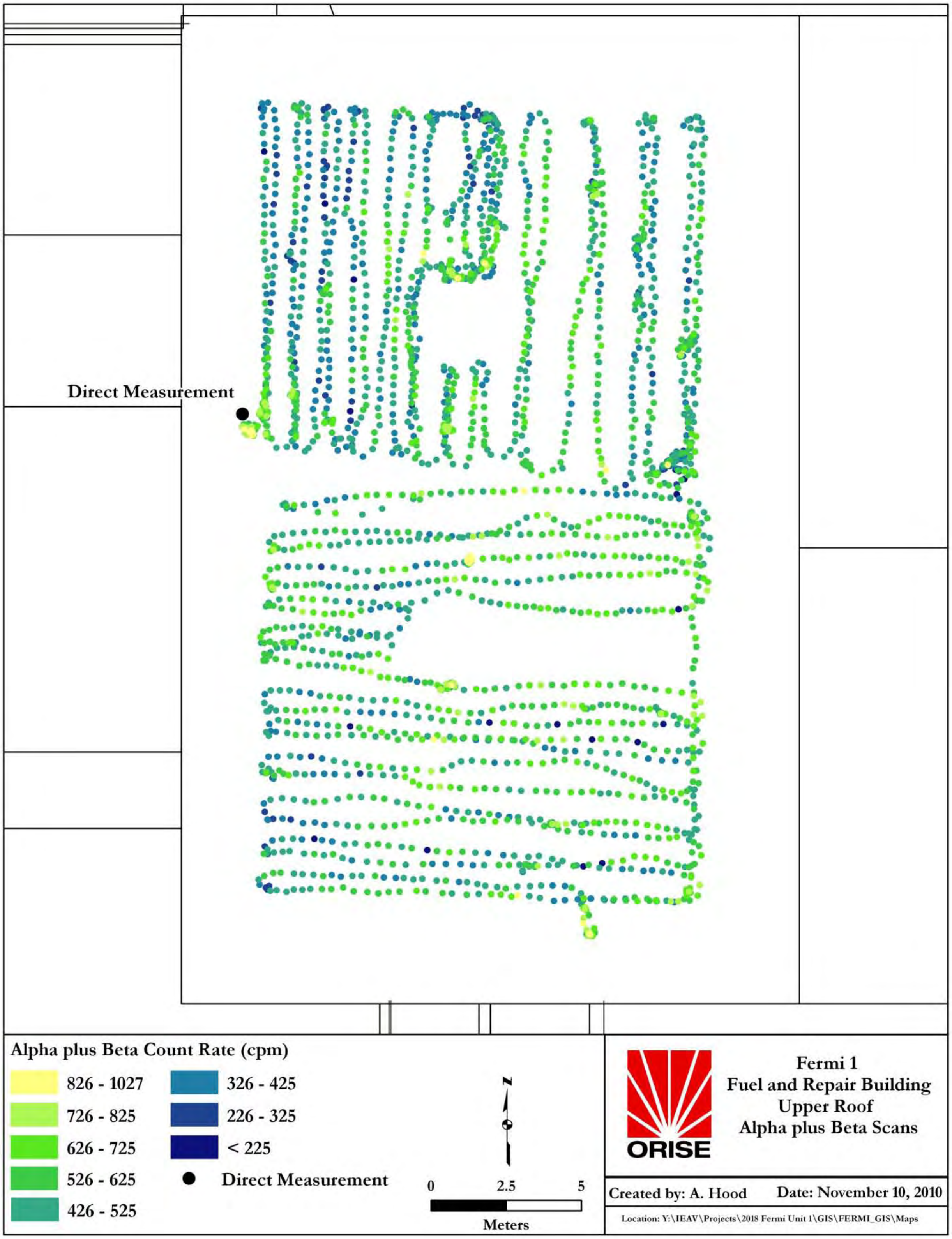

Figure A-5: Fuel and Repair Building, Upper Roof—Alpha plus Beta Scans

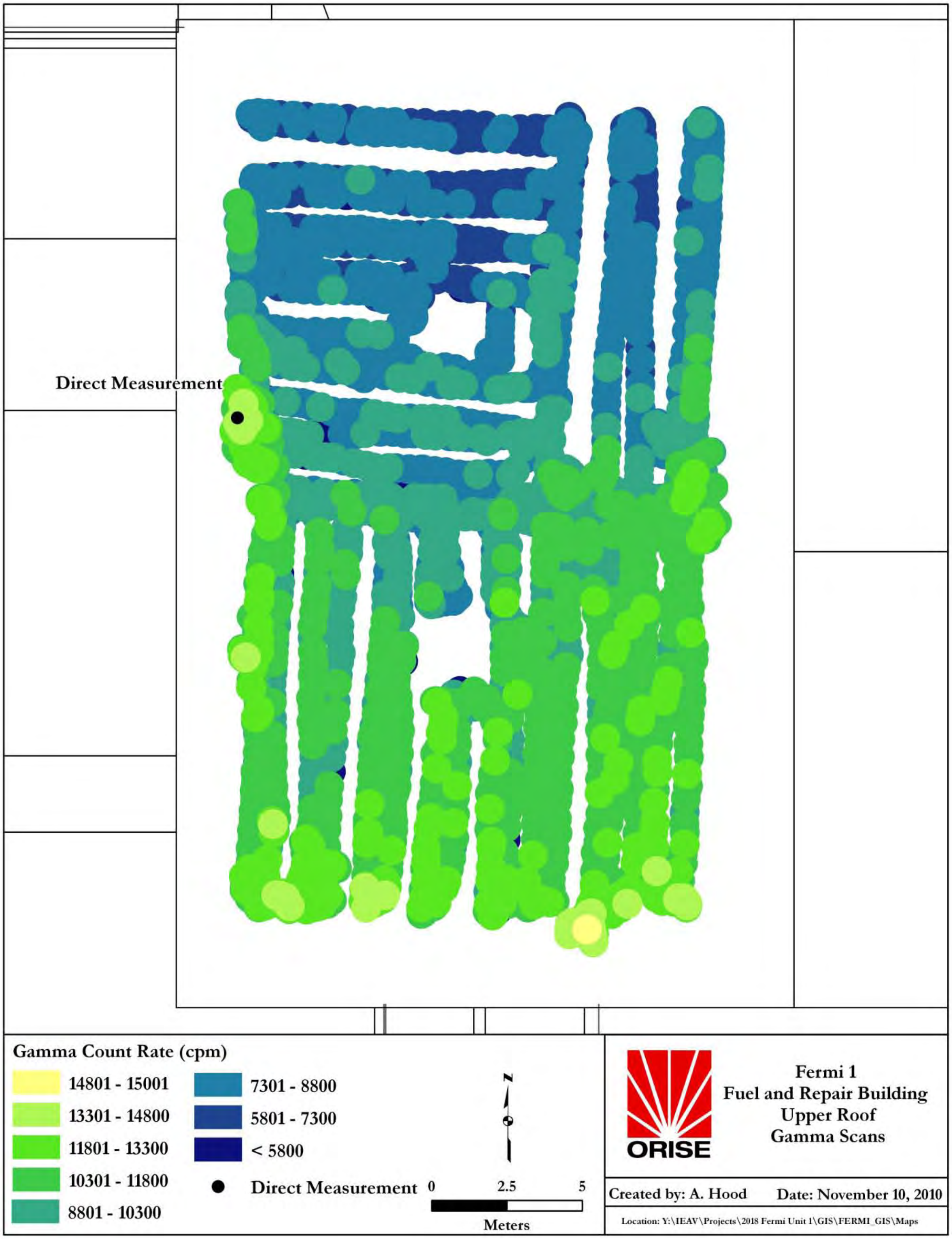

Figure A-6: Fuel and Repair Building, Upper Roof—Gamma Scans

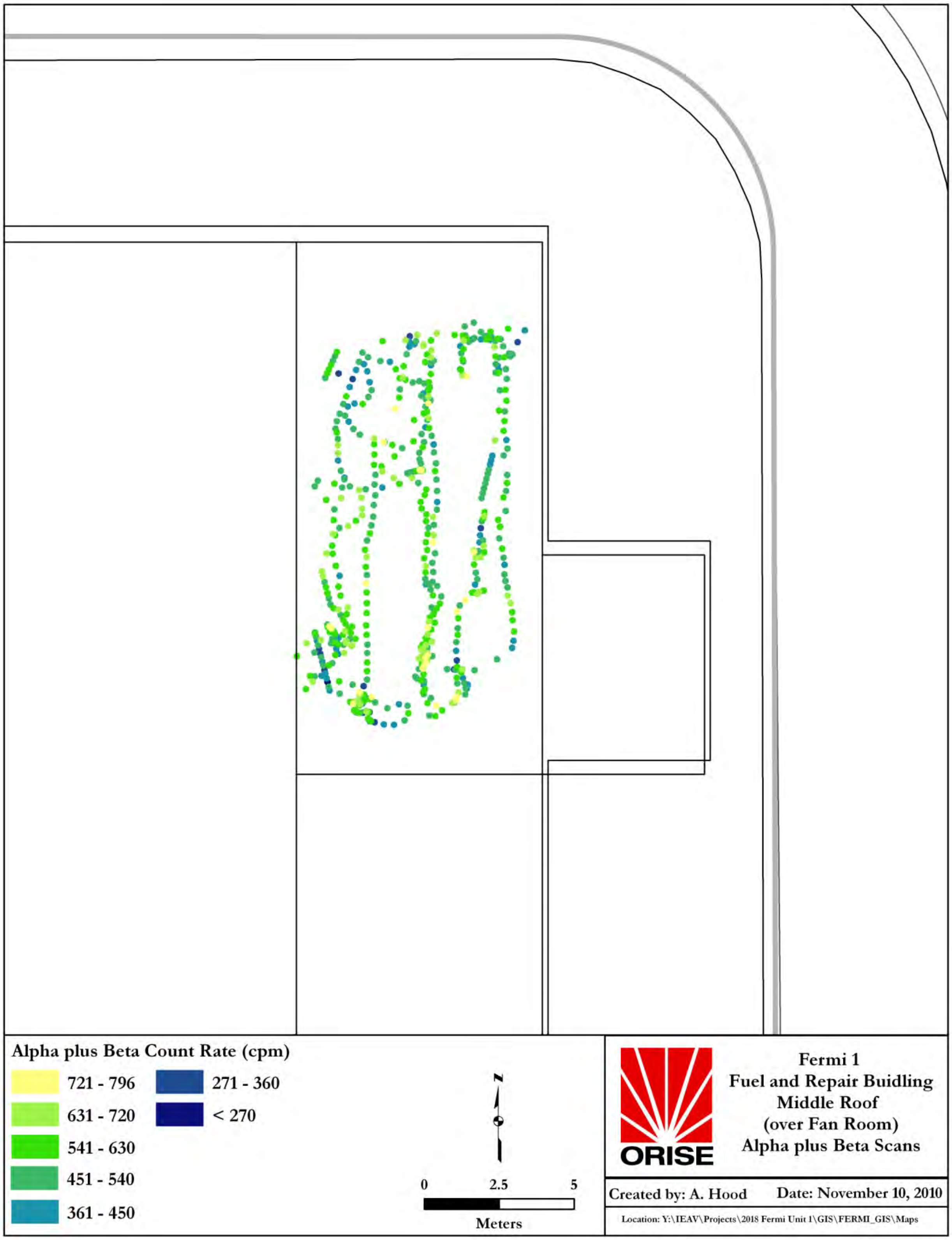

Figure A-7: Fuel and Repair Building, Middle Roof Over Fan Room—Alpha plus Beta Scans

Figure A-8: Fuel and Repair Building, Middle Roof Over Fan Room—Gamma Scans

Figure A-9: Fuel and Repair Building, Lower Roof Over Decay Pool—Gamma Scans

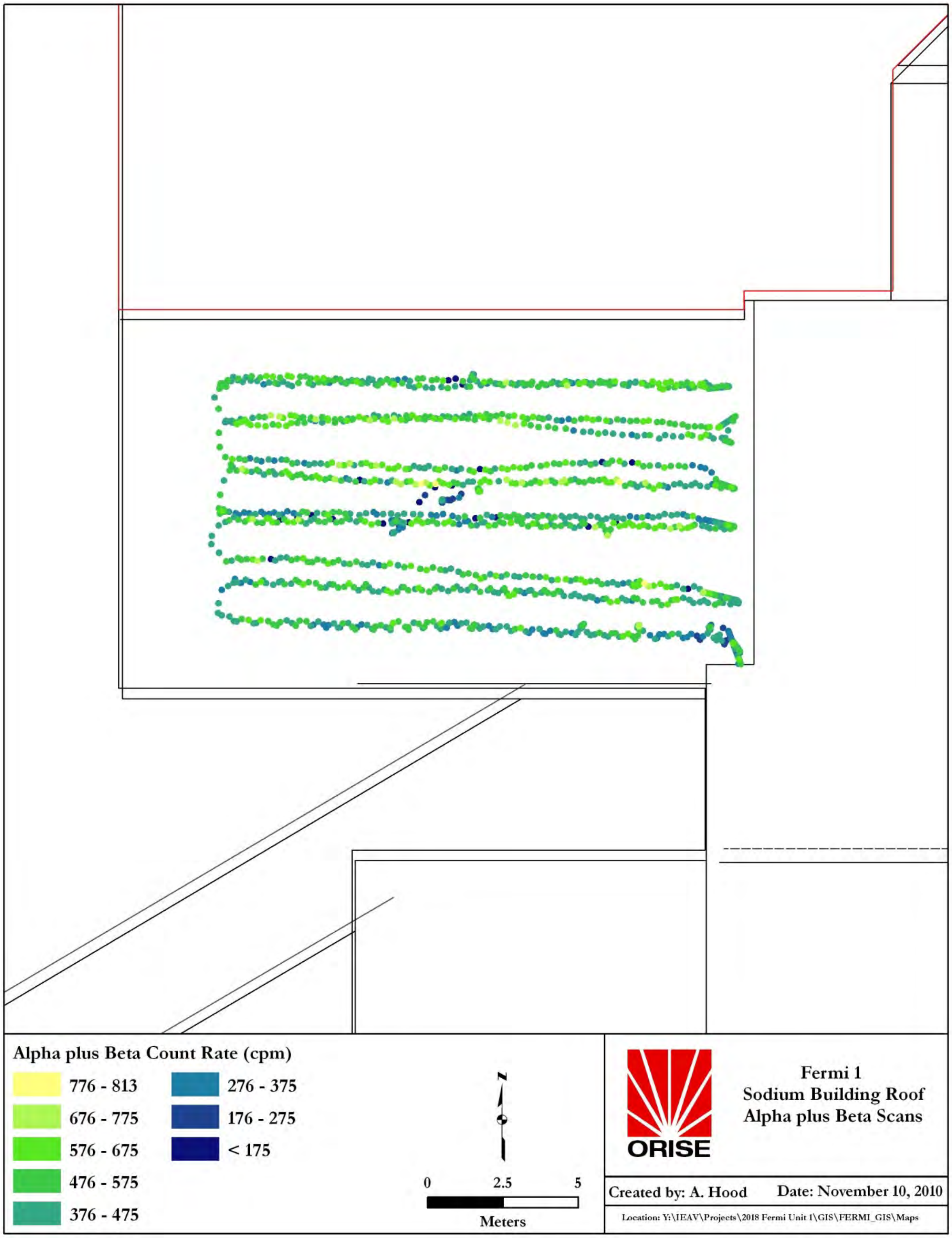

Figure A-10: Sodium Building Roof—Alpha plus Beta Scans

Figure A-11: Sodium Building Roof—Gamma Scans

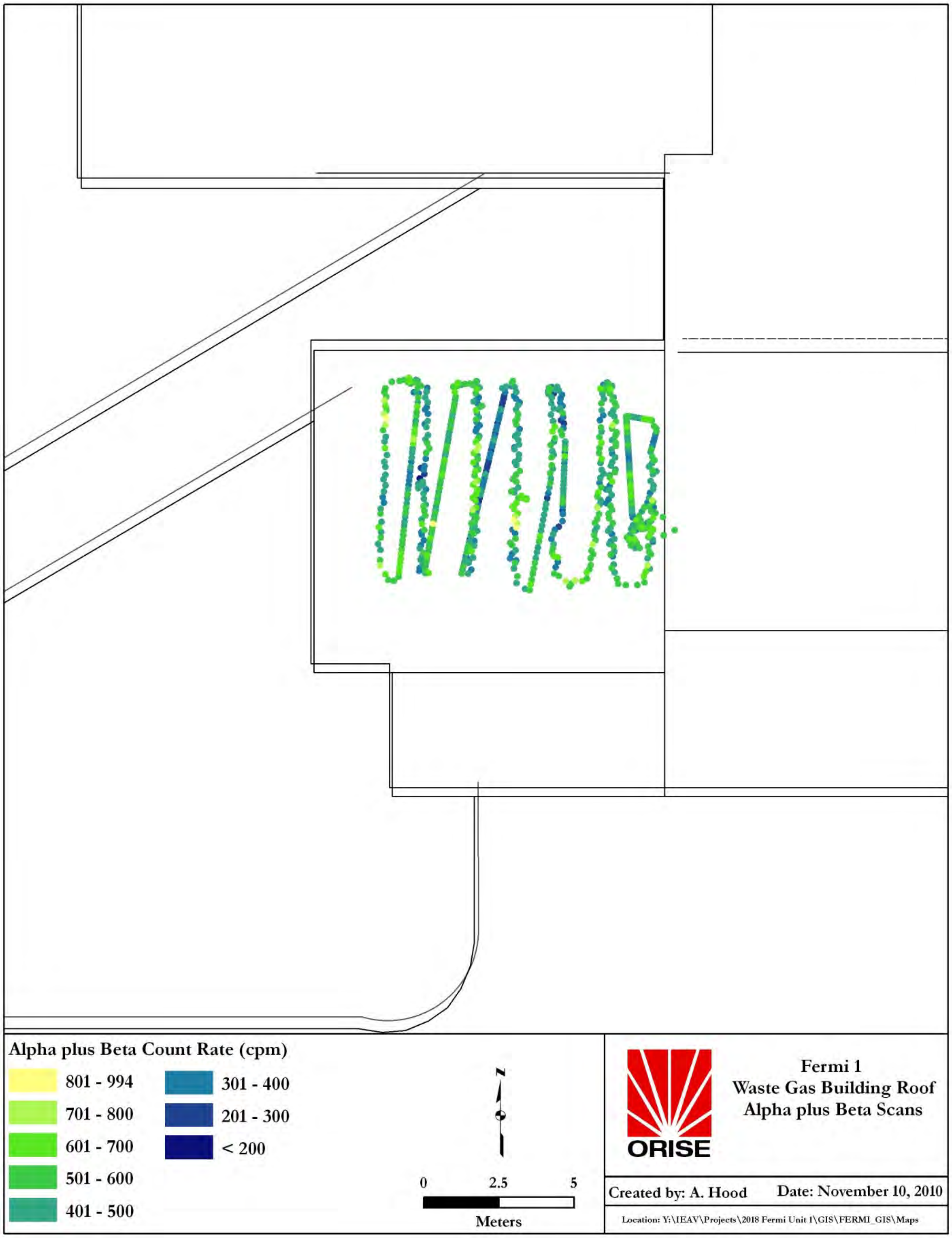

Figure A-12: Waste Gas Building Roof—Alpha plus Beta Scans

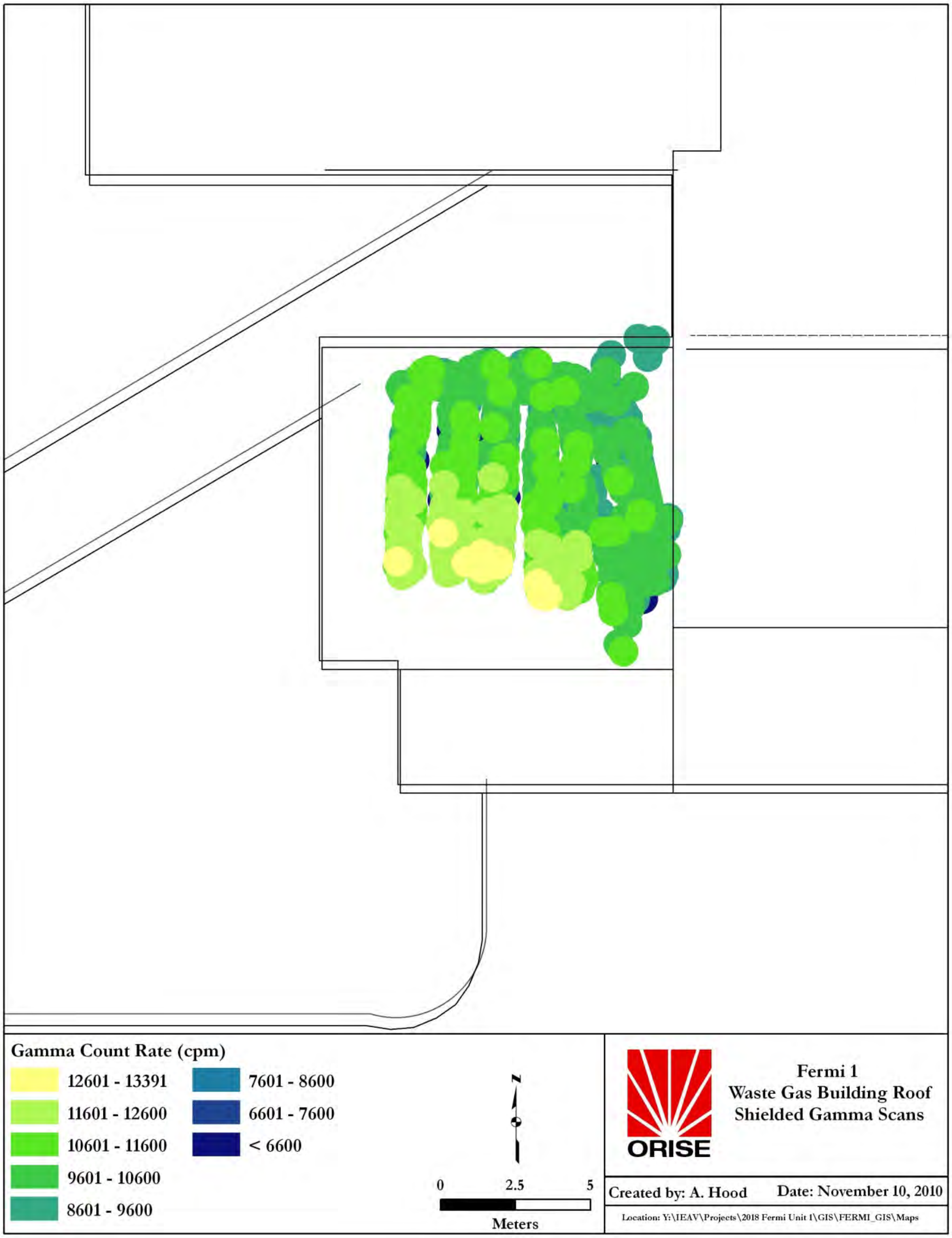

Figure A-13: Waste Gas Building Roof—Shielded Gamma Scans

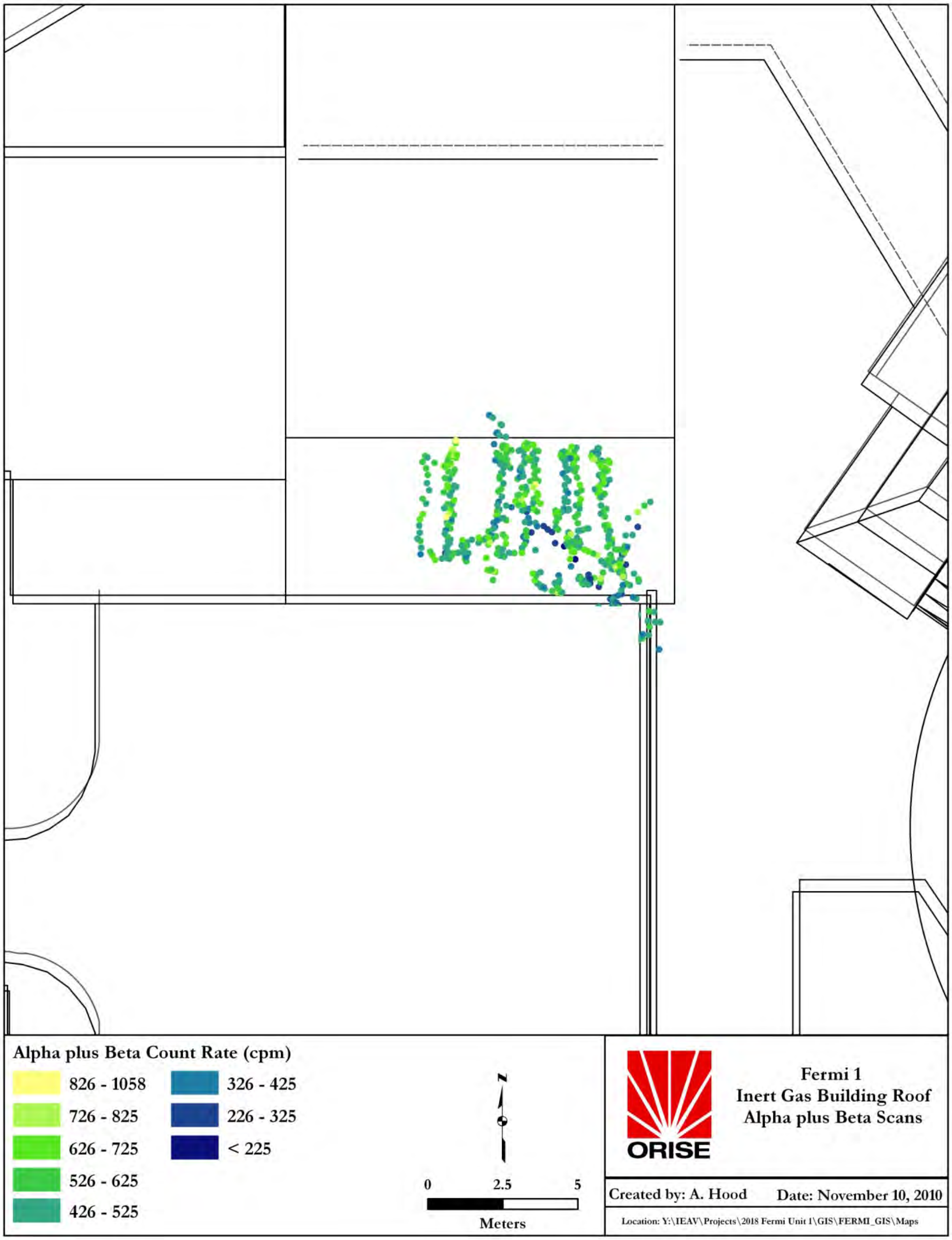

Figure A-14: Inert Gas Building Roof—Alpha plus Beta Scans

Figure A-15: Inert Gas Building Roof—Gamma Scans

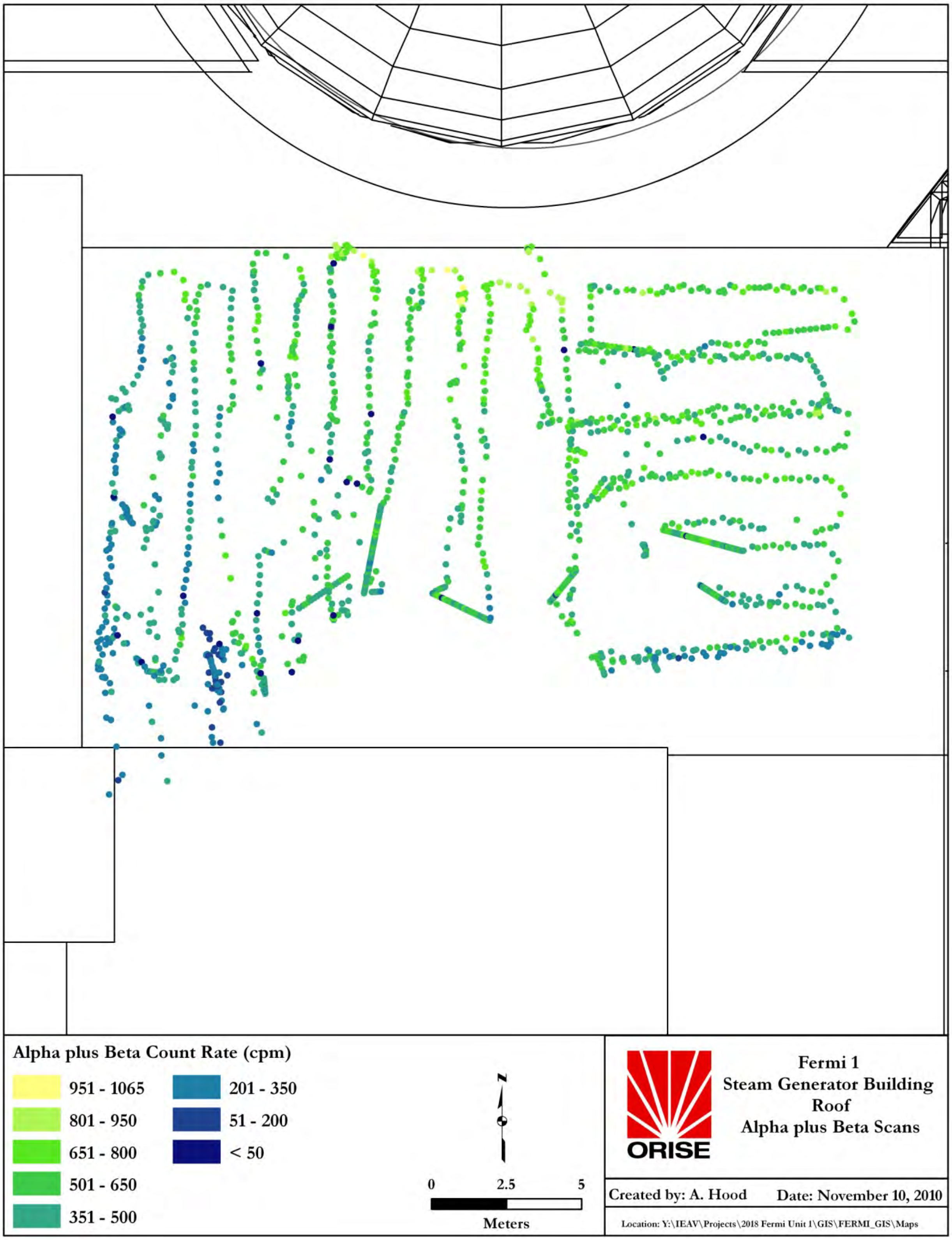

Figure A-16: Steam Generator Building Roof—Alpha plus Beta Scans

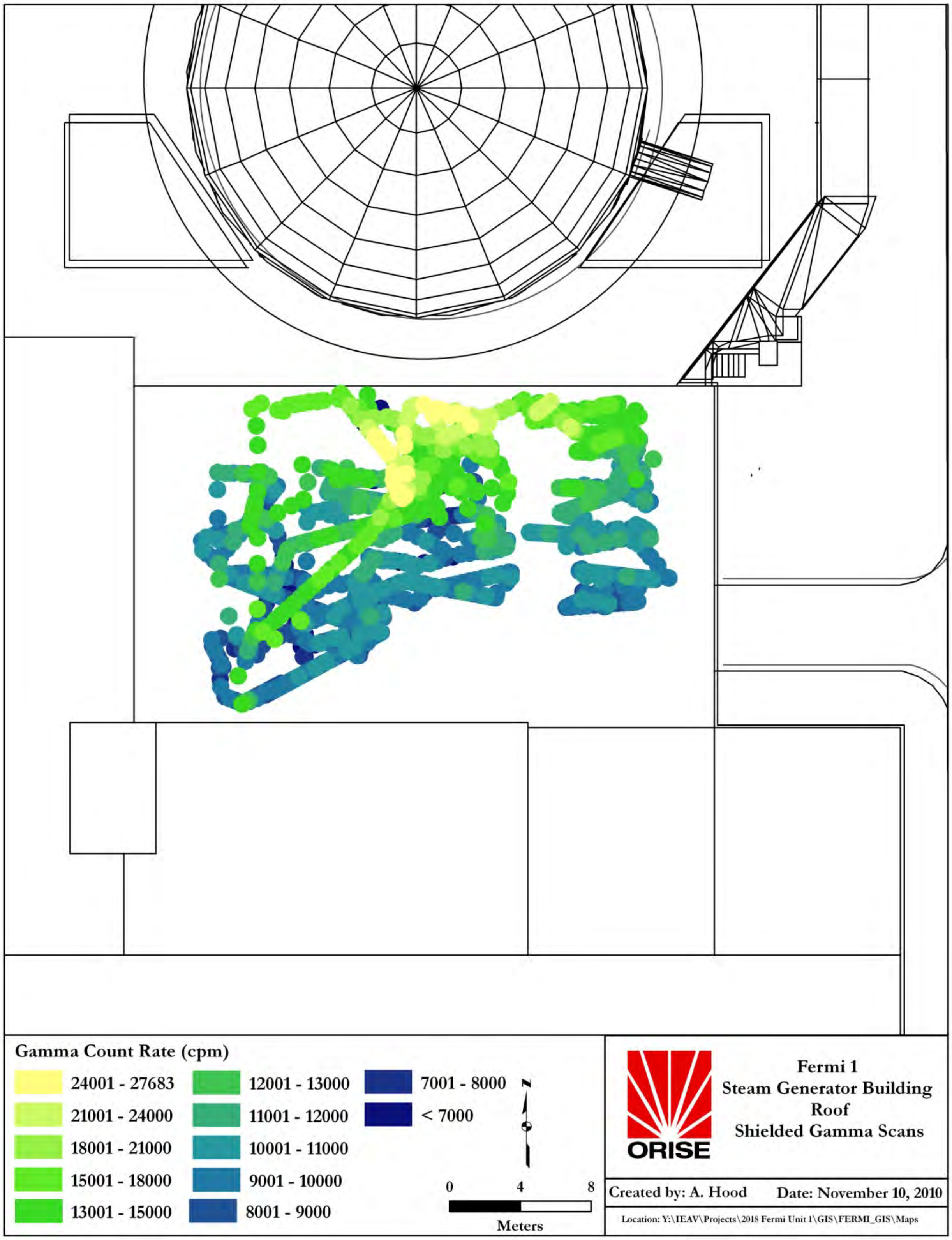

Figure A-17: Steam Generator Building Roof—Shielded Gamma Scans

Figure A-18: NOL Open Land Area Inside Controlled Area—43-37 Alpha plus Beta Scans

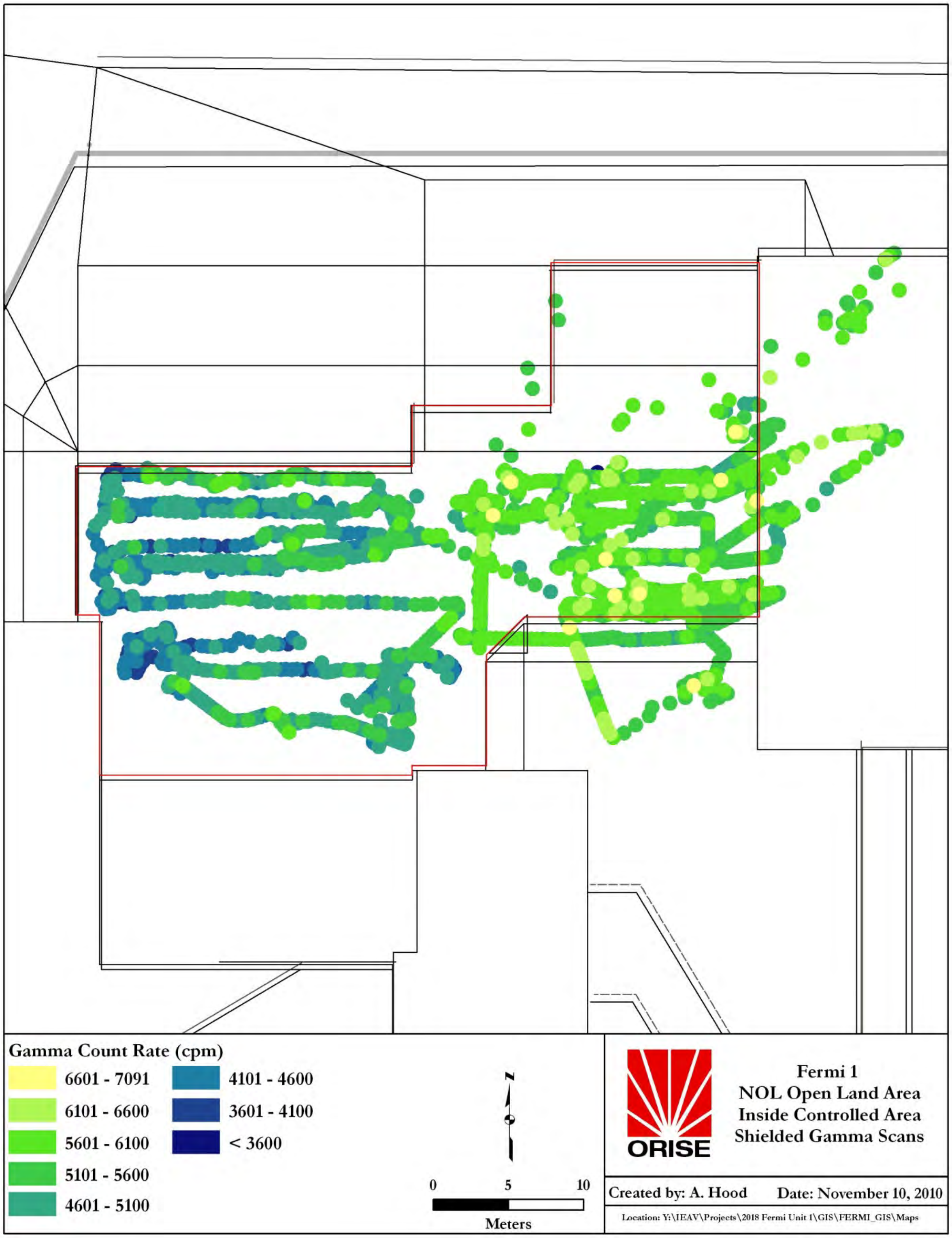

Figure A-19: NOL Open Land Area Inside Controlled Area—Shielded Gamma Scans

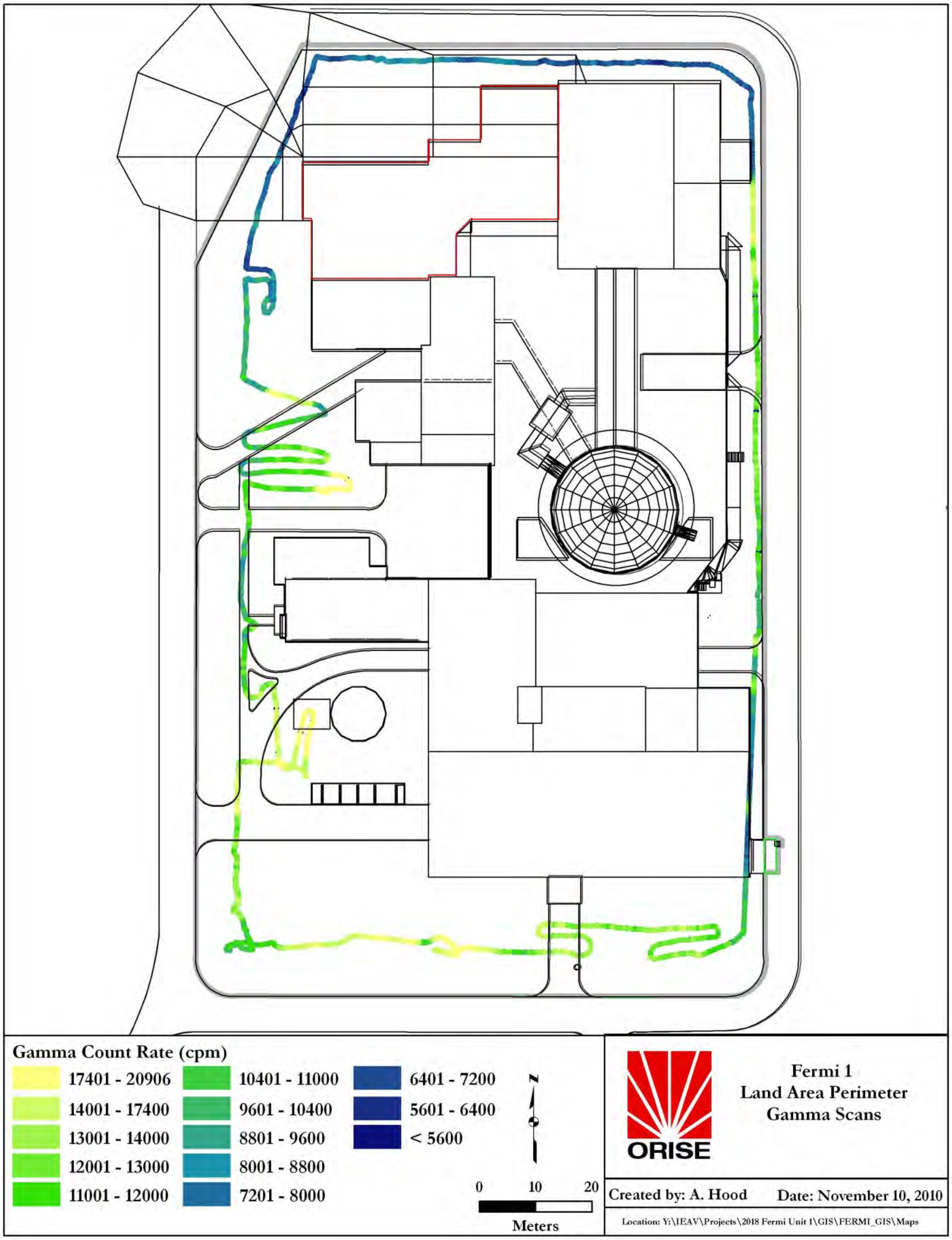

Figure A-20: Land Area Perimeter Gamma Scans

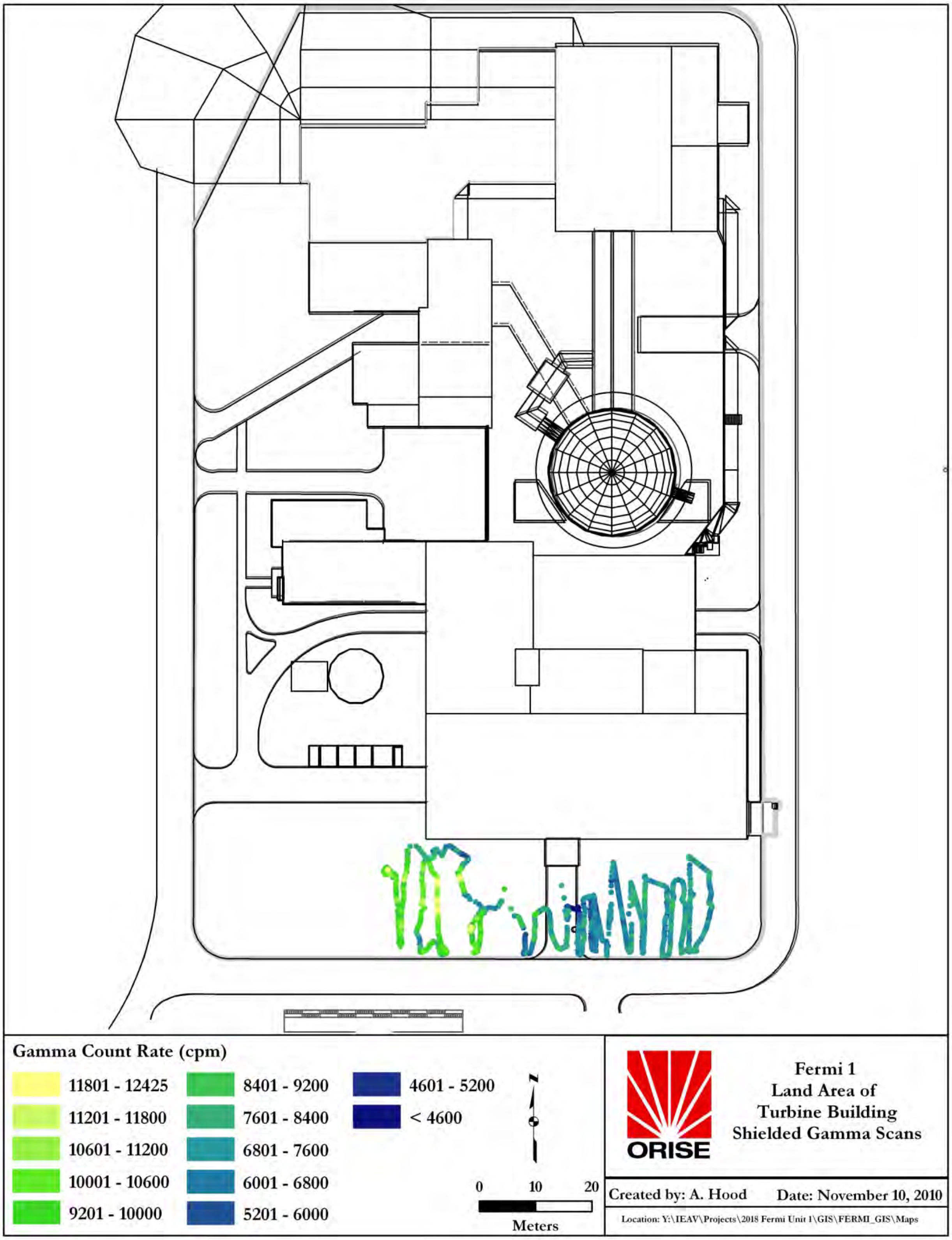

Figure A-21: Land Area of Turbine Building—Shielded Gamma Scans

APPENDIX B
TABLES

TABLE B-1: SURFACE ACTIVITY AND SOIL CONCENTRATION DCGLs		
Radionuclide	**Building Surface[a] (dpm/100cm²)**	**Soil[a] (pCi/g)**
Ag-108m	1.8E+04	7.8
Am-241	5.0E+03	130
C-14	1.0E+07	450
Cm-242	3.1E+05	7,700
Cm-243	7.2E+03	78
Co-60	1.1E+04	5.1
Cs-134	1.7E+04	8.3
Cs-137	3.9E+04	17
Eu-152	2.2E+04	11
Eu-154	2.0E+04	11
Eu-155	3.6E+05	400
Fe-55	4.1E+07	34,000
H-3	2.9E+08	31,000
Na-22	1.3E+04	6.2
Nb-94	1.5E+04	7.9
Ni-59	6.0E+05	11,000
Ni-63	3.6E+07	4,000
Pu-238	5.7E+03	160
Pu-239	5.0E+03	140
Pu-240	5.0E+03	140
Pu241	2.7E+05	5,200
Sb-125	5.9E+04	34
Sr-90	1.4E+05	12
Tc-99	1.4E+07	20

[a]$DCGL_W$ values correspond to an annual dose of 25 mrem.

TABLE B-2: CALCULATED MDCs FOR CO-60 AND CS-137 IN SOIL FOR 2×2 SODIUM IODIDE DETECTORS						
Background cpm	**b^i**	**s_i**	**MDCR**	**$MDCR_{surveyor}$**	**CO-60 MDC (pCi/g)**	**Cs-137 MDC (pCi/g)**
10000	167	30.0	1800	2550	5.8	10.8
11000	183	31.4	1880	2660	6.0	11.3
12000	200	32.8	1970	2790	6.3	11.8
13000	217	34.2	2050	2900	6.5	12.3
14000	233	35.4	2120	3000	6.8	12.7
15000	250	36.7	2200	3110	7.0	13.2
16000	267	37.9	2270	3210	7.2	13.6
17000	283	39.0	2340	3310	7.5	14.0
18000	300	40.2	2410	3410	7.7	14.5
19000	317	41.3	2480	3510	7.9	14.9
20000	333	42.3	2540	3590	8.1	15.2
21000	350	43.4	2600	3680	8.3	15.6
22000	367	44.4	2670	3780	8.5	16.0
23000	383	45.4	2720	3850	8.7	16.3
24000	400	46.4	2780	3930	8.9	16.7
25000	417	47.4	2840	4020	9.1	17.1
26000	433	48.3	2900	4100	9.2	17.4
27000	450	49.2	2950	4170	9.4	17.7
28000	467	50.1	3010	4260	9.6	18.1
29000	483	51.0	3060	4330	9.8	18.4
30000	500	51.9	3110	4400	9.9	18.7
31000	517	52.8	3170	4480	10.1	19.0
32000	533	53.6	3210	4540	10.2	19.3
33000	550	54.4	3260	4610	10.4	19.6
34000	567	55.2	3310	4680	10.6	19.9
35000	583	56.0	3360	4750	10.7	20.1

Constants used for 2×2 Sodium Iodide application (MARSSIM default values):

Co-60 = 0.97 pCi/g/uR/hr
Co-60 = 430 cpm/uR/hr
Cs-137 = 3.82 pCi/g/uR/hr
Cs-137 = 900 cpm/uR/hr
I = 1 observation interval (sec)
d'= 2.32 User input

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 her employer.

C.1 Scanning and Measurement Instrument/Detector Combinations

C.1.1 Gamma

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

C.1.2 Alpha Plus Beta

Ludlum Gas Proportional Detector Model 43-68, 126cm^2 physical area
coupled to:
Ludlum Ratemeter-scaler Model 2221
(Ludlum Measurements, Inc., Sweetwater, TX)

Ludlum Gas Proportional Detector Model 43-37, 582cm^2 physical area
coupled to:
Ludlum Ratemeter-scaler Model 2221
(Ludlum Measurements, Inc., Sweetwater, TX) coupled to:
Trimble S3 Total Station with TSC2 controller (Trimble Navigation Limited, Sunnyvale, CA)

C.2 Laboratory Analytical Instrumentation

Low-Background Gas Proportional Counter
Model LB-5100-W
(Tennelec/Canberra, Meriden, CT)

APPENDIX D
SURVEY AND ANALYTICAL PROCEDURES

D.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. Prior to on-site activities, a pre-job integrated safety management checklist was completed and discussed with field personnel. Additionally, upon arrival on site, the planned activities were thoroughly discussed with site personnel prior to implementation to identify hazards present. All survey and laboratory activities were conducted in accordance with Oak Ridge Institute for Science and Education (ORISE) health and safety and radiation protection procedures.

D.2 CALIBRATION AND QUALITY ASSURANCE

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

Analytical and field survey activities were conducted in accordance with procedures from the following documents of the Independent Environmental Assessment and Verification Program:

- Survey Procedures Manual (ORISE 2008)
- Laboratory Procedures Manual (ORISE 2010b)
- Quality Program Manual (ORAU 2010)

The procedures contained in these manuals were developed to meet the requirements of U.S. Department of Energy (DOE) Order 414.1C and the U.S. Nuclear Regulatory Commission (NRC) *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 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

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 one- or two-second 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 or plot plans of the facility. Positional accuracy was within 0.5 meters at the 95th percentile.

The scan MDCs for the 2x2 NaI scintillation detectors were approximately 3.4 pCi/g for cobalt-60 and 6.4 pCi/g for cesium-137, as provided in NUREG-1507.

Structural surface scans were performed by passing the detectors slowly over the surface while the distance between the detector and the surface was maintained at a minimum. Either large surface area (550 cm^2) gas proportional floor monitors or small area (126 cm^2) hand-held detectors (both with a 0.8 mg/cm^2 window) were used to scan the floors, walls, and other structural surfaces of the surveyed areas. Identification of elevated radiation levels is based on increases in the audible signal from the recording and/or indicating instrument.

D.3.2 Surface Activity Measurements

Measurements of total activity levels were performed using gas proportional detectors coupled to portable ratemeter-scalers. Surface activity measurements were performed at two locations in the Decay Pool, three locations on the exterior south wall of the Sodium Building, and one location on the upper roof of the FRB Building.

Count rates (cpm), which were integrated over one minute with the detector held in a static position, were converted to activity levels (dpm/100cm^2) by dividing the count rate (in counts per minute) by the physical detector area of 126 cm^2, and by the total weighted efficiency ($\varepsilon_i \times \varepsilon_s$) based on the applicable Radionuclide of Concern (ROCs) per survey unit (see formula below). Individual building material-specific background values were not subtracted from the confirmatory measurements in order to match the conservative DTE Final Status Survey procedure. The confirmatory measurement data represent gross activity levels for the remaining structures and surfaces.

$$(EsCs\quad)(Ei_{Cs})(f_{Cs}) + (Es_{Co})(Ei_{Co})(f_{Co}) + (EsSr\quad)(Ei_{Sr})(f_{Sr}) = E_{weighted}$$

The 2π instrument efficiencies (ε_i) were as follows: 0.45 for the gas proportional detectors calibrated to technetium-99; 0.57 for thalium-204 and 0.54 for strontium-90. The source efficiency factor (ε_s) was 0.25 for alpha measurements. Both 0.25 and 0.50 were used for the beta measurements, dependent upon the beta energy level of the contaminant(s) within specific survey units.

D.3.3 Removable Activity Measurements

Removable gross alpha and gross beta activity levels were determined using numbered filter paper disks, 47 mm in diameter. Moderate pressure was applied to the smear and approximately 100 cm^2 of the surface was wiped. Smears were placed in labeled envelopes with the location and other pertinent information recorded.

D.4 RADIOLOGICAL ANALYSIS

Smears were counted on a low-background gas proportional system for gross alpha and beta activity. The MDCs of the procedure were 11 dpm/100 cm^2 and 14 dpm/100 cm^2 for a 2-minute count time for gross alpha and gross beta, respectively.