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ORISE

OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION

June 24, 2009

Ms. Vivian Campbell, Chief
Nuclear Materials Safety Branch-A
U.S. Nuclear Regulatory Commission
Region IV
612 E. Lamar Boulevard, Suite 400
Arlington, TX 76011

SUBJECT: CONFIRMATORY SURVEY REPORT FOR BUILDING 1 LABORATORIES, BOULDER CAMPUS NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY, BOULDER, COLORADO (DOCKET NO. 030-03732; RFTA NOs. 09-008 AND 09-001) DCN 1788-SR-01-0

Dear Ms. Campbell:

The Oak Ridge Institute for Science and Education (ORISE) performed confirmatory survey activities within impacted interior and exterior locations of Building 1 at the National Institute of Standards and Technology (NIST) Boulder Campus in Boulder, Colorado. These confirmatory survey activities were performed during the period of April 14 through 16, 2009. These survey activities were requested and approved by the U.S. Nuclear Regulatory Commission (NRC). Enclosed is the final report that summarizes ORISE's survey procedures and results of the confirmatory surveys; NRC comments on the draft report are incorporated into this final report. The surveys included alpha and gamma surface scans and direct measurements for gross alpha activity. This report also includes the results for the NRC-collected soil samples from the interior and exterior excavations of the drain line which was part of a separate Request for Technical Assistance (RFTA). The soil data were included in this report to provide continuity for the confirmatory survey activities performed at the site.

If you have any questions, please direct them to me at 865.576.0065 or Tim Vitkus at 865.576.5073.

Sincerely,

Wade C. Adams

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ORISE Health Physicist/Project Leader
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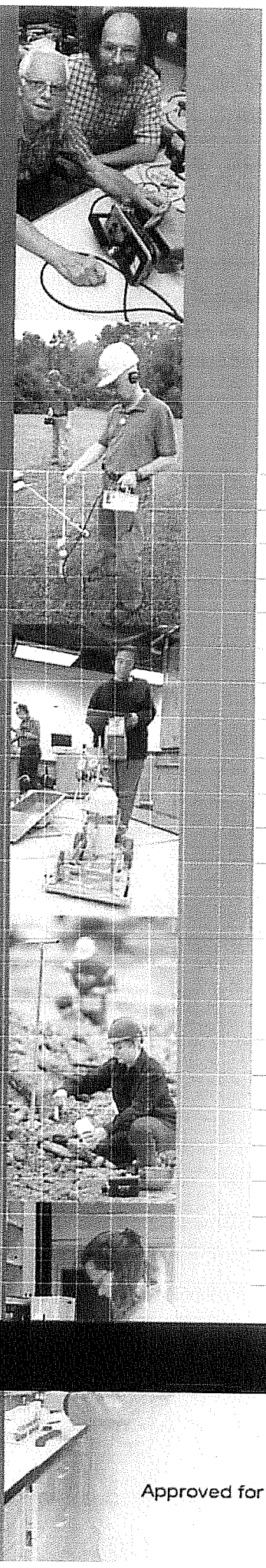

CONFIRMATORY SURVEY REPORT FOR BUILDING 1 LABORATORIES, BOULDER CAMPUS NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY BOULDER, COLORADO

W. C. Adams

Prepared for the
U.S. Nuclear Regulatory Commission

ORISE
Oak Ridge Institute for Science and Education

The Oak Ridge Institute for Science and Education (ORISE) is a U.S. Department of Energy facility 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. Established in 1946, ORAU is a consortium of 100 colleges and universities.

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The author would like to acknowledge the significant contributions of the following staff members:

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CONFIRMATORY SURVEY REPORT
FOR BUILDING 1 LABORATORIES, BOULDER CAMPUS
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
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ABBREVIATIONS AND ACRONYMS

b_i	number of background counts in the interval
d′	index of sensitivity
ε_i	instrument efficiency
ε_s	surface efficiency
ε_{total}	total efficiency
f_i	radionuclide fraction
y_i	radionuclide fraction yield
Am-241	americium-241
BKG	background
cm	centimeter
COC	contaminants of concern
cpm	counts per minute
DCGL	derived concentration guideline level
DOE	U.S. Department of Energy
dpm/100 cm^2	disintegrations per minute per 100 square centimeters
DQOs	data quality objectives
ESL	Energy*Solutions*, LLC
FIDLER	Field Instrument for the Detection of Low-Energy Radiation
FSS	final status survey
FSSP	final status survey plan
G	geometry factor
g	grams
ha	hectare
ISM	Integrated Safety Management
ITP	Intercomparison Testing Program
JHA	job hazard analysis
m^2	square meters
MAPEP	Mixed Analyte Performance Evaluation Program
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	minimum detectable concentration
MeV	million electron volts
mrem	millirem
NIST	National Institute of Standards and Technology
Np-237	neptunium-237
NRC	U.S. Nuclear Regulatory Commission
NRIP	NIST Radiochemistry Intercomparison Program
ORAU	Oak Ridge Associated Universities
ORISE	Oak Ridge Institute for Science and Education
pCi/g	picocuries per gram
Pu	plutonium
SU	survey unit
SRC	site release criteria
T	time
TAP	total absorption peaks
TEDE	total effective dose equivalent
Th-230	thorium-230
U	uranium
VSP	Visual Sample Plan
ZnS	zinc sulfide

CONFIRMATORY SURVEY REPORT
FOR BUILDING 1 LABORATORIES, BOULDER CAMPUS
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
BOULDER, COLORADO

INTRODUCTION

The National Institute of Standards and Technology (NIST) is a federal agency that promotes innovation and industrial competiveness by advancing measurement science, standards, and technology in ways that enhance economic security and quality of life improvements. NIST is a non-regulatory agency of the U.S. Department of Commerce. With a staff of 350 scientists, engineers, technicians, and support personnel, and an average of 300 visiting researchers, students and contractors annually, the NIST Boulder Campus Laboratories conduct research in a wide range of chemical, physical, materials, and information sciences and engineering.

NIST Boulder campus occupies 84-hectares (ha) in Boulder, Colorado. The NIST campus (Figure A-1) shares offices and laboratories with two other Department of Commerce agencies: the National Oceanic and Atmospheric Administration and the National Telecommunications and Information Administration.

PLUTONIUM INCIDENT HISTORY

On June 9, 2008, a vial containing 0.25 grams (g) of mixed plutonium (Pu) isotopes ruptured resulting in the contamination of several laboratories, a bathroom, a hallway, an office, a sink and associated drain lines, the hood ventilation system leading to the roof, and various laboratory equipment/furniture in Building 1 (Figure A-2). The spill impacted areas included: Rooms 2124, 2124A, 2120, 2120A (Figure A-3), the hallway, a bathroom, the researcher office in Room 2007 (Figure A-4), the roof (Figure A-5), and the soil within the excavation of the drain line in Room 2124 (Figure A-6).

The maximum contamination surface activity level was detected in Room 2124 during a survey that was performed by U.S Department of Energy (DOE) personnel. The surface activity was greater than 500,000 disintegrations per minute per 100 square centimeters (dpm/100 cm^2). DOE treated the remaining laboratories and Room 2007 as potentially contaminated.

NIST contracted with Energy*Solutions*, LLC (ESL) to perform the radiological cleanup activities within Building 1. ESL was tasked with stabilizing the contaminated areas, recovering and returning the source material to the DOE, decontaminating the affected areas, providing radiological data indicating that the impacted areas met release criteria, and the packaging and shipping of contaminated materials for waste disposal. ESL was responsible for the cleanup of Rooms 2007, 2120, 2120A, 2124, 2124A and the roof (ESL 2009).

Radioactive waste was stored within a 20-foot long intermodal container which was located within a secured fenced area (Figure A-2). ESL also had two additional intermodal containers that were used for temporary storage of items from the work areas that had been cleared for unrestricted release. These items were removed from the work areas to allow more room for decontamination activities and to prevent cross contamination.

The ESL staging area for the decontamination activities for entry into Room 2120 included Room 2109 (which served as the ESL personnel office) and the full width of the hallway between the doors to Rooms 2123 and 2121 (Figure A-2). This portion of the hallway was temporarily demarcated and closed off to pedestrian traffic during the early stages of the decontamination activities. The hallway was reopened to pedestrian traffic after initial decontamination efforts in Room 2120 were completed.

The U.S. Nuclear Regulatory Commission's (NRC's) Headquarters and Region IV Offices requested that the Oak Ridge Institute for Science and Education (ORISE) perform confirmatory surveys of the decontaminated areas within Building 1 at the NIST Campus Laboratories in Boulder, Colorado (NRC 2009). The NRC also tasked ORISE with performing limited radiological surveys of several additional rooms and outdoor areas, including the temporary waste storage area where radiological waste from the impacted areas was stored, the men's restroom, Room 2114, Room 2109, the hallway and a custodial closet. The confirmatory surveys were performed during the period of April 14 through 16, 2009.

CONTAMINANTS OF CONCERN

The contaminants-of-concern (COCs) for the NIST incident are well known since the contamination was from a standard radioactive source with an established radionuclide distribution and decay mode (Table 1).

TABLE 1: RUPTURED SOURCE ACTIVITY INFORMATION[a]				
Radionuclide	**Activity (μCi)**	**Activity (%)**	**Decay mode**	**Radionuclide of Concern (Y/N?)**
Pu-238	3.64E+02	0.81%	Alpha	Yes
Pu-239	1.41E+04	31.32%	Alpha	Yes
Pu-240	4.48E+03	9.95%	Alpha	Yes
Pu-241	2.15E+04	47.76%	Beta	Yes
Pu-242	3.28E-01	0.00%	Alpha	Yes
U-234	5.15E-02	0.00%	Alpha	No
U-235	5.85E-04	0.00%	Alpha	No
U-236	5.40E-03	0.00%	Alpha	No
Am-241	4.57E+03	10.15%	Alpha	Yes
Np-237	3.16E-02	0.00%	Alpha	No
U-238	4.46E-06	0.00%	Alpha	No
Total	**4.50E+04**	**100.00%**		

[a]Data provided by ESL (ESL 2009).

SITE RELEASE CRITERIA

The primary COCs for the NIST impacted areas were alpha emitters and a low-energy beta emitter resulting from the rupture of the Pu source (Refer to Table 1). ESL developed site-specific derived concentration guideline levels (DCGLs) based on dose modeling not to exceed 25 mrem/year total effective dose equivalent (TEDE) as presented in 10 CFR 20 (ESL 2009). ESL used the "Building Occupancy Scenario" and the "Residential Occupancy Scenario" in version 2.1.0 of the NRC DandD code in deriving the DCGLs for structural and soil surfaces, respectively (ESL 2009). With the exception of changing the resuspension factor for the "Building Occupancy Scenario" for structural surfaces, ESL used the default values. The ESL site-specific DCGLs for structural surfaces and surface soils are provided in Table 2. ESL also determined gross activity DCGLs for structural and soil surfaces based on activity and/or surrogate ratios.

TABLE 2: ESL DERIVED CONCENTRATION GUIDELINE LEVELS[a]		
Radionuclide	Structural Surfaces	Soil Surfaces
	$DCGL_W$ (dpm/100 cm^2)	$DCGL_W$ (pCi/g)
Pu-238	407	2.5
Pu-239	370	2.2
Pu-240	370	2.3
Pu-241	18,939	73
Pu-242	387	2.4
U-234	1,256	9.0
U-235	1,336	7.8
U-236	1,329	13.6
Am-241	358	2.1
Np-237	293	0.10
U-238	1,404	10.0
Gross Activity[b]	**696[c]**	**0.42 (Am-241)**

[a]Data in table provided by ESL (ESL 2009).
[b]Gross activity for structural surfaces calculated by ESL using MARSSIM. The gross concentration for soil surfaces was calculated by ESL with Am-241 as a surrogate for all radionuclides.
[c]The NRC-approved gross activity $DCGL_w$ is 696 dpm/100 cm^2 which was calculated using the COMPASS software.

ESL calculated the $DCGL_w$ for gross surface activity using the COMPASS Software, a *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM)-based implementation software package. The NRC approved the COMPASS-based $DCGL_w$ gross activity calculation of 696 dpm/100 cm^2 by License Amendment 34 dated January 24, 2009.

In developing the gross activity DCGL used for the final status survey (FSS), ESL used only those radionuclides that contribute greater than 1% or more to the 25 mrem/y TEDE. Therefore, all uranium isotopes and neptunium-237 (Np-237) were excluded from the final FSS DCGL calculations. Because one of the COCs—Pu-241—is a low energy beta emitter that is difficult to detect with direct beta surface activity measurements, ESL elected to only perform alpha direct surface activity measurements during the FSS activities.

CONFIRMATORY SURVEY OBJECTIVES

The objective of the confirmatory survey was to generate independent radiological data for use by

the NRC in evaluating the adequacy and accuracy of the licensee's FSS results. Data collected by ORISE and the licensee were reviewed to assess whether the data quality were sufficient for comparison to the NRC approved site-specific DCGLs. The objective of the document review of the licensee's proposed final status survey plan (FSSP) was to evaluate the technical processes and radiological survey techniques that were used to identify radiological contamination within the impacted areas.

DOCUMENT REVIEW

ORISE reviewed ESLs FSSP and preliminary final status survey data for adequacy and appropriateness, taking into account data quality objectives (DQOs) contained in the FSSP (ESL 2009). ORISE reviewed and evaluated the FSSP and final status survey data in accordance with the ORISE site-specific survey plan to ensure that FSS procedures and results adequately met site FSSP commitments and MARSSIM considerations (ORISE 2009a, ESL 2009 and NRC 2000).

FIELD SAMPLING AND MEASUREMENT PLAN

To expedite the confirmatory survey process, ORISE coordinated and worked with the NRC site representative to conduct confirmatory surveys as the licensee provided preliminary FSS survey data. This provided the NRC the quality assurance metric that the site's reported radiological status satisfied the site release criteria. ORISE survey activities were performed in a manner that addressed the confirmatory objective listed above.

SURVEY UNIT CLASSIFICATION

The MARSSIM FSS process relies upon the use of characterization surveys and site history to divide the site into properly classified survey units (SU) of appropriate physical area. Modifications to the SU classification can be made based on new survey findings or information. SUs are limited in size based on their classification, exposure pathway modeling assumptions and site-specific conditions.

Under MARSSIM, the level of survey effort required for a given SU is determined by the potential for residual contamination as indicated by the classification. SUs with a higher classification receive a higher degree of survey effort. The decontamination contractor used the following MARSSIM classifications:

- Non-impacted: Areas that have no reasonable potential for residual contamination from site operations.
- Impacted Areas: Areas that may contain residual contamination from licensed operations. Impacted areas include Class 1, 2, and 3 areas.
    - Class 1: Areas with the highest probability of contamination, with potential for containing concentrations of residual radioactivity that exceed the DCGLs.
    - Class 2: Areas with low potential for containing concentrations of residual radioactivity that exceed the DCGLs.
    - Class 3: Areas with little or no potential for containing concentrations of residual radioactivity that exceed the DCGLs.

ESL classified the impacted areas as either Class 1 or Class 2 SUs. The following table provides the ESL classifications and ORISE percent scan coverage for each area that received FSSs.

TABLE 3: SURVEY UNIT CLASSIFICATION[a]

Survey Unit	Size (m^2)	Survey Unit Classification	Scan Coverage (%)	Figure
SU001, Room 2124 Floor	89	1	100	A-8
SU002, Room 2124 Walls	197	1	100/5[c]	A-9
SU003, Room 2124 Ceiling	89	1	25	A-10
SU004, Room 2124A Floor	37	1	100	A-11
SU005, Room 2120 Floor	58	1	100	A-12
SU006, Room 2120A Floor	28	1	100	A-13
SU007, Room 2007 Floor	18	1	100	A-14
SU008, Room 2124A Walls & Ceiling	115	2	100/25[c]	A-15
SU009, Room 2120 Lower Walls <2m	120	1	100	A-16
SU010, Room 2120A Walls & Ceiling	93	2	100/25[c]	A-17
SU011, Room 2007 Walls & Ceiling	60	2	50	A-18
SU012, Roof Area	392	2	5	A-19
SU013, Room 2124 Excavation	---[b]	2	---	A-25
SU014, Excavation Outside Room 2124	---	2	---	A-26
SU015, Room 2120 Upper Walls and Ceiling	158	2	25	A-20

[a]Information provided by ESL.
[b]Excavation size not provided. ORISE did not perform confirmatory survey activities on these survey units as the excavations were already backfilled.
[c]Lower wall scan coverage/upper wall and ceiling scan coverage.

At the request of the NRC site representative, ORISE also performed radiological survey activities, based on incident history, within other potentially impacted areas. These areas included the following:

TABLE 4: POTENTIALLY IMPACTED AREAS ORISE CLASSIFICATION AND SCAN COVERAGE			
Potentially Impacted Area[a]	**ORISE Survey Unit Classification**	**Scan Coverage (%)**	**Figure**
Building 1 Hallway Floor	2	75	A-21
Men's Restroom	1	75	A-22
Room 2114	2	5	A-23
Room 2109	2	<5	A-24
Custodial Closet	2	<5	NA
Intermodal and Exterior Areas	2	75	A-25

[a]Potentially impacted areas based on incident history and at the discretion of the NRC site representative.

CONFIRMATORY SURVEY PROCEDURES

ORISE performed confirmatory survey activities in each of the survey units that were accessible. Since the excavations were already backfilled, ORISE did not perform any confirmatory surveys in SUs 013 and 014; for these survey units, ORISE analyzed split soil samples, collected by ESL personnel and sent to the ORISE laboratory by the NRC site representative. These confirmatory survey activities assessed whether decontamination activities on the structural surfaces (and the soil sample concentrations) met the DQOs for unrestricted release.

ORISE also conducted radiological confirmatory survey activities on potentially impacted structural surfaces within Building 1of the NIST Boulder Campus Laboratories. Confirmatory surveys included alpha and gamma surface scans and direct measurements for gross alpha activity. Locations of elevated direct radiation that potentially exceeded the NRC-approved site-specific DCGLs were marked for further investigation.

Confirmatory surveys were performed in accordance with a site-specific survey plan that was submitted to and approved by the NRC (ORISE 2009a). The site-specific survey plan followed the guidance provided in the ORISE Survey Procedures and the Oak Ridge Associated Universities (ORAU) Quality Program Manuals (ORISE 2008 and ORAU 2009).

REFERENCE SYSTEM

ORISE used ESL's FSSP data and the software Visual Sample Plan V.5.4.1 (VSP) to generate random direct measurement locations and figures for the ESL surveyed areas (Rooms 2007, 2120, 2120A, 2124, 2124A and the roof). Measurement locations for the potentially impacted areas that were not surveyed by ESL, were selected based on elevated radiation levels during ORISE surface scans and/or professional judgment. These measurement locations (Rooms 2109, 2114, the hallway, the men's restroom and the custodial closet) were referenced on NIST/ESL provided figures or on drawings by ORISE personnel. The NRC soil sample locations were marked on figures provided by ESL and were based on data provided by the NRC and NIST site representatives.

SURFACE SCANS

The scan percent coverages for each of the areas where confirmatory surveys were performed are provided in Tables 3 and 4.

Structural Scans

Surface scans for alpha radiation were performed on structural surfaces that could be safely accessed. Scan coverage percentage was based upon the SU classification and increased or decreased depending on findings as the survey progressed and project time constraints. Scans for alpha radiation were performed using zinc sulfide (ZnS) scintillation and/or gas proportional detectors. Particular attention was given to cracks and joints in the surfaces, exposed concrete surfaces, and other locations where material may have accumulated. Locations of elevated direct radiation, suggesting the presence of residual contamination, were marked and identified for judgmental measurements. All detectors were coupled to ratemeters or ratemeter-scalers with audible indicators.

Roof Scans

Limited surface scans for alpha radiation were conducted on up to 5% of accessible roof surfaces within the impacted areas; concentrating on the hood exhausts from the impacted rooms. Surface scans were performed using a ZnS scintillation detector coupled to a ratemeter-scaler with audible indicator.

Soil Scans

Surface scans for gamma radiation were conducted on up to 75% of accessible soil surfaces within the intermodal and exterior excavation areas. Surface scans were performed using a Field Instrument for the Detection of Low-Energy Radiation (FIDLER) detector coupled to a ratemeter-scaler with an audible indicator.

SURFACE ACTIVITY MEASUREMENTS

Static direct measurements were made to quantify total alpha activity levels. Direct measurements were performed at a minimum of ten randomly selected locations within each ESL impacted SU and at a minimum of two judgmentally selected locations within potentially impacted SUs. Direct measurements were performed using gas proportional and/or ZnS scintillation detectors coupled to ratemeter-scalers. Judgmental measurements were also collected at any location of elevated direct radiation detected during scanning, specifically for the hallway and men's restroom. Construction material-specific/radon background measurements were deemed not necessary in determining the mean residual activity levels in each ESL impacted SU laboratory as the majority of the alpha activity measurements were at backgrounds levels and/or well below the DCGL. Smears, as an investigative tool to determine if further investigations were required, were deemed not necessary since the majority of the alpha activity measurements were at background levels and investigations on elevated alpha activity direct measurement locations determined that elevated alpha activity was due to radon deposition on surfaces. Direct measurement locations are shown on Figures A-8 through A-24.

SOIL SAMPLING

The drain line excavations were already backfilled with clean fill and poured concrete prior to ORISE survey activities, thus precluding direct confirmatory surveys. During previous NRC site representative visits, soil samples were collected by ESL and split with the NRC. The NRC shipped eleven soil samples to the ORISE laboratory for radiological analyses.

SAMPLE ANALYSIS AND DATA INTERPRETATION

Samples and data were returned to the ORISE laboratory in Oak Ridge, Tennessee for analysis and interpretation. Soil samples were analyzed in accordance with the ORISE Laboratory Procedures

Manual (ORISE 2009b). Soil samples were analyzed by gamma spectroscopy and for isotopic plutonium by alpha spectroscopy and results reported in units of picocuries per gram (pCi/g). The primary radionuclides of concern are provided in Table 1; however, spectra were also reviewed for other gamma-emitting radionuclides. Direct measurement data were converted to units of dpm/100 cm^2.

The data generated were compared with the licensee's radiological sampling results and the applicable NRC approved site-specific DCGLs for the site-specific contaminants of concern (Table 2). Additional information regarding instrumentation and procedures may be found in Appendices C and D.

FINDINGS AND RESULTS

The results for the confirmatory surveys are provided below.

DOCUMENT REVIEW

ORISE's review of ESL's FSSP and preliminary FSS data packages indicated that the procedures and methods implemented for the FSS were appropriate and that the resultant data were acceptable.

SURFACE SCANS

Alpha surface scans in Building 1 determined that localized areas of residual elevated alpha radiation were present on the floors within the evaluated surveyed areas. Further investigations determined that the residual alpha activity was due to radon daughter deposition between the tiles on the floor surfaces. These areas were covered for approximately 16 hours and then resurveyed. The alpha activity levels dropped significantly, indicating that the alpha activity was due to radon deposition.

Gamma surface scans on the intermodal area and exterior excavation area surfaces did not detect any areas of elevated gamma radiation. Scans were performed on the soils, the concrete walkway and the newly poured concrete for the excavated trench area.

SURFACE ACTIVITY LEVELS

Individual total alpha surface activity measurements are documented in Table B-1. Based on alpha surface scans, elevated alpha activity locations were further investigated to determine whether the

residual alpha activity was from the incident or from radon daughter deposition on structural surfaces. As an example from the site, at Hallway #4 (Figure A-21), the original counts per minute (cpm) value was 310 cpm. This area was covered that evening and the next morning was uncovered and the follow-up alpha measurement was 2 cpm; a significant drop in alpha activity and an indication that the radon daughters had decayed. ORISE asked ESL personnel to collect a scraping of the material between the floor tiles at this location and perform a qualitative gamma spectroscopy analysis with their onsite radiological laboratory to determine if americium-241 (Am-241) was present in the sample. The ESL analysis did not indicate the presence of Am-241 within the sample. The summary data for the confirmatory alpha activity measurements are presented in Table 5.

TABLE 5: SUMMARY RESULTS FOR ALPHA ACTIVITY MEASUREMENTS[a]

Survey Unit	Alpha Activity Range (dpm/100 cm^2)	Survey Unit	Alpha Activity Range (dpm/100 cm^2)
SU001, Rm 2124 Floor	79 to 220	SU010, Rm 2120A Walls and Ceiling	-32 to 140
SU002, Rm 2124 Walls	32 to 350	SU011, Rm 2007 Walls and Ceiling	16 to 220
SU003, Rm 2124 Ceiling	-16 to 160	SU012, Roof	-82 to 250
SU004, Rm 2124A Floor	48 to 240	SU015, Rm 2120 Upper Walls and Ceiling	-32 to 48
SU005, Rm 2120 Floor	-16 to 290	Hallway	-41 to 700[b]
SU006, Rm 2120A Floor	-16 to 170	Men's Restroom	63 to 520[b]
SU007, Rm 2007 Floor	16 to 210	Room 2114	48 to 170
SU008, Rm 2124A Walls and Ceiling	-16 to 170	Room 2109	0 to 170
SU009, Rm 2120 Lower Walls	-16 to 110	Custodial Closet	170

[a]Refer to Table B-1.
[b]Elevated alpha activity measurements due to radon daughter depostion.

SOIL SAMPLES

The summary data for the confirmatory soil sample concentrations are presented in Table 6. Individual soil sample concentrations are documented in Tables B-2 and B-3.

TABLE 6: SUMMARY RESULTS FOR RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES		
Radionuclide	**Concentration Range (pCi/g)**	**$DCGL_w$ (pCi/g)**
U-238	0.74 to 1.47	10
Am-241	-0.07 to 0.10	2.1
Pu-238	-0.019 to 0.009	2.5
Pu-239/240	-0.0055 to 0.032	2.2/2.3
Pu-241	-2.7 to 2.6	73

COMPARISON OF RESULTS WITH SITE RELEASE CRITERIA

Confirmatory survey data for structural surfaces were compared with the structural site-specific gross DCGL for the evaluated SUs. With the exception of several hallway floor measurements and a measurement on the plastic paper towel dispenser on the Men's Restroom wall, all of the 205 direct alpha activity measurement results were at background levels and/or well below the gross alpha DCGL of 696 dpm/100 cm^2. Further investigation of the elevated alpha activity locations determined that elevated activity was due to radon deposition. All confirmatory direct surface activity measurements on the structural surfaces in the evaluated SUs were within the site-specific $DCGL_W$ as provided by ESL in the FSSP.

Confirmatory survey data for excavation soil samples were compared with the soil radionuclide-specific DCGL's, provided in Table 2, for U-238, Am-241, Pu-238, Pu-239/240 and Pu-241. Each of the eleven soil samples radionuclide concentration results were at background levels, were well below the radionuclide-specific DCGLs and/or were below the Am-241 surrogate DCGL of 0.42 pCi/g. All confirmatory soil sample results were within the site-specific $DCGL_W$ as provided by ESL in the FSSP.

CONCLUSION

During the period of April 14 through 16, 2009, ORISE performed confirmatory radiological survey activities which included alpha surface scans and alpha activity direct measurements on structural surfaces within Building 1 and gamma surface scans on the exterior soil and concrete surfaces in the immediate vicinity of the impacted area on the NIST Campus Laboratories in Boulder, Colorado.

Alpha and gamma surface scans did not identify any areas of elevated alpha radiation on the

structural surfaces within the hallway and restroom; other than those locations confirmed to be the result of naturally occurring radon daughter deposition. Direct measurements were performed at 205 locations. The NRC site representatives collected eleven soil samples from the drain line excavation areas. These samples were shipped to the ORISE laboratory for radiological analyses. Based on ORISE's confirmatory survey findings, all alpha activity direct measurements and all soil sample COCs were below the site-specific DCGLs as approved by the NRC.

The final confirmatory survey results for the evaluated SUs are in agreement with the radiological status of these SUs as presented in the licensee's preliminary FSS data packages.

REFERENCES

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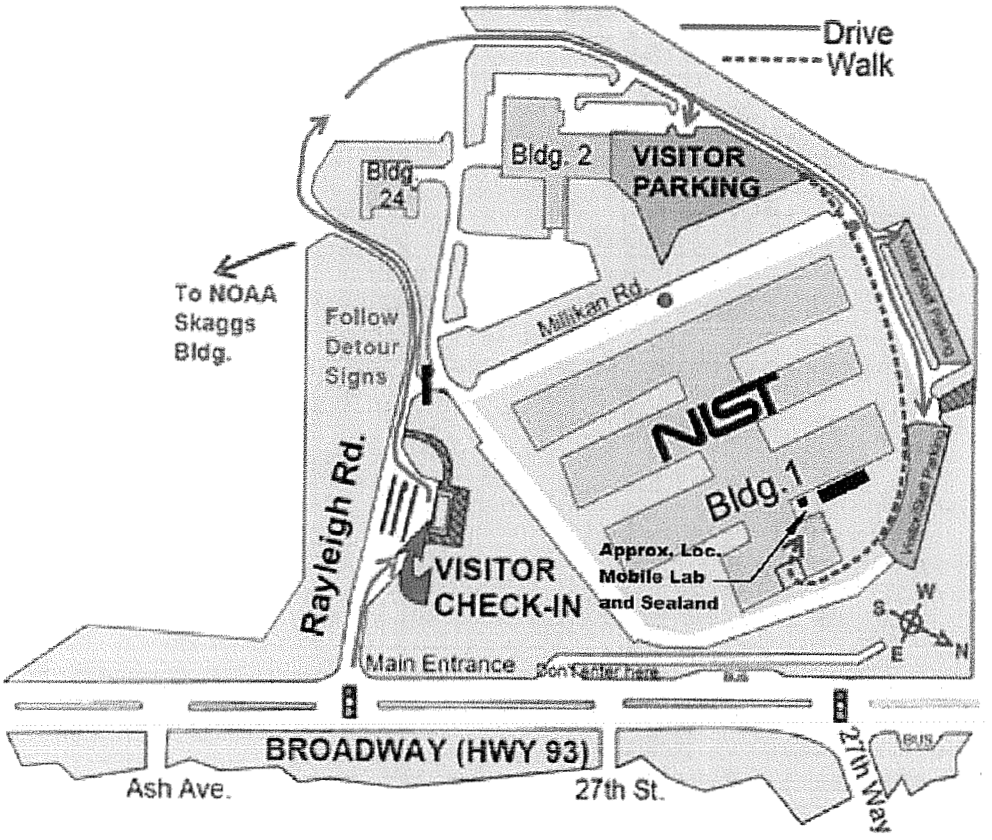
U.S. Nuclear Regulatory Commission. *Request for Technical Assistance – Description of Work for the National Institute of Standards and Technology*, NRC Form 305 (8-1997) completed by Robert Evans; March 16, 2009.

APPENDIX A

FIGURES



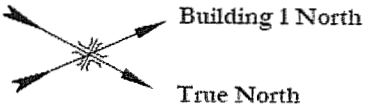


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Figure A-1: Location of Building 1 at the National Institute of Standards and Technology, Boulder Campus, Boulder, Colorado

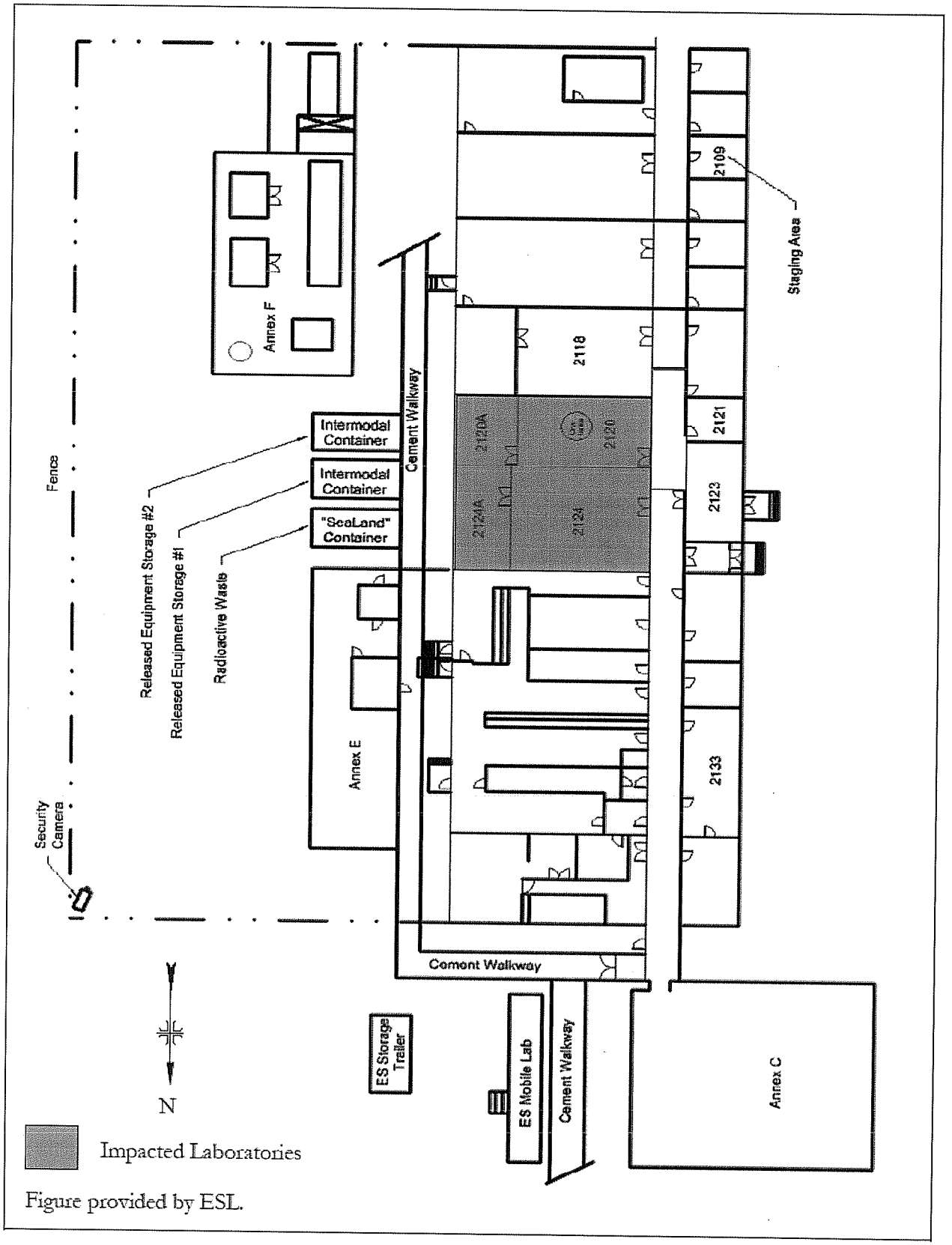

Figure provided by ESL.

Figure A-2: Plot Plan of Building 1 Indicating Impacted Laboratories and the Storage and Waste Areas

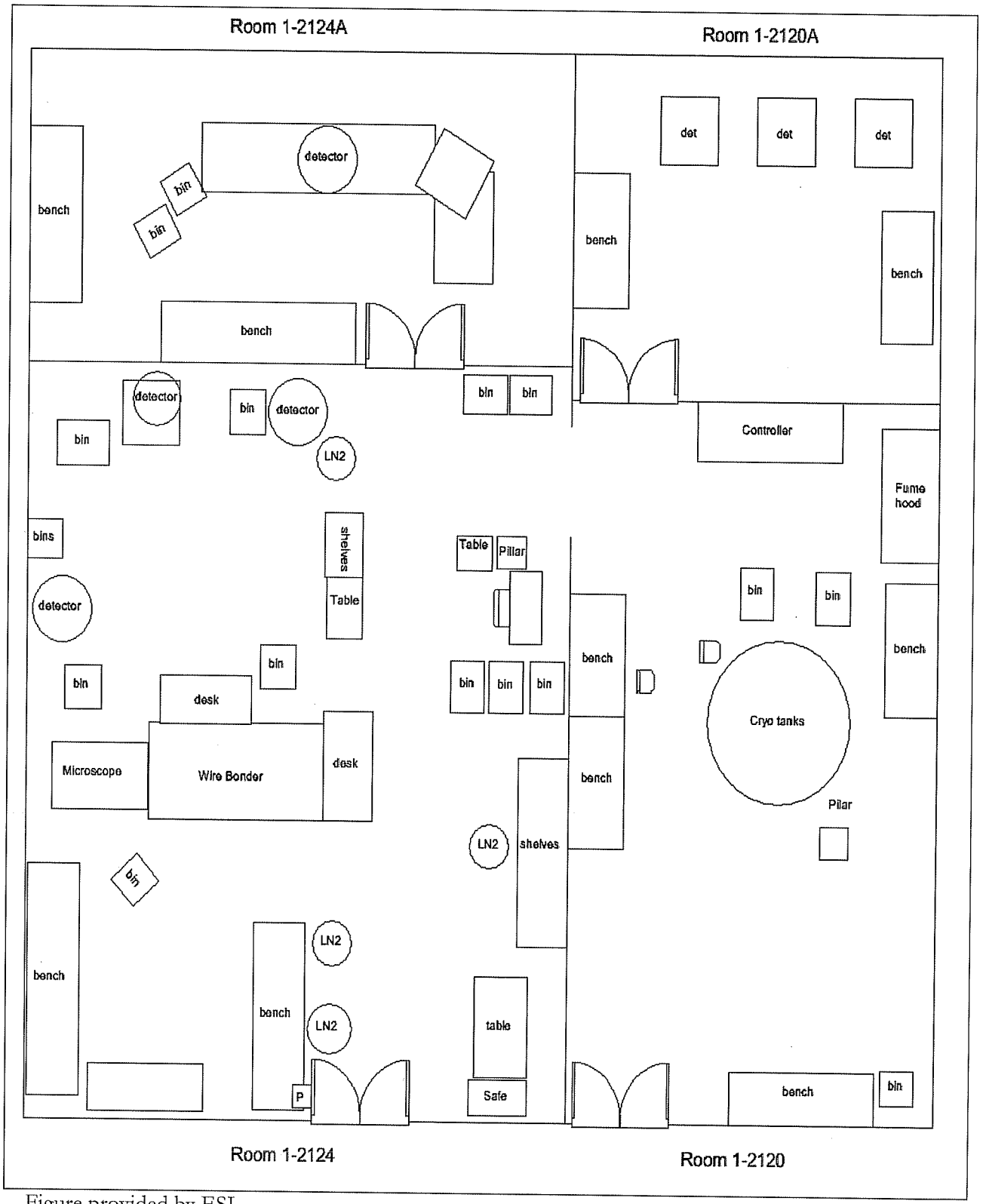

Figure provided by ESL.

Figure A-3: NIST Building 1 Impacted Laboratories

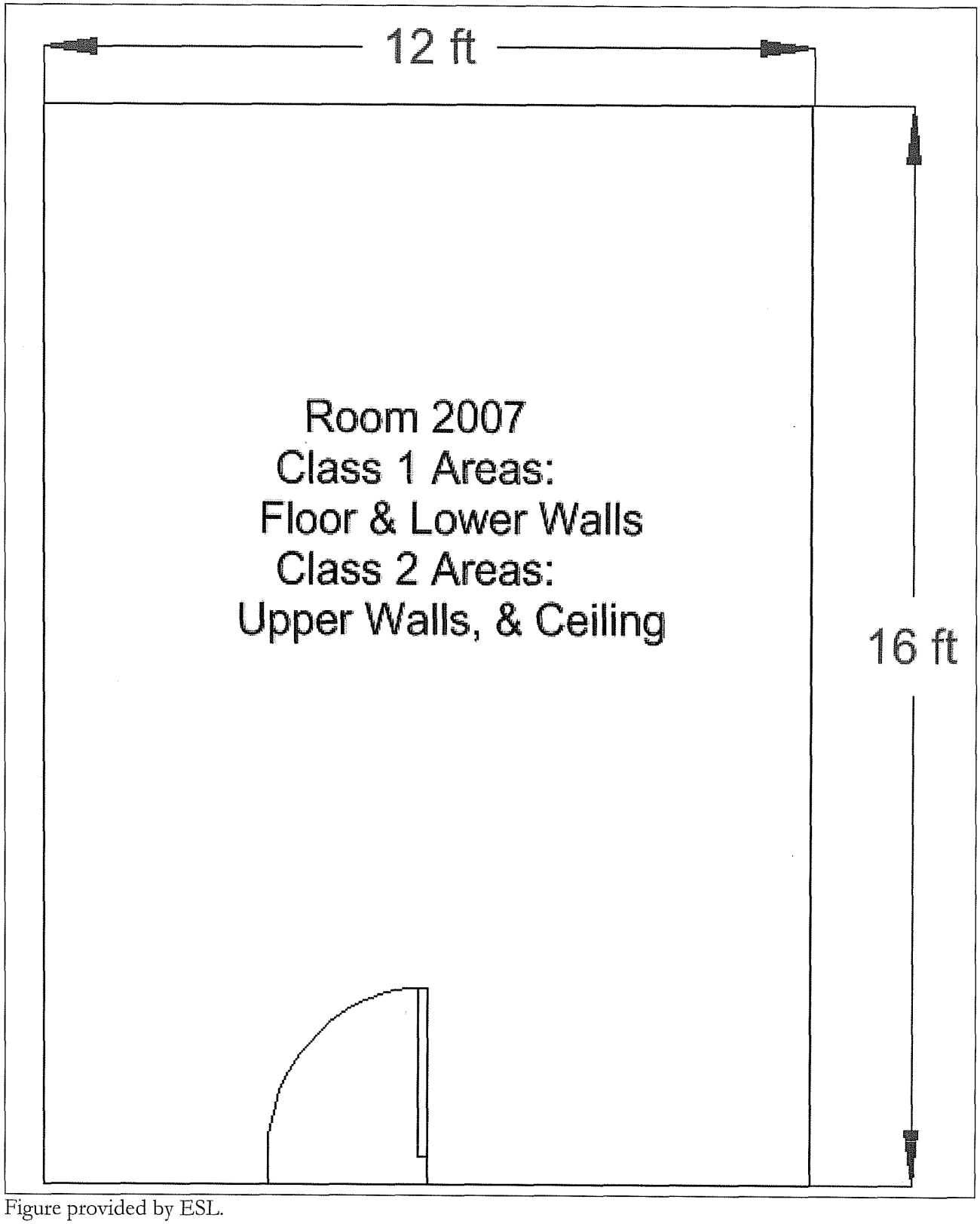

Figure provided by ESL.

Figure A-4: NIST Building 1, Room 2007

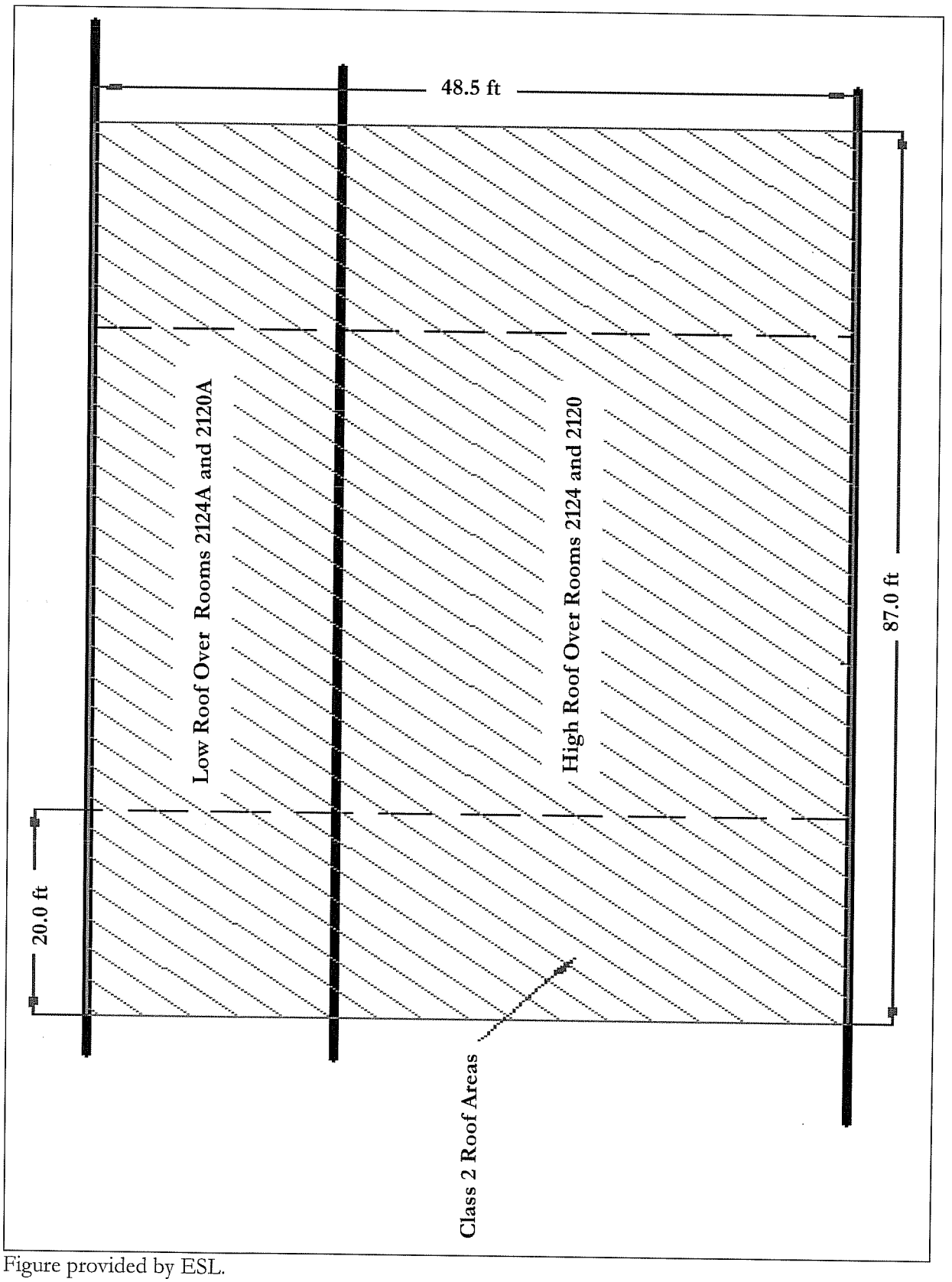

Figure provided by ESL.

Figure A-5: NIST Building 1, Impacted Roof Area

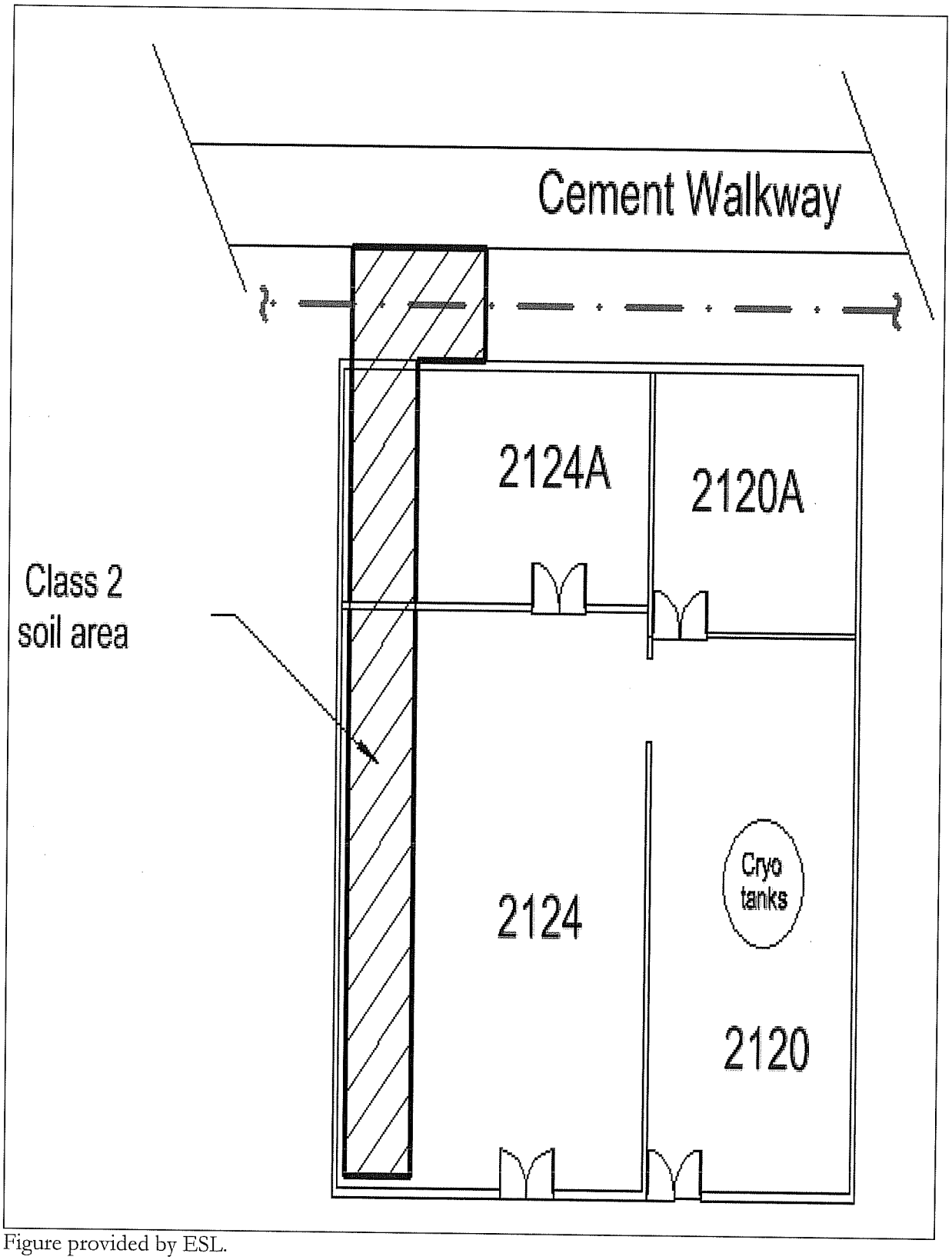

Figure provided by ESL.

Figure A-6: Impacted Area Soil Excavation – Interior

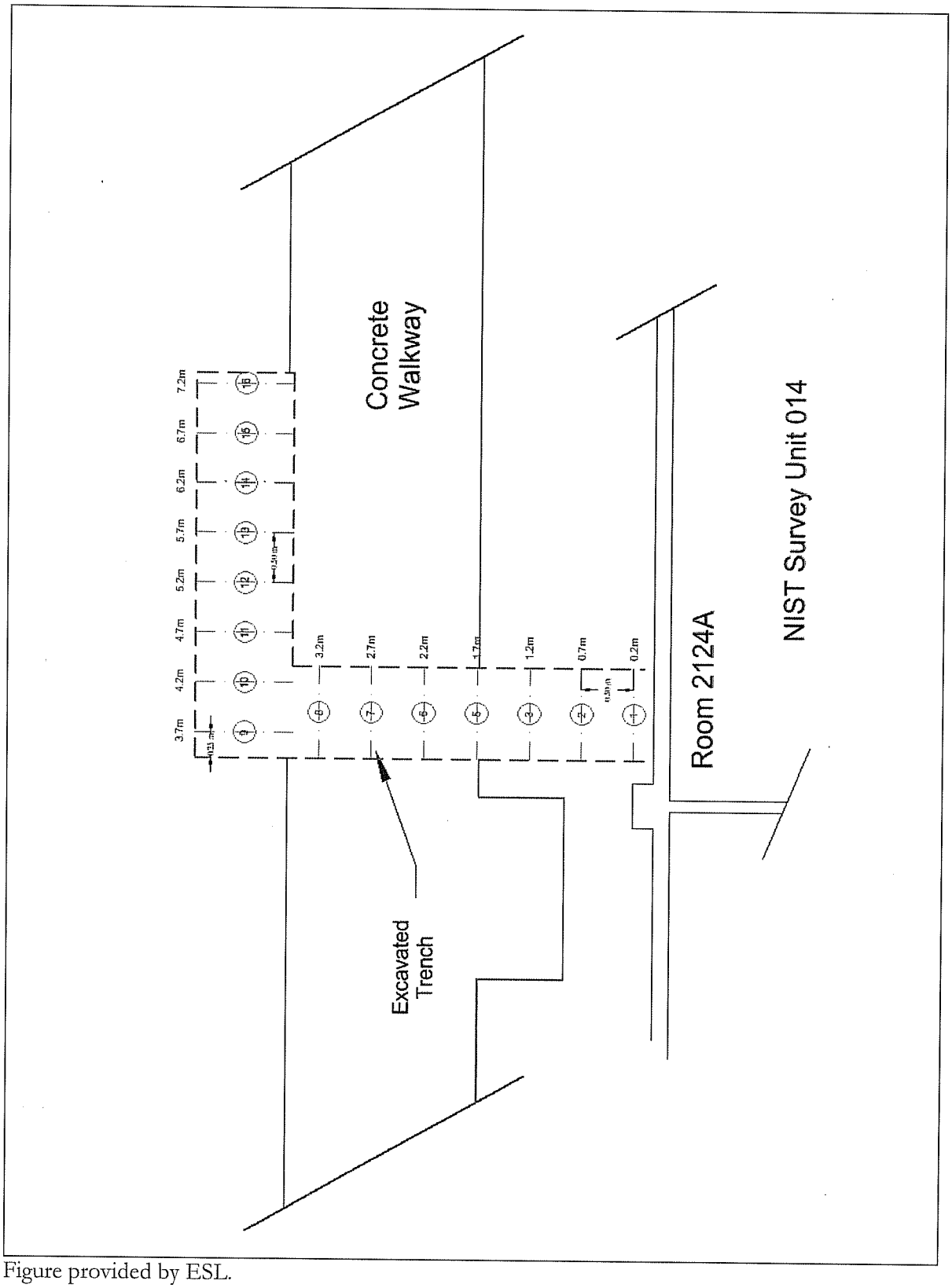

Figure provided by ESL.

Figure A-7: Impacted Area Soil Excavation – Exterior

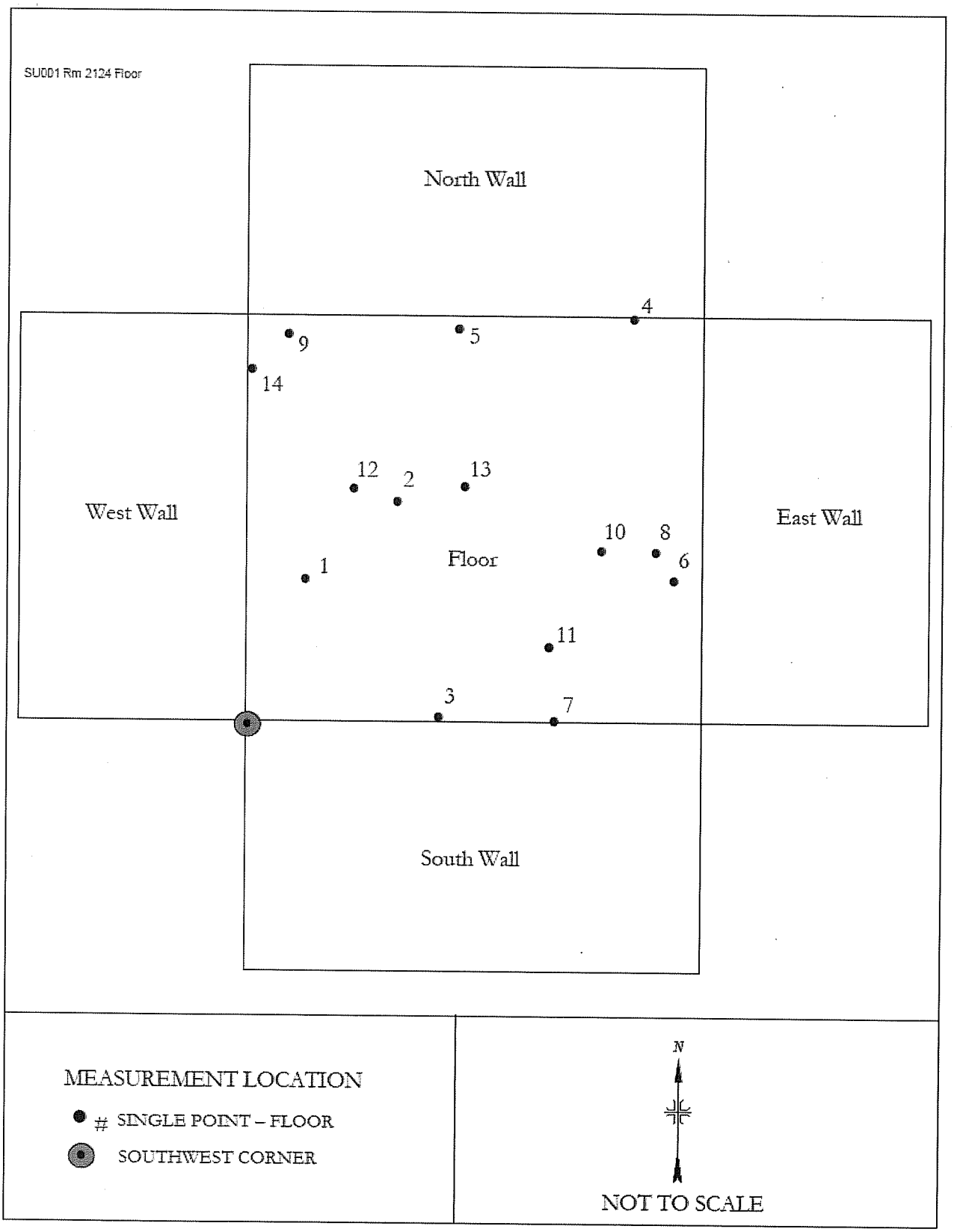

Figure A-8: Survey Unit 001, Room 2124 Floor – Direct Measurement Locations

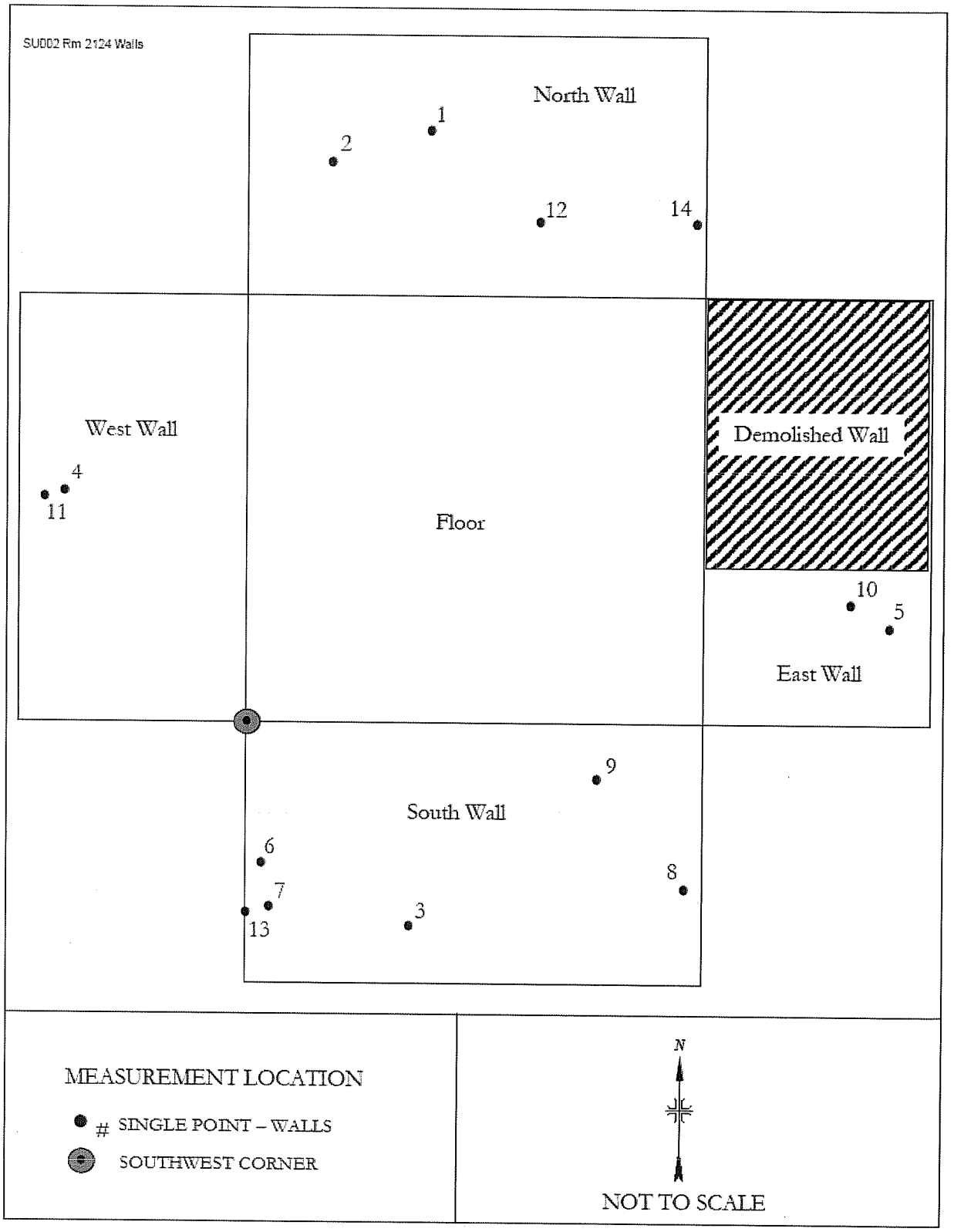

Figure A-9: Survey Unit 002, Room 2124 Walls – Direct Measurement Locations

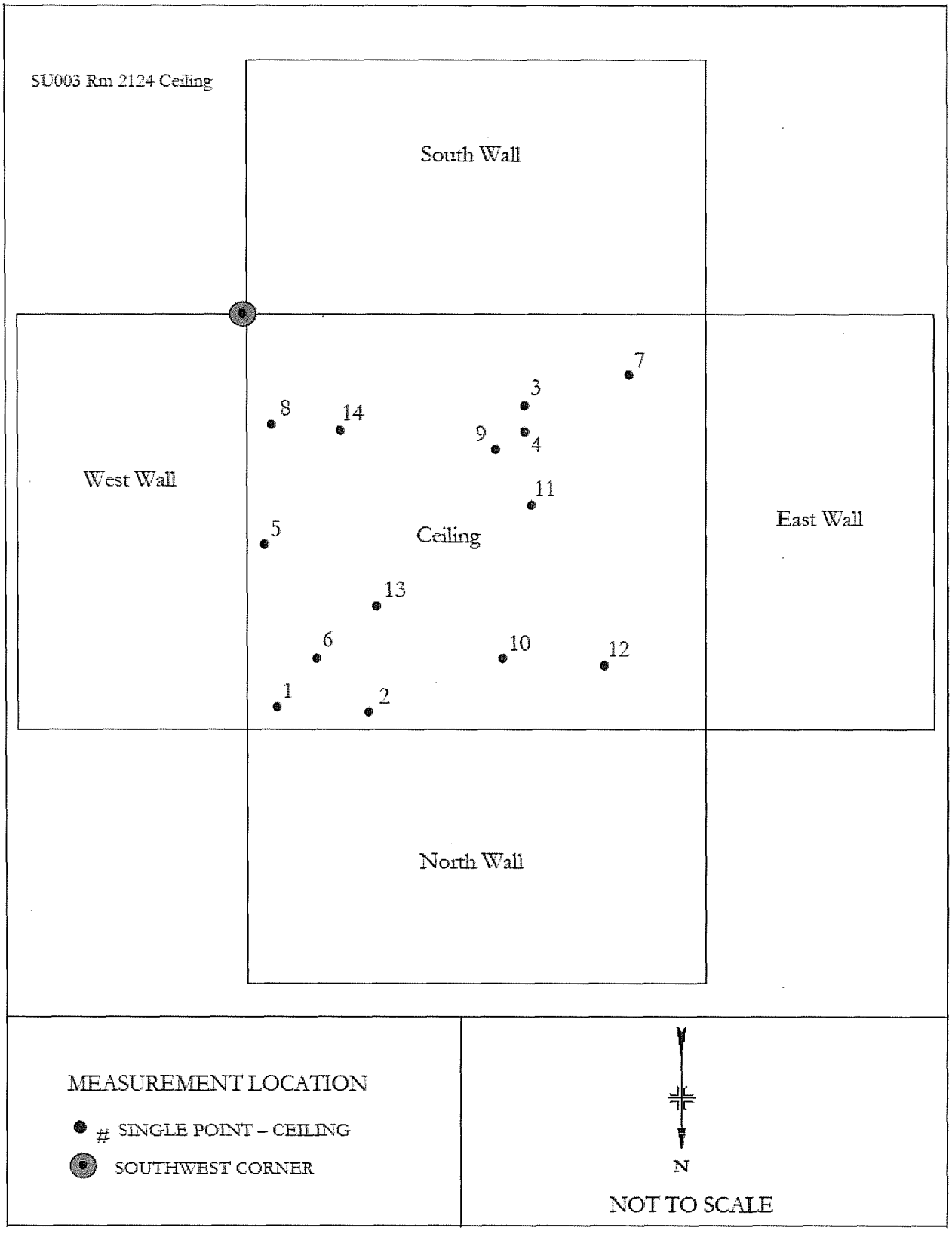

Figure A-10: Survey Unit 003, Room 2124 Ceiling – Direct Measurement Locations

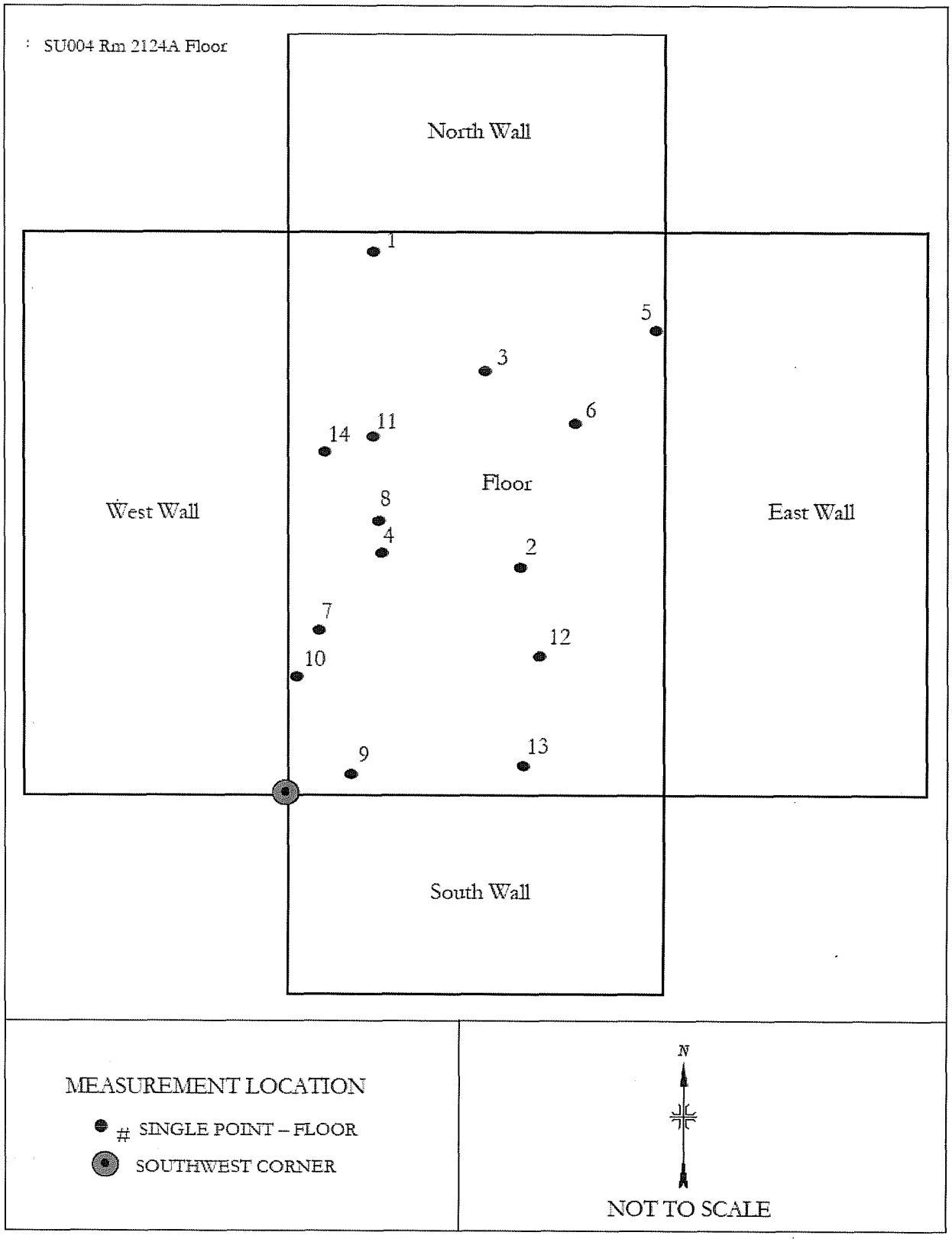

Figure A-11: Survey Unit 004, Room 2124A Floor – Direct Measurement Locations

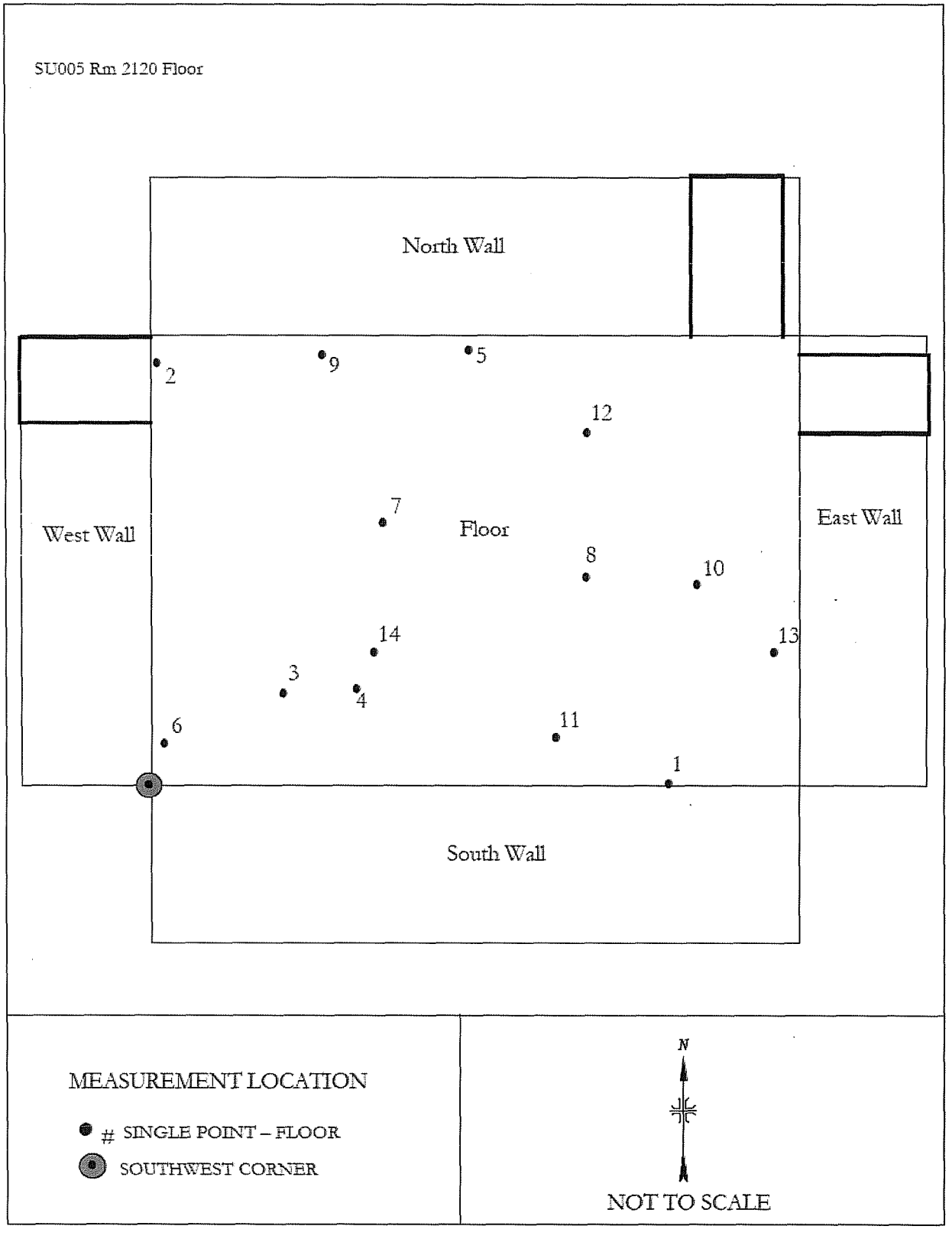

Figure A-12: Survey Unit 005, Room 2120 Floor – Direct Measurement Locations

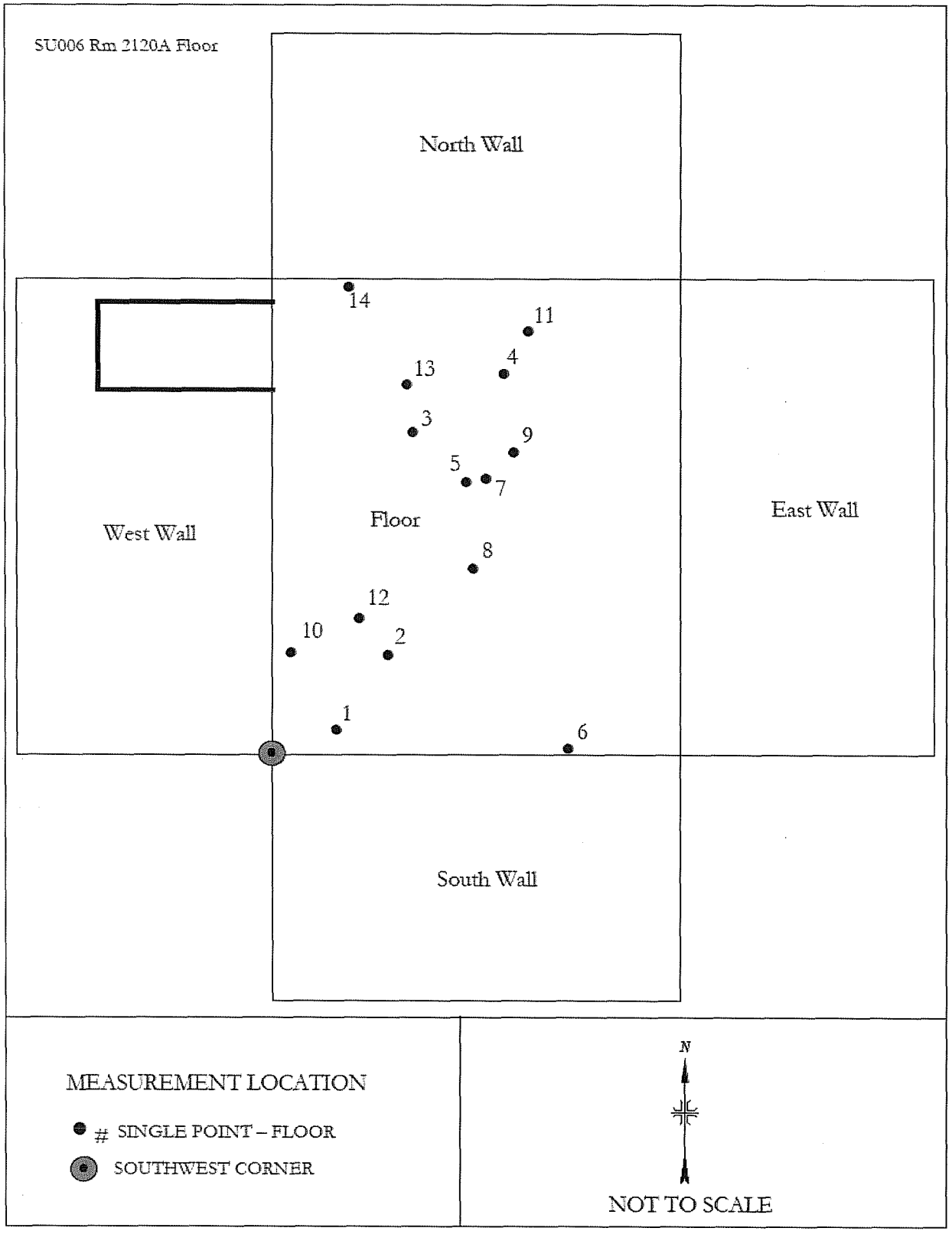

Figure A-13: Survey Unit 006, Room 2120A Floor – Direct Measurement Locations

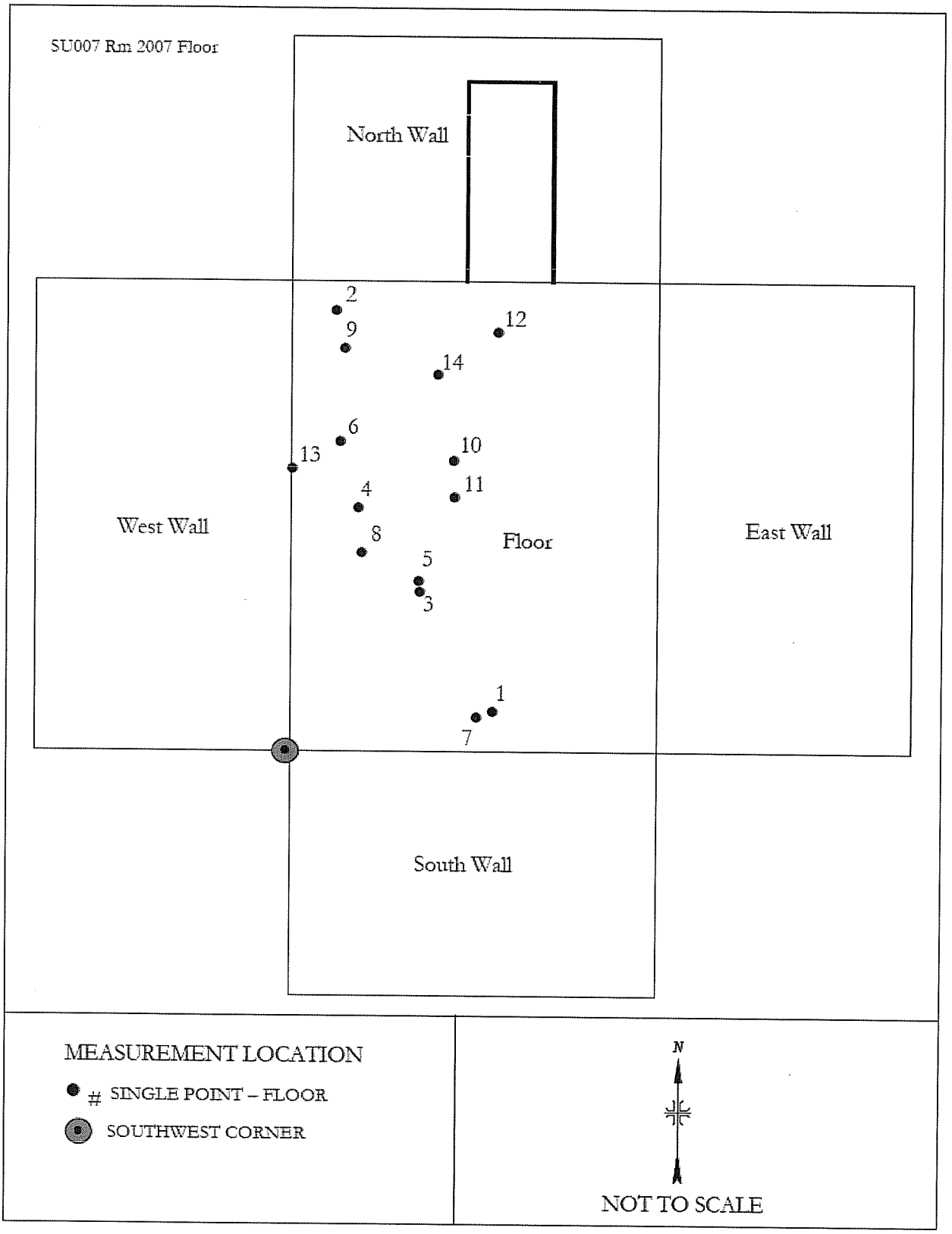

Figure A-14: Survey Unit 007, Room 2007 Floor – Direct Measurement Locations

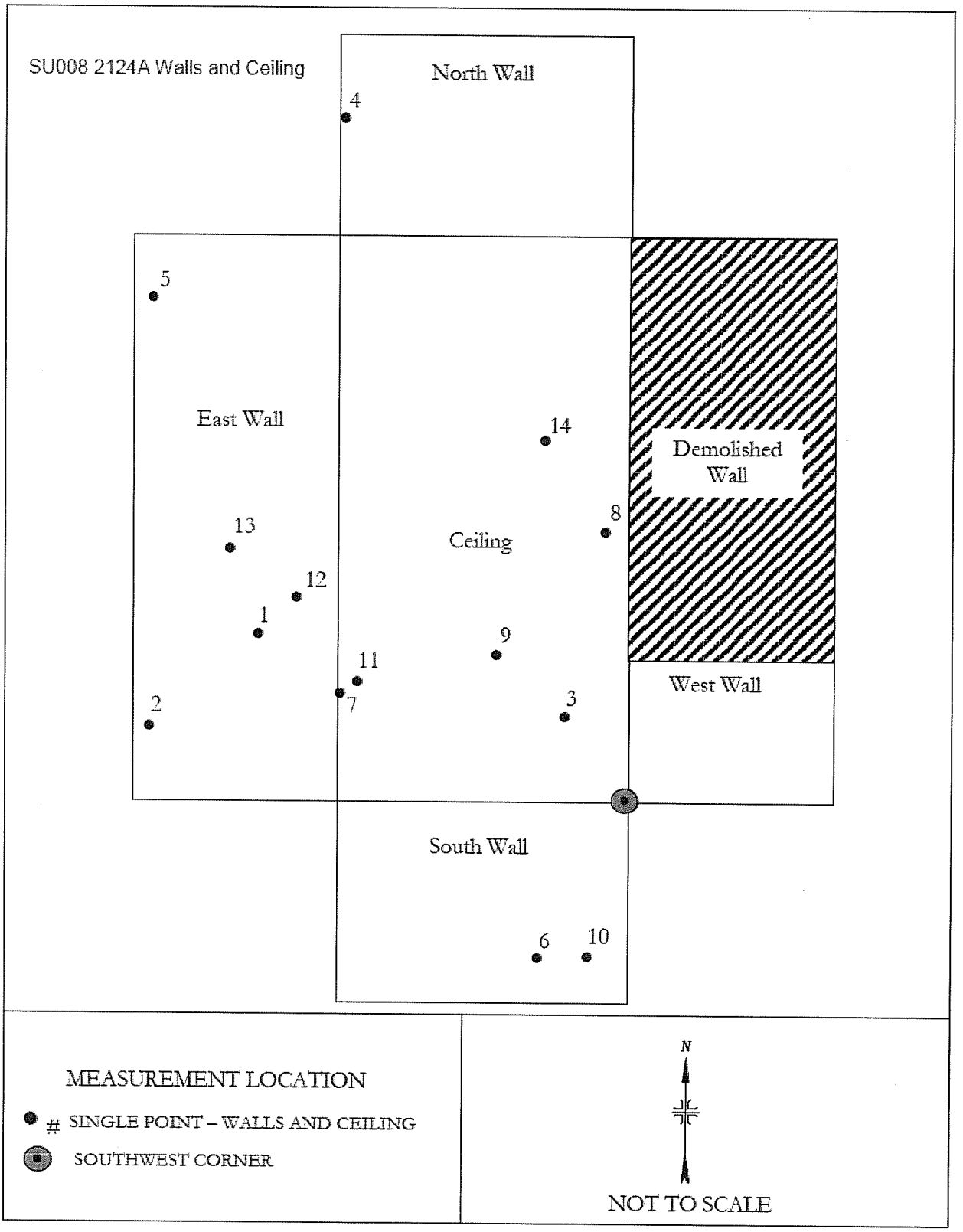

Figure A-15: Survey Unit 008, Room 2124A Walls and Ceiling – Direct Measurement Locations

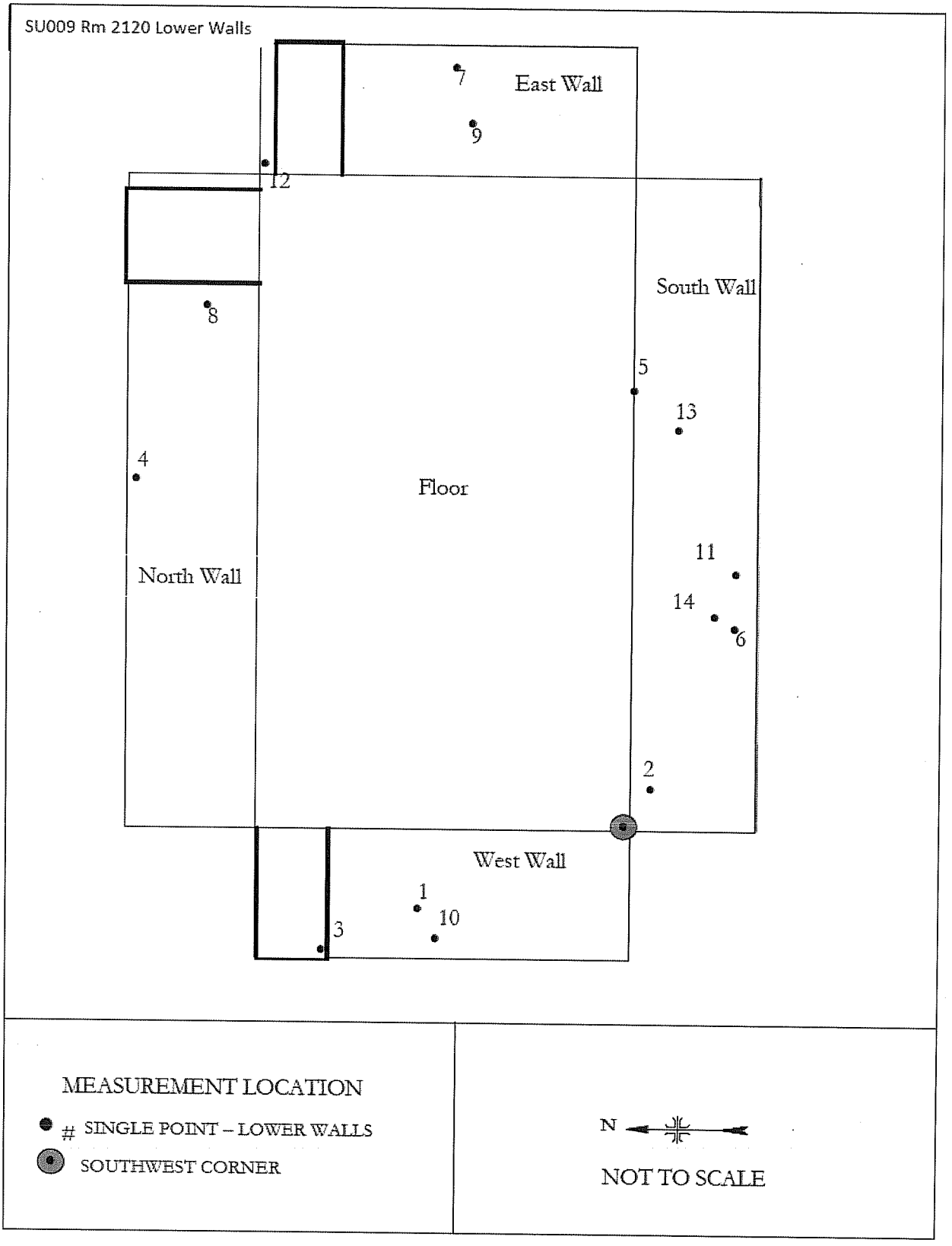

Figure A-16: Survey Unit 009, Room 2120 Lower Walls – Direct Measurement Locations

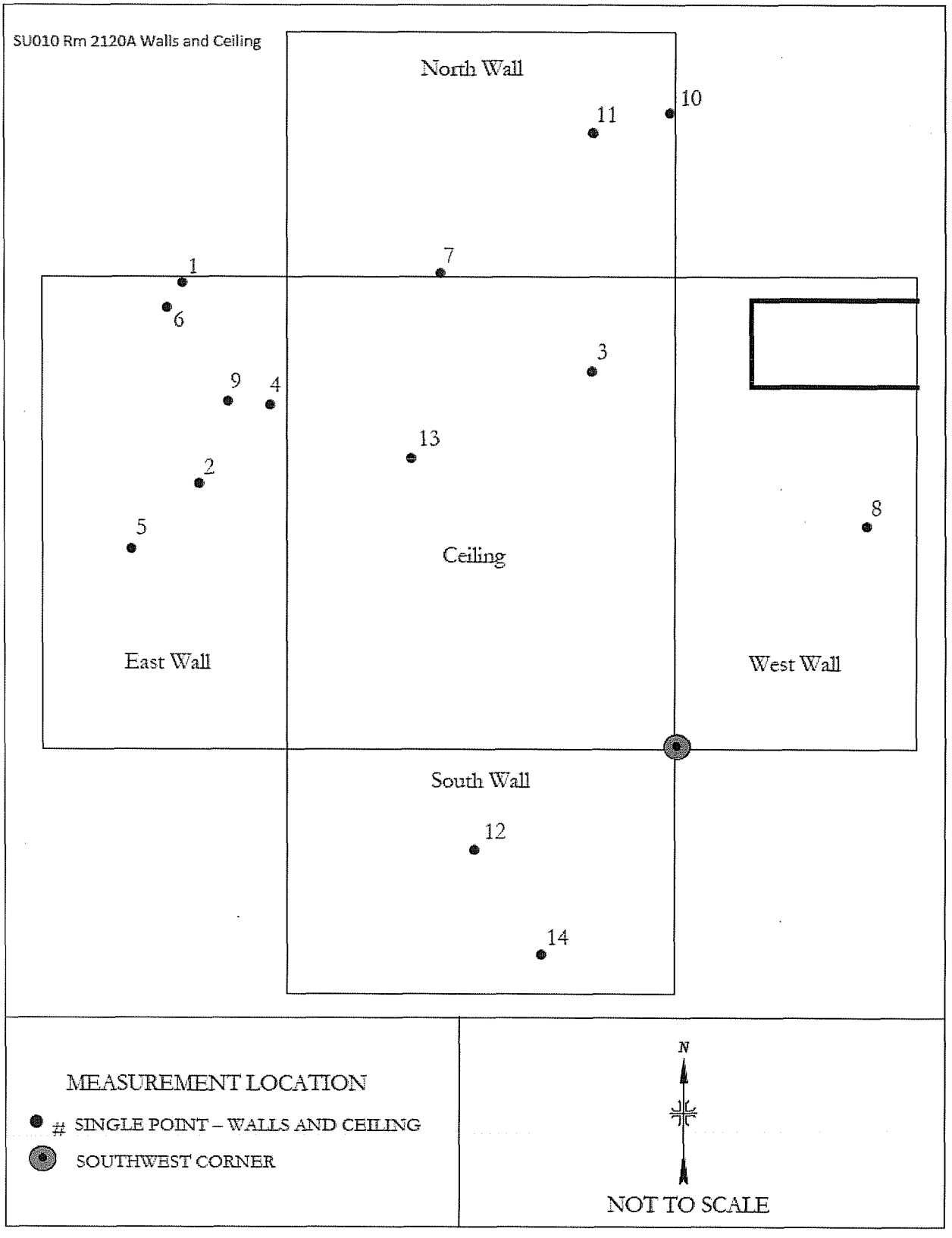

Figure A-17: Survey Unit 010, Room 2120A Walls and Ceiling – Direct Measurement Locations

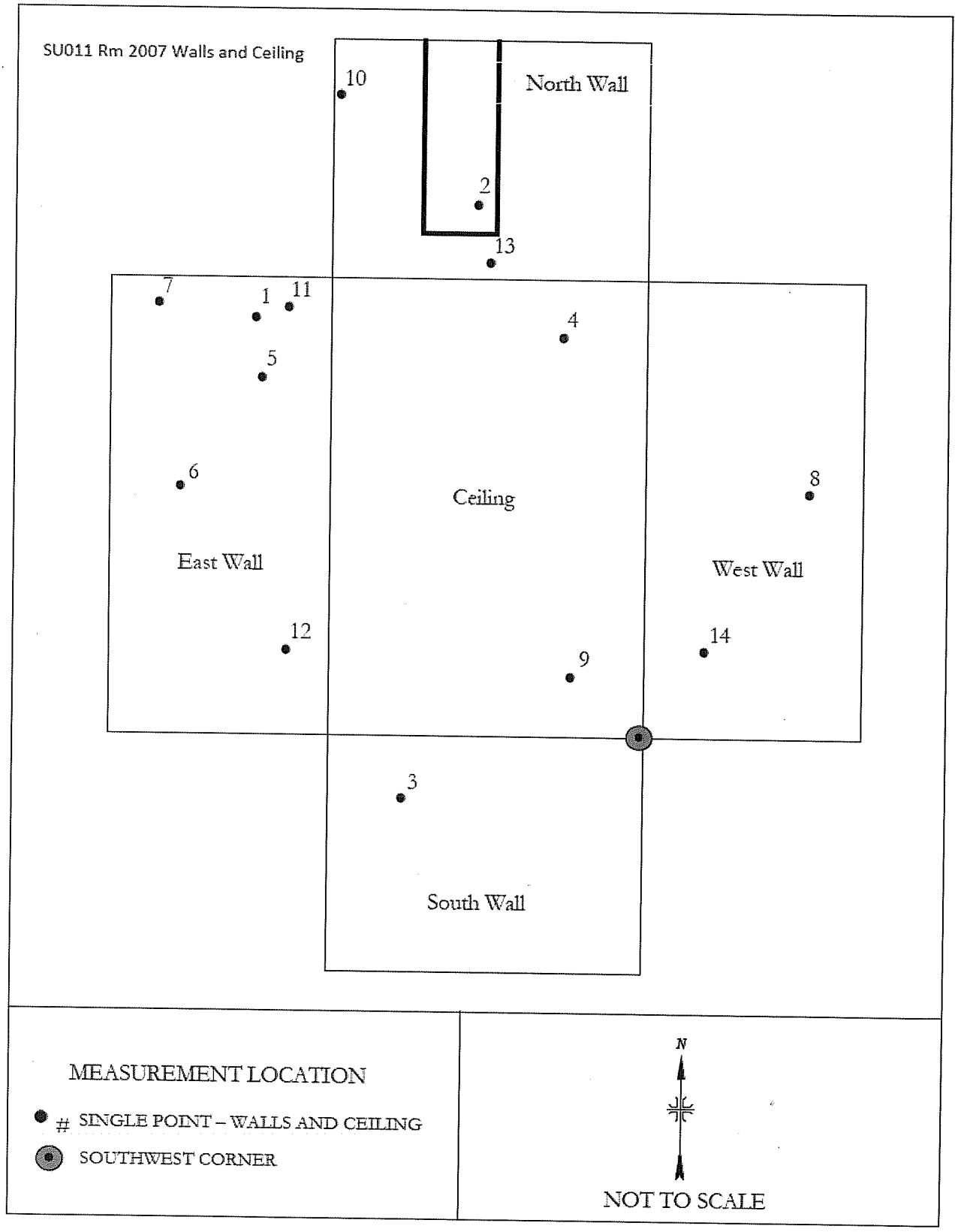

Figure A-18: Survey Unit 011, Room 2007 Walls and Ceiling – Direct Measurement Locations

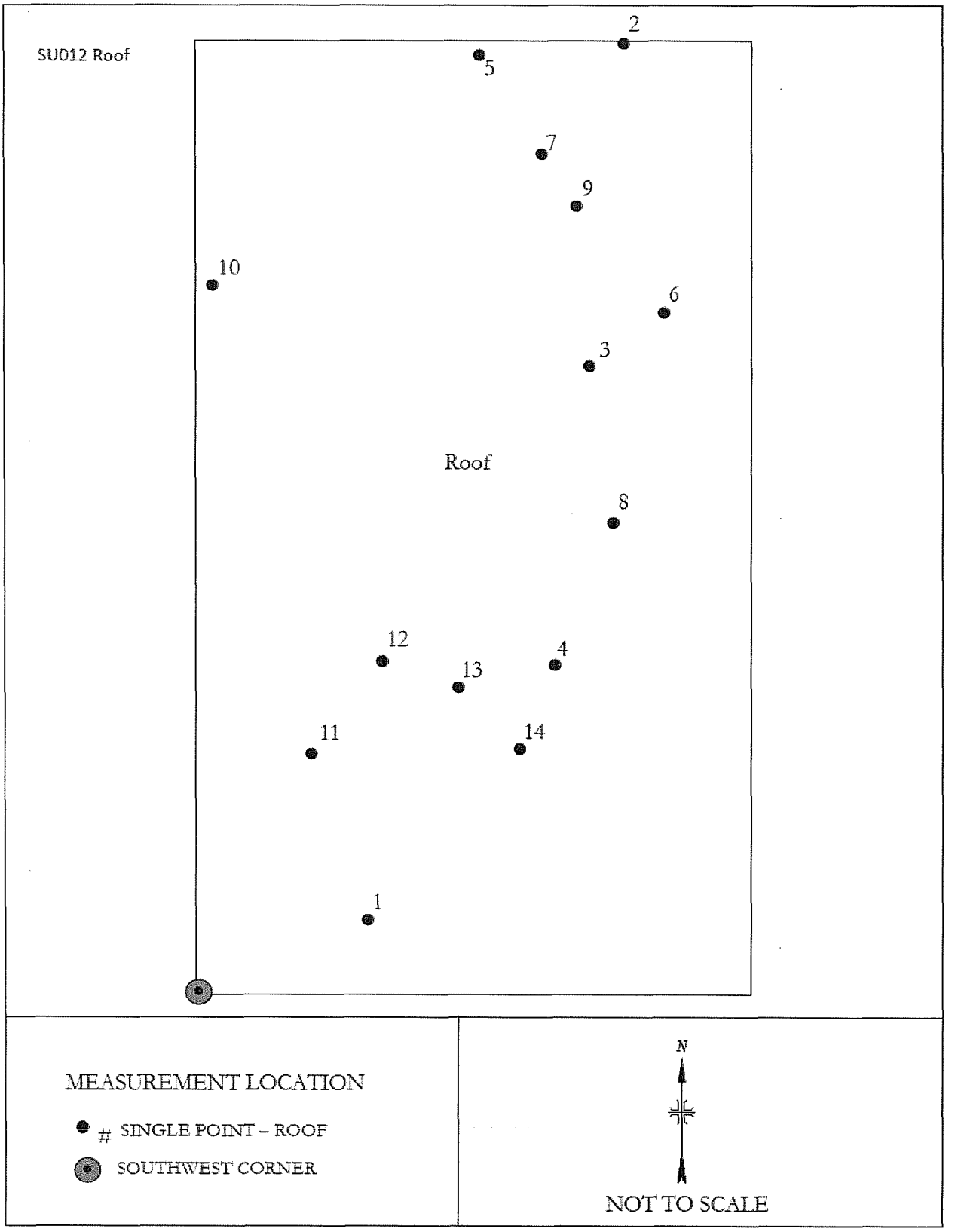

Figure A-19: Survey Unit 012, Roof – Direct Measurement Locations

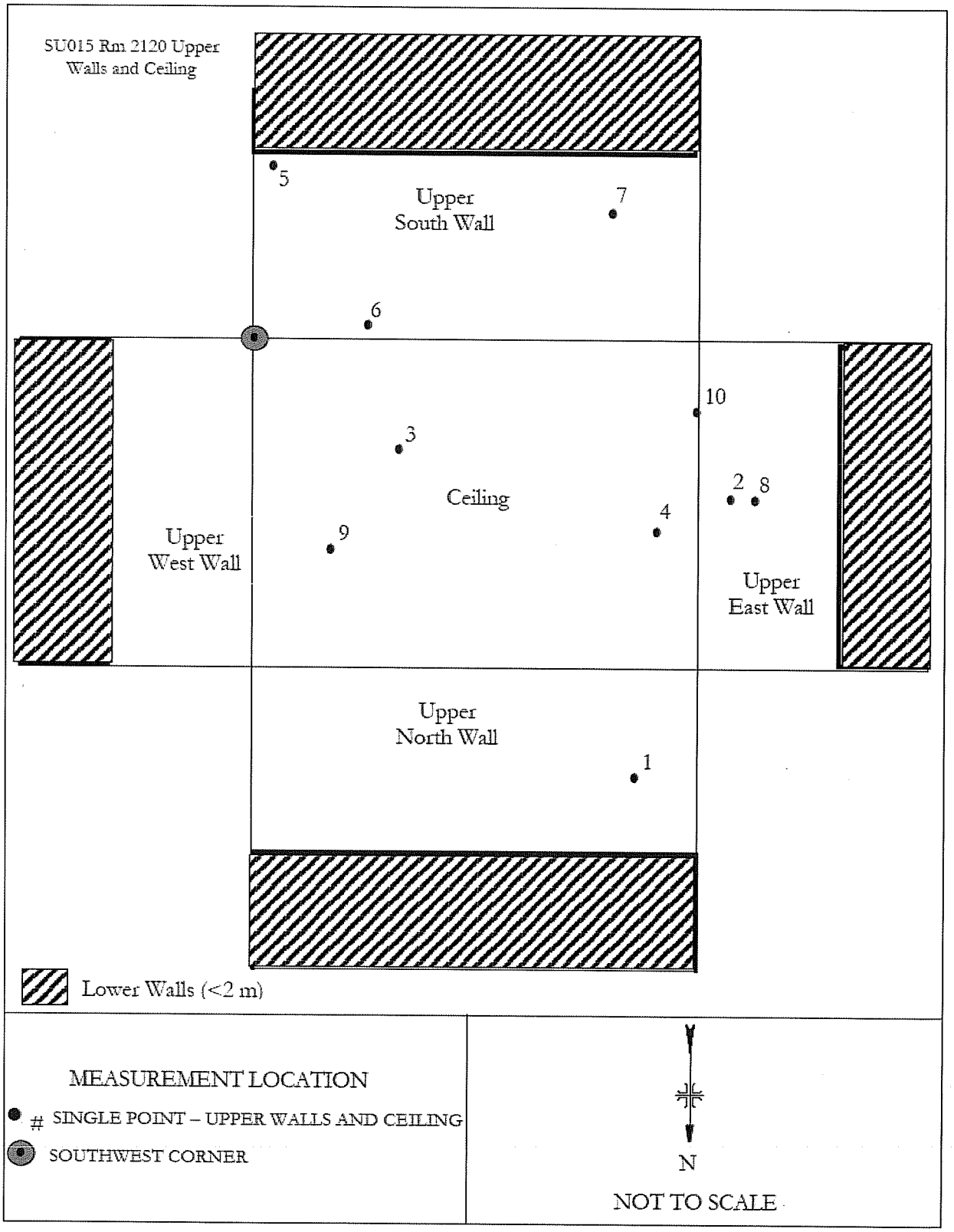

Figure A-20: Survey Unit 015, Room 2120 Upper Walls and Ceiling – Direct Measurement Locations

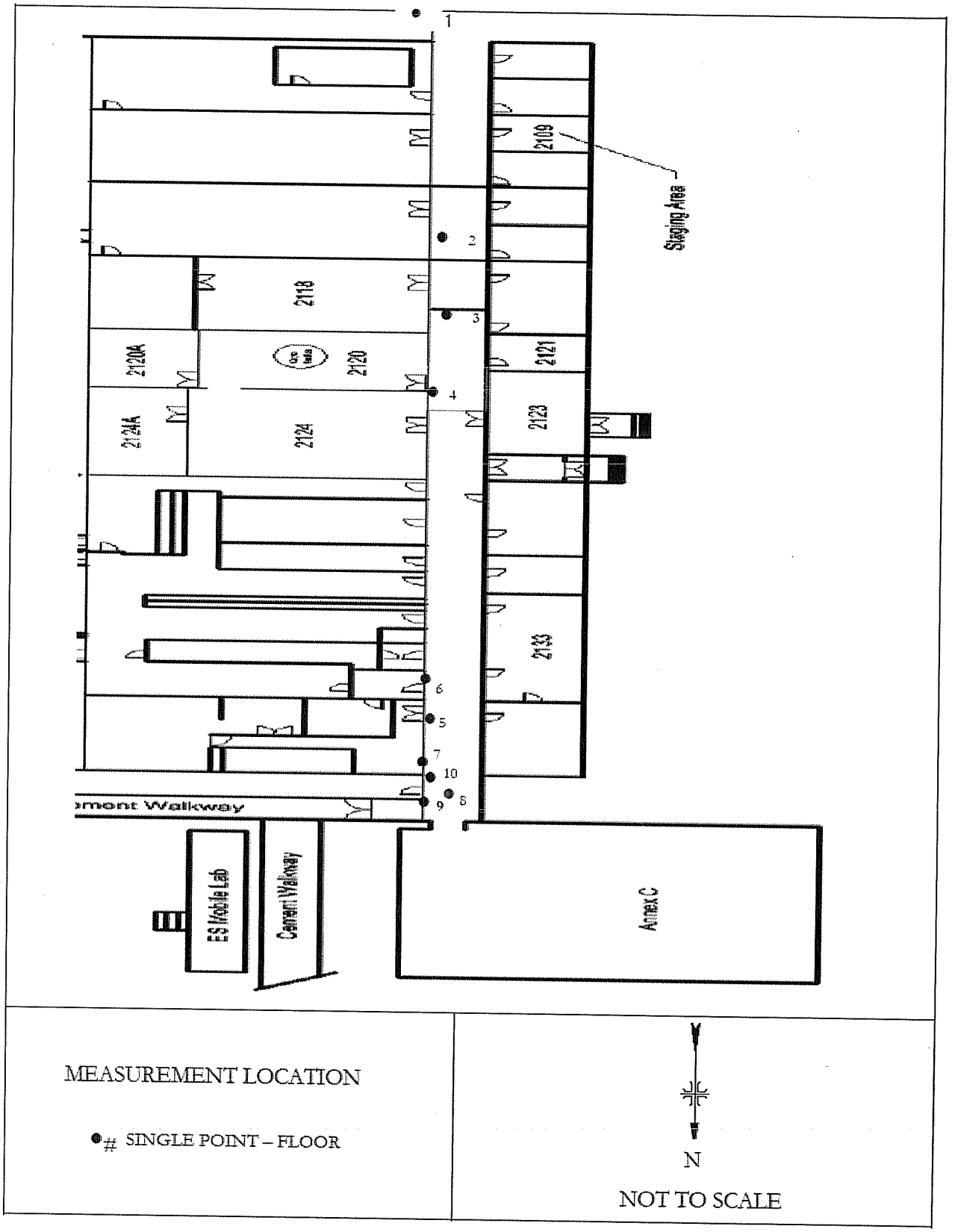

Figure A-21: Building 1, Hallway – Direct Measurement Locations

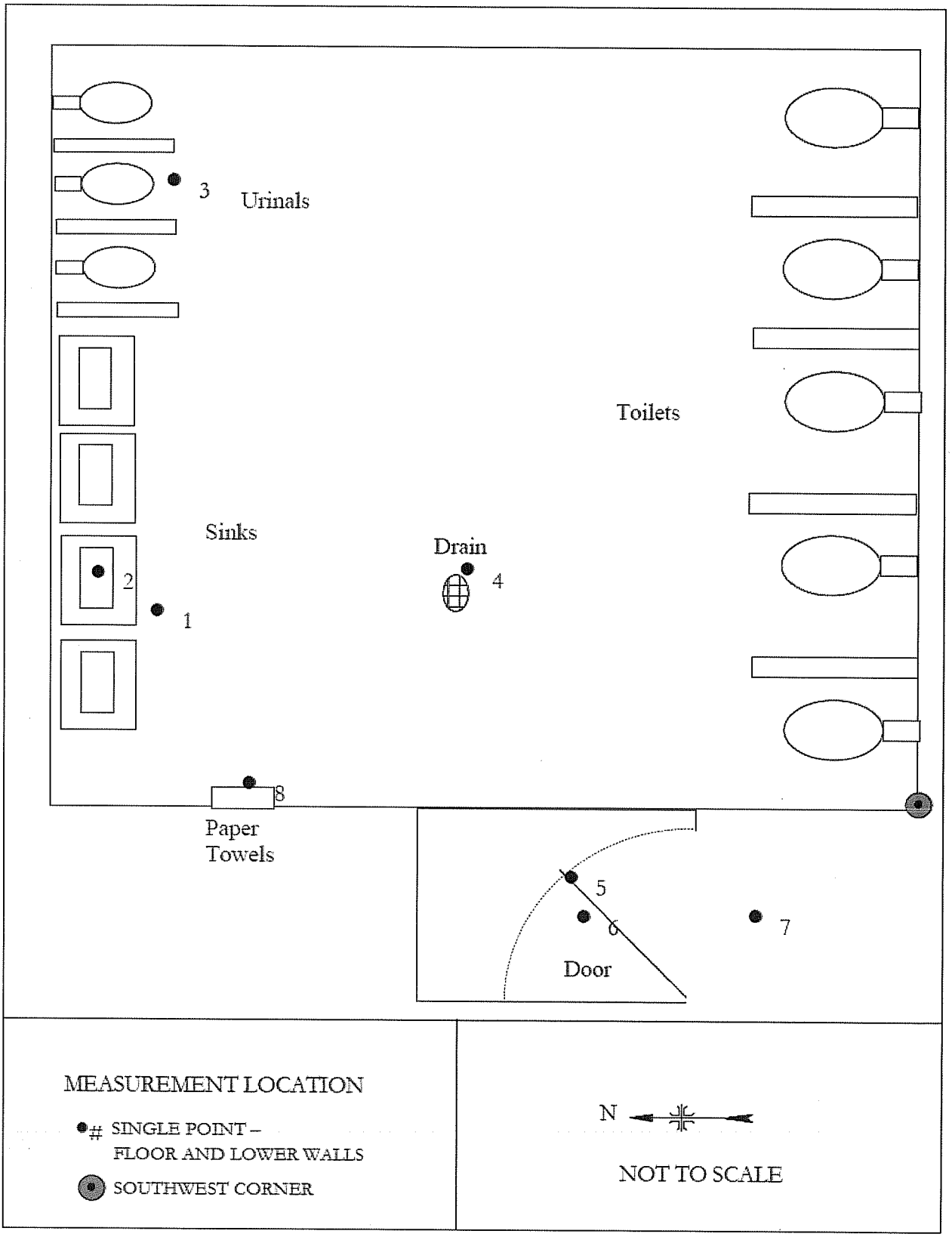

Figure A-22: Men's Restroom, Floor and Lower Walls – Direct Measurement Locations

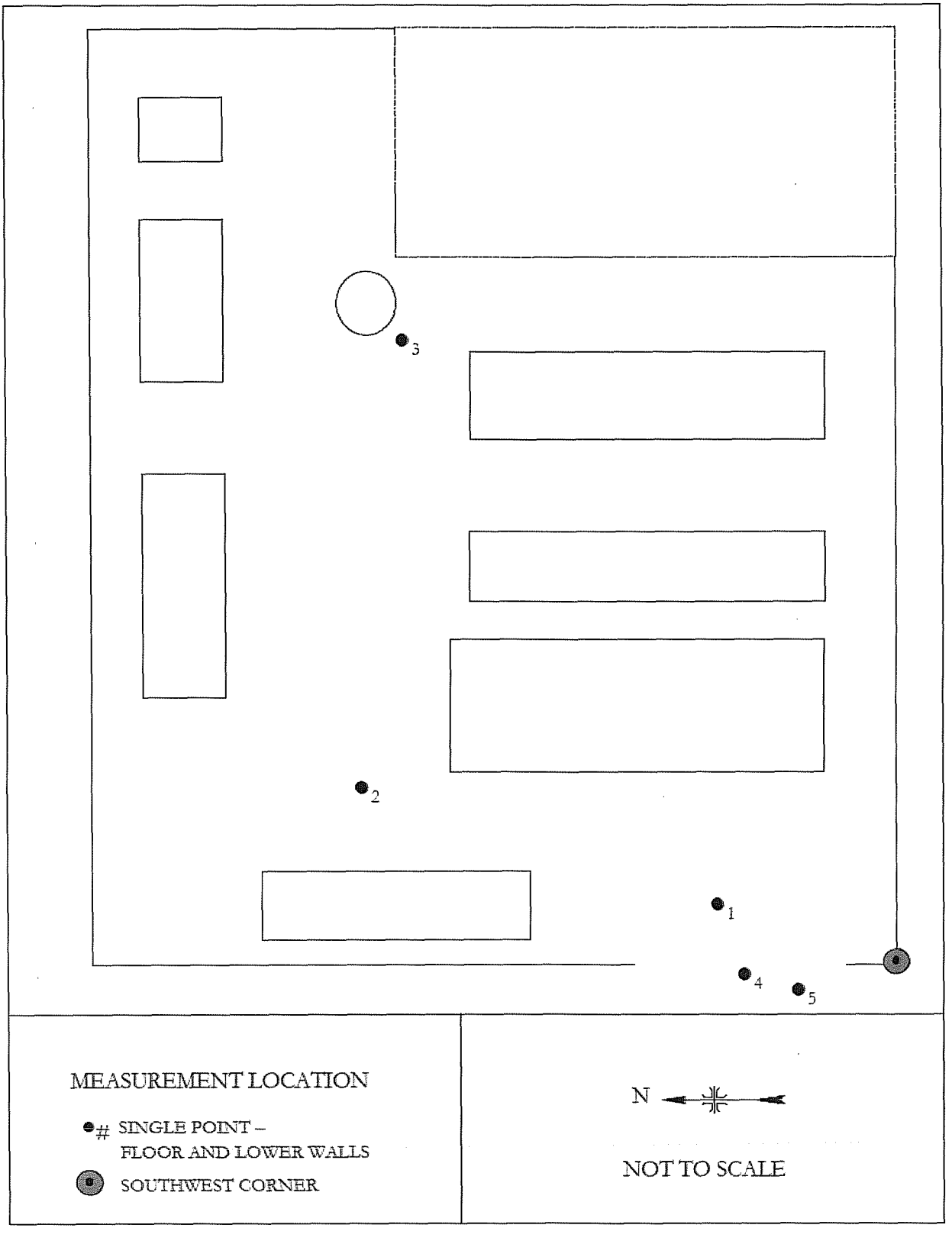

Figure A-23: Room 2114, Floor and Lower Walls – Direct Measurement Locations

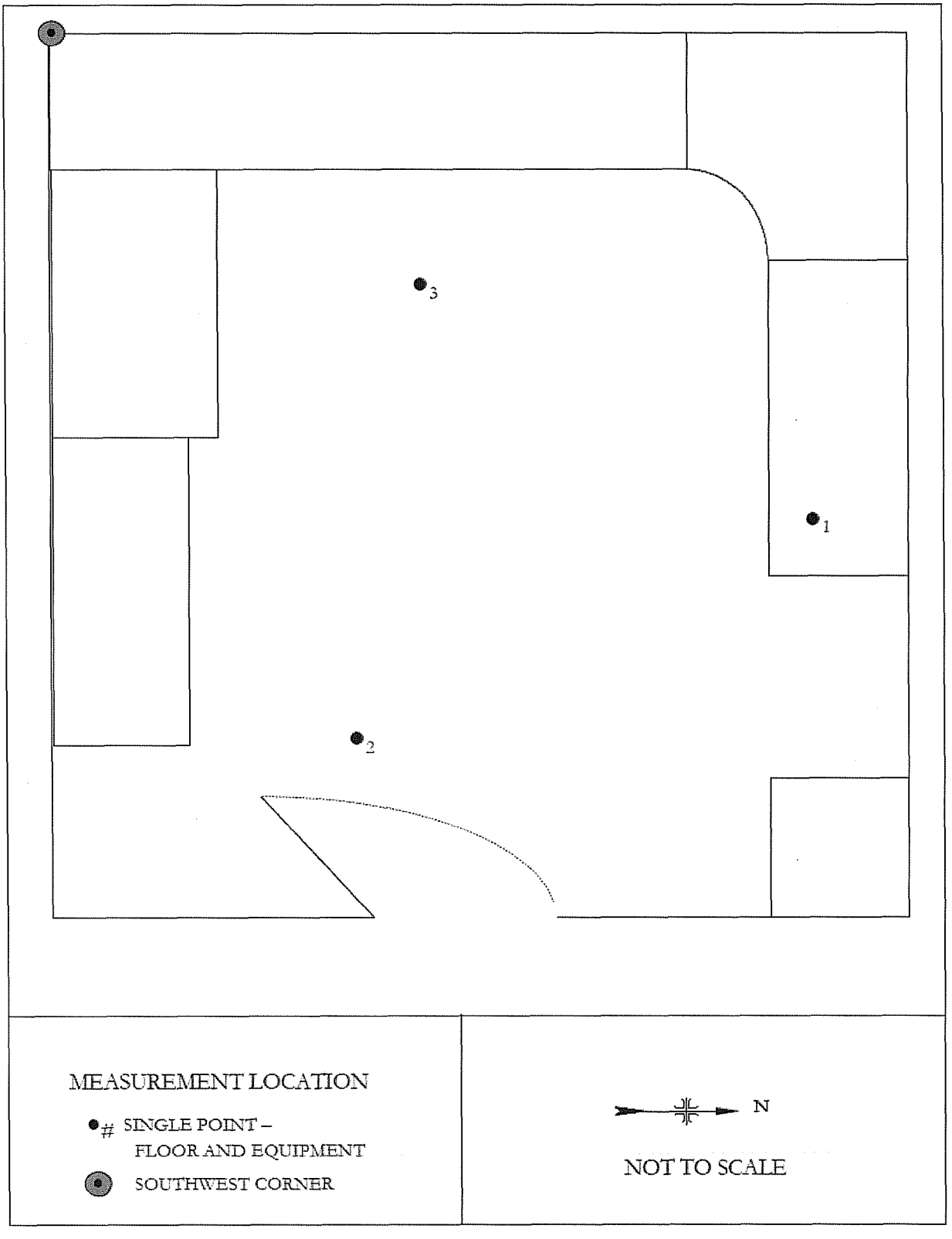

Figure A-24: Room 2109, Floor and Equipment – Direct Measurement Locations

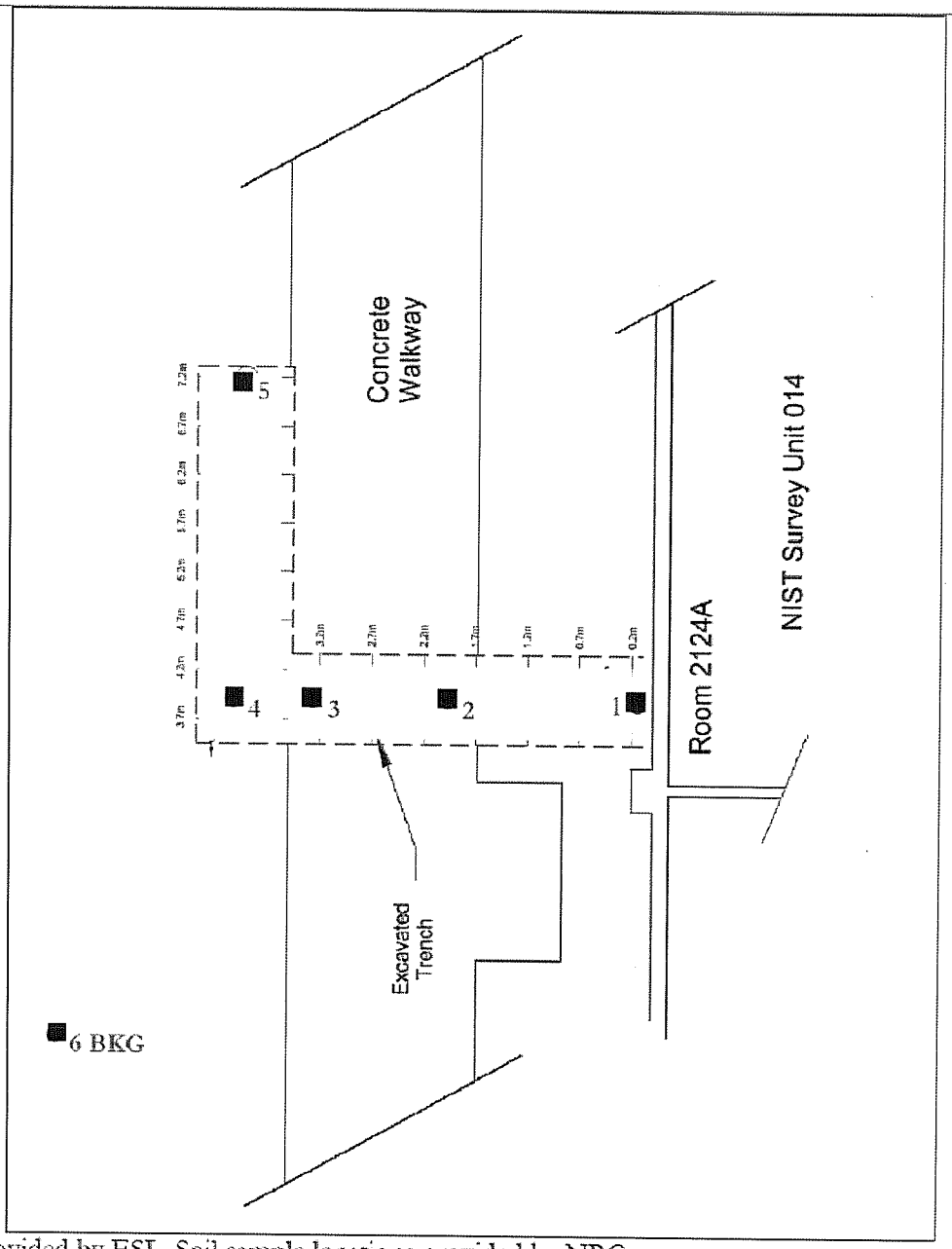

Figure provided by ESL. Soil sample locations provided by NRC.

NRC SOIL SAMPLE LOCATION

■# NRC SOIL SAMPLE

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Figure A-25: Exterior Excavation – NRC Soil Sample Locations

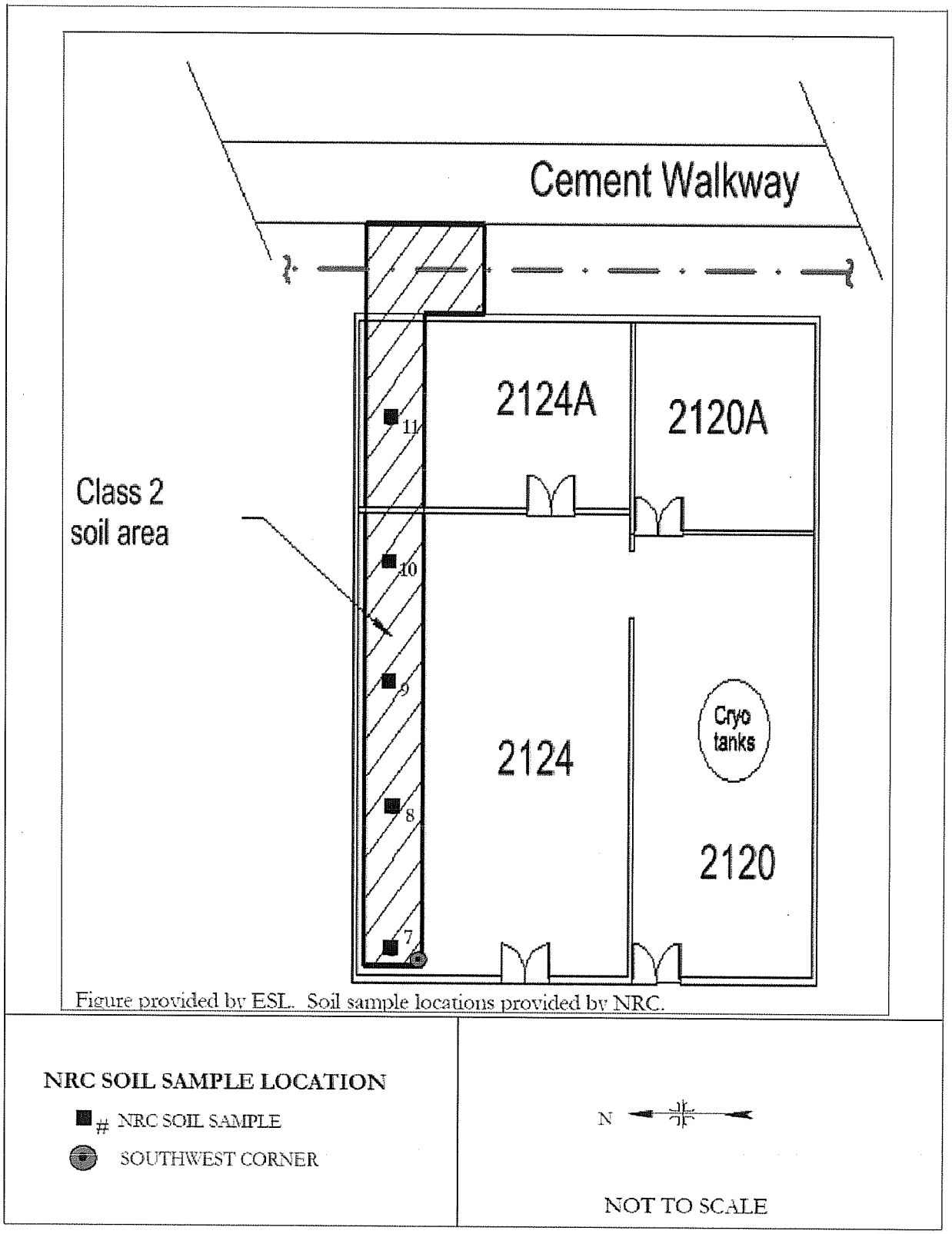

Figure A-26: Interior Excavation – NRC Soil Sample Locations

APPENDIX B

TABLES

TABLE B-1: ALPHA SURFACE ACTIVITY MEASUREMENTS NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)							
Survey Unit/ Location[a]	VSP Coordinates			Surface	Surface Material	Gross Alpha Activity[b] (dpm/100 cm^2)	Meets DCGL$_w$
	X	Y	Z				
Survey Unit 001, Room 2124 Floors							
1	1.34	2.96	0	Floor	Concrete	130	YES
2	3.44	4.61	0	Floor	Concrete	130	YES
3	4.41	0.1	0	Floor	Concrete	140	YES
4	8.82	8.43	0	Floor	Concrete	130	YES
5	4.82	8.21	0	Floor	Concrete	95	YES
6	9.75	2.99	0	Floor	Concrete	110	YES
7	7.04	0	0	Floor	Concrete	79	YES
8	9.34	3.55	0	Floor	Concrete	140	YES
9	0.93	8.07	0	Floor	Concrete	170	YES
10	8.1	3.59	0	Floor	Concrete	220	YES
11	6.92	1.56	0	Floor	Concrete	79	YES
12	2.43	4.86	0	Floor	Concrete	95	YES
13	4.98	4.91	0	Floor	Concrete	130	YES
14	0.1	7.36	0	Floor	Concrete	210	YES
Survey Unit 002, Room 2124 Walls							
1	4.14	8.5	3.28	North Wall	Concrete	210	YES
2	1.91	8.5	2.65	North Wall	Concrete	220	YES
3	3.72	0	4.05	South Wall	Sheetrock	300	YES
4	0	4.59	4.13	West Wall	Concrete	350	YES
5	10.4	1.91	4.28	East Wall	Sheetrock	32	YES
6	0.37	0	2.81	South Wall	Sheetrock	250	YES
7	0.54	0	3.68	South Wall	Sheetrock	160	YES
8	9.63	0	3.28	South Wall	Sheetrock	190	YES
9	7.66	0	1.11	South Wall	Sheetrock	190	YES
10	10.4	2.4	3.38	East Wall	Sheetrock	210	YES

TABLE B-1: ALPHA SURFACE ACTIVITY MEASUREMENTS NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)							
Survey Unit/ Location[a]	VSP Coordinates			Surface	Surface Material	Gross Alpha Activity[b] (dpm/100 cm^2)	Meets DCGL$_w$
	X	Y	Z				
Survey Unit 002, Room 2124 Walls – continued							
11	0	4.5	4.59	West Wall	Concrete	190	YES
12	6.63	8.5	1.47	North Wall	Concrete	320	YES
13	0	0	3.79	South Wall	Sheetrock	210	YES
14	10.2	8.5	1.46	North Wall	Concrete	330	YES
Survey Unit 003, Room 2124 Ceiling							
1	0.67	8.06	5.2	Ceiling	Concrete	32	YES
2	2.76	8.16	5.2	Ceiling	Concrete	130	YES
3	6.28	1.89	5.2	Ceiling	Concrete	140	YES
4	6.28	2.42	5.2	Ceiling	Concrete	95	YES
5	0.39	4.74	5.2	Ceiling	Concrete	32	YES
6	1.58	7.04	5.2	Ceiling	Concrete	0	YES
7	8.67	1.26	5.2	Ceiling	Concrete	32	YES
8	0.56	2.29	5.2	Ceiling	Concrete	-16	YES
9	5.63	2.79	5.2	Ceiling	Concrete	160	YES
10	5.77	7.06	5.2	Ceiling	Concrete	110	YES
11	6.44	3.92	5.2	Ceiling	Concrete	63	YES
12	8.1	7.2	5.2	Ceiling	Concrete	16	YES
13	2.94	6	5.2	Ceiling	Concrete	63	YES
14	2.13	2.39	5.2	Ceiling	Concrete	48	YES
Survey Unit 004, Room 2124A Floor							
1	0.99	8.19	0	Floor	Concrete	130	YES
2	2.66	3.43	0	Floor	Concrete	240	YES
3	2.26	6.4	0	Floor	Concrete	95	YES
4	1.09	3.65	0	Floor	Concrete	95	YES
5	4.21	7.02	0	Floor	Concrete	170	YES

TABLE B-1: ALPHA SURFACE ACTIVITY MEASUREMENTS NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)							
Survey Unit/ Location[a]	VSP Coordinates			Surface	Surface Material	Gross Alpha Activity[b] (dpm/100 cm^2)	Meets DCGL$_w$
	X	Y	Z				
Survey Unit 004, Room 2124A Floor – continued							
6	3.28	5.6	0	Floor	Concrete	130	YES
7	0.36	2.49	0	Floor	Concrete	63	YES
8	1.05	4.14	0	Floor	Concrete	170	YES
9	0.73	0.31	0	Floor	Concrete	170	YES
10	0.11	1.78	0	Floor	Concrete	110	YES
11	0.98	5.4	0	Floor	Concrete	63	YES
12	2.88	2.08	0	Floor	Concrete	95	YES
13	2.69	0.43	0	Floor	Concrete	79	YES
14	0.43	5.17	0	Floor	Concrete	48	YES
Survey Unit 005, Room 2120 Floor							
1	7.99	0.02	0	Floor	Tile	190	YES
2	0.1	5.35	0	Floor	Tile	110	YES
3	2.03	1.16	0	Floor	Tile	63	YES
4	3.16	1.21	0	Floor	Tile	63	YES
5	4.9	5.52	0	Floor	Tile	130	YES
6	0.2	0.52	0	Floor	Tile	79	YES
7	3.57	3.33	0	Floor	Tile	-16	YES
8	6.71	2.63	0	Floor	Tile	48	YES
9	2.64	5.46	0	Floor	Tile	140	YES
10	8.43	2.54	0	Floor	Tile	16	YES
11	6.25	0.6	0	Floor	Tile	32	YES
12	6.72	4.46	0	Floor	Tile	48	YES
13	9.62	1.69	0	Floor	Tile	-16	YES
14	3.43	1.7	0	Floor	Tile	290	YES

TABLE B-1: ALPHA SURFACE ACTIVITY MEASUREMENTS NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)							
Survey Unit/ Location[a]	VSP Coordinates			Surface	Surface Material	Gross Alpha Activity[b] (dpm/100 cm^2)	Meets DCGL$_w$
	X	Y	Z				
Survey Unit 006, Room 2120A Floor							
1	0.75	0.3	0	Floor	Tile	140	YES
2	1.37	1.21	0	Floor	Tile	170	YES
3	1.65	3.93	0	Floor	Tile	16	YES
4	2.72	4.64	0	Floor	Tile	95	YES
5	2.28	3.32	0	Floor	Tile	95	YES
6	3.49	0.06	0	Floor	Tile	0	YES
7	2.51	3.37	0	Floor	Tile	16	YES
8	2.37	2.26	0	Floor	Tile	95	YES
9	2.84	3.68	0	Floor	Tile	170	YES
10	0.22	1.24	0	Floor	Tile	48	YES
11	3	5.16	0	Floor	Tile	63	YES
12	1.03	1.66	0	Floor	Tile	32	YES
13	1.59	4.51	0	Floor	Tile	-16	YES
14	0.91	5.7	0	Floor	Tile	48	YES
Survey Unit 007, Room 2007 Floor							
1	2	0.41	0	Floor	Concrete	130	YES
2	0.44	4.5	0	Floor	Concrete	63	YES
3	1.27	1.63	0	Floor	Concrete	160	YES
4	0.66	2.49	0	Floor	Concrete	79	YES
5	1.26	1.74	0	Floor	Concrete	210	YES
6	0.48	3.15	0	Floor	Concrete	48	YES
7	1.84	0.35	0	Floor	Concrete	210	YES
8	0.7	2.02	0	Floor	Concrete	79	YES
9	0.53	4.12	0	Floor	Concrete	79	YES
10	1.6	2.96	0	Floor	Concrete	63	YES

TABLE B-1: ALPHA SURFACE ACTIVITY MEASUREMENTS NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)							
Survey Unit/ Location[a]	VSP Coordinates			Surface	Surface Material	Gross Alpha Activity[b] (dpm/100 cm^2)	Meets $DCGL_w$
	X	Y	Z				
Survey Unit 007, Room 2007 Floor - continued							
11	1.61	2.59	0	Floor	Concrete	63	YES
12	2.03	4.29	0	Floor	Concrete	63	YES
13	0.02	2.88	0	Floor	Concrete	63	YES
14	1.44	3.84	0	Floor	Concrete	16	YES
Survey Unit 008, Room 2124A Walls and Ceiling							
1	4.3	2.5	1.85	East Wall	Glass	48	YES
2	4.3	1.11	0.25	East Wall	Sheetrock	110	YES
3	0.95	1.28	3	Ceiling	Concrete	170	YES
4	4.2	8.5	1.25	North Wall	Concrete	130	YES
5	4	7.56	0.3	East Wall	Sheetrock	48	YES
6	1.34	0	1	South Wall	Sheetrock	48	YES
7	4.25	1.61	3	Ceiling	Concrete	16	YES
8	0.36	4.06	3	Ceiling	Concrete	79	YES
9	1.96	2.2	3	Ceiling	Concrete	16	YES
10	0.6	0	0.68	South Wall	Sheetrock	79	YES
11	4.01	1.8	3	Ceiling	Concrete	130	YES
12	4.3	3.06	2.41	East Wall	Glass	-16	YES
13	4.3	3.79	1.44	East Wall	Glass	63	YES
14	1.25	5.43	3	Ceiling	Concrete	130	YES
Survey Unit 009, Room 2120 Lower Walls							
1	0	3.23	1.21	West Wall	Sheetrock	63	YES
2	0.64	0	0.3	South Wall	Sheetrock	63	YES
3	0	4.69	1.85	West Wall	Wood	63	YES
4	5.34	5.7	1.85	North Wall	Sheetrock	79	YES
5	6.74	0	0.01	South Wall	Sheetrock	63	YES

TABLE B-1: ALPHA SURFACE ACTIVITY MEASUREMENTS NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)							
Survey Unit/ Location[a]	VSP Coordinates			Surface	Surface Material	Gross Alpha Activity[b] (dpm/100 cm^2)	Meets DCGL$_w$
	X	Y	Z				
Survey Unit 009, Room 2120 Lower Walls - continued							
6	3.11	0	1.58	South Wall	Sheetrock	-16	YES
7	10	2.73	1.65	East Wall	Sheetrock	16	YES
8	7.99	5.7	0.79	North Wall	Sheetrock	48	YES
9	10	2.48	0.8	East Wall	Sheetrock	48	YES
10	0	2.96	1.67	West Wall	Sheetrock	16	YES
11	3.94	0	1.59	South Wall	Sheetrock	32	YES
12	10	5.63	0.16	East Wall	Wood	110	YES
13	6.14	0	0.69	South Wall	Sheetrock	0	YES
14	3.29	0	1.27	South Wall	Sheetrock	63	YES
Survey Unit 010, Room 2120A Walls and Ceiling							
1	4.8	5.72	1.72	East Wall	Glass	-16	YES
2	4.8	3.25	1.93	East Wall	Glass	16	YES
3	1.03	4.63	3	Ceiling	Concrete	63	YES
4	4.8	4.23	2.8	East Wall	Sheetrock	16	YES
5	4.8	2.47	1.08	East Wall	Sheetrock	0	YES
6	4.8	5.43	1.54	East Wall	Sheetrock	48	YES
7	2.9	5.8	2.96	North Wall	Sheetrock	-32	YES
8	0	2.74	0.61	West Wall	Sheetrock	-32	YES
9	4.8	4.27	2.29	East Wall	Sheetrock	-16	YES
10	0.06	5.8	0.99	North Wall	Sheetrock	32	YES
11	1.02	5.8	1.24	North Wall	Sheetrock	0	YES
12	2.48	0	1.75	South Wall	Sheetrock	-16	YES
13	3.26	3.57	3	Ceiling	Concrete	140	YES
14	1.65	0	0.47	South Wall	Sheetrock	16	YES

TABLE B-1: ALPHA SURFACE ACTIVITY MEASUREMENTS NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)							
Survey Unit/ Location[a]	VSP Coordinates			Surface	Surface Material	Gross Alpha Activity[b] (dpm/100 cm^2)	Meets DCGL$_w$
	X	Y	Z				
Survey Unit 011, Room 2007 Walls and Ceiling							
1	3.6	4.37	1.65	East Wall	Sheetrock	16	YES
2	1.94	4.8	1.72	North Wall	Wood	79	YES
3	2.76	0	1.83	South Wall	Glass	220	YES
4	0.94	4.18	2.5	Ceiling	Fiberboard	160	YES
5	3.6	3.74	1.73	East Wall	Fiberboard	190	YES
6	3.6	2.6	0.8	East Wall	Sheetrock	79	YES
7	3.6	4.52	0.54	East Wall	Sheetrock	95	YES
8	0	2.56	0.62	West Wall	Sheetrock	130	YES
9	0.83	0.62	2.5	Ceiling	Fiberboard	95	YES
10	3.51	4.8	0.58	North Wall	Sheetrock	63	YES
11	3.6	4.48	2.02	East Wall	Fiberboard	63	YES
12	3.6	0.88	2.02	East Wall	Fiberboard	170	YES
13	1.8	4.8	2.34	North Wall	Fiberboard	160	YES
14	0	0.9	1.81	West Wall	Fiberboard	63	YES
Survey Unit 012, Roof							
1	4.55	2.09	0	Floor	Granules	82	YES
2	11.39	26.45	0	Floor	Granules	82	YES
3	10.5	17.49	0	Floor	Granules	-82	YES
4	9.57	9.16	0	Floor	Granules	82	YES
5	7.51	26.13	0	Floor	Granules	-41	YES
6	12.45	18.95	0	Floor	Granules	-41	YES
7	9.19	23.39	0	Floor	Granules	82	YES
8	11.09	13.13	0	Floor	Granules	0	YES
9	10.12	21.94	0	Floor	Granules	-41	YES

TABLE B-1: ALPHA SURFACE ACTIVITY MEASUREMENTS NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)							
Survey Unit/ Location[a]	VSP Coordinates			Surface	Surface Material	Gross Alpha Activity[b] (dpm/100 cm^2)	Meets DCGL$_w$
	X	Y	Z				
Survey Unit 012, Roof - continued							
10	0.44	19.73	0	Floor	Granules	120	YES
11	3.05	6.72	0	Floor	Granules	250	YES
12	4.96	9.28	0	Floor	Granules	120	YES
13	6.99	8.54	0	Floor	Granules	0	YES
14	8.62	6.83	0	Floor	Granules	120	YES
Survey Unit 015, Room 2120 Upper Walls and Ceiling							
1	8.62	5.7	3.31	North Wall	Sheetrock	48	YES
2	10	2.75	4.48	East Wall	Concrete	16	YES
3	3.28	1.92	5.2	Ceiling	Concrete	-32	YES
4	9.09	3.33	5.2	Ceiling	Concrete	-16	YES
5	0.45	0	2.23	South Wall	Concrete	-16	YES
6	2.58	0	4.97	South Wall	Concrete	-32	YES
7	8.06	0	3.03	South Wall	Concrete	-32	YES
8	10	2.77	3.93	East Wall	Concrete	32	YES
9	1.77	3.66	5.2	Ceiling	Concrete	16	YES
10	9.95	1.24	5.2	Ceiling	Concrete	48	YES
Hallway							
1	2.8	1.8	0	Floor	Tile	120	YES
2	2.2	32.7	0	Floor	Tile	41	YES
3	2.24	44.8	0	Floor	Tile	0	YES
4	1.8	50	0	Floor	Tile	-41	YES
5	1.7	78	0	Floor	Tile	330	YES
6	1.4	77.5	0	Floor	Tile	660[c]	YES
7	2.6	87	0	Floor	Tile	700[c]	YES[c]
8	0.37	91.7	0	Floor	Tile	200	YES

TABLE B-1: ALPHA SURFACE ACTIVITY MEASUREMENTS NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)							
Survey Unit/ Location[a]	VSP Coordinates			Surface	Surface Material	Gross Alpha Activity[b] (dpm/100 cm^2)	Meets DCGL$_w$
	X	Y	Z				
Hallway - continued							
9	1.9	92.7	0	Floor	Tile	410	YES
10	2.1	90.6	0	Floor	Rug	250	YES
Men's Restroom							
1	---[d]	---	---	Sink	Tile	170	YES
2	---	---	---	Floor	Tile	170	YES
3	---	---	---	Paper Towels	Plastic	520	YES
4	---	---	---	Drain	Tile	130	YES
5	---	---	---	Urinal #2	Tile	130	YES
6	---	---	---	Door Inside Handle	Metal	110	YES
7	---	---	---	Door Outside Handle	Metal	95	YES
8	---	---	---	Floor	Tile	63	YES
Room 2114							
1	---	---	---	Door Hall	Metal	63	YES
2	---	---	---	Door Inside	Metal	170	YES
3	---	---	---	Floor	Tile	140	YES
4	---	---	---	Floor	Tile	95	YES
5	---	---	---	Computer Area	Desktop	48	YES
Room 2109							
1	---	---	---	Desktop	Fiberboard	16	YES
2	---	---	---	Door	Metal	0	YES
3	---	---	---	Floor	Carpet	170	YES

TABLE B-1: ALPHA SURFACE ACTIVITY MEASUREMENTS NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)							
Survey Unit/ Location[a]	VSP Coordinates			Surface	Surface Material	Gross Alpha Activity[b] (dpm/100 cm^2)	Meets DCGL$_w$
	X	Y	Z				
Custodial Closet							
1	---	---	---	Drain	Tile	170	YES
2	---	---	---	Sink	Ceramic	170	YES

[a]Refer to Figures A-8 through A-24.
[b]Gross Alpha Activity DCGL accounts for radionuclide fractions and eliminates those radionuclides that contribute less than 1% to the DCGL (ESL 2009).
[c]Measurement approaching or greater than site-specific DCGL of 696 dpm/100 cm^2. However, these locations were small (<10 cm^2) and were in the spacing between the floor tiles. The day before, the count rate was 210 and 209 counts per minute (cpm), respectively. The areas were covered and re-measured the next morning and the count rates were 19 and 20 cpm, respectively. This indicated that the residual contamination was due to radon daughter plate-out on the floor within the spaces between the floor tiles. A smear of the cracks, counted on the ESL gamma spectroscopy system, did not indicate any traces of Am-241.
[d]Coordinates not measured for these measurement locations.

TABLE B-2: RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES BY GAMMA SPECTROSCOPY[a] NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY BOULDER, COLORADO				
ORISE Sample ID/Location[b]	NRC Region IV Sample ID[c]	Radionuclide Concentrations (pCi/g dry weight), MDC		Meets $DCGL_w$[d]
		Am-241	U-238	
1786S0001	NRC-1	0.04 ± 0.07[e], 0.09	1.06 ± 0.30, 0.58	YES
1786S0002	NRC-2	-0.05 ± 0.08, 0.11	1.45 ± 0.37, 0.81	YES
1786S0003	NRC-3	-0.06 ± 0.06, 0.08	1.19 ± 0.28, 0.52	YES
1786S0004	NRC-4	-0.07 ± 0.07, 0.07	1.40 ± 1.50, 0.65	YES
1786S0005	NRC-5	0.02 ± 0.14, 0.06	1.11 ± 0.31, 0.59	YES
1786S0006	NRC-6	0.04 ± 0.09, 0.13	1.47 ± 0.41, 0.93	YES
1786S0007	NRC-7	0.03 ± 0.11, 0.15	1.16 ± 0.46, 1.00	YES
1786S0008	NRC-8	0.10 ± 0.09, 0.12	0.74 ± 0.38, 0.80	YES
1786S0009	NRC-9	0.00[f] ± 0.07, 0.10	0.96 ± 0.30, 0.74	YES
1786S0010	NRC-10	-0.04 ± 0.08, 0.09	1.18 ± 0.35, 0.76	YES
1786S0011	NRC-11	-0.06 ± 0.07, 0.13	1.29 ± 0.44, 0.81	YES

[a]ORISE Laboratory Procedure, CP1, Revision 16.
[b]Refer to Figures 25 and 26.
[c]Sample ID provided by NRC.
[d]DCGL for Am-241 is 2.1 pCi/g and for U-238 is 10 pCi/g. Surrogate DCGL for all radionuclides is 0.42 pCi/g for Am-241.
[e]Uncertainties are total propagated uncertainties, based on the 95% confidence interval.
[f]Zero values due to rounding.

TABLE B-3: CONCENTRATIONS OF PLUTONIUM IN SOIL SAMPLES NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY BOULDER, COLORADO					
ORISE Sample ID/Location[a]	NRC Region IV Sample ID[b]	Plutonium Concentrations, TPUs, and MDCs By Alpha Spectroscopy[c] (pCi/g dry weight)		Pu-241 Concentrations, TPUs, and MDCs by Liquid Scintillation Analysis[d] (pCi/g dry weight)	Meets $DCGL_w$[e]
		Pu-238	Pu-239/240		
1786S0001	NRC-1	0.006 ± 0.017[f], 0.042	-0.0039 ± 0.0054, 0.0241	0.2 ± 3.1, 5.3	YES
1786S0002	NRC-2	0.009 ± 0.013, 0.030	-0.0055 ± 0.0062, 0.0263	0.4 ± 3.1, 5.2	YES
1786S0003	NRC-3	0.0000[g] ± 0.0048, 0.0164	0.0017 ± 0.0058, 0.0164	0.1 ± 2.8, 4.8	YES
1786S0004	NRC-4	0.006 ± 0.013, 0.032	0.0020 ± 0.0039, 0.0059	0.5 ± 3.1, 5.2	YES
1786S0005	NRC-5	-0.011 ± 0.014, 0.045	-0.0021 ± 0.0071, 0.0257	2.3 ± 3.3, 5.5	YES
1786S0006	NRC-6	0.002 ± 0.015, 0.040	0.010 ± 0.014, 0.030	2.6 ± 3.1, 5.2	YES
1786S0007	NRC-7	-0.002 ± 0.005, 0.018	0.0000 ± 0.0029, 0.0040	-1.1 ± 2.5, 4.4	YES
1786S0008	NRC-8	-0.017± 0.014, 0.048	-0.0019 ± 0.0038, 0.019	0.6 ± 3.4, 5.7	YES
1786S0009	NRC-9	-0.004 ± 0.013, 0.038	0.032 ± 0.016, 0.006	0.9 ± 3.2, 5.4	YES
1786S0010	NRC-10	-0.019 ± 0.014, 0.049	-0.0019 ± 0.0084, 0.0275	0.4 ± 3.3, 5.7	YES
1786S0011	NRC-11	-0.0016 ± 0.0031, 0.0153	-0.0016 ± 0.0031, 0.0153	-2.7 ± 2.9, 5.1	YES

[a]Refer to Figures A-25 and A-26.
[b]Sample ID provided by NRC.
[c]ORISE Laboratory Procedure, AP11, Revision 4; CP2, Revision 14.
[d]ORISE Laboratory Procedure, AP10, Revision 3 and CP3, Revision 2.
[e]DCGL's provided by ESL. 2.5 pCi/g for Pu-238, 2.2 and 2.3 pCi/g, respectively for Pu-239 and Pu-240, and 73 pCi/g for Pu-241.
[f]Uncertainties are total propagated uncertainties, based on the 95% confidence interval.
[g]Zero values due to rounding.

APPENDIX C

MAJOR INSTRUMENTATION

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. Each instrument/detector combination was within the required calibration intervals as per the ORISE Survey Procedures and Laboratory Procedures manuals.

SCANNING INSTRUMENT/DETECTOR COMBINATIONS

Alpha

Ludlum Floor Monitor Model 239-1
combined with
Ludlum Ratemeter-Scaler Model 2221
coupled to
Ludlum Gas Proportional Detector Model 43-37, Physical Area: 550 cm^2
(Ludlum Measurements, Inc., Sweetwater, TX)
Calibration Due Date: 10/11/09

Ludlum Ratemeter-Scaler Model 2221
coupled to
Ludlum Gas Proportional Detector Model 43-68, Physical Area: 126 cm^2
(Ludlum Measurements, Inc., Sweetwater, TX)
Calibration Due Date: 10/11/09

Ludlum Ratemeter-Scaler Model 2221
(Ludlum Measurements, Inc., Sweetwater, TX)
coupled to
Eberline AC3-7 ZnS Scintillation Detector, Physical Area: 74 cm^2
(Eberline Instrument Corporation, Santa Fe, NM)
Calibration Due Date: 5/17/09

Gamma

Ludlum Ratemeter-Scaler Model 2221
(Ludlum Measurements, Inc., Sweetwater, TX)
coupled to
Bicron Field Instrument Detector for Low Energy Radiation (FIDLER) Model G5
(Bicron Corporation, Newburg, OH)
Calibration Due Date: 5/17/09

DIRECT MEASUREMENT INSTRUMENT/DETECTOR COMBINATIONS

Alpha

Ludlum Ratemeter-Scaler Model 2221
coupled to
Ludlum Gas Proportional Detector Model 43-68, Physical Area: 126 cm^2
(Ludlum Measurements, Inc., Sweetwater, TX)
Calibration Due Date: 10/11/09

Ludlum Ratemeter-Scaler Model 2221
(Ludlum Measurements, Inc., Sweetwater, TX)
coupled to
Eberline AC3-7 ZnS Scintillation Detector, Physical Area: 74 cm^2
(Eberline Instrument Corporation, Santa Fe, NM)
Calibration Due Date: 5/17/09

LABORATORY ANALYTICAL INSTRUMENTATION

Alpha Spectrometry System
Tennelec Model 256
(Canberra, Meriden, CT)
Used in conjunction with:
Ion Implanted Detectors and
Multichannel Analyzer
Canberra Apex Alpha Software
Dell Workstation
(Canberra, Meriden, CT)

Alpha Spectrometry System
Canberra Model 7401VR
(Canberra, Meriden, CT)
Used in conjunction with:
Ion Implanted Detectors and
Multichannel Analyzer
Canberra Apex Alpha Software
Dell Workstation
(Canberra, Meriden, CT)

Tri-Carb Liquid Scintillation Analyzer
Model 3100
(Packard Instrument Co., Meriden, CT

LABORATORY ANALYTICAL INSTRUMENTATION (continued)

High Purity Extended Range Intrinsic Detector
CANBERRA/Tennelec Model No: ERVDS30-25195
(Canberra, Meriden, CT)
Used in conjunction with:
Lead Shield Model G-11
(Nuclear Lead, Oak Ridge, TN) and
Multichannel Analyzer
Canberra Apex Gamma Software
Dell Workstation
(Canberra, Meriden, CT)

High Purity Extended Range Intrinsic Detector
Model No. GMX-45200-5
(AMETEK/ORTEC, Oak Ridge, TN)
used in conjunction with:
Lead Shield Model SPG-16-K8
(Nuclear Data)
Multichannel Analyzer
Canberra Apex Gamma Software
Dell Workstation
(Canberra, Meriden, CT)

High-Purity Germanium Detector
Model GMX-30-P4, 30% Eff.
(AMETEK/ORTEC, Oak Ridge, TN)
Used in conjunction with:
Lead Shield Model G-16
(Gamma Products, Palos Hills, IL) and
Multichannel Analyzer
Canberra Apex Gamma Software
Dell Workstation
(Canberra, Meriden, CT)

APPENDIX D
SURVEY AND ANALYTICAL PROCEDURES

APPENDIX D
SURVEY AND ANALYTICAL PROCEDURES

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 (JHA). 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.

Pre-survey activities included the evaluation and identification of potential health and safety issues. Survey work was performed per the ORISE generic health and safety plans and a site-specific integrated safety management (ISM) pre-job hazard checklist. The National Institute of Standards and Technology (NIST) also provided site-specific safety awareness training.

CALIBRATION AND QUALITY ASSURANCE

Calibration of all field and laboratory instrumentation was based on standards/sources, traceable to NIST.

Analytical and field survey activities were conducted in accordance with procedures from the following Oak Ridge Associated Universities (ORAU) and ORISE documents:

- Survey Procedures Manual (May 2008)
- Laboratory Procedures Manual (April 2009)
- Quality Program Manual (May 2009)

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

Quality control procedures include:

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

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

CALIBRATION PROCEDURES

Th-230 was selected as the alpha calibration source in determining the total surface efficiency for the gas proportional detectors; Pu-239 was selected as the alpha calibration source for the ZnS scintillation detector. The 2π beta ε_i factor for the gas proportional detector used to collect direct measurements ranged from 0.37 to 0.38 and was 0.25 for the ZnS detector. ISO-7503 recommends an ε_s of 0.25 for all alpha energies. Detectors used for assessing surface activity of the evaluated structural surfaces were calibrated in accordance with ISO-7503[1] recommendations. The weighted total alpha efficiency (ε_{total}) was determined for the instrument/detector combinations used for all surface activity measurements and consisted of the product of the 2π instrument efficiency (ε_i), the surface efficiency (ε_s), and the alpha fraction contribution of the source (f_i): $\varepsilon_{total} = \varepsilon_i \times \varepsilon_s. \times f_i$. From Table 1, the beta contribution from the source was 47.76%; therefore, the total alpha fraction contribution of the source is (1 – 0.4776 =) 52.3%. The resulting total alpha efficiency was 0.05 for the gas proportional detectors and was 0.033 for the ZnS detector.

SURVEY PROCEDURES

Action Levels

The field action level for the hand-held gas proportional instrument based on the specific site criteria and background was calculated as follows:

- NIST Site Release Criteria (SRC): 696 dpm/100 cm^2
- 43-68 weighted total efficiency (ε_{total}): 0.05
- Background (BKG): 2 cpm
- Time (T): 1 minute count time
- $G = \text{geometry} = \dfrac{Physical\ Detector\ Area\ cm^2}{100}$

[1]International Standard. ISO 7503-1, Evaluation of Surface Contamination - Part 1: Beta-emitters (maximum beta energy greater than 0.15 MeV) and alpha-emitters. August 1, 1988.

Determine Action Level

- Action Level (cpm) = (SRC * ε_{total} * G * T) + (BKG * T)
- Action Level = 46 cpm

The field action level for the ZnS scintillation detector was 17 cpm. A field count at or above the calculated action level value indicates that further investigation of the area would be necessary.

Surface Scans

Structural surface scans were performed by passing the detectors slowly over the surface; the distance between the detector and the surface was maintained at a minimum—nominally about 1 cm. Building structural surfaces were scanned using a floor monitor gas proportional detector (550 cm^2), a small area (126 cm^2) hand-held gas proportional detector and/or a ZnS scintillation detector (74 cm^2). Identification of elevated radiation levels was based on increases in the audible signal from the recording and/or indicating instrument.

A FIDLER scintillation detector, with a detector area 127 cm^2, was used to scan for elevated gamma radiation on the exterior soil and concrete surfaces. 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 cm. Identification of elevated radiation levels was based on increases in the audible signal from the instrument.

The scan minimum detectable concentrations (MDCs) for the NaI scintillation detector for the contaminants of concern in surface soil were obtained directly from NUREG-1507 when available or estimated using the approach described in NUREG-1507[2]. ORISE used the FIDLER for qualitative measurements. An audible increase in the activity rate was investigated by ORISE. It is standard procedure for the ORISE staff to pause and investigate any locations where gamma radiation is distinguishable from background levels.

The alpha scan MDC was determined using the calculational approach described in Section 6.7.2.2 of the MARSSIM, which is based on the probability (P) of detecting an area of contamination at a

[2]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.

predetermined guideline level for given scan rates.

$$AlphaScanMDC = \frac{[-\ln(1-P)]60}{i * \varepsilon_{Total}}$$

Setting the Alpha Scan MDC at the $DCGL_w$, using the calculated weighted efficiency of 0.05 (for the gas proportional detector), a scan rate of approximately 2.5 cm per second, and an observation interval (i) of 4 seconds, ORISE determined that the probability of detecting a "hot-spot" of 696 dpm/100 cm^2 was approximately 90%.

The identification of elevated radiation levels that could exceed the site criteria was determined based on an increase in the audible signal from the indicating instrument.

Surface Activity Measurements

Measurements of total alpha surface activity levels were performed using hand-held gas proportional detectors or ZnS scintillation detectors coupled to portable ratemeter-scalers. Count rates which were integrated over one minute with the detector held in a static position, were converted to activity levels (dpm/100 cm^2) by dividing the count rate by the total static efficiency ($\varepsilon_i \times \varepsilon_s$) and correcting for the physical area of the detector. ORISE did not determine construction material-specific backgrounds for each surface type encountered for determining net count rates. Instead, ORISE took the conservative approach and did not subtract material specific backgrounds in determining surface activity levels.

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

$$MDC = \frac{3 + (4.65\sqrt{BKG})}{T * \varepsilon_{Total} * G}$$

Where:

BKG = background (total counts) in time interval, T

T = count time (min) used for field instruments

ε_{Total} = total efficiency = ε_i x ε_s

ε_i = instrument efficiency

ε_s = source efficiency

G = geometry (physical detector area cm^2/100)

The alpha static MDC for the gas proportional detector was 152 dpm/100 cm^2 using the total efficiency of 0.05 and an instrument background of 2 cpm. The physical surface area assessed by the gas proportional detector used was 126 cm^2. The alpha static MDC for the ZnS scintillation detector was 392 dpm/100 cm^2 using the total efficiency of 0.033 and an instrument background of 2 cpm. The physical surface area assessed by the ZnS scintillation detector used was 74 cm^2.

RADIOLOGICAL ANALYSIS

Alpha Spectroscopy

Soil samples were homogenized then dissolved by a combination of potassium hydrogen fluoride and pyrosulfate fusions. The fusion cakes are dissolved and all alpha emitters are co-precipitated on barium sulfate. The barium sulfate is re-dissolved and the contaminants-of-concern (COC) are separated from the other actinides by extraction chromatography using Eichrom resins, co-precipitated with a cerium fluoride carrier, and analyzed using ion implanted detectors, alpha spectrometers, and multichannel analyzer.

An alpha spectroscopy detector system calculates an MDC for each individual isotope per sample based on the detector background, counting efficiency, yield, and quantity. An MDC is printed out with each sample results. The typical MDC for a 1,000-minute count time was 0.02 pCi/g.

Gamma Spectroscopy

Soil 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) 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 *a priori* MDCs for a one-hour count time have been provided in the following table:

Radionuclide	TAP (MeV)	MDC (pCi/g)
Th-234	0.063	1.00
Cs-137	0.662	0.07
Am-241	0.059	0.15

The *a priori* MDCs are based on background concentrations of radionuclides in soil for the purpose of estimating the capability of the measuring system to detect an activity concentration. Spectra were also reviewed for other identifiable TAPs.

Uncertainties

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

DETECTION LIMITS

Detection limits, referred to as minimum detectable concentrations, 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.