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RADIOLOGICAL SURVEY OF BUILDINGS 401, 403, AND THE HITTMAN BUILDING NIAGARA FALLS STORAGE SITE LEWISTON, NEW YORK

T. J. VITKUS

Prepared for the Office of Environmental Restoration
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ORISE

OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION

Environmental Survey and Site Assessment Program
Energy/Environment Systems Division

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ABBREVIATIONS AND ACRONYMS

AEC	Atomic Energy Commission
A#	affected survey unit designation
BKG	background
BNI	Bechtel National, Inc.
cm^2	square centimeter
cpm	counts per minute
DOE	Department of Energy
dpm/100 cm^2	disintegrations per minute per 100 square centimeters
EML	Environmental Measurement Laboratory
EPA	Environmental Protection Agency
ERDA	Energy Research and Development Administration
ESSAP	Environmental Survey and Site Assessment Program
FUSRAP	Formerly Utilized Sites Remedial Action Program
ha	hectare
g	gram
GM	Geiger-Mueller
kg	kilogram
LOOW	Lake Ontario Ordnance Works
m	meter
m^2	square meter
MDA	minimum detectable activity
MED	Manhattan Engineer District
MeV	million electron volts
mm	millimeter
NaI	sodium iodide
NFSS	Niagara Falls Storage Site
NIST	National Institute of Standards and Technology
ORISE	Oak Ridge Institute for Science and Education
pCi/g	picocuries per gram
PIC	pressurized ionization chamber
PMC	Project Management Contractor
U#	unaffected survey unit designation
WCS	Waste Containment Structure
ZnS	zinc sulfide
μR/h	microroentgens per hour

EXECUTIVE SUMMARY

The U.S. Department of Energy and its predecessor organizations have used the Niagara Falls Storage Site, formerly the Lake Ontario Ordnance Works, since 1944 for the storage of various radiologically contaminated materials. The facility, located in western New York state, near the town of Lewiston, received contaminated materials that were generated at a number of facilities involved in work from the early years of the Nations atomic energy program. Storage activities resulted in the radiological contamination of site grounds and structures. Remedial activities were initiated in the 1970's and continued through the 1980's to remediate the residual contamination and to contain stored materials in an on-site engineered containment structure.

The site has been in "caretaker" status since remedial actions were completed. DOE plans to release to unrestricted use those portions of the site not required for waste containment and environmental monitoring. Prior to doing so, the DOE requested that the Environmental Survey and Site Assessment Program of the Oak Ridge Institute for Science and Education survey the remaining surplus structures in order to determine the radiological status of each building. The final three remaining site buildings requiring survey were Building 401 (the former steam plant and boron production facility), Building 403 (formerly the fire house and currently the administrative office), and the Hittman Building (currently an equipment storage facility).

The resultant surveys of these facilities determined that residual radiological contamination, in excess of the current DOE guidelines for release to unrestricted use, is present in both Buildings 401 and 403. The majority of the contamination identified in Building 401 was in those areas suspected as having a radiological use history, although contamination was also identified in non-suspect areas. Several localized areas of contaminated soil were also noted around the exterior perimeter of Building 401, and contamination was identified at a number of locations throughout Building 403. There were no areas of residual contamination identified in the Hittman Building.

RADIOLOGICAL SURVEY
OF BUILDING 401, BUILDING 403, AND THE HITTMAN BUILDING
NIAGARA FALLS STORAGE SITE
LEWISTON, NEW YORK

INTRODUCTION

The Niagara Falls Storage Site (NFSS) is a U. S. Department of Energy (DOE) surplus facility located in western New York State near the town of Lewiston. The property containing the site is a portion of the U. S. Army's former Lake Ontario Ordnance Works (LOOW). The 3040 hectare (7500 acre) LOOW was established in the early 1940's for the production of TNT during World War II. These operations ceased and approximately 608 hectares (ha) of the property was transferred to the Manhattan Engineer District (MED), predecessor agency to the Atomic Energy Commission (AEC) and DOE.

In 1944, the MED began to use buildings and open areas on the site for the storage of pitchblende (uranium ore) processing residues from Linde Air Products Division in Tonawanda, New York, the Middlesex Sampling Plant in Middlesex, New Jersey and Mallinckrodt Chemical Company in St. Louis, Missouri. From 1947 until 1954, the AEC continued to use the site for storage of radioactively contaminated equipment, materials, and residues which resulted from decontamination and ongoing uranium extraction activities from other facilities that were used for similar operations during the war. Additional wastes received for storage and subsequent transshipment included uranium and thorium processing wastes from various New York State facilities, material from Knolls Atomic Power Laboratory, the University of Rochester, and the Electro-Metallurgical Company.

The final active site usage involved modification of the original site steam plant, Building 401, for boron-10 production. Boron-10 was produced during two time periods, from 1953 to 1959, and again between 1965 and 1971.

Both during and since these time frames, cleanup activities have been conducted at the site which have resulted in all but approximately 77 ha of the original area declared surplus and sold or

transferred by the General Services Administration to private, commercial or government agencies. The remaining property was retained by the AEC and its successor, the DOE, and placed in caretaker status.

Various organizations have conducted radiological surveys of the site since 1971. The surveys identified residual contamination, primarily uranium and its progeny - mainly radium; as well as smaller quantities of thorium, strontium-90, and cesium-137, both on the site and surrounding vicinity properties. The residual contamination exceeded the guidelines for release to unrestricted use; therefore, the property was included in the DOE's Formerly Utilized Sites Remedial Action Program (FUSRAP). FUSRAP was created in 1974 to identify and eliminate residual radioactive contamination that exceeds guidelines from sites used during the early years of the nation's atomic energy program. Bechtel National, Inc. (BNI), the FUSRAP Project Management Contractor (PMC), has performed remedial actions to remove both on-site and off-site contamination and has consolidated the materials in an engineered waste containment structure (WCS) on the NFSS.

Most of the original site buildings were demolished during remediation. Buildings 401A, 402, and 416 were demolished in 1993 and Building 429 was renovated following the completion of radiological surveys by the Environmental Survey and Site Assessment Program (ESSAP) of Oak Ridge Institute for Science and Education (ORISE), formerly known as Oak Ridge Associated Universities (Vitkus 1992). Site plans call for release without radiological restrictions of additional NFSS structures and land areas, to include Building 401. However, the use of the facility for storage of contaminated materials during remedial actions and the identification of localized contamination during cursory building surveys, necessitated determination of the building's radiological status. A review of the site history by BNI and ESSAP identified six rooms where either contaminated material had been stored, elevated direct radiation was detected during inspection surveys, and/or previously contaminated and remediated surfaces were contained. Because these areas had the potential for residual contamination from site activities, an assessment of the current radiological status was required. The remaining rooms had not been documented as having known contamination, or use for storage of contaminated or potentially contaminated materials.

The two other buildings that remain on the site are the former fire hall (Building 403), currently used for administrative and laboratory purposes and the Hittman Building, now used for equipment storage. These buildings were not suspected as having a radiological use history.

Because of the future site plans for the unrestricted release of these remaining structures, DOE requested that ESSAP perform radiological surveys of the remaining structures at NFSS.

PROJECT ORGANIZATION AND RESPONSIBILITY

DOE Headquarters provides overview and coordination for all FUSRAP activities. DOE Oak Ridge (DOE-OR) is responsible for implementation of FUSRAP and The Former Sites Restoration Division of DOE-OR, manages the daily activities.

Under the FUSRAP protocol, an initial investigation/survey of a potential site is performed by ORISE or Oak Ridge National Laboratory (ORNL), under contract to DOE Headquarters. If appropriate, DOE Headquarters designates the site into FUSRAP based upon the results provided by the initial investigation/survey. DOE's Project Management Contractor (PMC) for FUSRAP is Bechtel National, Inc. (BNI). BNI is responsible for planning and implementation of FUSRAP activities and managing any required remedial actions. The final phase for a FUSRAP site is independent verification, which is provided by ORISE or ORNL, after remedial action is complete. This verification activity provides independent (third party) data to assist DOE in evaluating the accuracy of the post-remedial action status of the site, as presented by the PMC, and in assuring that the documentation accurately and adequately describes the condition of the site. DOE Headquarters uses the information developed by the remediation and verification activities to certify that a site can be released for use, without restrictions.

SITE DESCRIPTION

The NFSS is located on Pletcher Road, approximately 6 kilometers (km [3.7 miles]) northeast of the town of Lewiston, New York (Figure 1). Site boundaries are N Street to the north and R Street to the south. Security fences form the east and west boundaries and roughly parallel

Castle Garden Road and Lutts Road. Building 401, 403, and the Hittman Building are located in the south-central portion of the site (Figure 2). Building 401 construction is predominantly of steel and concrete. The exterior of the building consists of transite panels. The 2,800 m^2 floor space is divided between two floors with a number of high bay areas (Figures 3 and 4). Building 403 is a 270 m^2 structure containing a garage area, offices, laboratory, restrooms, and storage areas (Figure 5). Construction is frame, structural steel, and siding on a concrete slab. The Hittman Building is an 82 m^2 aluminum building on a concrete slab (Figure 6).

OBJECTIVE

The objective of the survey was to obtain adequate data for use by the DOE in evaluating the radiological condition of the buildings relative to the guidelines for release to unrestricted use.

PROCEDURES

A survey team from ESSAP visited the NFSS during the period September 12 through 22, 1994 and performed visual inspections and measurement and sampling activities. Survey activities were conducted in accordance with a DOE approved site-specific survey plan (Vitkus 1994; Williams 1994). As specified in this plan, rooms or areas were divided into survey units that were classified according to radiological use history. Those rooms or areas where contamination had been previously identified, or where potentially contaminated materials had been stored, were classified as affected (A) survey units. Rooms or areas in Building 401 that did not have a known radiological use history were classified as an unaffected (U) survey unit (Figures 7 and 8 show survey unit designations). The survey plan also provided for the reclassification of a survey unit from unaffected to affected during the course of the survey if contamination was identified. Additional information regarding survey and analytical instrumentation and procedures may be found in Appendices A and B. It should also be noted that the survey plan design and implementation was intended to provide adequate data for determining whether or not contamination existed in a given area and generalized bounding of any contamination, and did not serve to completely characterize the residual contamination that may have been present.

SURVEY PROCEDURES: AFFECTED AREAS

The following survey procedures were used for Building 401 Rooms 102 (Survey Unit A2), 117/119 (Survey Unit A1), 121 (Survey Unit A3), 122 (Survey Unit A4), and portions of 217 (Survey Unit A5) where contamination had been previously identified or the potential existed for contamination due to use history. In addition, Room 115 (Survey Unit A6), the lockers (Survey Units A7 and A8) in Rooms 108 and 211, and the entire east wall of Room 217 (added to Survey Unit A5), were added as affected areas based on findings during the course of the survey where residual surface activity was detected at greater than 75% of the guidelines. These affected survey units are illustrated on Figures 7 and 8.

Reference Grid

ESSAP established a 1 m × 1 m grid system on the floor and lower walls (up to 2 m) to reference survey information. The ceiling and upper walls (above 2 m) were not gridded. Measurements and samples collected on ungridded surfaces were referenced to the floor and/or lower wall grid coordinates or to prominent building features. Reference grids and floor plans for affected survey units are illustrated on Figures 9 through 16.

Surface Scans

Surface scans for alpha, beta, and gamma activity were performed over 100% of the accessible floor and lower wall surfaces. Approximately 25% of the accessible upper walls, ceilings, overhead pipe runs, beams, and equipment were also scanned. Particular attention was given to cracks and joints in the floor and walls, and to ledges, ducts, drains, and horizontal surfaces where residual contamination may have accumulated. Scans were performed using gas proportional, ZnS, GM, and/or NaI detectors coupled to ratemeters or ratemeter-scalers with audible indicators. Locations of elevated direct radiation, as identified by surface scans, were marked for further investigation.

Surface Activity Measurements

Direct measurements for total alpha and total beta activity were performed in the center of each floor and lower wall grid block. Additional measurements, as necessary to determine the average residual surface activity in 1 m^2 areas, were also performed on, and around locations of elevated direct radiation detected by scans. On ungridded surfaces, direct measurements and smears were performed every 5 to 10 m^2 and at locations of elevated direct radiation. Direct measurements were made using gas proportional, ZnS, or GM detectors coupled to ratemeter-scalers. A smear sample was collected from each direct measurement location, or when multiple measurements were made within a grid block, from the highest direct measurement location, to determine removable gross alpha and gross beta activity levels. Figures 17 through 30 show measurement and sampling locations.

Exposure Rates

Exposure rate measurements were made at six locations within each room, (Figure 31 and 32). Exposure rates were measured at 1 m above the floor using a pressurized ionization chamber (PIC) with the exception of A2, where exposure rates were qualitatively determined based on the results of gamma scans.

Miscellaneous Samples

A total of five residue samples were collected from drains, ledges, and I-beams where elevated direct radiation was detected. Figures 18, 20, 22, 24, and 26 show these sampling locations.

SURVEY PROCEDURES: UNAFFECTED AREAS

The following procedures were used for the survey of the unaffected survey units in Building 401, Building 403, and the Hittman Building. Building 401 unaffected survey units were comprised of multiple rooms and were listed as U1 through U9. These units, including

the room numbers that comprised each, are shown on Figures 7 and 8. Figures 5 and 6 show the floor plans of Building 403 and the Hittman Building.

Reference System

Prominent building features were used to reference survey locations.

Surface Scans

Surface scans for alpha, beta, and gamma activity were performed over 25 to 50 percent of floors and lower walls. Two to five percent of upper wall, ceiling, and overhead structures were also scanned with emphasis on horizontal areas where material may have settled and accumulated. Scans were performed using gas proportional, ZnS, GM, and/or NaI detectors coupled to ratemeters or ratemeter-scalers with audible indicators. Locations of elevated direct radiation were marked for further investigation and as previously noted, several areas were reclassified as affected areas. Surface scans were also performed within Rooms 123, 124, and 130 (Figure 3).

Surface Activity Measurements

Direct measurements were made at a minimum of 30 randomly selected locations, ten of which were on upper surfaces, within each survey unit. Eight of the measurements performed in survey unit U6 were later incorporated into the data for survey unit A5. Additional measurements were also made at locations of elevated direct radiation detected by surface scans. Within Building 403, all direct measurement locations were selected on the basis of surface scan results. Measurements were made using gas proportional, ZnS, or GM detectors coupled to ratemeter-scalers. A smear sample for determining removable activity levels was collected from each direct measurement location. Figures 33 through 43 show measurement and sampling locations.

Exposure Rate Measurements

Exposure rate measurements were made at six locations within each survey unit (Figures 31, 32, 44, and 45). Exposure rates were measured at 1 m above the floor using a PIC.

EXTERIOR SURVEY

The following procedures are applicable to the survey of the exterior of Building 401.

Reference System

Survey locations were referenced to prominent site features.

Surface Scans

Surface scans for gamma activity were performed over 100% of the exterior perimeter of Building 401, extending out to 20 m. Scans were performed using NaI detectors coupled to ratemeters with audible indicators. Locations of elevated direct radiation were marked for further investigation (Figure 46).

Exposure Rate Measurements

Exposure rate measurements, at 1 m above the surface, were made at seven locations of elevated direct gamma radiation using a PIC (Figure 47).

Soil Sampling

A total of seven soil samples were collected; six of these were surface soil samples (0 to 15 cm) and one was a subsurface soil sample (15 to 30 cm). Figure 47 shows soil sampling locations.

SAMPLE ANALYSIS AND DATA INTERPRETATION

Samples and data were returned to ORISE's ESSAP laboratory in Oak Ridge, Tennessee for analysis and interpretation. Soil and residue samples were analyzed by solid state gamma spectrometry. The spectra were reviewed primarily for Ra-226, U-235, U-238, Th-232, Cs-137, and any other identifiable photopeaks. Selected soil samples were also analyzed by alpha spectrometry for isotopic uranium. The soil and residue sample results were reported in units of picocuries per gram (pCi/g). Smears were analyzed for gross alpha and gross beta activity using a low background proportional counter. Smear and direct measurement data were converted to units of disintegrations per minute per 100 square centimeters (dpm/100 cm^2). Exposure rates were reported in units of microroentgens per hour (μR/h).

FINDINGS AND RESULTS

AFFECTED AREAS

The results of the affected area surveys are discussed below.

Surface Scans

Surface scans identified elevated direct alpha and/or beta radiation on floors, lower walls, and/or upper surfaces (primarily I-beams) in survey units A1, A2, A3, A4, and A5. In addition, elevated direct alpha radiation was detected on the floor of Room 115, requiring reclassification of the area as affected survey unit A6. Elevated direct alpha and beta radiation was also identified on the interior of the lockers in rooms 108 and 211, requiring reclassification of the lockers as affected units A7 and A8. The actual rooms where the lockers were located were not reclassified as there was no indication of contamination on any of the room surfaces. Finally, elevated direct beta radiation was identified along an I-beam and ledge of the east wall of Room 217. The entire east wall was then reclassified as affected and incorporated into survey unit A5.

Surface Activity Levels

Surface activity levels are summarized in Table 1. Total alpha activity levels ranged from less than 39 to 1,600 dpm/100 cm^2 for survey unit A1, less than 37 to 580 dpm/100 cm^2 for survey unit A2, less than 37 to 1,400 dpm/100 cm^2 for survey unit A3, less than 37 to 480 dpm/100 cm^2 for survey unit A4, less than 39 to 180 dpm/100 cm^2 for survey unit A5, less than 35 to 2,900 dpm/100 cm^2 for survey unit A6, and for the contaminated lockers in units A7 and A8, less than 39 to 280 dpm/100 cm^2. Alpha grid block (1 m^2) averages ranged from less than 35 to less than 47 dpm/100 cm^2 for survey units A1, A3, A4, A5, and A6.

The total beta activity levels were as follows: survey unit A1, less than 430 to 44,000 dpm/100 cm^2; survey unit A2, less than 430 to 2,700 dpm/100 cm^2; survey unit A3, less than 460 to 240,000 dpm/100 cm^2; survey unit A4, less than 430 to 6,200 dpm/100 cm^2; survey unit A5, less than 430 to 110,000 dpm/100 cm^2; survey unit A6, less than 450 to 6,000 dpm/100 cm^2; survey unit A7, less than 470 to 13,000 dpm/100 cm^2; and survey unit A8, 2,300 to 14,000 dpm/100 cm^2. Beta grid block averages were less than 470 to 1,200 dpm/100 cm^2 for survey unit A1, 600 to 2,600 dpm/100 cm^2 for survey unit A3, less than 450 to 1,000 dpm/100 cm^2 for survey unit A4, 900 to 1,500 dpm/100 cm^2 for survey unit A5, and less than 450 dpm/100 cm^2 for survey unit A6.

Removable activity levels for the affected survey units ranged from less than 12 to 29 dpm/100 cm^2 for gross alpha and less than 16 to 42 dpm/100 cm^2 for gross beta.

Exposure Rates

Exposure rates at 1 m above the surface in the affected survey units, summarized in Table 2, ranged from 6 to 8 μR/h. The average exposure rates in each affected survey unit were 8 μR/h for survey units A1, A3, and A4; and 7 μR/h for survey units A5 and A6. Direct gamma radiation levels in survey unit A2 were comparable to those in all other affected survey units.

Radionuclide Concentrations in Miscellaneous Samples

Concentrations of radionuclides in miscellaneous samples collected within Building 401 are presented in Table 3. Concentration ranges were less than 0.2 to 35.0 pCi/g for Am-241, 0.2 to less than 2.4 pCi/g for Cs-137, 0.2 to less than 4.5 pCi/g for Ra-226, less than 21 to 1,333 pCi/g for Th-230, less than 0.8 to 198.9 pCi/g for Th-232, less than 0.5 to 185 pCi/g for U-235, and 4.9 to 4,025 pCi/g for U-238.

UNAFFECTED AREAS

The results of the surveys of the unaffected areas are discussed below.

Surface Scans

Areas of elevated direct radiation were identified in Room 115 (initially part of survey unit U1), the lockers in Rooms 108 (part of survey unit U2) and Room 211 (part of survey unit U8), and the east wall of room 217 (originally part of survey unit U6). Each of these areas was reclassified as an affected survey unit and were discussed under the affected survey unit section of this report. One additional location of elevated direct beta radiation was identified in survey unit U7 (western half of room 217). Initially, the elevated beta activity was thought to have been located on the floor. However, an investigation of the area indicated that the source of the activity was from suspected contaminated material within the elbow of a blower housing. There were no access points to investigate or sample the interior of the blower, therefore the cause of the elevated activity could not be confirmed. It is believed that the blower served as air handling equipment for Room 117/119 (Survey Unit A1).

Surface Activity Levels

Surface activity levels in Building 401 unaffected survey units are summarized in Table 4. Total alpha activity ranges for each survey unit were: U1, less that 35 to less than 39 dpm/100 cm^2; U2, less than 35 to 130 dpm/100 cm^2; U3, U4, and U5, less than 35 dpm/100 cm^2; U6, less

than 39 to 84 dpm/100 cm^2; U7, less than 39 to 190 dpm/100 cm^2; U8, less than 39 to 84 dpm/100 cm^2; U9, less than 39 dpm/100 cm^2; and the west silo, less than 39 to 79 dpm/100 cm^2. The alpha levels (up to 130 dpm/100 cm^2) in survey unit U2 were associated with ceramic tile, which typically contains naturally occurring radioactivity. Removable gross alpha activity levels were all less than the minimum detectable activity (MDA) of the procedure which was less than 12 dpm/100 cm^2.

Total beta activity levels in Building 401 unaffected areas were: U1, less than 450 to less than 470 dpm/100 cm^2; U2, less than 450 to 2,200 dpm/100 cm^2; U3, less than 450 to 610 dpm/100 cm^2; U4, less than 450 to 550 dpm/100 cm^2; U5, less than 450 dpm/100 cm^2; U6, less than 470 to 2,600 dpm/100 cm^2; U7, less than 470 to 49,000 dpm/100 cm^2; U8, less than 470 to 1,300 dpm/100 cm^2; U9, less than 470 dpm/100 cm^2; and the west silo, less than 470 dpm/100 cm^2. Removable activity levels for gross beta were all less than the MDA of 16 dpm/100 cm^2. The beta levels (up to 2,200 dpm/100 cm^2) in survey unit U2 were also associated with the natural radioactive constituents in the ceramic tile.

Building 403 activity levels are summarized in Table 4. The total activity ranges were less than 47 to 1,700 dpm/100 cm^2 for total alpha and less than 430 to 15,000 dpm/100 cm^2 for total beta. Removable activity levels were less than 12 to 42 dpm/100 cm^2 and less than 16 to 44 dpm/100 cm^2 for gross alpha and gross beta, respectively.

The activity levels in the Hittman Building, summarized in Table 4, were less than 47 dpm/100 cm^2 and less than 430 to 640 dpm/100 cm^2 for total alpha and total beta, respectively. Removable activity levels were less than 12 dpm/100 cm^2 for gross alpha and less than 16 dpm/100 cm^2 for gross beta.

Exposure Rates

Exposure rates are summarized in Table 2. Exposure rates at 1 m above surfaces in the unaffected areas of Building 401 ranged from 6 to 14 μR/h. The average exposure rates in

individual survey units ranged from 7 to 10 μR/h. Exposure rates in the Hittman Building ranged from 7 to 8 μR/h and averaged 7 μR/h. Exposure rates in Building 403 were all 9 μR/h.

EXTERIOR AREAS

The survey results of the exterior of Building 401 are provided below.

Surface Scans

Gamma surface scans of the exterior perimeter of Building 401 identified six locations of elevated direct radiation. At one location, the elevated direct gamma radiation was determined to be below the 0 to 15 cm surface layer. These areas are illustrated on Figure 46.

Exposure Rates

Exposure rates for the exterior of Building 401 are summarized in Table 2. Exposure rates at 1 m above the surface ranged from 9 to 17 μR/h. The maximum observed rate of 17 μR/h was found at location number 3 (Figure 47).

Radionuclide Concentrations in Soil

Radionuclide concentrations in soil samples collected from locations of elevated direct radiation are summarized in Table 5. Concentration ranges were as follows: Cs-137, 0.1 to 0.6 pCi/g; Ra-226, 3.2 to 114.9 pCi/g; Th-230, 5.5 to 280 pCi/g, Th-232, 0.2 to less than 1.3 pCi/g; U-235, 0.09 to 1.62 pCi/g, U-238, 1.08 to 33.05 pCi/g, total uranium, 2.32 to 69.00 pCi/g.

COMPARISON OF RESULTS WITH GUIDELINES

Radionuclides from several guideline categories have been identified at the NFSS. As a result, the data were compared with the most restrictive applicable residual surface activity guidelines which are provided in Appendix C.

The alpha guidelines are those for Ra-226 which are as follows:

Total Activity

100 dpm/100 cm^2, average in a 1 m^2 area

300 dpm/100 cm^2, maximum in a 100 cm^2 area

Removable Activity

20 dpm/100 cm^2

The beta activity levels were compared to the thorium guidelines which are:

Total Activity

1,000 dpm/100 cm^2, average in a 1 m^2 area

3,000 dpm/100 cm^2, maximum in a 100 cm^2 area

Removable Activity

200 dpm/100 cm^2

Table 6 provides a list of all measurement locations where either the 1 m^2 average or maximum residual surface activity levels exceeded the alpha and/or beta average or maximum residual surface contamination guidelines. These locations are also illustrated on Figures 48 through 58. In summary, contamination above guidelines was identified in Building 401 survey units A1, A2, A3, A4, A5, A7, A8, U7, U8, and Building 403.

In survey unit A1, localized areas of contamination exceeding the alpha and/or beta maximum guideline values were identified on an I-beam and within one floor grid block. A residue sample collected from the I-beam identified uranium and americium-241 as the contaminants (Table 3). Two other measurement locations, one on the floor and the second within a floor drain, had residual beta activity between the average and maximum guidelines. Average activity within the floor grid block satisfied the guideline; however, additional measurements for the determination of compliance with the average guideline, could not be performed within the drain.

In survey unit A2, one area of residual activity above the maximum alpha guideline, and between the beta guidelines, was identified within a pipe which protrudes through the ceiling into Room 102. A residue sample collected from within the pipe, identified elevated concentrations of Th-230, Th-232, and Am-241 (Table 3).

The most extensive residual contamination was found in survey unit A3. On the floor, one location exceeded the maximum beta activity guideline. Twenty-three locations had residual beta activity levels between the average and maximum guidelines. Additional measurements within these grid blocks indicated that nineteen of these areas exceeded the average residual activity guideline. One location on a lower wall ledge exceeded both the maximum alpha and beta activity guidelines. For upper surfaces, two locations were identified with residual alpha activity in excess of the maximum activity guideline. One location was on an I-beam, where the beta maximum activity guideline was also exceeded, and the second was on one of the mezzanines. Five locations of beta activity in excess of the maximum guideline were found on I-beams and one location was identified on an air duct. Four additional measurements, performed on the I-beams, adjacent to where these hot spots were noted, showed residual contamination levels between the average and maximum beta guidelines.

One location on the floor of survey unit A4 exceeded the maximum and removable alpha activity guidelines. The beta activity at this location was between the average and maximum guideline. Five additional locations of beta activity between the average and maximum guidelines were identified on the floor. Of these, the average activity in the surrounding 1 m^2 area of one grid

block exceeded the average activity guideline. A lower wall ledge in two contiguous grid blocks contained elevated beta radiation levels in excess of the average activity guideline. One upper wall measurement location exceeded the average alpha activity guideline, but additional measurements indicated that the activity in the 1 m^2 area satisfied the guidelines. Beta contamination in excess of the maximum activity guideline was identified on one I-beam. However, the residue sample, collected from this I-beam, contained elevated concentrations of uranium rather than radionuclides from the guideline categories used for surface activity level comparisons (Table 3). The guidelines for uranium are based on alpha activity of 5,000 dpm/100 cm^2 average in a 1 m^2 area and 15,000 dpm/100 cm^2 maximum. An air duct was also identified with residual beta activity levels between the average and maximum guidelines. Additional measurements, to determine the average activity within the surrounding 1 m^2, were not performed at this location because surface scans of the area did not indicate the presence of distributed contamination.

Beta contamination was identified at seven locations on the floor and lower wall ledge of the eastern portion of survey unit A5. In each of these areas, either the average activity in 1 m^2 areas or the maximum activity guidelines was exceeded. A residue sample collected from the ledge contained elevated concentrations of uranium (Table 3). An I-beam plate was identified on the upper wall with beta contamination in excess of the maximum guideline levels. One of the measurements performed on this plate also had alpha surface activity levels between the average and maximum guidelines. The contamination on this plate was determined to extend along the entire length of the east wall, including that portion of the east wall in survey unit U6 (all data from the east wall has been incorporated into the results for Survey Unit A5).

One area on the floor of survey unit A6 had residual alpha and beta contamination in excess of the maximum respective guidelines. A floor drain was also noted in the area where this contamination was identified. Due to the restrictive size of the drain opening, direct measurements, to determine surface activity levels inside of the drain, could not be performed.

Survey units A7 and A8 were comprised of the lockers located in rooms 108 and 211. The floor of most of these lockers had residual surface activity in excess of the average or maximum beta

activity guidelines. Alpha activity levels in several of the surveyed lockers were in excess of the average alpha activity guideline.

Survey unit U7 contained a blower with beta activity levels greater than the maximum guideline. As previously discussed, the source of this residual contamination could not be identified. In survey unit U8, a second blower was identified with distributed alpha contamination exceeding the average guideline.

There were 25 measurement locations in Building 403 that exceeded either the average or maximum alpha guideline and/or the beta surface activity guidelines. Five of the locations exceeded the maximum alpha guideline, nine exceeded the average alpha activity guideline, and 11 locations exceeded the beta maximum activity guideline. Thirteen locations exceeded the average beta activity guideline. The average activity within the 1 m^2 areas surrounding seven of these locations exceeded the average activity guideline and five locations were the result of ceramic tile, which typically contains naturally occurring elevated direct radiation levels. The average alpha and beta activity levels in the surrounding 1 m^2 area of one area satisfied the average activity guideline. At five locations, the removable alpha activity guideline was also exceeded.

The DOE exposure rate guideline is 20 μR/h above background. All interior and exterior exposure rates were less than this value and therefore satisfy the guideline.

Soil concentration guidelines are as follows:

<u>Ra-226, Ra-228, Th-230, and Th-232</u>

5 pCi/g, averaged over the first 15 cm of soil below the surface

15 pCi/g, averaged over 15-cm-thick layers of soil more than 15 cm below the surface.

<u>Total uranium</u>

The site-specific guideline is 90 pCi/g (Gross 1988)

Cs-137

The site-specific guideline is 33 pCi/g (Gross 1988)

The residual soil concentration guideline levels for Ra-226 and Th-230 were exceeded at 4 of the surface sampling locations and the one subsurface location. The soil guidelines permit averaging residual radionuclide concentration levels over 100 m^2 areas and the application of hot spot criteria. The size of the areas of elevated direct gamma radiation ranged from 1 m^2 to approximately 3 m^2. The field application of the hot spot criteria allows multiplication factors of from 6 to 10 times the authorized limit (or 30 to 50 pCi/g for Ra-226 and Th-230), based on $(100/A)^{1/2}$, where A equals the area of the hot spot. In addition, because the hot spots contain a mixture of radionuclides at elevated concentration levels, the sum of the ratios of the soil concentration of each radionuclide to the allowable limit for that radionuclide shall not exceed 1. These factors indicate that the Ra-226 and Th-230 guidelines were exceeded at sample locations 3, 4, 6, and 7 (Table 5 and Figure 47).

SUMMARY

The Environmental Survey and Site Assessment Program of the Oak Ridge Institute for Science and Education performed radiological surveys of the remaining structures at the Niagara Falls Storage Site during the period September 12 through 22, 1994. The survey included alpha, beta, and gamma surface scans, direct and removable surface activity measurements and sampling, exposure rate measurements within Building 401, 403, and the Hittman Building and exposure rate measurements and soil sampling of the Building 401 exterior.

The surveys determined that residual fixed and removable activity in excess of the DOE guidelines for release to unrestricted use remain on interior surfaces of Buildings 401 and 403 and localized soil contamination is present around the perimeter of Building 401. There was no residual contamination identified within the Hittman Building.

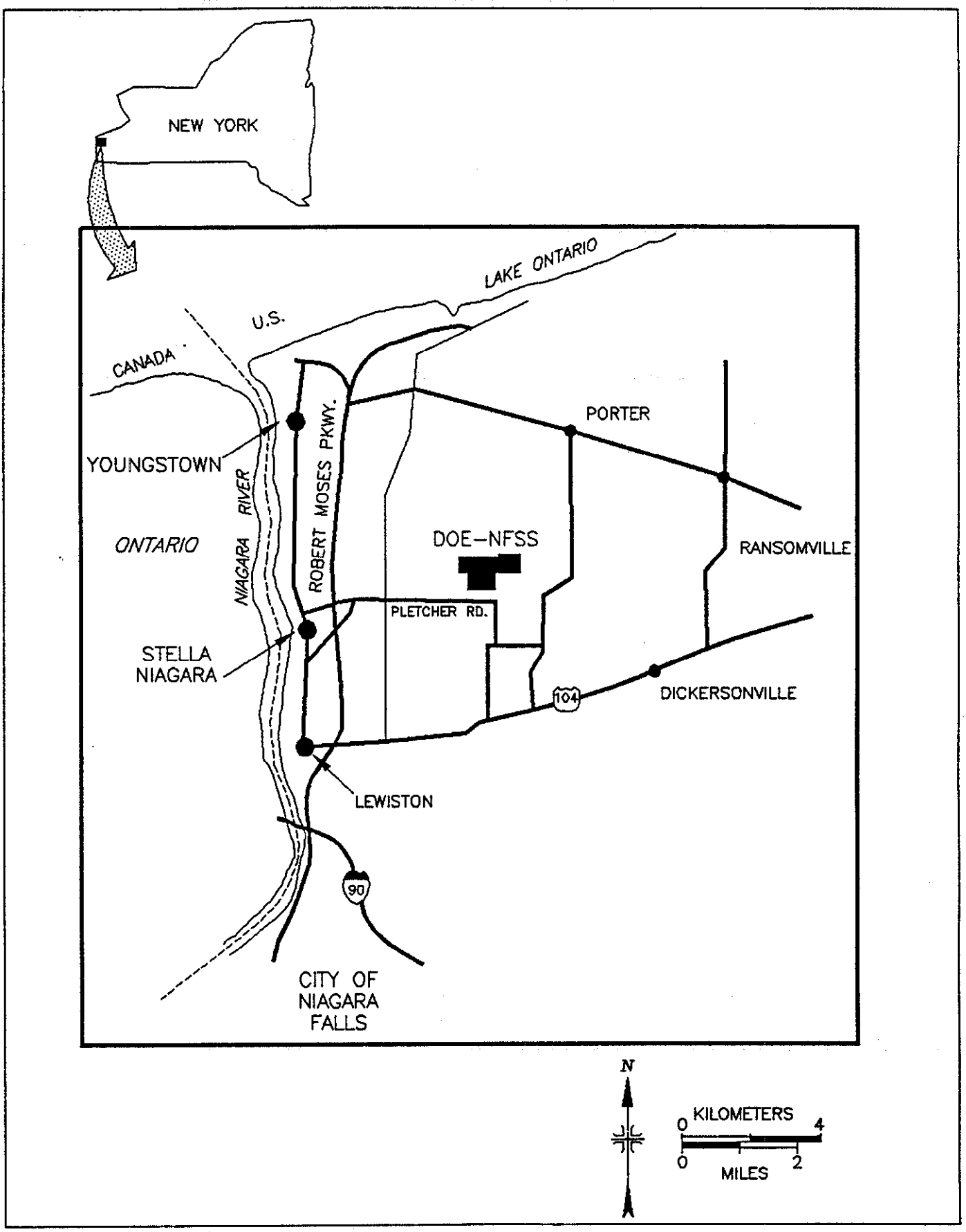


FIGURE 1: Location of the Niagara Falls Storage Site

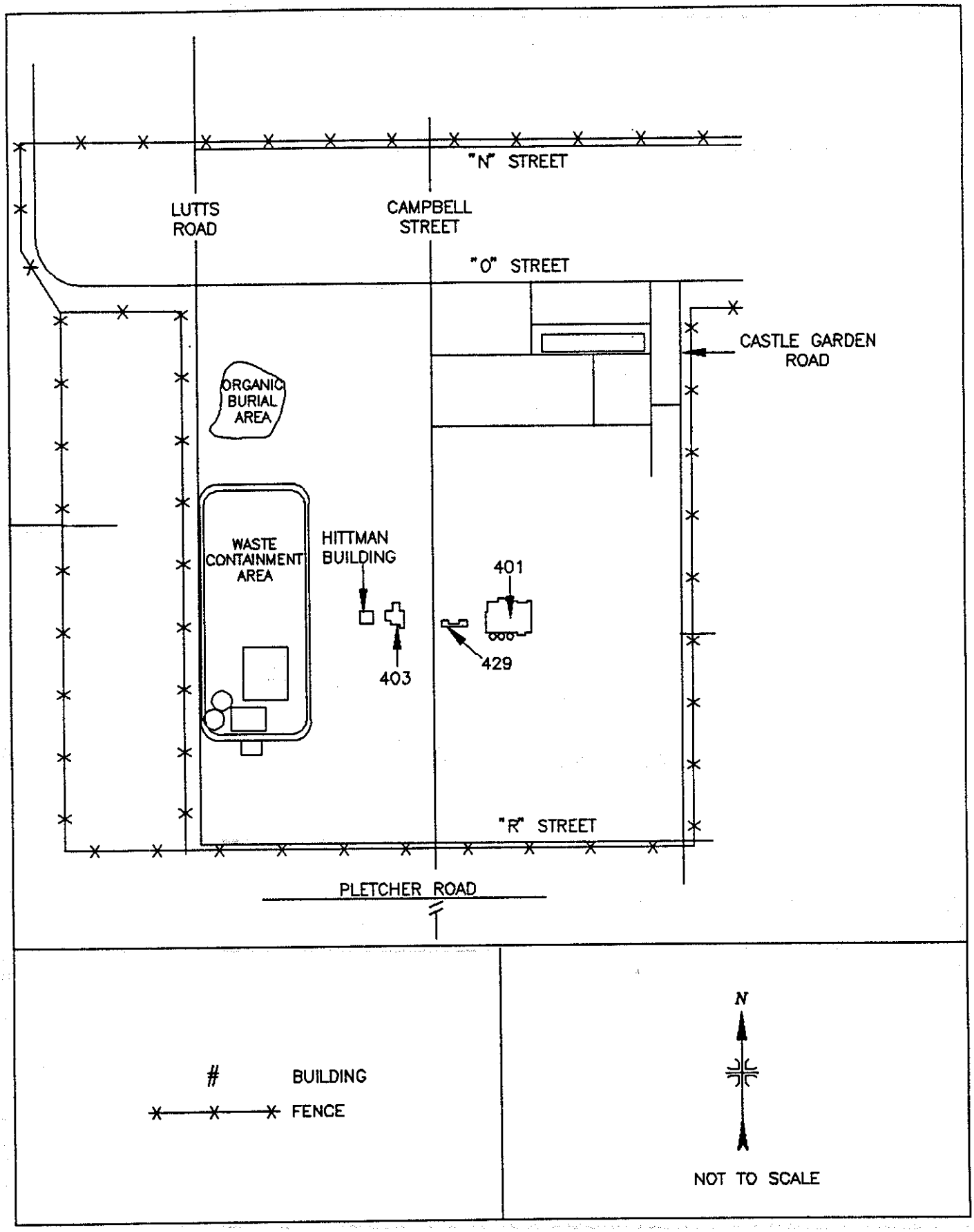


FIGURE 2: Niagara Falls Storage Site – Plot Plan

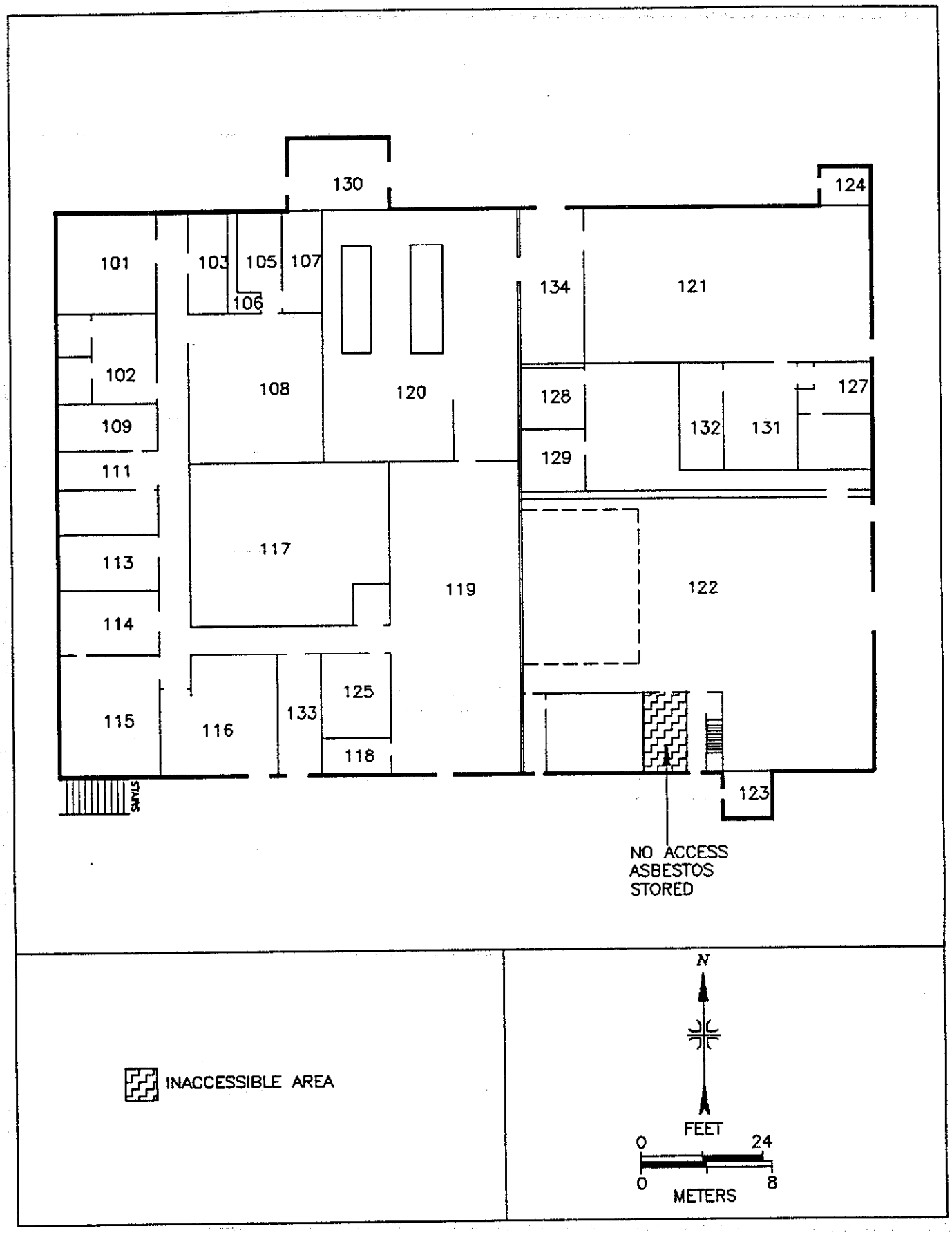
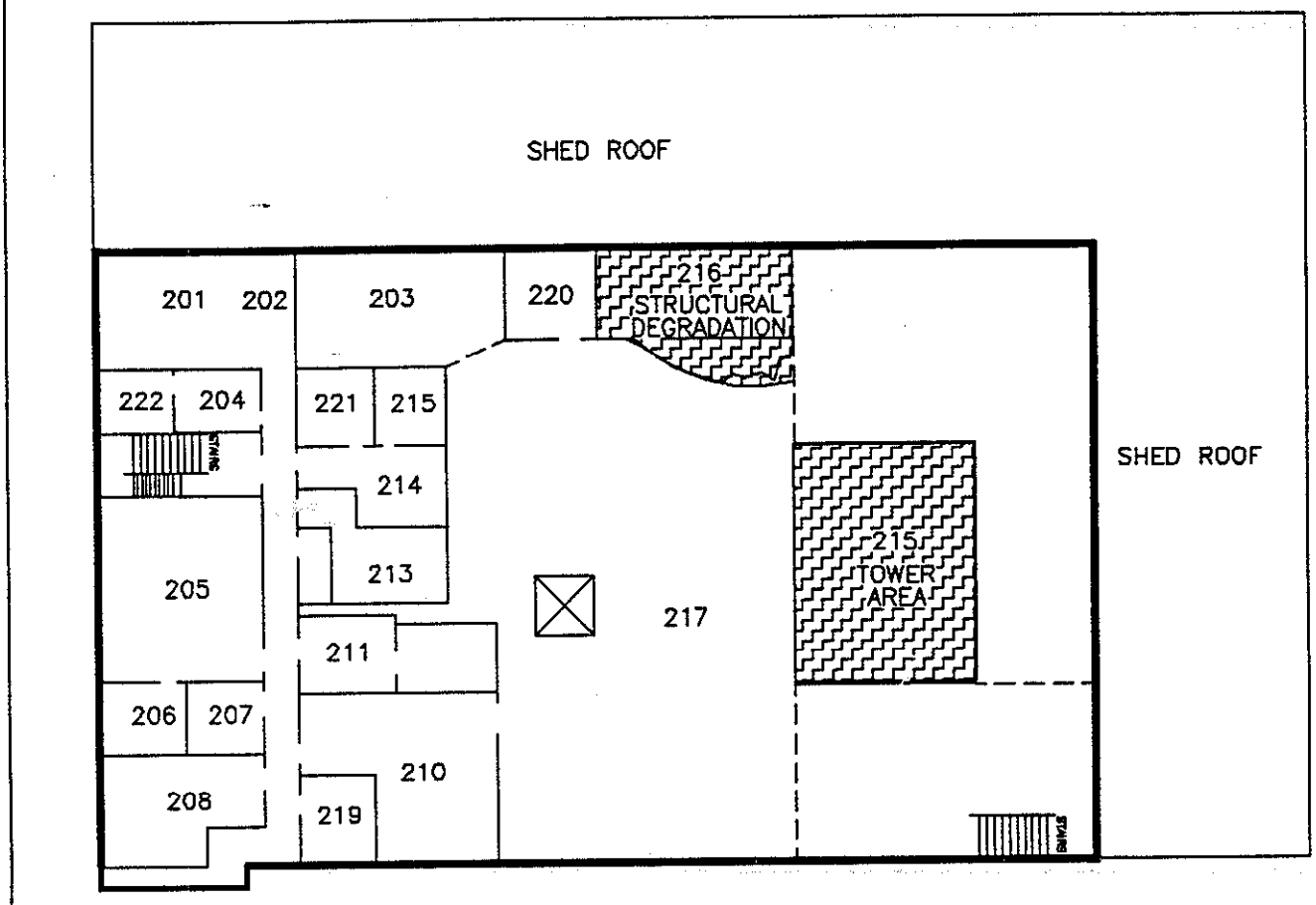


FIGURE 3: Building 401, First Floor – Floor Plan



INACCESSIBLE AREA

N

0 FEET 24

0 METERS 8

FIGURE 4: Building 401, Second Floor – Floor Plan

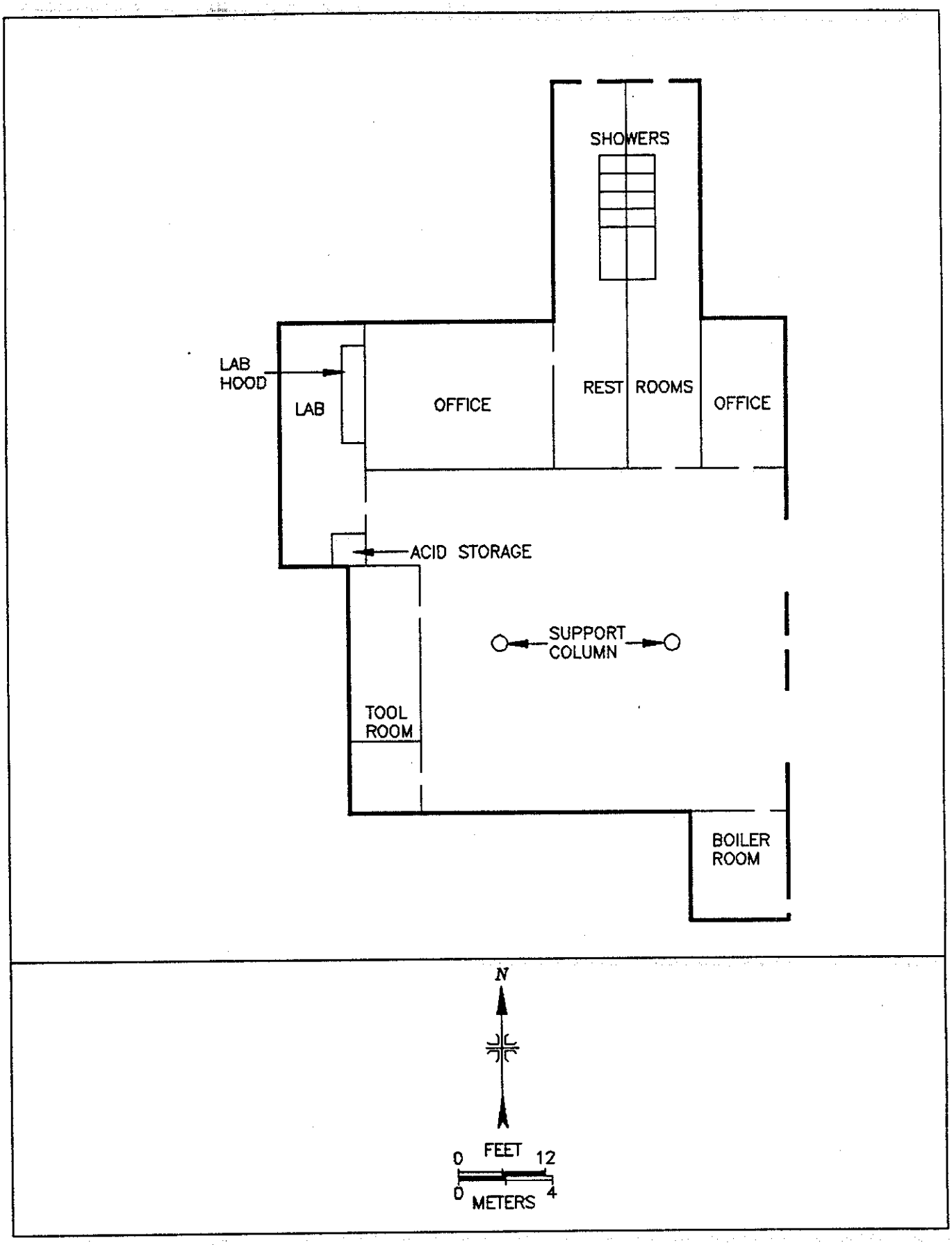


FIGURE 5: Building 403 – Floor Plan

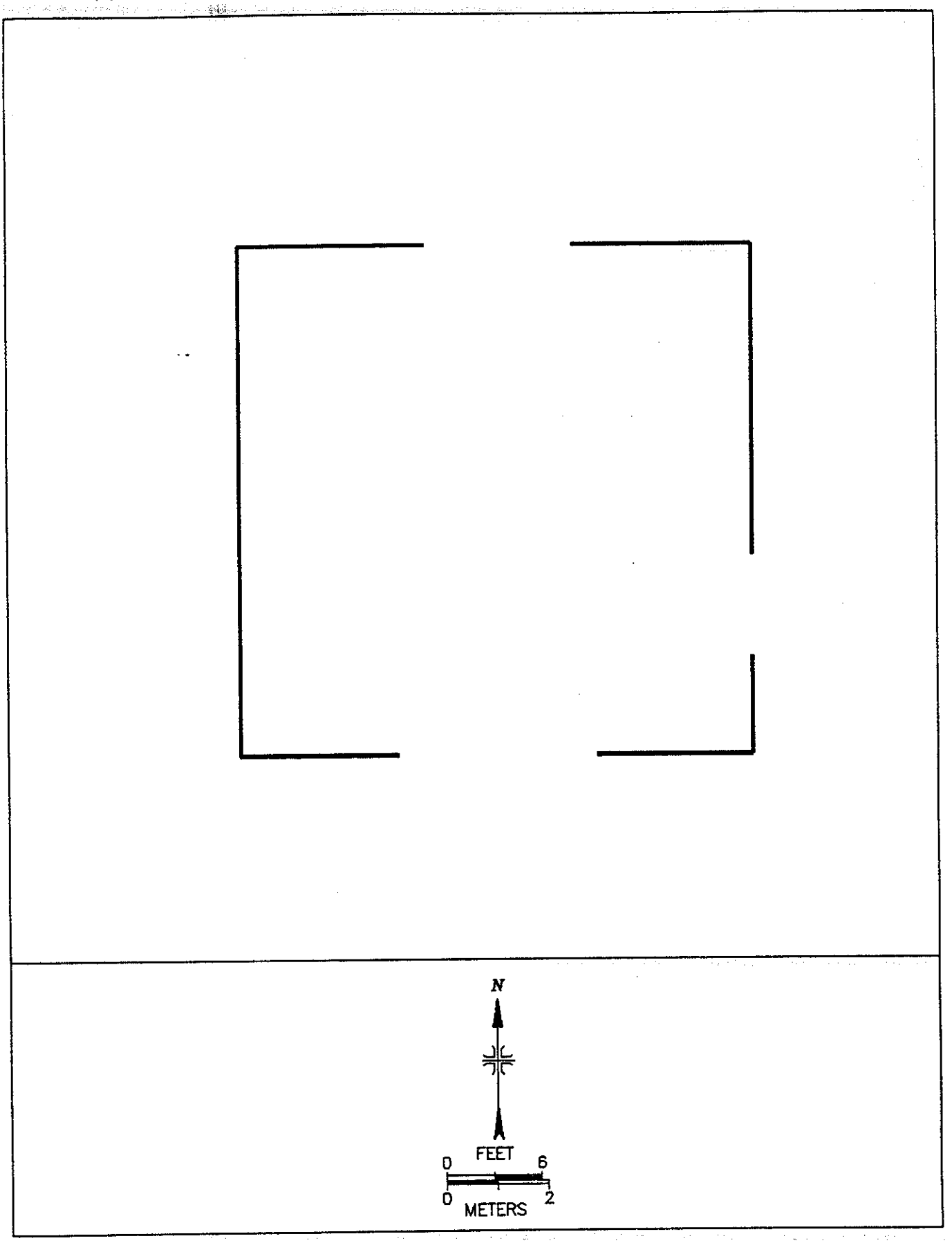


FIGURE 6: Hittman Building – Floor Plan

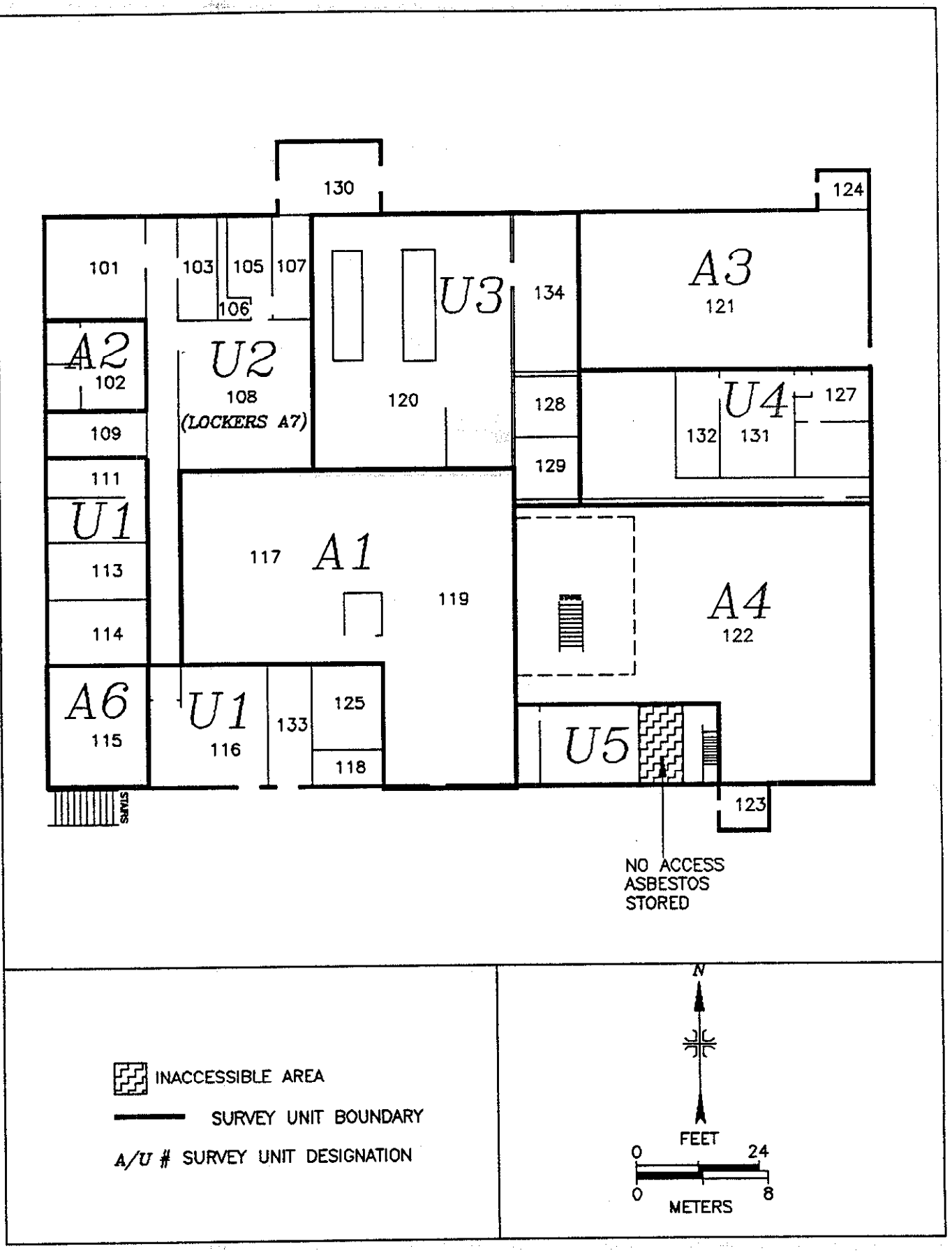


FIGURE 7: Building 401, First Floor – Survey Units

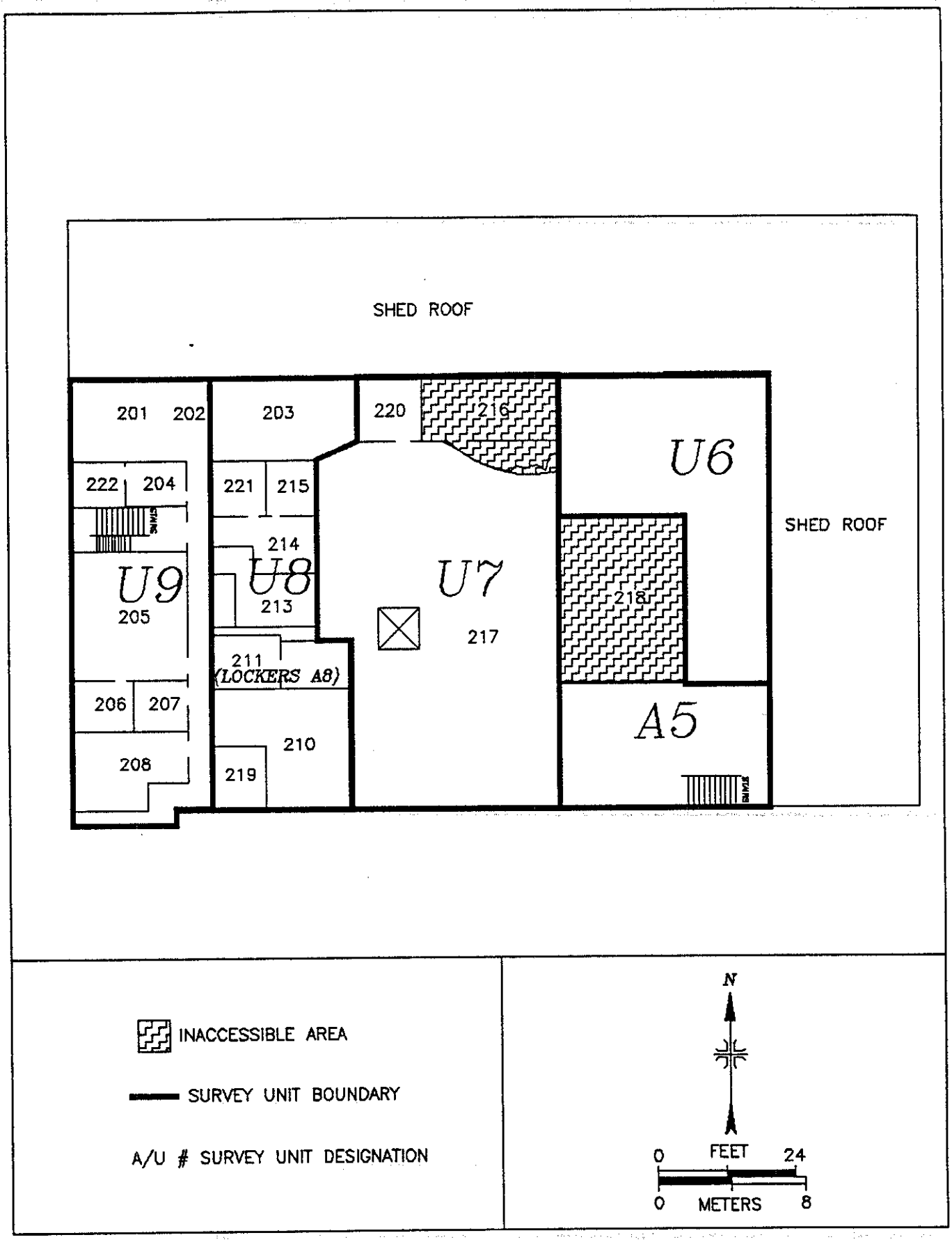


FIGURE 8: Building 401, Second Floor – Survey Units

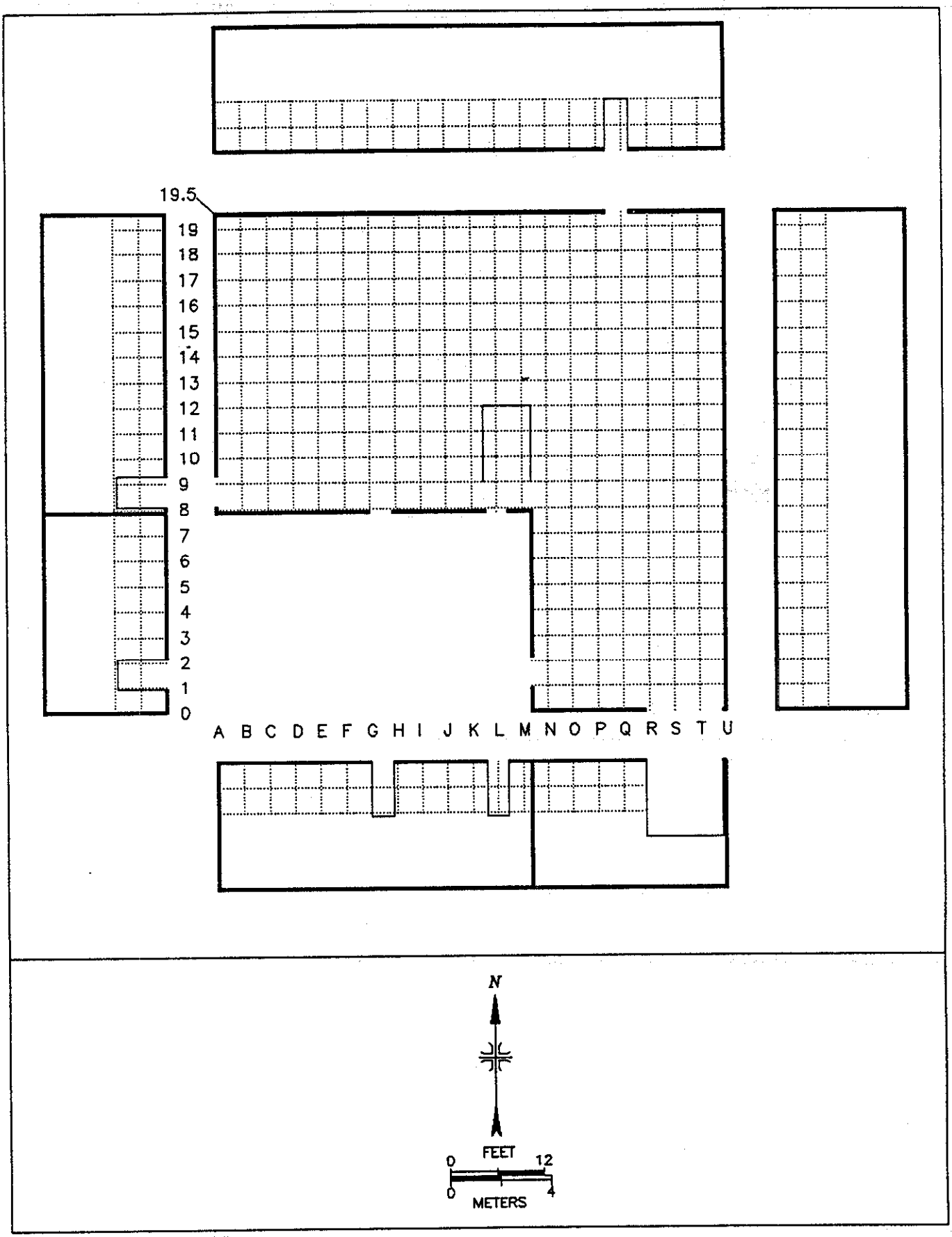


FIGURE 9: Survey Unit A1, Rooms 117 and 119 – Floor Plan and Reference Grid

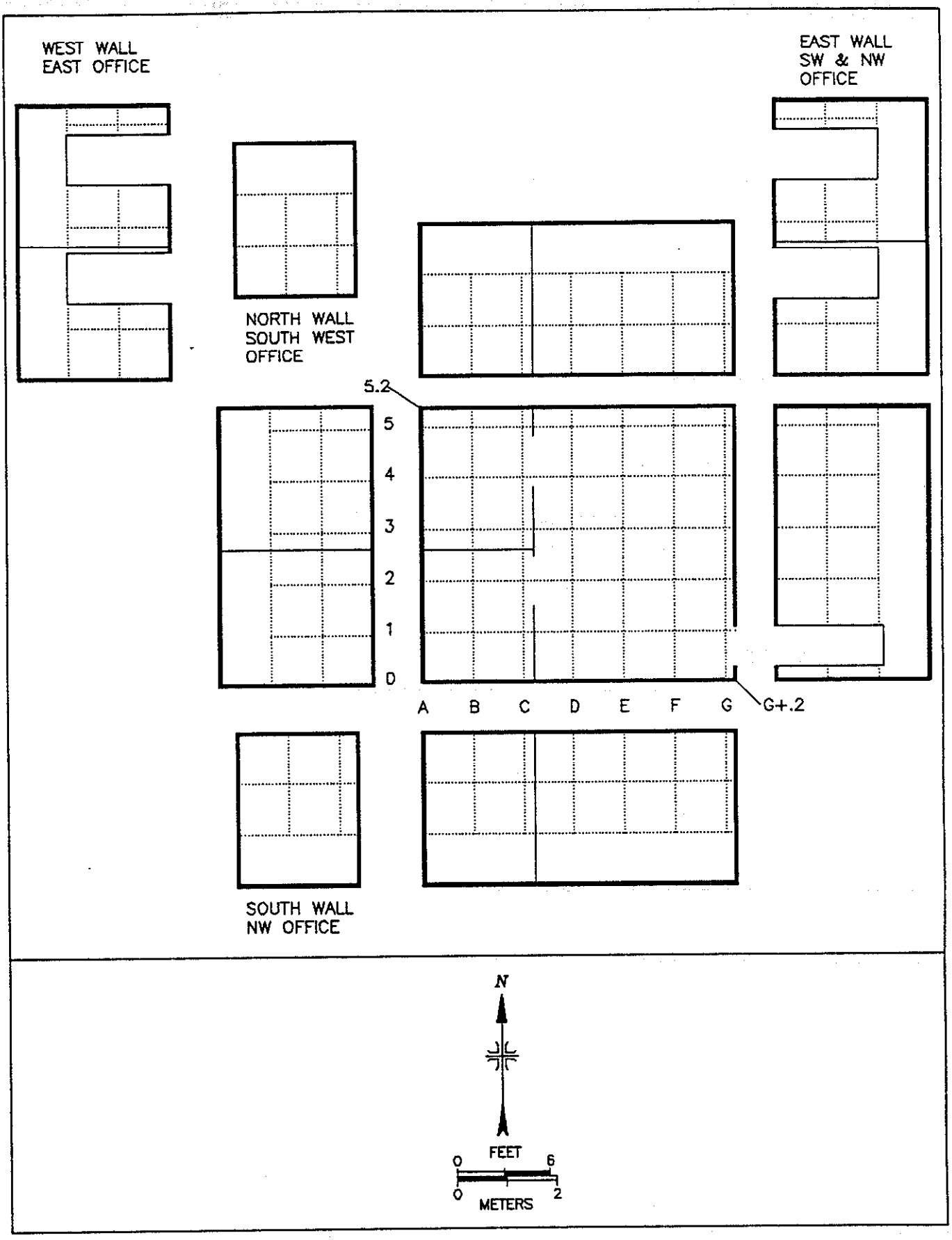


FIGURE 10: Survey Unit A2, Room 102 – Floor Plan and Reference Grid

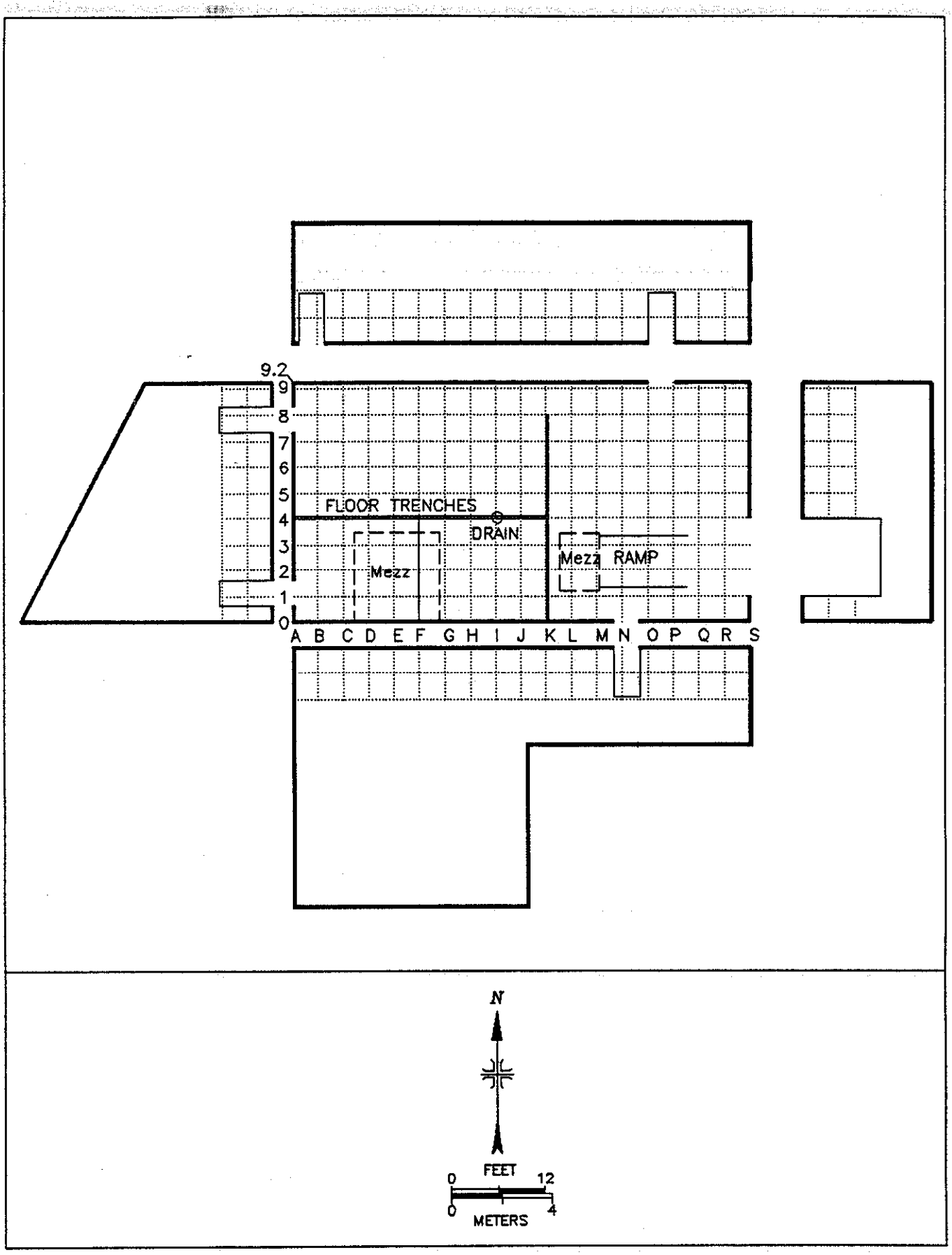


FIGURE 11: Survey Unit A3, Room 121 – Floor Plan and Reference Grid

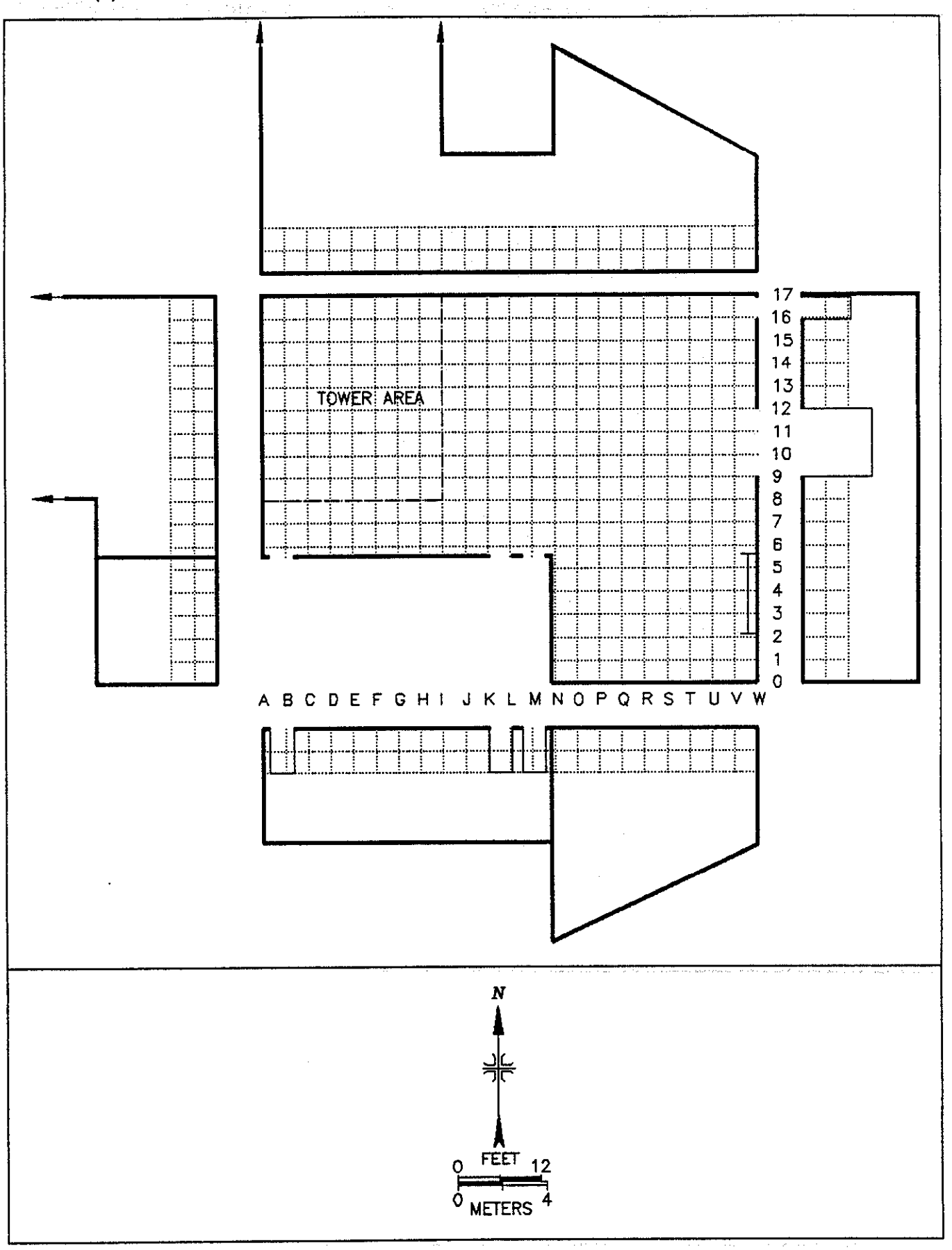


FIGURE 12: Survey Unit A4, Room 122 – Floor Plan and Reference Grid

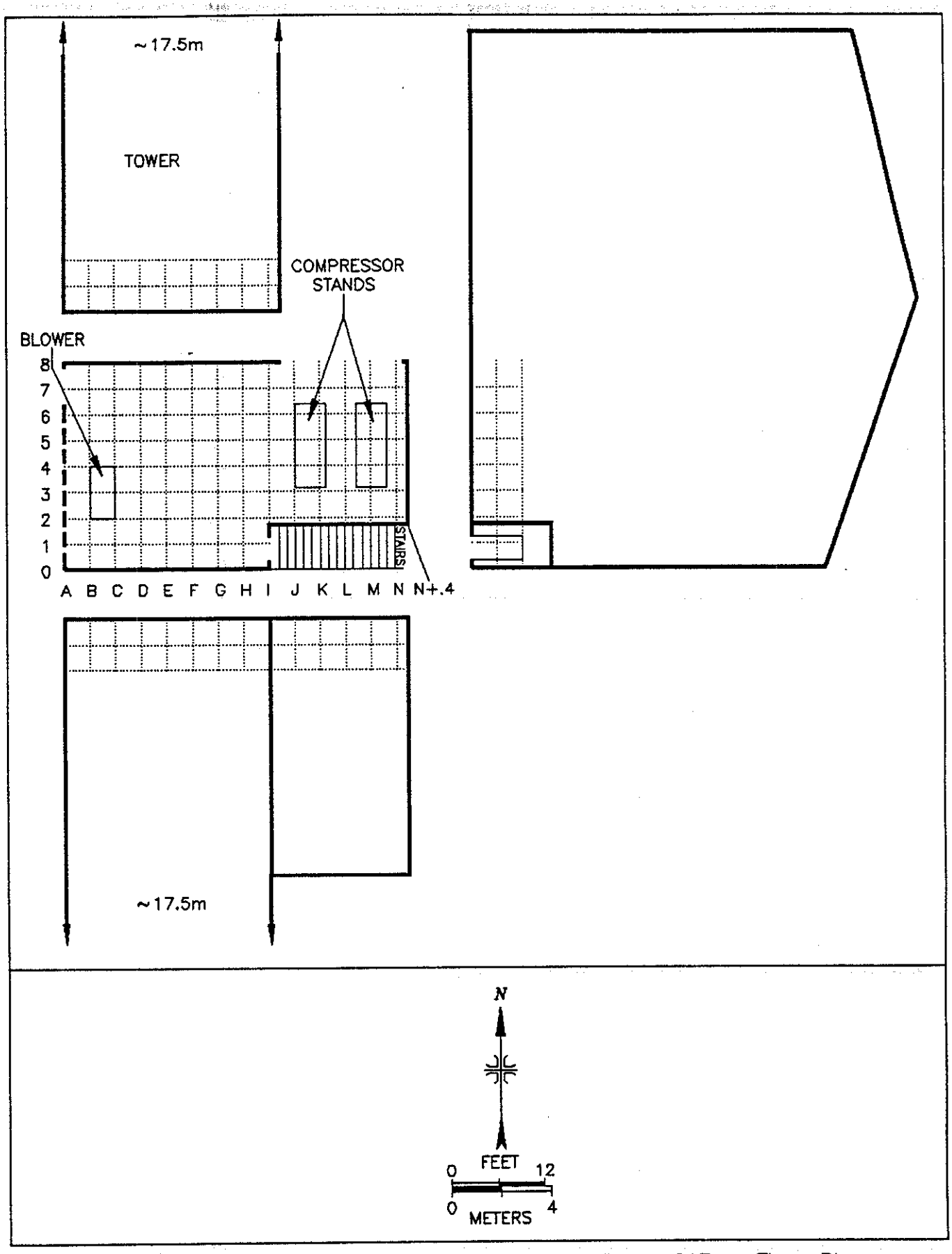
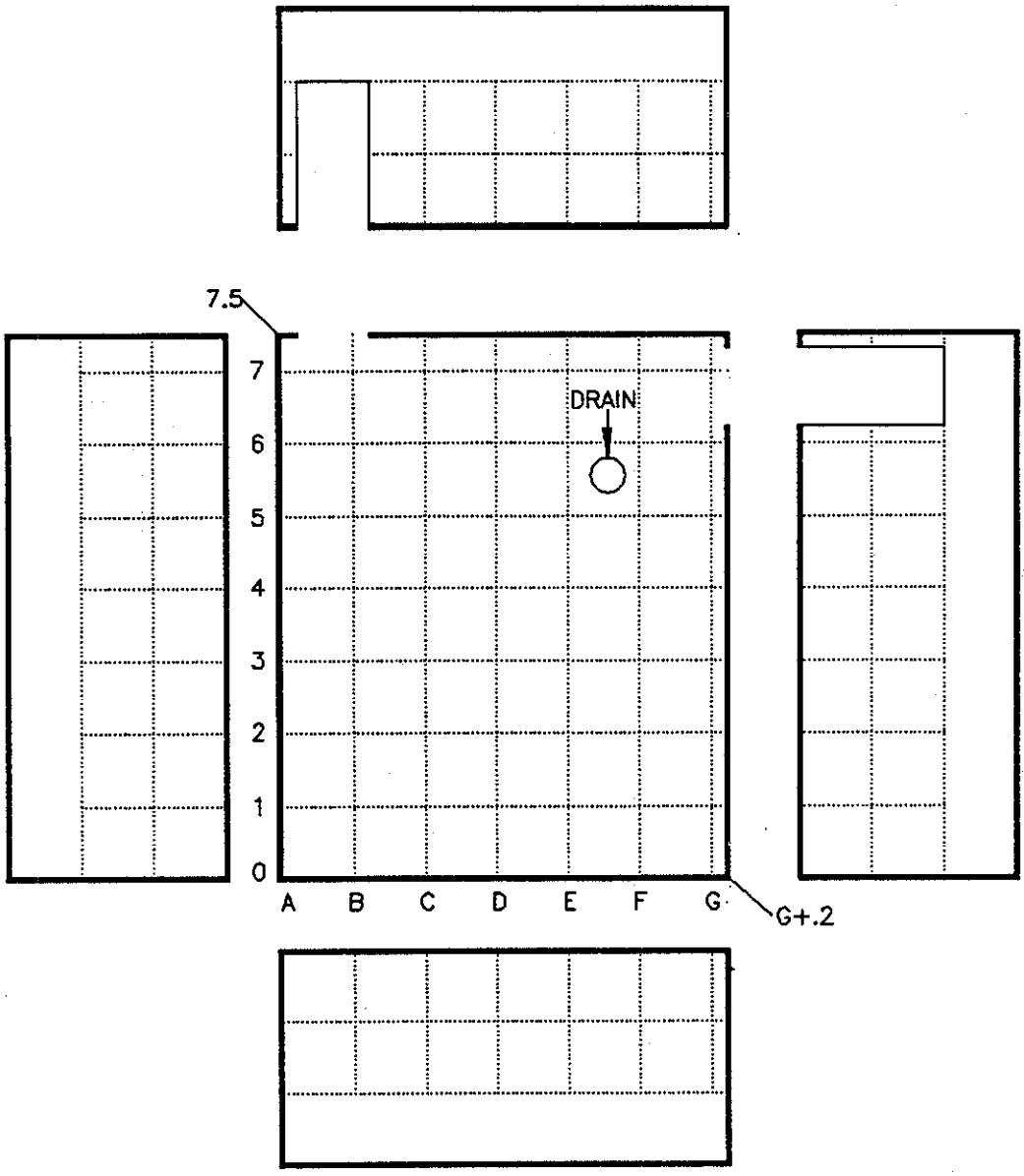


FIGURE 13: Survey Unit A5, Southeast Area of Room 217 – Floor Plan and Reference Grid



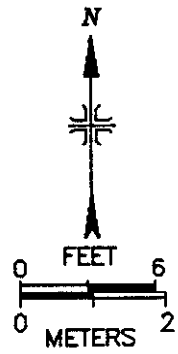


FIGURE 14: Survey Unit A6, Room 115 – Floor Plan and Reference Grid

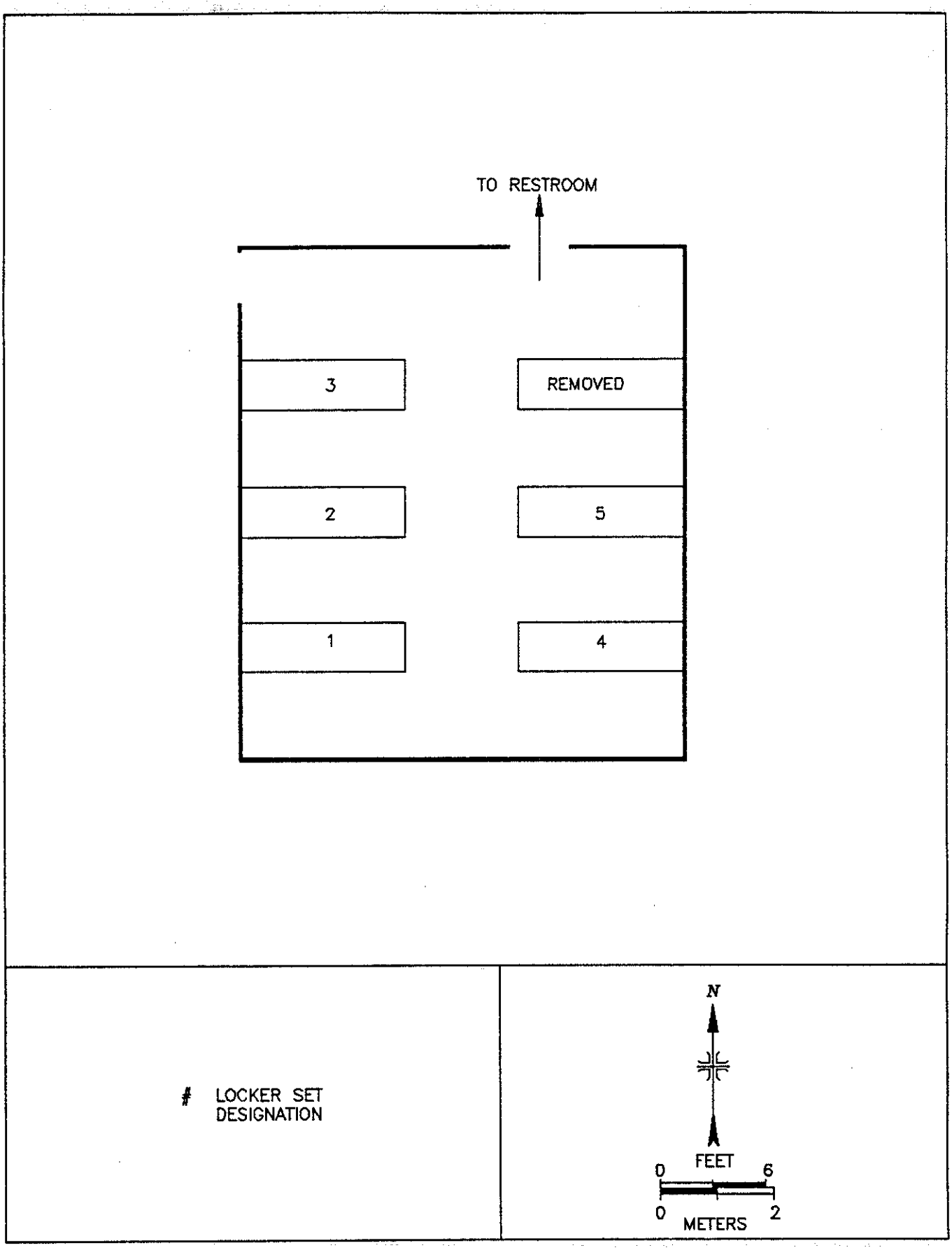


FIGURE 15: Survey Unit A7, Lockers, Room 108 – Floor Plan

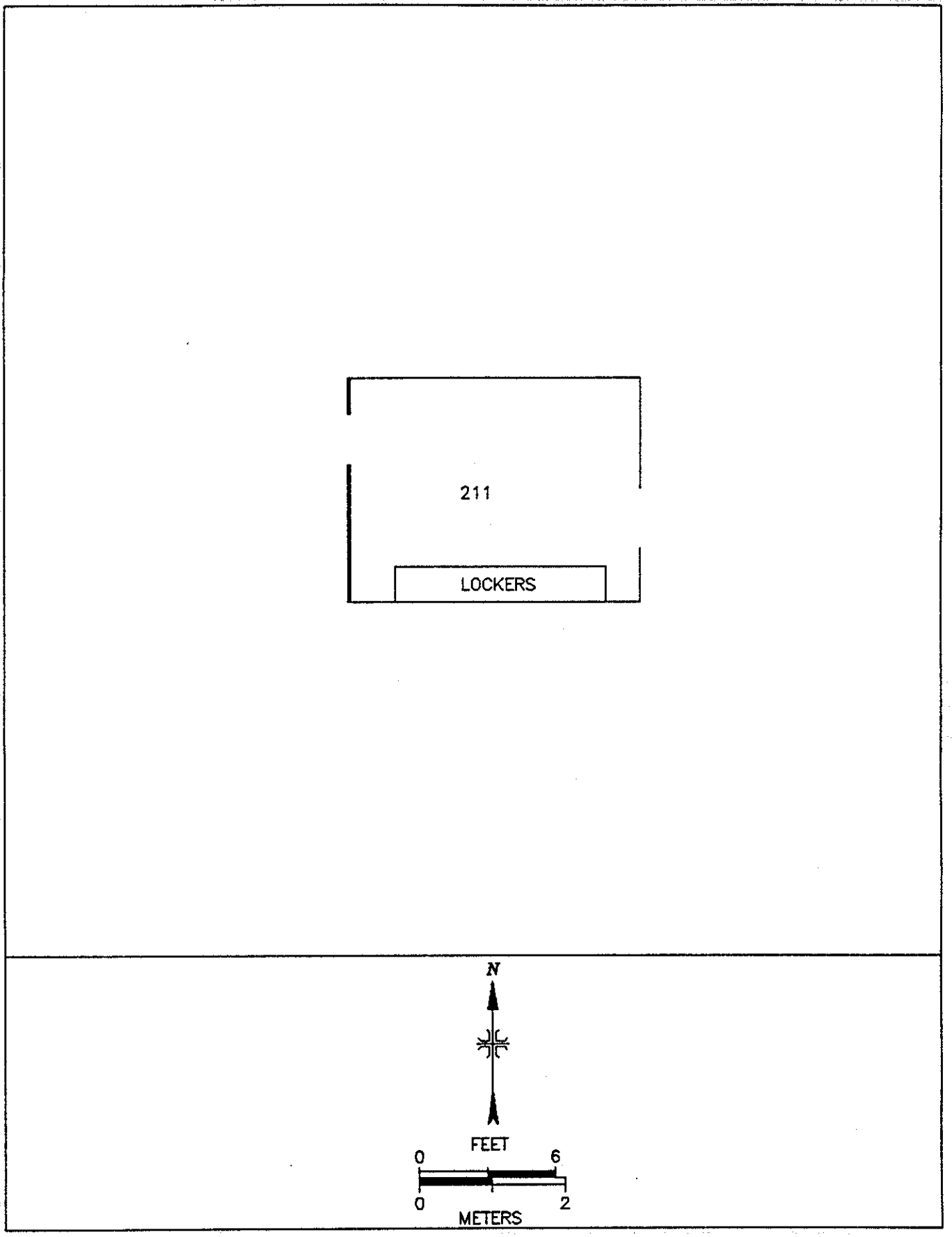


FIGURE 16: Survey Unit A8, Lockers, Room 211 – Floor Plan

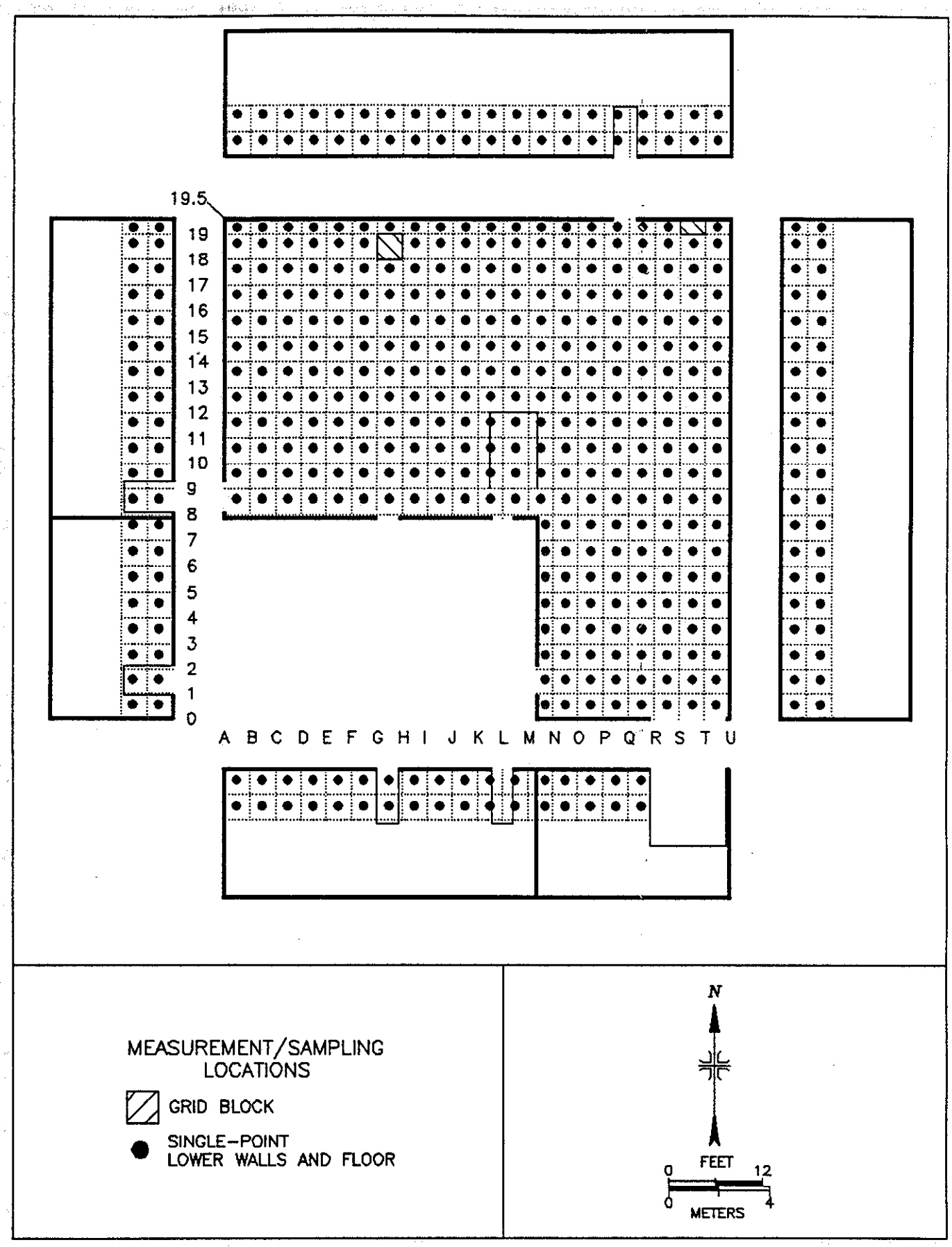
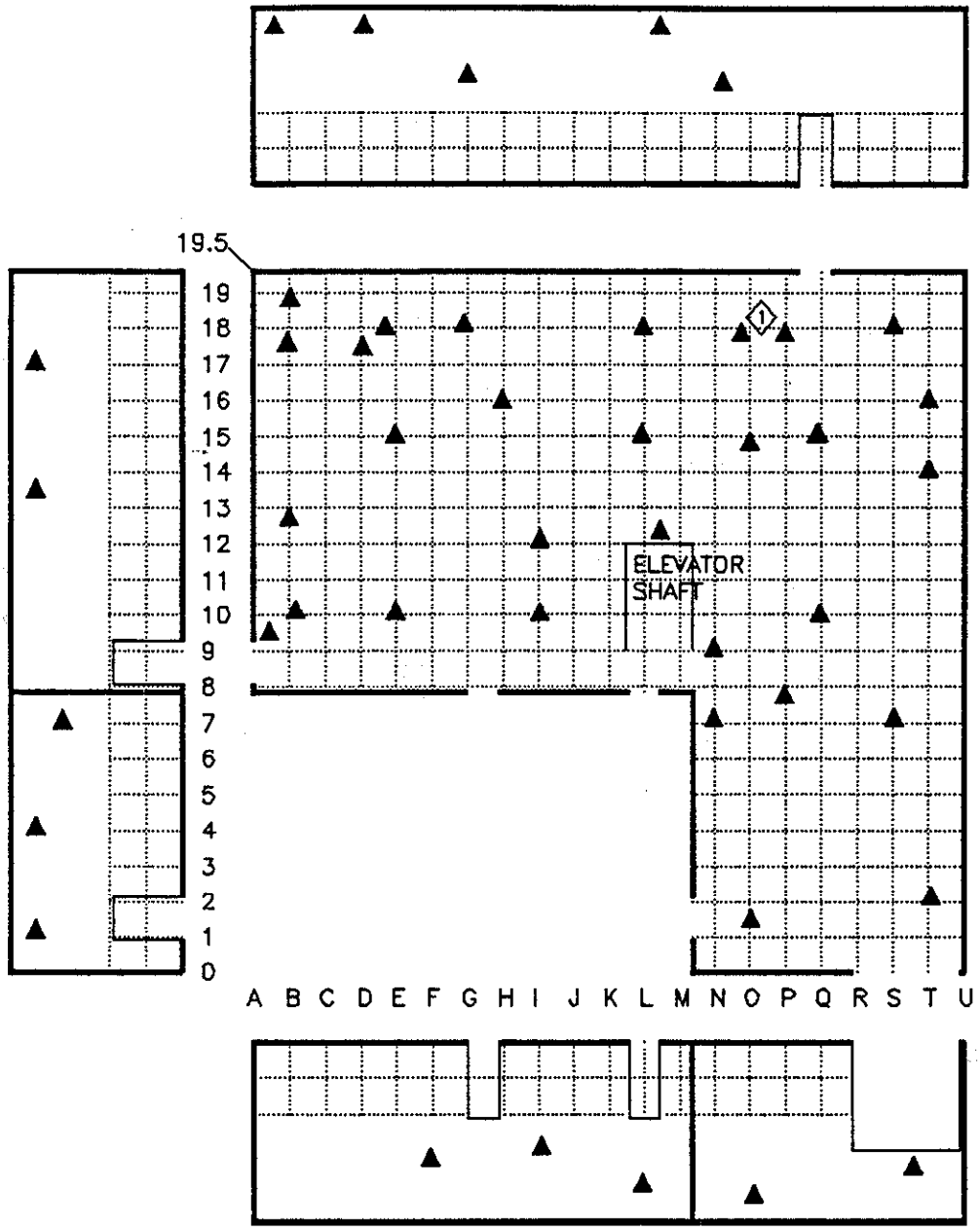


FIGURE 17: Survey Unit A1, Rooms 117 and 119 – Measurement and Sampling Locations



MEASUREMENT/SAMPLING LOCATIONS

▲ SINGLE-POINT UPPER SURFACES

◈ MISCELLANEOUS SAMPLE

FIGURE 18: Survey Unit A1, Rooms 117 and 119 – Measurement and Sampling Locations

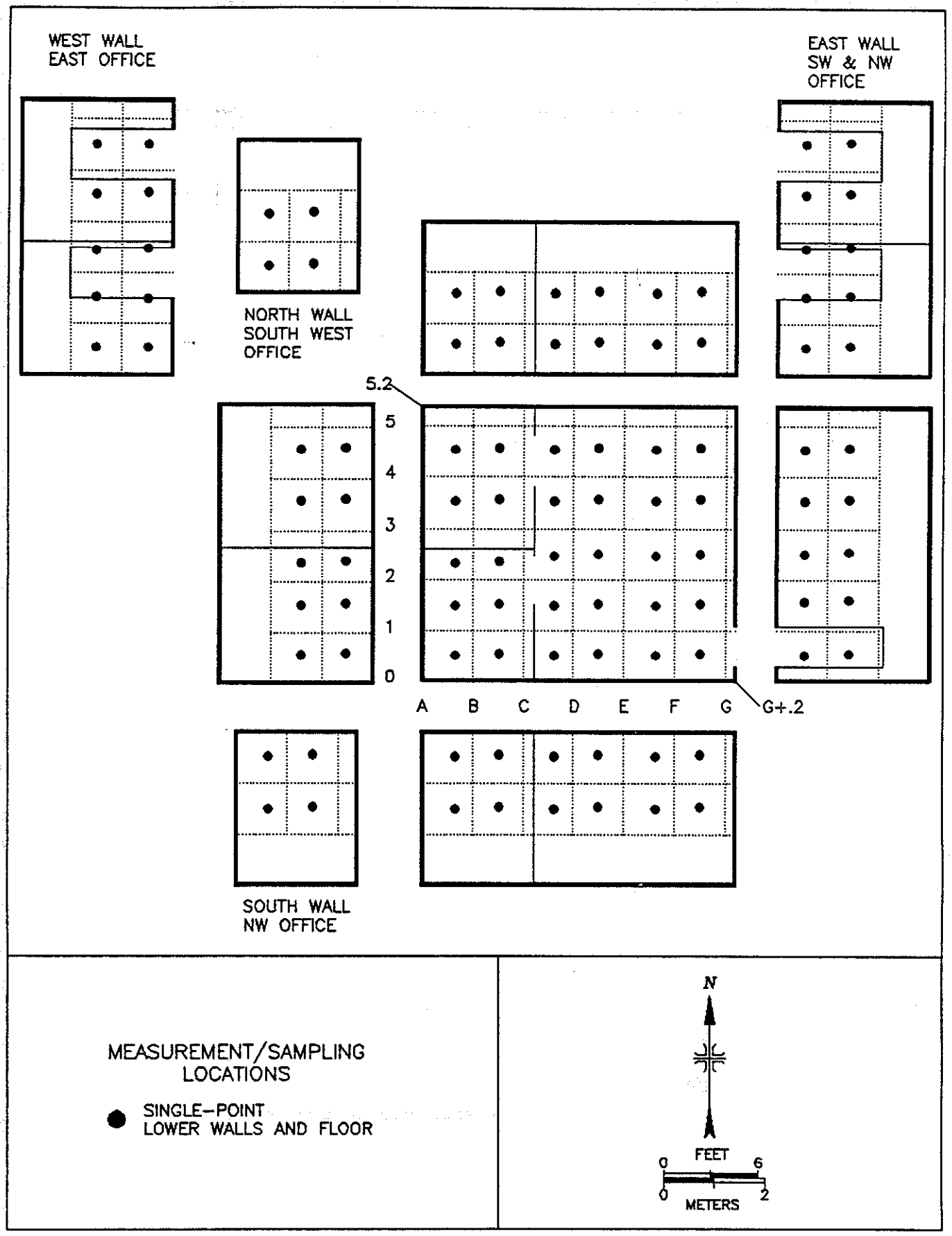


FIGURE 19: Survey Unit A2, Room 102 – Measurement and Sampling Locations

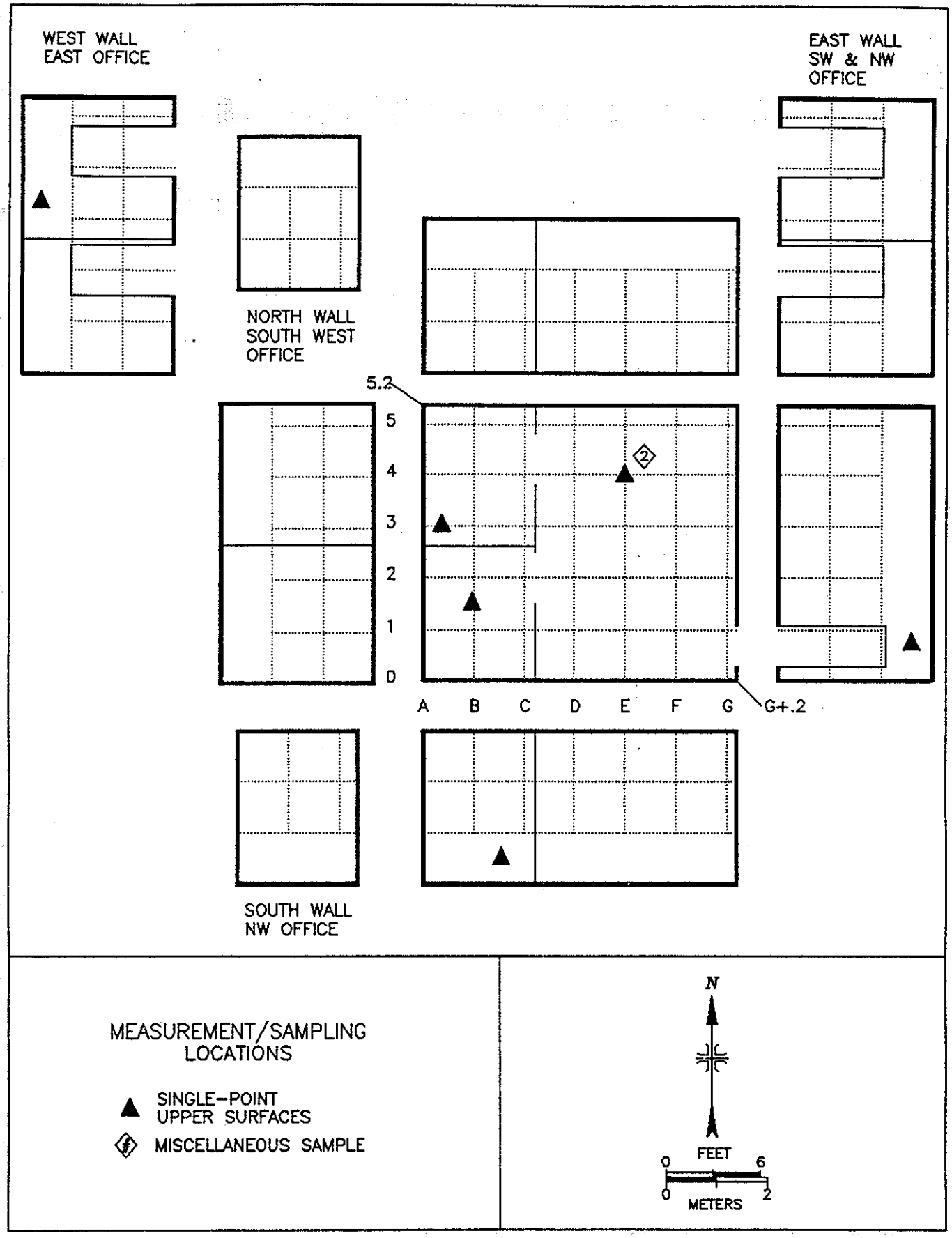


FIGURE 20: Survey Unit A2, Room 102 – Measurement and Sampling Locations

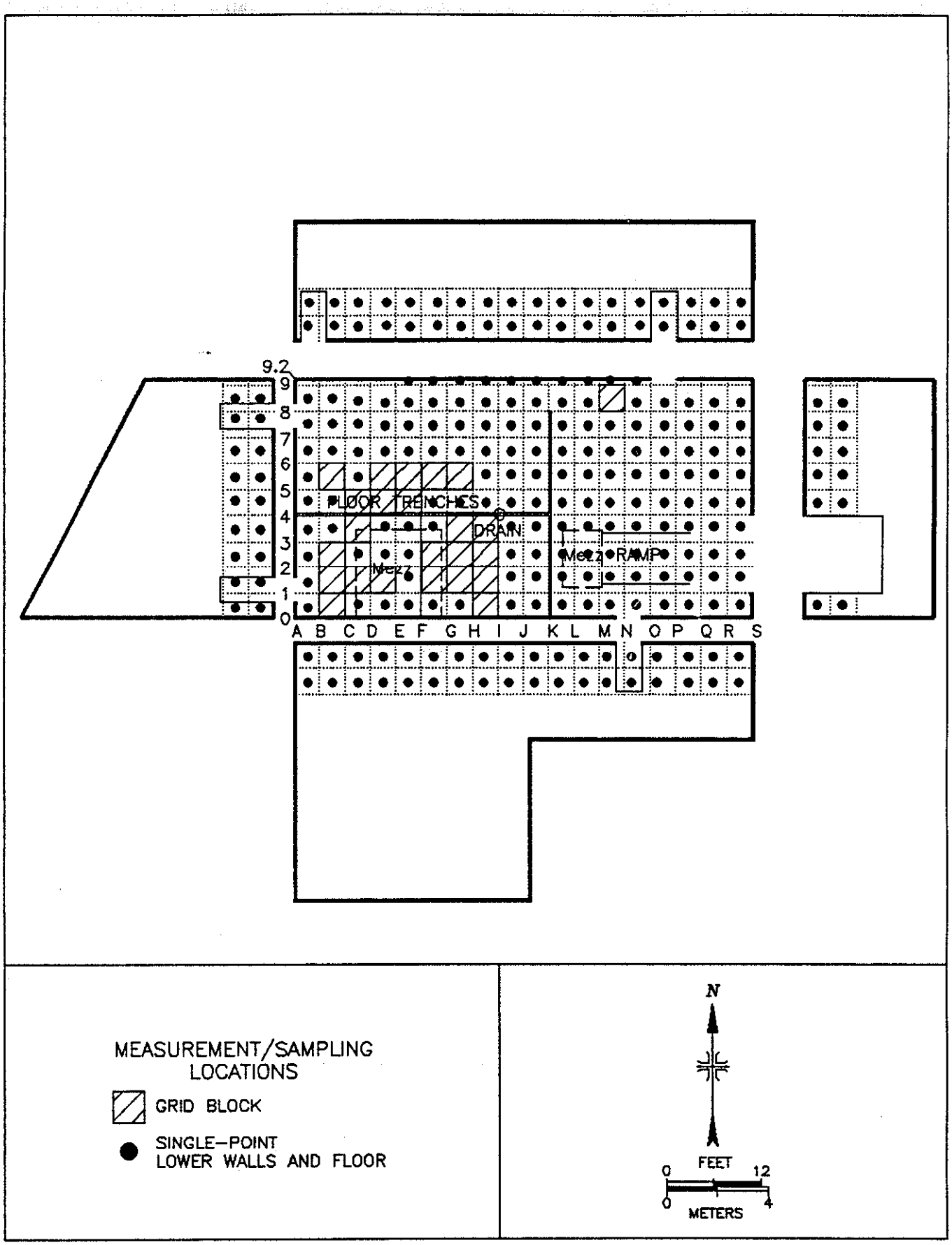


FIGURE 21: Survey Unit A3, Room 121 – Measurement and Sampling Locations

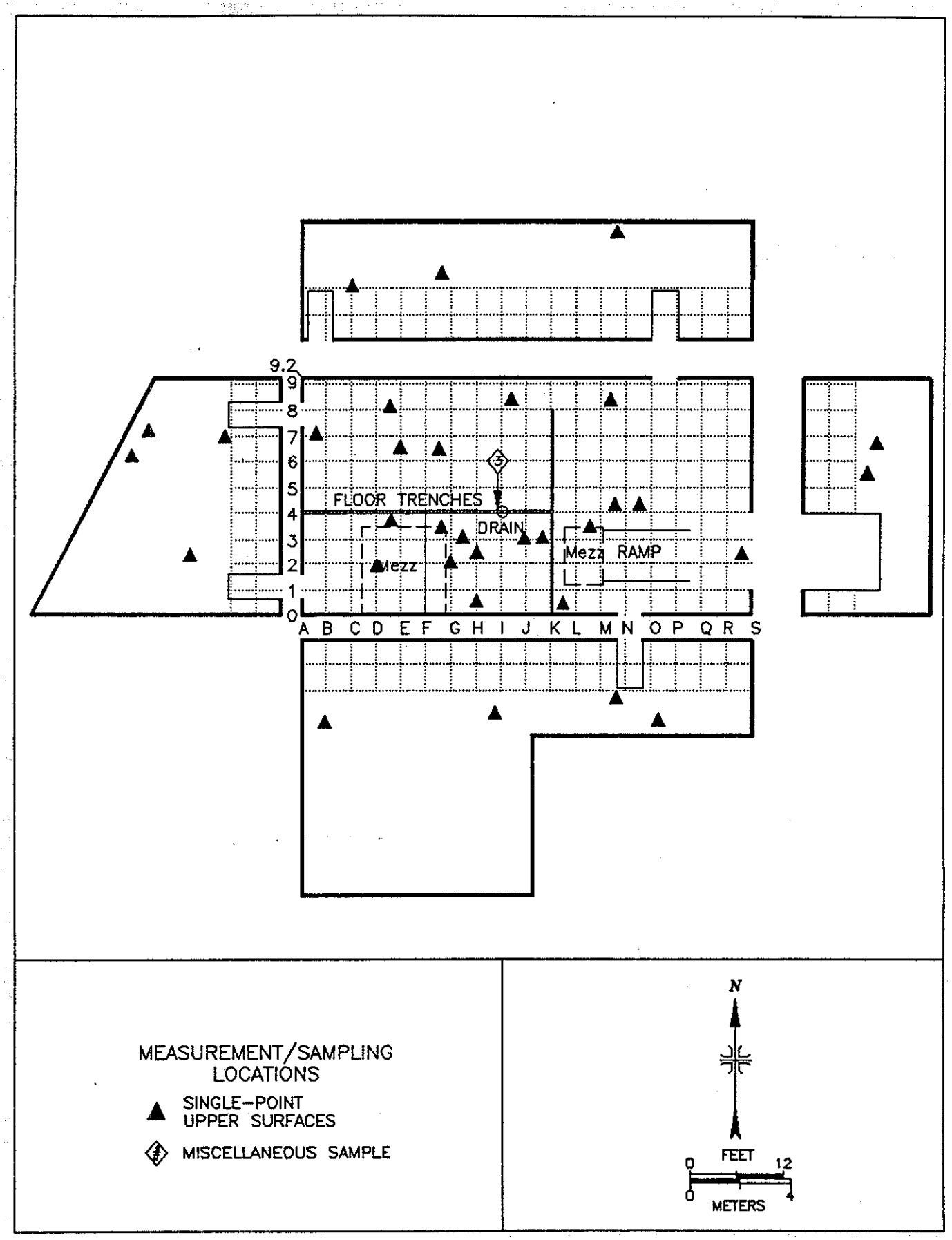


FIGURE 22: Survey Unit A3, Room 121 – Measurement and Sampling Locations

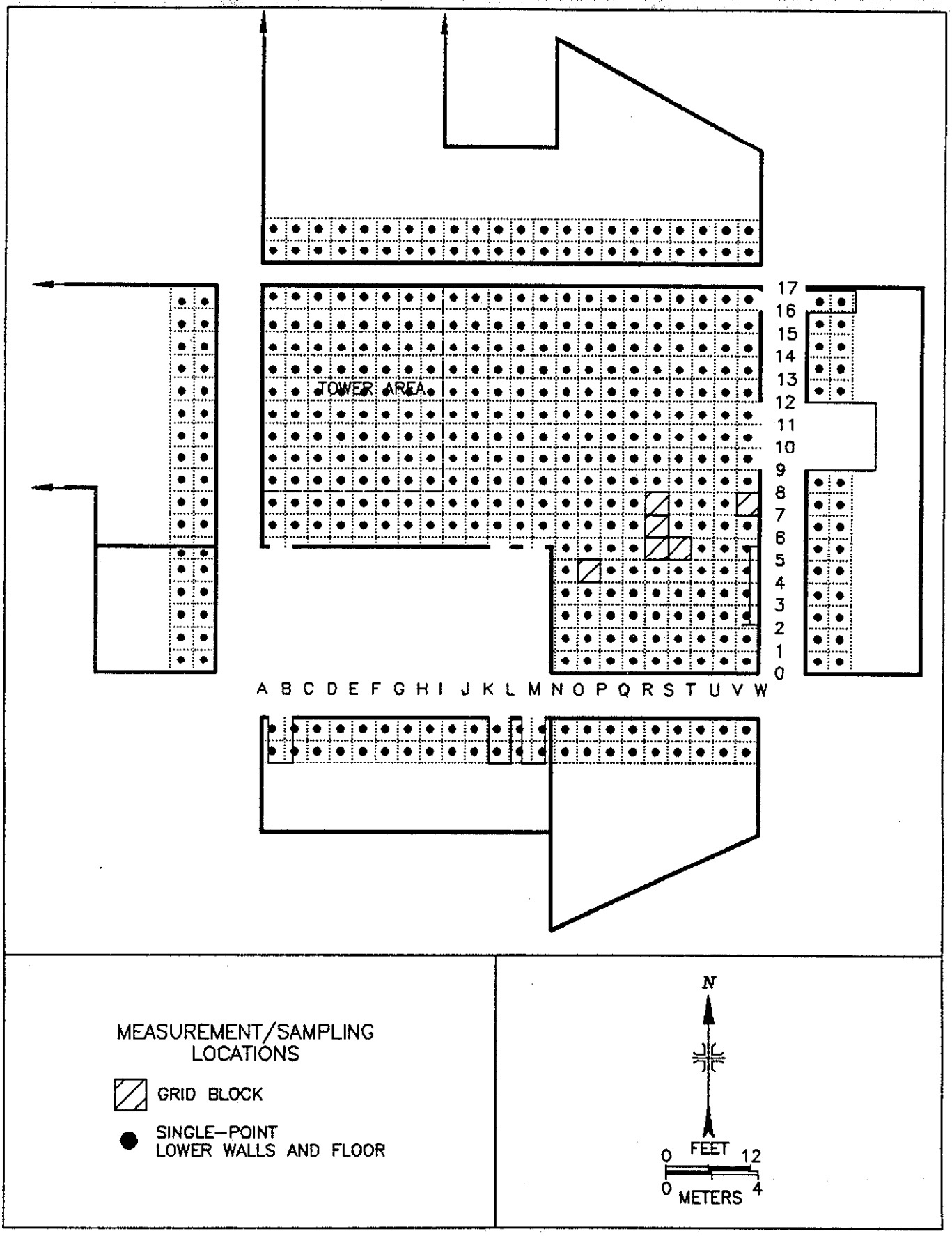


FIGURE 23: Survey Unit A4, Room 122 – Measurement and Sampling Locations

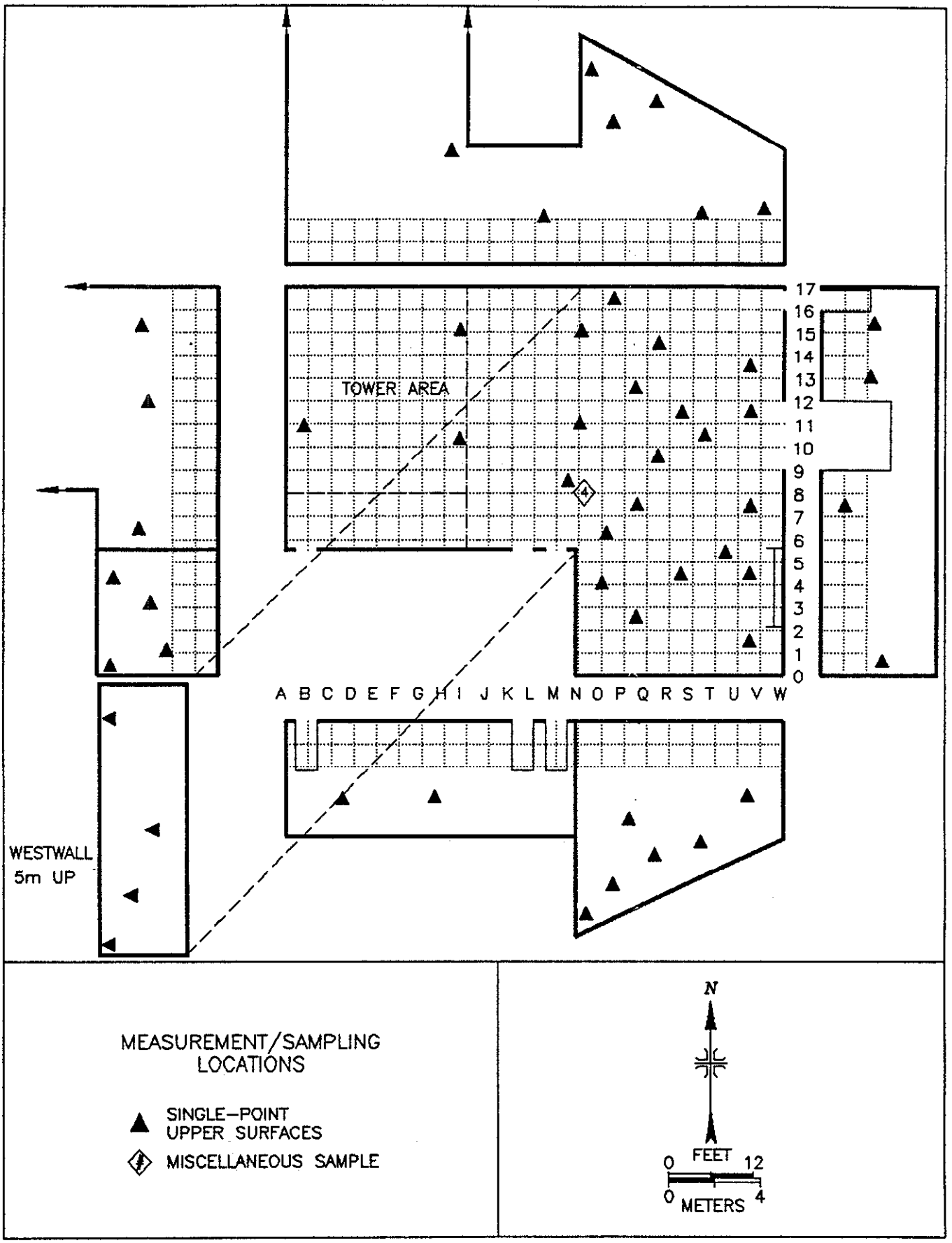


FIGURE 24: Survey Unit A4, Room 122 – Measurement and Sampling Locations

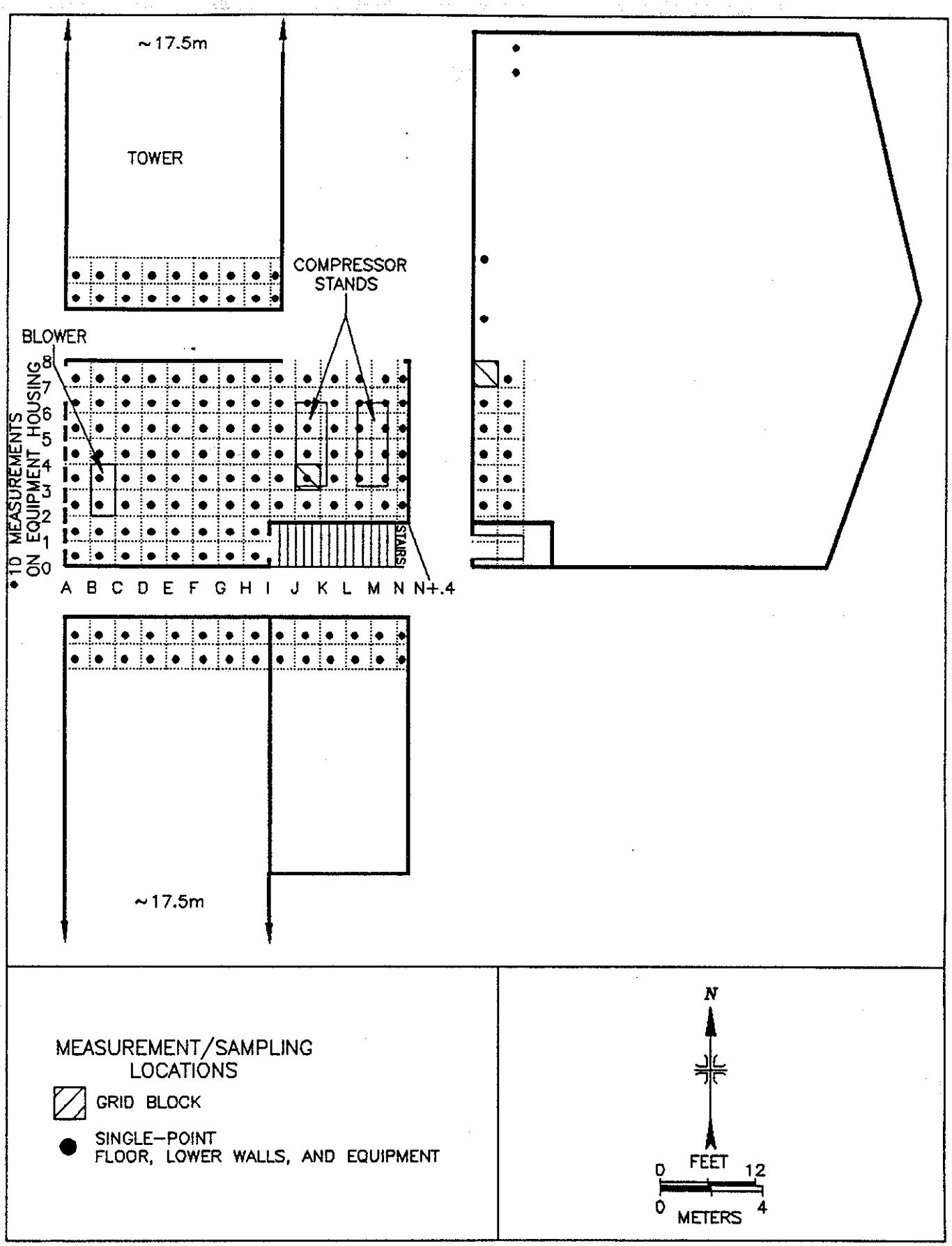


FIGURE 25: Survey Unit A5, Southeast Area of Room 217 – Measurement and Sampling Locations

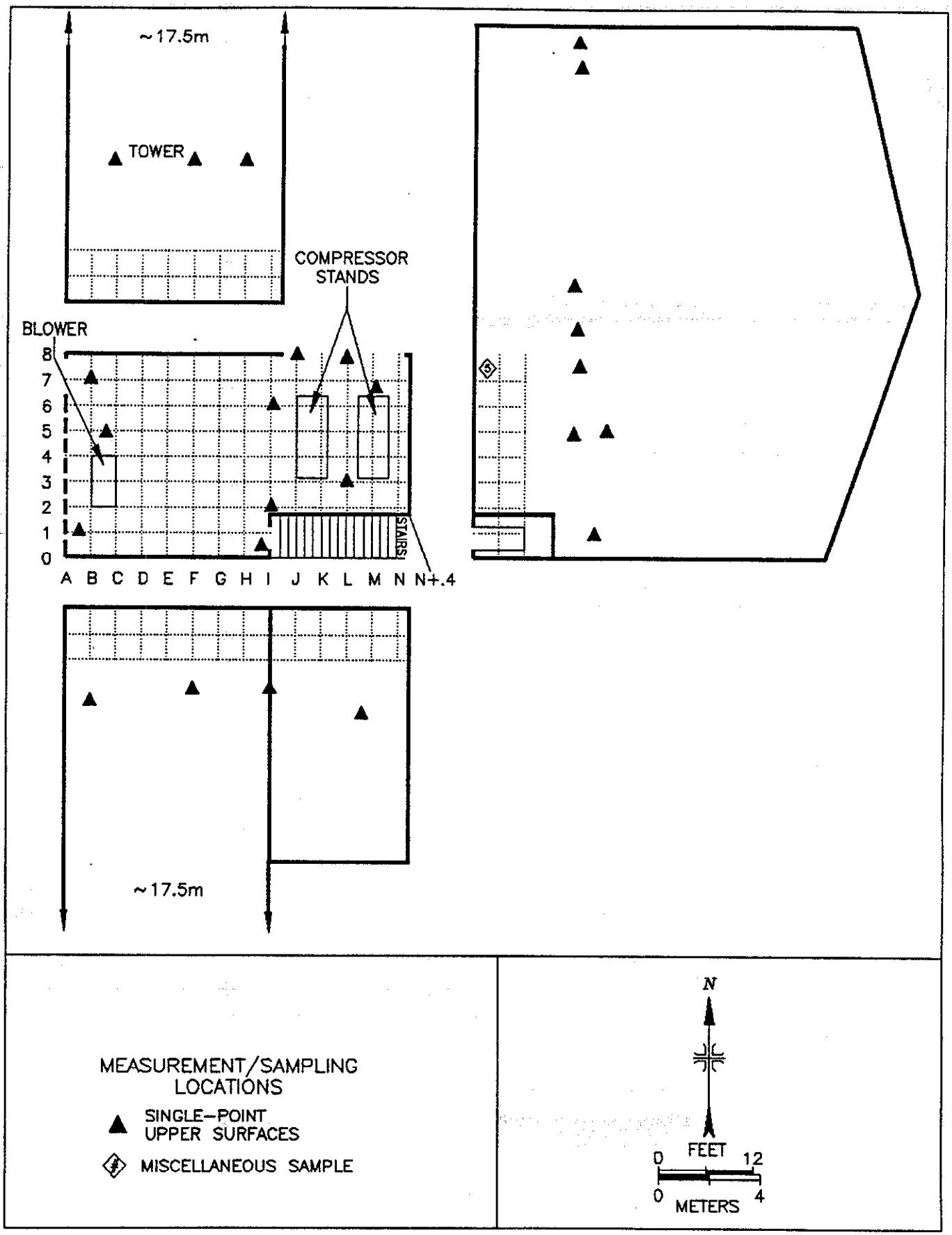


FIGURE 26: Survey Unit A5, Southeast Area of Room 217 – Measurement and Sampling Locations

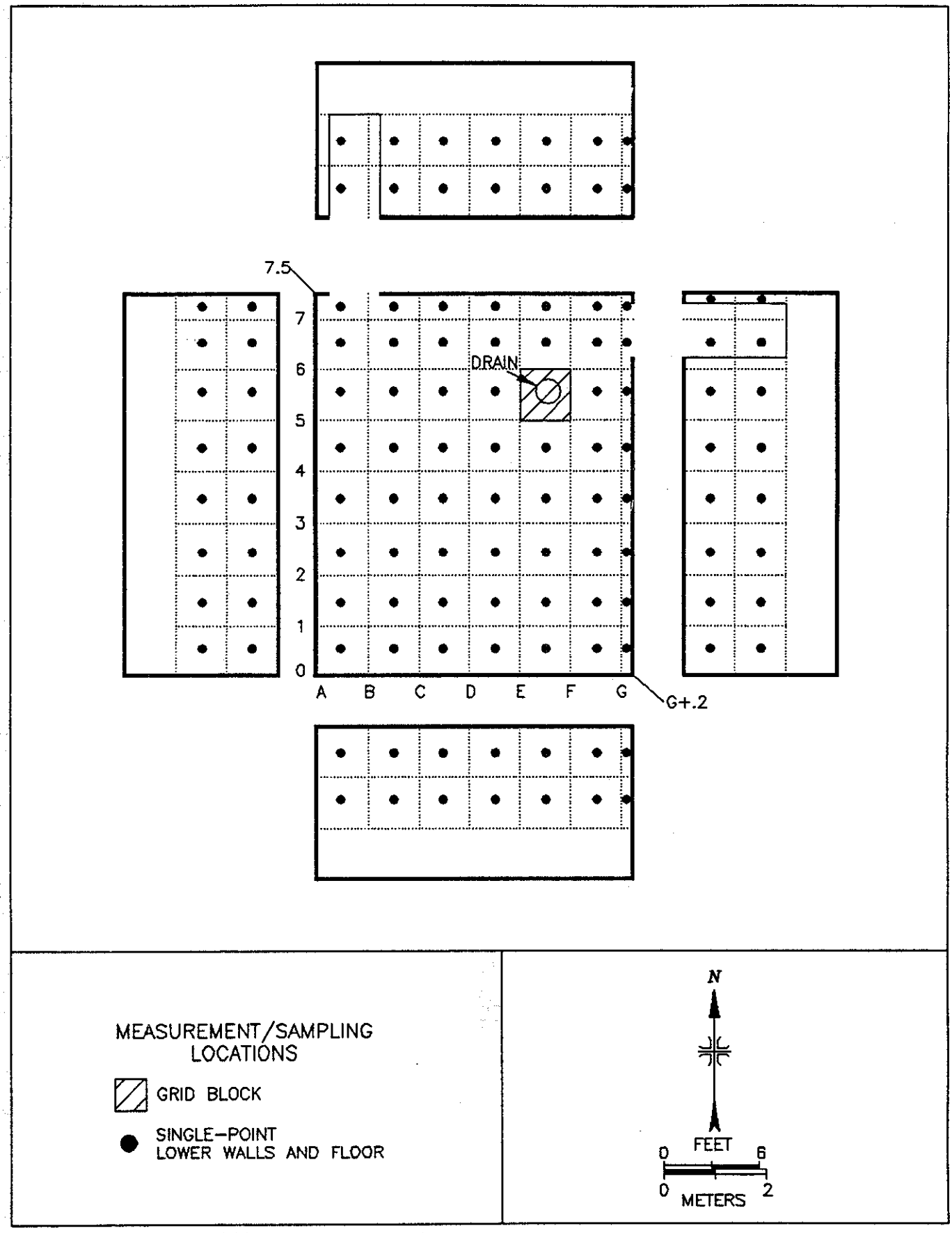


FIGURE 27: Survey Unit A6, Room 115 – Measurement and Sampling Locations

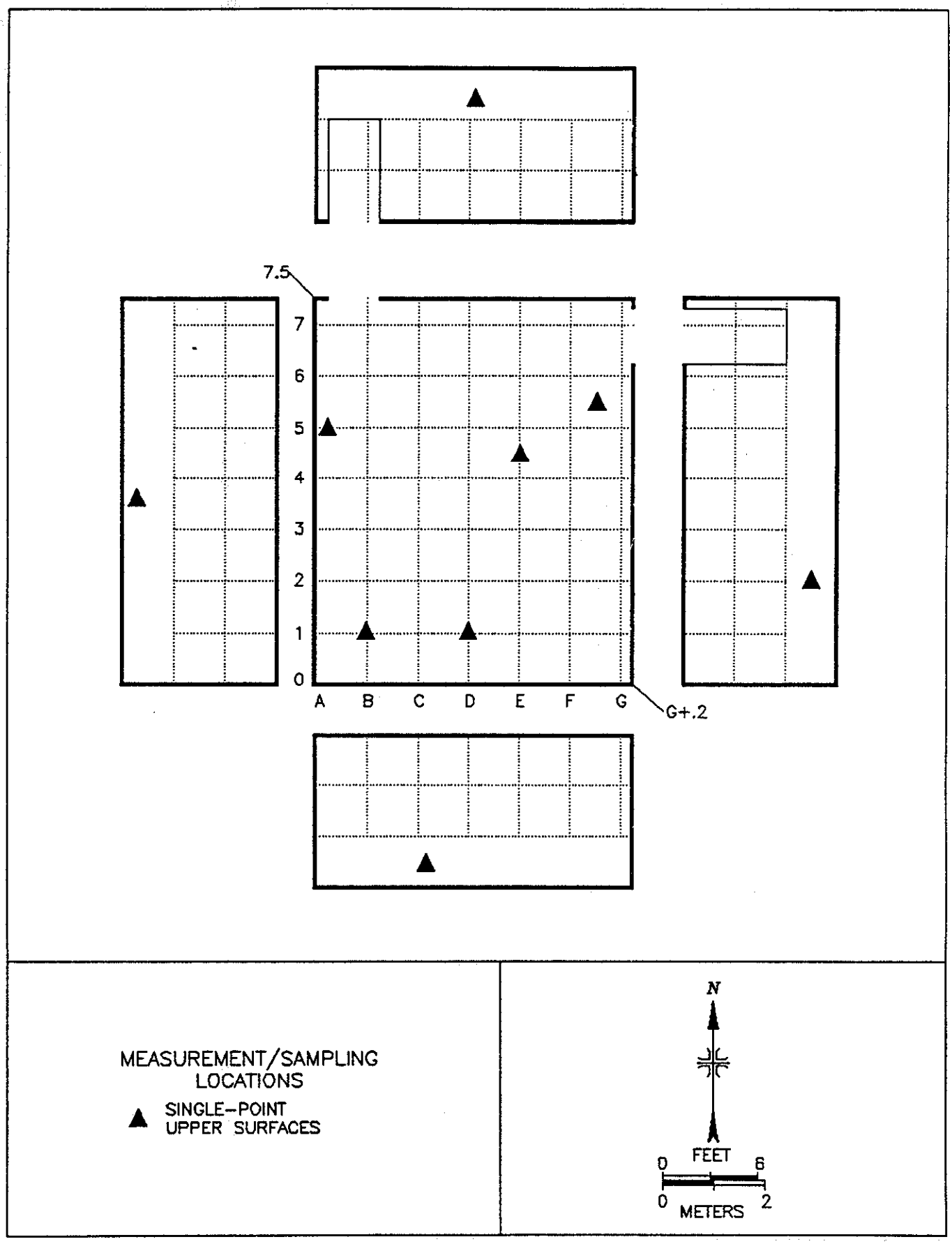


FIGURE 28: Survey Unit A6, Room 115 – Measurement and Sampling Locations

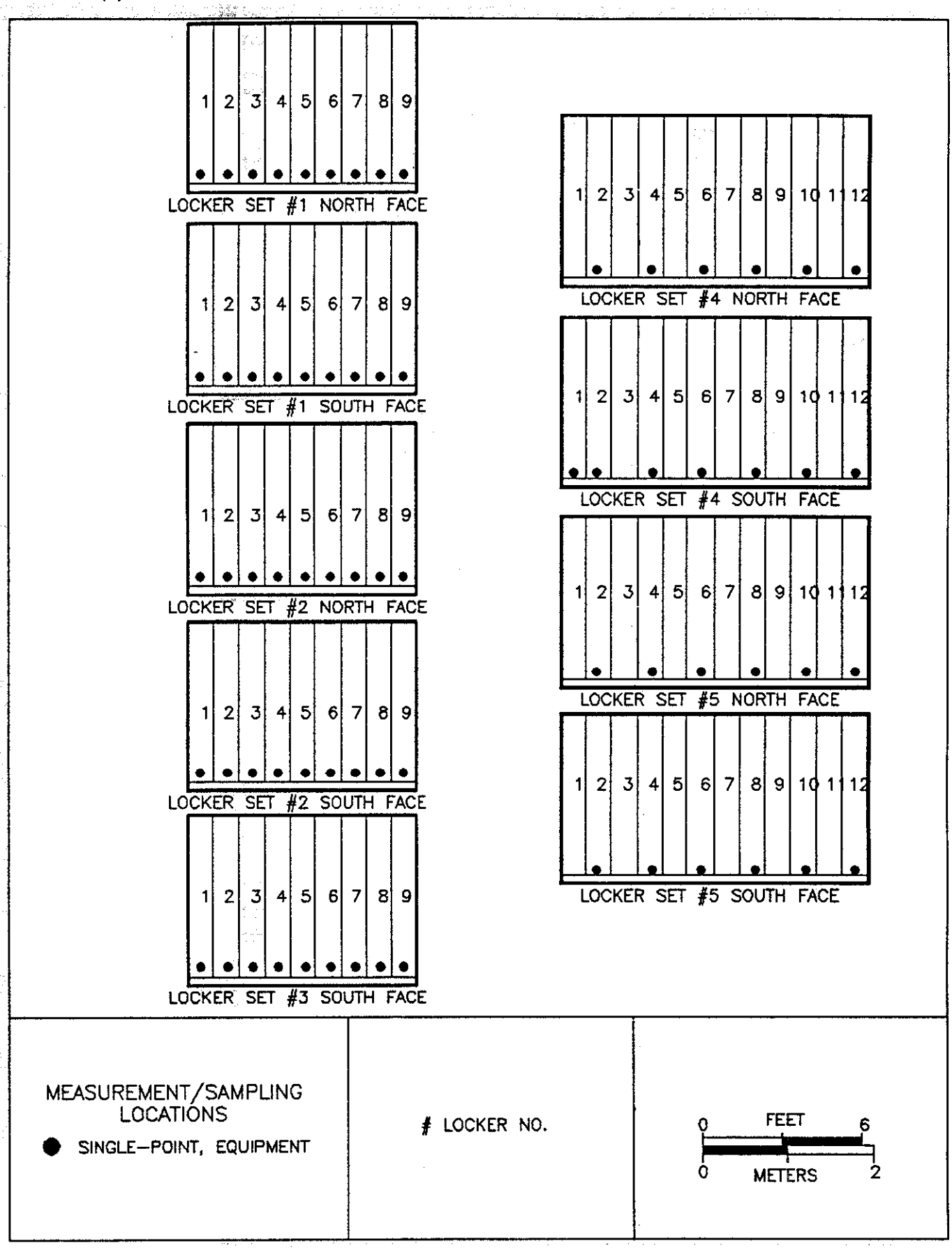
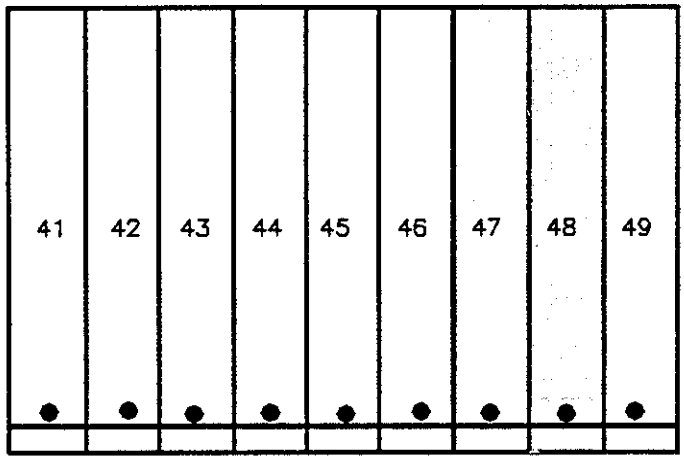


FIGURE 29: Survey Unit A7, Lockers, Room 108 – Measurement and Sampling Locations



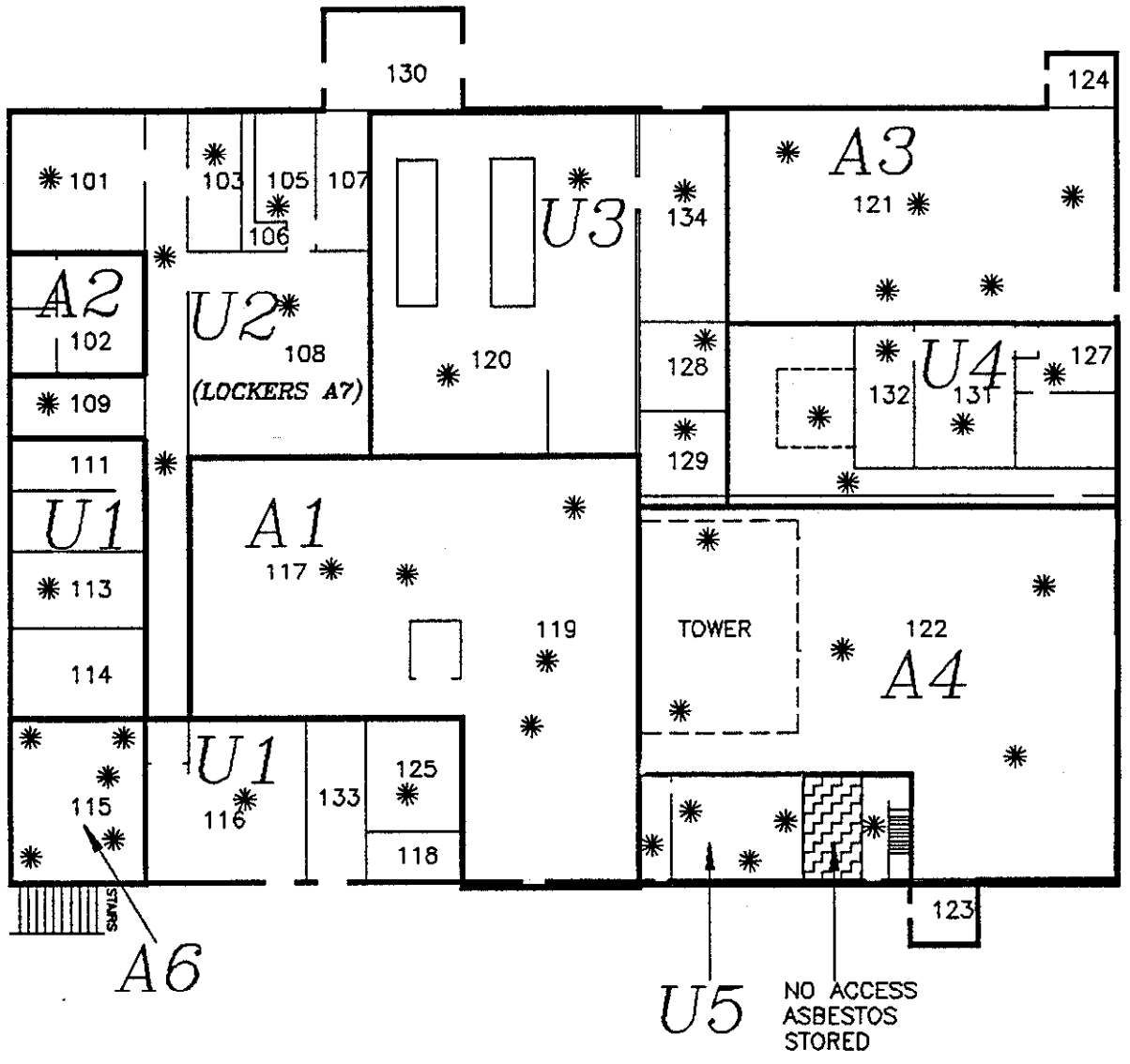
MEASUREMENT/SAMPLING LOCATIONS

● SINGLE-POINT EQUIPMENT

LOCKER NO.

FEET
0 3
0 1
METERS

FIGURE 30: Survey Unit A8, Lockers, Room 211 – Measurement and Sampling Locations



MEASUREMENT LOCATIONS

✱ EXPOSURE RATE

INACCESSIBLE AREA

SURVEY UNIT BOUNDARY

A/U # SURVEY UNIT DESIGNATION

N

FEET

0 24

0 8

METERS

FIGURE 31: Building 401, First Floor – Exposure Rate Measurement Locations

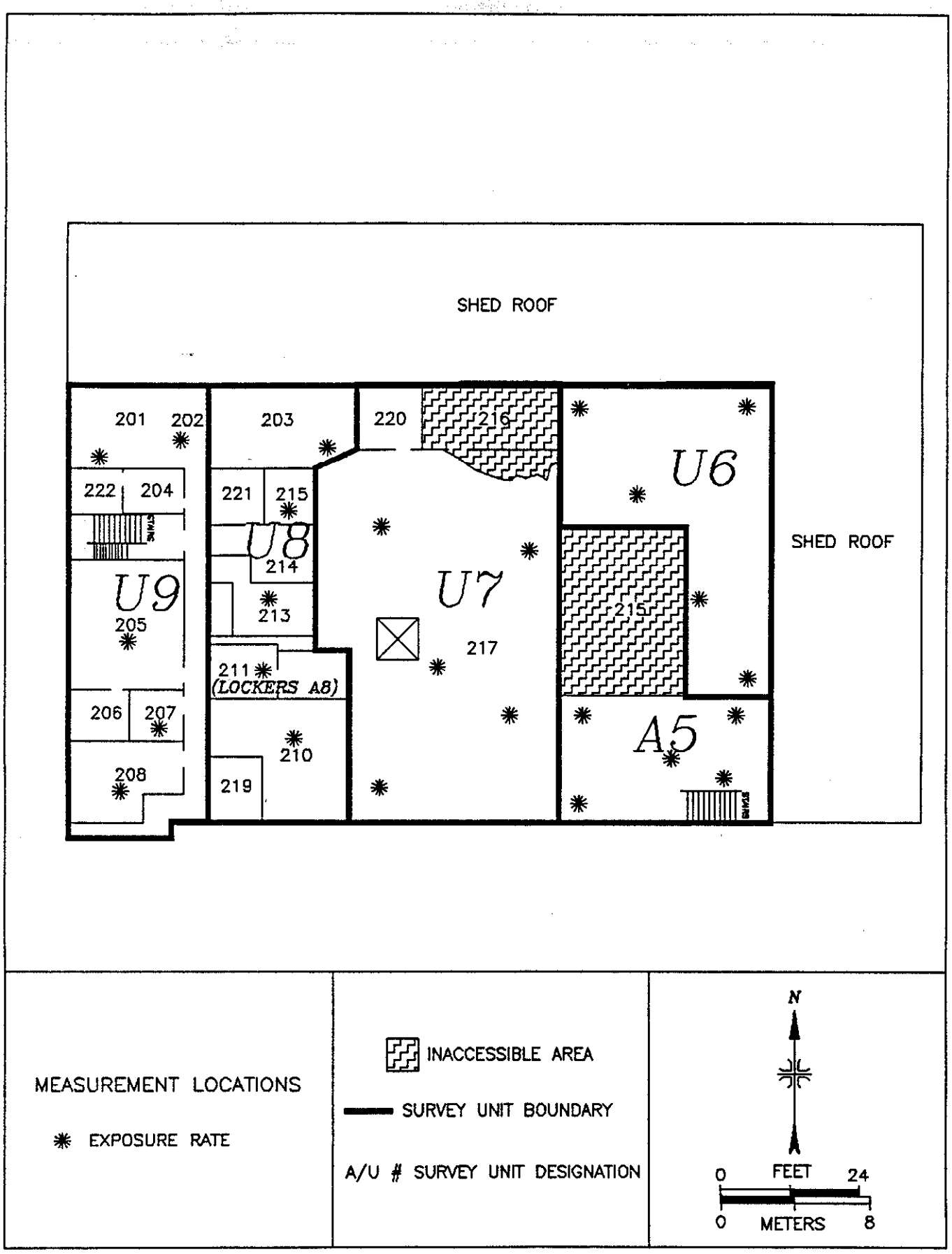


FIGURE 32: Building 401, Second Floor – Exposure Rate Measurement Locations

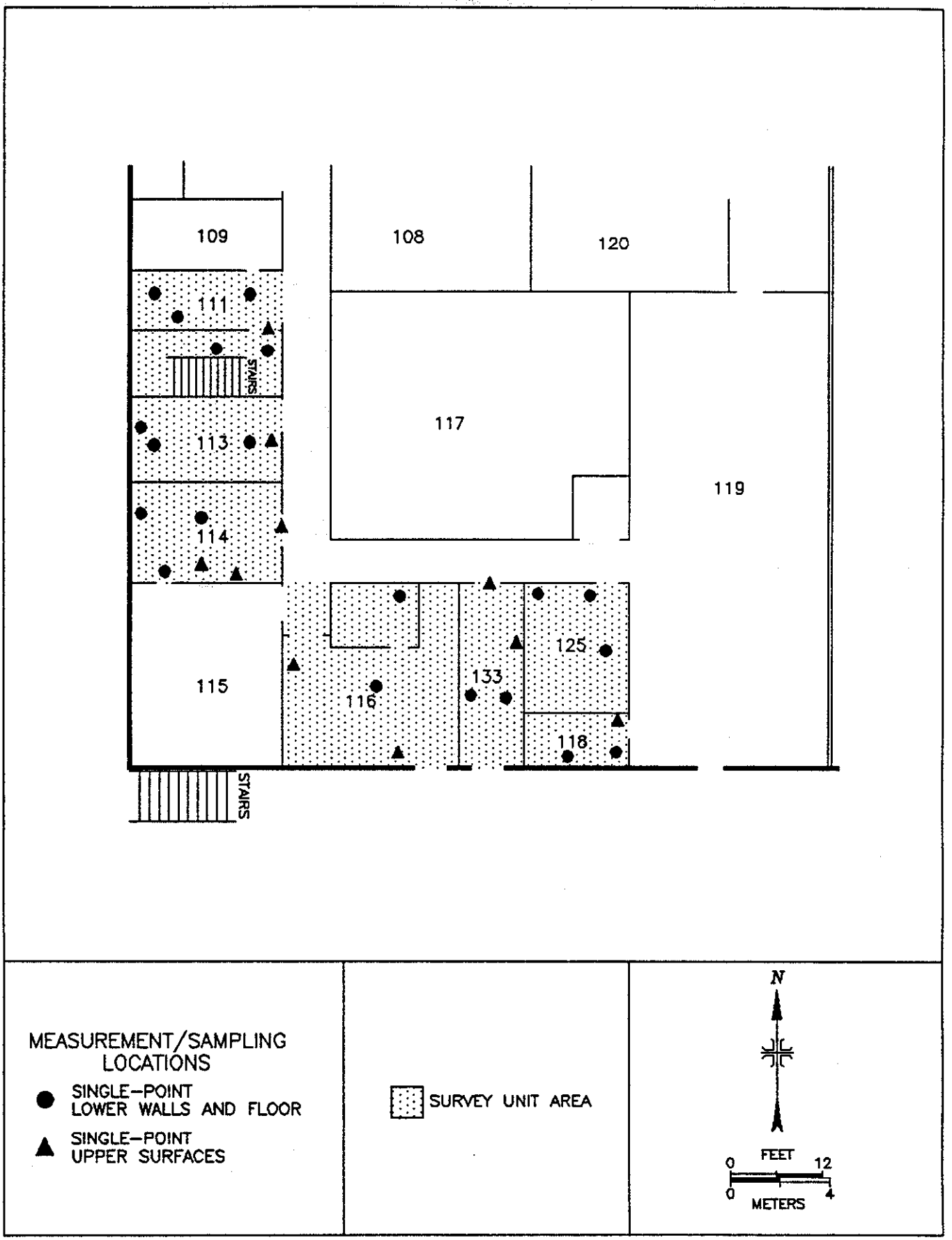


FIGURE 33: Survey Unit U1 – Measurement and Sampling Locations

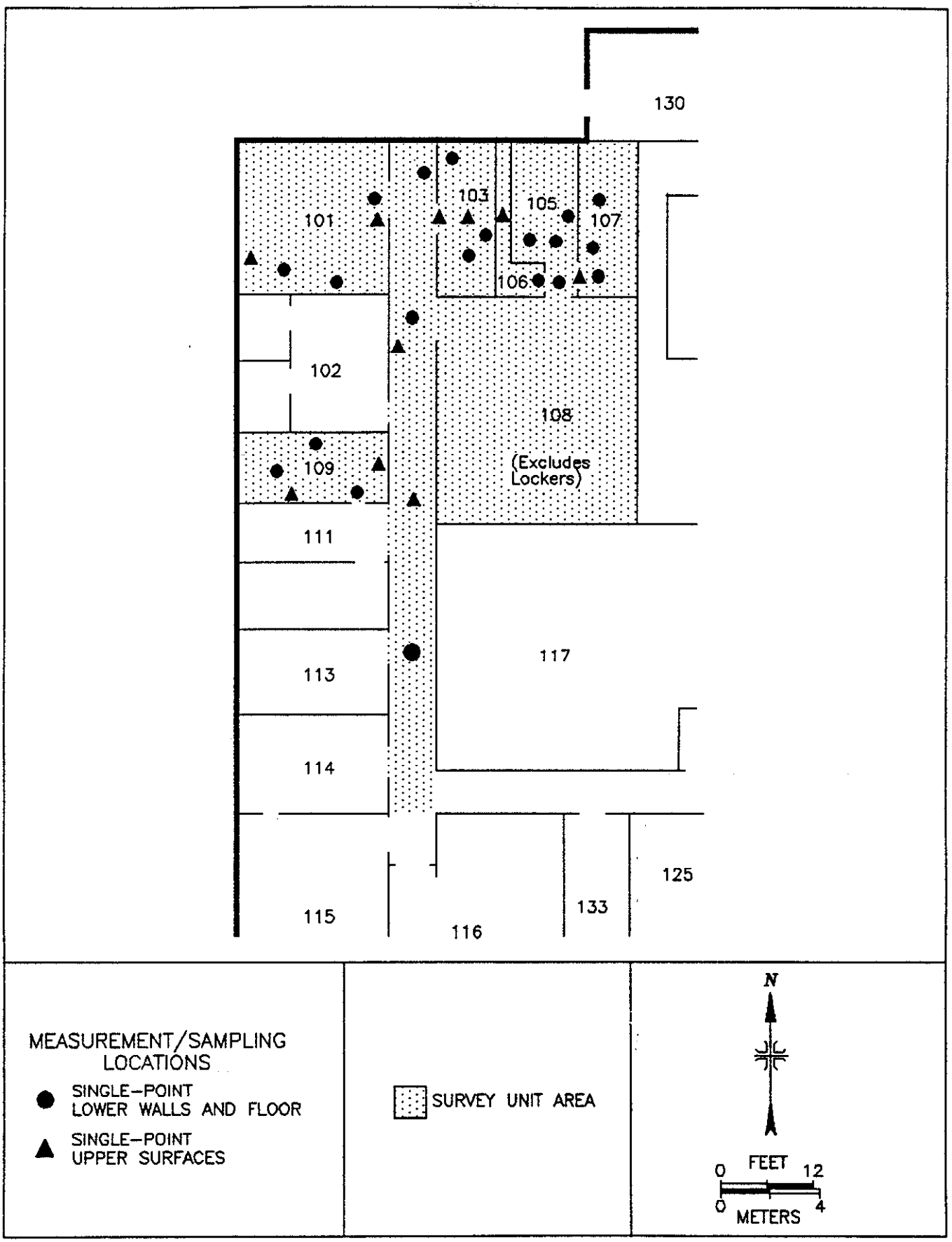


FIGURE 34: Survey Unit U2 – Measurement and Sampling Locations

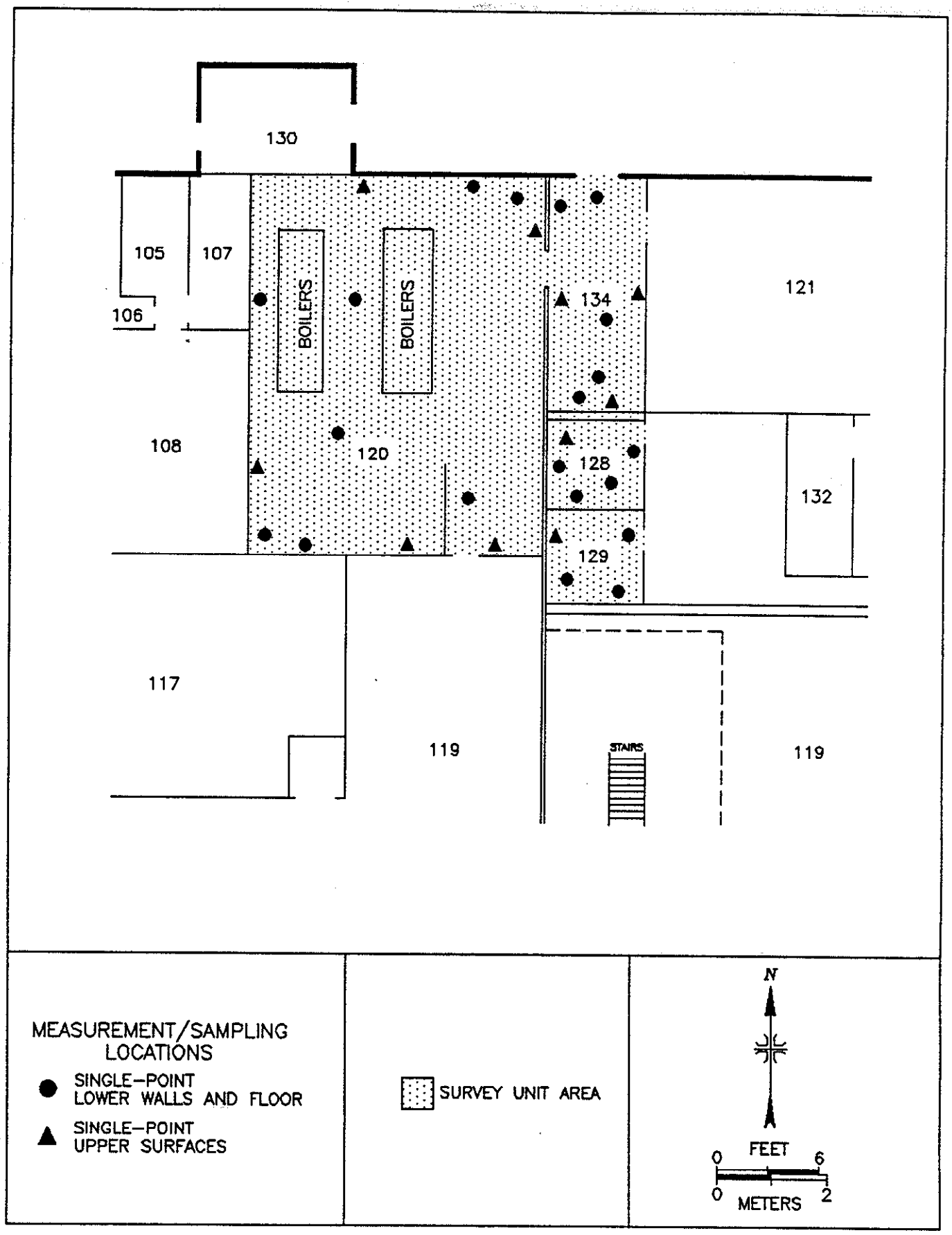


FIGURE 35: Survey Unit U3 – Measurement and Sampling Locations

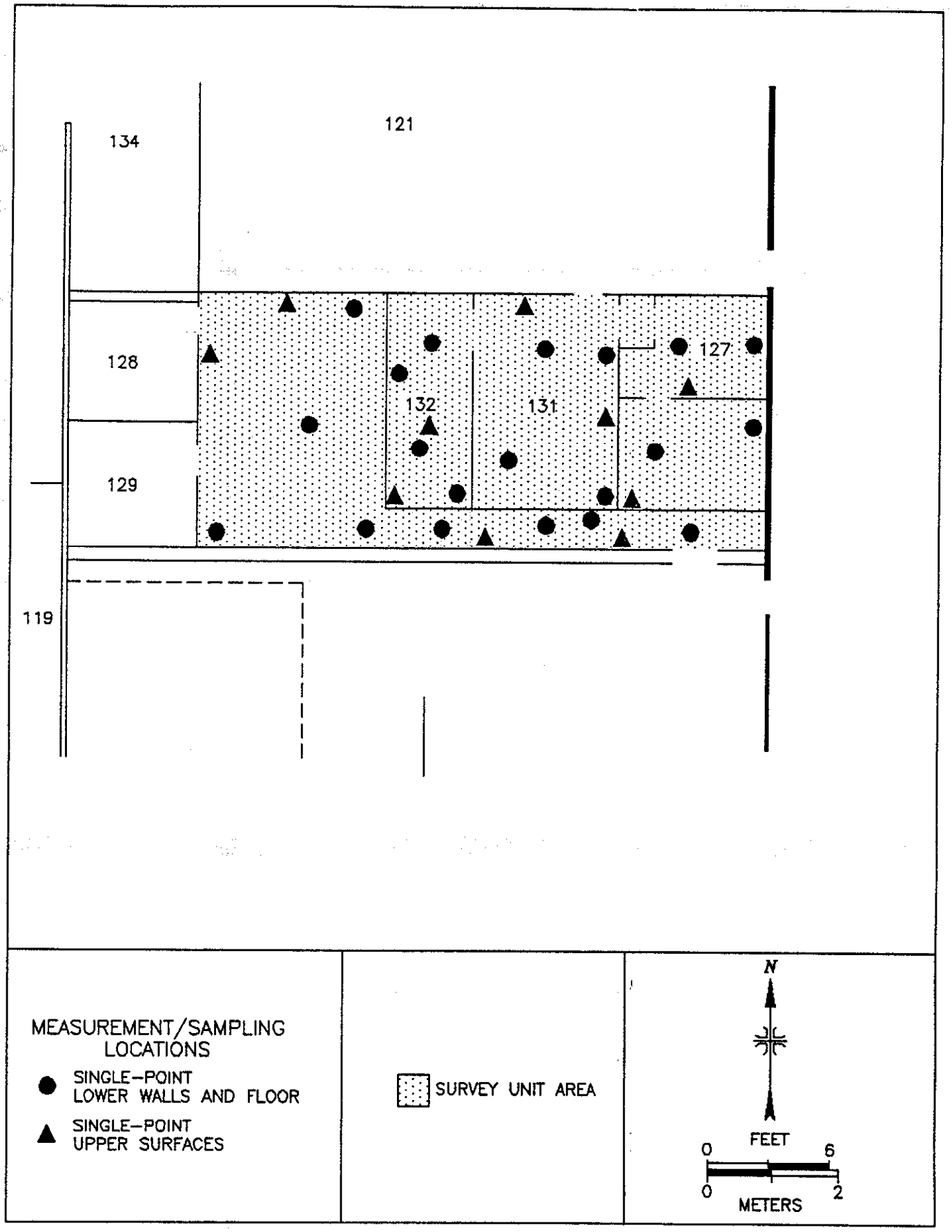


FIGURE 36: Survey Unit U4 – Measurement and Sampling Locations

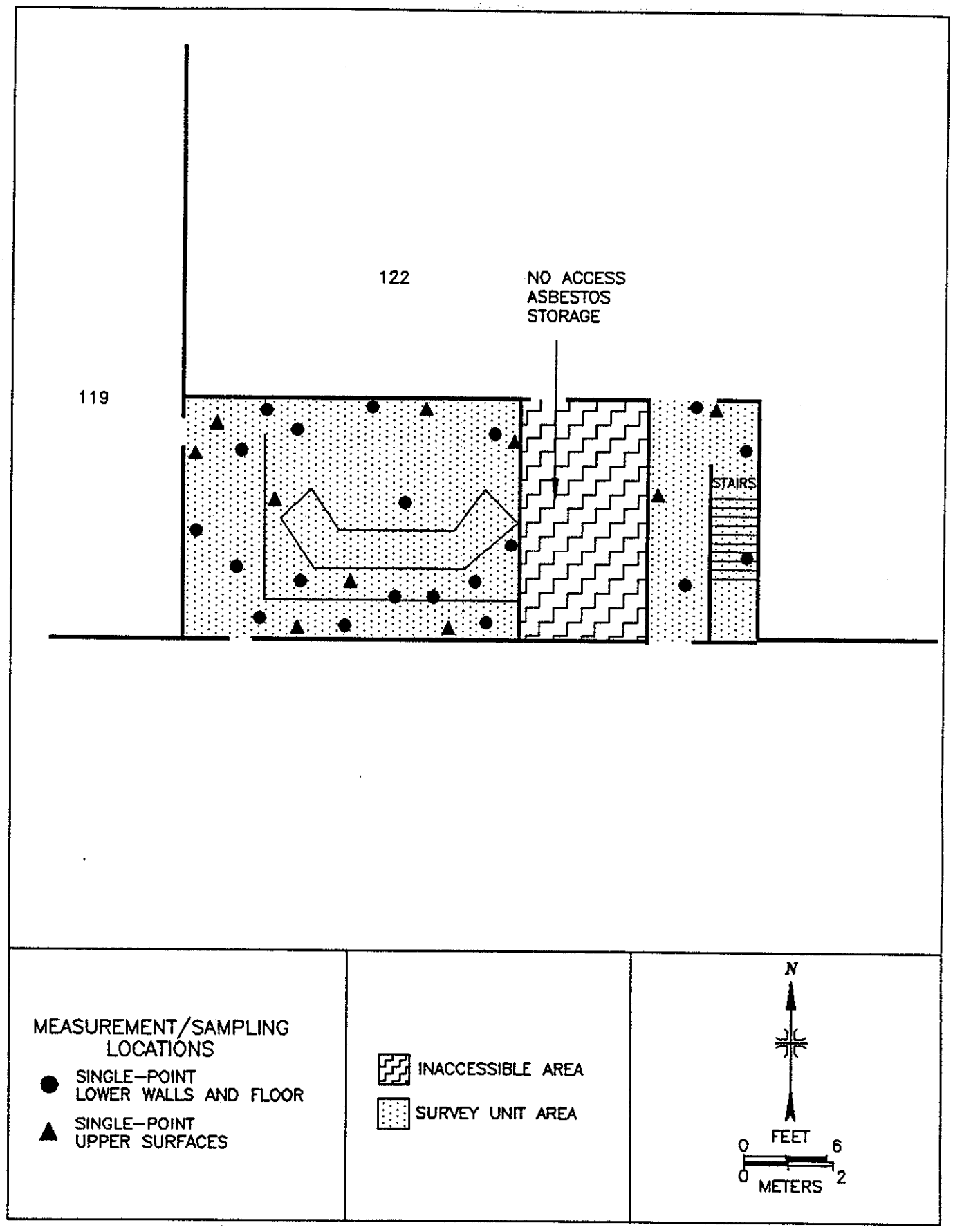


FIGURE 37: Survey Unit U5 – Measurement and Sampling Locations

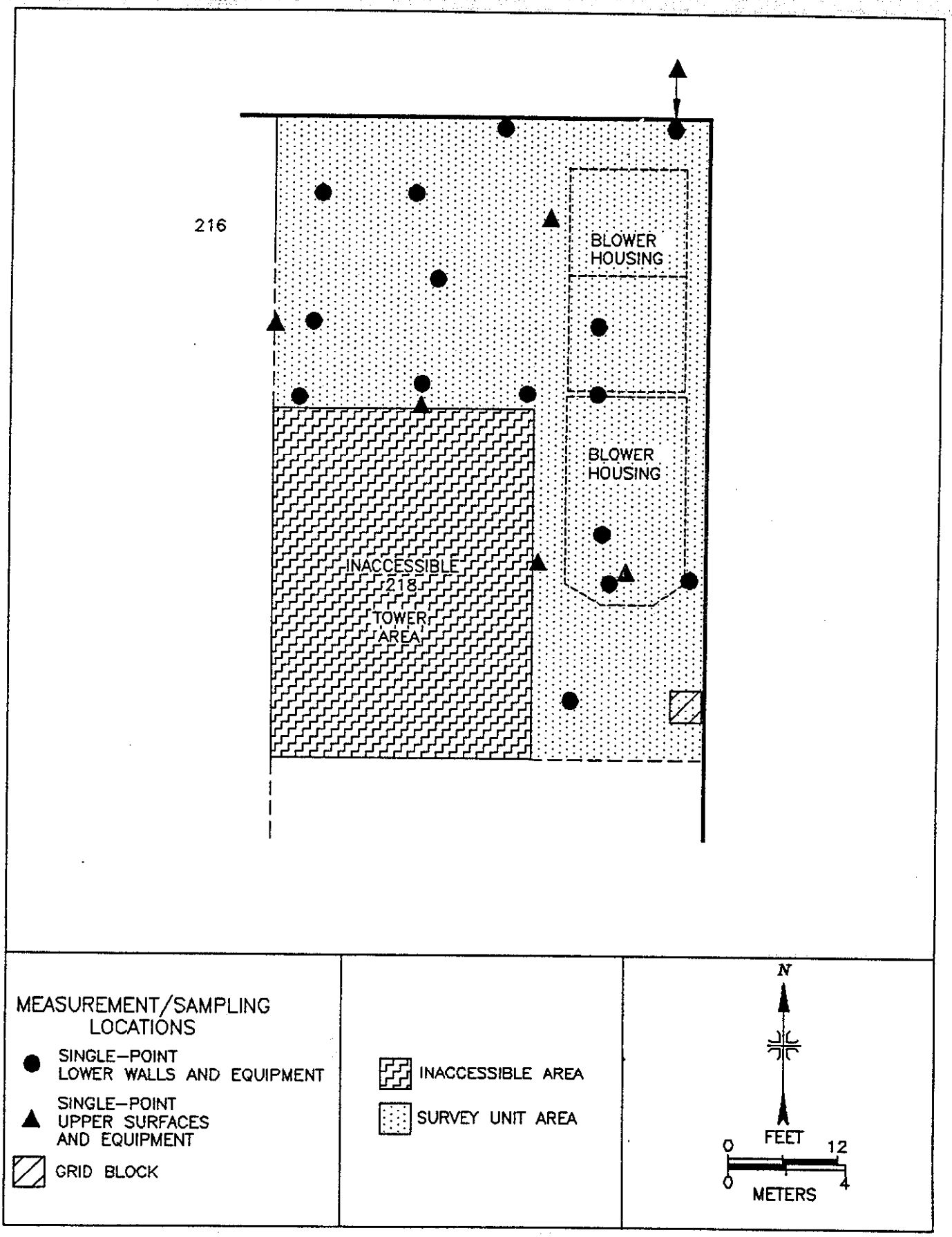


FIGURE 38: Survey Unit U6 – Measurement and Sampling Locations

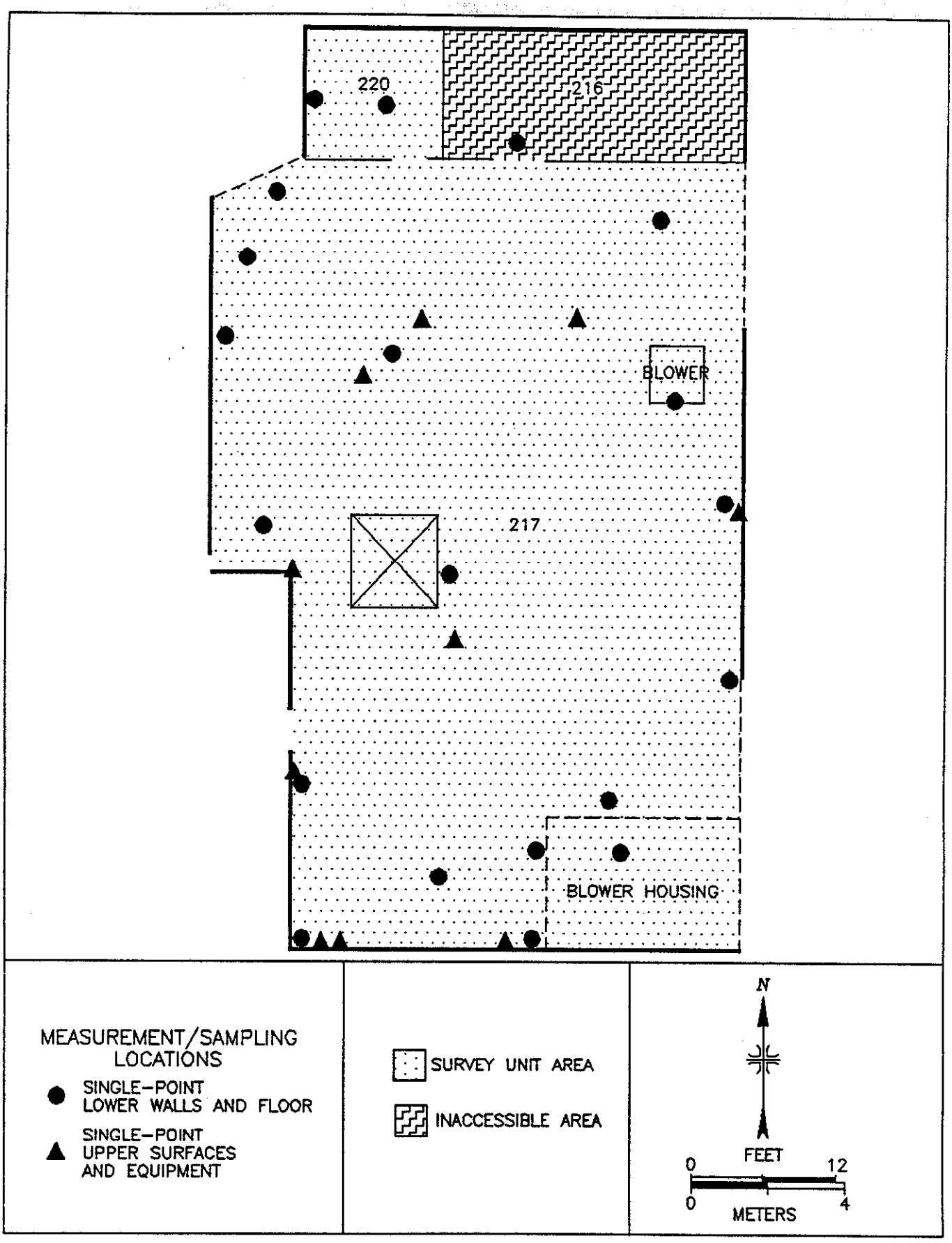


FIGURE 39: Survey Unit U7 – Measurement and Sampling Locations

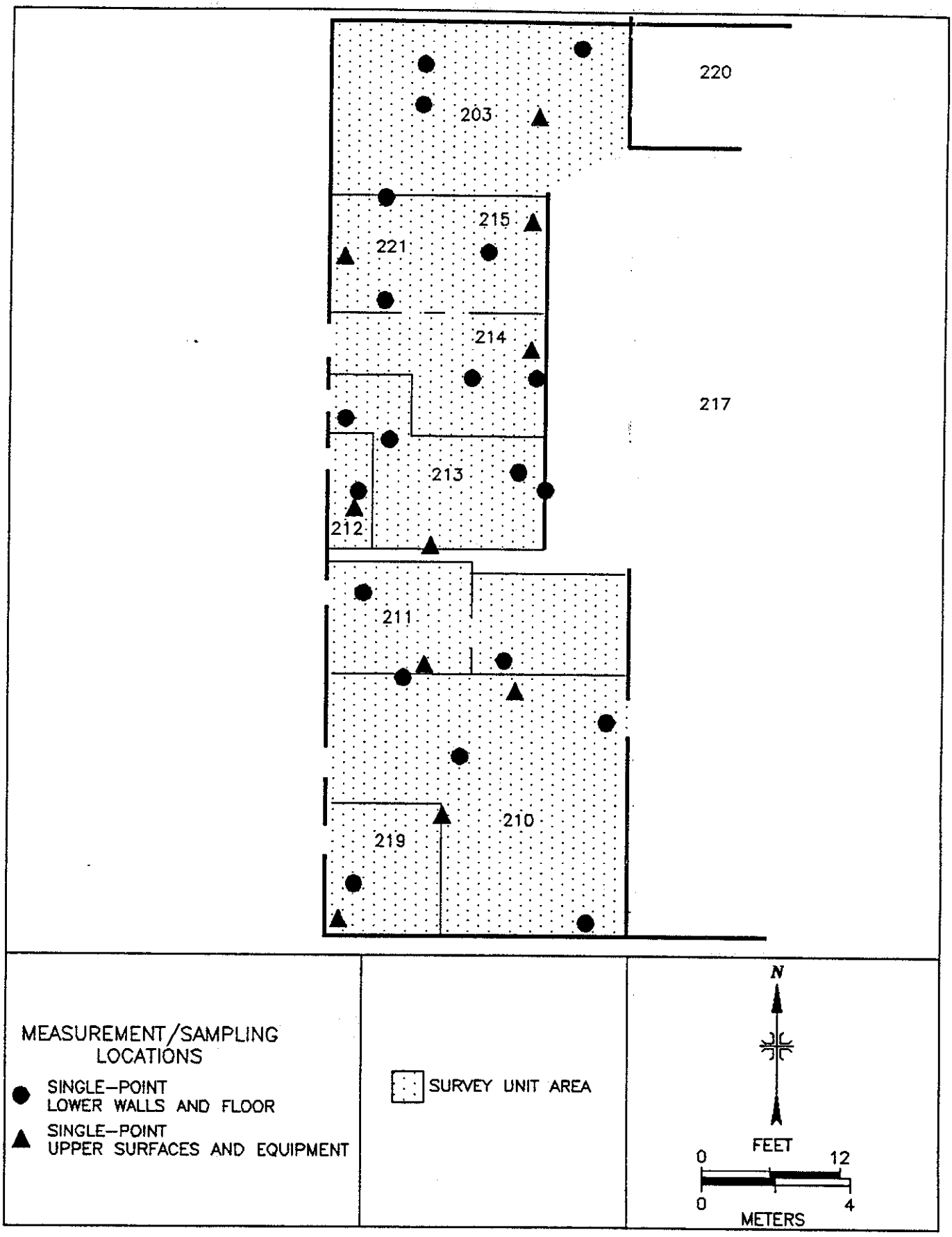


FIGURE 40: Survey Unit U8 – Measurement and Sampling Locations

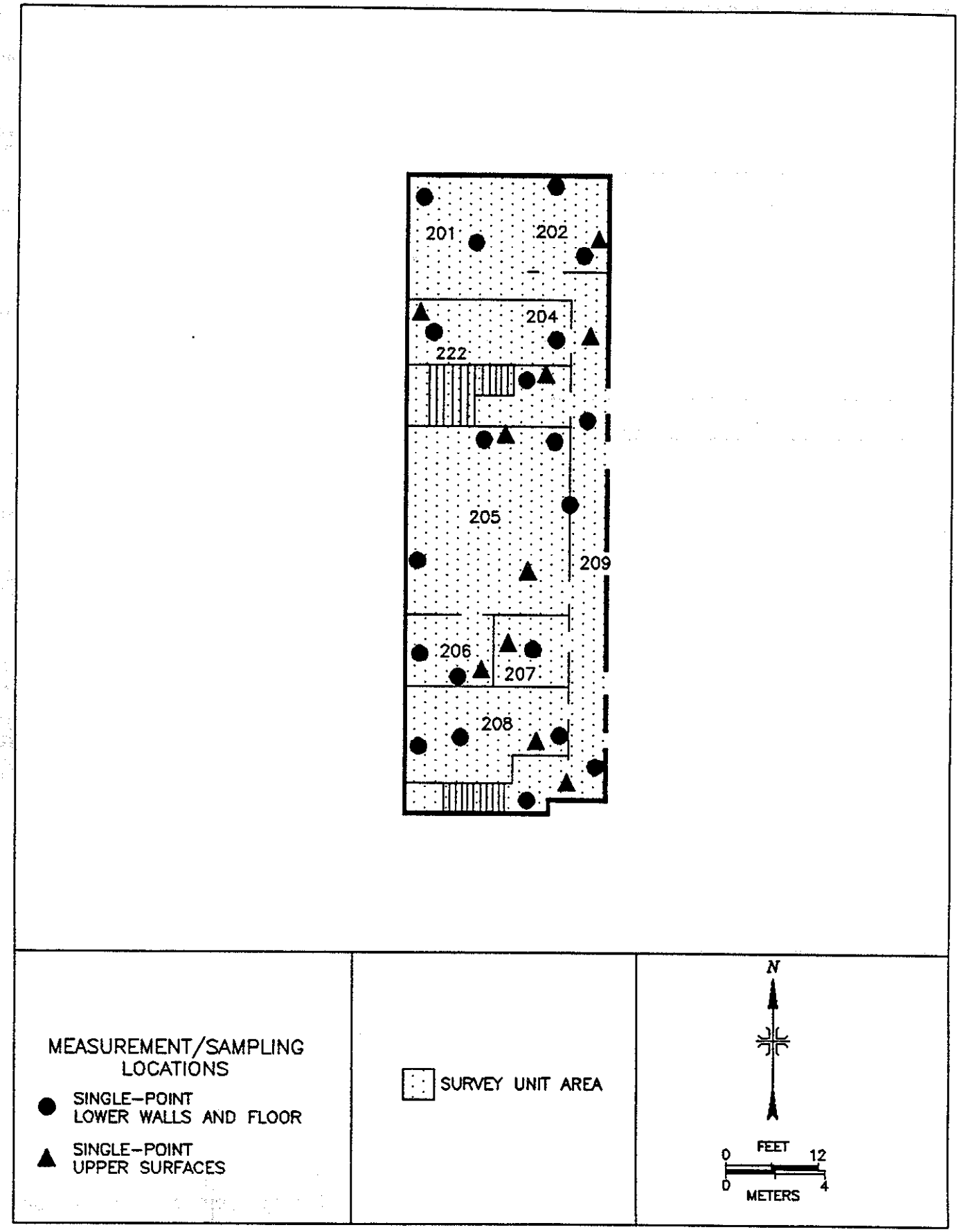


FIGURE 41: Survey Unit U9 – Measurement and Sampling Locations

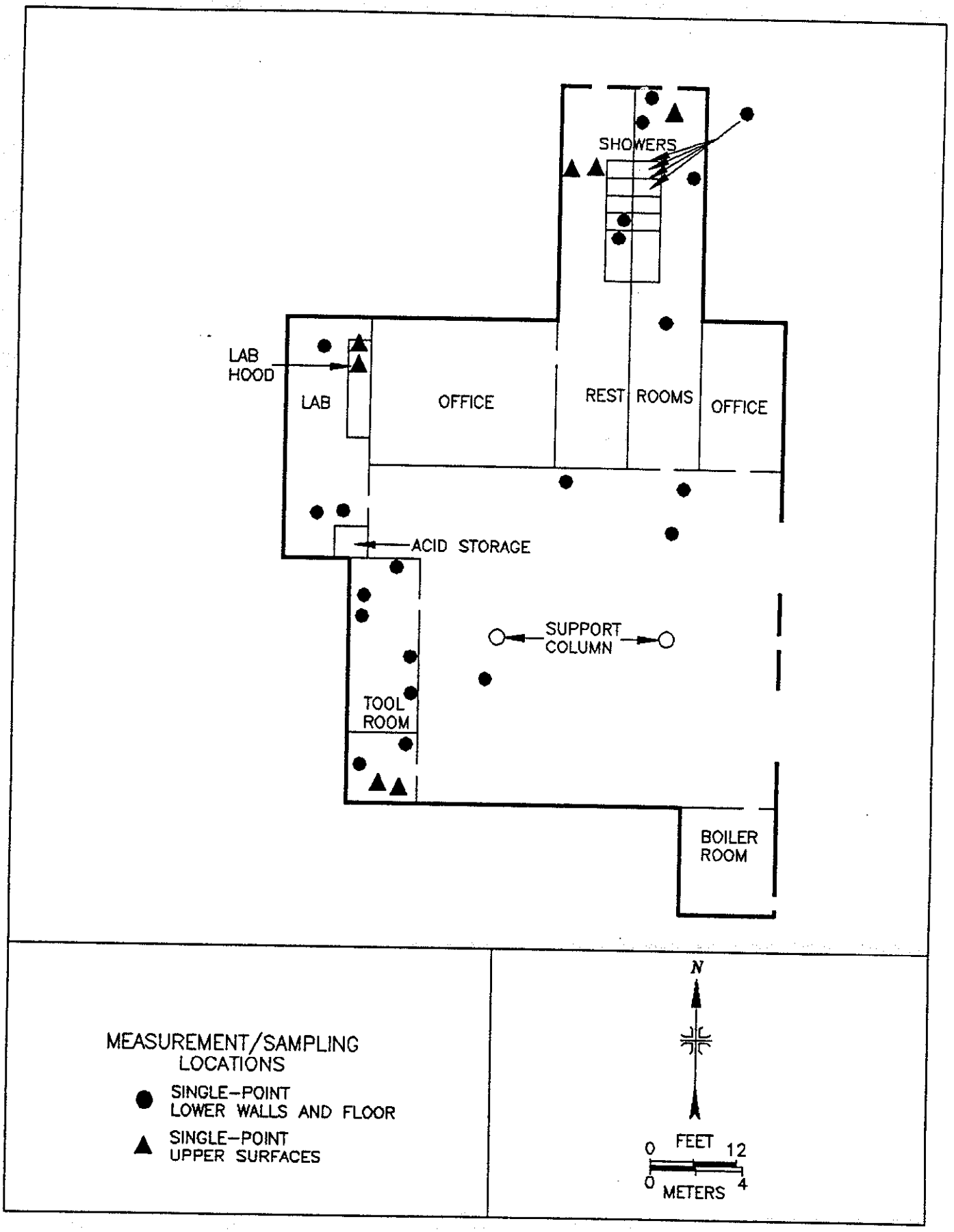


FIGURE 42: Building 403 – Measurement and Sampling Locations

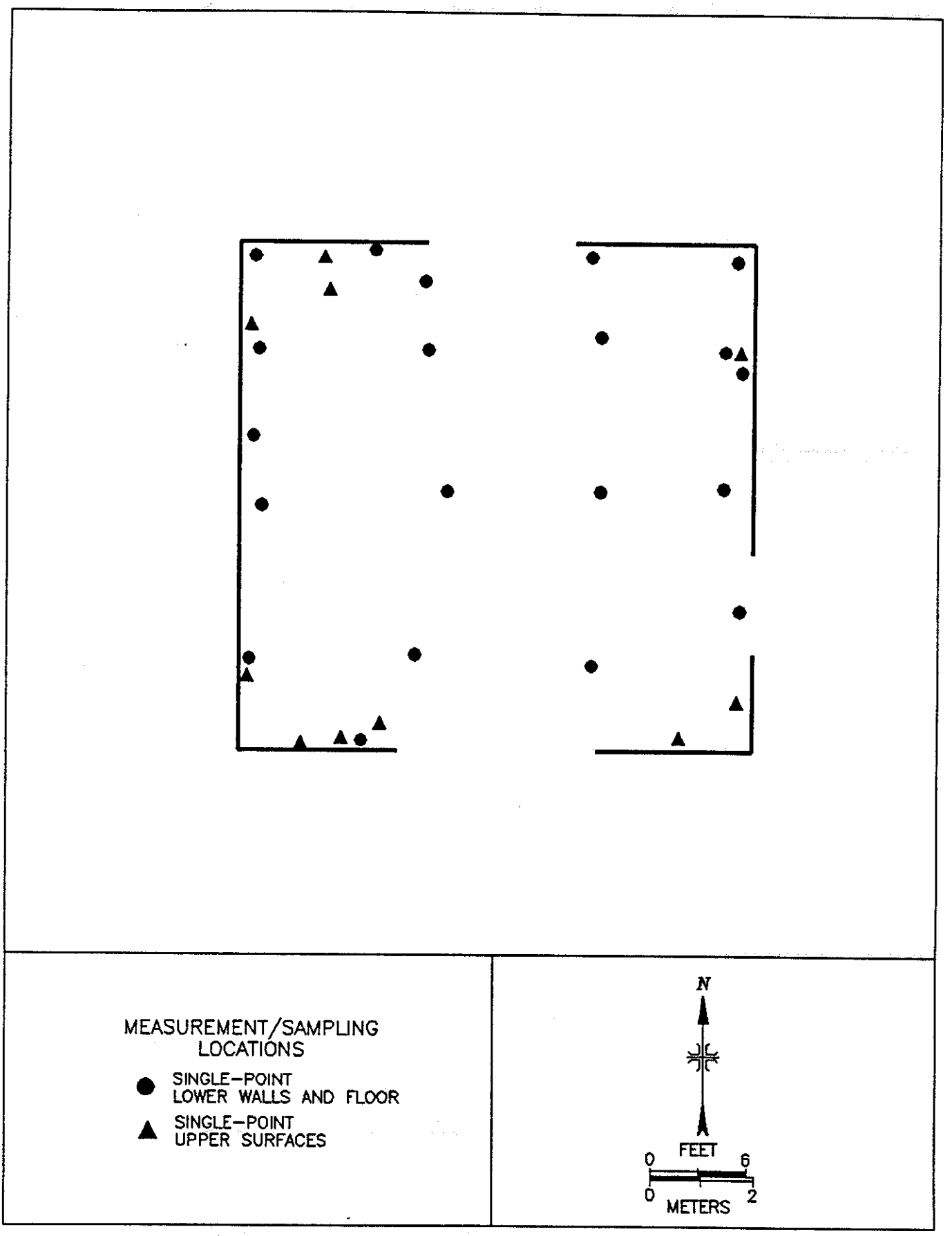


FIGURE 43: Hittman Building – Measurement and Sampling Locations

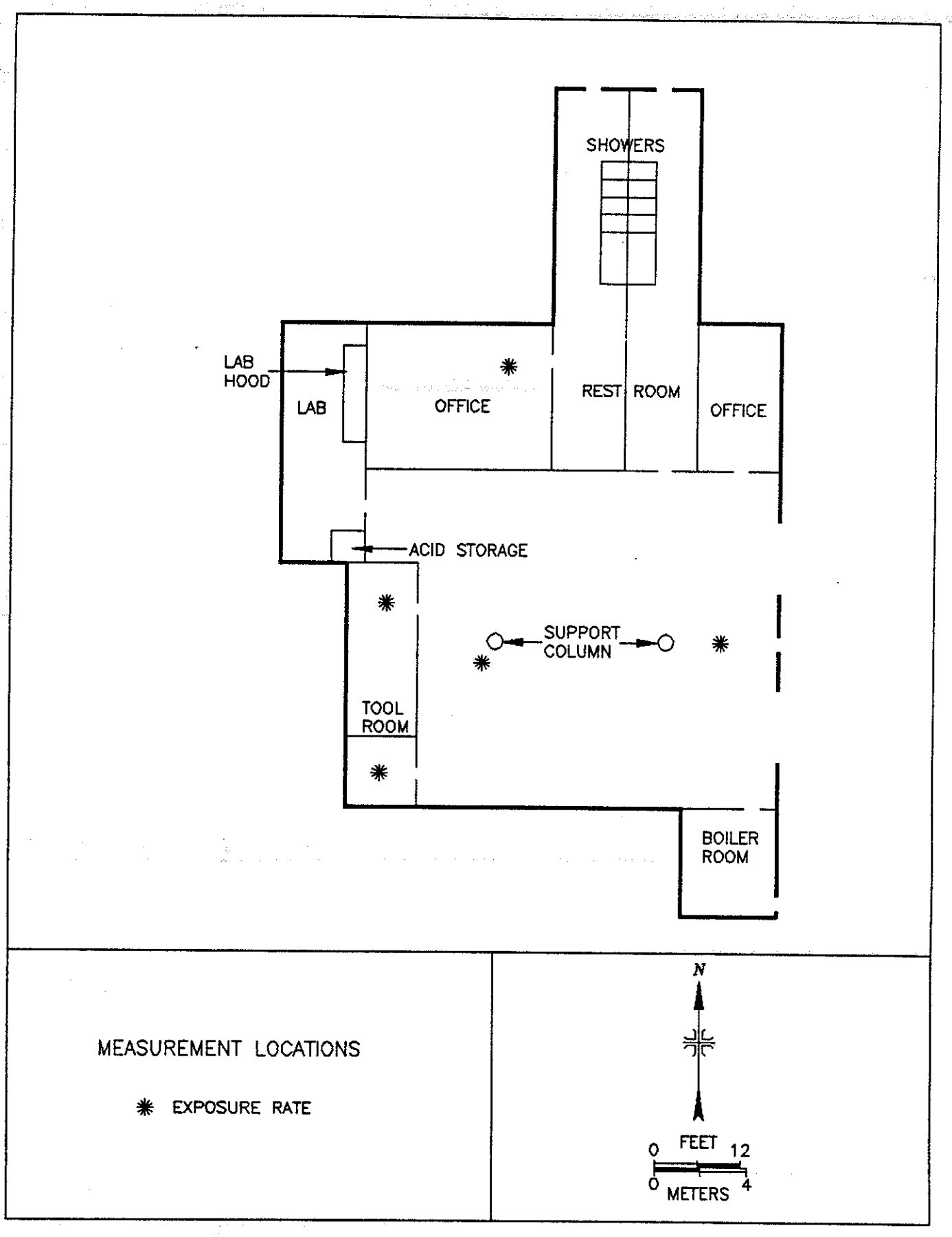


FIGURE 44: Building 403 – Exposure Rate Measurement Locations

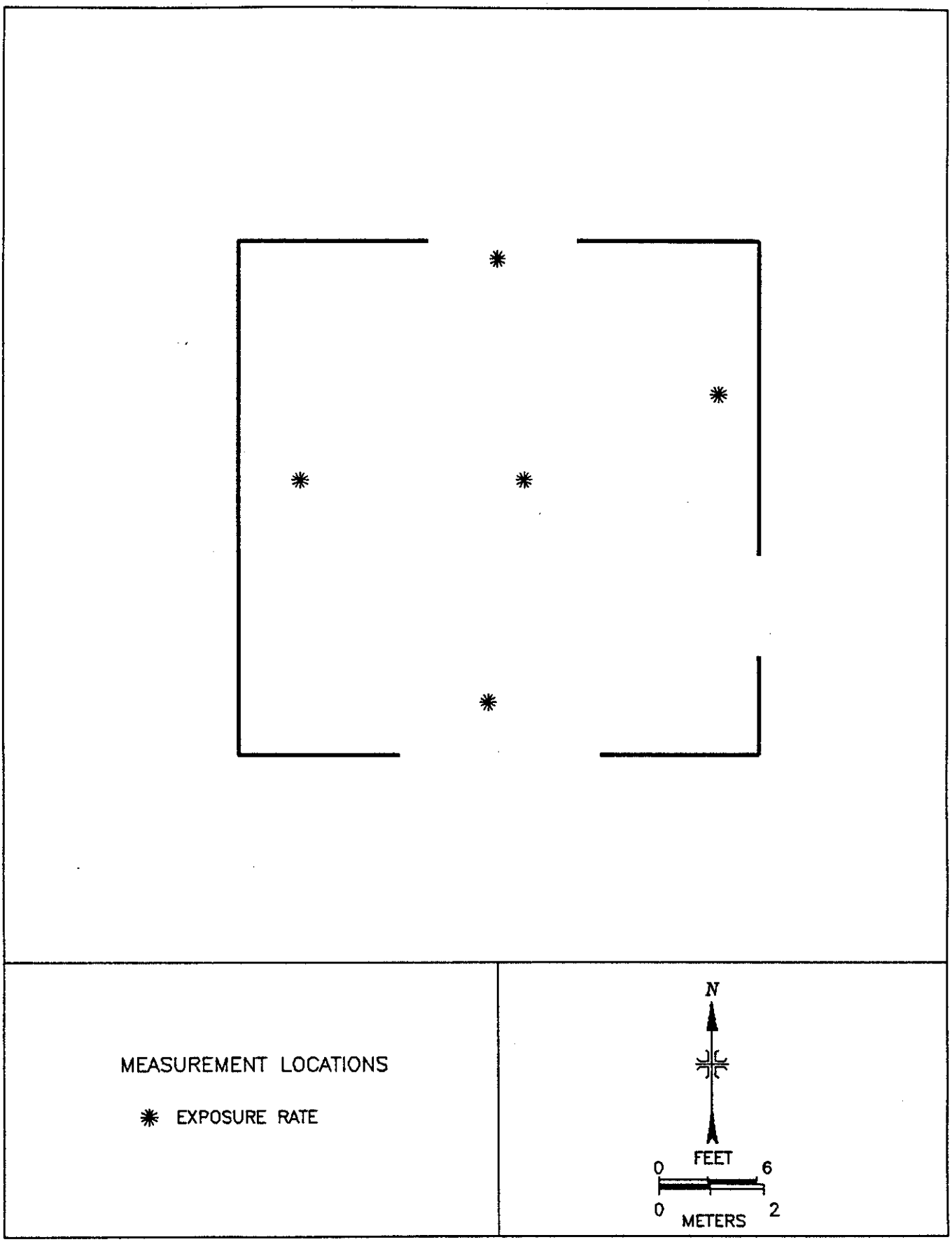


FIGURE 45: Hittman Building – Exposure Rate Measurement Locations

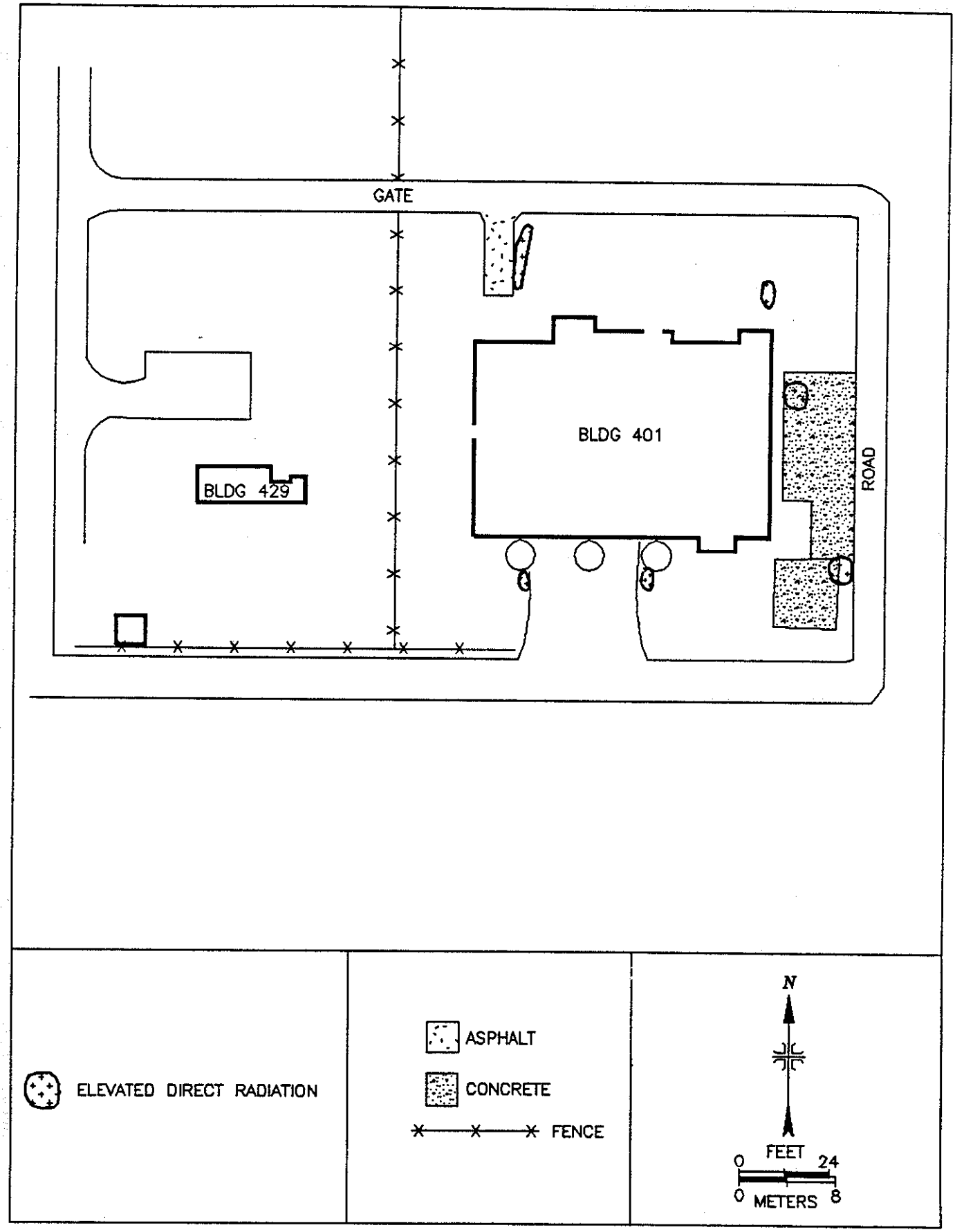


FIGURE 46: Building 401 Exterior – Locations of Elevated Direct Radiation

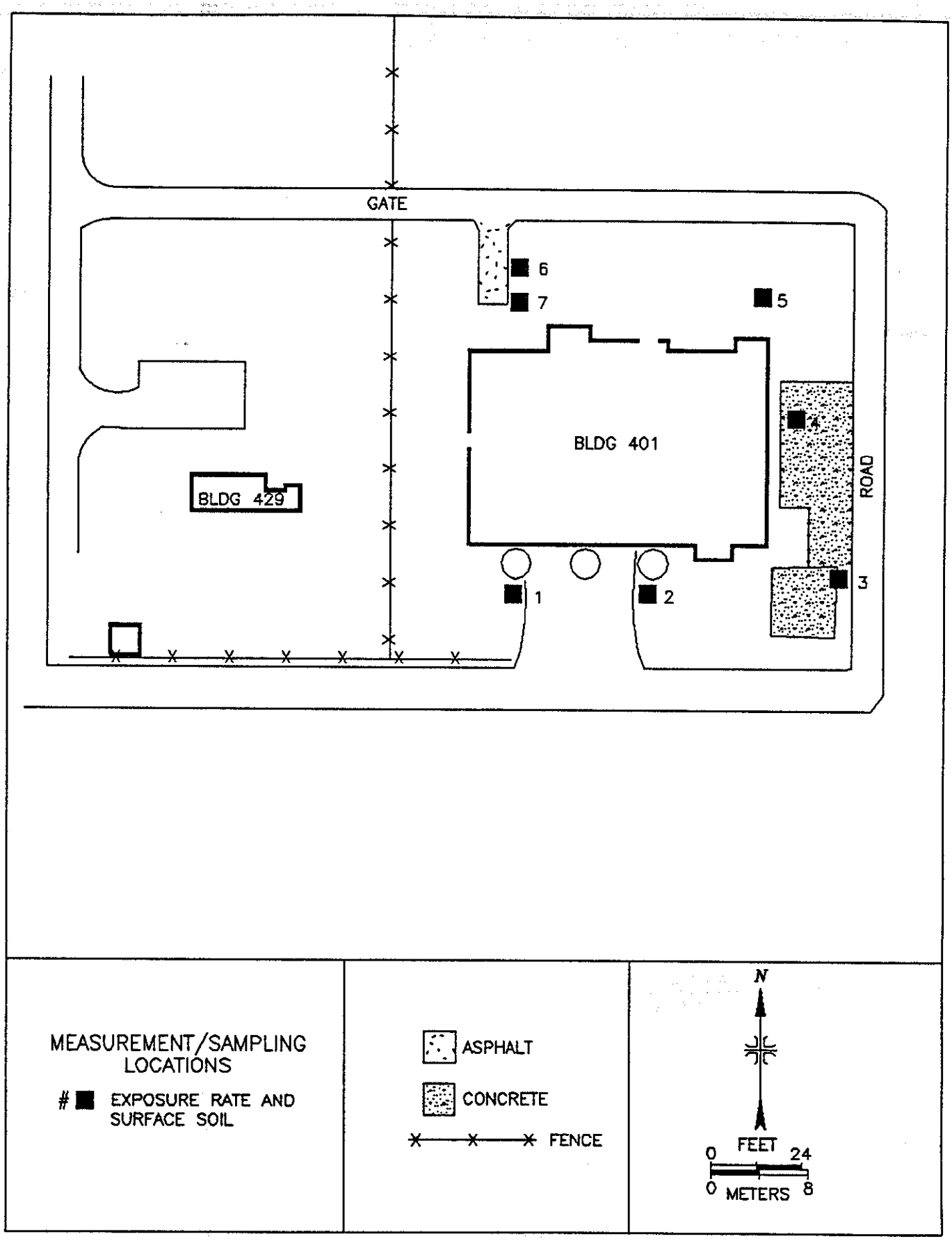


FIGURE 47: Building 401, Exterior – Measurement and Sampling Locations

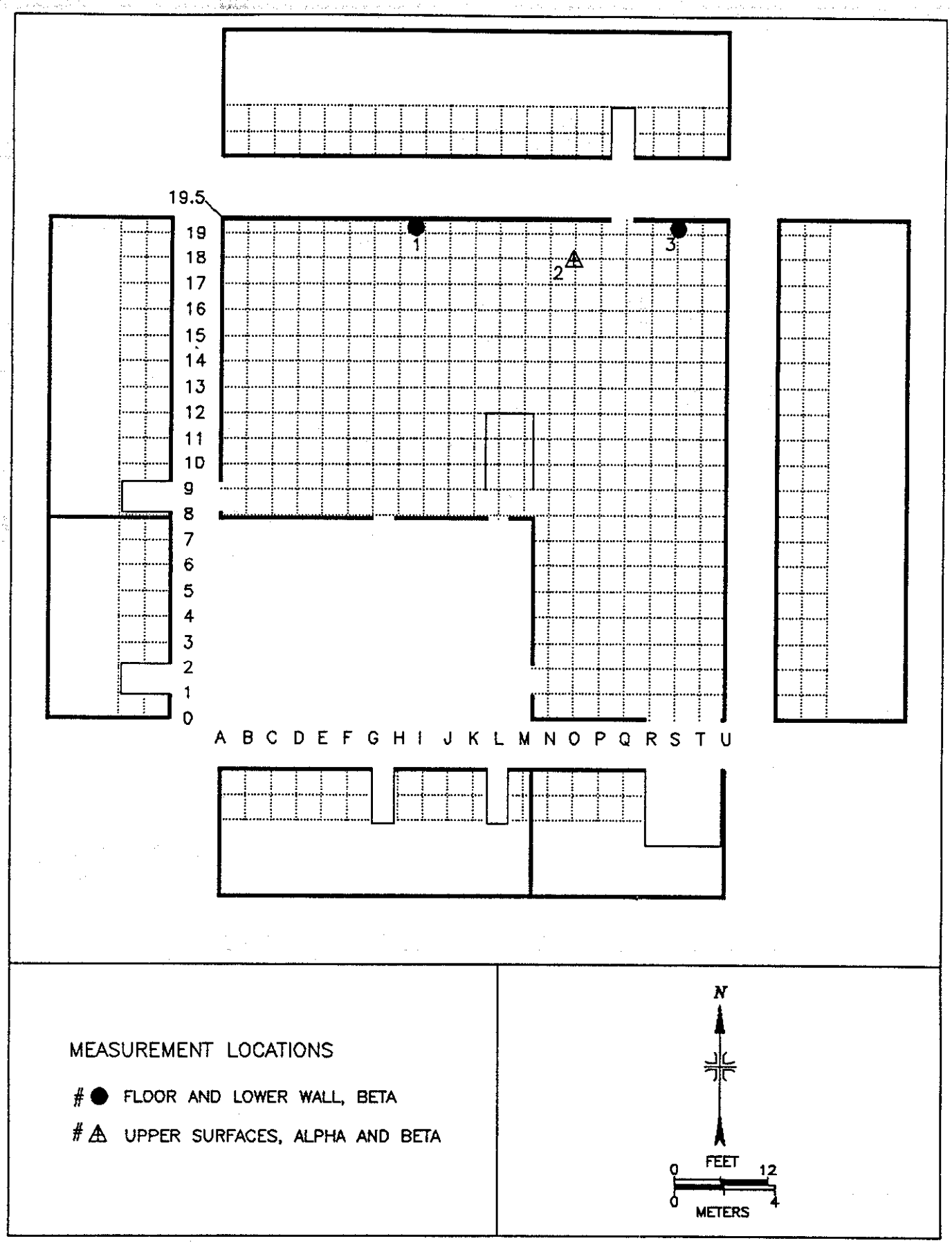


FIGURE 48: Survey Unit A1, Rooms 117 and 119 – Direct Measurements Exceeding Guidelines

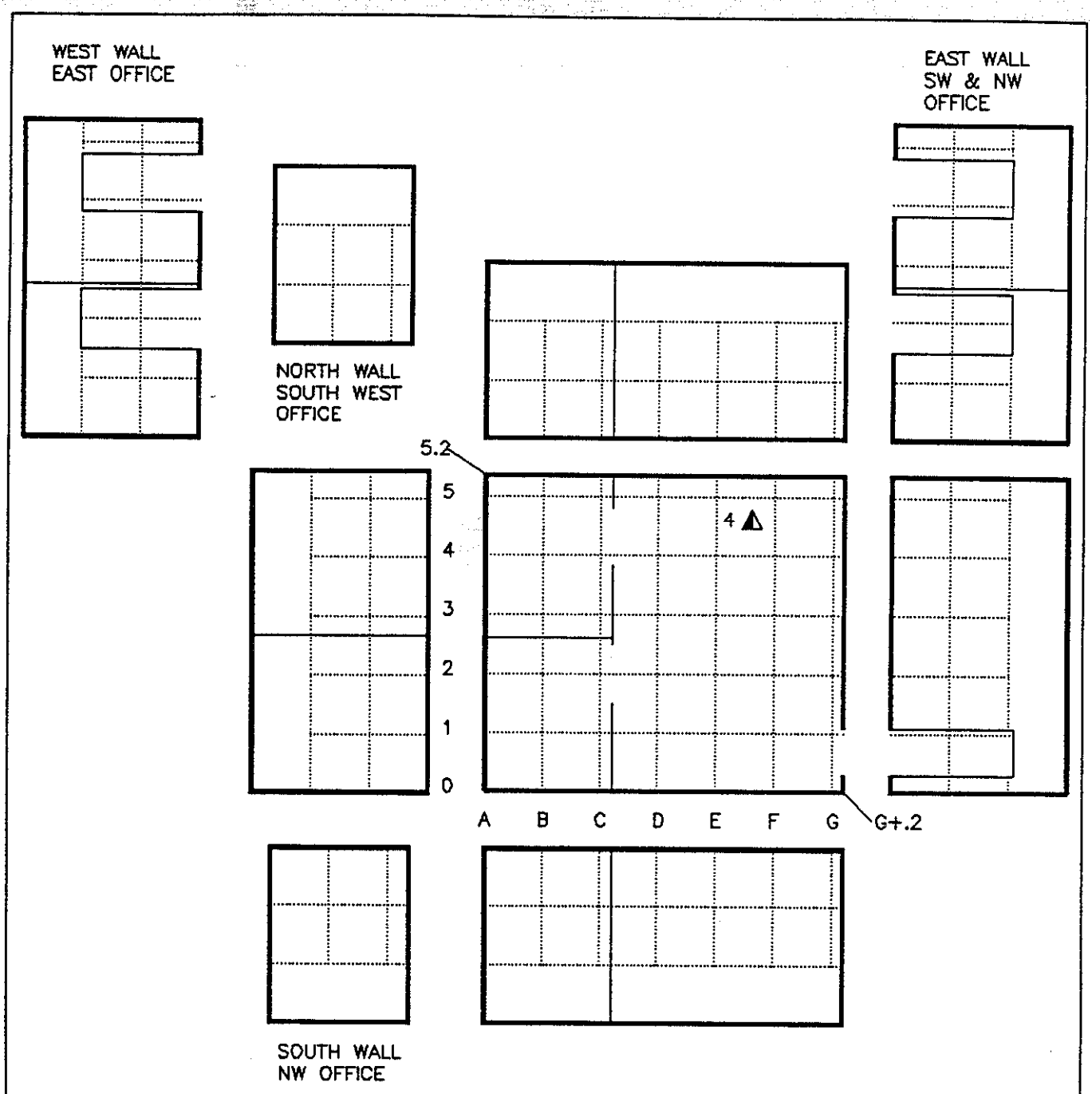


FIGURE 49: Survey Unit A2, Room 102 – Direct Measurements Exceeding Guidelines

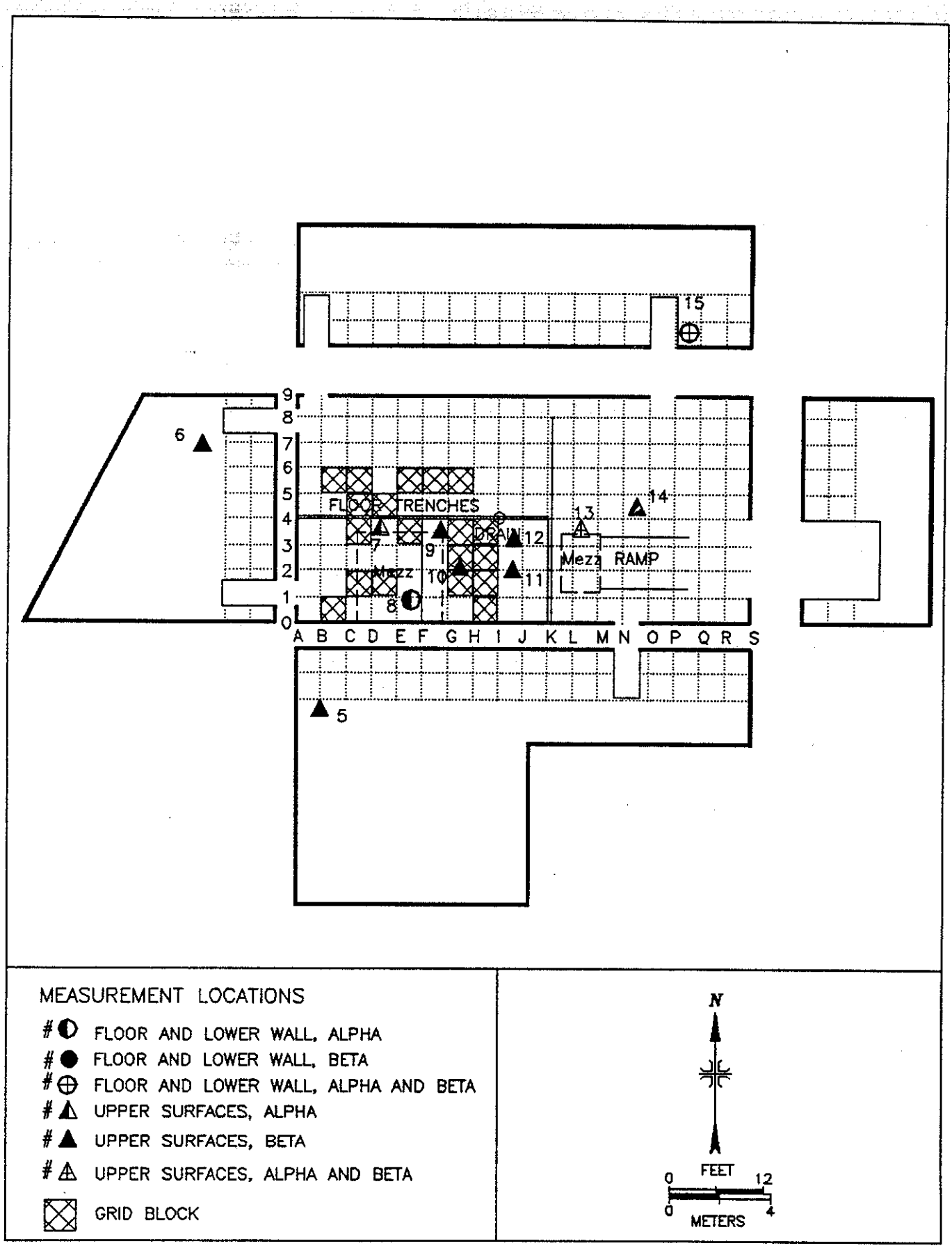


FIGURE 50: Survey Unit A3, Room 121 – Direct Measurements Exceeding Guidelines

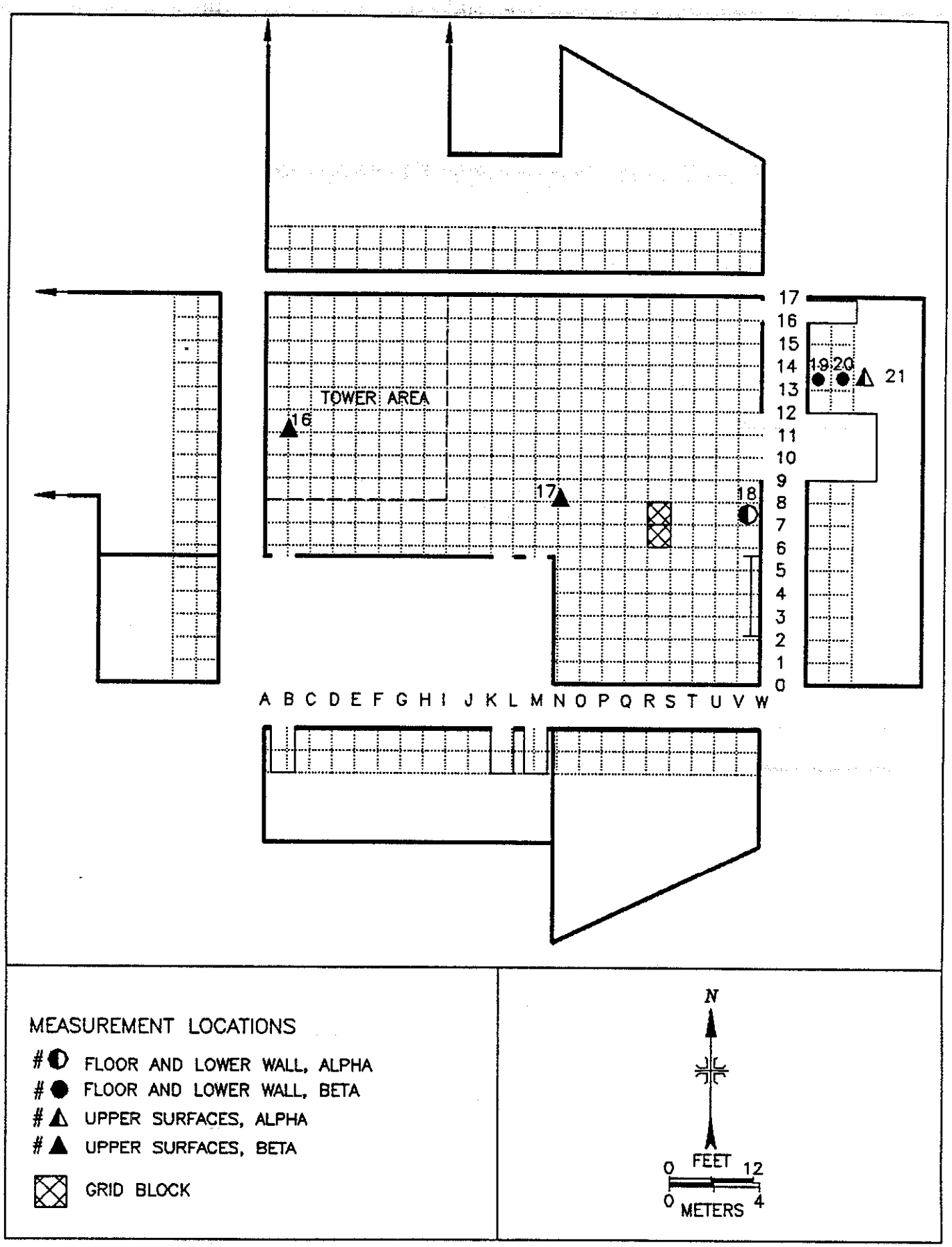


FIGURE 51: Survey Unit A4, Room 122 – Direct Measurements Exceeding Guidelines

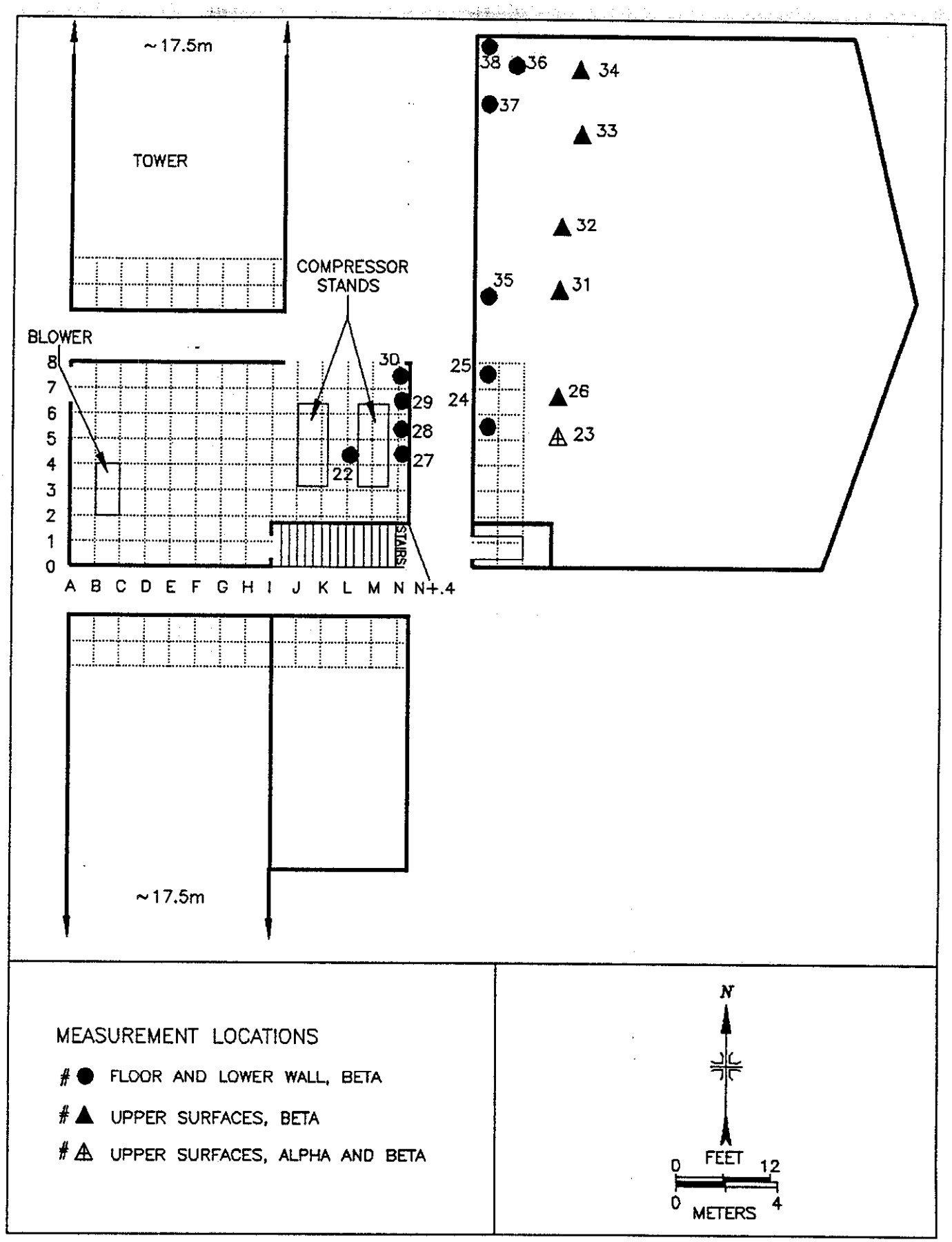


FIGURE 52: Survey Unit A5, Southeast Area of Room 217 – Direct Measurement Locations Exceeding Guidelines

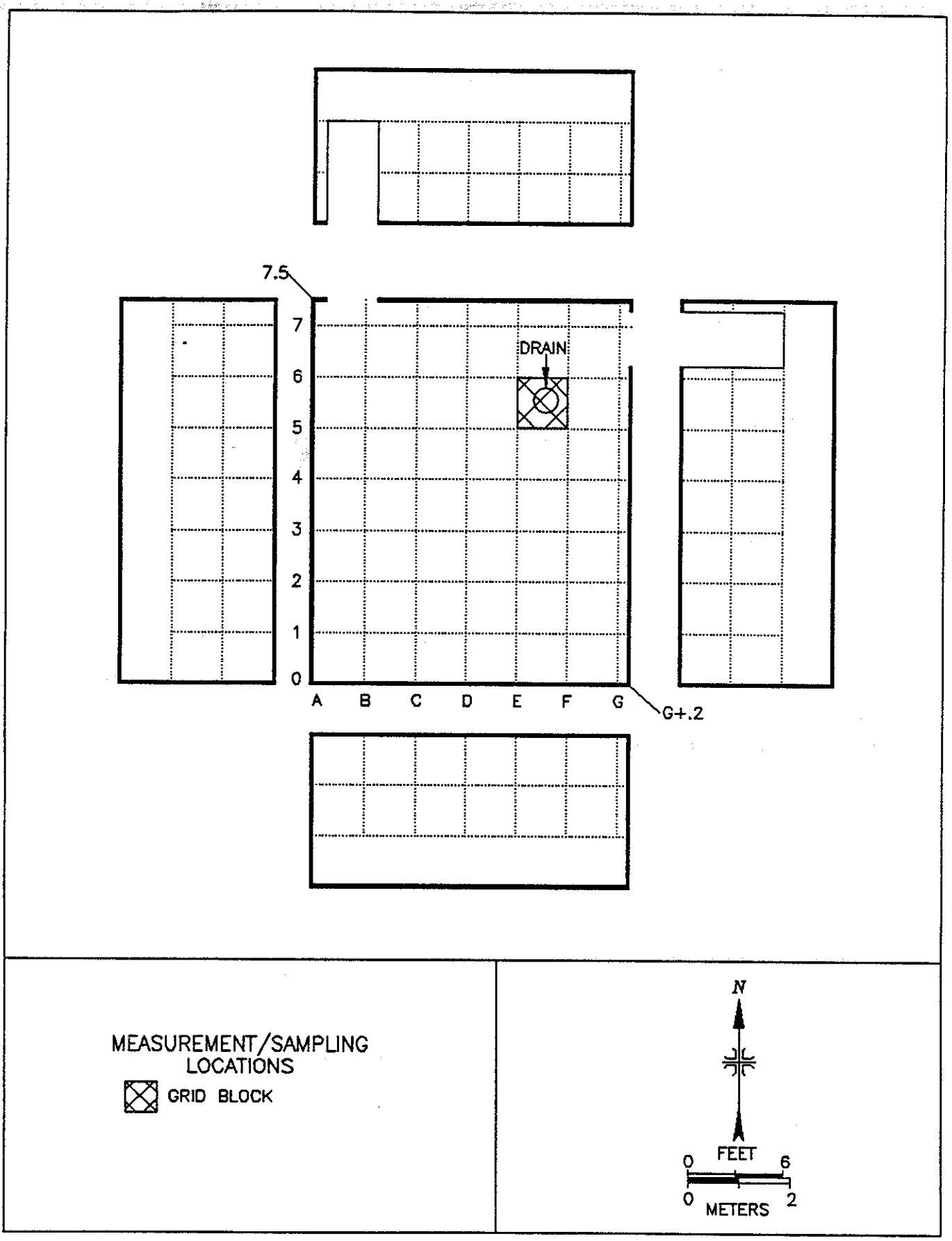


FIGURE 53: Survey Unit A6, Room 115 – Direct Measurement Exceeding Guideline

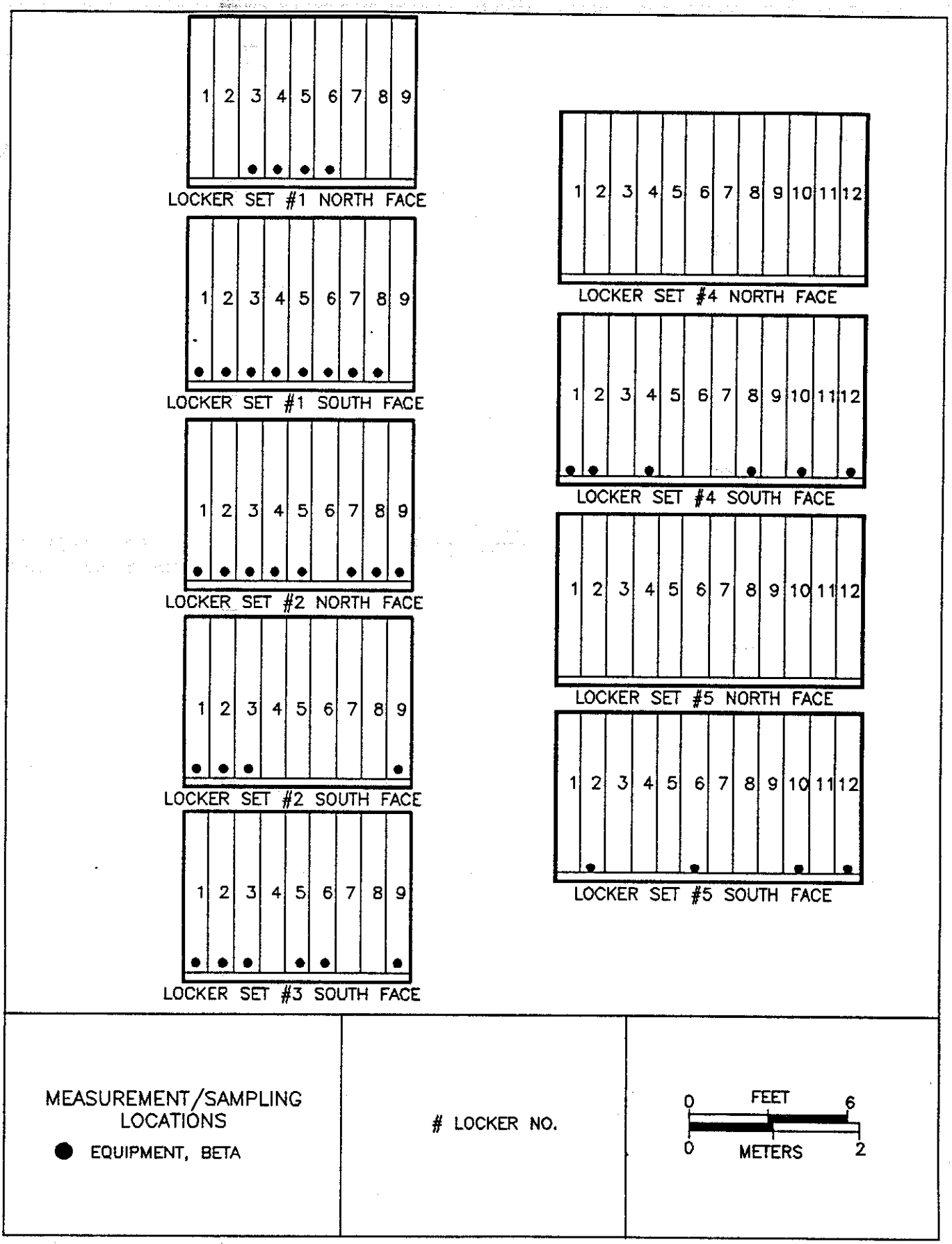
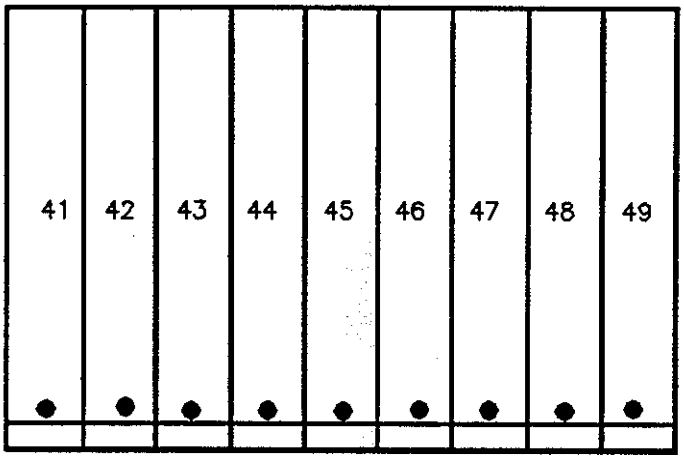


FIGURE 54: Survey Unit A7, Lockers, Room 108 – Direct Measurements Exceeding Guidelines



MEASUREMENT LOCATIONS

● EQUIPMENT, BETA

LOCKER NO.

FEET
0 3
0 1
METERS

FIGURE 55: Survey Unit A8, Lockers, Room 211 – Direct Measurements Exceeding Guidelines

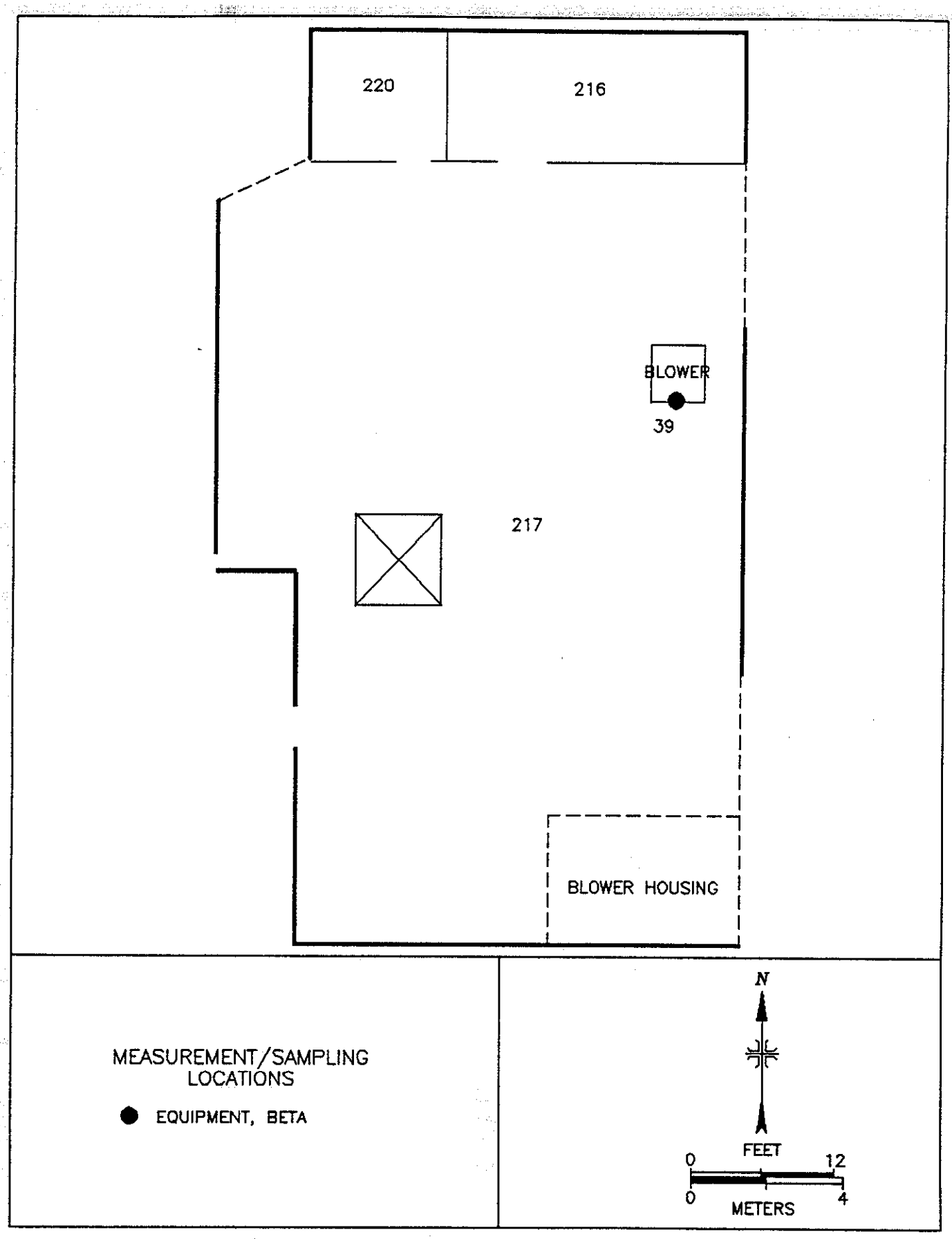


FIGURE 56: Survey Unit U7 – Direct Measurement Exceeding Guidelines

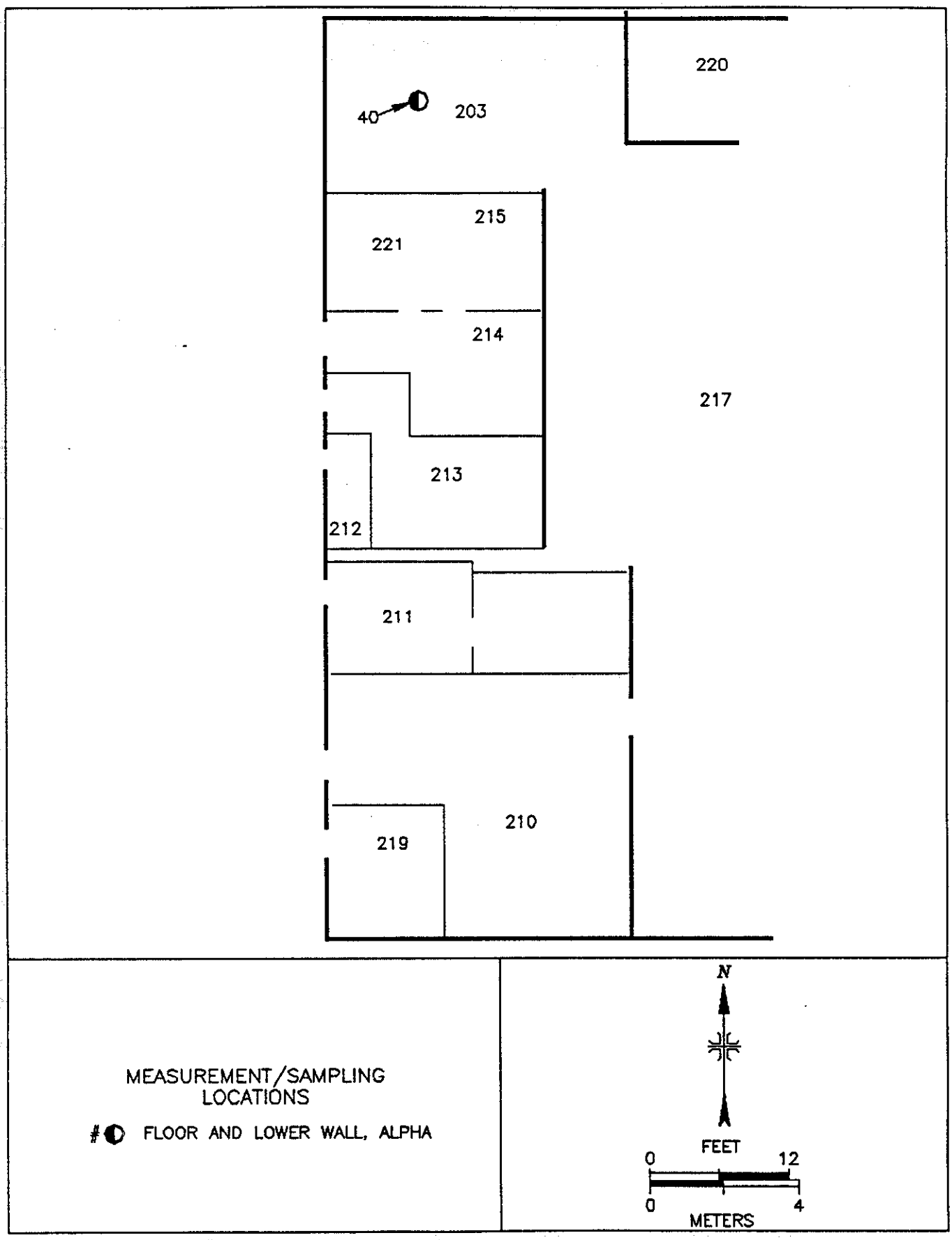


FIGURE 57: Survey Unit U8 – Direct Measurement Exceeding Guidelines

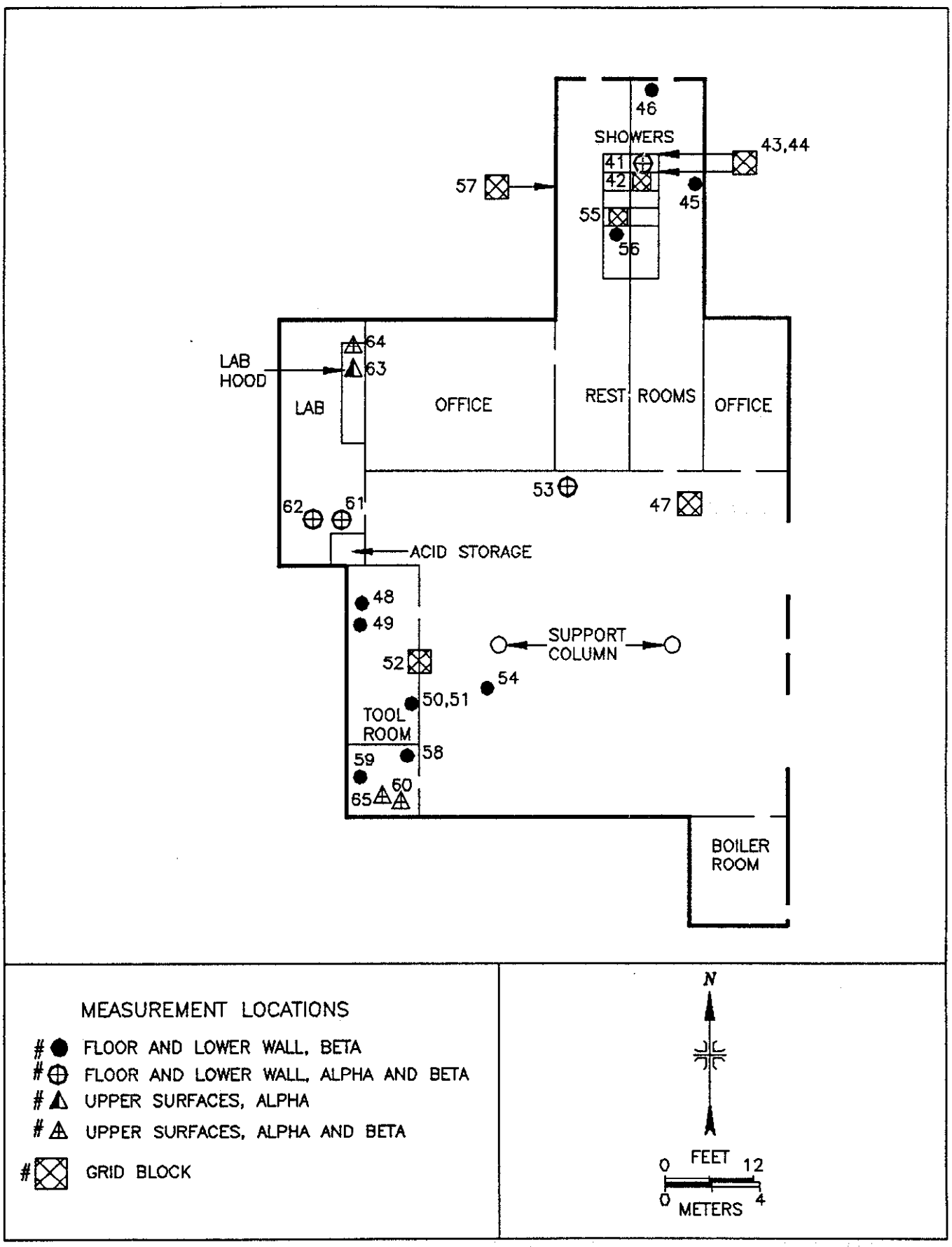


FIGURE 58: Building 403 – Direct Measurements Exceeding Guidelines

TABLE 1

SUMMARY OF SURFACE ACTIVITY MEASUREMENTS
NIAGARA FALLS STORAGE SITE, BUILDING 401—AFFECTED SURVEY UNITS
LEWISTON, NEW YORK

Location[a]	Number of Measurement Locations		Total Activity Range (dpm/100 cm²)				Removable Activity Range (dpm/100 cm²)	
			Single Measurements		1 m² Average			
	Single-point	Grid Blocks	Alpha	Beta	Alpha	Beta	Alpha	Beta
Survey Unit A1 (Room 117 & 119)								
Floor	306	2	<39 to 84	<470 to 3,600	<39	<470 to 1,200	<12	<16 to 20
Lower Walls	156	---[b]	<39 to 53	<470	---	---	<12	<16
Upper Walls and Ceiling	52	---	<47 to 1,600	≤430 to 44,000	---	---	<12	<16
Survey Unit A2 (Room 102)								
Floor	30	---	<37 to 60	<430	---	---	<12	<16
Lower Walls	72	---	<37 to 40	<430	---	---	<12	<16
Upper Walls, Ceilings, Equipment	7	---	<37 to 580	<430 to 2,700	---	---	<12	<16
Survey Unit A3 (Room 121)								
Floor	172	24	<37 to 85	<460 to 34,000	<47	600 to 2,600	<12	<16
Lower Walls	98	---	<47 to 810	<460 to 6,200	---	---	<12	<16
Upper Walls and Ceiling	33	---	<47 to 1,400	<460 to 240,000	---	---	<12	<16
Survey Unit A4 (Room 122)								
Floor	296	6	<37 to 480	<430 to 2,700	<35	<450 to 1,000	<12 to 29	<16 to 42
Lower Walls, Equipment	150	---	<37 to 75	<430 to 6,200	---	---	<12	<16
Upper Walls and Ceiling	52	---	<47 to 140	<460 to 1,200	---	---	<12	<16

TABLE 1 (Continued)

SUMMARY OF SURFACE ACTIVITY MEASUREMENTS
NIAGARA FALLS STORAGE SITE, BUILDING 401—AFFECTED SURVEY UNITS
LEWISTON, NEW YORK

Location[a]	Number of Measurement Locations		Total Activity Range (dpm/100 cm²)				Removable Activity Range (dpm/100 cm²)	
			Single Measurements		1 m² Average			
	Single-point	Grid Blocks	Alpha	Beta	Alpha	Beta	Alpha	Beta
Survey Unit A5 (Room 217)								
Floor	106	1	<39 to 79	<470 to 6,600	<39	900	<12	<16
Lower Walls and Equipment	74	1	<39 to 65	<430 to 59,000	<37	1,500	<12	<16
Upper Walls and Ceiling	25	---	<39 to 180	<470 to 110,000	---	---	<12	<16
Survey Unit A6 (Room 115)								
Floor	56	1	<35 to 2,900	<450 to 6,000	<35	<450	<12 to 22	<16 to 23
Lower Walls	60	---	<35 to 38	<450	---	---	<12	<16
Upper Walls and Ceiling	9	---	<35	<450	---	---	<12	<16
Survey Unit A7 (Lockers, Room 108)								
Lockers	70	---	<39 to 240	<470 to 13,000	---	---	<12	<16
Survey Unit A8 (Lockers, Room 211)								
Lockers	9	---	<39 to 280	2,300 to 14,000	---	---	<12	<16

[a]Refer to Figures 17 through 30.
[b]---=not performed

TABLE 2

EXPOSURE RATES
NIAGARA FALLS STORAGE SITE
LEWISTON, NEW YORK

Location[a]	Exposure Rate at 1 m (μR/h)	Average
Affected Survey Units, Building 401		
A1	7 to 8	8
A3	7 to 8	8
A4	7 to 8	8
A5	6 to 7	7
A6	7	7
Unaffected Survey Units, Building 401		
U1	7 to 8	8
U2	8 to 14	10
U3	7 to 8	8
U4	7 to 8	7
U5	7 to 8	7
U6	6 to 7	7
U7	6 to 7	7
U8	7 to 13	9
U9	7 to 8	8
Exterior, Building 401		
1	10	NA[b]
2	10	NA
3	17	NA
4	10	NA
5	10	NA
6	10	NA
7	9	NA
Hittman Building		
1	8	NA
2	7	NA
3	7	NA
4	7	NA
5	7	NA

TABLE 2 (Continued)

EXPOSURE RATES
NIAGARA FALLS STORAGE SITE
LEWISTON, NEW YORK

Location[a]	Exposure Rate at 1 m (μR/h)	Average
Building 403		
1	9	NA
2	9	NA
3	9	NA
4	9	NA
5	9	NA

[a]Refer to Figures 31, 32, 44, 45, and 47.
[b]NA = Not Applicable.

TABLE 3

RADIONUCLIDE CONCENTRATION IN MISCELLANEOUS SAMPLES
BUILDING 401
NIAGARA FALLS STORAGE SITE
LEWISTON, NEW YORK

Location[a]	Radionuclide Concentrations (pCi/g)						
	Am-241	Cs-137	Ra-226	Th-230	Th-232	U-235	U-238
1	12.1 ± 6.7[b]	<2.4	<4.5	<790	<7.6	185 ± 15	4,025 ± 97
2	35.0 ± 1.1	<0.7	0.6 ± 0.9	1,333 ± 77	198.9 ± 4.8	<0.5	4.9 ± 5.2
3	<0.2	<0.1	0.6 ± 0.1	<21	1.3 ± 0.3	1.1 ± 0.4	11.3 ± 2.0
4	<0.3	0.2 ± 0.1	0.2 ± 0.3	<30	<0.8	1.8 ± 0.8	31.0 ± 3.3
5	<0.7	0.6 ± 0.2	1.8 ± 0.5	<54	<1.0	14.5 ± 1.3	294.6 ± 8.4

[a]Refer to Figures 18, 20, 22, 24, and 26.
[b]Uncertainties represent the 95% confidence level, based only on counting statistics.

TABLE 4

SUMMARY OF SURFACE ACTIVITY MEASUREMENTS
NIAGARA FALLS STORAGE SITE, BUILDING 401, BUILDING 403, AND THE HITTMAN BUILDING—UNAFFECTED SURVEY UNITS
LEWISTON, NEW YORK

Location[a]	Number of Measurement Locations		Total Activity Range (dpm/100 cm²)				Removable Activity Range (dpm/100 cm²)	
			Single Measurements		1 m² Average			
	Single-point	Grid Blocks	Alpha	Beta	Alpha	Beta	Alpha	Beta
Survey Unit U1 (111, 113, 114, 116, 118, 125, 133)								
Floor	11	---	<39	<470	---	---	<12	<16
Lower Walls	9	---	<39	<470	---	---	<12	<16
Upper Walls and Ceiling	10	---	<35	<450	---	---	<12	<16
Survey Unit U2 (Rooms 101, 102, 103, 104, 105, 106, 107, 108, 109, and 112)								
Floor	13	---	<35	<450 to 1,500	---	---	<12	<16
Lower Walls	7	---	<35 to 130	<450 to 2,200	---	---	<12	<16
Upper Walls and Ceiling	10	---	<35	<450	---	---	<12	<16
Survey Unit U3 (Rooms 120, 128, 129, and 134)								
Floor	12	---	<35	<450 to 610	---	---	<12	<16
Lower Walls	8	---	<35	<450	---	---	<12	<16
Upper Walls and Ceiling	10	---	<35	<450	---	---	<12	<16

TABLE 4 (Continued)

**SUMMARY OF SURFACE ACTIVITY MEASUREMENTS
NIAGARA FALLS STORAGE SITE, BUILDING 401, BUILDING 403, AND THE HITTMAN BUILDING—UNAFFECTED SURVEY UNITS
LEWISTON, NEW YORK**

Location[a]	Number of Measurement Locations		Total Activity Range (dpm/100 cm^2)				Removable Activity Range (dpm/100 cm^2)	
			Single Measurements		1 m^2 Average			
	Single-point	Grid Blocks	Alpha	Beta	Alpha	Beta	Alpha	Beta
Survey Unit U4 (Rooms 127, 131, and 132)								
Floor	12	---	<35	<450 to 550	---	---	<12	<16
Lower Walls	8	---	<35	<450	---	---	<12	<16
Upper Wall and Ceiling	10	---	<35	<450	---	---	<12	<16
Survey Unit U5 (Room 122)								
Floor	11	---	<35	<450	---	---	<12	<16
Lower Walls	9	---	<35	<450	---	---	<12	<16
Upper Walls and Ceiling	10	---	<35	<450	---	---	<12	<16
Survey Unit U6 (Room 217-Second Floor)								
Floor	11	1	<39 to 84	<470 to 2,600	58	700	<12	<16
Lower Walls and Equipment	5	---	<39	<470	---	---	<12	<16
Upper Walls and Ceiling	6	---	<39 to 52	<470	---	---	<12	<16

TABLE 4 (Continued)

SUMMARY OF SURFACE ACTIVITY MEASUREMENTS
NIAGARA FALLS STORAGE SITE, BUILDING 401, BUILDING 403, AND THE HITTMAN BUILDING—UNAFFECTED SURVEY UNITS
LEWISTON, NEW YORK

Location[a]	Number of Measurement Locations		Total Activity Range (dpm/100 cm^2)				Removable Activity Range (dpm/100 cm^2)	
			Single Measurements		1 m^2 Average			
	Single-point	Grid Blocks	Alpha	Beta	Alpha	Beta	Alpha	Beta
Survey Unit U7 (Room 217-Second Floor)								
Floor	10	---	<39 to 95	<470	---	---	<12	<16
Lower Walls, Equipment	10	---	<39	<470 to 49,000	---	---	<12	<16
Upper Walls	10	---	<39 to 190	<470	---	---	<12	<16
Survey Unit U8 (Rooms 203, 210, 211, 212, 213, 214, 215, 219, 221)								
Floor	10	---	<39 to 63	<470 to 1,300	---	---	<12	<16
Lower Walls, Equipment	10	---	<39 to 84	<470 to 1,300	---	---	<12	<16
Upper Walls and Ceiling	10	---	<39 to 63	<470	-----	---	<12	<16
Survey Unit U9 (Rooms 201, 202, 204, 205, 206, 207, 208, 209, and 222)								
Floor	12	---	<39	<470	---	---	<12	<16
Lower Walls	8	---	<39	<470	---	---	<12	<16
Upper Walls and Ceiling	10	---	<39	<470	---	---	<12	<16

TABLE 4 (Continued)

SUMMARY OF SURFACE ACTIVITY MEASUREMENTS
NIAGARA FALLS STORAGE SITE, BUILDING 401, BUILDING 403, AND THE HITTMAN BUILDING—UNAFFECTED SURVEY UNITS
LEWISTON, NEW YORK

Location[a]	Number of Measurement Locations		Total Activity Range (dpm/100 cm²)				Removable Activity Range (dpm/100 cm²)	
			Single Measurements		1 m² Average			
	Single-point	Grid Blocks	Alpha	Beta	Alpha	Beta	Alpha	Beta
West Silo								
Floor	2	---	<39	<470	---	---	<12	<16
Lower Walls	2	---	<39 to 79	<470	---	---	<12	<16
Building 403								
Floor	42	6	<47 to 810	<430 to 15,000	---	2,100	<12 to 33	<16
Lower Walls	23	2	<47 to 470	<470 to 7200	---	2,100	<12 to 42	<16
Upper Walls and Ceiling	12	1	<47 to 1,700	<470 to 14,000	---	2,100	<12 to 29	<16 to 44
Hittman Building								
Floor	16	---	<47	<430 to 640	---	---	<12	<16
Lower Walls	4	---	<47	<430	---	---	<12	<16
Upper Walls and Ceiling	10	---	<47	<430	---	---	<12	<16

[a]Refer to Figures 33 through 43.

TABLE 5

EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN SOIL
BUILDING 401, EXTERIOR
NIAGARA FALLS STORAGE SITE
LEWISTON, NEW YORK

Location[a]	Exposure Rate at 1 m (μR/h)	Radionuclide Concentrations (pCi/g)						
		Cs-137	Ra-226	Th-230	Th-232	U-235	U-238	Total U
1 (0 to 15 cm)	10	0.5 ± 0.1[b]	16.9 ± 0.6	19 ± 7	0.5 ± 0.9	0.50 ± 0.12	9.80 ± 0.47	20.35 ± 0.68[c]
2 (0 to 15 cm)	10	0.1 ± 0.1	3.2 ± 0.3	<6.2	0.6 ± 0.3	<0.6	3.1 ± 1.7	6.3[d]
3 (0 to 15 cm)	17	<0.3	114.9 ± 1.6	280 ± 65	<1.3	<0.5	1.08 ± 0.16	2.32 ± 0.24[c]
4 (15 to 30 cm)	10	0.3 ± 0.1	31.8 ± 0.9	36 ± 33	<1.0	1.62 ± 0.22	33.05 ± 0.87	69.00 ± 1.26[c]
5 (0 to 15 cm)	10	0.6 ± 0.1	4.1 ± 0.4	5.5 ± 4.1	0.6 ± 0.4	0.64 ± 0.13	13.19 ± 0.54	29.10 ± 0.80[c]
6 (0 to 15 cm)	10	0.3 ± 0.1	17.6 ± 0.7	50 ± 32	0.5 ± 0.6	0.09 ± 0.05	1.84 ± 0.20	3.8 ± 0.29[c]
7 (0 to 15 cm)	9	0.5 ± 0.1	9.7 ± 0.4	32 ± 23	0.2 ± 0.3	<0.7	5.4 ± 2.4	11.5[d]

[a]Refer to Figure 47.
[b]Uncertainties represent the 95% confidence level, based only on counting statistics.
[c]Total uranium determined by alpha spectrometry. Sum of U-234, U-235, and U-238 activity concentrations.
[d]Total uranium determined by gamma spectrometry (U-238 activity concentration × 2) + U-235 activity concentration.

TABLE 6

SUMMARY OF RESIDUAL SURFACE ACTIVITY EXCEEDING GUIDELINES
BUILDINGS 401 AND 403
NIAGARA FALLS STORAGE SITE
LEWISTON, NEW YORK

Survey Unit	Figure No.	Measurement Location Number and/or Grid Block	Surface	Total Activity		1 m^2 Average ($dpm/100\ cm^2$)	Removable Activity $dpm/100\ cm^2$	
				Alpha ($dpm/100\ cm^2$)	Beta ($dpm/100\ cm^2$)	Alpha (α)/ Beta (β)	Alpha	Beta
A-1	48	1/G,19	Floor Drain	42	1,600	NA[b]	<12	<16
A-1	48	2/O,18,6	Ceiling	1600	44,000	NA	<12	<16
A-1	48	3/S,19	Floor	<39	3,600	NA	<12	<16
A-2	49	4/E,4	Equipment (Pipe)	580	2,700	NA	-	-
A-3	50	5/A+0.7,2	Equipment (Air Duct)	70	3,700	NA	<12	<16
A-3	50	6/A,7,3.5	Upper Wall I-Beam	50	1,400	1,100 β	<12	<16
A-3	50	7/D,4.5	Mezzanine	870	2,000	NA	<12	<16
A-3	50	8/E,1	Floor	<47	34,000	NA	<12	<16
A-3	50	9/F,4	Mezzanine I-Beam	<47	4,300	NA	<12	<16
A-3	50	10/G+0.5,3	Ceiling I-Beam	<47	3,000	NA	<12	<16
A-3	50	11/H,4	Ceiling I-Beam	<47	6,500	NA	<12	<16
A-3	50	12/I-4	Mezzanine I-Beam	<47	2,000	1,200 β	<12	<16
A-3	50	13/L,3.5	Ceiling I-Beam	1400	240,000	NA	<12	<16
A-3	50	14/N,4	Support Beam	95	3,500	NA	<12	<16

TABLE 6 (Continued)

SUMMARY OF RESIDUAL SURFACE ACTIVITY EXCEEDING GUIDELINES
BUILDINGS 401 AND 403
NIAGARA FALLS STORAGE SITE
LEWISTON, NEW YORK

Survey Unit	Figure No.	Measurement Location Number and/or Grid Block	Surface	Total Activity		1 m^2 Average ($dpm/100\ cm^2$)	Removable Activity $dpm/100\ cm^2$	
				Alpha ($dpm/100\ cm^2$)	Beta ($dpm/100\ cm^2$)	Alpha (α)/ Beta (β)	Alpha	Beta
A-3	50	15/P,9,0	Lower Wall Ledge	810	6,200	NA	<12	<16
A-3	50	B,0	Floor	<37	1,700	1,200 β	<12	<16
A-3	50	B,5	Floor	40	1,500	1,200 β	<12	<16
A-3	50	C,1	Floor	<37	2,000	1,300 β	<12	<16
A-3	50	C,3	Floor	<37	1,600	1,600 β	<12	<16
A-3	50	C,4	Floor	<37	1,600	1,300 β	<12	<16
A-3	50	D,1	Floor	<47	1,400	1,100 β	<12	<16
A-3	50	D,4	Floor	<37	1,800	1,400 β	<12	<16
A-3	50	D,5	Floor	<37	1,400	1,300 β	<12	<16
A-3	50	E,4	Floor	<47	1,200	1,100 β	<12	<16
A-3	50	E,5	Floor	<47	1,400	1,300 β	<12	<16
A-3	50	F,5	Floor	<47	1,400	1,400 β	<12	<16
A-3	50	G,1	Floor	<47	2,700	1,600 β	<12	<16
A-3	50	G,2	Floor	<47	1,700	2,600 β	<12	<16

TABLE 6 (Continued)

SUMMARY OF RESIDUAL SURFACE ACTIVITY EXCEEDING GUIDELINES
BUILDINGS 401 AND 403
NIAGARA FALLS STORAGE SITE
LEWISTON, NEW YORK

Survey Unit	Figure No.	Measurement Location Number and/or Grid Block	Surface	Total Activity		1 m^2 Average ($dpm/100\ cm^2$)	Removable Activity $dpm/100\ cm^2$	
				Alpha ($dpm/100\ cm^2$)	Beta ($dpm/100\ cm^2$)	Alpha (α)/ Beta (β)	Alpha	Beta
A-3	50	G,3	Floor	<47	2,000	1,200 β	<12	<16
A-3	50	G,5	Floor	<47	1,300	1,200 β	<12	<16
A-3	50	H,0	Floor	<47	1,500	1,300 β	<12	<16
A-3	50	H,1	Floor	<47	1,300	1,300 β	<12	<16
A-3	50	H,2	Floor	<47	1,900	1,400 β	<12	<16
A-3	50	H,3	Floor	<47	2,100	1,300 β	<12	<16
A-4	51	16/B,11,5	Air Duct	<47	1,200	NA	-	-
A-4	51	17/N,8	Support Beam	75	6,200	NA	-	-
A-4	51	18/V,7	Floor	480	2,700	NA	29	42
A-4	51	19/W,13,0	Lower Wall Ledge	<35	2,000	>1000[c] β	<12	<16
A-4	51	20/W,13,1	Lower Wall Ledge	<35	1,600	>1000[c] β	<12	<16
A-4	51	21/W,13,2.3	Upper Wall Ledge	140	500	88 α	<12	<16
A-4	51	R,6	Floor	38	2,300	1,100 β	<12	<16
A-4	51	R,7	Floor	<35	1,800	1,000 β	<12	<16

TABLE 6 (Continued)

SUMMARY OF RESIDUAL SURFACE ACTIVITY EXCEEDING GUIDELINES
BUILDINGS 401 AND 403
NIAGARA FALLS STORAGE SITE
LEWISTON, NEW YORK

Survey Unit	Figure No.	Measurement Location Number and/or Grid Block	Surface	Total Activity		1 m^2 Average ($dpm/100\ cm^2$)	Removable Activity $dpm/100\ cm^2$	
				Alpha ($dpm/100\ cm^2$)	Beta ($dpm/100\ cm^2$)	Alpha (α)/ Beta (β)	Alpha	Beta
A-5	52	22/L-4	Floor	<39	6,600	NA	<12	<16
A-5	52	23/N+0.4,5,4	Upper Wall I-Beam	180	110,000	NA	<12	<16
A-5	52	24/N+0.4,6,0	Lower Wall I-Beam	45	4,100	NA	<12	<16
A-5	52	25/N+0.4,8,0	Lower Wall I-Beam	55	15,000	NA	<12	<16
A-5	52	26/N+0.4,8,4	Upper Wall I-Beam	42	10,000	NA	<12	<16
A-5	52	27/N,4	Floor	63	3,700	NA	<12	<16
A-5	52	28/N,5	Floor	58	1,300	>1,000[c] β	<12	<16
A-5	52	29/N,6	Floor	<39	3,700	NA	<12	<16
A-5	52	30/N,7	Floor	79	2,300	>1,000[c] β	<12	<16
A-5	52	31/E. Wall	Upper Wall I-Beam	<39	21,000	NA	<12	<16
A-5	52	32/E. Wall	Upper Wall I-Beam	42	7,200	NA	<12	<16
A-5	52	33/E. Wall	Upper Wall I-Beam	<39	8,800	NA	<12	<16
A-5	52	34/E. Wall	Upper Wall I-Beam	84	63,000	NA	<12	<16
A-5	52	35/E. Wall	Lower Wall I-Beam	68	2,100	>1,000[c] β	-	-
A-5	52	36/E. Wall	Lower Wall I-Beam	160	13,000	NA	<12	<16

TABLE 6 (Continued)

SUMMARY OF RESIDUAL SURFACE ACTIVITY EXCEEDING GUIDELINES
BUILDINGS 401 AND 403
NIAGARA FALLS STORAGE SITE
LEWISTON, NEW YORK

Survey Unit	Figure No.	Measurement Location Number and/or Grid Block	Surface	Total Activity		1 m^2 Average ($dpm/100\ cm^2$)	Removable Activity $dpm/100\ cm^2$	
				Alpha ($dpm/100\ cm^2$)	Beta ($dpm/100\ cm^2$)	Alpha (α)/ Beta (β)	Alpha	Beta
A-5	52	37/E. Wall	Lower Wall I-Beam	<39	7,800	NA	<12	<16
A-5	52	38/E. Wall	Lower Wall I-Beam	42	59,000	NA	<12	<16
A-6	53	39/E,5	Floor	2,900	6,000	NA	<12	<16
A-7	54	Locker 1,N3	Equipment	52	2,800	NA	<12	<16
A-7	54	Locker 1,N4	Equipment	38	4,900	NA	<12	<16
A-7	54	Locker 1,N5	Equipment	<35	1,600	NA	<12	<16
A-7	54	Locker 1,N6	Equipment	<35	1,400	NA	<12	<16
A-7	54	Locker 1,S1	Equipment	130	13,000	NA	<12	<16
A-7	54	Locker 1,S2	Equipment	<35	1,500	NA	<12	<16
A-7	54	Locker 1,S3	Equipment	48	1,100	NA	<12	<16
A-7	54	Locker 1,S4	Equipment	81	2,900	NA	<12	<16
A-7	54	Locker 1,S5	Equipment	<35	1,200	NA	<12	<16
A-7	54	Locker 1,S6	Equipment	62	3,500	NA	<12	<16
A-7	54	Locker 1,S7	Equipment	190	13,000	NA	<12	<16

TABLE 6 (Continued)

SUMMARY OF RESIDUAL SURFACE ACTIVITY EXCEEDING GUIDELINES
BUILDINGS 401 AND 403
NIAGARA FALLS STORAGE SITE
LEWISTON, NEW YORK

Survey Unit	Figure No.	Measurement Location Number and/or Grid Block	Surface	Total Activity		1 m^2 Average (dpm/100 cm^2)	Removable Activity dpm/100 cm^2	
				Alpha (dpm/100 cm^2)	Beta (dpm/100 cm^2)	Alpha (α)/ Beta (β)	Alpha	Beta
A-7	54	Locker 1,S8	Equipment	<35	8,200	NA	<12	<16
A-7	54	Locker 2, S1	Equipment	47	2,500	NA	<12	<16
A-7	54	Locker 2, S2	Equipment	89	5,300	NA	<12	<16
A-7	54	Locker 2, S3	Equipment	<39	3,000	NA	<12	<16
A-7	54	Locker 2, S9	Equipment	47	2,400	NA	<12	<16
A-7	54	Locker 2,N1	Equipment	79	4,500	NA	<12	<16
A-7	54	Locker 2,N2	Equipment	53	4,300	NA	<12	<16
A-7	54	Locker 2,N3	Equipment	<39	1,800	NA	<12	<16
A-7	54	Locker 2,N4	Equipment	74	4,100	NA	<12	<16
A-7	54	Locker 2,N5	Equipment	<39	2,700	NA	<12	<16
A-7	54	Locker 2,N7	Equipment	58	2,100	NA	<12	<16
A-7	54	Locker 2,N8	Equipment	42	2,500	NA	<12	<16
A-7	54	Locker 2,N9	Equipment	58	2,400	NA	<12	<16
A-7	54	Locker 3,S1	Equipment	63	2,300	NA	<12	<16

TABLE 6 (Continued)

SUMMARY OF RESIDUAL SURFACE ACTIVITY EXCEEDING GUIDELINES
BUILDINGS 401 AND 403
NIAGARA FALLS STORAGE SITE
LEWISTON, NEW YORK

Survey Unit	Figure No.	Measurement Location Number and/or Grid Block	Surface	Total Activity		1 m^2 Average ($dpm/100\ cm^2$)	Removable Activity $dpm/100\ cm^2$	
				Alpha ($dpm/100\ cm^2$)	Beta ($dpm/100\ cm^2$)	Alpha (α)/ Beta (β)	Alpha	Beta
A-7	54	Locker 3,S2	Equipment	74	1,800	NA	<12	<16
A-7	54	Locker 3,S3	Equipment	180	10,000	NA	<12	<16
A-7	54	Locker 3,S5	Equipment	47	1,100	NA	<12	<16
A-7	54	Locker 3,S6	Equipment	53	2,000	NA	<12	<16
A-7	54	Locker 3,S9	Equipment	58	5,000	NA	<12	<16
A-7	54	Locker 4,S1	Equipment	67	1,300	NA	<12	<16
A-7	54	Locker 4,S10	Equipment	57	2,600	NA	<12	<16
A-7	54	Locker 4,S12	Equipment	100	11,000	NA	<12	<16
A-7	54	Locker 4,S2	Equipment	38	1,500	NA	<12	<16
A-7	54	Locker 4,S4	Equipment	<35	1,800	NA	<12	<16
A-7	54	Locker 4,S8	Equipment	38	4,800	NA	<12	<16
A-7	54	Locker 5,S10	Equipment	<35	1,600	NA	<12	<16
A-7	54	Locker 5,S12	Equipment	67	2,900	NA	<12	<16
A-7	54	Locker 5,S2	Equipment	<35	7,000	NA	<12	<16

TABLE 6 (Continued)

SUMMARY OF RESIDUAL SURFACE ACTIVITY EXCEEDING GUIDELINES
BUILDINGS 401 AND 403
NIAGARA FALLS STORAGE SITE
LEWISTON, NEW YORK

Survey Unit	Figure No.	Measurement Location Number and/or Grid Block	Surface	Total Activity		1 m^2 Average (dpm/100 cm^2)	Removable Activity dpm/100 cm^2	
				Alpha (dpm/100 cm^2)	Beta (dpm/100 cm^2)	Alpha (α)/ Beta (β)	Alpha	Beta
A-7	54	Locker 5, S6	Equipment	200	13,000	NA	<12	<16
A-8	55	Locker No. 41	Equipment	53	7,100	NA	<12	<16
A-8	55	Locker No. 42	Equipment	280	13,000	NA	<12	<16
A-8	55	Locker No. 43	Equipment	47	2,300	NA	<12	<16
A-8	55	Locker No. 44	Equipment	120	14,000	NA	<12	<16
A-8	55	Locker No. 45	Equipment	95	4,500	NA	<12	<16
A-8	55	Locker No. 46	Equipment	58	3,500	NA	<12	<16
A-8	55	Locker No. 47	Equipment	<39	6,100	NA	<12	<16
A-8	55	Locker No. 48	Equipment	68	12,000	NA	<12	<16
A-8	55	Locker No. 49	Equipment	47	2,400	NA	<12	<16
U-7	56	39/SE Corner	Equipment (Blower)	<39	49,000	NA	<12	<16
U-8	57	40/Room 203	Equipment (Blower)	120	<470	>100[c] α	<12	<16
Bldg. 403	58	41/Men's Room Shower	Floor	810	3,000	NA	33	<16
Bldg. 403	58	42/Men's Room Shower	Floor	<47	1,300	1,200 β	<12	<16

TABLE 6 (Continued)

SUMMARY OF RESIDUAL SURFACE ACTIVITY EXCEEDING GUIDELINES
BUILDINGS 401 AND 403
NIAGARA FALLS STORAGE SITE
LEWISTON, NEW YORK

Survey Unit	Figure No.	Measurement Location Number and/or Grid Block	Surface	Total Activity		1 m^2 Average ($dpm/100\ cm^2$)	Removable Activity $dpm/100\ cm^2$	
				Alpha ($dpm/100\ cm^2$)	Beta ($dpm/100\ cm^2$)	Alpha (α)/ Beta (β)	Alpha	Beta
Bldg. 403	58	43/Men's Room Shower	Lower Wall	<47	2,400	2,600[d] β	<12	<16
Bldg. 403	58	44/Men's Room Shower	Lower Wall	<47	2,800	2,600[d] β	<12	<16
Bldg. 403	58	45/Men's Room Shower	Upper Wall	55	2,200	NA	<12	<16
Bldg. 403	58	46/Men's Room	Floor	120	1,100	55 α ,840 β	<12	<16
Bldg. 403	58	47/Garage @ Men's Room	Floor	<47	1,400	1,100 β	<12	<16
Bldg. 403	58	48/Tool Room-NW Corner	Floor	280	12,000	NA	<12	<16
Bldg. 403	58	49/Tool Room-Ledge	Lower Wall	105	5,200	NA	<12	<16
Bldg. 403	58	50/Tool Room-SE Corner	Floor	50	1,700	NA	<12	<16
Bldg. 403	58	51/Tool Room-SE Corner	Floor	110	6,000	NA	<12	<16
Bldg. 403	58	52/Tool Room @ E. Wall	Floor	240	2,400	140 α, 2,100 β	<12	<16
Bldg. 403	58	53/Garage @ Storage Room	Floor Drain	650	15,000	NA	<12	<16
Bldg. 403	58	54/Garage SW Quad	Floor	<47	4,300	NA	<12	<16
Bldg. 403	58	55/Ladies Room S. Shower	Floor	<47	1,200	1,100[d] β	<12	<16
Bldg. 403	58	56/Ladies Room	Lower Wall	<47	2,600	NA[d]	<12	<16

TABLE 6 (Continued)

SUMMARY OF RESIDUAL SURFACE ACTIVITY EXCEEDING GUIDELINES
BUILDINGS 401 AND 403
NIAGARA FALLS STORAGE SITE
LEWISTON, NEW YORK

Survey Unit	Figure No.	Measurement Location Number and/or Grid Block	Surface	Total Activity		1 m^2 Average ($dpm/100\ cm^2$)	Removable Activity $dpm/100\ cm^2$	
				Alpha ($dpm/100\ cm^2$)	Beta ($dpm/100\ cm^2$)	Alpha (α)/ Beta (β)	Alpha	Beta
Bldg. 403	58	57/Ladies Room	Upper Wall	<47	2,400	2,200[d] β	<12	<16
Bldg. 403	58	58/S. Tool Rm. NE Corner	Floor	95	4,100	NA	<12	<16
Bldg. 403	58	59/S. Tool Rm. @ W Wall	Floor	130	3,600	NA	<12	<16
Bldg. 403	58	60/S. Tool Rm.-S Wall	Lower Wall	470	7,200	NA	42	<16
Bldg. 403	58	61/Lab Near Sink	Lower Wall	110	1,800	NA	<12	<16
Bldg. 403	58	62/Lab Near Sink	Lower Wall	100	1,100	NA	<12	<16
Bldg. 403	58	63/Lab East Wall	Equipment (Hood)	220	800	NA	22	44
Bldg. 403	58	64/Lab East Wall	Equipment (Hood Vent)	790	7,900	NA	<12	<16
Bldg. 403	58	65/S. Tool Room	Ceiling	1,700	14,000	NA	29	25

[a]Alpha only, beta only, or alpha and beta 1 m^2 averages determined.
[b]NA = Not applicable, additional measurements to determine average activity were not performed.
[c]Additional measurements to determine average activity not performed. Surface scans or direct measurements within contiguous locations indicated the presence of distributed activity.
[d]Measurements made on ceramic tile.

REFERENCES

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Vitkus, T.J. Oak Ridge Institute for Science and Education, 1992. Radiological Survey of Buildings 401A, 402, 416, and 429, Niagara Falls Storage Site, Lewiston, New York. October 1992.

Vitkus, T.J. 1994. Letter to A. Williams, U.S. Department of Energy. May 10, 1994.

Williams, W.A. 1994. Letter to T. Vitkus, Oak Ridge Institute for Science and Education. May 25, 1994.

APPENDIX A
MAJOR INSTRUMENTATION

APPENDIX A
MAJOR INSTRUMENTATION

The display of a specific product is not to be construed as an endorsement of the product or its manufacturer by the authors or their employers.

DIRECT RADIATION MEASUREMENT

Instruments

Eberline Pulse Ratemeter
Model PRM-6
(Eberline, Santa Fe, NM)

Eberline "Rascal" Ratemeter-Scaler
Model PRS-1
(Eberline, Santa Fe, NM)

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

Detectors

Eberline GM Detector
Model HP-260
Effective Area, 15.5 cm^2
(Eberline, Santa Fe, NM)

Eberline ZnS Scintillation Detector
Model AC-3-7
Effective Area, 59 cm^2
(Eberline, Santa Fe, NM)

Ludlum Gas Proportional Detector
Model 43-37
Effective Area, 550 cm^2
(Ludlum Measurements, Inc.,
Sweetwater, TX)

Ludlum Gas Proportional Detector
Model 43-68
Effective Area, 100 cm^2
(Ludlum Measurements, Inc.,
Sweetwater, TX)

Reuter-Stokes Pressurized Ion Chamber
Model RSS-112
(Reuter-Stokes, Cleveland, OH)

Victoreen NaI Scintillation Detector
Model 489-55
3.2 cm x 3.8 cm Crystal
(Victoreen, Cleveland, OH)

LABORATORY ANALYTICAL INSTRUMENTATION

Low Background Gas Proportional Counter
Model LB-5100-W
(Oxford, Oak Ridge, TN)

Alpha Spectrometry System
Using Canberra and Tennelec Alpha Spectrometers
In conjunction with:
Multichannel Analyzer
3100 Vax Workstations
(Canberra, Meriden, CT)

High-Purity Extended Range Intrinsic Detectors
Model No: ERVDS30-25195
(Tennelec, Oak Ridge, TN)
Used in conjunction with:
Lead Shield Model G-11
(Nuclear Lead, Oak Ridge, TN) and
Multichannel Analyzer
3100 Vax Workstation
(Canberra, Meriden, CT)

High-Purity Germanium Detector
Model GMX-23195-S, 23% Eff.
(EG&G ORTEC, Oak Ridge, TN)
Used in conjunction with:
Lead Shield Model G-16
(Gamma Products, Palos Hills, IL) and
Multichannel Analyzer
3100 Vax Workstation
(Canberra, Meriden, CT)

APPENDIX B

SURVEY AND ANALYTICAL PROCEDURES

APPENDIX B

SURVEY AND ANALYTICAL PROCEDURES

SURVEY PROCEDURES

Surface Scans

Surface scans were performed in accordance with ESSAP surface scanning procedures by passing the probes slowly over the surface; the distance between the probe and the surface was maintained at a minimum - nominally about 1 centimeter (cm). A large surface area, gas proportional floor monitor was used to scan the floors and portions of the lower walls of the surveyed areas. Other surfaces were scanned using small area (15.5 square centimeters (cm^2), 59 cm^2, and 100 cm^2) hand-held detectors. Identification of elevated surface activity levels was based on increases in the audible signal from the recording and/or indicating instrument. Combinations of detectors and instruments used for the scans were:

Alpha	—	gas proportional detector with ratemeter-scaler
	—	ZnS scintillation detector with ratemeter-scaler
Beta	—	gas proportional detector with ratemeter-scaler
	—	pancake GM detector with ratemeter-scaler
Gamma	—	NaI scintillation detector with ratemeter

Surface Activity Measurements

Alpha and beta activity measurements were performed in accordance with alpha radiation measurement and beta radiation measurement procedures on floors, walls, upper room surfaces, equipment, and at locations of elevated direct radiation, using gas proportional and ZnS scintillation detectors with ratemeter-scalers.

Count rates (cpm), which were integrated over 1 minute in a static position, were converted to activity levels in disintegrations per minute per 100 cm^2 (dpm/100 cm^2) by dividing the net rate by the 4 π efficiency and correcting for the active area of the detector. The alpha activity background countrates for the gas proportional and ZnS scintillation detectors averaged approximately 1 cpm for each detector. Alpha efficiency factors for the gas proportional detectors, based on calibration with Th-230, ranged from 0.19 to 0.21. Alpha efficiency factors, based on calibration with Pu-239, ranged from 0.18 to 0.19 for the ZnS scintillation detectors. The beta activity background count rates for the gas proportional detectors averaged approximately 370 cpm and the beta efficiency factors for Tc-99 ranged from 0.20 to 0.21. The effective window for the gas proportional and ZnS scintillation were 100 cm^2 and 59 cm^2, respectively.

Removable Activity Measurements

Removable activity levels were determined in accordance with ESSAP determination of removable activity procedures, using numbered filter paper disks, 47 mm in diameter. Moderate pressure was applied to the smear with two or three fingers, and approximately 100 cm^2 of the surface was wiped. Smears were placed in labeled envelopes with the location and other pertinent information recorded.

Exposure Rate Measurements

Quantitative measurements of gamma exposure rates, at 1 m above surfaces, were performed in accordance with ESSAP gamma radiation (exposure rate) measurement procedures using a pressurized ionization chamber (PIC). Qualitative exposure rates were determined by comparing gamma count rates, from NaI scintillation detector ratemeter combinations, and cross calibrating to site exposure rates obtained using the PIC.

Soil Sampling

Approximately 1 kg of soil was collected at each sample location. Collected samples were placed in a plastic bag, sealed, and labeled. Sampling and labeling was in accordance with ESSAP surface soil sampling and sample identification and labeling procedures.

Miscellaneous Sampling

Residue samples (dust, drain, sediment, etc.) were collected from horizontal surfaces and drains, placed in appropriate containers, which were sealed, and labeled. Sampling and labeling were in accordance with ESSAP miscellaneous sampling and sample identification and labeling procedures.

ANALYTICAL PROCEDURES

Removable Activity

Smears were counted on a low background gas proportional system for gross alpha and gross beta activity.

Gamma Spectrometry

Soil and miscellaneous samples were dried, mixed, crushed, and/or homogenized as necessary, and a portion sealed in 0.5-liter Marinelli beaker or other appropriate container. The quantity placed in the beaker was chosen to reproduce the calibrated counting geometry and ranged from 643 to 902 gram (g) of material. 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. Energy peaks used for determination of radionuclides of concern were:

Am-241	0.059 MeV
Cs-137	0.662 MeV
Ra-226	0.351 MeV from Pb-214*
Th-230	0.067 MeV
Th-232	0.911 MeV from Ac-228*
U-235	0.143 MeV
U-238	0.063 MeV from Th-234*

*Secular equilibrium assumed.

Spectra were also reviewed for other identifiable photopeaks.

Alpha Spectrometry

Soil samples were crushed, homogenized and analyzed for isotopic uranium. Samples were dissolved by potassium fluoride and pyrosulfate fusion and the elements of interest were precipitated with barium sulfate. Barium sulfate precipitate was redissolved and the specific elements of interest were individually separated by liquid-liquid extraction and re-precipitated with a cerium fluoride carrier. The precipitate was then counted using surface barrier and ion implanted detectors (ORTEC), alpha spectrometers (Tennelec and Canberra), and a multichannel analyzer (Nuclear Data).

UNCERTAINTIES AND DETECTION LIMITS

The uncertainties associated with the analytical data presented in the tables of this report represent the 95% confidence level for that data. These uncertainties were calculated based on both the gross sample count levels and the associated background count levels. Additional uncertainties, associated with sampling and measurement procedures, have not been propagated into the data presented in this report.

Detection limits, referred to as minimum detectable activity (MDA), were based on 2.71 plus 4.66 times the standard deviation of the background count:

$$2.71 + (4.66 \sqrt{BKG})$$

When the activity was determined to be less than the MDA of the measurement procedure, the result was reported as less than MDA. Because of variations in background levels, measurement efficiencies, the detection limits differ from sample to sample and instrument to instrument.

CALIBRATION AND QUALITY ASSURANCE

Calibration of all field and laboratory instrumentation was based on standards/sources traceable to NIST (National Institute of Standards and Technology), when such standards/sources were available. In cases where they were not available, standards of an industry recognized organization were used. Calibration of pressurized ionization chambers was performed by the manufacturer.

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

- Survey Procedures Manual, Revision 8 (December 1993)
- Laboratory Procedures Manual, Revision 8 (August 1993)
- Quality Assurance Manual, Revision 6 (July 1993)

The procedures contained in these manuals were developed to meet the requirements of DOE Order 5700.6C for Quality Assurance and NQA-1 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 EPA and EML laboratory Quality Assurance Programs.
- Training and certification of all individuals performing procedures.
- Periodic internal and external audits.

APPENDIX C

RESIDUAL RADIOACTIVE MATERIAL GUIDELINES SUMMARIZED FROM DOE ORDER 5400.5

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BASIC DOSE LIMITS

The basic limit for the annual radiation dose (excluding radon) received by an individual member of the general public is 100 mrem/yr. In implementing this limit, DOE applies as low as reasonable achievable principles to set site-specific guidelines.

STRUCTURE GUIDELINES

Indoor/Outdoor Structure Surface Contamination

Radionuclides[a]	Allowable Total Residual Surface Contamination (dpm/100 cm^2)[b] Average[c,d]	Maximum[d,e]	Removable[f]
Transuranics, Ra-226, Ra-228, Th-230 Th-228, Pa-231, Ac-227, I-125, I-129 [g]	100	300	20
Th-Natural, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000	3,000	200
U-Natural, U-235, U-238, and associated decay products	5,000α	15,000α	1,000α
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above [h]	5,000β-γ	15,000β-γ	1,000β-γ

External Gamma Radiation

The average level of gamma radiation inside a building or habitable structure on a site that has no radiological restriction on its use shall not exceed the background level by more than 20 μR/h and will comply with the basic dose limits when an appropriate-use scenario is considered.

SOIL GUIDELINES

Radionuclides	Soil Concentration (pCi/g) Above Background[i,j,k]
Ra-226 and Th-230	5 pCi/g averaged over the first 15 cm layer of soil below the surface 15 pCi/g averaged over 15 cm thick layers of soil more than 15 cm below the surface
Cesium-137	33 pCi/g[3]
Uranium	90 pCi/g[3]

[a] Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides should apply independently.

[b] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[c] Measurements of average contamination should not be averaged over an area of more than 1 m^2. For objects of less surface area, the average should be derived for each such object.

[d] The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at 1 cm.

[e] The maximum contamination level applies to an area of not more than 100 cm^2.

[f] The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping an area of that size with dry filter or soft absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less than 100 cm^2 is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. It is not necessary to use wiping techniques to measure removable contamination levels, if direct scan surveys indicate that total residual surface contamination levels are within the limits for removable contamination.

[g] Guidelines for these radionuclides are not given in DOE Order 5400.5; however, these guidelines are considered applicable until guidance is provided.

[h] This category of radionuclides includes mixed fission products, including the Sr-90 which is present in them. It does not apply to Sr-90, which has been separated from the other fission products, or mixtures where the Sr-90 has been enriched.

[i] These guidelines take into account ingrowth of radium-226 from thorium-230 or thorium-232 and radium-228 and assume secular equilibrium. If either Th-230 and Ra-226 or Th-232 and Ra-228 are both present, not in secular equilibrium, the guidelines apply to the higher concentration. If other mixtures of radionuclides occur, the concentrations of individual radionuclides shall be reduced so that (1) the dose for the mixtures will not exceed the basic dose limit, or (2) the sum of ratios of the soil concentration of each radionuclide to the allowable limit for that radionuclide will not exceed 1 ("unity").

[j] These guidelines represent allowable residual concentrations above background averaged across any 15-cm-thick layer to any depth and over any contiguous 100 m^2 surface area.

[k] If the average concentration in any surface or below-surface area, less than or equal to 25 m^2, exceeds the authorized limit of guideline by a factor of $(100/A)^{½}$, where A is the area or the elevated region in square meters, limits for "hot spots" shall also be applicable. Procedures for calculating these hot spot limits, which depend on the extent of the elevated local concentrations, are given in the DOE Manual for Implementing Residual Radioactive Materials Guidelines, DOE/CH/8901. In addition, every reasonable effort shall be made to remove any source of radionuclide that exceeds 30 times the appropriate limit for soil, irrespective of the average concentration in the soil.

REFERENCES

1. "U.S. Department of Energy Guidelines for Residual Radioactive Material at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites," Revision 2, March 1987.

2. "DOE Order 5400.5, Radiation Protection of the Public and the Environment," February 1990.

3. Gross, P.J., U.S. Department of Energy. Memorandum to J. Fiore, U.S. Department of Energy, "NFSS Residual Radioactive Material Guidelines," August 30, 1988.