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Projects

U.S. Department
of Energy

**VERIFICATION
OF
REMEDIAL ACTION
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS**

J. D. BERGER

**Radiological Site Assessment Program
Manpower Education, Research, and Training Division**

**FINAL REPORT
FEBRUARY 1988**

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INTRODUCTION

Beginning in March 1942, the Illinois National Guard Armory at Washington Park, 52nd Street and Cottage Grove Avenue, Chicago, Illinois (Figure 1), was used by the Manhattan Engineer District (MED) and its successor, the Atomic Energy Commission (AEC), for the storage and processing of uranium metal. In 1951, the AEC terminated use of the facility, and the property was returned to the State of Illinois. Decontamination, including removal of soil from the arena floor, was apparently performed at the time that MED/AEC activities were completed; however, no records, documenting the decontamination efforts and resulting radiological conditions, can be located.

During 1977 and 1978, Argonne National Laboratory conducted a radiological survey of the Armory. Findings identified some areas of residual contamination. The primary radioactive contaminant in the Armory was processed natural uranium, with minimal amounts of associated decay products (i.e., thorium-230 and radium-226).¹ Although contamination was generally limited to relatively small areas and the direct radiation levels resulting from the contamination were quite low, the levels of surface contamination exceeded the DOE guidelines.² As a result of these findings, the Illinois National Guard Armory was included in the Department of Energy's (DOE) Formerly Utilized Sites Remedial Action Program (FUSRAP).

In early 1987, Bechtel National, Inc. (BNI), the Project Management Contractor for FUSRAP, conducted additional characterization surveys, where necessary, to more accurately define the boundaries of the contamination. Results of the BNI survey were in good agreement with the earlier survey conducted by Argonne National Laboratory.³ A work plan was prepared by BNI⁴, and, during the period April through June 1987, remedial action was performed to remove or reduce radiological contamination at the Illinois National Guard Armory.

Followup survey results, presented in the BNI post-remedial action report, indicate that the remedial actions were successful in meeting the DOE guidelines.⁵

It is the policy of DOE to perform independent verifications of the effectiveness of remedial actions conducted within FUSRAP. The Radiological Site Assessment Program of Oak Ridge Associated Universities (ORAU) was designated by DOE as the organization responsible for this task at the Illinois National Guard Armory site. During the period remedial actions were being conducted, ORAU representatives performed independent measurements and sampling at this site. In addition, documents describing the project were reviewed, and selected samples were analyzed for comparison with BNI's results. This report describes the procedures and findings of these verification activities.

PROCEDURES

Objectives

The objectives of the verification were to confirm that the surveys, sampling, and analyses conducted prior to, during, and following remedial action and associated project documentation provide an accurate and complete description of the condition of the property and, thereby, confirm that remedial actions have been effective in meeting established criteria.

Procedures

General Approach

1. Radiological survey reports, work plans, and the post-remedial action report (references 1, 3-5) were reviewed. Data were evaluated to assure that areas exceeding current DOE guidelines were identified and had undergone remedial action. Post-remedial action radionuclide concentrations, surface contamination levels, and direct radiation levels were compared to guidelines, and the post-remedial action report and data were reviewed for general thoroughness and accuracy.

2. Nine of 16 soil samples, collected by BNI during the post-remedial action survey, were obtained from BNI and independently analyzed for U-238, by the ORAU laboratory, to confirm the accuracy of BNI analyses. Twelve of 40 smear samples, collected by BNI during the post-remedial action survey, were also obtained and analyzed for gross alpha and gross beta levels.

3. Survey teams from ORAU visited the site and performed visual inspections and limited independent gamma scans, exposure rate measurements, surface contamination measurements, and soil sampling on representative portions of both remediated and non-remediated areas. Dates of these independent surveys were April 28 to May 5, 1987; May 10 to 20, 1987; and June 16 to 25, 1987. Survey procedures are described in a plan⁶, prepared by ORAU and submitted to DOE's Office of Nuclear Energy; these procedures are described below.

Facility Survey

General

Independent radiological surveys were performed on almost 100% of the remediated areas. In addition, about 10% of the non-remediated rooms throughout the Armory were selected at random for surface scans and contamination measurements. Figures 2 thru 8 indicate those areas included in the ORAU surveys.

Reference Grids

In Rooms 1 and 5 of the South Head House, a 2 m x 2 m grid (Figures 9 and 10) was established on the floor and lower walls (up to 2 m) around remediated areas. Upper walls and ceilings of these areas were not gridded; survey locations on these areas were referenced to other grids or building features.

One meter grids were established on the floor of Rooms 5A and S201/202 (Figures 11 and 12) and surrounding remediated areas of greater than 1 m² in other rooms of the Armory.

Remediated areas of less than 1 m^2 and non-remediated rooms or areas were not gridded; measurements were referenced to building features.

Surface Scans

The floor and lower walls in areas selected for verification were surface scanned using NaI(Tl) gamma scintillation detectors, ZnS alpha detectors, and "pancake" GM beta-gamma detectors. Where surface areas and conditions permitted, floor scans for alpha and beta contamination were conducted with a gas-proportional floor monitor. Upper wall and overhead surface scanning on ledges, beams, piping, fixtures, equipment, and ductwork was conducted using hand held alpha and beta-gamma detectors. Elevated areas were marked for additional measurements.

Measurement of Surface Contamination Levels

In gridded areas, measurements of total alpha and beta-gamma contamination were performed in randomly selected grid blocks. A total of 140 grid-block surveys were performed (Figures 9 to 12); these consisted of measurements at the block center and at four points, midway between the center and block corners. Smears for removable alpha and beta contamination were performed at the location in each grid block, where the highest direct beta-gamma reading was obtained.

In ungridded areas, total and removable contamination levels were measured at random single point locations on the floors, walls, ceilings, and miscellaneous overhead objects. A total of 101 single-point measurements were performed at locations of remedial action; 305 single-point measurements were performed in 39 non-remediated rooms, throughout the Armory building (Figures 4 to 8).

Exposure Rate Measurements

Gamma exposure rate measurements, were performed at one meter above the floor, throughout the building. Gamma scintillation detectors, cross-calibrated onsite with a pressurized ion chamber, were used for these

measurements. The background exposure rate was established, using the pressurized ionization chamber, in areas that were not radiologically contaminated but of similiar construction material.

Catch Basin Drain System

Inside surfaces of catch basins 1, 2, 4, 5, and 6 were scanned using alpha, beta-gamma, and gamma detectors. Measurements of total beta-gamma surface contamination were performed on the catch basin walls and bottoms and on interior piping surfaces. Gamma and beta-gamma scans were performed in the main piping between all basins, in lateral drain lines entering the catch basins, and in the lateral lines connecting Room 5A and the piping section between catch basins 3 and 4.

Excavated sections along the main piping between catch basins 3 and 4, and the area where catch basin 3 was removed, were gamma scanned. Soil samples were collected from 13 locations along the piping; 16 samples were collected from the catch basin 3 excavation (Figures 13 and 14).

Outdoor Survey

Gridding

A 10 m grid was established outside the south portion of the building. This grid is shown on Figure 15.

Surface Scans

Walkover surface scans, using portable NaI(Tl) gamma scintillation detectors attached to portable ratemeters, were conducted at 1-2 meter intervals over the gridded area, to identify locations of elevated contact gamma radiation.

Exposure Rate Measurements

Gamma exposure rates were measured at the surface and at 1 meter above the surface, at grid block centers, using gamma scintillation detectors.

Conversion to exposure rates in microroentgens per hour ($\mu\text{R/h}$) were made by onsite cross calibration of the NaI(Tl) detectors with a pressurized ionization chamber (PIC).

Soil Sampling

Surface (0-15 cm) soil samples were collected from the center of each grid block.

Sample Analysis and Interpretation of Results

Smears for the determination of removable contamination were counted for gross alpha and gross beta activity. Soils were analyzed by gamma spectroscopy for uranium-238 and other identifiable photopeaks. Major analytical equipment used in support of this survey is listed in Appendix A; Appendix B describes the measurement and analytical procedures.

Findings of the inspections and radiological surveys were compared with the post-remedial action report and the established Illinois National Guard Armory guidelines (Appendix C).

FINDINGS AND RESULTS

Document Review

Review of the ANL and BNI characterization reports indicated that the major areas of contamination were identified by both surveys. These major areas were surfaces in Rooms 1 and 5 and the catch basin system servicing these two rooms. Other locations identified by both organizations were Rooms 1E, 5B, S201/202 (messhall), S213, S212, and S250 (the 2nd floor corridor). In addition to the locations identified by ANL, BNI also found small areas of contamination in Rooms 1A, S215, and S234. It should be noted that in the time period between the ANL and BNI surveys numerous changes in room partitioning have taken place; also, the room numbering identification system has been changed throughout the facility. (Throughout this verification report, the current room identification numbers are used. For comparison of current and past room layout and identification, the reader should consult references 1, 3, and 5.)

Review of characterization and interim remedial action data indicated that decisions regarding requirements for remediation were appropriate. Visual inspections confirmed that identified areas were remediated to the extent described in the post-remedial action report. Data presented in the post-remedial action report demonstrate that the remedial actions were effective in meeting the established cleanup guidelines at all identified locations.

Confirmatory Sample Analyses

Table 1 presents the results of gamma spectrometry analyses, performed by ORAU and BNI, for 9 soil samples from the remediated areas. For the primary radionuclide of concern, U-238, data are in agreement within their respective 99% confidence intervals for 8 of the 9 samples. It should be noted that most of the samples contained U-238 concentrations near or below the detection limits of the analytical procedures. Therefore these concentration values have relatively large uncertainty values associated with them. In addition, BNI analyzed the samples in an unprocessed form (not dried or ground), and, because the levels were well below the guideline values, BNI did not have the samples reanalyzed after processing. ORAU analyses were on processed samples; direct comparison of results is therefore not technically correct. The one sample for which the analytical results of the 2 laboratories differed by greater than the 99% confidence intervals was sample 258. The BNI analysis indicated 38 ± 14 pCi/g; the ORAU measurement was 18.1 ± 2.1 pCi/g. Although this difference has not been explained, it is important to emphasize that all measurements on these samples by both laboratories were well within the guideline soil concentration of 150 pCi/g.

Results of the confirmatory analyses on 12 smear samples are also presented in Table 1. Gross alpha results on all of these samples indicated agreement within the 99% confidence intervals. As with the soil samples, most of these smears contained radioactivity levels below or near the detection sensitivities of the procedures and consequently have relatively large uncertainty values. BNI did not measure gross beta levels on these smears; however, ORAU measurements of the gross beta levels indicated that most of these, too, were very low. All smears measured by ORAU and BNI were well below the DOE surface contamination guideline level of 5000 dpm/100 cm²,

averaged over 1 m², for both alpha and beta radiations associated with uranium contamination. On the basis of these findings, it is ORAU's opinion that the BNI data are accurate, within the statistical limitations of the analytical procedures and adequately represent the radiological status of the site.

Verification Surveys

Remediated Areas

Surface scans of remediated areas identified small sites of residual contamination exceeding guidelines at several locations in Rooms 5B (floor, walls, and drain), S201/202 (floor), and S212 (sump). These were brought to the attention of the remedial-action contractor. Further decontamination of these areas was performed immediately and followup scans by ORAU verified the effectiveness of the additional cleanup actions. Scans of other remediated areas indicated no areas of residual surface contamination in excess of guidelines.

The results of contamination measurements on remediated surface areas are summarized in Table 2. Total alpha levels ranged from <30 to 990 dpm/100 cm², beta-gamma levels ranged from <560 to 8000 dpm/100 cm². All locations exceeding 5000 dpm/100 cm² beta-gamma were small isolated spots and averaging over adjacent 1 m² areas resulted in levels below the 5000 dpm/100 cm² guideline. None of these locations exceeded the limit of 15000 dpm for maximum contamination levels averaged over a 100 cm² area. The maximum beta-gamma level of 8000 dpm/100 cm² is equivalent to a surface dose rate of approximately 0.19 mrad/h, which is within the guideline values of 0.20 mrad/h, average, and 1.0 mrad/h, maximum. Removable surface contamination ranges were <3 to 19 alpha dpm/100 cm² and <6 to 23 beta dpm/100 cm².

Scans of catch basins 1, 2, 4, 5, and 6 and remaining piping indicated no locations of gross residual contamination in excess of DOE guidelines. Surface contamination measurements in the catch basins are summarized in Table 3. Total beta-gamma levels ranged from <620 to 14770 dpm/100 cm². The porous, rough, and dirt and oil coated condition of the catch basin and piping surfaces prevented meaningful alpha contamination measurements. Although small areas of the surfaces in these drainage and collection systems are above

5000 dpm/100 cm², the average contamination levels were below that guideline value. In addition, the individual isolated spots, when averaged over 100 cm², were within the maximum guideline level of 15000 dpm/100 cm². Beta-gamma dose rates satisfied the criteria of 1.0 mrad/h, maximum, and 0.2 mrad/h, average.

Uranium 238 concentrations in samples of soil from the excavated area of catch basin 3 and trenches, where piping was removed, are presented in Table 4. The highest U-238 concentration was 13.4 ± 2.0 pCi/g from the bottom of the catch basin 3 excavation. This is well within the guideline of 150 pCi/g. For comparison, the background concentration of U-238 in samples, collected by ORAU from the vicinity of the Armory, ranged from <1.1 to 2.5 pCi/g.

Non-remediated Areas

Surface scans and contamination measurements in randomly selected non-remediated areas indicated that all of these areas satisfy the DOE guidelines. Results of the measurements in these rooms are presented in Table 5. Total alpha contamination levels ranged from <30 to 140 dpm/100 cm²; total beta-gamma levels ranged from <600 to 5400 dpm/100 cm². Highest levels were located on the floor of the 2nd floor corridor (area S250) in the South Head House. Detectable contamination was limited to small (<100 cm²) isolated areas. The contamination levels at these locations are within the 15000 dpm/100 cm² guideline for maximum concentrations, averaged over areas of 100 cm². Also, averaging the detectable contamination over surface areas of 1 m² results in levels well below the 5000 dpm/100 cm² guideline value for such areas. Removable levels of alpha and beta contamination were <3 to 5 dpm/100 cm² and <6 to 52 dpm/100 cm², respectively.

In addition to the surveys of 39 non-remediated rooms, scans for alpha and beta-gamma contamination were performed on portions of the arena floor and on the floors of the aisles on all sides of the arena floor. No areas of residual contamination were identified by these scans.

Exposure Rates

Table 6 summarizes gamma exposure rates, measured throughout the Armory. Measurements ranged from 8 to 16 µR/h. Levels were slightly higher in small

rooms on the first floor of the South Head House, probably due, in part, to natural activity in concrete material and storage of instruments with luminous dials (Ra-226) in this general area. All levels are well within the DOE guideline of 20 $\mu\text{R/h}$ above background. Background exposure rates, measured in the vicinity of the Armory by ORAU, averaged approximately 8 $\mu\text{R/h}$; inside the concrete Armory structure the background exposure rates averaged approximately 11 $\mu\text{R/h}$.

Outdoor Survey

Surface scans did not identify any locations of significantly elevated gamma radiation in the gridded area outside the south portion of the Armory. Exposure rates over this area ranged from 8 to 11 $\mu\text{R/h}$, with an average of approximately 9 $\mu\text{R/h}$ (Table 7), which is comparable to the average background level of 8 $\mu\text{R/h}$. Concentrations of uranium-238 in soil samples from this area are also presented in Table 7. The maximum concentration of U-238 in these samples was 16.5 ± 2.1 pCi/g, which is well within the site specific guideline value of 150 pCi/g. No other radionuclides were present in these samples at concentrations higher than those naturally occurring in surface soil from this area.

CONCLUSIONS

During April to June 1987, Oak Ridge Associated Universities' Radiological Site Assessment Program performed independent activities to verify the adequacy of remedial actions at the Illinois National Guard Armory and the accuracy of documentation supporting the remedial actions. The verification activities included document review, confirmatory laboratory analyses, and independent direct measurements and sampling analysis. Based on the results and findings of these activities it is ORAU's opinion that the remedial action has been effective in satisfying the established DOE criteria. It is also ORAU's opinion that the documentation supporting the remedial action process is adequate and accurate. A verification letter, indicating these opinions, was provided to DOE in June 1987.⁷

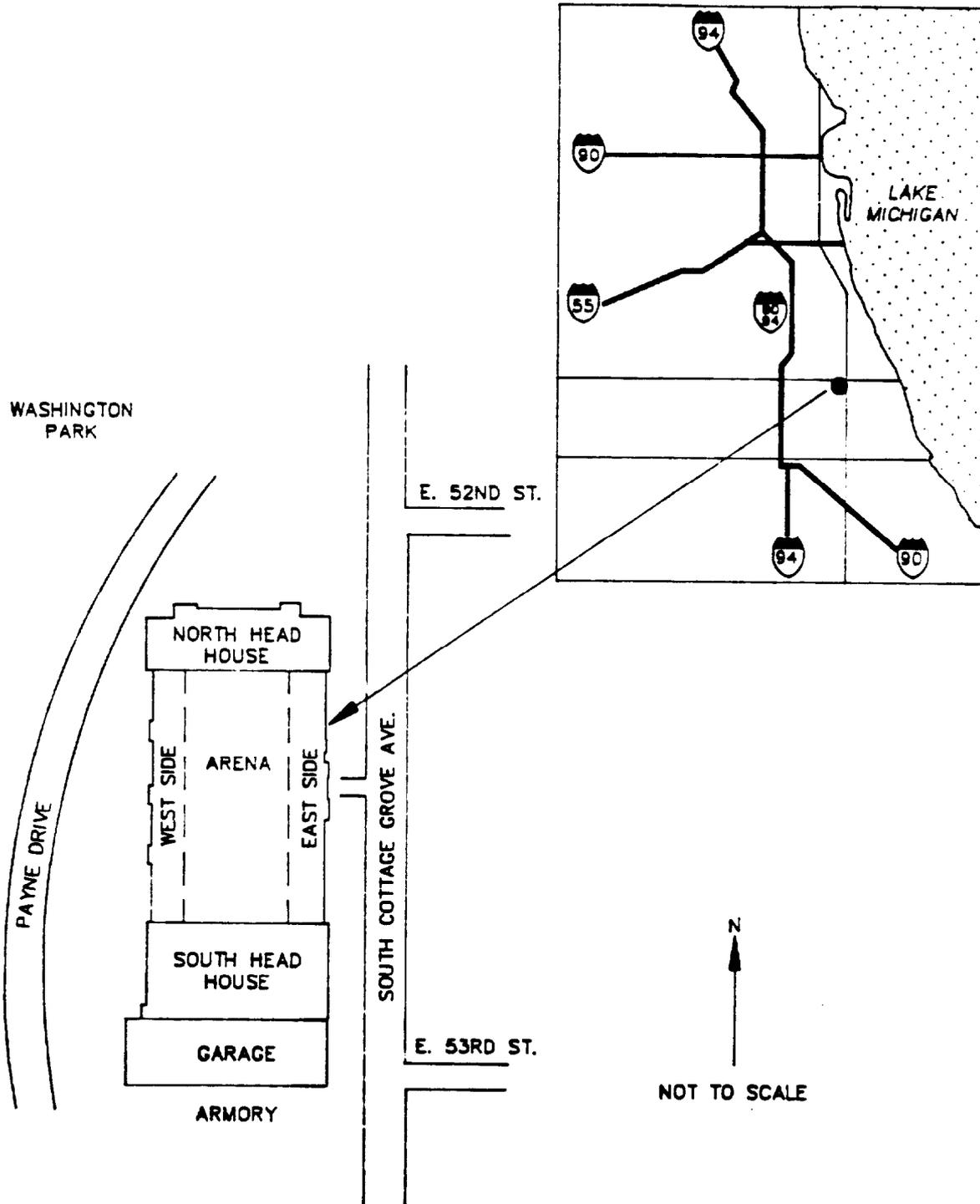


FIGURE 1: Chicago Area, Indicating the Location of the Illinois National Guard Armory

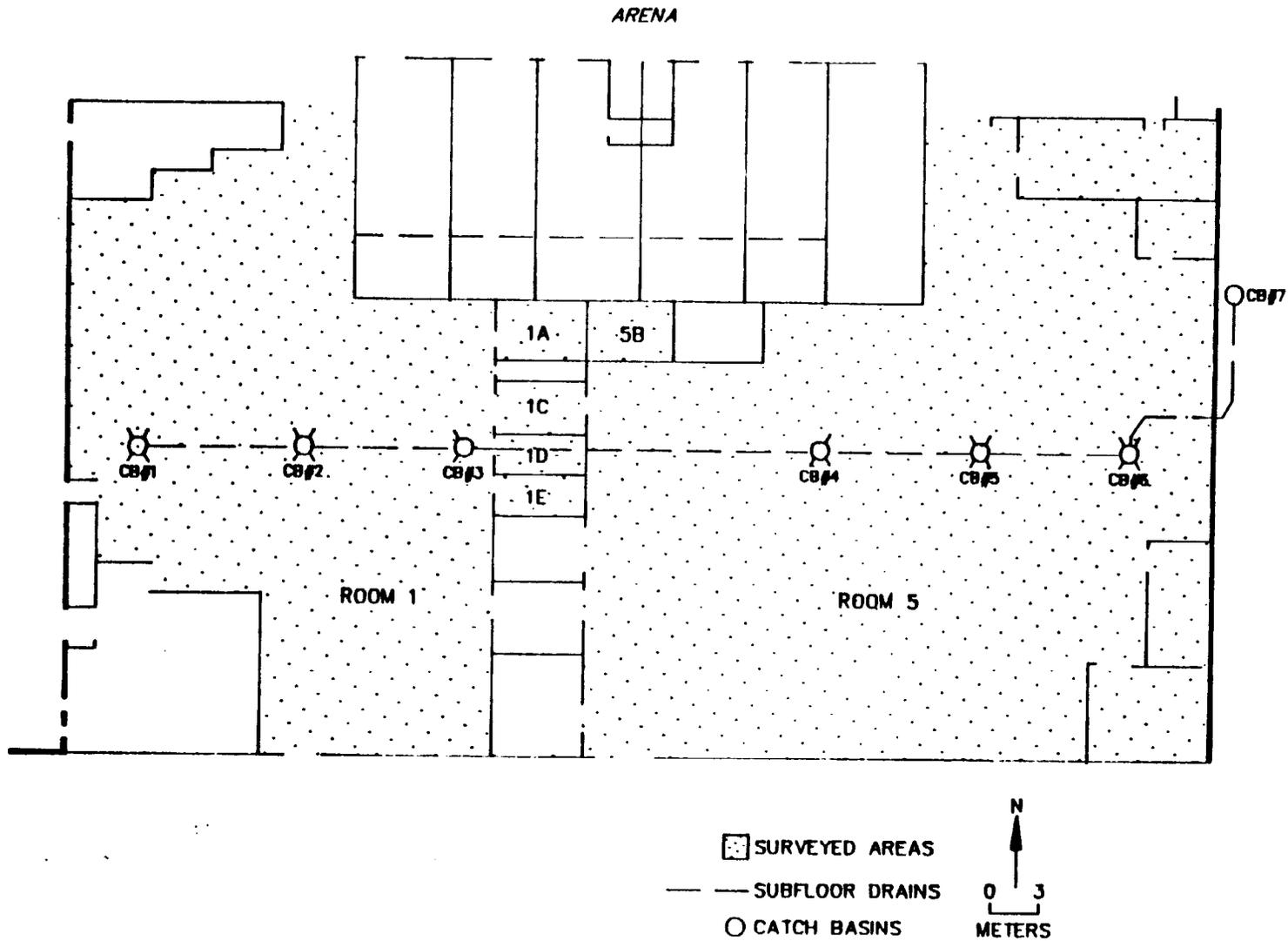


FIGURE 2: Locations of Remediated Areas on the First Level of the South Head House, Surveyed by the IVC

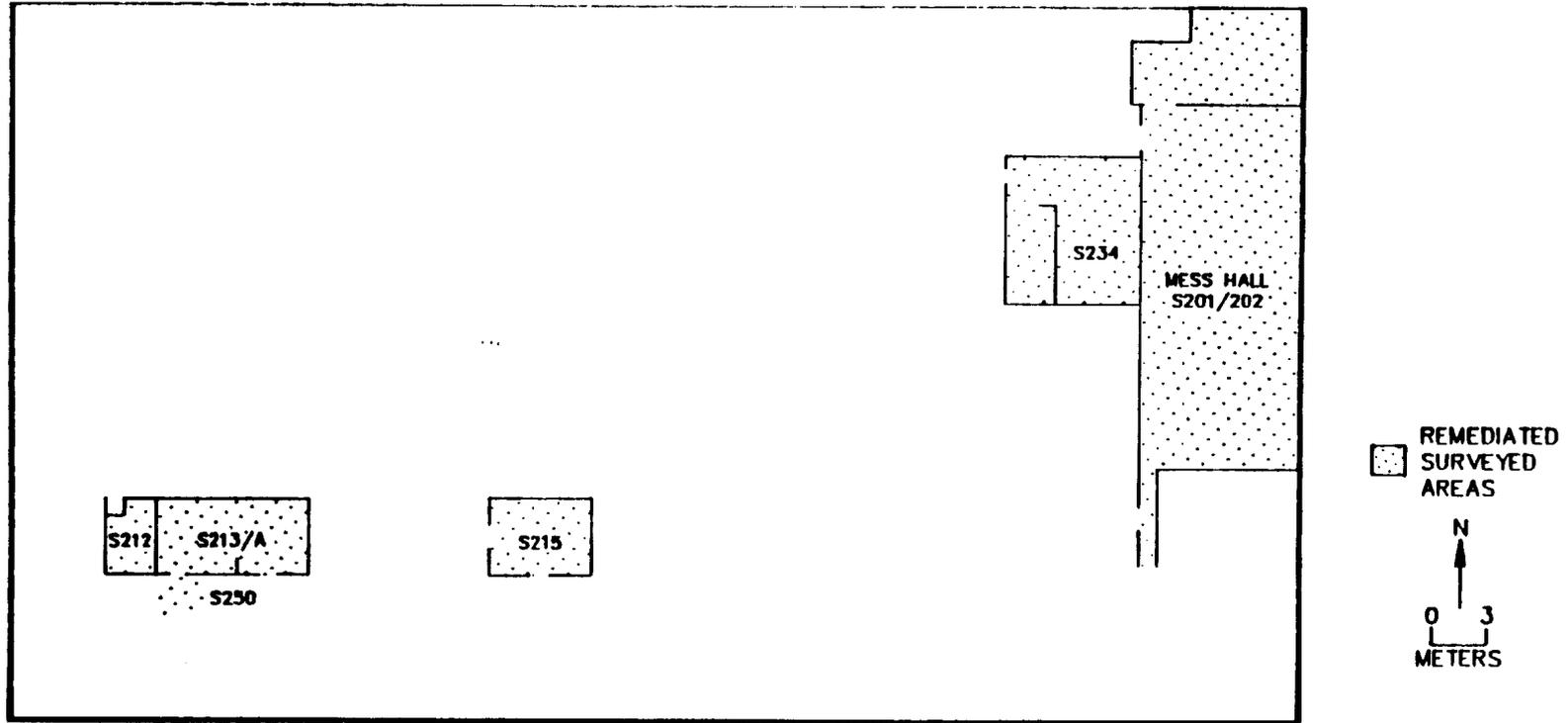


FIGURE 3: Locations of Remediated Areas on the Second Level of the South Head House, Surveyed by the IVC

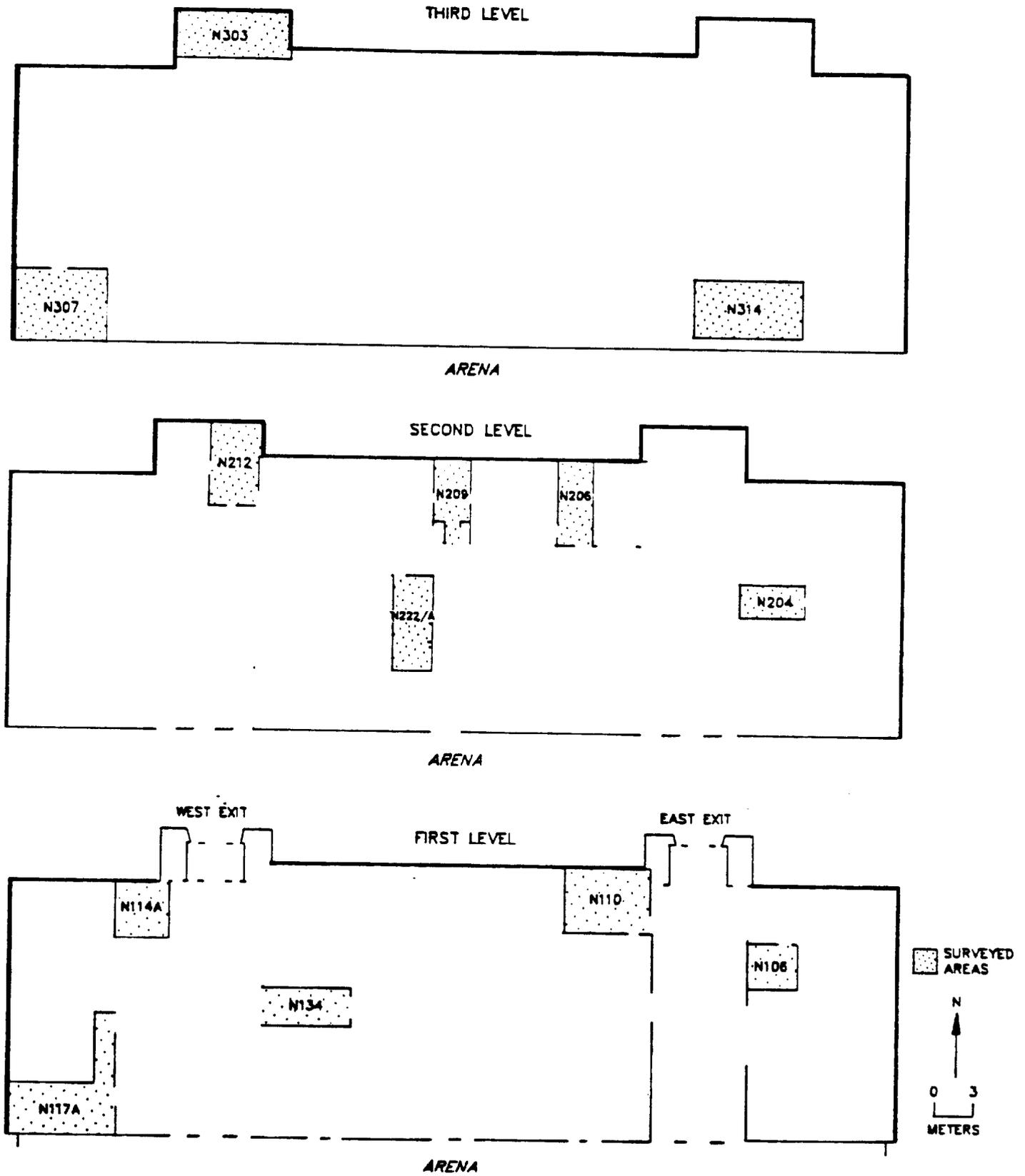
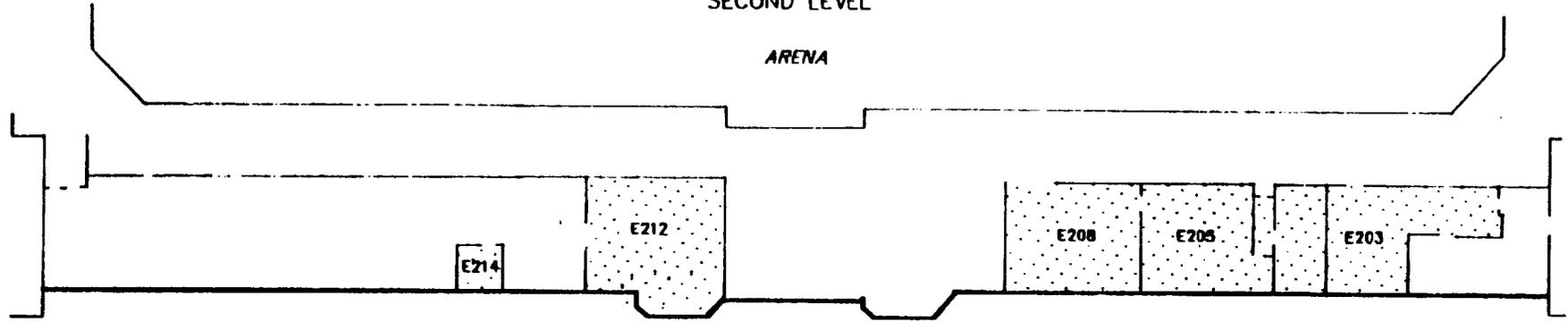


FIGURE 4: Non-remediated Areas of the North Head House, Randomly Selected for Survey

SECOND LEVEL

ARENA



FIRST LEVEL

ARENA

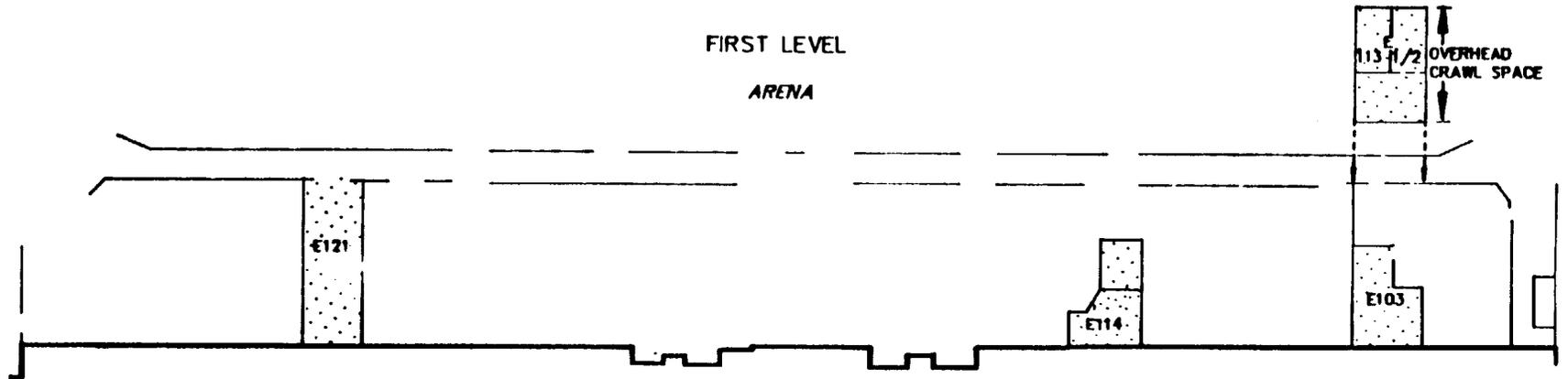


FIGURE 5: Non-remediated Areas of the East Wing, Randomly Selected for Survey

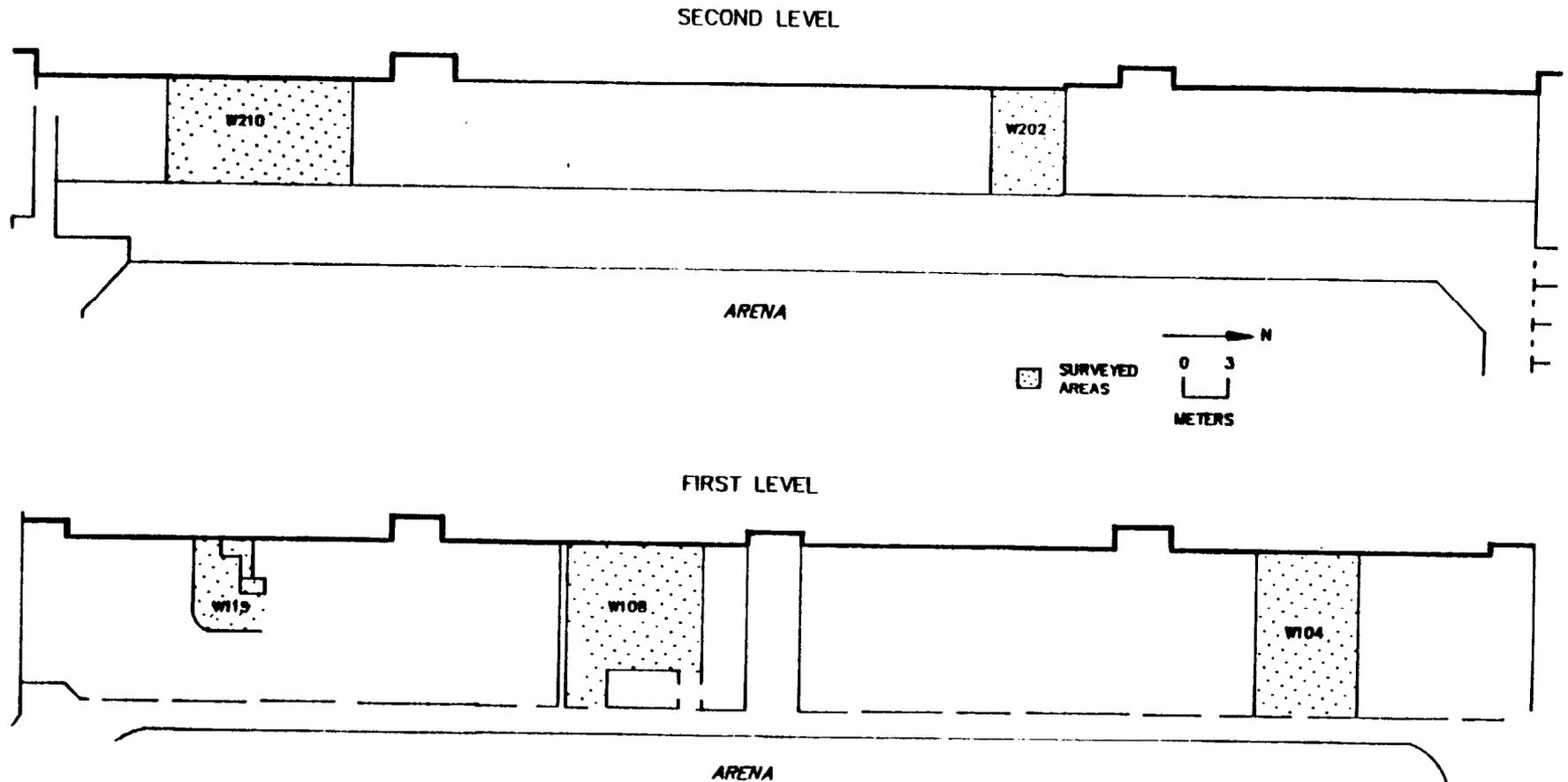


FIGURE 6: Non-remediated Areas of the West Wing, Randomly Selected for Survey

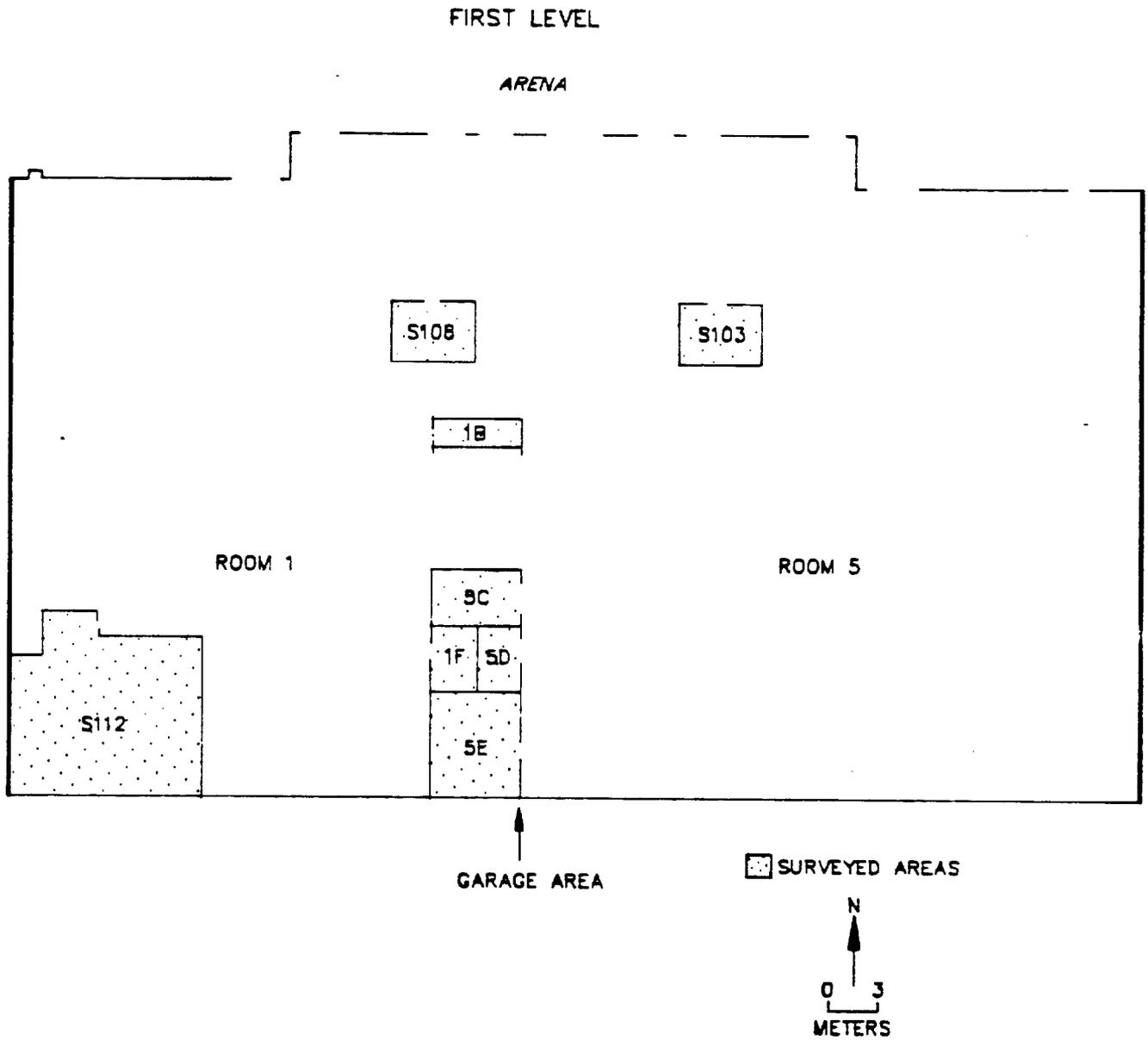


FIGURE 7: Non-remediated Areas of South Head House (First Level), Selected for Survey

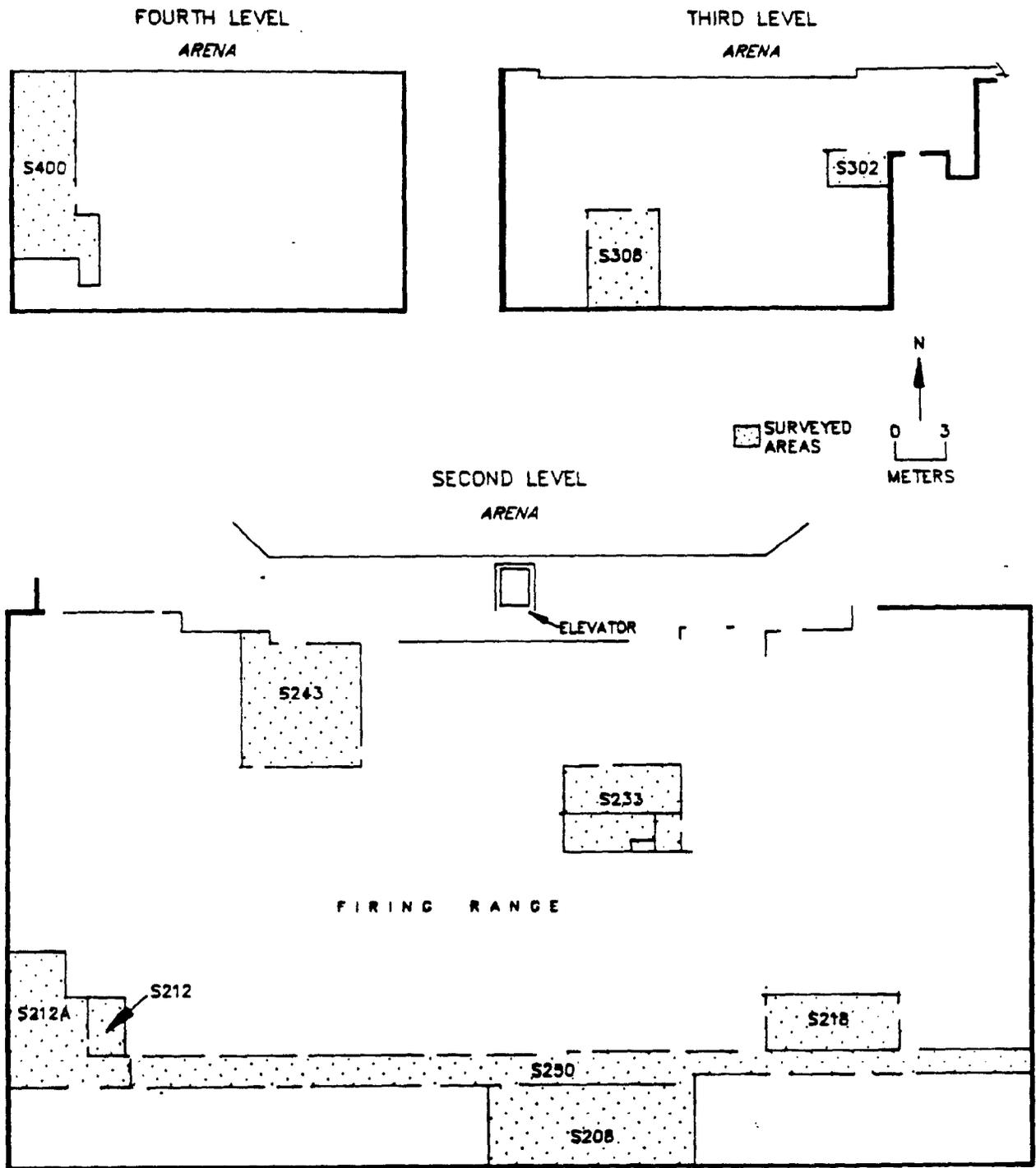


FIGURE 8: Non-remediated Areas of the South Head House, (Second, Third, and Fourth Levels) Randomly Selected for Survey

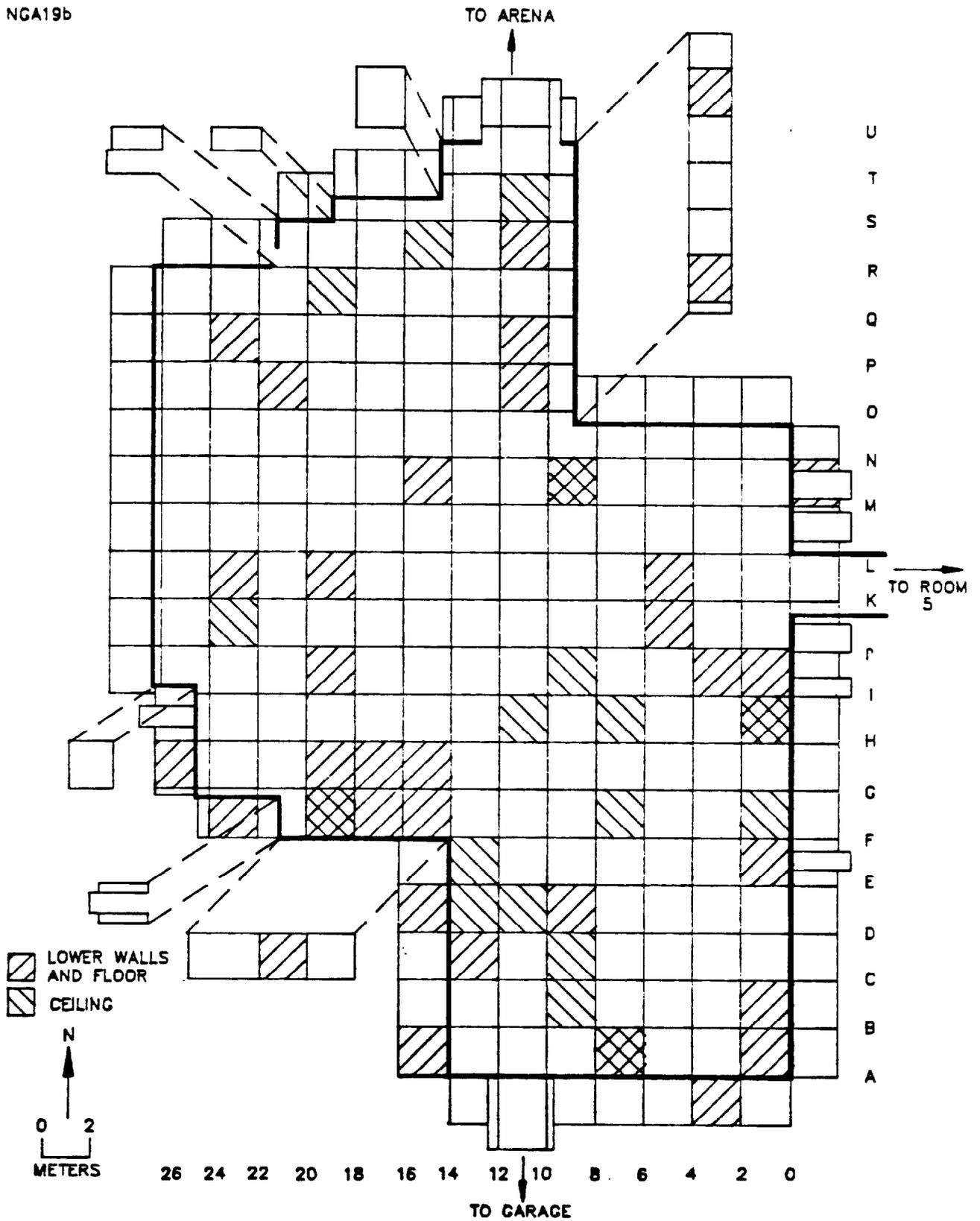


FIGURE 9: Grid System in Room 1 of the South Head House, Indicating Areas Selected for Surface Contamination Measurements

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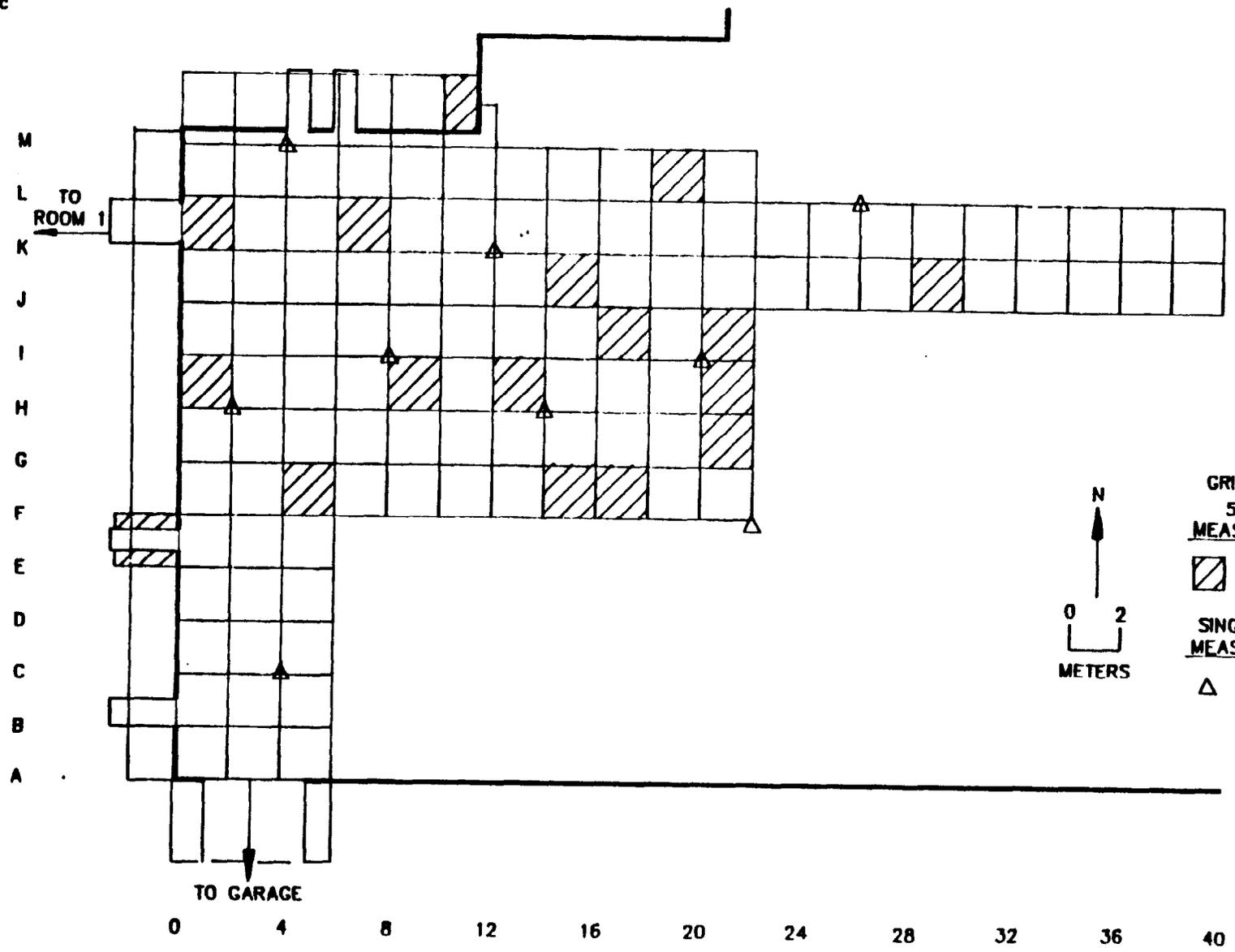


FIGURE 10: Grid System in Room 5 of the South Head House, Indicating Areas Selected for Surface Contamination Measurements

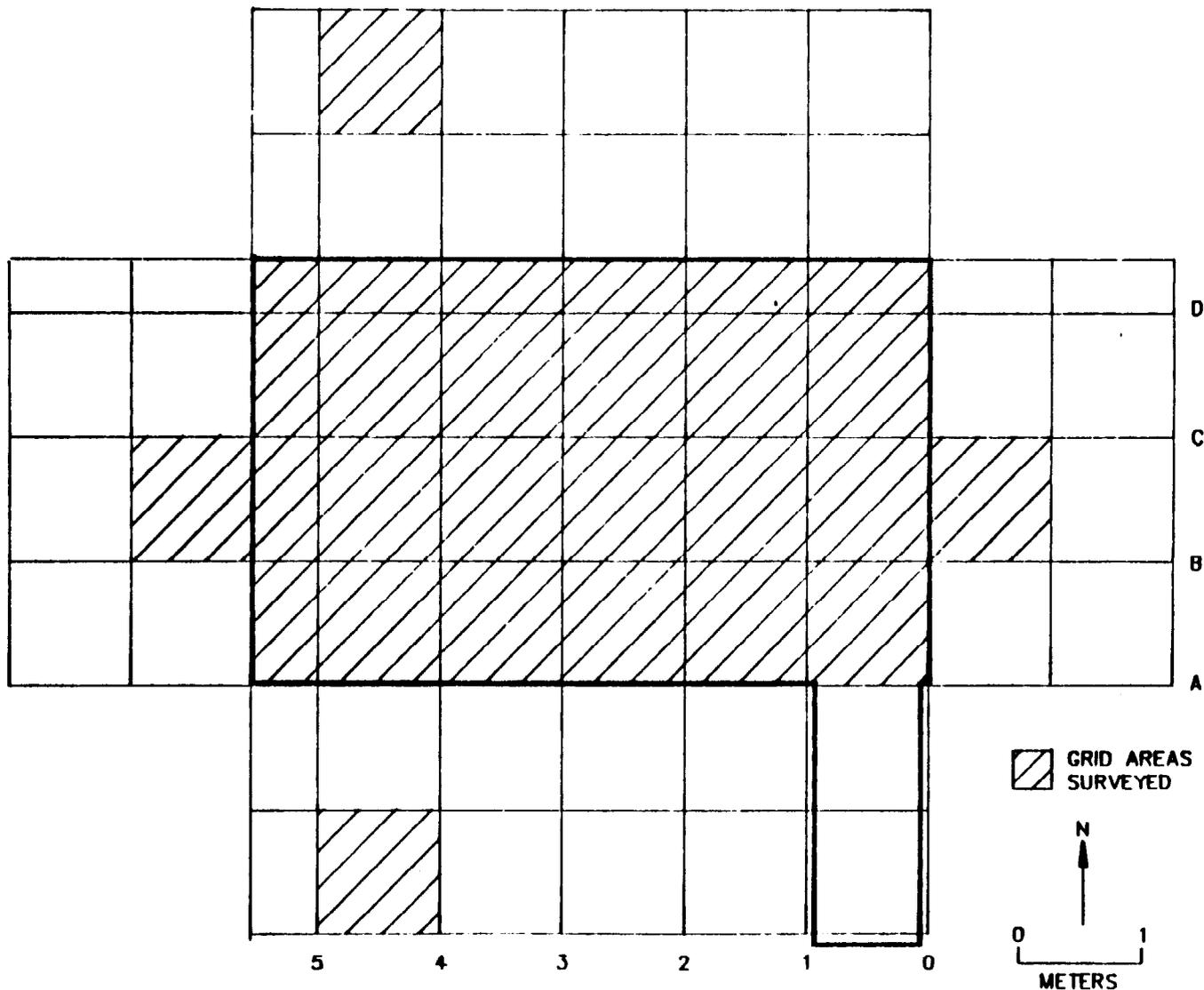


FIGURE 11: Reference Grid Established in Room 5B, Indicating Grid Blocks Surveyed

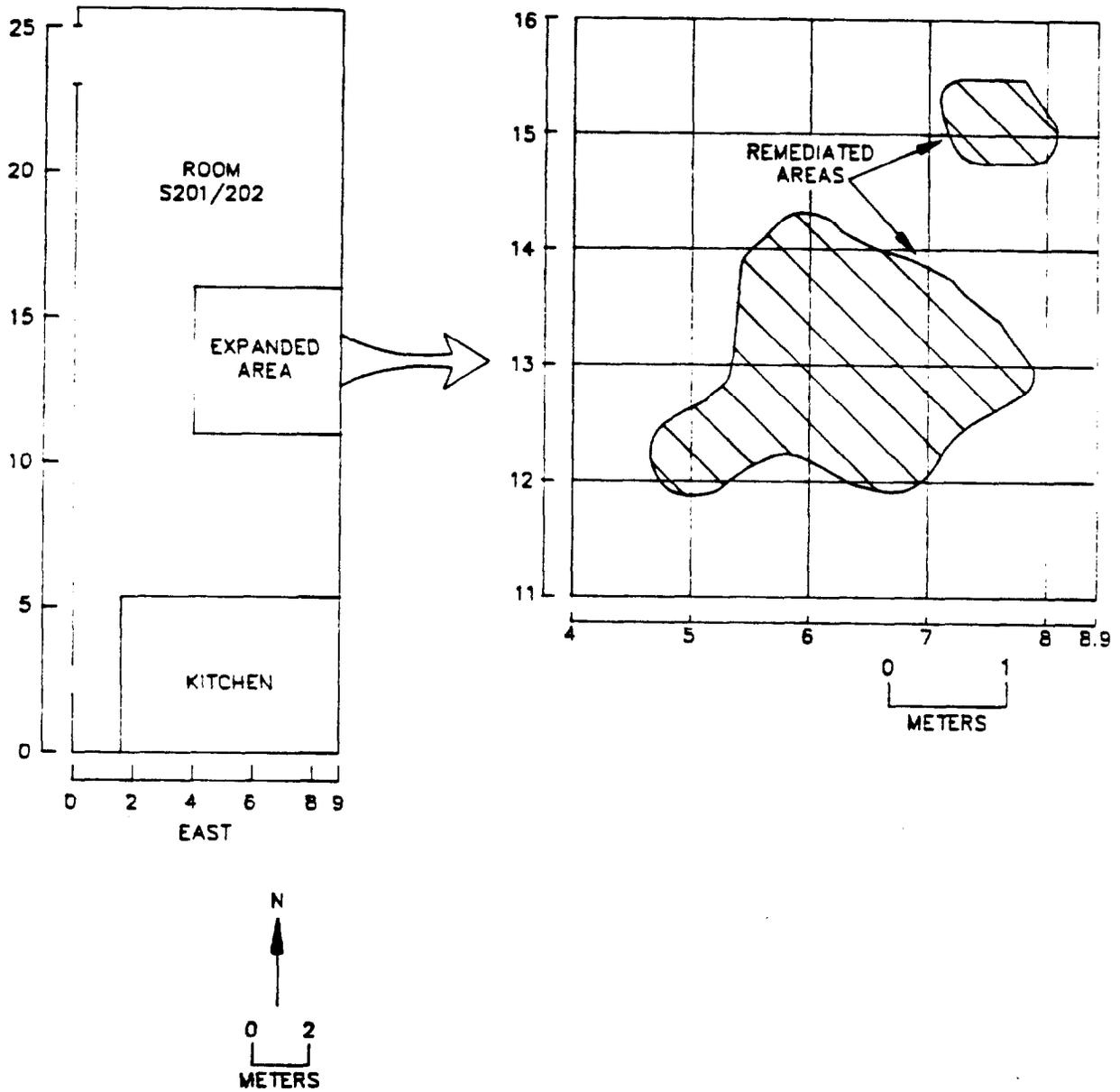
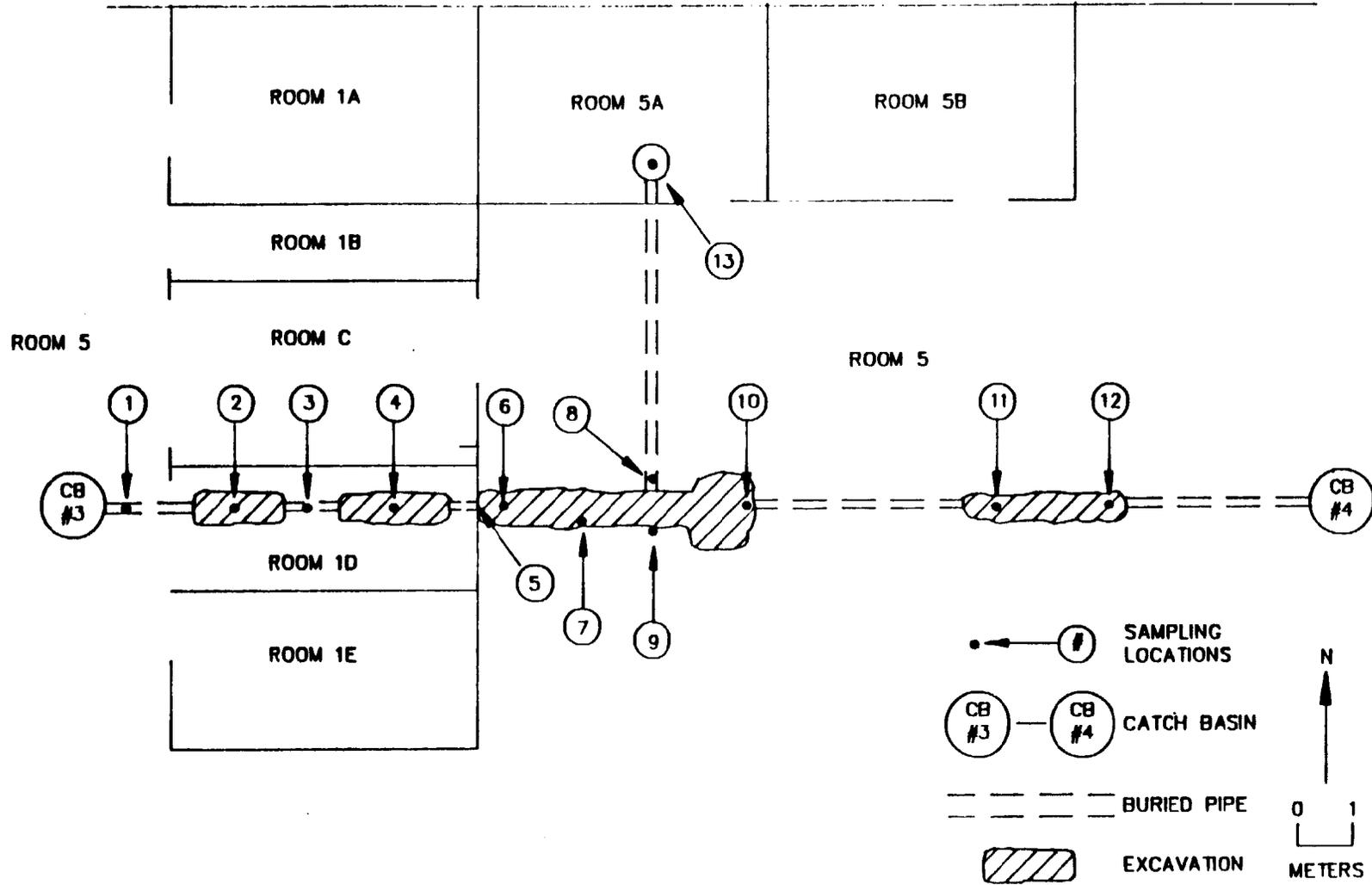


FIGURE 12: Room S201/202 Indicating Remediated Area and Grid System Established for Survey Reference



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FIGURE 13: Locations of Samples from Excavations Between Catch Basins #3 and #4

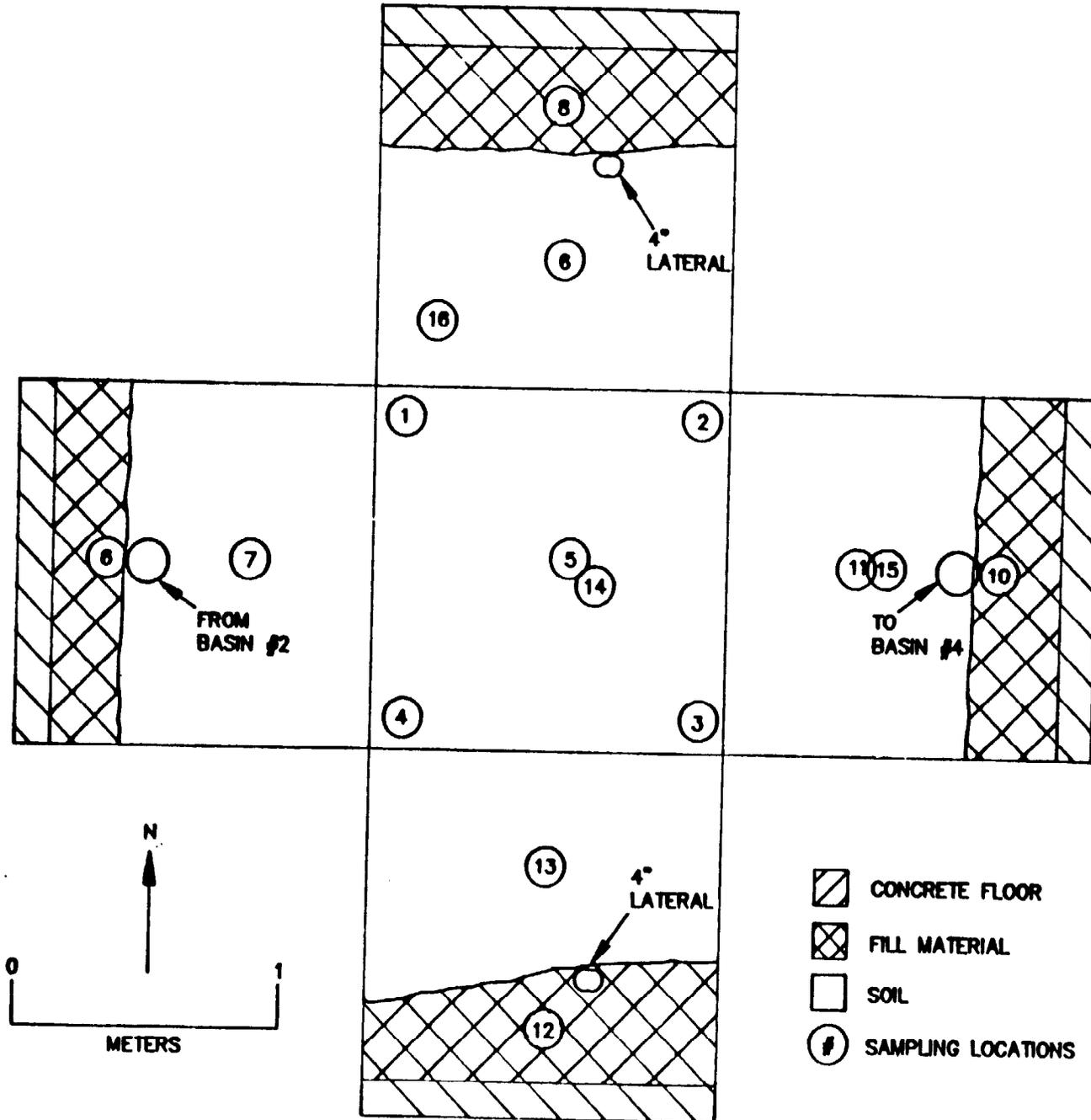


FIGURE 14: Locations of Soil Samples In Excavated Catch Basin #3 Area

NGA3

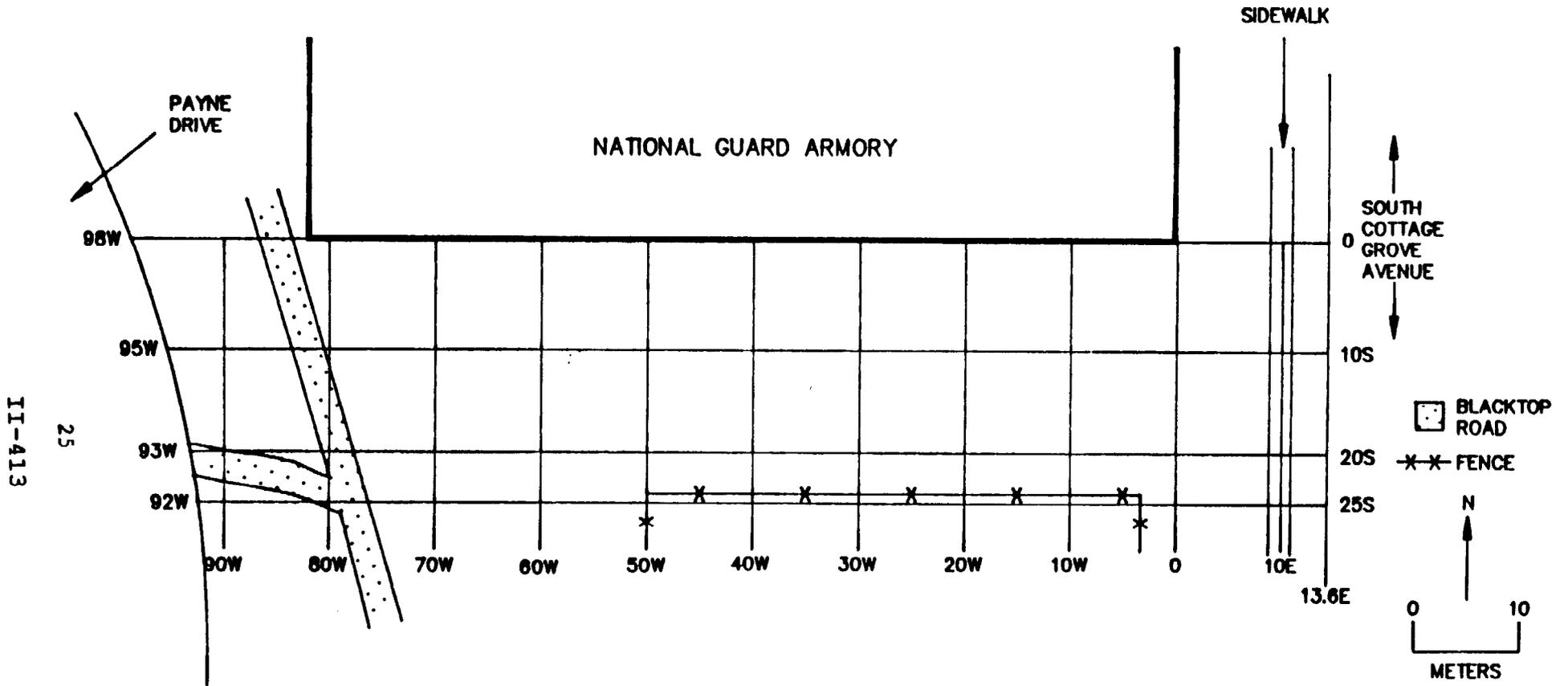


FIGURE 15: Exterior Grid System Established at South End of National Guard Armory Facility

TABLE 1

RESULTS OF CONFIRMATORY ANALYSES
ON SOIL AND SMEAR SAMPLES
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Sample ^a	Analysis By	Concentration			
		U-238 (pCi/g)	Gross alpha (dpm/100 cm ²)	Gross beta (dpm/100 cm ²)	
<u>SOIL</u>					
244	Catch Basin 3, NW Corner	BNI	<5	--- ^c	---
		ORAU	3.0 ± 0.9 ^b	--	---
247	Catch Basin 3, SE Corner	BNI	<4	--	---
		ORAU	0.7 ± 0.9	--	---
251	Excavation Between Catch Basin 3 & 4	BNI	<6	--	---
		ORAU	0.9 ± 1.5	--	---
252	Excavation Between Catch Basin 3 & 4	BNI	<14	--	---
		ORAU	<0.5	--	---
254	Excavation Between Catch Basin 3 & 4	BNI	8 ± 9	--	---
		ORAU	1.3 ± 1.2	--	---
257	Composite, Barrel "G"	BNI	11 ± 9	--	---
		ORAU	9.5 ± 2.4	--	---
258	Composite, Barrel "H"	BNI	38 ± 14	--	---
		ORAU	18.1 ± 2.1	--	---
279	Excavation	BNI	<8	--	---
		ORAU	2.4 ± 1.4	--	---
281	Drain, Room 5B	BNI	<6	--	---
		ORAU	2.1 ± 2.2	--	---

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TABLE 1 (Continued)
 RESULTS OF CONFIRMATORY ANALYSES
 ON SOIL AND SMEAR SAMPLES
 ILLINOIS NATIONAL GUARD ARMORY
 CHICAGO, ILLINOIS

Sample ^a	Analysis By	Concentration		
		U-238 (pCi/g)	Gross alpha (dpm/100 cm ²)	Gross beta (dpm/100 cm ²)
<u>SMEAR</u>				
996	BNI	--	5 ± 12	--
	ORAU	--	<4	<9
998	BNI	--	8 ± 15	--
	ORAU	--	16 ± 17	15 ± 12
999	BNI	--	5 ± 12	--
	ORAU	--	10 ± 12	19 ± 14
1003	BNI	--	5 ± 12	--
	ORAU	--	<4	13 ± 11
1008	BNI	--	8 ± 15	--
	ORAU	--	7 ± 11	<9
1010	BNI	--	10 ± 17	--
	ORAU	--	<4	13 ± 11
1013	BNI	--	<2	--
	ORAU	--	<4	<8
1015	BNI	--	36 ± 30	--
	ORAU	--	21 ± 18	31 ± 17
1020	BNI	--	10 ± 17	--
	ORAU	--	5 ± 9	15 ± 12

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TABLE I (Continued)

RESULTS OF CONFIRMATORY ANALYSES
ON SOIL AND SMEAR SAMPLES
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Sample ^a	Analysis By	Concentration		
		U-238 (pCi/g)	Gross alpha (dpm/100 cm ²)	Gross beta (dpm/100 cm ²)
<u>SMEAR</u>				
1022	BNI	--	<2	--
	ORAU	--	<4	<9
1028	BNI	--	13 ± 16	--
	ORAU	--	<4	<9
1032	BNI	--	132 ± 57	--
	ORAU	--	110 ± 45	136 ± 39

^aSample identification as obtained from TMA/Eberline analytical report forms.

^bUncertainties represent the 99% confidence limits based only on counting statistics.

^cDash indicates analysis was not performed

TABLE 2

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS
IN REMEDIATED AREAS
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Room and ^a Area	Number of Grid Blocks or Locations Surveyed	TOTAL CONTAMINATION					
		Alpha (dpm/100 cm ²)		Beta-Gamma (dpm/100 cm ²)		REMOVABLE CONTAMINATION	
		Highest Grid Block Avg.	Range of Measurements	Highest Grid Block Avg.	Range of Measurements	Alpha Range (dpm/100 cm ²)	Beta Range (dpm/100 cm ²)
<u>Room 1</u>							
Floors/L. Walls ^b	36	190	<32 - 540	2,500	<600 - 8,000	<3 - 7	<6 - 14
U. Walls/Ceilings ^b	18	620	<30 - 990	1,400	<570 - 2,600	<3 - 19	<6 - 23
<u>Room 1A</u>							
Floors/L. Walls ^b	4	280	<30 - 470	1,600	<600 - 2,000	<3	<6 - 7
U. Walls/Ceilings	0	N/A ^d	N/A	N/A	N/A	N/A	N/A
<u>Room 1B</u>							
Floors/L. Walls ^c	5	N/A	<30 - 91	N/A	<600 - 1,500	<3	<6
U. Walls/Ceiling	0	N/A	N/A	N/A	N/A	N/A	N/A
<u>Room 1D</u>							
Floors/L. Walls ^c	5	N/A	<30 - 39	N/A	<600 - 1,500	<3	<6
U. Walls/Ceilings ^c	1	N/A	<30	N/A	<600	<3	<6
<u>Room 1E</u>							
Floors/L. Walls ^b	6	32	<30 - 39	1,100	<600 - 1,700	<3	<6
U. Walls/Ceilings	0	N/A	N/A	N/A	N/A	N/A	N/A
<u>Room 1F</u>							
Floors/L. Walls ^c	6	N/A	<30 - 39	N/A	<600 - 880	<3	<6
U. Walls/Ceilings	0	N/A	N/A	N/A	N/A	N/A	N/A

TABLE 2 (Continued)

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS
IN REMEDIATED AREAS
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Room and Area	Number of Grid Blocks or Locations Surveyed	TOTAL CONTAMINATION				REMOVABLE CONTAMINATION	
		Alpha (dpm/100 cm ²)		Beta-Gamma (dpm/100 cm ²)		Alpha Range	Beta Range
		Highest Grid Block Avg.	Range of Measurements	Highest Grid Block Avg.	Range of Measurements	(dpm/100 cm ²)	(dpm/100 cm ²)
<u>Room 5</u>							
Floors/L. Walls ^b	17	50	<21 - 110	970	<600 - 1,700	<3	<6 - 7
U. Walls/Ceilings ^c	10	N/A	<30 - 110	N/A	<570 - 770	<3	<6
<u>Room 5A</u>							
Floors/L. Walls ^b	28	49	<30 - 125	2,300	<620 - 7,600	<3 - 5	<6 - 18
U. Walls/Ceilings	0	N/A	N/A	N/A	N/A	N/A	N/A
<u>Room 5C</u>							
Floors/L. Walls ^c	6	N/A	<30 - 39	N/A	<600 - 690	<3	<6
U. Walls/Ceiling	0	N/A	N/A	N/A	N/A	N/A	N/A
<u>Room 5D</u>							
Floors/L. Walls ^c	7	N/A	<30 - 39	N/A	<600 - 690	<3	<6
U. Walls/Ceilings	0	N/A	N/A	N/A	N/A	N/A	N/A
<u>Room 5E</u>							
Floors/L. Walls ^c	6	N/A	<30 - 39	N/A	<570	<3 - 7	<6
U. Walls/Ceilings	0	N/A	N/A	N/A	N/A	N/A	N/A
<u>Room S201/202</u>							
Floors/L. Walls ^b	31	94	<35 - 350	3,000	<560 - 7,800	<3 - 5	<6 - 15
U. Walls/Ceilings ^c	12	N/A	<39 - 98	N/A	<630 - 690	<3	<6 - 7

TABLE 2 (Continued)

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS
IN REMEDIATED AREAS
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Room and Area	Number of Grid Blocks or Locations Surveyed	TOTAL CONTAMINATION				REMOVABLE CONTAMINATION	
		Alpha (dpm/100 cm ²)		Beta-Gamma (dpm/100 cm ²)		Alpha Range	Beta Range
		Highest Grid Block Avg.	Range of Measurements	Highest Grid Block Avg.	Range of Measurements	(dpm/100 cm ²)	(dpm/100 cm ²)
<u>Room S212</u>							
Floors/L. Walls ^c	6	N/A	<30 - 320	N/A	<620 - 6,300	<3	<6
U. Walls/Ceilings	0	N/A	N/A	N/A	N/A	N/A	N/A
<u>Room S213/A</u>							
Floors/L. Walls ^c	12	N/A	<35 - 88	N/A	<630 - 7,000	<3	<6
U. Walls/Ceilings ^c	4	N/A	<35 - 53	N/A	<630	<3	<6
<u>Room S215</u>							
Floors/L. Walls ^c	7	N/A	<35 - 88	N/A	<630	<3	<6 - 9
U. Walls/Ceilings ^c	2	N/A	<35 - 53	N/A	<630	<3	<6 - 7
<u>Room S234</u>							
Floors/L. Walls ^c	6	N/A	<35 - 53	N/A	<630 - 1,100	<3	<6 - 7
U. Walls/Ceilings ^c	6	N/A	<35 - 71	N/A	<630	<3	<6 - 8

^aRefer to Figures 2, 3, 9, 10, 11, and 12.

^bFive-point measurements in grid blocks.

^cSingle-point measurements.

^dN/A = Not applicable.

TABLE 3
 SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS
 IN CATCH BASINS AND PIPING
 ILLINOIS NATIONAL GUARD ARMORY
 CHICAGO, ILLINOIS

Location	Beta-Gamma Contamination Levels	
	(dpm/100 cm ²)	(mrad/h)
Catch Basin #1		
walls	<620	<0.01
bottom	<620	<0.01
piping	<620 - 2030	<0.01 - 0.04
Catch Basin #2		
walls	1000	0.20
bottom	1750 - 14770	0.04 - 0.30
piping	<620 - 10640	<0.01 - 0.22
Catch Basin #4		
walls	<620 - 11270	<0.01 - 0.23
bottom	<620	<0.01
piping	<620 - 14350	<0.01 - 0.30
Catch Basin #5		
walls	<620 - 4130	<0.01 - 0.08
bottom	1440 - 5250	0.03 - 0.11
piping	<620 - 12040	<0.01 - 0.25
Catch Basin #6		
walls	<620 - 6650	<0.01 - 0.14
bottom	<620	<0.01
piping	1120 - 1750	0.02 - 0.04

TABLE 4
 URANIUM 238 CONCENTRATIONS IN
 SOIL SAMPLES FROM EXCAVATED AREAS
 ILLINOIS NATIONAL GUARD ARMORY
 CHICAGO, ILLINOIS

Location	U-238 Concentration (pCi/g) ^a
Catch Basin 3 ^b	
1	3.9 ± 0.8 ^c
2	7.7 ± 1.3
3	3.8 ± 0.7
4	4.8 ± 0.9
5	13.4 ± 2.0
6	4.2 ± 2.8
7	10.6 ± 1.4
8	4.8 ± 1.6
9	5.1 ± 1.3
10	0.8 ± 1.5
11	1.5 ± 0.6
12	1.7 ± 1.2
13	11.9 ± 1.3
14	2.4 ± 1.5
15	3.1 ± 1.2
16	0.9 ± 0.9

TABLE 4 (Continued)

URANIUM 238 CONCENTRATIONS IN
SOIL SAMPLES FROM EXCAVATED AREAS
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Location	U-238 Concentration (pCi/g)
Piping Trenchs ^d	
1	1.1 ± 1.2
2	<0.8
3	0.7 ± 0.8
4	<0.7
5	<0.9
6	0.5 ± 0.9
7	<1.1
8	<0.6
9	1.4 ± 1.5
10	<0.6
11	<0.8
12	<0.4
13	3.1 ± 1.2

^aData includes background level.

^bRefer to Figure 14.

^cUncertainties are 95% confidence levels based only on counting statistics; additional analytical uncertainties of ± 6 to 10% have not been propagated in these data.

^dRefer to Figure 13.

TABLE 5

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS
IN NON-REMEDiated AREAS
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Room and ^a Area	Number of Measurements	TOTAL CONTAMINATION		REMOVABLE CONTAMINATION	
		Alpha (dpm/100 cm ²) Range of Measurements	Beta-Gamma (dpm/100 cm ²) Range of Measurements	Alpha Range (dpm/100 cm ²)	Beta Range (dpm/100 cm ²)
NORTH HEAD HOUSE					
<u>Room N106</u>					
Floors/L. Walls	5	<35	<630	<3	<6
U. Walls/Ceilings	1	<35	<630	<3	<6
<u>Room N110</u>					
Floors/L. Walls	7	<35 - 120	<630	<3	<6 - 10
U. Walls/Ceilings	1	<35	<630	<3	<6
<u>Room N114A</u>					
Floors/L. Walls	5	<35 - 71	<630	<3	<6
U. Walls/Ceiling	1	<35	<630	<3	<6
<u>Room N117A</u>					
Floors/L. Walls	6	<39	<630	<3	<6 - 14
U. Walls/Ceilings	1	58	750	<3	<6
<u>Room N134</u>					
Floors/L. Walls	5	<35 - 53	<630 - 1,200	<3	<6 - 7
U. Walls/Ceilings	1	<35	<630	<3	<6

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TABLE 5 (Continued)

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS
IN NON-REMEDIATED AREAS
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Room and Area	Number of Measurements	TOTAL CONTAMINATION		REMOVABLE CONTAMINATION	
		Alpha (dpm/100 cm ²) Range of Measurements	Beta-Gamma (dpm/100 cm ²) Range of Measurements	Alpha Range (dpm/100 cm ²)	Beta Range (dpm/100 cm ²)
<u>Room N204</u>					
Floors/L. Walls	5	<35	<630	<3	<6
U. Walls/Ceilings	1	<35	<630	<3	<6
<u>Room N206</u>					
Floors/L. Walls	5	<35 - 71	<630	<3	<6
U. Walls/Ceilings	1	53	<630	<3	<6
<u>Room N209</u>					
Floors/L. Walls	5	<35	<630	<3	<6
U. Walls/Ceilings	1	<35	<630	<3	<6
<u>Room N212</u>					
Floors/L. Walls	5	<35 - 53	<630	<3	<6
U. Walls/Ceilings	1	53	<630	<3	<6
<u>Room N222/A</u>					
Floors/L. Walls	5	<35 - 53	<630	<3	<6
U. Walls/Ceilings	1	53	<630	<3	<6

TABLE 5 (Continued)

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS
IN NON-REMEDIATED AREAS
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Room and Area	Number of Measurements	TOTAL CONTAMINATION		REMOVABLE CONTAMINATION	
		Alpha (dpm/100 cm ²) Range of Measurements	Beta-Gamma (dpm/100 cm ²) Range of Measurements	Alpha Range (dpm/100 cm ²)	Beta Range (dpm/100 cm ²)
<u>Room N303</u>					
Floors/L. Walls	5	<35	<630 - 1,500	<3	<6
U. Walls/Ceilings	1	53	1,100	<3	<6
<u>Room N307</u>					
Floors/L. Walls	5	<35	<630 - 750	<3	<6
U. Walls/Ceilings	1	53	<630	<3	<6
<u>Room N314</u>					
Floors/L. Walls	6	<35 - 53	<630 - 1,100	<3	<6 - 8
U. Walls/Ceilings	0	N/A ^b	N/A	N/A	N/A

TABLE 5 (Continued)

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS
IN NON-REMIATED AREAS
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Room and Area	Number of Measurements	TOTAL CONTAMINATION		REMOVABLE CONTAMINATION	
		Alpha (dpm/100 cm ²) Range of Measurements	Beta-Gamma (dpm/100 cm ²) Range of Measurements	Alpha Range (dpm/100 cm ²)	Beta Range (dpm/100 cm ²)
EAST WING					
<u>Room E103</u>					
Floors/L. Walls	3	<30 - 39	<620	<3	<6 - 7
U. Walls/Ceilings	0	N/A	N/A	N/A	N/A
<u>Room E113 1/2</u>					
Floors/L. Walls	5	<30 - 74	<620 - 2,200	<3	<6
U. Walls/Ceilings	1	<30	<620	<3	<6
<u>Room E114</u>					
Floors/L. Walls	5	<30 - 39	<620 - 1,000	<3	<6
U. Walls/Ceiling	1	<39	<620	<3	<6
<u>Room E121</u>					
Floors/L. Walls	8	<30 - 56	<620 - 2,100	<3	<6 - 52
U. Walls/Ceilings	0	N/A	N/A	N/A	N/A
<u>Room E203</u>					
Floors/L. Walls	3	<30	<620 - 1,900	<3	<6 - 8
U. Walls/Ceilings	1	<30	<620	<3	<6

TABLE 5 (Continued)

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS
IN NON-REMIATED AREAS
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Room and Area	Number of Measurements	TOTAL CONTAMINATION		REMOVABLE CONTAMINATION	
		Alpha (dpm/100 cm ²)	Beta-Gamma (dpm/100 cm ²)	Alpha Range (dpm/100 cm ²)	Beta Range (dpm/100 cm ²)
		Range of Measurements	Range of Measurements		
<u>Room E205</u>					
Floors/L. Walls	8	<30 - 56	<620 - 760	<3	<6
U. Walls/Ceilings	2	<30 - 74	<620	<3	<6
<u>Room E208</u>					
Floors/L. Walls	6	<30 - 56	<620 - 1,700	<3	<6 - 8
U. Walls/Ceilings	0	N/A	N/A	N/A	N/A
<u>Room E212</u>					
Floors/L. Walls	7	<30 - 74	<620 - 1,700	<3	<6
U. Walls/Ceilings	1	<30	<620	<3	<6
<u>Room E214</u>					
Floors/L. Walls	5	<30 - 39	<620	<3	<6
U. Walls/Ceiling	1	<30	<620	<3	<6

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TABLE 5 (Continued)

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS
IN NON-REMEDIATED AREAS
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Room and Area	Number of Measurements	TOTAL CONTAMINATION		REMOVABLE CONTAMINATION	
		Alpha (dpm/100 cm ²)	Beta-Gamma (dpm/100 cm ²)	Alpha Range (dpm/100 cm ²)	Beta Range (dpm/100 cm ²)
		Range of Measurements	Range of Measurements		
WEST WING					
<u>Room W104</u>					
Floors/L. Walls	11	<30 - 74	<620 - 1,800	<3	<6 - 8
U. Walls/Ceilings	2	56 - 74	970 - 1,700	<3	<6
<u>Room W108</u>					
Floors/L. Walls	9	<30 - 39	<620 - 1,200	<3	<6
U. Walls/Ceilings	2	39 - 56	<620	<3 - 5	<6
<u>Room W115</u>					
Floors/L. Walls	6	<30	<620 - 900	<3	<6
U. Walls/Ceiling	1	<30	<620	<3	<6
<u>Room W202</u>					
Floors/L. Walls	8	<30 - 56	<620 - 1,400	<3	<6
U. Walls/Ceilings	2	<30 - 74	<620	<3	<6 - 13
<u>Room W210</u>					
Floors/L. Walls	8	<30	<620 - 2,000	<3 - 5	<6 - 10
U. Walls/Ceilings	2	<30 - 39	<620	<3	<6

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TABLE 5 (Continued)

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS
IN NON-REMIEDIATED AREAS
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Room and Area	Number of Measurements	TOTAL CONTAMINATION		REMOVABLE CONTAMINATION	
		Alpha (dpm/100 cm ²) Range of Measurements	Beta-Gamma (dpm/100 cm ²) Range of Measurements	Alpha Range (dpm/100 cm ²)	Beta Range (dpm/100 cm ²)
SOUTH HEAD HOUSE					
<u>Room S103</u>					
Floors/L. Walls	5	<30	<600	<3	<6 - 8
U. Walls/Ceilings	0	N/A	N/A	N/A	N/A
<u>Room S108</u>					
Floors/L. Walls	4	<30 - 91	<600 - 620	<3	<6 - 9
U. Walls/Ceilings	1	<30	<600	<3	<6
<u>Room S112</u>					
Floors/L. Walls	9	<30 - 39	<600 - 1,900	<3	<6
U. Walls/Ceiling	0	N/A	N/A	N/A	N/A
<u>Room S208</u>					
Floors/L. Walls	10	<30 - 39	<620 - 630	<3	<6
U. Walls/Ceilings	0	N/A	N/A	N/A	N/A
<u>Room S121A</u>					
Floors/L. Walls	10	<30 - 56	<620 - 2,000	<3	<6 - 8
U. Walls/Ceilings	1	<30	<620	<3	<6

TABLE 5 (Continued)

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS
IN NON-REMEDiated AREAS
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Room and Area	Number of Measurements	TOTAL CONTAMINATION		REMOVABLE CONTAMINATION	
		Alpha (dpm/100 cm ²) Range of Measurements	Beta-Gamma (dpm/100 cm ²) Range of Measurements	Alpha Range (dpm/100 cm ²)	Beta Range (dpm/100 cm ²)
<u>Room S218</u>					
Floors/L. Walls	6	<30 - 56	<620	<3	<6
U. Walls/Ceilings	0	N/A	N/A	N/A	N/A
<u>Room S233</u>					
Floors/L. Walls	16	<30 - 56	<620 - 1,700	<3	<6 - 8
U. Walls/Ceilings	3	<30 - 39	<620	<3	<6
<u>Room S243</u>					
Floors/L. Walls	8	<30 - 74	<620 - 1,200	<3	<6 - 7
U. Walls/Ceilings	1	<30	<620	<3	<6
<u>Room S250</u>					
Floors/L. Walls	15	<39 - 97	<630 - 5,400	<3 - 5	<6 - 8
U. Walls/Ceilings	7	<39 - 140	<630	<3	<6 - 18
<u>Room S302</u>					
Floors/L. Walls	4	<30 - 74	<600 - 620	<3	<6 - 7
U. Walls/Ceilings	0	N/A	N/A	N/A	N/A

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TABLE 5 (Continued)

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS
IN NON-REMEDIATED AREAS
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Room and Area	Number of Measurements	TOTAL CONTAMINATION		REMOVABLE CONTAMINATION	
		Alpha (dpm/100 cm ²) Range of Measurements	Beta-Gamma (dpm/100 cm ²) Range of Measurements	Alpha Range (dpm/100 cm ²)	Beta Range (dpm/100 cm ²)
<u>Room S308</u>					
Floors/L. Walls	7	<30 - 56	<600 - 1,100	<3	<6
U. Walls/Ceilings	0	N/A	N/A	N/A	N/A
<u>Room S400</u>					
Floors/L. Walls	8	<30 - 39	<600	<3	<6 - 19
U. Walls/Ceilings	1	<30	<600	<3	<6

^aRefer to Figures 4 to 8.

^bN/A = Not applicable.

TABLE 6
 SUMMARY OF EXPOSURE RATE MEASUREMENTS
 THROUGHOUT ARMORY BUILDING
 ILLINOIS NATIONAL GUARD ARMORY
 CHICAGO, ILLINOIS

Location	Number of Rooms	<u>Exposure Rates at 1 m above Floor^a</u> (μ R/h)
North Head House		
First Level	5	8 - 13
Second Level	5	9 - 13
Third Level	3	11 - 13
East Wing		
First Level	4	9 - 11
Second Level	5	9 - 10
West Wing		
First Level	3	10 - 11
Second Level	2	10
South Head House		
First Level	15	9 - 16
Second Level	1	8 - 13
Third Level	2	10 - 11
Fourth Level	1	10
Arena	N/A	8 - 13

^aData includes average background level of about 11 μ R/h.

TABLE 7
 DIRECT RADIATION LEVELS AND URANIUM-238 CONCENTRATIONS MEASURED
 AT GRID BLOCK CENTERS - SOUTH OF ARMORY
 ILLINOIS NATIONAL GUARD ARMORY
 CHICAGO, ILLINOIS

Location ^a	Gamma Exposure Rates ($\mu\text{R/h}$) ^b		U-238 Concentration ^b (pCi/g)
	1 m above surface	surface contact	
5S, 12E	10	10	<0.8
5E	10	10	12.5 \pm 4.3 ^c
5W	9	10	2.8 \pm 0.8
15W	11	10	2.7 \pm 1.7
25W	11	10	<1.3
35W	10	10	1.6 \pm 0.8
45W	11	10	2.9 \pm 1.3
55W	9	9	<1.4
65W	9	9	4.0 \pm 1.0
75W	9	9	4.6 \pm 1.5
85W	8	8	<0.9
93W	9	9	16.5 \pm 2.1
15S, 12E	10	10	<0.9
5E	9	9	<1.3
5W	9	9	2.9 \pm 1.1
15W	8	9	<0.8
25W	9	9	<1.2
35W	8	9	2.7 \pm 1.1
45W	9	9	2.0 \pm 2.0
55W	10	9	4.6 \pm 1.5
65W	10	10	3.0 \pm 2.0
75W	8	8	8.5 \pm 3.6
85W	9	9	16.1 \pm 3.6
93W	8	8	<1.4
22S, 12E	11	9	2.4 \pm 1.2
5E	9	9	2.7 \pm 1.7
5W	9	8	<1.1
15W	8	8	3.2 \pm 1.1
25W	8	9	5.0 \pm 1.3
35W	9	9	<1.1
45W	8	8	0.7 \pm 0.7
55W	8	9	4.0 \pm 1.7
65W	9	9	<1.0
75W	9	9	3.7 \pm 0.8
85W	9	9	d
91W	8	8	d

^aRefer to Figure 15.

^bData include background levels.

^cUncertainties are 95% confidence levels, based only on counting statistics;

additional analytical uncertainties of \pm 6 to 10% have not been propagated in these data.

^dNo sample obtained.

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7. Letter from J.D. Berger (ORAU), to J.J. Fiore (DOE/NE), "Verification of Remedial Actions at the National Guard Armory, Chicago, Illinois," Oak Ridge, TN, June 30, 1987.
8. Argonne National Laboratory, Derivation of a Uranium Residual Radioactivity Guideline for the National Guard Armory in Chicago, Illinois, Chicago, IL, May 1987. (BNI CCN 047186)

APPENDIX A

MAJOR SURVEY AND ANALYTICAL EQUIPMENT

APPENDIX A

Major Survey and Analytical Equipment

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

A. Direct Radiation Measurements

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

Eberline PRM-6
Portable Ratemeter
(Eberline, Santa Fe, NM)

Eberline Alpha Scintillation Detector
Model AC-3-7
(Eberline, Santa Fe, NM)

Eberline Beta-Gamma "Pancake" Detector
Model HP-260
(Eberline, Santa Fe, NM)

Ludlum Alpha-Beta Floor Monitor
Model 239-1
(Ludlum, Sweetwater, TX)

Ludlum Ratemeter-Scaler
Model 2220
(Ludlum, Sweetwater, TX)

Reuter-Stokes Pressurized Ionization Chamber
Model RSS-111
(Reuter-Stokes, Cleveland, OH)

Victoreen Beta-Gamma "Pancake" Detector
Model 489-110
(Victoreen, Cleveland, OH)

Victoreen NaI Scintillation Detector
Model 489-55
(Victoreen, Cleveland, OH)

B. Laboratory Analyses

Low Background Alpha-Beta Counter
Model LB-5110
(Tennelec, Oak Ridge, TN)

Ge(Li) Detector
Model LGCC2220SD, 23% Efficiency
(Princeton Gamma-Tech, Princeton, NJ)

used in conjunction with:
Lead Shield Model SPG-16
(Applied Physical Technology, Atlanta, GA)

High Purity Germanium Detector
Model GMX-23195-S, 23% Efficiency
(EG&G ORTEC, Oak Ridge, TN)

used in conjunction with:
Lead Shield Model G-16
(Gamma Products, Palos Hills, IL)

High Purity Germanium Coaxial Well Detector
Model GWL-110210-PWS-S, 23% Efficiency
(EG&G ORTEC, Oak Ridge, TN)

used in conjunction with:
Lead Shield Model G-16
(Applied Physical Technology, Atlanta, GA)

High Purity Germanium Detector
Model IGC25, 25% Efficiency
(Princeton Gamma-Tech, Princeton, NJ)

used in conjunction with:
Lead Shield
(Nuclear Data, Schaumburg, IL)

Multichannel Analyzer
ND66/680 System
(Nuclear Data, Schaumburg, IL)

APPENDIX B
MEASUREMENT AND ANALYTICAL PROCEDURES

APPENDIX B

Measurement and Analytical Procedures

Alpha and Beta-gamma Measurements

Measurements of total alpha radiation levels were performed using Eberline Model PRS-1 portable scaler/ratemeters with Model AC-3-7 alpha scintillation probes. Measurements of total beta-gamma radiation levels were performed using Eberline Model PRS-1 portable scaler/ratemeters with Model HP-260 thin-window "pancake" G-M probes. Count rates (cpm) were converted to disintegration rates (dpm/100 cm²) by dividing the net rate by the 4 π efficiency and correcting for the active area of the detector. Effective window areas were 59 cm² for the ZnS detectors and 15 cm² for the G-M detectors. The background count rate for ZnS alpha probes averaged approximately 2 cpm; the average background count rate was approximately 40 cpm for the G-M detectors.

Surface Scans

Surface scans in the facility were performed by passing the probes slowly over the surface. The distance between the probe and the surface was maintained at a minimum - nominally about 1 cm. Identification of elevated levels was based on increases in the audible signal from the recording or indicating instrument. Alpha and beta-gamma scans of large surface areas on the floor of the facility were accomplished by use of a gas proportional floor monitor, with a 600 cm² sensitive area. The instrument is slowly moved in a systematic pattern to cover 100% of the accessible area. Combinations of detectors and instrument for the scans were:

- Beta-Gamma - Pancake G-M probe with PRM-6 ratemeter.
- Beta-Gamma - Pancake G-M probe with PRS-1 scaler/ratemeter.
- Gamma - NaI scintillation detector (3.2 cm x 3.8 cm crystal) with PRM-6 ratemeter.
- Alpha - ZnS probe with PRS-1 scaler/ratemeter.
- Alpha/Beta - Gas proportional floor monitor with Ludlum Model 2220 scaler/ratemeter.

Exposure Rate Measurement

Walkover surface scans and measurements of gamma exposure rates were performed using Eberline Model PRM-6 portable ratemeters with Victoreen Model 489-55 gamma scintillation probes, containing 3.2 cm x 3.8 cm NaI(Tl) scintillation probes. Count rates were converted to exposure rates ($\mu\text{R/h}$) by onsite cross-calibration with a Reuter-Stokes Model RSS-111 pressurized ionization chamber (PIC).

Removable Contamination Measurements

Smear measurements were performed using numbered filter paper disks, 47 mm in diameter. Smears were sealed in labeled envelopes with the location and other pertinent information recorded. The smears were returned to Oak Ridge and evaluated using a low-background alpha-beta proportional system.

Soil Sample Analysis

Gamma Spectrometry

The soil sample was dried, mixed, and a portion sealed in 0.5-liter Marinelli beaker. The quantity placed in the beaker was chosen to reproduce the calibrated counting geometry and typically ranged from 600 to 800 g of soil. Net soil weight was determined and the sample counted using germanium detectors coupled to a Nuclear Data Model ND-680 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. The 0.094 MeV energy peak from Th-234 used for determination of the U-238 concentration (secular equilibrium was assumed). The spectra were also reviewed for the presence of other radionuclides.

Uncertainties and Detection Limits

The uncertainties associated with the analytical data presented in the tables of this report, represent the 95% (2σ) confidence levels for that data. These uncertainties were calculated, based on both the gross sample count levels

and the associated background count levels. When the net sample count was less than the 95% statistical deviation of the background count, the sample concentration was reported as less than (<) the detection capability of the measurement procedure. Because of variations in backgrounds and in Compton contributions from other radionuclides in the samples, the detection sensitivities for specific radionuclides may differ from sample to sample and instrument to instrument. Additional uncertainties of ± 6 to 10%, associated with sampling and laboratory procedures, have not been propagated into the data presented in this report.

Calibration and Quality Assurance

Laboratory and field survey procedures are documented in the following manuals, developed specifically for the Oak Ridge Associated Universities' Radiological Site Assessment Program: "Survey Procedures Manual", Revision 3, May 1987; "Laboratory Procedures Manual", Revision 3, May 1987 and "Quality Assurance Manual", Revision 1, June 1987.

With the exception of the portable gamma scintillation survey meters, field and laboratory instruments are calibrated with NBS-traceable standards. The calibration procedures for the portable gamma instruments are performed by comparison with an NBS-traceable pressurized ionization chamber.

Quality control procedures on all instruments included daily background and check-source measurements to confirm equipment operation within acceptable statistical fluctuations. The ORAU laboratory participates in the EPA Cross Check and EML Quality Assurance Programs.

APPENDIX C

CRITERIA APPLICABLE TO THE ILLINOIS NATIONAL GUARD ARMORY

APPENDIX C

Criteria Applicable to the Illinois National Guard Armory

The Department of Energy's radiological criteria for remedial action are presented in the "U.S. Department of Energy Guidelines for Residual Radioactivity at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites" Revision 2, March 1987.² The portions of those guidelines applicable to the site are:

1. Building Surfaces

- a. Total uranium surface contamination of 5,000 α dpm/100 cm^2 averaged over an area not exceeding 1 m^2 , with a maximum of 15,000 α dpm/100 cm^2 in areas of not more than 100 cm^2 .
- b. Removable uranium contamination of 1,000 α dpm/100 cm^2 .
- c. Average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h at 1 cm and 1.0 mrad/h at 1 cm, respectively, measured through not more than 7 mg/cm^2 of total absorber.

2. Direct Radiation

External direct gamma radiation levels should be such that, under reasonable conditions of site use and occupancy, an individual would not receive a dose equivalent in excess of 100 mrem/y above background.

A site specific uranium concentration guide for soil was developed for the Armory site by Argonne National Laboratory.⁶ This guideline is 150 pCi/g of U-238 per gram of dry soil (approximately 300 pCi/g of total U per gram of soil, based on equal activities of U-238 and U-234, i.e., naturally occurring abundancies).

Exhibit II (8) - State, County, and Local Comments on Remedial Action

The State of Illinois was kept fully informed of all DOE activities in connection with remedial action performed at the NGA. Communication was maintained with the Illinois Department of Nuclear Safety during the development of a site-specific remedial action guideline for uranium in soil.

Exhibit II (9) - Restrictions

There are no radiologically based restrictions on use of the subject site following the completion of remedial action under FUSRAP.

Exhibit II (10) - Federal Register Notice

This section contains the text of the Federal Register notice that was approved by DOE for publication in the Federal Register. It documents the certification that the subject property has no radiological restrictions on its use.