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Contract No. DE-AC05-81OR20722

POST-REMEDIAL ACTION REPORT FOR THE ALBANY RESEARCH CENTER

Albany, Oregon

April 1989

Bechtel National, Inc.

DOE/OR/20722-207

POST-REMEDIAL ACTION REPORT
FOR THE ALBANY RESEARCH CENTER
ALBANY, OREGON

APRIL 1989

Prepared for

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OAK RIDGE OPERATIONS OFFICE

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ABBREVIATIONS

cm	centimeter
cm^2	square centimeters
cpm	counts per minute
dpm	disintegrations per minute
dpm/100 cm^2	disintegrations per minute per 100 square centimeters
ft	foot
ft^2	square feet
g	gram
in.	inch
l	liter
m	meter
m^2	square meter
MeV	mega electron volts
mi	mile
μCi/ml	microcuries per milliliter
μR/h	microroentgens per hour
mrad/h	millirad per hour
mrem	millirem
mrem/yr	millirem per year
pCi/g	picocuries per gram
WL	working level
yd^3	cubic yards

1.0 INTRODUCTION AND BACKGROUND

The purpose of this report is to document post-remedial action sampling performed at the Albany Research Center (ARC) in Albany, Oregon (see Figure 1-1), which is owned by the U.S. Department of the Interior and operated by the U.S. Bureau of Mines. The work was performed under the Formerly Utilized Sites Remedial Action Program (FUSRAP), a U.S. Department of Energy (DOE) program to identify and decontaminate or otherwise control sites where residual radioactive contamination (exceeding current guidelines) remains from the early years of the nation's atomic energy program. Bechtel National, Inc. (BNI) is the project management contractor for DOE and represents DOE in the planning, management, and implementation of FUSRAP. As part of work conducted during 1987 and 1988 under FUSRAP, BNI removed radioactive contamination from buildings and grounds at ARC. Remedial action was performed at 31 distinct ground areas and in portions of 11 buildings.

This report documents the methods used to determine the extent of contamination, and the type of remedial action performed at ARC. This report also identifies the guidelines used in performing the remedial action, documents final excavation limits and depths, and provides data on the current radiological status of the property.

The ARC was established in 1943 to investigate innovative approaches for developing strategic mineral resources in the United States, reducing costs for metallurgical manufacturing processes, developing materials to fight corrosion, and other activities relevant to metallurgical research. The center is located on a 17-ha (42-acre) site of the former Albany College in Albany, Oregon. The ARC property is roughly rectangular in shape and is bounded on the north by Queen Avenue, on the east by Liberty Street, on the south by a tennis club, and on the west by Broadway Street. A plan view of the site is shown in Figure 1-2.

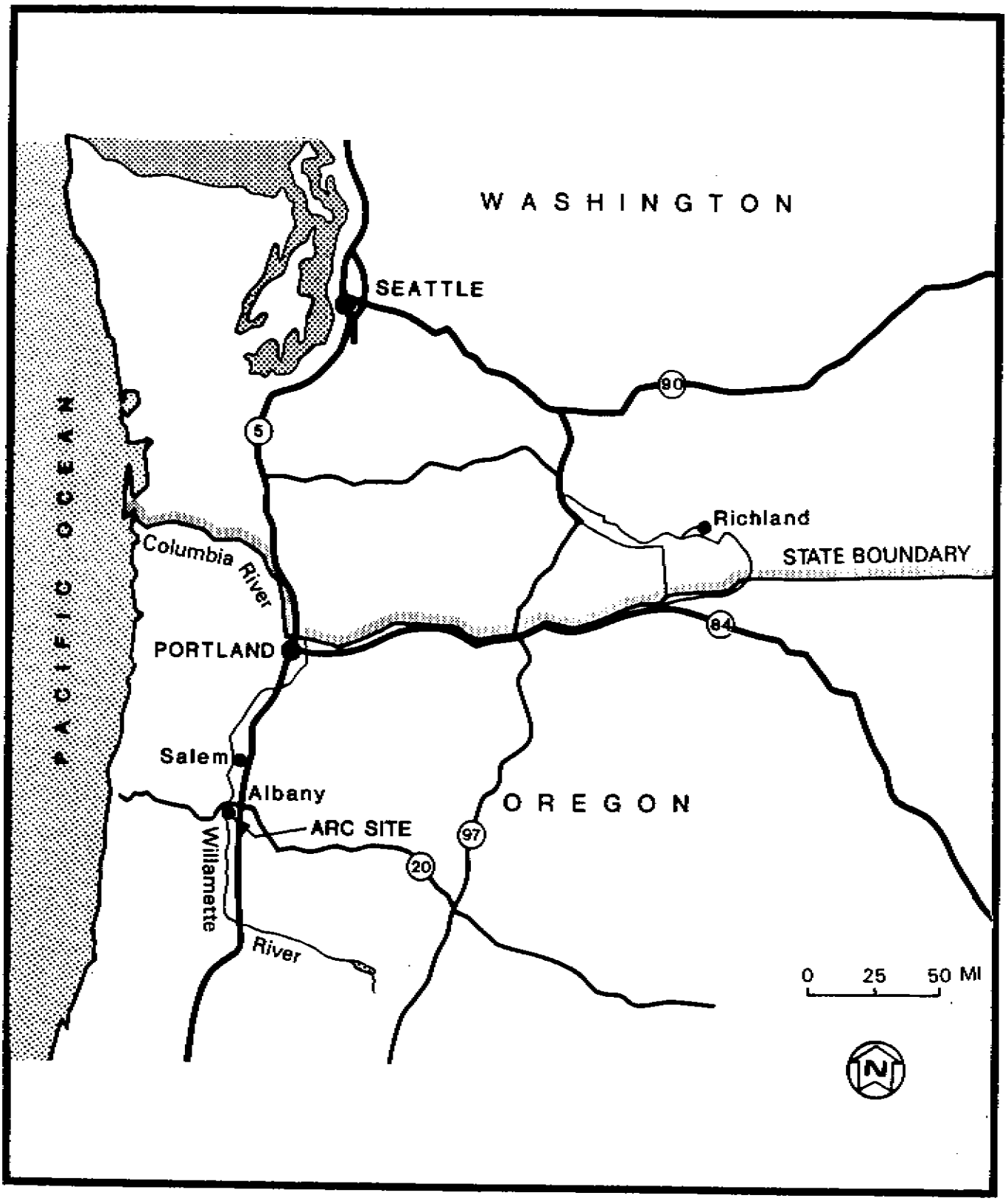

FIGURE 1-1 LOCATION OF THE ALBANY RESEARCH CENTER

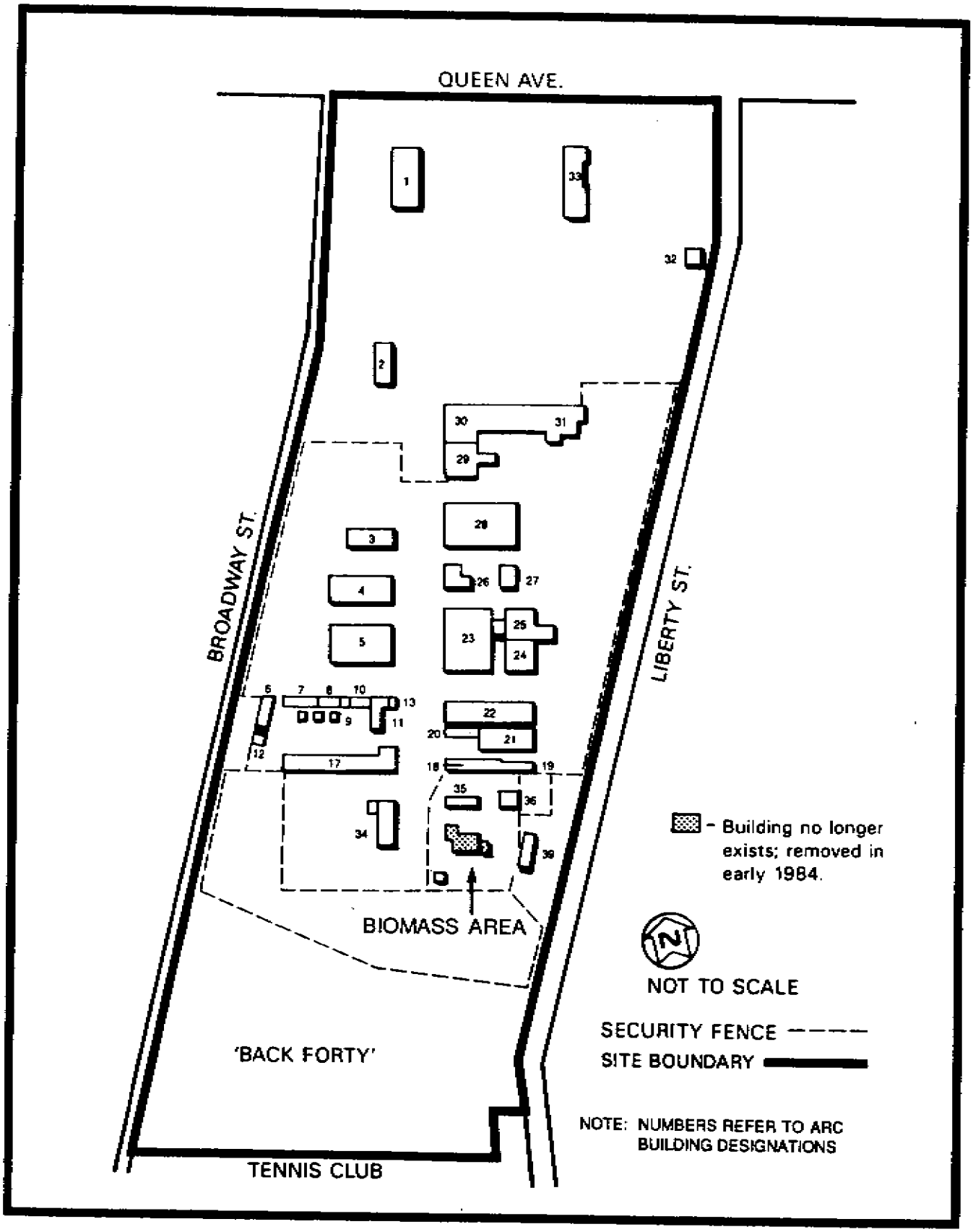

FIGURE 1-2 PLAN OF THE ALBANY RESEARCH CENTER

The site includes three main areas: ARC proper, which consists of a number of buildings in the northern and central portions of the site; a 0.8-ha (2-acre) biomass research facility (inactive) located south of the site's approximate center; and a 5.7-ha (14-acre) open area identified as the "Back Forty" occupying the south end of the facility.

Various operations involving radioactive materials have been conducted at the ARC. From 1948 to 1956, ARC conducted work for the Atomic Energy Commission (AEC) involving the melting, machining, welding, and alloying of thorium. Additional work with uranium and thorium was also performed at ARC for the Energy Research and Development Agency (ERDA), a predecessor agency of DOE. In addition to work conducted for AEC and ERDA, ARC has performed work for others with radioactive materials that has resulted in some building contamination not subject to FUSRAP responsibility.

During the era of AEC and ERDA contracts (1948 to 1978), process buildings and surroundings were decontaminated at various times to guidelines acceptable to AEC, ERDA, and DOE. The decontamination guidelines provided at those times were not as stringent as those in effect in 1978 when work at ARC was terminated, and the records relating to the decontamination effort were not adequate to determine if the buildings and surrounding areas met the 1978 DOE radiological guidelines. As a result, a radiological assessment of ARC was initiated by Argonne National Laboratory (ANL) in 1978. Subsequent to this assessment, ANL advised that although the levels of contamination at the ARC did not pose an immediate health hazard, further decontamination of the property was advisable (Refs. 1 and 2).

In early 1984 BNI conducted a radiological survey at ARC (Ref. 3) to determine actual levels of contamination in each area identified by ANL and to define the locations and boundaries of above-guideline contamination. This survey revealed that approximately 1,988 m^3 (2,600 yd^3) of contaminated material would require removal for the ARC site to comply with guidelines.

In June 1985 BNI issued a report documenting an evaluation of remedial alternatives for the ARC site (Ref. 4). Of the disposal options discussed, transportation of the contaminants to the Hanford DOE disposal facility, located at Richland, Washington (see Figure 1-1) for disposal was selected for implementation.

A work plan for remediation of selected areas at ARC was issued by BNI in February 1987 (Ref. 5). This covered building decontamination, soil excavation, backfilling and seeding of contaminated areas, and transportation of soil and rubble to Hanford. The remedial action was initiated in July 1987 and completed in January 1988. Collection of post-remedial action data was completed in February 1988. This report provides information on the status of the ARC after completion of the 1987 remedial effort.

The 1987 remedial action resulted in decontamination of most of the areas at ARC requiring remediation under FUSRAP. Surveys conducted after the 1987 remedial effort identified additional areas of contamination exceeding guidelines. These areas were, primarily, building areas that had not been surveyed previously under FUSRAP. A second remedial effort is being planned by BNI to complete the decontamination of areas subject to FUSRAP requirements.

2.0 REMEDIAL ACTION GUIDELINES

Radioactive contamination at ARC consists primarily of thorium-232. Uranium-238 was identified as the sole contaminant in only one area, the attic of Building 17. Much lower levels of radium-226 were found at a few locations. Table 2-1 lists the DOE residual contamination guidelines for release of formerly contaminated property (Ref. 6). DOE implemented these guidelines on the basis of their compatibility with the criteria used for a similar purpose by the Environmental Protection Agency (EPA)(Ref. 7).
Guidelines presented in Table 2-1 are applicable to surfaces such as walls, floors, ceilings, drains, and equipment, as well as to soil. As part of the remedial effort, selected contaminated materials were removed until residual radionuclide concentrations were within guidelines. Not all of the radioactive contamination present at ARC has been removed. Additional remedial action and hazard evaluations of radioactive contaminants on certain structural features remain to be completed.

The remedial action guidelines for thorium-232 in soil are 5 pCi/g averaged over the first 15 cm of soil below the surface and 15 pCi/g when averaged over any 15-cm-thick soil layer below the surface layer. These guidelines are applied to soil after background soil concentrations are subtracted.

There is no generic guideline for uranium in soil. At ARC, compliance with the remedial action guideline for radium in soil, which is the same as that for thorium-232, ensures that the concentration of residual uranium-238 is also acceptably low because the characterization data indicate that exterior contamination is in secular equilibrium. For this reason, a site-specific guideline for uranium-238 was not calculated. Remedial action guidelines for surface contamination at the ARC vary depending upon the primary contaminant. For areas where thorium-232 is the primary contaminant, the guidelines are 1,000 dpm/100 cm^2 average, 3,000 dpm/100 cm^2 maximum, and 200 dpm/100 cm^2 for removable contamination. For areas where uranium-238 is the primary

TABLE 2-1

SUMMARY OF RESIDUAL CONTAMINATION GUIDELINES

FOR THE ALBANY RESEARCH CENTER

BASIC DOSE LIMITS

The basic limit for the annual radiation dose received by an individual member of the general public is 100 mrem/yr.

SOIL (LAND) GUIDELINES

Radionuclide	Soil Concentration (pCi/g) above background[a,b,c]
Radium-226 Radium-228 Thorium-230 Thorium-232	5 pCi/g, averaged over the first 15 cm of soil below the surface; 15 pCi/g when averaged over any 15-cm-thick soil layer below the surface layer.
Other radionuclides	Soil guidelines will be calculated on a site-specific basis using the DOE manual developed for this use.

STRUCTURE GUIDELINES

Airborne Radon Decay Products

Generic guidelines for concentrations of airborne radon decay products shall apply to existing occupied or habitable structures on private property that has no radiological restrictions on its use; structures that will be demolished or buried are excluded. The applicable generic guideline (40 CFR 192) is: In any occupied or habitable building, the objective of remedial action shall be, and reasonable effort shall be made to achieve, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 WL.[d] In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL. Remedial actions are not required in order to comply with this guideline when there is reasonable assurance that residual radioactive materials are not the cause.

External Gamma Radiation

The average level of gamma radiation inside a building or habitable structure on a site that has no radiological restrictions on its use shall not exceed the background level by more than 20 mR/h.

Indoor/Outdoor Structure Surface Contamination

	Allowable Surface Residual Contamination[e] (dpm/100 cm^2)		
Radionuclide[f]	Average[g,h]	Maximum[h,i]	Removable[h,j]
Transuranics, Ra-226, Ra-228, Th-230, Th-228 Pa-231, Ac-227, I-125, I-129	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

TABLE 2-1

(continued)

Indoor/Outdoor Structure Surface Contamination (continued)

Radionuclide[f]	Allowable Surface Residual Contamination[e] (dpm/100 cm^2) Average[g,h]	Maximum[h,i]	Removable[h,j]
U-Natural, U-235, U-238, and associated decay products	5,000 a	15,000 a	1,000 a
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above	5,000 β - q	15,000 β - q	1,000 β - q

[a]These guidelines take into account ingrowth of radium-226 from thorium-230 and of radium-228 from thorium-232, and assume secular equilibrium. If either thorium-230 and radium-226 or thorium-232 and radium-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 the dose for the mixtures will not exceed the basic dose limit.

[b]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.

[c]Localized concentrations in excess of these limits are allowable provided that the average over a 100-m^2 area is not exceeded.

[d]A working level (WL) is any combination of short-lived radon decay products in 1 liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha energy.

[e]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 observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[f]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.

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

[h]The average and maximum radiation levels 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.

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

[j]The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area 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. The numbers in this column are maximum amounts.

contaminant, the guidelines are 5,000 dpm/100 cm^2 average, 15,000 dpm/100 cm^2 maximum, and 1,000 dpm/100 cm^2 for removable contamination. The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters are not to exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at 1 cm.

3.0 REMEDIAL ACTION

After determining that ARC was contaminated in excess of DOE guidelines, DOE designated the site for remedial action under FUSRAP. Just prior to the start of remedial action, BNI and its radiological support subcontractor, Thermo Analytical/Eberline (TMA/E), again surveyed the site for radiation to more accurately define the boundaries of contamination in the areas that had been designated (Ref. 3). Information obtained during these surveys was used to delineate necessary remedial actions at the site.

3.1 REMEDIAL ACTION ACTIVITIES

After completion of remedial design work by BNI, a local subcontractor removed 2,276 m^3 (2,977 yd^3) of soil over an area of 6,050 m^2 (65,100 ft^2), approximately 306 m^3 (400 yd^3) of building materials, and 51 m^2 (67 yd^3) of equipment. The contaminated soil and building debris were placed in dump trucks and transported to the Hanford DOE facility in Richland, Washington, for disposal.

The following text and figures provide information on the specific areas of the ARC that were remediated. Remedial action areas can be broken into two distinct types: outside areas and buildings.

3.1.1 Outside Areas

Remedial action performed on 31 distinct outside areas involved excavation of contaminated soil. Excavated areas were backfilled and restored to original conditions. Figure 3-1 shows the locations and sizes of the excavated areas and the excavation depths.

3.1.2 Buildings

Remedial action was performed in 11 buildings, and with the exception of Room 107 in Building 4, remediated areas were restored

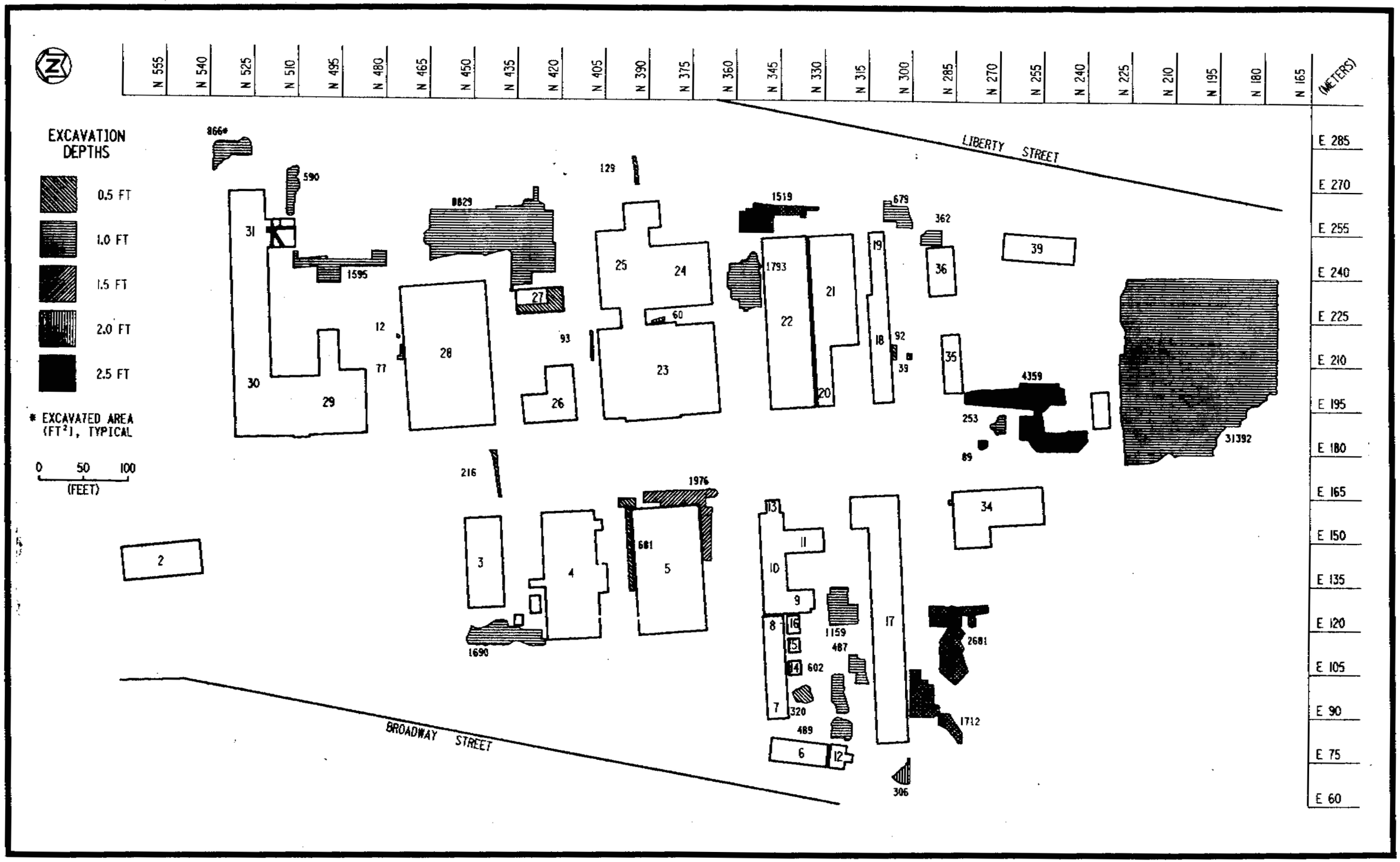

FIGURE 3-1 AREAS AND DEPTHS OF EXCAVATION AT ARC

to their original condition. In Room 107 the floor was restored and the remainder of the room was not restored, by agreement with ARC management.

Building 2

A contaminated sink drain was removed from Room 105 (Figure 3-2). The contaminated material involved was completely enclosed by the drain, so removal of the drain also removed the contaminated material. All sections of the drainline that exceeded criteria were removed for disposal.

Building 4

Extensive remediation was carried out in Room 107, known as the Owl Room (see Figure 3-3). Contaminated equipment from the Owl Room was removed for disposal. Two rooms adjacent to the Owl Room were also remediated. Room 108 is a small laboratory and Room 109 is a restroom. In all three of these rooms, walls were scabbled and sections of the floor were jackhammered and removed and/or scabbled. On the second floor, wood planking and flooring were removed from Room 206 (Figure 3-4). In the Owl Room and in Room 206, contaminated metal ducting was removed and replaced. A contaminated drain line was removed from underneath the floor of the Owl Room (Figure 3-4) and Rooms 108 and 109. The rafters located above the Owl Room were remediated, and contaminated rectifiers were removed from Room 104.

Building 5

Contaminated cracks and electrical conduit junction boxes were removed from the concrete floor in the machine shop (Figure 3-5). The south wall of the machine shop was scabbled extensively.

Windows, trusses, conduits, light fixtures, stringers, and roof support beams located in the machine shop were decontaminated by wiping and vacuuming.

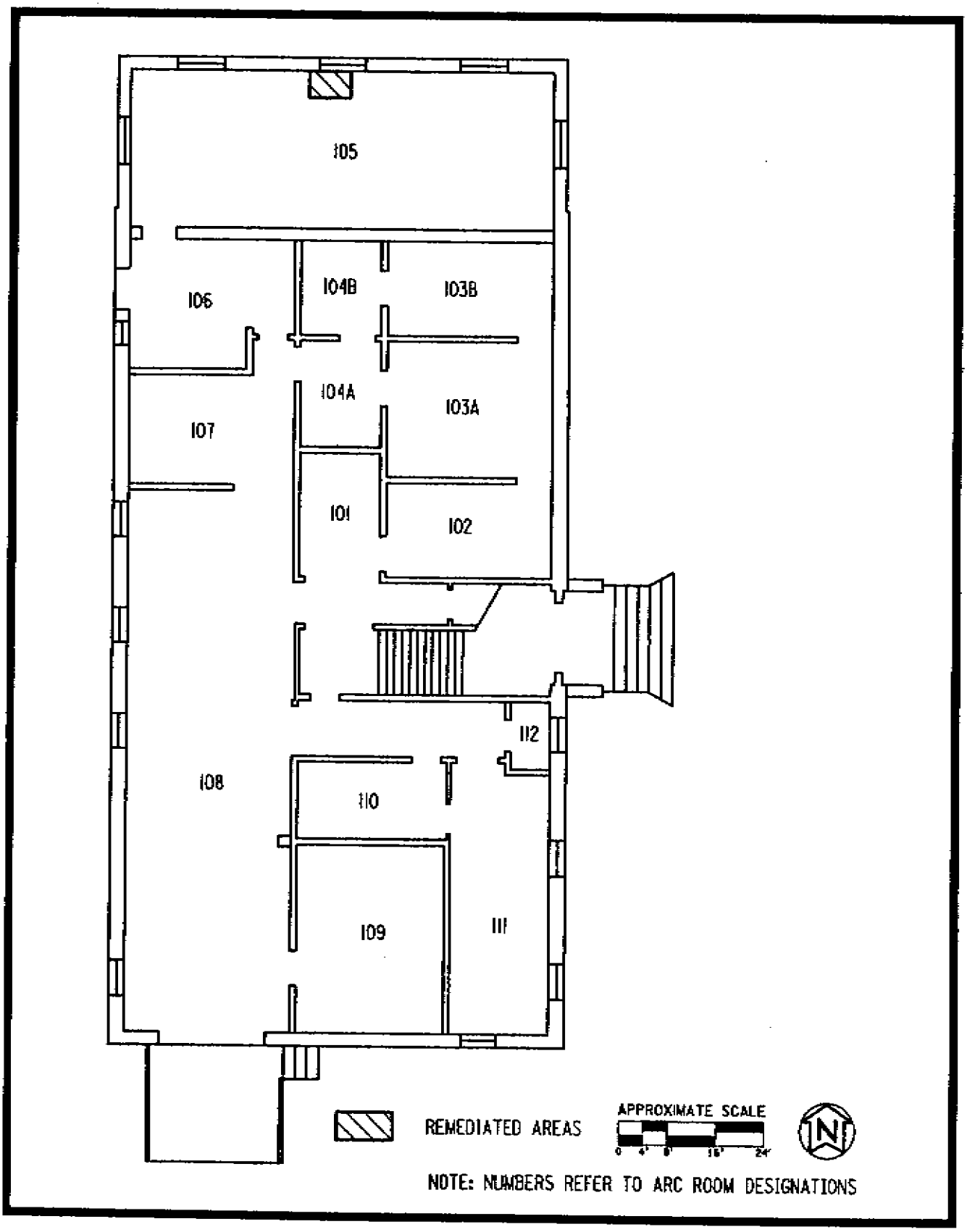

FIGURE 3-2 BUILDING 2, FIRST FLOOR

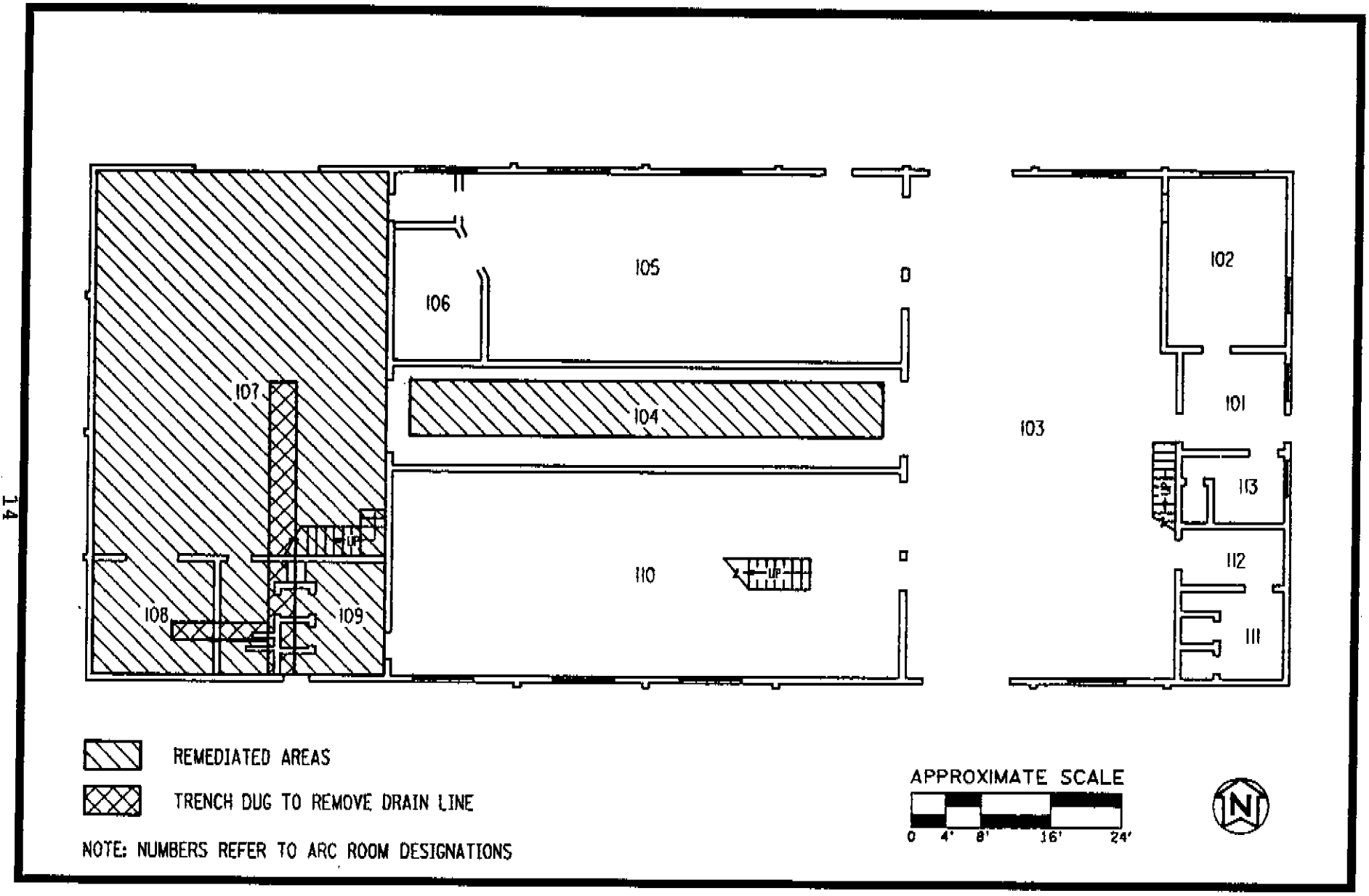

FIGURE 3-3 BUILDING 4, FIRST FLOOR

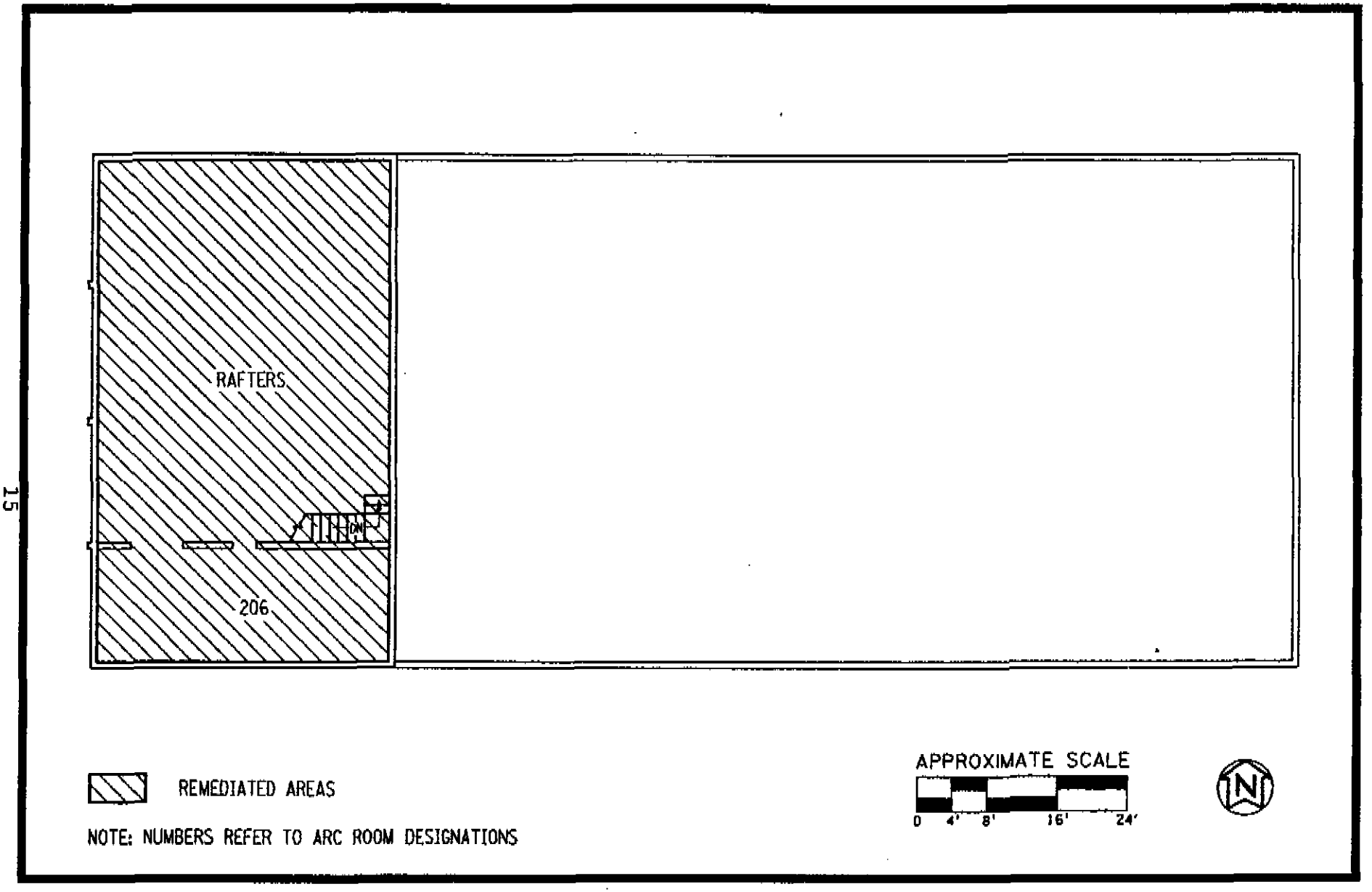

FIGURE 3-4 BUILDING 4, SECOND FLOOR

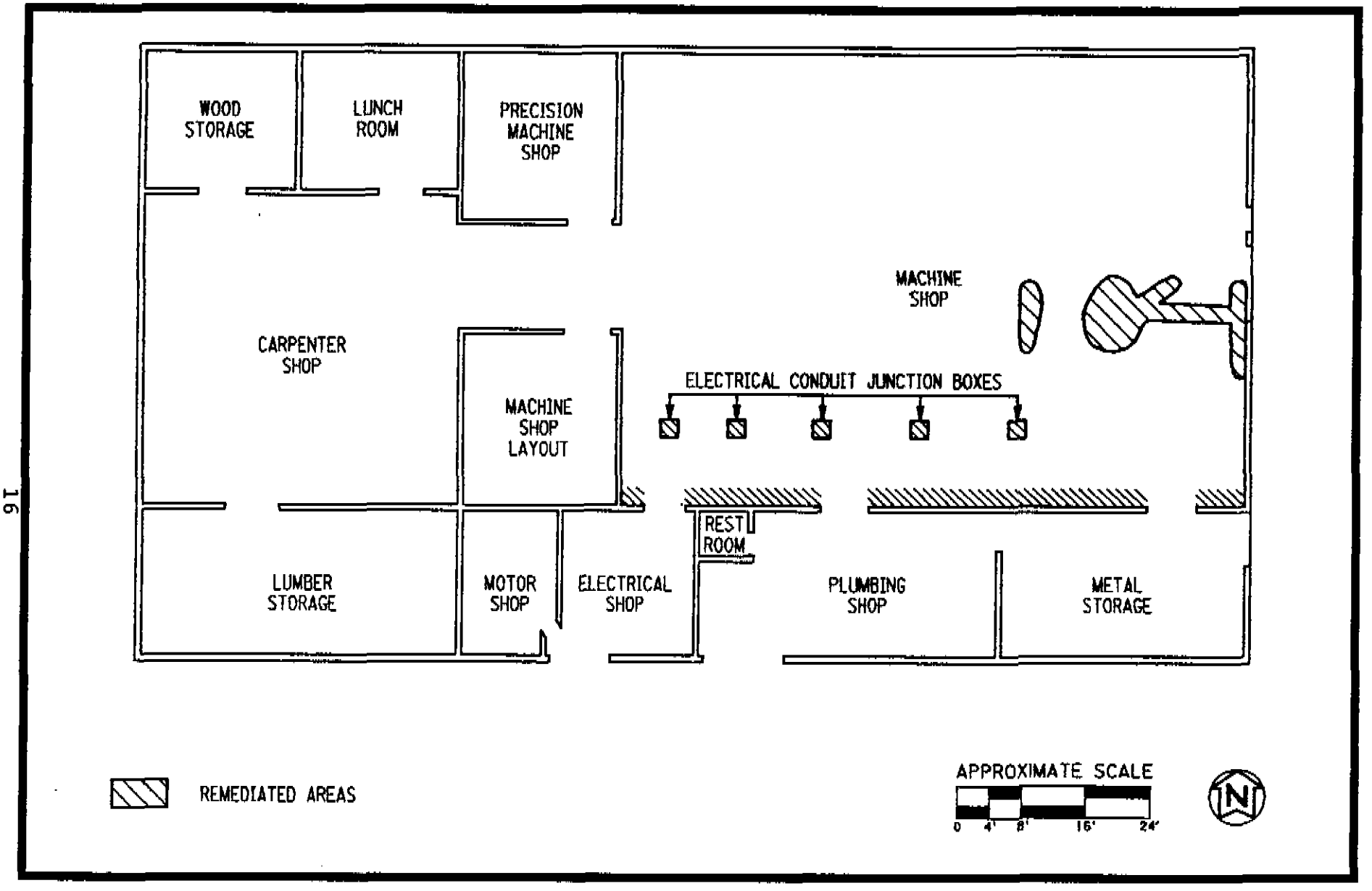

FIGURE 3-5 BUILDING 5

Building 17

An area beneath the motor control center on the east wall of Laboratory 10 was remediated (Figure 3-6).

Building 19

A contaminated hood was removed from storage on the north wall of Building 19 (Figure 3-7).

Building 23

The ore dressing room on the first floor and the sump area under the south stairwell in the basement were scabbled. Trenches in Laboratory 1 were vacuumed, scabbled, and washed.

Building 27

Room 102 of Building 27 was remediated by scabbling the entire floor and the bottom several feet of the walls (Figure 3-8). A contaminated drain line was removed from beneath Room 102 by jackhammering through the floor. Contaminated soil and drain lines were removed from the crawl space under the building (Figure 3-9).

Building 28

The floor of the small area adjoining Room 15 in Building 28 was remediated by scabbling (Figure 3-10).

Building 29

Remediation in Building 29 included removal of a contaminated sink drain in Room 109, removal of a floor drain in Room 111, and scabbling of the wall and floor around the drain (Figure 3-11). The contaminated material contained in the drains was completely enclosed by the drains, so removal of the drains also removed the

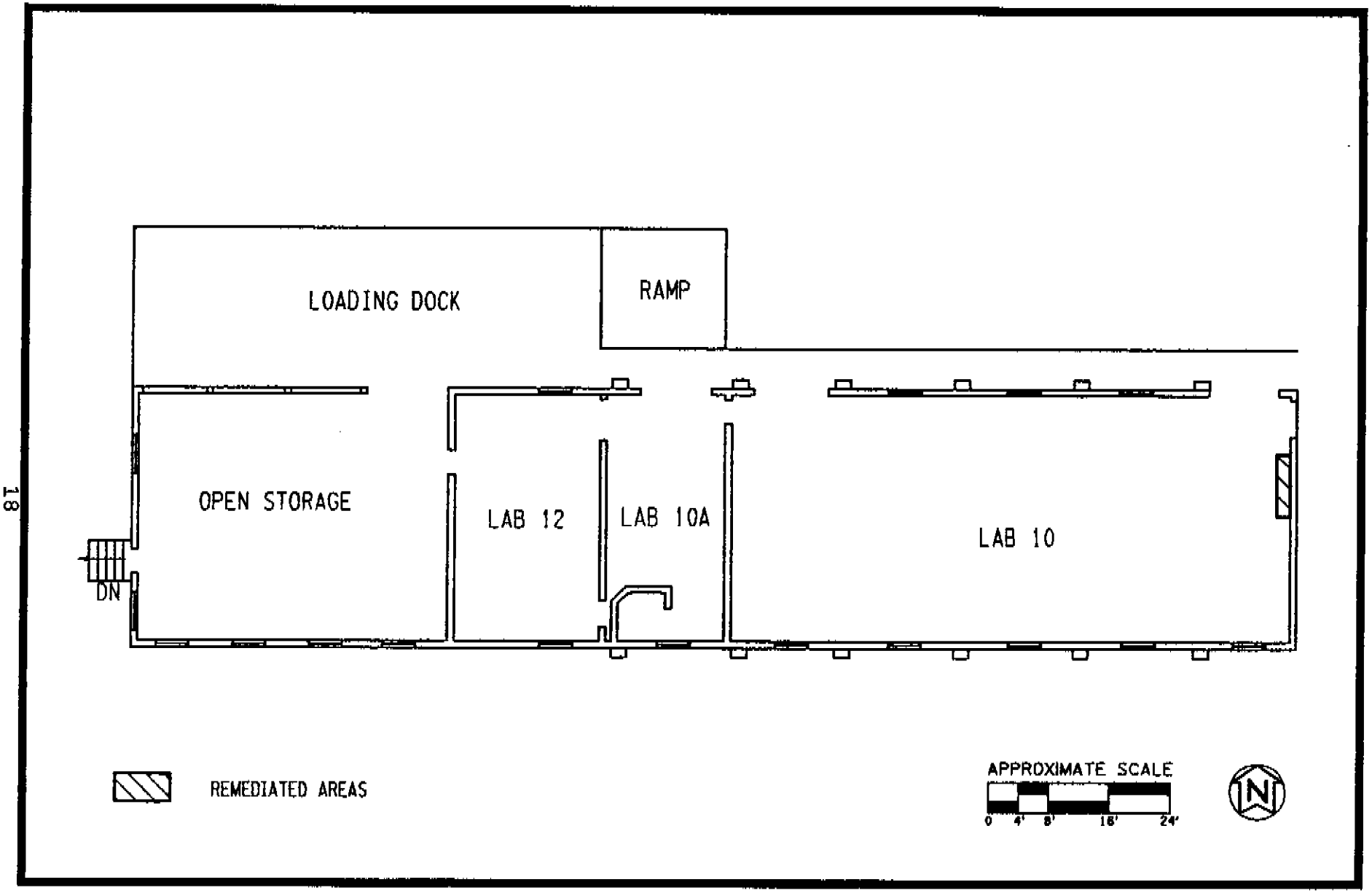

FIGURE 3-6 BUILDING 17, WEST END

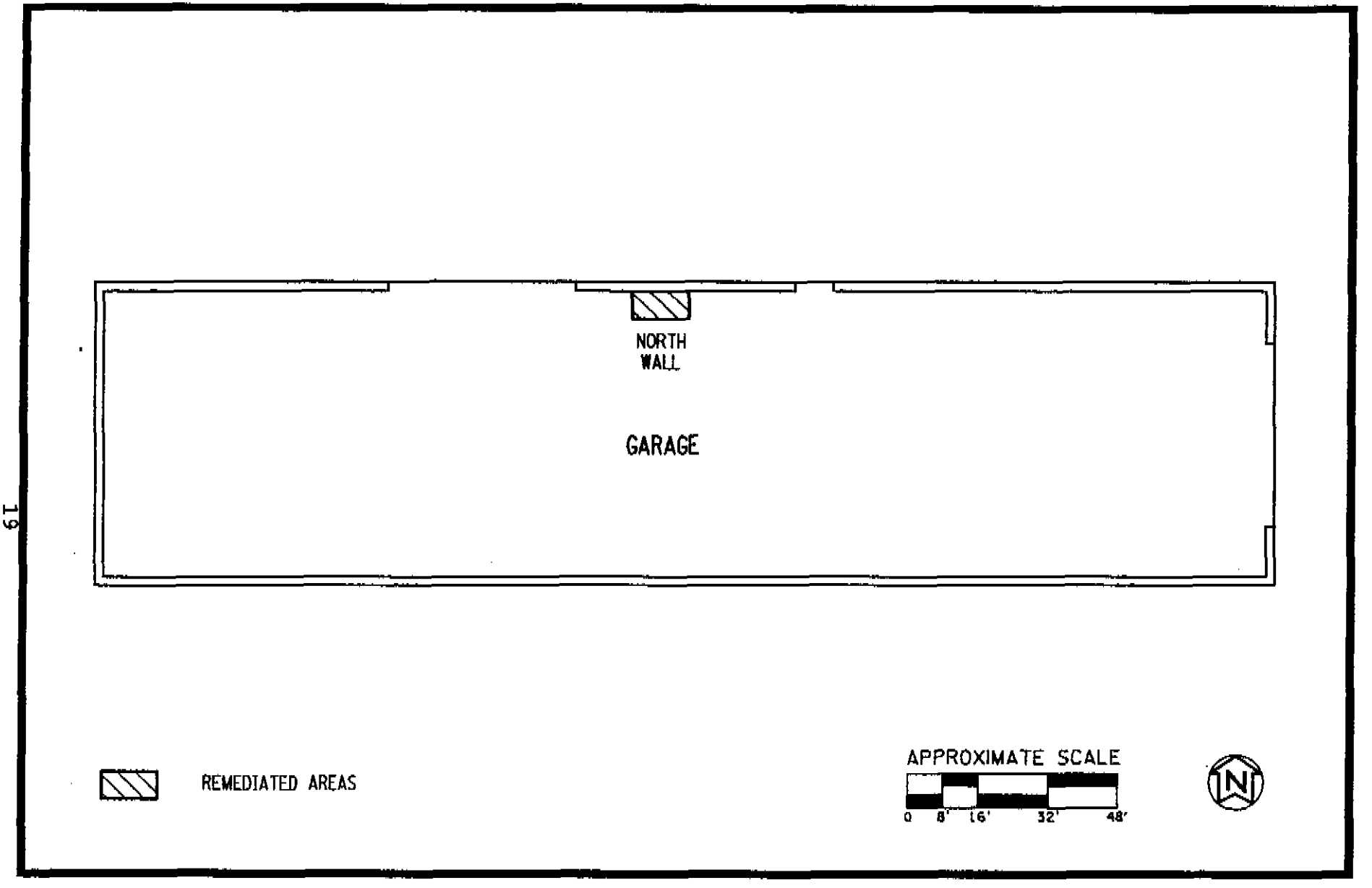

FIGURE 3-7 BUILDING 19 (GARAGE)

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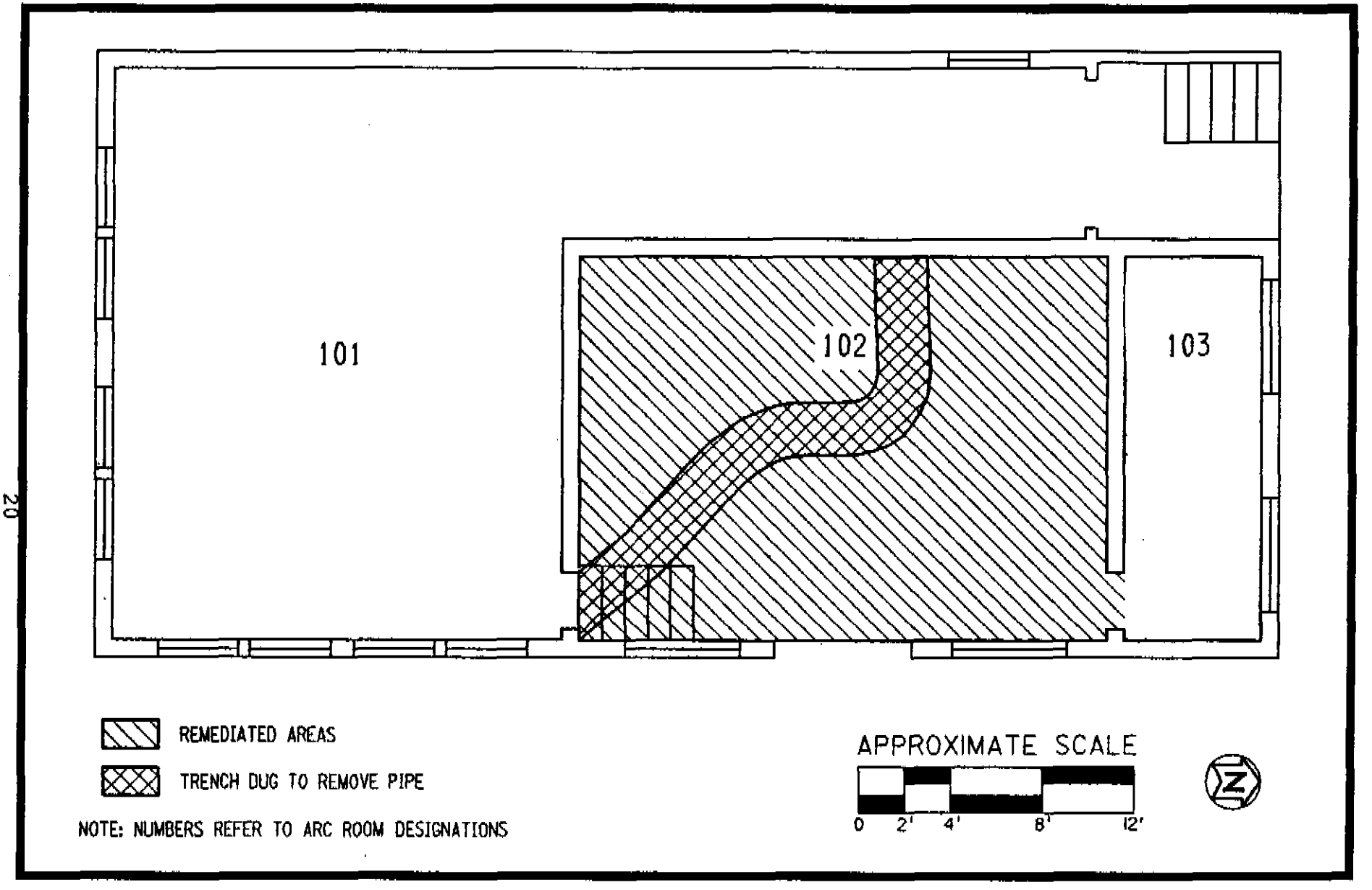

FIGURE 3-8 BUILDING 27

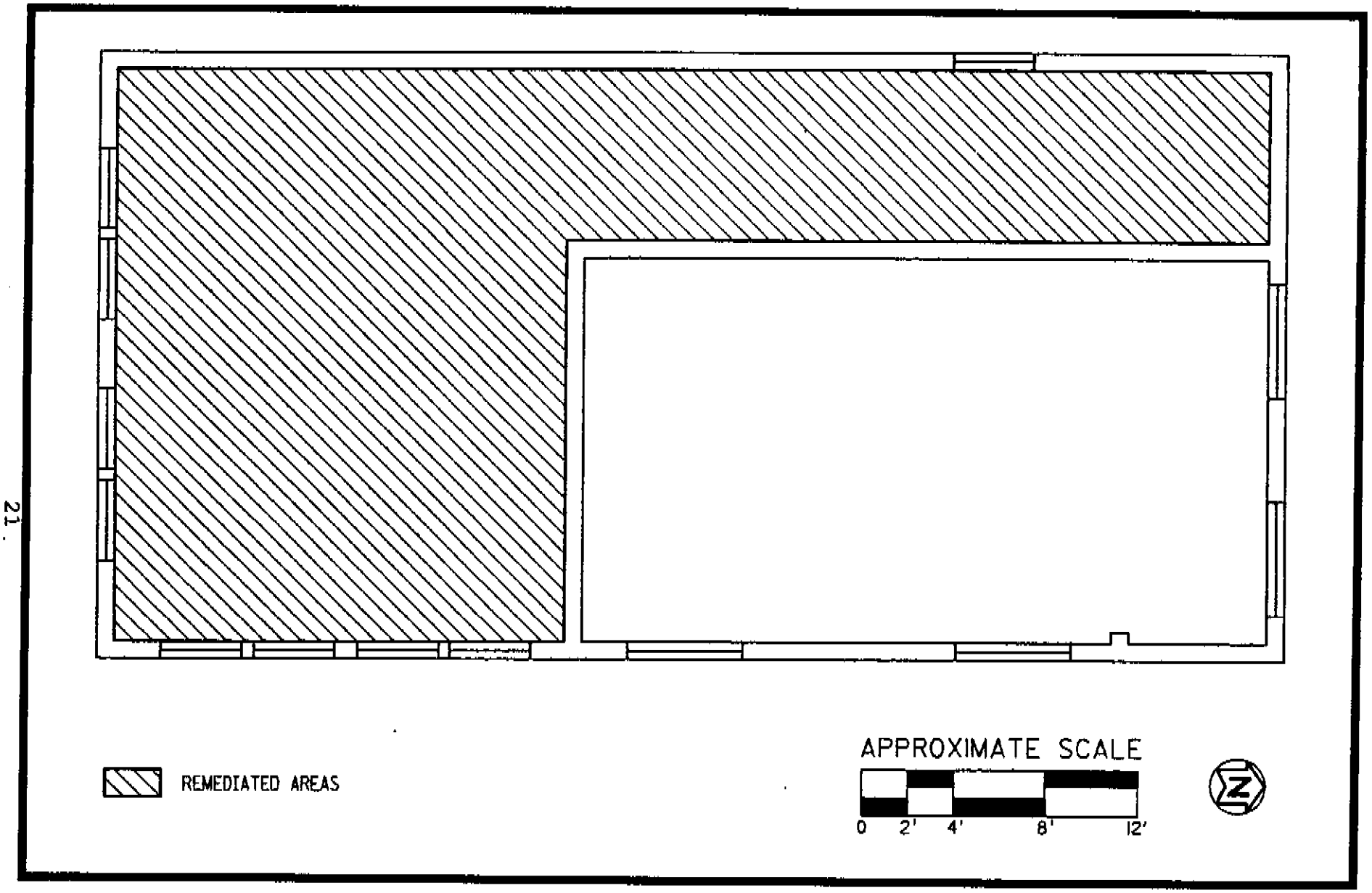

FIGURE 3-9 BUILDING 27, CRAWL SPACE

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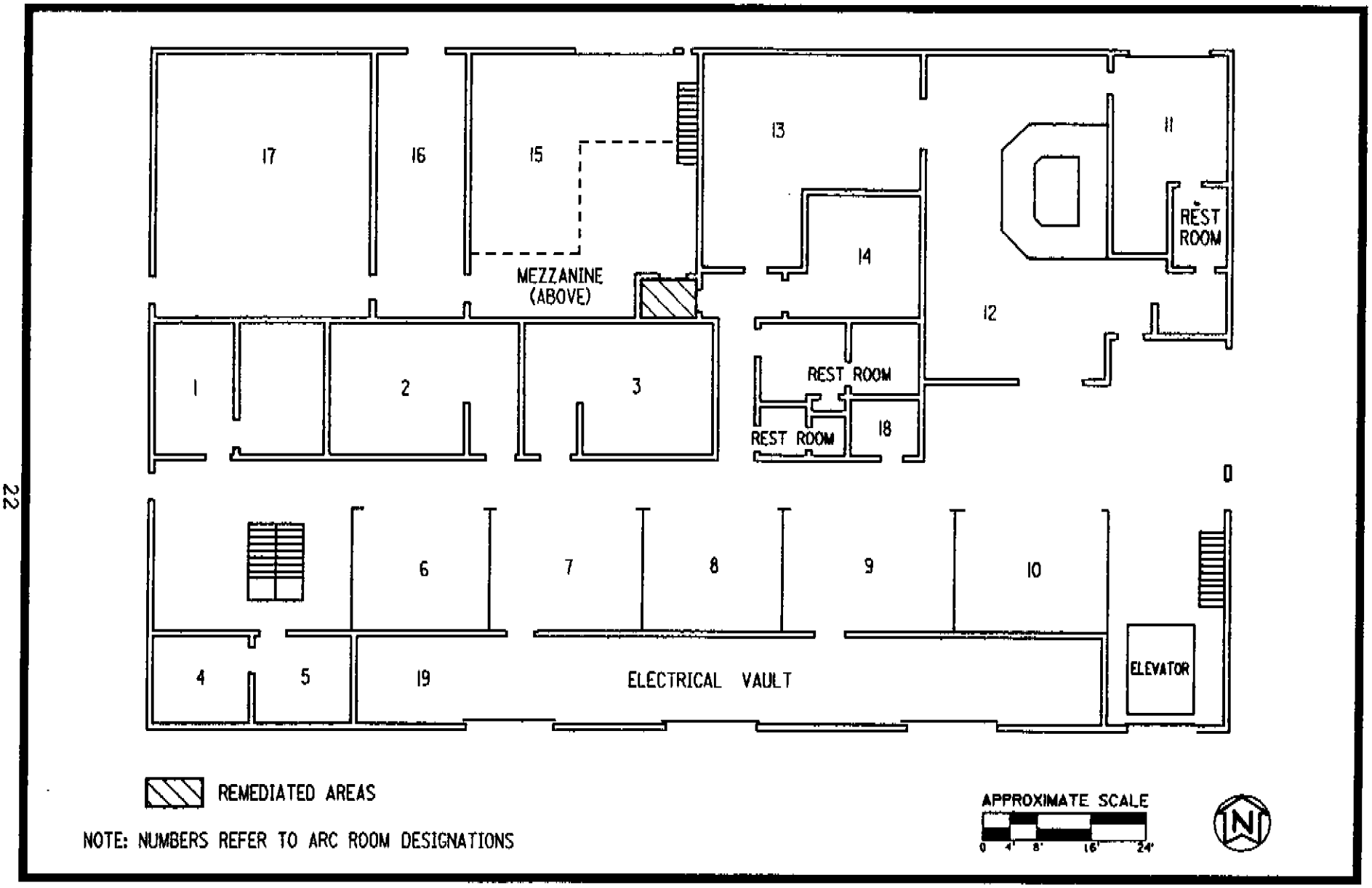

FIGURE 3-10 BUILDING 28, FIRST FLOOR

CDN: [42,1] A02W9809.DGN JKL

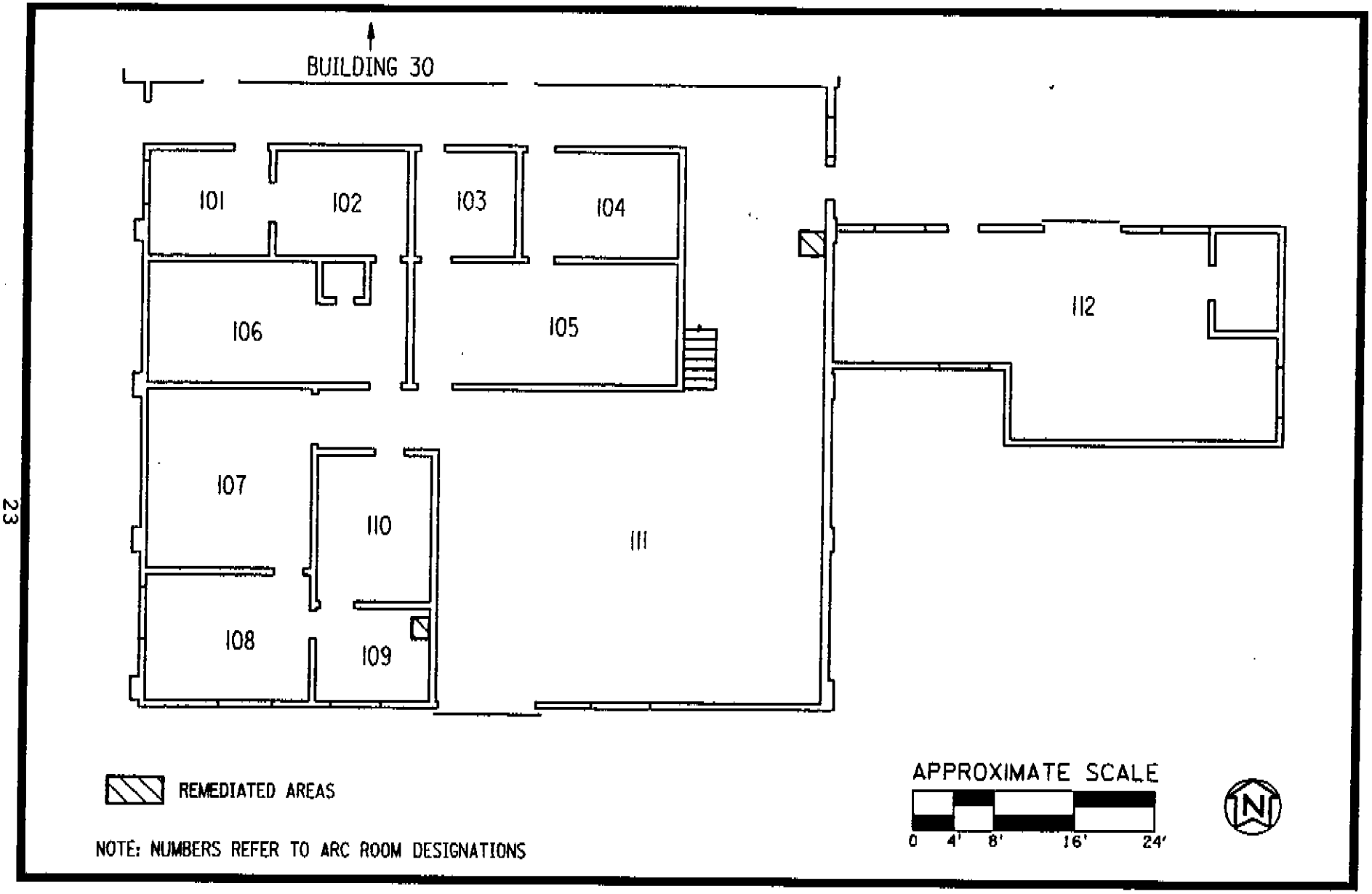

FIGURE 3-11 BUILDING 29, FIRST FLOOR

CAD: (42,1) A02W9809.DGN JKL

contaminated material. Lengths of drainline were removed until all sections containing contamination above applicable criteria were removed.

Building 30

Selected floor areas and equipment were remediated in the fabrication room by scabbling and grinding or removal (Figure 3-12). Duct work and HEPA filters were removed and replaced in the mezzanine of the fabrication room. Additional duct work was removed from the machine shop east of the fabrication room. The floor of the mezzanine (Figure 3-13) was also remediated by scraping select surfaces and vacuuming all walkway surfaces.

Building 31

Rooms 1, 14, and 15 were remediated by jackhammering and scabbling the floor-wall intersection areas, floor, and selected portions of trenches (Figure 3-14). Some sections of the floor in Room 1 had to be excavated to allow contaminated drain lines to be removed.

3.2 CONTAMINATION CONTROL DURING REMEDIAL ACTION

During the cleanup, several measures were implemented to protect workers from exposure to radiation in excess of applicable standards, and to control the migration of radioactive materials to adjacent properties. The primary pathway by which local residents could have been exposed to radiation was through airborne dust generated during the excavations. To prevent such exposure during interior scabbling operations, plastic sheeting was installed around the work areas to control dust migration. During remediation of exterior areas, the subcontractor was required to keep all excavations and work areas free from dust by maintaining adequate soil moisture to prevent excessive generation of airborne dust.

During the exterior and interior cleanup, particulate air monitoring devices were placed near or in the vicinity of the excavation

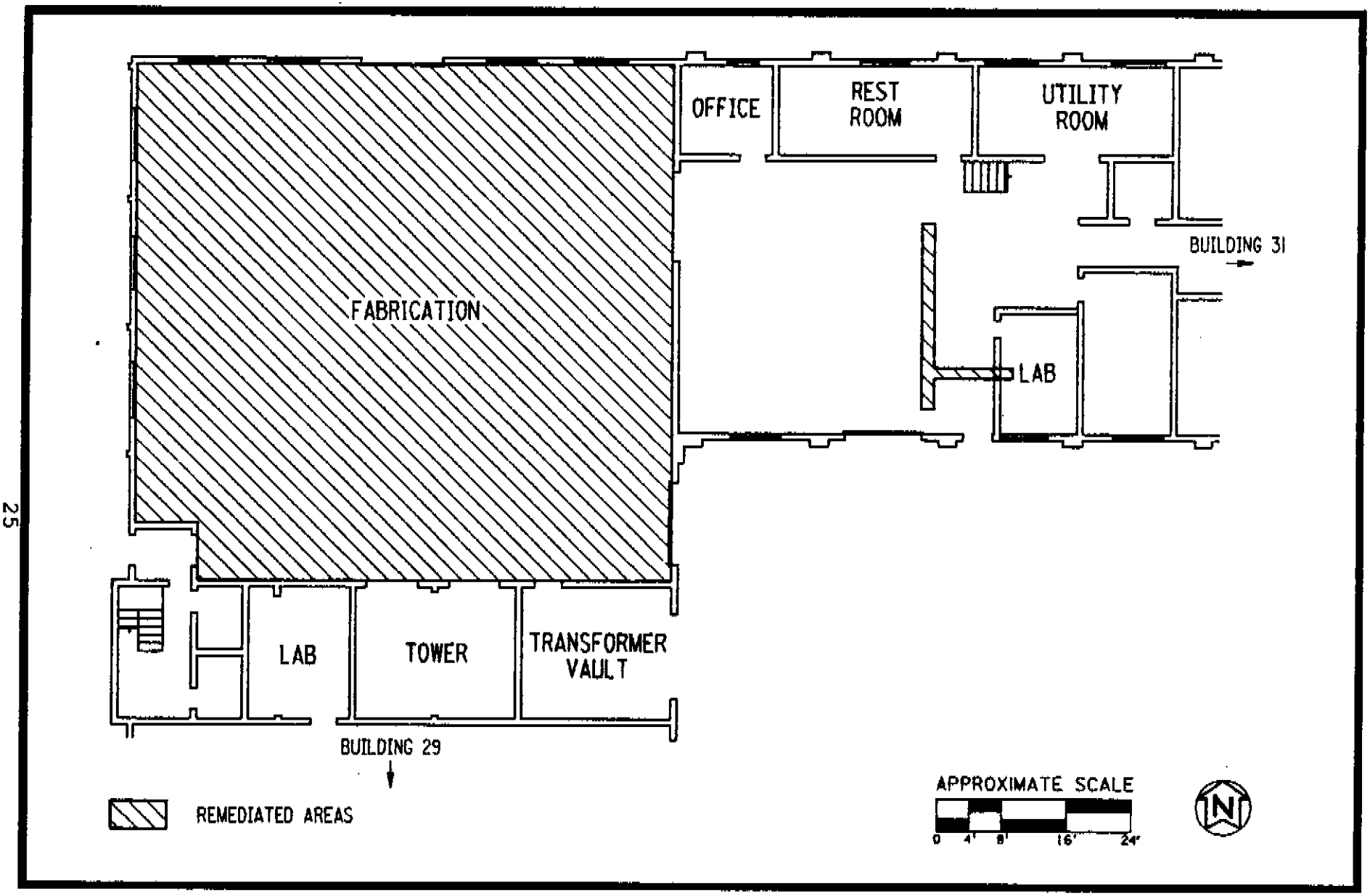

FIGURE 3-12 BUILDING 30

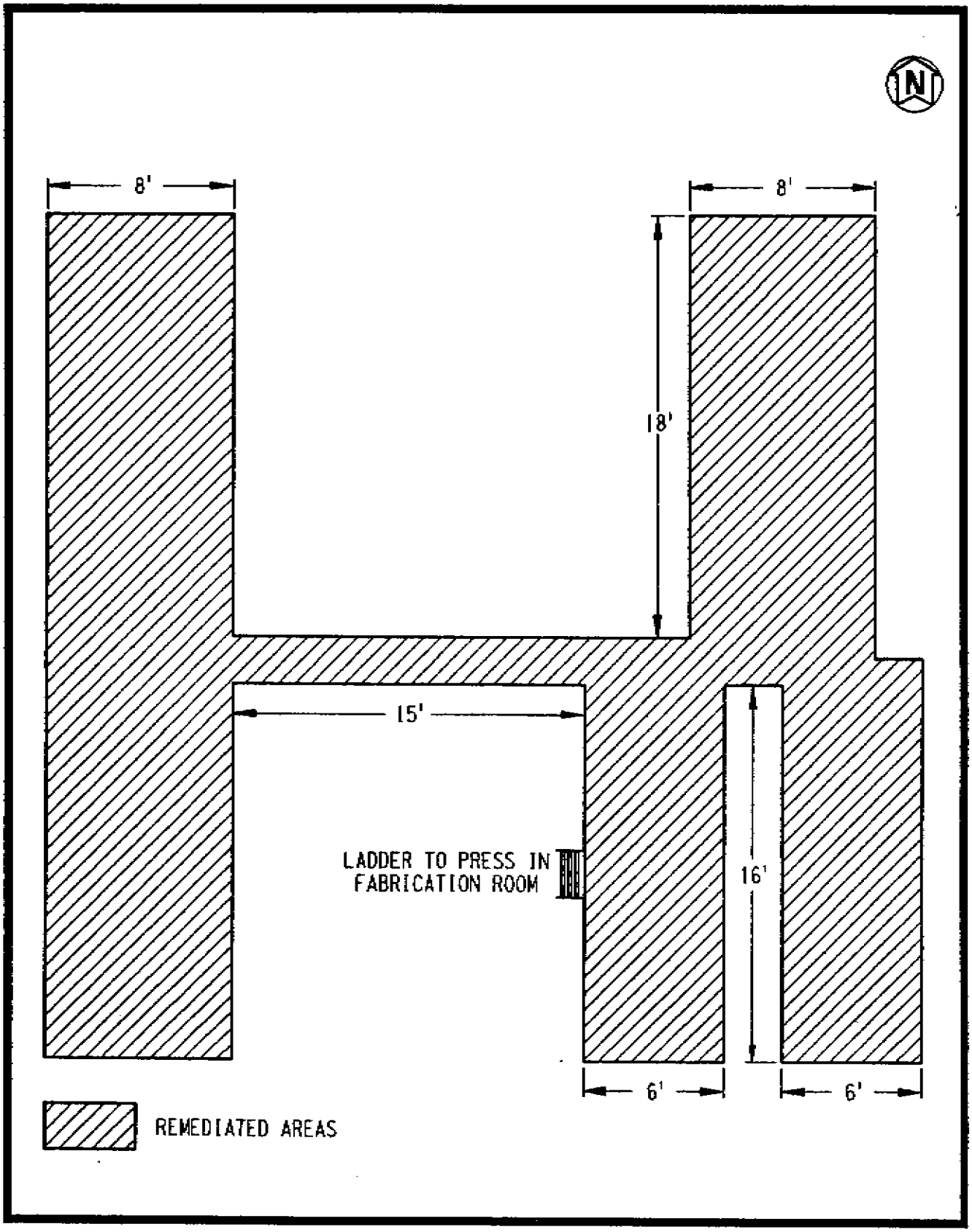

FIGURE 3-13 BUILDING 30, MEZZANINE WALKWAY ABOVE FABRICATION ROOM

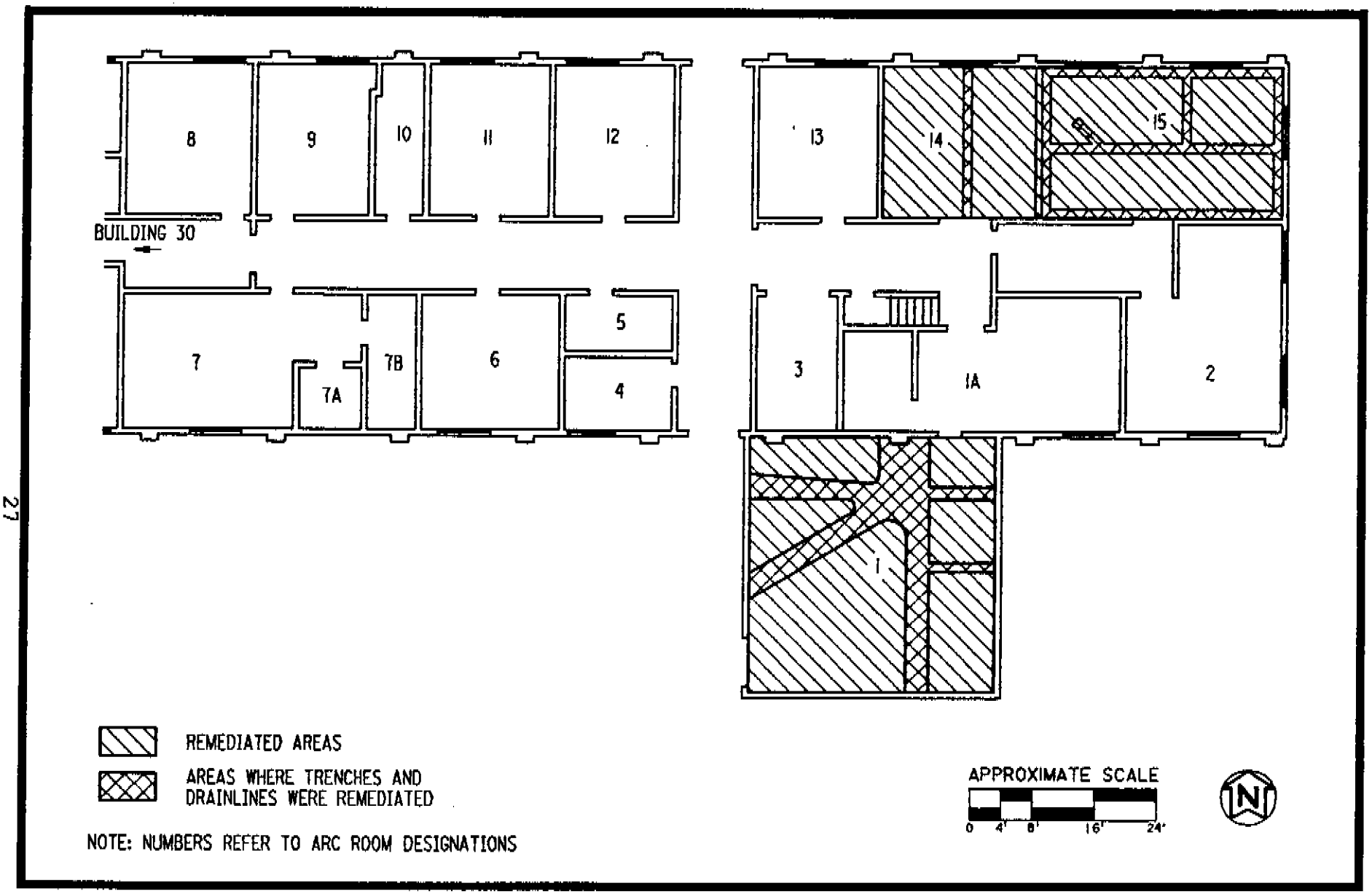

FIGURE 3-14 BUILDING 31

GRB: (42,1) A02W9809.DGN JKL

areas (Figure 3-15) to provide continuous air monitoring of the concentration of alpha-emitting radionuclides. The average concentration of 238 air particulate samples collected was 8×10^{-14} µCi/ml. All concentrations measured were below the applicable DOE guideline for airborne thorium-232 (1.0×10^{-12} µCi/ml) (Ref. 8).

Haul trucks were lined with plastic before they were loaded to prevent free water and dirt from escaping. Absorbent material was placed in the rear of the truck beds to help contain any free water that might drain from contaminated equipment. The liner was large enough to drape over the sides of the truck to keep the truck exterior from becoming contaminated during loading. Finally, before shipment of the radioactive soil to the Hanford DOE facility, the liner was folded over the top and sealed and the truck was covered to prevent soil from falling or blowing out of the truck. Truck tailgates were equipped with watertight gaskets to prevent spillage.

Before and after implementation of waste transportation activity, the local haul route was radiologically surveyed and differences in conditions were noted. These surveys confirmed that contamination control measures implemented during transportation activities were successful.

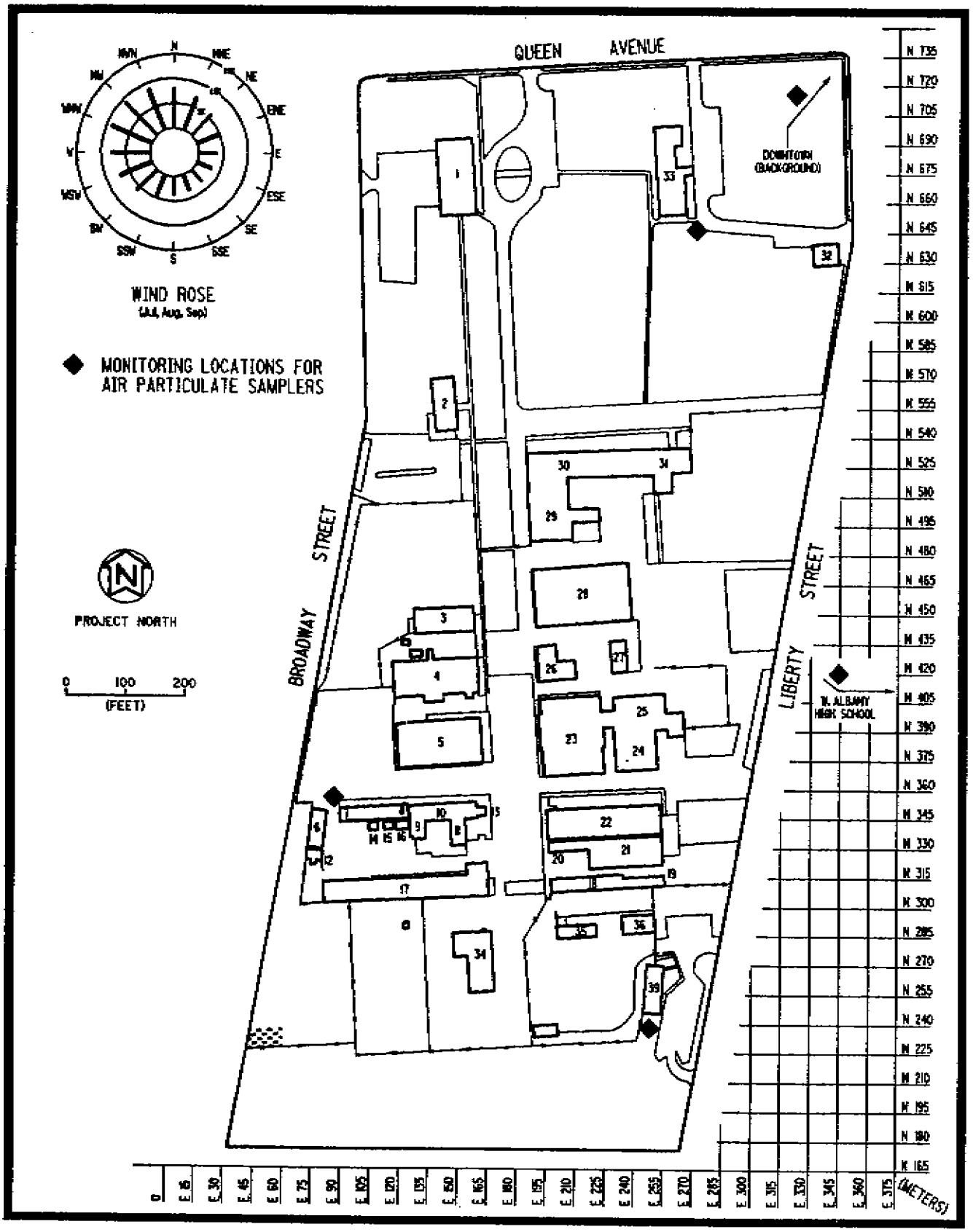

FIGURE 3-15 AIR MONITOR LOCATIONS AT ARC

4.0 POST-REMEDIAL ACTION MEASUREMENTS

After remedial action was completed, a radiological survey of the remediated areas was conducted. Measurements and soil samples were taken to ensure that no radionuclide contamination exceeding DOE guidelines remained. The interior measurements consisted primarily of direct alpha and beta-gamma measurements.

In the tables at the end of this section, use of the "less than" (<) notation in reporting results indicates that the radionuclide was not present in concentrations that are quantifiable with the instruments and techniques used. The "less than" value represents the lower limit of the quantitative capacity of the instrument and technique used. It is based on various factors, including the volume, size, and weight of the sample for bulk samples; surface area of the detector for direct and transferable measurements; the type of detector used; the counting time; and the background count rate. The actual concentration of the radionuclide is less than the value preceded by the "less than" symbol. Because radioactive decay is a random process, no correlation between the rate of disintegration and a given radionuclide concentration can be precisely established. For this reason, the exact concentration of the radionuclide cannot be determined. Accordingly, each value that can be quantitatively determined has an associated uncertainty term (±) that represents the amount by which the actual concentration can be expected to differ from the value given in the table. The uncertainty term has an associated confidence level of 95 percent.

All the direct alpha and beta-gamma measurements are reported with instrument background levels having been subtracted. These measurements were all taken with portable, hand-held instruments. Background measurements recorded with such instruments can vary from room to room for various reasons, including the use of different instruments in the various rooms, small changes in the response of the instrument, and small day-to-day changes in the ambient background.

4.1 OUTSIDE AREAS

As shown in Table 4-1, analytical results from soil samples taken after remediation indicate that no contamination in excess of DOE remedial action guidelines remains in these areas. Soil analysis results reported in Table 4-1 include background, which typically measures about 0.98 pCi/g for thorium-232, 0.82 pCi/g for radium-226, and 1.6 pCi/g for total uranium. (Uranium-238 accounts for 48.87 percent of the total, or 0.78 pCi/g.) A site-specific guideline was not derived for uranium-238, because the characterization data indicate that the exterior contamination is in secular equilibrium. Compliance with the remedial action guideline for radium in soil ensures that the residual concentration of uranium-238 is also acceptably low (Ref. 2).

4.1.1 Surface Gamma Radiation Scans

Two types of gamma radiation scans are conducted to aid in determining whether all radioactively contaminated soil in excess of DOE guidelines has been removed from an area. In the first, a walkover scan, the surveyor holds the radiation detector a few centimeters above the ground surface and slowly moves it over the ground while walking over the excavated area. This type of survey is performed to detect areas of residual contamination. If contamination appears to be in excess of remedial action guidelines, additional excavation is performed; the area is then scanned again to determine if the contamination has been removed. The advantage of the walkover survey is that the detector quickly scans the areas as the excavation proceeds.

The second type of gamma radiation scan is performed after all contamination detected by the walkover scan has been removed. This survey uses a cone-shielded detector to ensure that the only radiation detected is that coming from the ground directly beneath the unit.

TABLE 4-1

POST-REMEDIAL ACTION RESULTS FOR SOIL AT THE ALBANY RESEARCH CENTER

Grid Location	Concentration (pCi/g +/- 2 sigma)[a,b]		
	Uranium-238	Radium-226	Thorium-232
E 55 N 145	< 9.0	3.3 ± 0.9	< 2.0
E 55 N 155	< 7.0	1.4 ± 0.7	2.0 ± 1.0
E 65 N 145	< 8.0	1.0 ± 0.7	1.2 ± 0.8
E 65 N 155	<11.0	2.4 ± 0.8	< 2.0
E 69 N 303	< 7.0	0.6 ± 0.5	1.6 ± 0.8
E 71 N 302	< 3.0	0.8 ± 0.3	1.4 ± 0.5
E 85 N 324	< 6.0	1.4 ± 0.7	2.0 ± 1.0
E 86 N 286	< 9.0	0.9 ± 0.7	< 2.0
E 90 N 295	< 7.0	1.0 ± 0.5	2.0 ± 1.0
E 95 N 295	< 8.0	1.1 ± 0.7	2.0 ± 1.0
E 95 N 325	< 9.0	1.3 ± 0.6	2.0 ± 1.0
E 97 N 336	<10.0	1.5 ± 0.7	2.0 ± 1.0
E 102 N 325	< 8.0	0.8 ± 0.6	2.0 ± 1.0
E 103 N 299	< 9.0	1.7 ± 0.7	2.0 ± 1.0
E 105 N 285	< 3.0	0.9 ± 0.3	1.2 ± 0.5
E 105 N 317	< 9.0	1.2 ± 0.8	2.0 ± 1.0
E 107 N 321	<10.0	1.1 ± 0.5	2.0 ± 1.0
E 115 N 286	< 8.0	1.3 ± 0.6	2.0 ± 1.0
E 117 N 428	< 9.0	0.7 ± 0.7	2.0 ± 1.0
E 117 N 445	<11.0	1.1 ± 0.6	5.0 ± 2.0
E 117 N 451	<10.0	1.4 ± 0.9	< 2.0
E 118 N 437	< 8.0	0.9 ± 0.6	4.0 ± 2.0
E 121 N 442	< 8.0	1.0 ± 0.6	3.0 ± 1.0
E 122 N 439	< 9.0	1.4 ± 0.8	3.0 ± 2.0
E 124 N 292	< 9.0	0.7 ± 0.7	2.0 ± 1.0
E 125 N 279	< 5.0	0.7 ± 0.6	2.0 ± 1.0
E 125 N 285	< 3.0	0.9 ± 0.3	1.5 ± 0.4
E 125 N 319	< 8.0	1.1 ± 0.8	< 1.0
E 125 N 325	< 4.0	1.1 ± 0.8	< 1.0
E 132 N 325	< 4.0	2.1 ± 0.8	< 1.0
E 136 N 396	< 7.0	1.0 ± 0.6	2.0 ± 1.0
E 145 N 397	< 9.0	0.9 ± 0.7	2.0 ± 1.0
E 146 N 371	< 8.0	0.7 ± 0.6	2.0 ± 1.0
E 147 N 369	< 7.0	0.8 ± 0.6	1.0 ± 1.0
E 155 N 369	< 7.0	< 1.0	< 1.0
E 155 N 371	< 7.0	1.0 ± 0.6	< 1.0
E 155 N 397	< 7.0	1.3 ± 0.5	2.0 ± 1.0
E 162 N 397	< 8.0	0.7 ± 0.5	3.0 ± 2.0
E 163 N 377	< 7.0	1.1 ± 0.6	1.0 ± 1.0
E 164 N 385	< 9.0	1.9 ± 0.8	2.0 ± 1.0
E 164 N 391	< 7.0	0.5 ± 0.5	1.3 ± 0.9
E 165 N 369	< 9.0	1.2 ± 0.6	3.0 ± 1.0
E 165 N 441	< 5.0	0.7 ± 0.2	1.2 ± 0.4

TABLE 4-1

(continued)

Grid Location	Concentration (pCi/g +/- 2 sigma)[a,b] Uranium-238	Radium-226	Thorium-232
E 175 N 443	< 3.0	0.9 ± 0.3	1.4 ± 0.5
E 179 N 219	<10.0	1.4 ± 0.8	3.0 ± 2.0
E 179 N 225	< 7.0	2.2 ± 0.8	< 2.0
E 184 N 246	< 3.0	0.6 ± 0.3	1.0 ± 0.5
E 185 N 195	< 5.0	0.5 ± 0.2	0.8 ± 0.4
E 185 N 205	< 4.0	0.7 ± 0.2	1.2 ± 0.4
E 185 N 215	< 3.0	1.0 ± 0.3	0.9 ± 0.4
E 185 N 225	< 4.0	1.7 ± 0.4	1.7 ± 0.5
E 185 N 256	< 3.0	0.7 ± 0.3	1.7 ± 0.5
E 185 N 265	< 3.0	0.7 ± 0.3	1.0 ± 0.4
E 185 N 275	< 3.0	0.5 ± 0.3	0.9 ± 0.5
E 195 N 185	< 4.0	0.5 ± 0.2	0.6 ± 0.3
E 195 N 185	< 4.0	0.5 ± 0.2	0.6 ± 0.3
E 195 N 195	< 3.0	0.8 ± 0.3	2.8 ± 0.6
E 195 N 205	< 6.0	1.1 ± 0.3	2.5 ± 0.6
E 195 N 215	< 3.0	1.1 ± 0.3	3.2 ± 0.6
E 195 N 225	< 5.0	0.7 ± 0.6	3.0 ± 1.0
E 197 N 259	< 3.0	1.0 ± 0.3	1.3 ± 0.5
E 198 N 249	< 3.0	0.9 ± 0.3	1.6 ± 0.5
E 198 N 265	< 3.0	0.7 ± 0.3	1.1 ± 0.4
E 198 N 275	< 3.0	0.5 ± 0.3	1.2 ± 0.5
E 198 N 281	< 3.0	0.6 ± 0.3	1.0 ± 0.5
E 201 N 249	< 4.0	1.0 ± 0.3	1.3 ± 0.5
E 201 N 266	< 2.0	0.8 ± 0.3	0.9 ± 0.4
E 201 N 275	< 4.0	0.9 ± 0.3	1.8 ± 0.6
E 205 N 175	< 6.0	0.7 ± 0.3	0.8 ± 0.4
E 205 N 185	< 5.0	0.6 ± 0.2	0.4 ± 0.3
E 205 N 195	< 5.0	0.8 ± 0.3	0.9 ± 0.4
E 205 N 205	< 4.0	1.0 ± 0.4	2.6 ± 0.6
E 211 N 301	< 6.0	1.2 ± 0.6	2.0 ± 1.0
E 212 N 255	< 3.0	1.6 ± 0.3	1.2 ± 0.4
E 213 N 307	< 6.0	0.7 ± 0.6	0.8 ± 0.7
E 213 N 475	< 4.0	0.7 ± 0.3	1.5 ± 0.5
E 215 N 175	< 6.0	0.6 ± 0.2	0.7 ± 0.3
E 215 N 185	< 5.0	1.1 ± 0.3	1.1 ± 0.5
E 215 N 195	< 3.0	1.7 ± 0.4	1.6 ± 0.6
E 215 N 205	< 4.0	1.3 ± 0.4	2.4 ± 0.6
E 215 N 215	< 4.0	1.2 ± 0.3	2.8 ± 0.5
E 215 N 225	< 4.0	1.6 ± 0.4	3.1 ± 0.7
E 215 N 225	< 4.0	1.5 ± 0.4	2.3 ± 0.6
E 215 N 410	< 9.0	1.0 ± 0.7	2.0 ± 1.0
E 224 N 387	< 3.0	1.1 ± 0.3	1.4 ± 0.5
E 225 N 175	6.0 ± 2.0	0.7 ± 0.2	0.9 ± 0.3
E 225 N 185	< 3.0	1.0 ± 0.3	2.1 ± 0.5
E 225 N 195	< 4.0	2.7 ± 0.5	1.8 ± 0.6
E 225 N 205	< 5.0	1.1 ± 0.3	1.4 ± 0.5

TABLE 4-1

(continued)

Grid Location		Concentration (pCi/g +/- 2 sigma)[a,b]		
		Uranium-238	Radium-226	Thorium-232
E 225	N 225	< 3.0	1.0 ± 0.3	2.0 ± 0.5
E 229	N 357	< 8.0	1.2 ± 0.7	1.0 ± 1.0
E 235	N 175	< 6.0	0.8 ± 0.3	1.6 ± 0.5
E 235	N 185	< 5.0	0.5 ± 0.2	0.9 ± 0.4
E 235	N 195	< 3.0	0.9 ± 0.3	2.0 ± 0.5
E 235	N 205	< 2.0	1.5 ± 0.4	2.3 ± 0.6
E 235	N 215	< 7.0	1.4 ± 0.4	2.7 ± 0.7
E 235	N 225	< 4.0	1.6 ± 0.5	2.7 ± 0.7
E 235	N 357	< 8.0	1.9 ± 0.7	2.0 ± 1.0
E 235	N 362	< 7.0	2.1 ± 0.9	1.0 ± 1.0
E 239	N 435	< 3.0	0.9 ± 0.3	1.0 ± 0.5
E 239	N 498	< 4.0	0.6 ± 0.2	0.5 ± 0.3
E 239	N 502	< 3.0	0.6 ± 0.3	2.6 ± 0.5
E 242	N 362	< 7.0	0.8 ± 0.6	3.0 ± 1.0
E 243	N 357	< 7.0	1.0 ± 0.7	1.4 ± 0.8
E 243	N 495	< 4.0	0.6 ± 0.2	1.0 ± 0.4
E 245	N 427	< 5.0	0.6 ± 0.3	1.3 ± 0.4
E 245	N 435	< 5.0	0.6 ± 0.3	0.8 ± 0.4
E 245	N 485	< 4.0	0.7 ± 0.2	1.0 ± 0.4
E 245	N 505	< 4.0	0.9 ± 0.2	4.1 ± 0.6
E 245	N 511	< 8.0	0.5 ± 0.3	6.0 ± 1.0
E 247	N 463	< 4.0	0.9 ± 0.2	0.5 ± 0.3
E 249	N 445	< 5.0	0.6 ± 0.2	0.9 ± 0.4
E 249	N 455	< 5.0	0.7 ± 0.3	0.8 ± 0.4
E 251	N 463	< 5.0	1.3 ± 0.3	2.2 ± 0.5
E 253	N 294	< 6.0	1.5 ± 0.6	2.0 ± 1.0
E 255	N 427	< 4.0	0.7 ± 0.2	1.1 ± 0.4
E 255	N 435	< 5.0	0.8 ± 0.3	1.1 ± 0.4
E 255	N 445	< 3.0	0.6 ± 0.2	1.6 ± 0.4
E 255	N 455	< 4.0	0.4 ± 0.2	0.7 ± 0.4
E 255	N 465	< 3.0	0.6 ± 0.3	1.3 ± 0.4
E 257	N 349	< 8.0	1.2 ± 0.6	< 1.0
E 257	N 355	< 9.0	1.1 ± 0.5	3.0 ± 1.0
E 259	N 305	< 6.0	1.3 ± 0.7	3.0 ± 1.0
E 261	N 355	< 6.0	1.4 ± 0.7	4.0 ± 1.0
E 261	N 435	< 7.0	1.2 ± 0.3	5.0 ± 1.0
E 261	N 445	< 2.0	0.6 ± 0.2	0.8 ± 0.4
E 261	N 455	< 5.0	0.6 ± 0.3	0.7 ± 0.4
E 262	N 307	< 8.0	1.0 ± 0.5	1.0 ± 1.0
E 262	N 338	< 6.0	1.0 ± 0.6	3.0 ± 1.0
E 262	N 345	< 7.0	1.4 ± 0.7	2.0 ± 1.0
E 265	N 429	< 5.0	0.9 ± 0.2	1.1 ± 0.4
E 265	N 515	< 3.0	0.8 ± 0.2	2.3 ± 0.6
E 275	N 395	< 3.0	0.6 ± 0.3	0.9 ± 0.3
E 275	N 515	< 3.0	0.5 ± 0.2	3.1 ± 0.6

TABLE 4-1

(continued)

Grid Location	Concentration (pCi/g +/- 2 sigma)[a,b] Uranium-238	Radium-226	Thorium-232
E 275 N 535	< 5.0	0.4 ± 0.2	0.9 ± 0.4
E 285 N 525	< 4.0	0.5 ± 0.2	0.7 ± 0.4
E 285 N 535	< 4.0	0.4 ± 0.2	0.7 ± 0.3
Bldg 31 Room 1[c]	< 2.0	0.8 ± 0.2	1.2 ± 0.4
Bldg 31 Room 1[c]	< 5.0	0.7 ± 0.2	0.9 ± 0.3
Bldg 31 Room 1[c]	< 2.0	0.6 ± 0.2	0.8 ± 0.4
Bldg 31 Room 1[c]	< 3.0	0.7 ± 0.2	1.5 ± 0.4
Bldg 31 Room 1[c]	< 4.0	0.8 ± 0.3	2.8 ± 0.6
Bldg 31 Room 1[c]	< 3.0	0.6 ± 0.2	0.6 ± 0.4
Bldg 31 Room 1[c]	< 2.0	0.9 ± 0.3	0.9 ± 0.4
Bldg 31 Room 1[c]	< 4.0	1.0 ± 0.3	1.6 ± 0.6
Bldg 31 Room 1[c]	< 3.0	0.7 ± 0.3	1.1 ± 0.5
Bldg 31 Room 1[c]	< 2.0	0.6 ± 0.2	0.7 ± 0.3
Bldg 31 Room 1[c]	< 6.0	0.6 ± 0.2	0.9 ± 0.4
Bldg 31 Room 1[c]	< 2.0	0.5 ± 0.2	1.1 ± 0.4
Bldg 31 Room 1[c]	< 2.0	0.7 ± 0.2	0.7 ± 0.3
Bldg 31 Room 1[c]	< 2.0	0.8 ± 0.2	1.3 ± 0.4
Bldg 31 Room 1[c]	< 3.0	0.6 ± 0.2	0.9 ± 0.3
Bldg 31 Room 14	< 6.0	1.0 ± 0.2	1.7 ± 0.4
Bldg 31 Room 14	< 6.0	0.7 ± 0.2	3.0 ± 1.0
Bldg 27 Crawlspace[d]	< 3.0	1.5 ± 0.4	2.3 ± 0.5
Bldg 4 N-S Trench	< 4.0	1.5 ± 0.4	1.4 ± 0.6
Bldg 4 E-W Trench	< 5.0	1.4 ± 0.6	1.0 ± 0.8

[a]Samples taken from bottom of excavation.

[b]Sample concentrations include background.

[c]Samples taken from soil that had surrounded the contaminated drain lines in Room 1, Building 31, to determine whether all contamination was contained within the drain lines.

[d]Sample taken from soil in the crawlspace beneath Building 27.

Gamma radiation scans were done in all excavated areas to ensure that each area had been cleaned of radioactively contaminated soils. When either type of gamma radiation scan detected contamination that appeared to be in excess of the DOE guidelines, additional soil was removed, and the survey process was repeated until DOE guidelines were met.

4.1.2 Soil Sampling

Soil sampling was the primary method used in outside areas to ensure that the DOE remedial action guidelines were met. To confirm that all radioactive contamination exceeding guidelines was removed, samples were taken at horizontal grid intervals of 5.0 m (16 ft) over the excavated area and composited to form samples representative of 100 m^2 (1,080 ft^2). The samples were analyzed in the laboratory to determine the concentrations of radium-226, thorium-232, and uranium-238. Soil sampling locations are shown in Figure 4-1.

4.1.3 Dose Rate Measurements

Measurements were taken at 1 m above the ground surface to measure the residual gamma radiation dose rate after removal of contamination. Locations where dose rate measurements were taken are shown in Figure 4-2. The calculated gamma radiation dose rates, assuming a conservative continuous exposure, are given in Table 4-2. For comparison, the DOE radiation protection standard is 100 mrem/yr above the background radiation level. Table 4-2 reflects the values calculated after subtraction of a measured background of 101 mrem/yr.

4.2 INSIDE BUILDINGS

Remediated areas in the buildings were radiologically surveyed to determine whether remedial action guidelines had been met. Direct contact beta-gamma measurements were obtained with a Geiger-Mueller

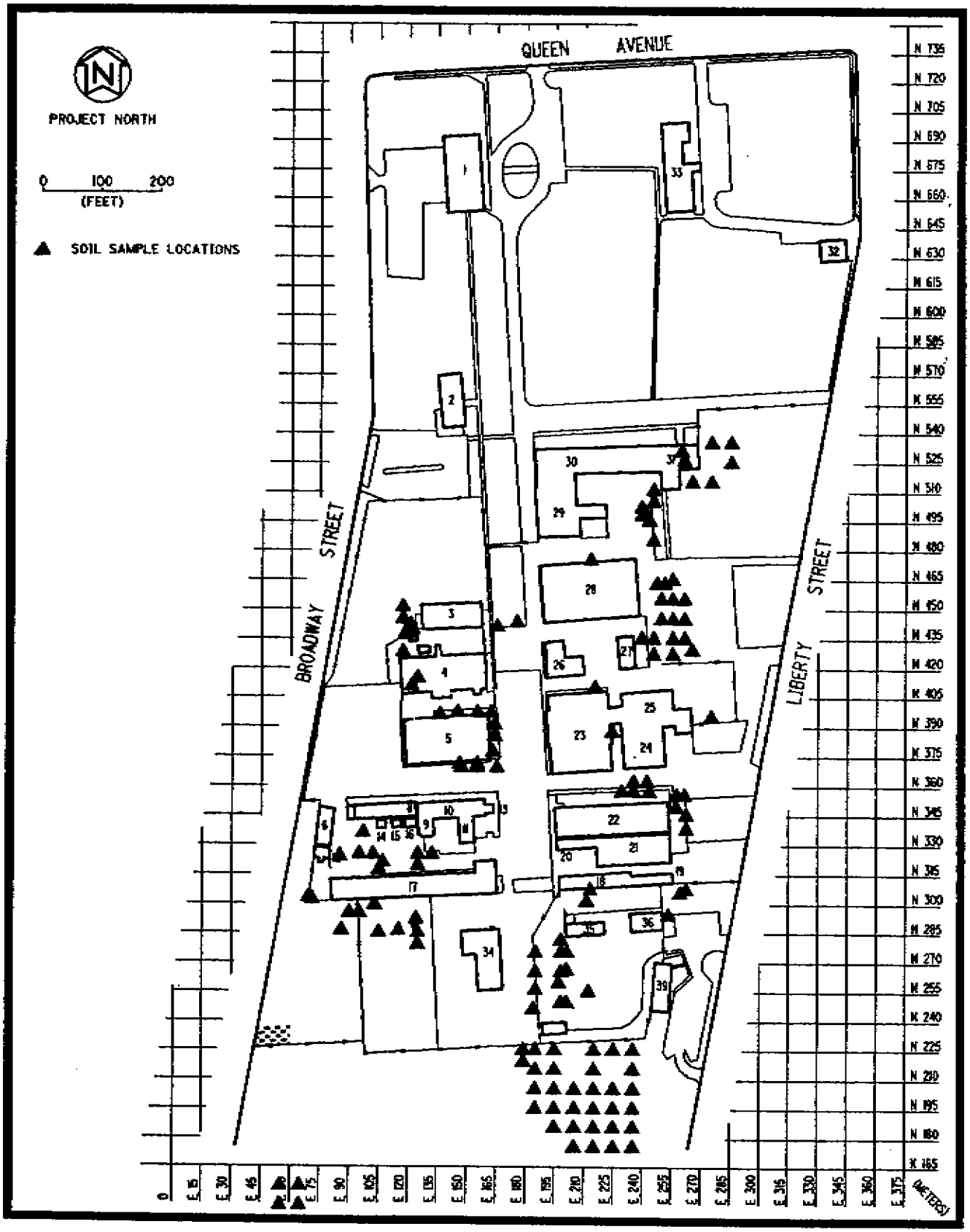

FIGURE 4-1 POST-REMEDIAL ACTION SOIL SAMPLING LOCATIONS AT ARC

GRB: (42,1) A02WMS10.DGN JKL

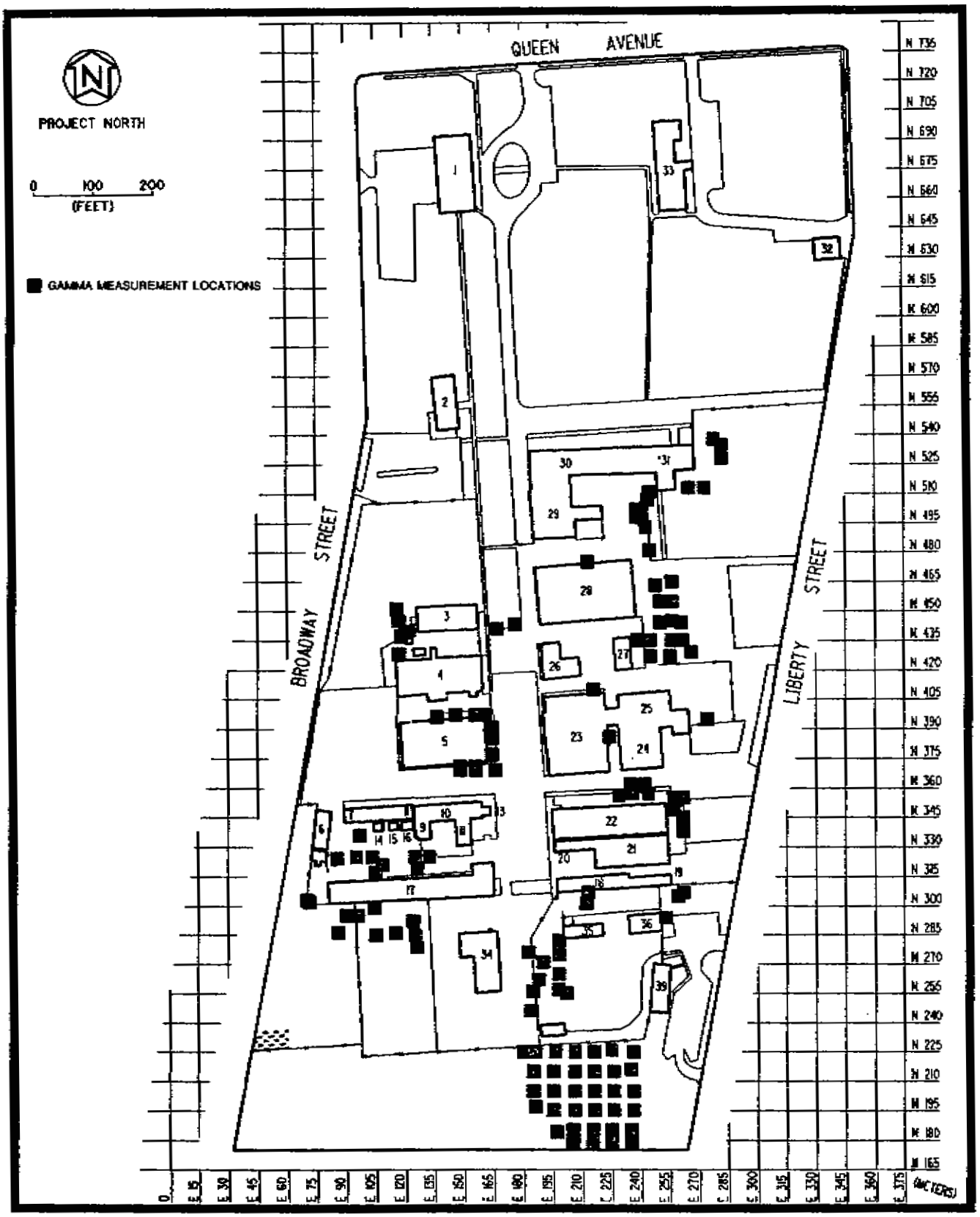

FIGURE 4-2 GAMMA RADIATION DOSE RATE MEASUREMENT LOCATIONS AT ARC

TABLE 4-2

GAMMA RADIATION DOSE RATE MEASUREMENTS

FOR THE ALBANY RESEARCH CENTER

Grid Coordinates East	Grid Coordinates North	Dose Rate[a] (mrem/yr)
70	303	0
71	302	10
85	324	6
86	286	6
90	295	1
95	325	6
96	295	0
97	336	8
103	325	5
104	299	0
105	285	0
105	317	0
108	321	0
115	286	0
116	451	0
117	428	0
117	445	0
118	437	0
122	440	0
124	292	0
125	285	0
125	325	0
126	279	0
126	319	0
132	325	0
136	396	13
146	397	13
148	369	9
148	371	8
156	369	8
156	371	9
156	397	15
161	397	0
164	377	8
164	385	13
164	391	8
166	369	14
167	441	0
176	443	0
180	225	0
183	276	0
184	246	0

TABLE 4-2

(continued)

Grid Coordinates East	North	Dose Rate[a] (mrem/yr)
185	205	0
185	215	0
185	256	0
186	197	0
186	225	0
188	262	1
190	271	0
195	195	0
195	205	0
195	215	0
196	225	0
197	184	0
198	257	0
198	265	0
198	275	0
198	282	0
202	255	0
205	179	5
205	185	1
206	195	0
206	205	0
206	215	0
206	225	0
212	301	0
213	307	0
213	475	0
215	179	14
215	185	6
216	195	0
216	205	0
216	215	0
216	225	0
216	410	0
224	386	0
225	179	9
225	185	0
225	226	0
226	195	0
226	205	0
226	215	0
229	356	0
235	179	6
235	185	0
235	216	0
235	362	7

TABLE 4-2

(continued)

Grid Coordinates East	North	Dose Rate[a] (mrem/yr)
236	195	0
236	205	0
236	225	0
236	357	0
238	498	10
238	502	1
239	435	9
241	500	6
242	362	16
243	493	0
244	357	7
244	507	0
245	427	15
245	435	8
245	481	0
245	511	0
248	463	6
250	444	18
250	455	15
253	294	0
255	427	26
256	435	16
256	445	16
256	455	15
256	465	0
257	349	17
257	355	16
259	305	0
261	444	15
262	307	7
262	338	13
262	345	22
262	355	15
262	435	18
265	513	14
266	429	14
273	513	11
274	395	26
278	538	9
282	528	2
282	535	13

[a]Background has been subtracted.

counter. The direct contact alpha measurements were obtained with an alpha scintillation detector. The number of readings generally averaged five per square meter. Where physical features permitted, measurements were obtained in the center of a 1-m by 1-m square and at the four corners of the square. Removable alpha readings were also obtained, at a minimum, at the locations that exhibited direct alpha measurements above guidelines for removable contamination. These measurements were obtained by wiping a 100-cm^2 area with a filter and measuring alpha emissions from the filter with an alpha scintillation counter. Post-remedial action measurements for the building interiors are found in Table 4-3. Footnote b, Table 4-3, describes how to convert the beta-gamma dose rate to beta-gamma activity.

During the inside remedial action contaminated materials were removed from the crawlspace of Building 27 and the subfloor of Building 31, Room 1. Soil samples were taken in these two areas to verify that all contaminated materials were removed. Sample results are shown in Table 4-1.

TABLE 4-3

RADIOLOGICAL SURVEY RESULTS FOR BUILDINGS AT THE ALBANY RESEARCH CENTER[a]

Location	Direct Readings: Alpha Activity (dpm/100 cm^2) Average	Maximum	Minimum	Number of Samples	Beta-Gamma Dose Rate[b] (mrad/h) Average	Maximum	Minimum	Number of Samples	Removable Alpha Activity (dpm/100 cm^2) Average	Maximum	Minimum	Number of Samples
Building 4												
Room 107 (Owl Room)												
Flopr	42	120	<40	293	0.01	0.03	<0.01	293	2	4	<2	291
East Wall	<50	<50	<50	60	0.01	0.01	<0.01	60	2	4	<2	60
West Wall	50	70	<50	59	0.01	0.02	<0.01	59	2	9	<2	60
North Wall	45	50	<40	45	<0.01	<0.01	<0.01	45	2	7	<2	45
South Wall	42	70	<40	45	<0.02	<0.02	<0.02	45	2	2	<2	45
Rafters	60	250	<40	40	0.01	0.02	<0.01	40	2	6	<2	40
Room 108												
Floor	50	100	<50	46	0.01	0.02	<0.01	46	2	3	<2	46
East Wall	<70	<70	<70	21	<0.02	<0.02	<0.02	21	2	2	<2	20
West Wall	<50	<50	<50	21	<0.01	<0.01	<0.01	21	3	11	<2	21
North Wall	<50	<50	<50	21	<0.02	<0.02	<0.02	21	2	3	<2	21
South Wall	<40	<40	<40	21	<0.01	<0.01	<0.01	21	2	3	<2	21

TABLE 4-3

(continued)

Location	Direct Readings: Alpha Activity (dpm/100 cm^2) Average	Maximum	Minimum	Number of Samples	Direct Readings: Beta-Gamma Dose Rate[b] (mrad/h) Average	Maximum	Minimum	Number of Samples	Removable Alpha Activity (dpm/100 cm^2) Average	Maximum	Minimum	Number of Samples
Building 4 (Continued)												
Room 109 (Bathroom)												
Floor	41	70	<40	45	0.02	0.02	<0.02	45	2	4	<2	44
East Wall	<50	<50	<50	17	<0.01	<0.01	<0.01	17	2	2	<2	21
West Wall	<40	<40	<40	19	<0.01	<0.01	<0.01	19	<2	<2	<2	19
North Wall	<50	<50	<50	24	<0.02	<0.02	<0.02	24	2	2	<2	24
South Wall	<50	<50	<50	24	<0.01	<0.01	<0.01	24	2	3	<2	24
Divider (Facing East)	<40	<40	<40	18	<0.01	<0.01	<0.01	18	<2	<2	<2	15
Divider (Facing West)	<50	<50	<50	15	<0.01	<0.01	<0.01	15	2	2	<2	15
Room 206												
Floor	<50	<50	<50	54	<0.01	<0.01	<0.01	54	2	6	<2	36
East Wall	<50	<50	<50	15	<0.01	<0.01	<0.01	15	2	2	<2	15
West Wall	52	70	<50	18	<0.01	<0.01	<0.01	18	<2	<2	<2	18
North Wall	<50	<50	<50	24	<0.01	<0.01	<0.01	24	2	2	<2	24
South Wall	<50	<50	<50	27	<0.01	<0.01	<0.01	27	2	3	<2	27

TABLE 4-3

(continued)

Location	Direct Readings: Alpha Activity (dpm/100 cm^2) Average	Maximum	Minimum	Number of Samples	Direct Readings: Beta-Gamma Dose Rate[b] (mrad/h) Average	Maximum	Minimum	Number of Samples	Removable Alpha Activity (dpm/100 cm^2) Average	Maximum	Minimum	Number of Samples
Building 5												
Machine Shop												
Floor	80	280	<70	315	0.02	0.03	<0.02	315	7	23	<5	315
South Wall	31	40	<30	53	0.01	0.02	<0.01	53	<5	<5	<5	53
South Wall Windows	54	220	<40	230	0.01	0.03	<0.01	230	3	13	<2	230
South Wall Windows Lower Channel	100	440	<40	65	<0.02	<0.02	<0.02	65	3	12	<2	78
South Wall Square Conduit Bottom of Windows	67	210	<30	48	<0.02	<0.02	<0.02	48	6	7	<6	19
2-in. Conduit 2 m North of South Wall	120	610	<40	60	0.02	0.03	<0.02	60	4	16	<2	60
South Wall Top Window Channel	93	980	<30	90	0.02	0.02	<0.02	90	3	12	<2	90

TABLE 4-3

(continued)

Location	Direct Readings: Alpha Activity (dpm/100 cm^2) Average	Maximum	Minimum	Number of Samples	Direct Readings: Beta-Gamma Dose Rate[b] (mrad/h) Average	Maximum	Minimum	Number of Samples	Removable Alpha Activity (dpm/100 cm^2) Average	Maximum	Minimum	Number of Samples
Building 5 (Continued)												
Truss #2												
Top Beam	120	420	<30	22	<0.02	<0.02	<0.02	22	4	13	<2	22
Bottom Beam	130	580	<30	35	0.02	0.02	<0.02	35	3	17	<2	35
Diagonal Supports	73	230	<30	31	0.02	0.02	<0.02	31	2	4	<2	30
Lower Brace	41	110	<30	7	<0.02	<0.02	<0.02	7	4	9	<2	7
Truss #3												
Top Beam	77	130	<50	7	<0.02	<0.02	<0.02	7	6	11	<2	7
Bottom Beam	69	310	<50	30	0.02	0.02	<0.02	30	3	9	<2	30
Cross Member	<50	<50	<50	7	<0.02	<0.02	<0.02	7	3	4	<2	7
Light Fixture #2 Light Bank West of Truss #3	<50	<50	<50	6	<0.02	<0.02	<0.02	6	2	3	<2	7
Big Conduit West of Truss #3	55	130	<50	20	<0.02	<0.02	<0.02	20	2	2	<2	20

TABLE 4-3

(continued)

Location	Direct Readings: Alpha Activity (dpm/100 cm^2) Average	Maximum	Minimum	Number of Samples	Beta-Gamma Dose Rate[b] (mrad/h) Average	Maximum	Minimum	Number of Samples	Removable Alpha Activity (dpm/100 cm^2) Average	Maximum	Minimum	Number of Samples
Building 5 (Continued)												
#1 Stringer	53	260	<40	40	0.02	0.02	<0.02	40	3	14	<2	40
#1 Roof Support Beam	36	70	<30	45	0.02	0.02	<0.02	45	3	12	<2	45
Building 19												
Laboratory Hood	130	600	<50	7	<0.02	<0.02	<0.02	7	6	14	<4	7
Building 27												
Room 102												
Floor	70	90	<70	87	0.02	0.03	<0.01	87	8	<11	<5	89
East Wall	<60	<60	<60	33	0.02	0.03	<0.02	33	5	6	<5	33
West Wall	70	80	<70	33	0.01	0.02	<0.01	33	<7	<7	<7	32
North Wall	71	90	<70	24	0.01	0.01	<0.01	24	<7	<7	<7	24
South Wall	73	120	<70	24	0.01	0.03	<0.01	24	6	<7	<5	24

TABLE 4-3

(continued)

Location	Direct Readings: Alpha Activity (dpm/100 cm^2) Average	Maximum	Minimum	Number of Samples	Direct Readings: Beta-Gamma Dose Rate[b] (mrad/h) Average	Maximum	Minimum	Number of Samples	Removable Alpha Activity (dpm/100 cm^2) Average	Maximum	Minimum	Number of Samples
Building 28												
Corridor	<40	<40	<40	8	<0.02	<0.02	<0.02	8	<4	<4	<4	8
Building 29												
Room 109												
Sink Drain	<20	<20	<20	3	<0.02	<0.02	<0.02	3	<4	<4	<4	2
Room 111												
Northeast Wall/ Floor Interface Around Drain	51	60	<50	18	0.01	0.02	<0.01	18	4	6	<4	18
Building 30												
Fabrication Room												
1st E. Mezzanine	70	140	<40	60	<0.02	<0.02	<0.02	60	7	17	<5	60
2nd E. Mezzanine	60	320	<40	54	<0.02	<0.02	<0.02	54	7	14	<5	54
3rd E. Mezzanine	70	570	<40	50	0.02	0.03	<0.02	50	8	29	<6	50

TABLE 4-3

(continued)

Location	Direct Readings: Alpha Activity (dpm/100 cm^2) Average	Maximum	Minimum	Number of Samples	Beta-Gamma Dose Rate[b] (mrad/h) Average	Maximum	Minimum	Number of Samples	Removable Alpha Activity (dpm/100 cm^2) Average	Maximum	Minimum	Number of Samples
Building 30 (Continued)												
Ductwork												
1st Mezzanine Southernmost	<40	<40	<40	5	<0.02	<0.02	<0.02	5	<4	<4	<4	5
1st Mezzanine Northernmost	<40	<40	<40	5	<0.02	<0.02	<0.02	5	<4	<4	<4	5
2nd Mezzanine	<40	<40	<40	5	<0.02	<0.02	<0.02	5	<4	<4	<4	5
3rd Mezzanine Southernmost	<40	<40	<40	5	<0.02	<0.02	<0.02	5	4	5	<4	5
3rd Mezzanine Northernmost	<40	<40	<40	5	<0.02	<0.02	<0.02	5	<4	<4	<4	5
HEPA Filters												
1st Mezzanine	95	260	<40	4	<0.02	<0.02	<0.02	4	<4	<4	<4	4
2nd Mezzanine	75	90	<40	5	<0.02	<0.02	<0.02	5	7	13	<4	5
3rd Mezzanine	46	60	<40	5	<0.02	<0.02	<0.02	5	5	8	<4	5
4th Mezzanine	62	150	<40	5	<0.02	<0.02	<0.02	5	8	26	<4	5

TABLE 4-3

(continued)

Location	Direct Readings: Alpha Activity (dpm/100 cm^2) Average	Maximum	Minimum	Number of Samples	Beta-Gamma Dose Rate[b] (mrad/h) Average	Maximum	Minimum	Number of Samples	Removable Alpha Activity (dpm/100 cm^2) Average	Maximum	Minimum	Number of Samples
Building 30 (Continued)												
5th Mezzanine	43	50	<40	4	<0.02	<0.02	<0.02	4	5	9	<4	4
6th Mezzanine	<40	<40	<40	4	<0.02	<0.02	<0.02	4	7	12	<4	4
Building 31												
Room 1												
Floor	60	420	<30	225	0.02	0.03	<0.01	225	2	20	<2	225
East Wall	70	70	<70	50	<0.02	<0.02	<0.02	50	<2	<2	<2	50
West Wall	72	90	<70	42	0.02	0.02	<0.02	42	2	2	<2	45
North Wall	73	120	<70	40	0.02	0.03	<0.02	40	2	3	<2	40
South Wall	70	70	<70	45	<0.02	<0.02	<0.02	45	<2	<2	<2	45
Room 14												
Floor	61	350	<20	90	0.02	0.02	<0.02	90	4	8	<3	87
East Wall	87	400	<50	38	0.02	0.03	<0.02	38	<6	<6	<6	44
West Wall	68	270	<50	27	0.02	0.02	<0.02	27	<4	<4	<4	27

TABLE 4-3

(continued)

Location	Direct Readings: Alpha Activity (dpm/100 cm^2) Average	Maximum	Minimum	Number of Samples	Beta-Gamma Dose Rate[b] (mrad/h) Average	Maximum	Minimum	Number of Samples	Removable Alpha Activity (dpm/100 cm^2) Average	Maximum	Minimum	Number of Samples
Building 31 (Continued)												
North Wall	63	280	<50	70	0.02	0.02	<0.02	70	4	<4	<4	79
South Wall	64	180	<50	38	<0.02	<0.02	<0.02	38	<5	<5	<5	40
Room 15												
Floor	76	320	<60	135	0.02	0.03	<0.02	135	<2	<2	<2	135
East Wall	78	120	<70	27	0.02	0.02	<0.01	27	2	4	<2	27
West Wall	85	200	<70	27	0.01	0.03	<0.01	27	2	6	<2	27
North Wall	120	440	<70	45	0.01	0.03	<0.01	45	2	7	<2	45
South Wall	84	331	<70	39	0.01	0.02	<0.01	39	2	2	<2	39
Mezzanine Stringers	76	220	<50	59	<0.02	<0.02	<0.02	59	3	9	<2	59
Heater Pipes	61	130	<50	118	<0.02	<0.02	<0.02	118	2	3	<2	118

[a]Background has been subtracted.

[b]The beta-gamma dose was calculated by subtracting background from the gross counts per minutes of the Geiger-Mueller counter and then dividing by the conversion factor (x mrad/h/cpm) for the device. To convert the beta-gamma dose rate in the table to beta-gamma activity, multiply the dose rate by the conversion factor for the devices used at the ARC, which ranged from a low of 1,436 cpm/mrad/h to a high of 1,818 cpm/mrad/h. Then, multiply this number by the area factor for the probe and the efficiency of the device, which ranged from a low of (38 dpm/100 cm^2)/cpm to a high of (46 dpm/100 cm^2)/cpm. An example case would be (0.03 mrad/h x 1,764 cpm/mrad/h) x (41 dpm/100 cm^2)/cpm = 2,100 dpm/100 cm^2. All beta-gamma data were evaluated using specific instrument response factors and the equivalent activity levels were determined to satisfy the remedial action criteria.

5.0 POST-REMEDIAL ACTION STATUS

The post-remedial action data indicate that the contaminated ARC areas subject to remediation during 1987-88 were successfully brought into compliance with applicable DOE guidelines for cleanup of radioactive contamination. Based on a review of post-remedial action measurements, measurement procedures, and quality assurance data, an independent verification contractor (IVC) will determine whether the measurements obtained verify that these areas have been decontaminated to the guidelines established for the site (Refs. 6 and 7).

No post-remedial action measurements were taken in several areas in Buildings 2, 17, 23, 27, and 30. No samples were taken anywhere within Buildings 2 and 23. Remedial action was effective in Building 2, however, because all contamination was contained within a drain that was removed. The areas in Buildings 17, 23, and 30 where final post-remedial action samples were not taken are adjacent to sections known to be contaminated and in need of future remedial action. Comprehensive post-remedial action samples will be taken when contamination from proximate areas is removed.

During post-remedial action sampling, a number of additional contaminated interior sections not addressed by the 1987-88 remedial action were identified as requiring further remediation before meeting remedial action guidelines. These areas will be described in a characterization report, which is currently in preparation for publication. Of the buildings in which remedial action occurred, only Buildings 2, 19, and 27 were completed.

The IVC is responsible for preparing a generic plan outlining the procedures to be used in conducting verification activities. There are two types of verification reviews (Type A and Type B); the IVC will conduct either or both types as specified in the verification plan. Type A verification consists of a review of post-remedial

action data and data collected by radiological contractors; it may also include the collection and analysis of additional samples. In performing a Type B verification review, the IVC visits the site and conducts a survey that includes direct measurements as well as sampling and/or split sample analyses.

After completing verification activities, the IVC will notify DOE-Headquarters, Division of Facility and Site Decommissioning, and DOE-Oak Ridge Operations, Technical Services Division, of its findings and recommendations. DOE will review the data to determine whether the remedial action was successful. If radiological conditions at the site are determined based on this review to be in compliance with DOE decontamination criteria and standards developed to protect health, safety, and the environment, DOE will certify the site as being appropriate for future use.

REFERENCES

1. Argonne National Laboratory. Radiological Survey of the Albany Metallurgical Research Center, United States Bureau of Mines Biomass Facility and the "Back Forty" Area, Albany, Oregon, DOE/EV-0005/39, ANL-OHS/HP-83-101, Argonne, IL, April 1983.

2. Argonne National Laboratory. Formerly Utilized MED/AEC Sites Remedial Action Program Radiological Survey of the Albany Metallurgical Research Center, United States Bureau of Mines, Albany, Oregon, DOE/EV-0005/40, ANL-OHS/HP-83-102, Argonne, IL, August 1983.

3. Bechtel National, Inc. Radiological Survey of the Albany Research Center, DOE/OR/20722-29, Oak Ridge, TN, January 1985.

4. Bechtel National, Inc. Preliminary Engineering Evaluation of Selected Remedial Action Alternatives for the Albany Research Center, DOE/OR/20722-14, Oak Ridge, TN, June 1985.

5. U.S. Department of Energy. Remedial Action Work Plan for the Albany Research Center, DOE/OR-881, Oak Ridge, TN, February 1987.

6. Memorandum, J.J. Fiore, Director, Division of Facility and Site Decommissioning Projects, Office of Nuclear Energy, to S.W. Ahrends, Director, Technical Services Division, Oak Ridge Operations, U.S. Department of Energy. "Revised Guidelines for Residual Radioactive Material at FUSRAP and Remote SFMP Sites," with Attachment: 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," April 2, 1987, BNI CCN 045227.

7. U.S. Code of Federal Regulations, 40 CFR 192, Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings, Washington, DC, July 1986.

8. U.S. Department of Energy. Order 5480.1A, "Environmental Protection, Safety and Health Protection for DOE Operations," Attachment xi-L, August 13, 1981.

GLOSSARY

Alpha-emitting - See radiation.

Background radiation - Background radiation refers to naturally occurring radiation emitted from either cosmic (e.g., from the sun) or terrestrial (e.g., from the earth) sources. Exposure to this type of radiation is unavoidable and its level varies greatly depending on geographic location; e.g., New Jersey typically receives 100 mrem/yr, Colorado receives about 300 mrem/yr, and some areas in South America receive up to 7000 mrem/yr. Naturally occurring terrestrial radionuclides include uranium, radium, potassium, thorium, etc. These dose levels do not include the concentrations of naturally occurring radon inside buildings.

Beta-gamma-emitting - See radiation.

Centimeter - A centimeter is a metric unit of measurement for length; 1 inch is equal to 2.54 centimeters; 1 foot is equal to approximately 30 centimeters.

Contamination - Contamination is used generally to mean a concentration of radioactive materials in the soil exceeding naturally occurring levels. Contamination may or may not exceed the DOE cleanup guidelines.

Counts per minute - A count is the unit of measurement registered by a radiation detection instrument when radiation imparts its energy within the sensitive range of the detector probe. The number of counts registered per minute can be related to the number of disintegrations per minute occurring from a radioactive material.

Disintegrations per minute - Disintegrations per minute is the measurement indicating the amount of radiation being released from a substance per minute. See the definition of picocurie.

Dose - Dose as used in this report is actually dose equivalent and is used to relate absorbed dose (mrad) to an effect on the body. Dose is measured in millirems. Examples of dose are: a dose of 500,000 mrem to the whole body in a short time causes death in 50 percent of the people who receive it; a dose of 5,000,000 mrem may be delivered to a cancerous tumor during radiation treatment; normal background radiation results in an annual dose of about 100 mrem; DOE radiation protection standards limit the dose to members of the general public to 100 mrem/yr above background levels; living in a brick house results in a dose of about 75 mrem/yr above background.

Exposure rate - Exposure rate is the rate at which radiation imparts energy to the air. Exposure is typically measured in microroentgens (μR) and the exposure rate is typically given as μR/h. The dose to the whole body can be approximated by multiplying the exposure rate by the number of hours of exposure. For example, if an individual were exposed to gamma radiation at a rate of 20 μR/h for 168 hours per week (continuous exposure) for 52 weeks per year, the whole-body dose would be approximately 170 mrem.

Gamma radiation - See radiation.

Gram - A gram is a metric unit for weight. It takes approximately 454 grams to make 1 pound; 1 ounce equals approximately 28 grams.

Meter - A meter (100 cm) is a metric unit of measurement for length; 1 meter is equal to approximately 39 inches.

Microcurie - A microcurie is 1,000,000 picocuries (see picocuries for additional explanation).

Microroentgen - A microroentgen (μR) is a unit used to measure radiation exposure. For further information, see the definition of exposure rate.

Milliliter - A milliliter is a unit of measure for volume. There are 3785 ml in 1 gal.

Millirad - Millirad is a measure of the amount of energy imparted by radiation to a unit of mass. An absorbed dose rate is expressed in terms of mrad/h.

Millirem - A millirem is the unit used to measure radiation doses to man. The DOE limit is 100 mrem above background radiation levels for members of the general public in any one year. Naturally occurring radioactive substances in the ground result in a yearly exposure to everyone of about 100 mrem. To date, no difference can be detected in the health of population groups exposed to 100 mrem/yr above background and in the health of groups who are not exposed.

Picocurie - A picocurie is the unit of measure for radioactivity. One picocurie means that one radioactive particle is released about every 27 seconds on the average.

Radium-226 - Radium-226 is a naturally occurring, radioactive material that spontaneously emits alpha radiation.

Radiation - There are three primary types of radiation: alpha, beta, and gamma. Alpha radiation travels less than an inch in air before it stops; it cannot penetrate the outer layer of skin on the body. Beta radiation can penetrate the outer layers of skin but cannot reach the internal organs of the body. Gamma radiation is the most penetrating type and can usually reach the internal organs.

Radionuclide - A radionuclide is another word meaning a particular radioactive element. For example, uranium-235 is a radionuclide, uranium-238 is another, thorium-232 another, and so on.

Remedial action - Remedial action is a general term used to mean "cleanup of contamination that exceeds DOE guidelines." It refers

to any action necessary for a property to be released without restrictions as uncontaminated. In practice, this may mean removing grass and soil, cutting trees, removing asphalt, etc. Remedial action also includes restoring remediated properties to their original conditions to the extent that this is possible.

Secular equilibrium - Radioactive equilibrium in which the parent and all the daughters in the decay chain have the same activity.

Thorium - Thorium is a naturally occurring element that is recovered from monazite for commercial purposes. Monazite contains from 3 to 9 percent thorium oxide. The principal use of thorium to date has been in the manufacture of gas lantern mantles because thorium oxide burns with a brilliant white light. Thorium oxide is also commonly found in high quality glasses and camera lenses because of its good optical characteristics.

Uranium - Uranium is a naturally occurring, radioactive element. The principal use of uranium -- when refined -- is for the production of fuel for nuclear reactors. Uranium in its natural form is not suitable for use as a fuel source.

Working level - Working level is a unit to measure the energy expended in air by radon or its radioactive decay products. The term was derived to measure radon progeny concentrations to which uranium miners were exposed.