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Results of the Radiological Survey at the Former Associate Aircraft Tool and Manufacturing Company Site, Fairfield, Ohio (FOH001)

M. E. Murray
R. F. Carrier
R. A. Mathis

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FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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ORNL/RASA-93/2

HEALTH AND SAFETY RESEARCH DIVISION

Environmental Restoration and Waste Management Non-Defense Programs
(Activity No. EX 20 20 00 10; ADS1310)

Results of the Radiological Survey at the Former Associate Aircraft Tool and Manufacturing Company Site, Fairfield, Ohio (FOH001)

M. E. Murray, R. F. Carrier, and R. A. Mathis

Publication issued —March 1993

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U. S. DEPARTMENT OF ENERGY
under contract DE-AC05-84OR21400

CONTENTS

LIST OF FIGURES v

LIST OF TABLES vii

ACKNOWLEDGMENTS ix

ABSTRACT xi

INTRODUCTION 1

SURVEY METHODS 2

SURFACE RADIATION MEASUREMENTS 2
SAMPLING AND ANALYSES 3

SURVEY RESULTS 3

OUTDOOR SURVEY RESULTS 3

Outdoor Radiation Measurements 3
Outdoor Sample Results 4

INDOOR SURVEY RESULTS 4

Directly Measured Radiation Levels Near or on Floor Surfaces 4
Removable Alpha and Beta-gamma Activity Levels 5
Analysis Results for Samples from Floor Seams and Drains 6
Results of Overhead Beam Measurements and Sample Analyses 6

SIGNIFICANCE OF FINDINGS 7

REFERENCES 8

LIST OF FIGURES

1 Diagram showing the general location of Fairfield, Ohio. 9

2 View of the building at the former Associate Aircraft site, looking east (July 1992) 10

3 View of the building at the former Associate Aircraft site showing construction area, looking east (September 1992) 11

4 Diagram showing the area surveyed (July 1992) west of the building at the former Associate Aircraft site, Fairfield, Ohio 12

5 Diagram showing the floor plan of the building at the former Associate Aircraft site, Fairfield, Ohio 13

6 Diagram showing surface gamma exposure rate measurements and locations of soil samples collected in the area west of the building prior to construction activities (July 1992) 14

7 Diagram showing surface gamma exposure rate measurements and locations of soil samples collected outdoors in September 1992 15

8 Drawing showing directly measured radiation levels in Section 3 of the building at the former Associate Aircraft site 16

9 Drawing showing directly measured radiation levels and sample locations in Section 4 of the building at the former Associate Aircraft site 17

10 Photograph showing the location of the floor drain (M5) in Section 4 of the building at the former Associate Aircraft site. 18

11 Drawing showing directly measured radiation levels in Section 5 of the building at the former Associate Aircraft site 19

12 Diagram showing locations of smears taken on equipment and structural surfaces near floor level in the building at the former Associate Aircraft site 20

13 Photograph of survey team accessing the floor seam in Section 4 to collect samples M3 and M4 21

14 Diagram showing directly measured radiation levels and locations of samples on overhead structures in the building at the former Associate Aircraft site 22

15 Photograph of survey team taking radiation measurements on overhead beams 23

LIST OF TABLES

1 Applicable guidelines for protection against radiation 24

2 Background radiation levels and concentrations of selected radionuclides in soil in the Fairfield, Ohio, area 26

3 Concentrations of radionuclides in soil samples collected outdoors at the former Associate Aircraft site, Fairfield, Ohio 27

4 Concentrations of radionuclides in floor drain and seam samples collected from Section 4 of the building at the former Associate Aircraft site 28

5 Total and removable alpha and beta-gamma activity levels and radionuclide concentrations in dust samples from selected locations on overhead beams at the former Associate Aircraft site 29

ACKNOWLEDGMENTS

This project was sponsored by the Office of Environmental Restoration, U.S. Department of Energy, under contract DE-AC05-84OR21400 with Martin Marietta Energy Systems, Inc. The authors wish to acknowledge the contributions of W. D. Cottrell, V. P. Patania, and D. A. Roberts of the Measurement Applications and Development Group, Oak Ridge National Laboratory, for participation in the analyses, editing, and reporting of data for this survey. The authors also wish to thank J. F. Allred and D. A. Rose for sample preparation and T. R. Stewart for computer graphics.

ABSTRACT

At the request of the U.S. Department of Energy (DOE), a team from Oak Ridge National Laboratory conducted a radiological survey of the former Associate Aircraft Tool and Manufacturing Company facility, Fairfield, Ohio. The survey was performed in July and September 1992. The purpose of the survey was to determine if the facility had become contaminated with residuals containing radioactive materials during the work performed under government contract from February to September, 1956. The survey included gamma scanning over a circumscribed area around and outside of the building, and gamma scanning over most accessible indoor floor surfaces as well as the collection of soil and other samples for radionuclide analyses. Roof trusses were beta-gamma scanned in locations where floor contamination was found.

Results of the survey demonstrated radionuclide concentrations in indoor and outdoor samples, and radiation measurements over floor and overhead surfaces, in excess of the DOE Formerly Utilized Sites Remedial Action Program guidelines. Elevated uranium concentrations outdoors were limited to several small, isolated spots. Radiation measurements exceeded guidelines indoors over numerous spots and areas inside the building, mainly in the areas that had been used in the early government work.

Results of the Radiological Survey at the Former Associate Aircraft Tool and Manufacturing Company Site, Fairfield, Ohio (FOH001)*

INTRODUCTION

From February to September, 1956, Associate Aircraft Tool and Manufacturing Company owned and operated a facility at 3550 Dixie Highway, Fairfield, Ohio, which performed work for National Lead of Ohio (NLO), a prime contractor for the U.S. Atomic Energy Commission (AEC) during that time period. NLO was one of several companies performing work associated with the development of nuclear energy for defense-related projects under contract to AEC. The machine shop at the Fairfield site was one of two Cincinnati area shops selected by AEC and NLO to augment the capacity of the Feed Materials Production Center at Fernald by the production of hollow uranium slugs. Operations included hollow drilling, reaming, and turning slugs to a final outside diameter. Based on the contractual records, approximately 95,000 slugs were machined during the eight-month period of operation. During the last three months of the contract, Associate Aircraft production was maintained at a minimum operating level of 10,000 to 15,000 slugs per month as future AEC requirements were not known.[1]

Such operations for the AEC sometimes resulted in equipment, buildings, and land at the sites becoming radiologically contaminated with small amounts of the material resulting in low levels of contamination on the properties. At contract termination, release limits and decontamination operations were typically applied in conformance with standards currently deemed adequate for purposes of health and environmental protection. Subsequent to original assessments and the release of these facilities, new research and information have resulted in the development of more stringent guidelines for release of such facilities for unrestricted use. Furthermore, in some instances, documentation is limited or nonexistent, and conditions at a specific site may be unknown. It is the policy of the U.S. Department of Energy (DOE) to verify that radiological conditions at such facilities comply with existing guidelines.[2] The Formerly Utilized Sites Remedial Action Program (FUSRAP) was established by DOE in 1974 to assist in assessment and cleanup activities at these sites. In the absence of substantial information regarding the current condition of the former Associate Aircraft site, the DOE requested that members of the Oak Ridge National Laboratory (ORNL) conduct a radiological survey of the facility under the FUSRAP program.

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*The survey was performed by members of the Measurement Applications and Development Group of the Health and Safety Research Division of Oak Ridge National Laboratory under DOE contract DE–AC05-84OR21400.

The decontamination which immediately followed cessation of the contract at this site was performed by Associate Aircraft under NLO supervision and health physics support. All machining equipment was to have been returned to NLO with the exception of two motors and a watch clock station. The present occupant of the site, Force Control Industries, purchased the site in 1969 from Dixie Machinery. A current employee who had visited the site in the 50s reports that no extensive remodeling of the sole building on the property has been done.[1] The city of Fairfield is located approximately 10 miles northwest of Cincinnati (Fig. 1).

Photographs of the front of the building as it appeared in July and September 1992, respectively, are provided in Figs. 2 and 3. The ground surface directly in front of and west of the building was thoroughly surveyed in July prior to the construction shown in the second photograph. The complete radiological characterization of the building and of a 25–ft–wide perimeter of ground surface around the remaining three sides of the building was performed in September, 1992. The results of the two surveys are combined in this report. The approximate outdoor areas surveyed west of the building are diagrammed in Fig. 4. Figure 5 shows a floor plan of the building and indicates the six arbitrary sections into which it was divided, east to west, for purposes of identifying and locating measurements and samples. Most accessible indoor areas were scanned, and equipment and materials were moved aside wherever possible to allow access for surveying. At the time of the surveys, the owner operated a multipurpose machine shop in the facility.

SURVEY METHODS

The radiological survey included: (1) a surface gamma scan over a defined outdoor area; (2) collection and radionuclide analysis of systematic and biased soil samples; (3) measurement of direct radiation levels on accessible floor surfaces inside the building; (4) collection and analysis of debris and dust samples from indoor drains and overhead beams; and (5) collection of smear samples from selected indoor locations to determine removable alpha and beta-gamma surface activity levels. A description of the typical survey methods and instrumentation providing guidance for the survey is given in *Procedures Manual for the ORNL Radiological Survey Activities (RASA) Program*, ORNL/TM-8600 (April 1987).[3]

SURFACE RADIATION MEASUREMENTS

Gamma radiation levels were determined using a portable NaI gamma scintillation meter. Because NaI gamma scintillators are energy dependent, measurements of gamma radiation levels in counts per minute (cpm) are normalized to pressurized ionization chamber (PIC) measurements to estimate gamma exposure rates in μR/h. Using a Geiger–Mueller pancake detector, beta-gamma radiation levels in cpm were measured over selected paved and other hard surfaces, and then converted to mrad/h and/or disintegrations per minute over 100 cm^2 (dpm/100 cm^2). Alpha measurements were made using a Bicron

ratemeter connected to a ZnS scintillation probe. Those results were subsequently converted to dpm/100 cm^2. Removable alpha and beta–gamma activity levels were assessed by gross counting and gamma spectrometry analysis of smear samples that had been collected by wiping selected surfaces. Radionuclide concentrations (pCi/g) in dust, which is easily removable from overhead horizontal surfaces, can be compared to removable surface contamination guidelines (dpm/100 cm^2) when the sample weight and area from which the samples were taken are known.

SAMPLING AND ANALYSES

Surface and subsurface soil samples were collected near the building to determine if contamination had been transported from inside the building. Relevant indoor materials, including concrete chips, dust, and debris were also collected. All samples were analyzed to determine ^{226}Ra, ^{232}Th, and ^{238}U concentrations.

SURVEY RESULTS

Current DOE guidelines for sites included within the FUSRAP are summarized in Table 1. Typical background radiation levels for the Fairfield, Ohio, area are presented in Table 2. These data are provided for comparison with the survey results presented in this section. Gamma radiation levels are reported in gross μR/h. Background concentrations have not been subtracted from radionuclide concentrations in soil, debris, and other samples.

OUTDOOR SURVEY RESULTS

Outdoor Radiation Measurements

Results of the ground surface gamma scans are shown on Fig. 6 (July survey) and Fig. 7 (September survey). Because this was a designation survey, the outdoor surveying was generally limited to an area 10- to 30-ft from the building. Surface gamma exposure rates generally ranged from 4 to 10 μR/h, values comparable to the typical range of background radiation levels in the Fairfield, Ohio, area (3 to 11 μR/h, Table 2). Exceptions were found in several isolated locations, of which two are particularly notable. A small area at the southwest corner of the building showed gamma levels of 16 to 24 μR/h (Fig. 6). A spot measuring ~0.09 m^2 (1 ft^2) and having surface radiation levels of 16 μR/h gamma and 0.03 mrad/h beta-gamma was found in the parking lot about 22 ft north of the building (Fig. 7). A maximum exposure rate of 100 μR/h was noted at a depth of 20 cm (8 in.) at that spot.

Outdoor Sample Results

Locations of systematic (S) and biased (B) soil samples collected outdoors are shown on Figs. 6 and 7, and results of analysis are listed in Table 3. Maximum concentrations of ^{226}Ra, ^{232}Th, and ^{238}U in systematic soil samples collected from the surface (0–15 cm) were 1.1, 0.91, and 13 pCi/g, respectively. Maximum concentrations of ^{226}Ra, ^{232}Th, and ^{238}U in systematic soil samples collected from subsurface soil (15–30 and 30–45 cm) were 1.1, 0.92, and 4 pCi/g, respectively. With the exception of uranium concentrations in samples S8A and S8B (13 and 4.0 pCi/g) all values are comparable to those typically found in the Fairfield, Ohio, area (Table 2). The elevated concentrations in samples S8A and S8B are well below site-specific guidelines of 30 to 40 pCi/g ^{238}U previously applied at other FUSRAP sites (Table 1).

Maximum ^{226}Ra and ^{232}Th concentrations in biased soil samples are 5.2 pCi/g and 3.3 pCi/g, which are less than the guideline (Table 1). Concentrations of ^{238}U ranged from 1.4 to 4.3 pCi/g in samples from locations B4, B5, and B6. However, ^{238}U concentrations were elevated up to 450 pCi/g and 2900 pCi/g in soil samples from locations B1 and B2. The maximum ^{238}U concentrations exceed the 30 to 40 pCi/g site-specific guideline value (Table 1, footnote d). Sample collection at those two spots effectively remediated the contamination.

INDOOR SURVEY RESULTS

Directly Measured Radiation Levels Near or on Floor Surfaces

Section 1. Gamma exposure rates on surfaces throughout Section 1 near floor level showed no elevated measurements above background values of 2 to 4 μR/h.

Section 2. Gamma exposure rates were low throughout Section 2, reading 2 to 4 μR/h and, with two exceptions, beta-gamma dose rates were 0.02 mrad/h. Maximum beta-gamma dose rates of 0.1 mrad/h, 50% of the DOE guideline, were found in two small areas on the floor along the wall between Sections 1 and 2.

Section 3. Directly measured radiation levels within Section 3 are shown on Fig. 8. This entire area of the building was found to be generally contaminated with all concrete cracks, seams, and joints in the floor and all red–painted floors showing elevated measurements. Beta-gamma dose rates in many areas were above guidelines (Table 1) up to a measured maximum of 7 mrad/h (420,000 dpm/100 cm^2).

An apparent floor drain near the center of the section showed no gamma radiation levels at the floor surface. The drain was covered by a perforated plate at floor level beneath which the drain opening was sealed with a cap. Beneath the cap was a brick-lined annulus in which gamma radiation levels were 24 μR/h and beta-gamma dose rates were 0.12 mrad/h. The connecting horizontal pipeline beneath the annulus was filled with debris.

Section 4. A caged area and adjoining locker room in Section 4 were generally contaminated as shown by the hatching on Fig. 9. Gamma exposure rates in the caged area were background (8 μR/h) but beta-gamma activity levels of 60,000 dpm/100 cm^2 (1 mrad/h) exceed the average surface contamination guideline of 5000 dpm/100 cm^2 by a factor of 12 (Table 1). Gamma exposure rates in the locker room were a maximum of 70 μR/h and beta-gamma dose rates reached 5 mrad/h (300,000 dpm/100 cm^2). Miscellaneous spots and floor cracks in the south end of Section 4 had radiation levels in excess of DOE guidelines. Gamma exposure rates were as high as 120 μR/h at a spot just north of the door into the grinding area. Individual spots in the cracks had gamma exposure rates ranging from 50 to 160 μR/h. The associated beta-gamma dose rate was 0.3 mrad/h, equivalent to an activity level of 18,000 dpm/100 cm^2. Gamma levels were 100 μR/h at a spot in a floor crack outside the northeast corner of the grinding room and beta-gamma activity levels were 5 mrad/h (300,000 dpm/100 cm^2).

A drain having gamma exposure rates of 80 μR/h on contact with the surface at floor level had a gamma reading of 50 mR/h at 20 in. down into the drain. Radiation levels decreased progressively with depth, measuring from 10 mR/h at 30 in. to 5 mR/h at 42 in. The drain was located beneath the table as seen in Fig. 10.

Section 5. This area was generally uncontaminated with the exception of 2 small spots on the floor near the offices between the N and S exits (Fig. 11). Beta-gamma dose rates at those spots were 0.3 and 0.18 mrad/h (18,000 and 10,500 dpm/100 cm^2, respectively). The spots are above the total (fixed plus removable) dose rate guideline and the average activity level guideline (Table 1).

Section 6. Gamma exposure rates in this office area were all low in comparison to background values, measuring 2 to 4 μR/h. No elevated radiation levels were found.

Removable Alpha and Beta-gamma Activity Levels

The locations of 15 smears (numbered 27 through 41) collected from equipment and structural surfaces near or at floor level in the building are shown on Fig. 12. Analysis results for alpha activity levels in all samples were less than the minimum detectable activity (MDA)*. Five of the 15 smears showed beta-gamma activity levels of more than MDA. Those results ranged from 6 to 12 dpm/100 cm^2, well below the 1000 dpm/100 cm^2 for removable activity levels resulting from uranium contamination (Table 1).

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*The instrument-specific minimum detectable activities (MDAs) for directly measured and removable alpha radiation levels are 25 and 10 dpm/100 cm^2, respectively. For directly measured and removable beta-gamma radiation levels the MDAs are 0.01 mrad/h and 200 dpm/100 cm^2, respectively.

Analysis Results for Samples from Floor Seams and Drains

Samples of material from floor drains and seams in Section 4 (M samples) were analyzed for radionuclide concentrations. Results are listed in Table 4. Sample locations are shown on Fig. 9. Figure 13 shows the survey team collecting samples from a floor seam.

Concentrations of ^{226}Ra and ^{232}Th in samples M3 through M5D were all below MDAs. Concentrations of ^{238}U in samples M3, M4, (both from the floor seam) and M5 ranged from 2000 to 62,000 pCi/g. At location M6, a hole was drilled and concrete dust samples were collected to assess the possibility that multiple layers of concrete might be sandwiching the contamination that was found in the nearby seam (M3 and M4 samples). Maximum subsurface concentrations of ^{226}Ra, ^{232}Th, and ^{238}U in M6 samples were 0.58, 0.30 pCi/g, and 5.9 pCi/g, respectively. These results are comparable to background values typical for concrete. The concrete floor did not appear to be layered.

Results of Overhead Beam Measurements and Sample Analyses

Dust samples (T1B—T8B) were collected from overhead beams in eight locations showing elevated total alpha and/or beta-gamma activity levels (Fig. 14). Smear samples (T1A—T8A) were collected from the surfaces after the dust was removed. The direct radiation measurements, the results of radionuclide analysis of smears and dust samples, and the derived removable beta-gamma activity levels for the eight locations are detailed in Table 5. Figure 15 shows the survey team collecting overhead measurements.

Directly measured alpha activity levels on overhead beams in Section 3 at six sample locations (T1, T4–T8) were 85 to 1000 dpm/100 cm^2, values below the DOE guideline for total (fixed and removable) alpha emitters. However, beta-gamma dose rates at those locations ranged from 0.09 to 0.24 mrad/h (5400 to 14,000 dpm/100 cm^2), exceeding guidelines for dose rates of 0.2 mrad/h over an area not more than 1 m^2 and the average surface contamination level of 5000 dpm/100 cm^2.

Directly measured alpha activity levels on beams in Section 4 were 140 and 1300 dpm/100 cm^2 in two locations. These values are below guidelines (Table 1). Total beta-gamma dose rates were 0.14 and 3.8 mrad/h (8700 and 50,000 dpm/100 cm^2), exceeding dose rate and average surface contamination guidelines.

Alpha activity levels of 6 to 90 dpm/100 cm^2 in TnA beam smear samples (see Table 5 for sample designations) taken in Sections 3 and 4 are well below the DOE limit of 1000 dpm/100 cm^2 for removable ^{238}U residuals (Table 1). Beta-gamma activity levels in smears were all less than MDAs. Radionuclide analysis shows that the beta-emitting surface contamination was the result of concentrations of ^{238}U ranging from 115 to 1900 pCi/g in the dust/debris samples collected from the smear locations. The beta-gamma activity levels derived from the ^{238}U concentrations and the sample weight and area range from 700 to 3800 dpm/100 cm^2. Most values exceed the DOE guideline of 1000 dpm/100 cm^2 for removable contamination (Table 1). When the debris activity is combined with the smear results a true representation of the transferable activity is achieved (Table 5).

Maximum concentrations of ^{226}Ra and ^{232}Th in TnB samples (dust/debris) were 1.2 and 0.88 pCi/g with most results below MDAs. These values are comparable to typical background values for the Fairfield area.

Overhead locations in Sections 1 and 2 had directly measured beta-gamma dose rates and activity levels of 0.02 mrad/h and 1200 dpm/100 cm^2, respectively, values which are well below the guidelines shown in Table 1. Beta-gamma dose rates in overhead areas of Section 5 were below guidelines, ranging from 0.02 to 0.04 mrad/h (1200 to 2200 dpm/100 cm^2).

SIGNIFICANCE OF FINDINGS

The results of the radiological survey at the former Associate Aircraft site demonstrate uranium concentrations and surface contamination in excess of previously applied DOE limits in numerous locations inside the building and in isolated spots outdoors. Concentrations of ^{238}U in outdoor soil, and in indoor samples of debris, concrete, and dust from within drains and from overhead surfaces exceeded guidelines. Directly measured radiation levels in many areas of some portions of the building also exceeded guidelines.

In the limited areas surveyed outdoors, the contamination was found in two small areas near the building. These were located in the parking lot north of the building, and near the southwest corner of the building. The collection of ^{238}U–contaminated samples of soil from near the southwest corner of the building effectively remediated the spots. The maximum concentration of ^{238}U found in soil was 2900 pCi/g, a factor of nearly 98 in excess of the most conservative previously applied site-specific guideline (Table 1).

Indoors, direct radiation measurements in Sections 3 and 4 showed beta-gamma activity levels above guidelines in floor joints, cracks and seams, as high as 420,000 and 300,000 dpm/100 cm^2 (7 and 5 mrad/h), respectively. Concentrations of ^{238}U were elevated in Sections 3 and 4 in dust samples collected from overhead areas (115 to 1900 pCi/g). Calculations using the sample areas, weights, and ^{238}U content showed derived surface contamination levels as high as 3800 dpm/100 cm^2 that exceed the DOE guideline of 1000 dpm/100 cm^2 for removable activity shown in Table 1 by a factor of nearly four. Concentrations of ^{238}U were also elevated from 2000 to 62,000 pCi/g in samples obtained from old floor drains in Section 4. Two very small areas of beta-gamma measurements in Section 5 exceeded guidelines. No anomalies were identified in Sections 1, 2, and 6.

Survey findings demonstrate concentrations of ^{238}U in indoor and outdoor samples from the facility and surface contamination levels over floor and overhead surfaces inside the building above DOE guidelines established for other sites. The ultimate destination of the floor drain system was not discovered during these surveys and should be investigated

since significant quantities of radioactive materials were found in the system. Because two distinct areas of soil contamination were found outdoors and the transport mechanism is not apparent, it is recommended that any subsequent examination incorporate all areas of the property as it existed when the uranium work was performed.

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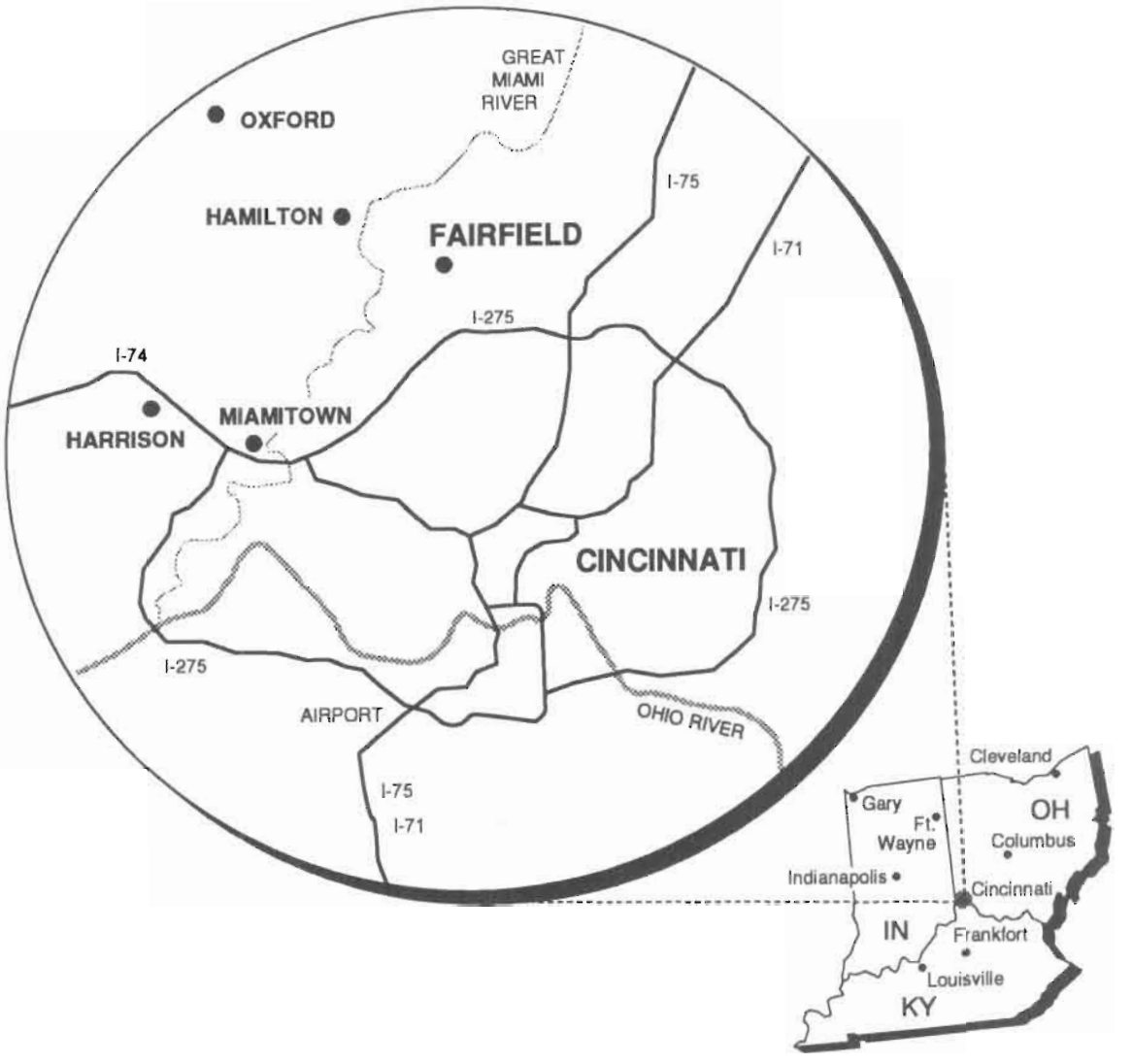

Fig. 1. Diagram showing the general location of Fairfield, Ohio.

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Fig. 2. View of the building at the former Associate Aircraft site, looking east (July 1992).

ORNL PHOTO 1115-93

Fig. 3. View of the building at the former Associate Aircraft site showing construction area, looking east (September 1992).

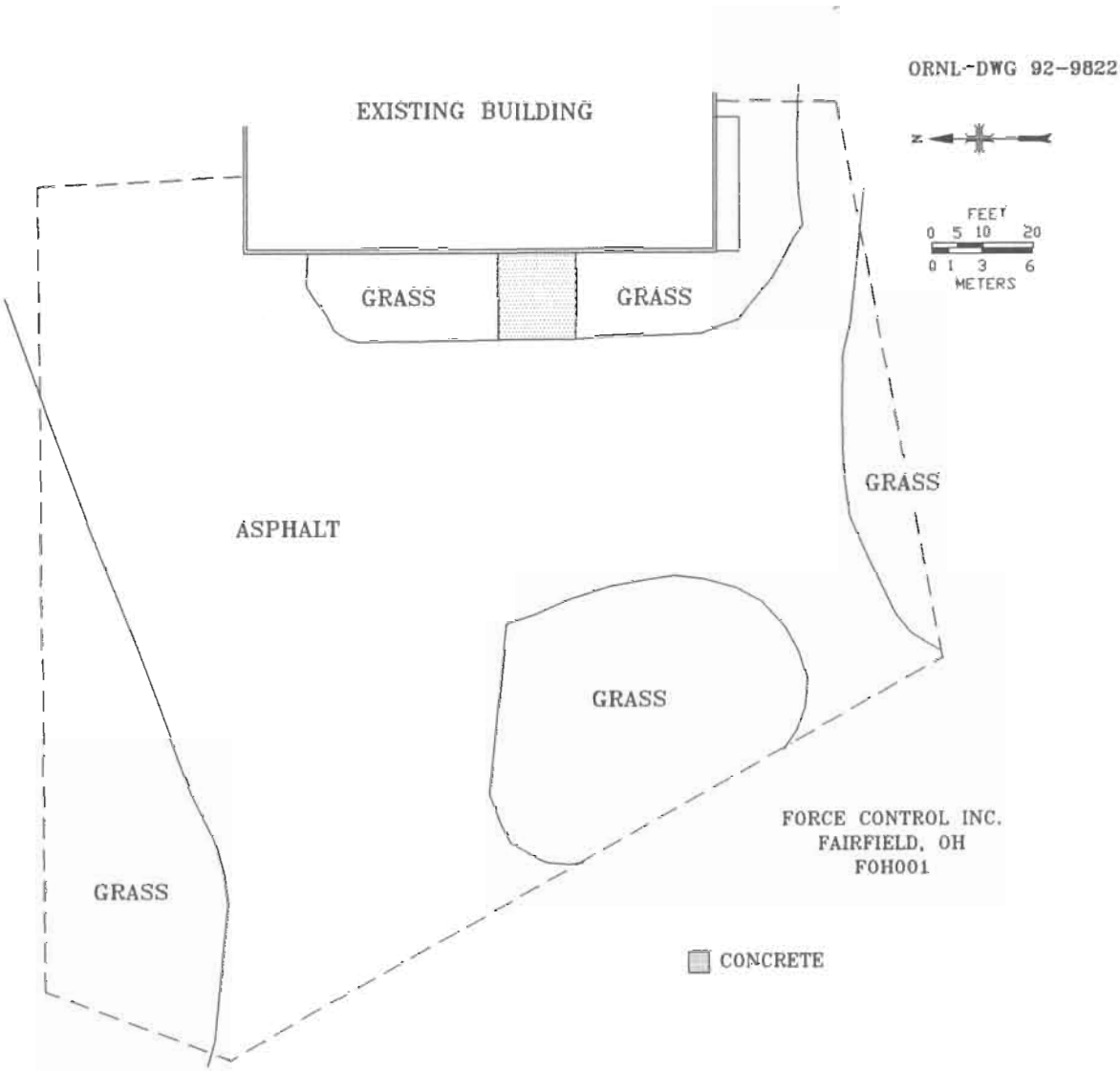

Fig. 4. Diagram showing the area surveyed (July 1992) west of the building at the former Associate Aircraft site, Fairfield, Ohio

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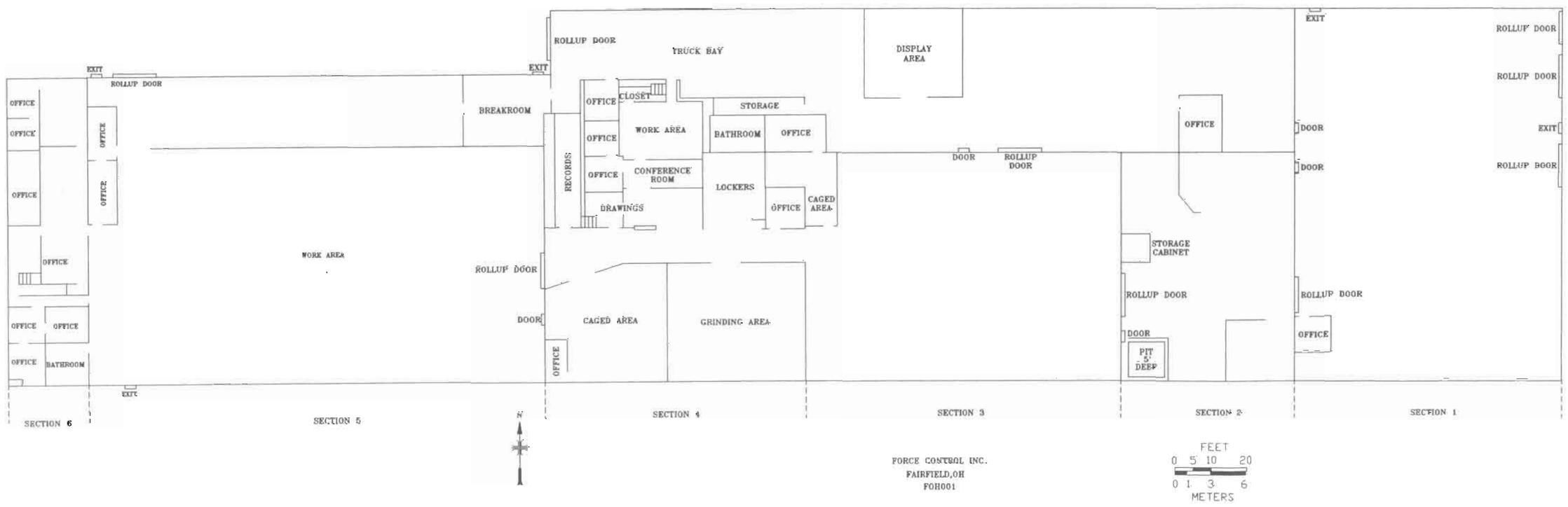

Fig. 5. Diagram showing the floor plan of the building at the former Associate Aircraft site, Fairfield, Ohio.

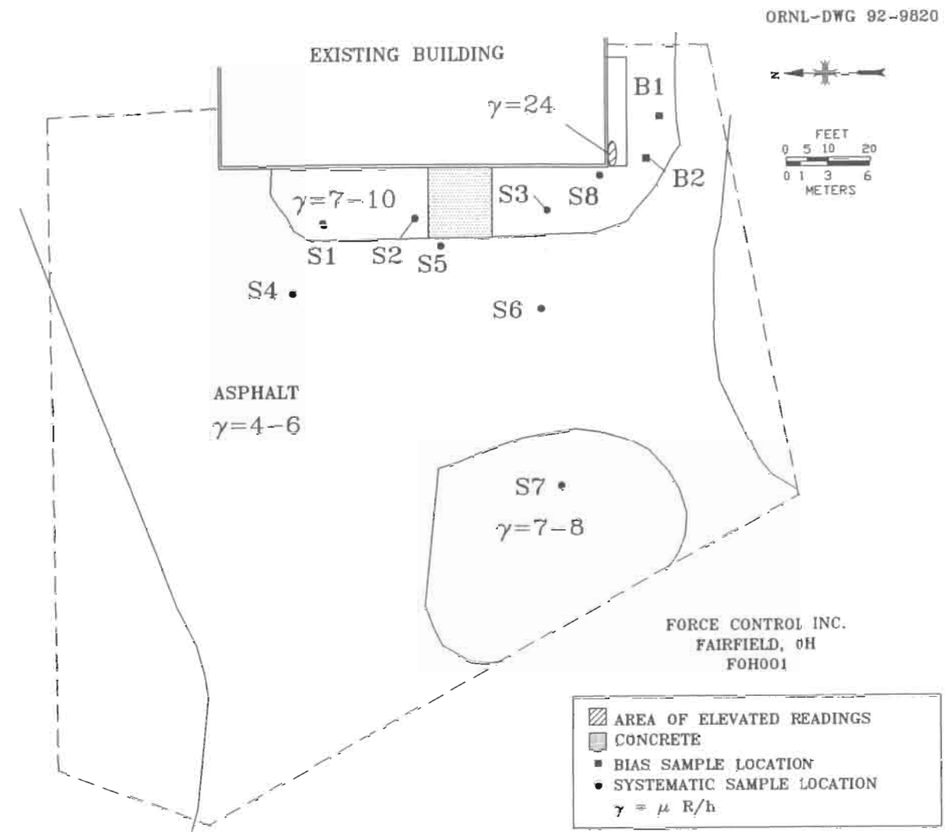

Fig. 6. Diagram showing surface gamma exposure rate measurements and locations of soil samples collected in the area west of the building prior to construction activities (July 1992)

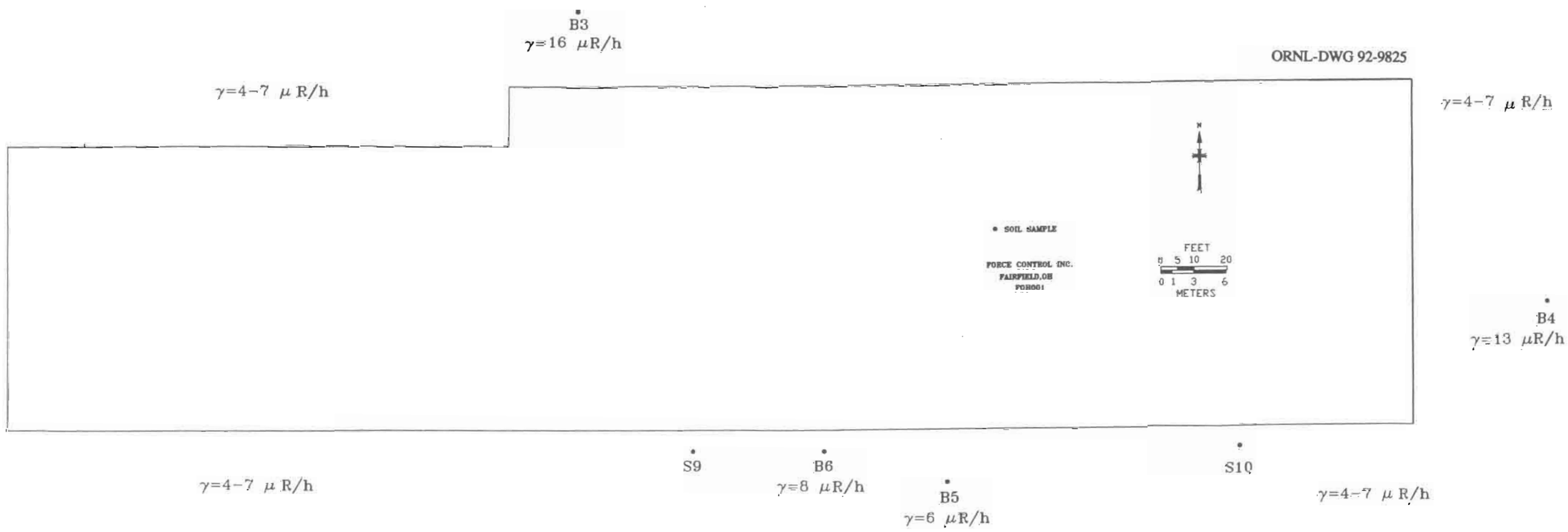

Fig. 7. Diagram showing surface gamma exposure rate measurements and locations of soil samples collected outdoors in September 1992.

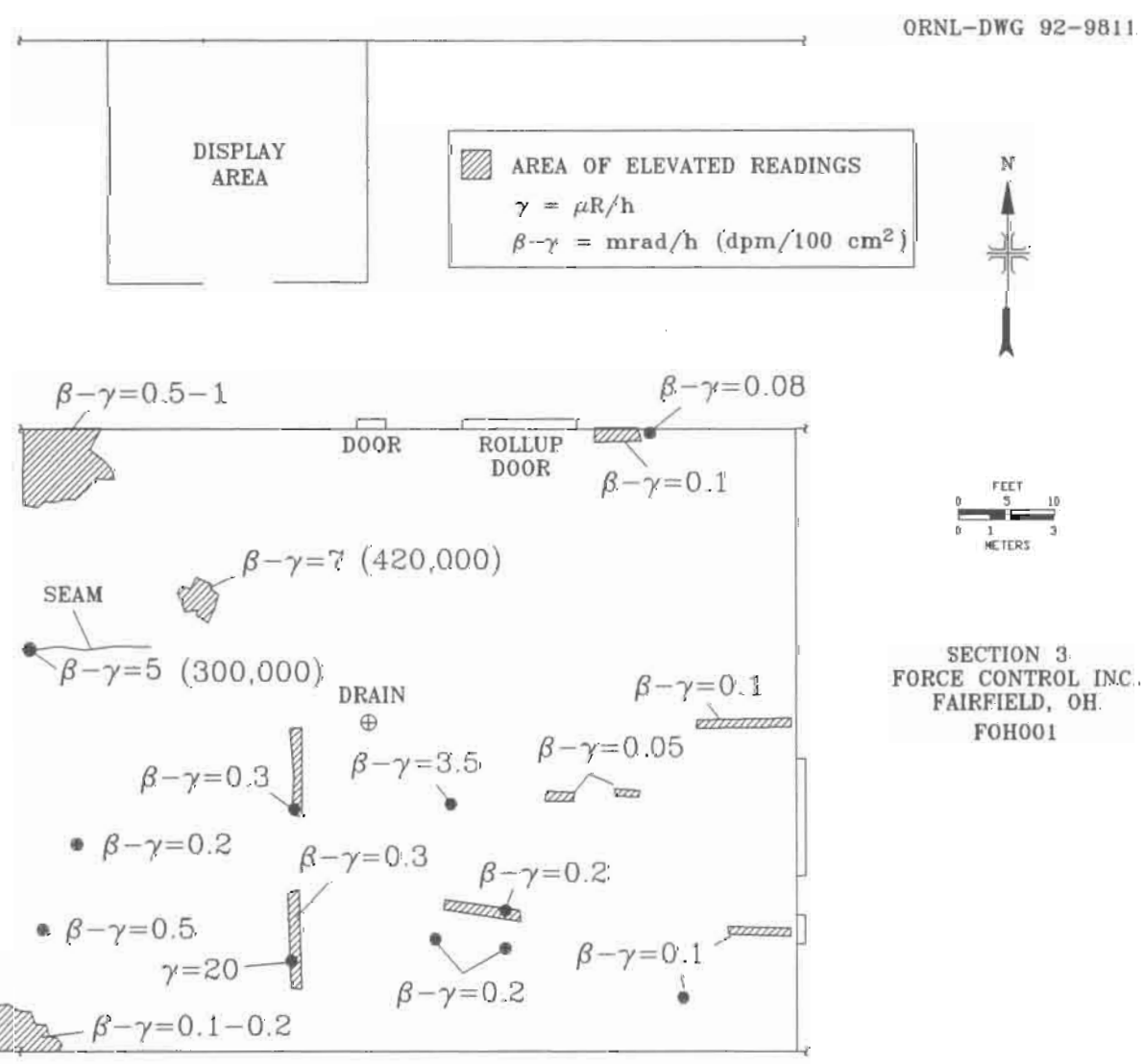

Fig. 8. Drawing showing directly measured radiation levels in Section 3 of the building at the former Associate Aircraft site.

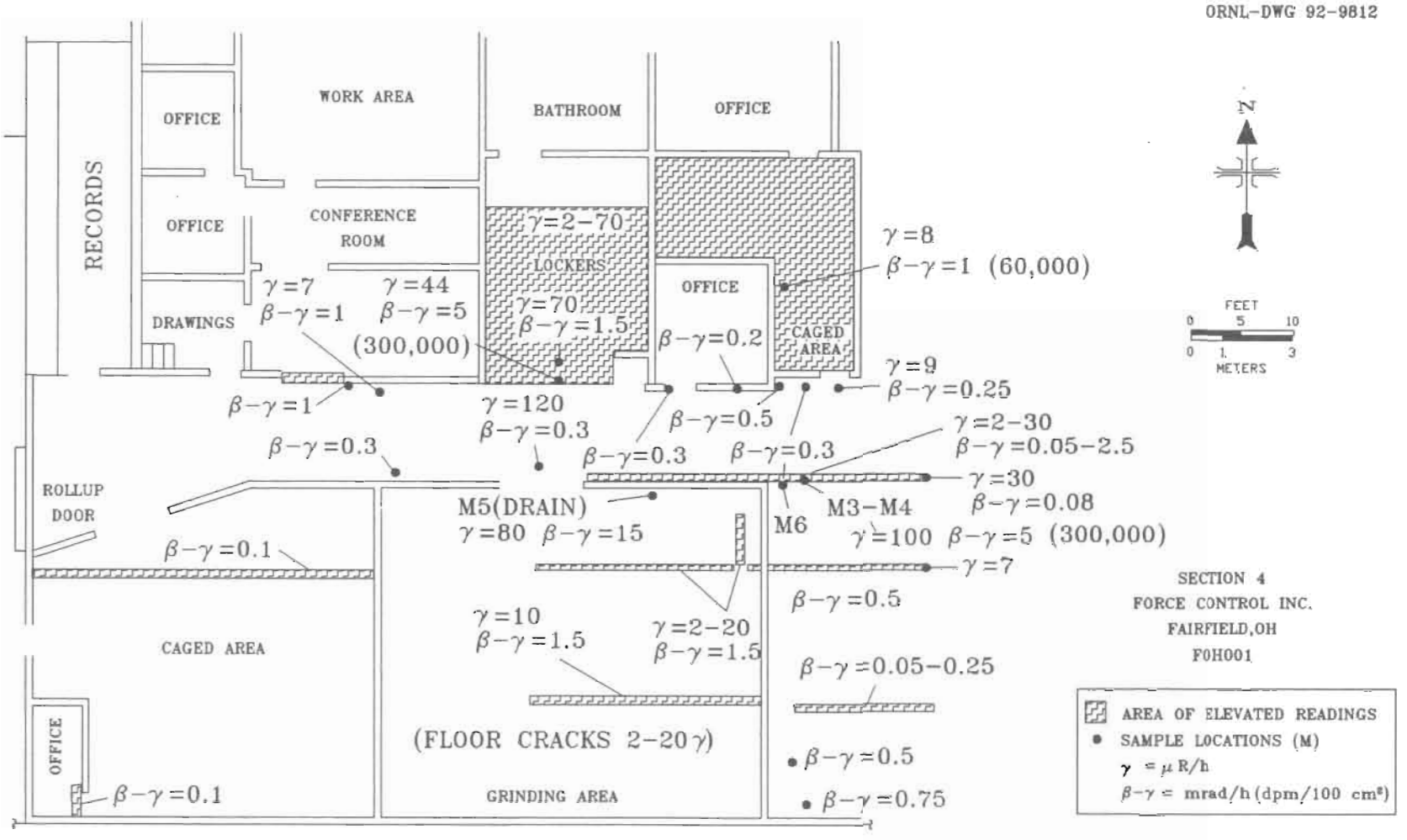

Fig. 9. Drawing showing directly measured radiation levels and sample locations in Section 4 of the building at the former Associate Aircraft site.

ORNL PHOTO 1114-93

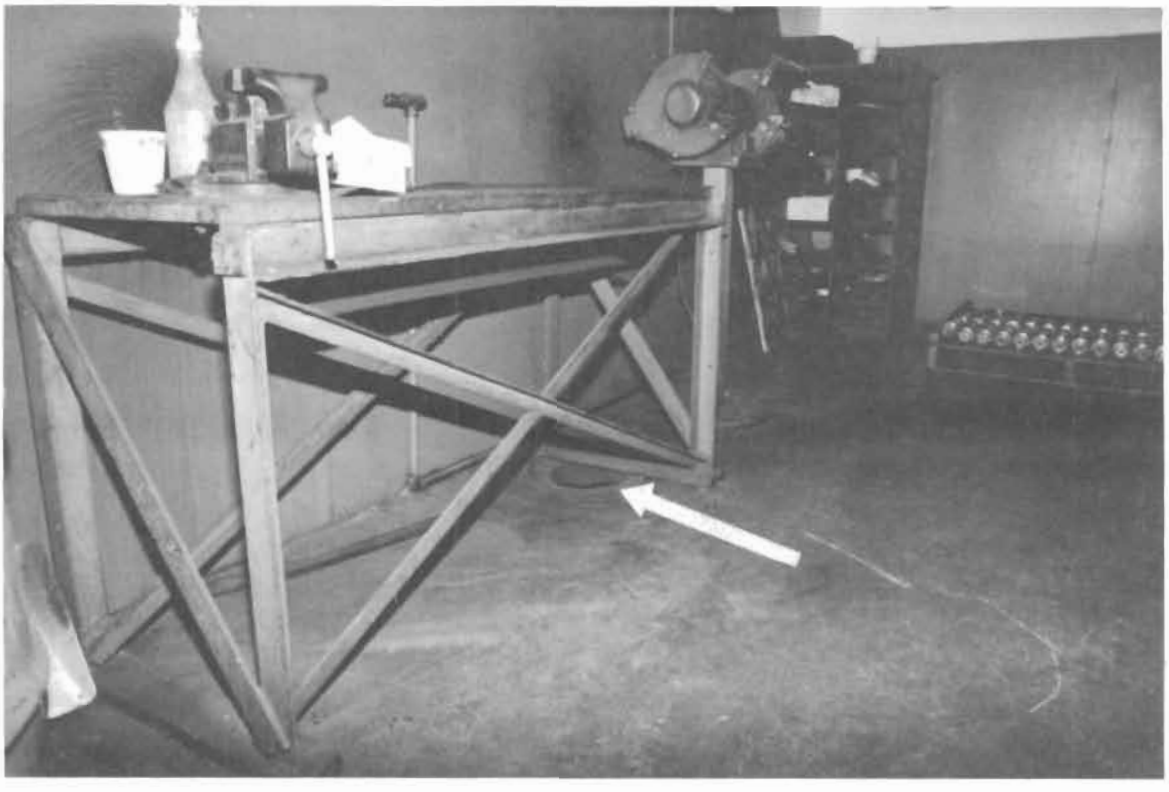

Fig. 10. Photograph showing the location of the the floor drain (M5) in Section 4 of the building at the former Associate Aircraft site. Drain is located beneath the table as indicated by the arrow.

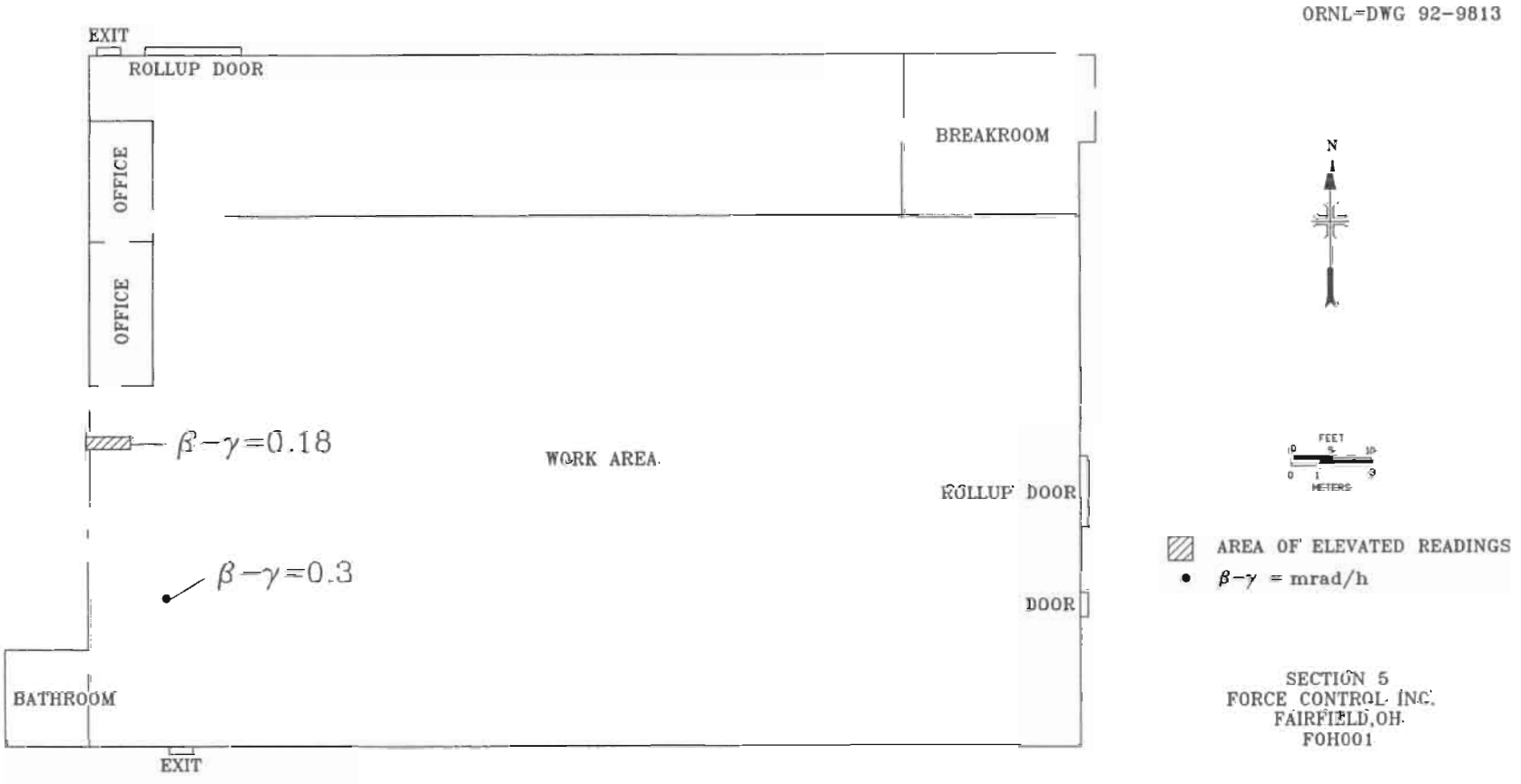

Fig. 11. Drawing showing directly measured radiation levels in Section 5 of the building at the former Associate Aircraft site.

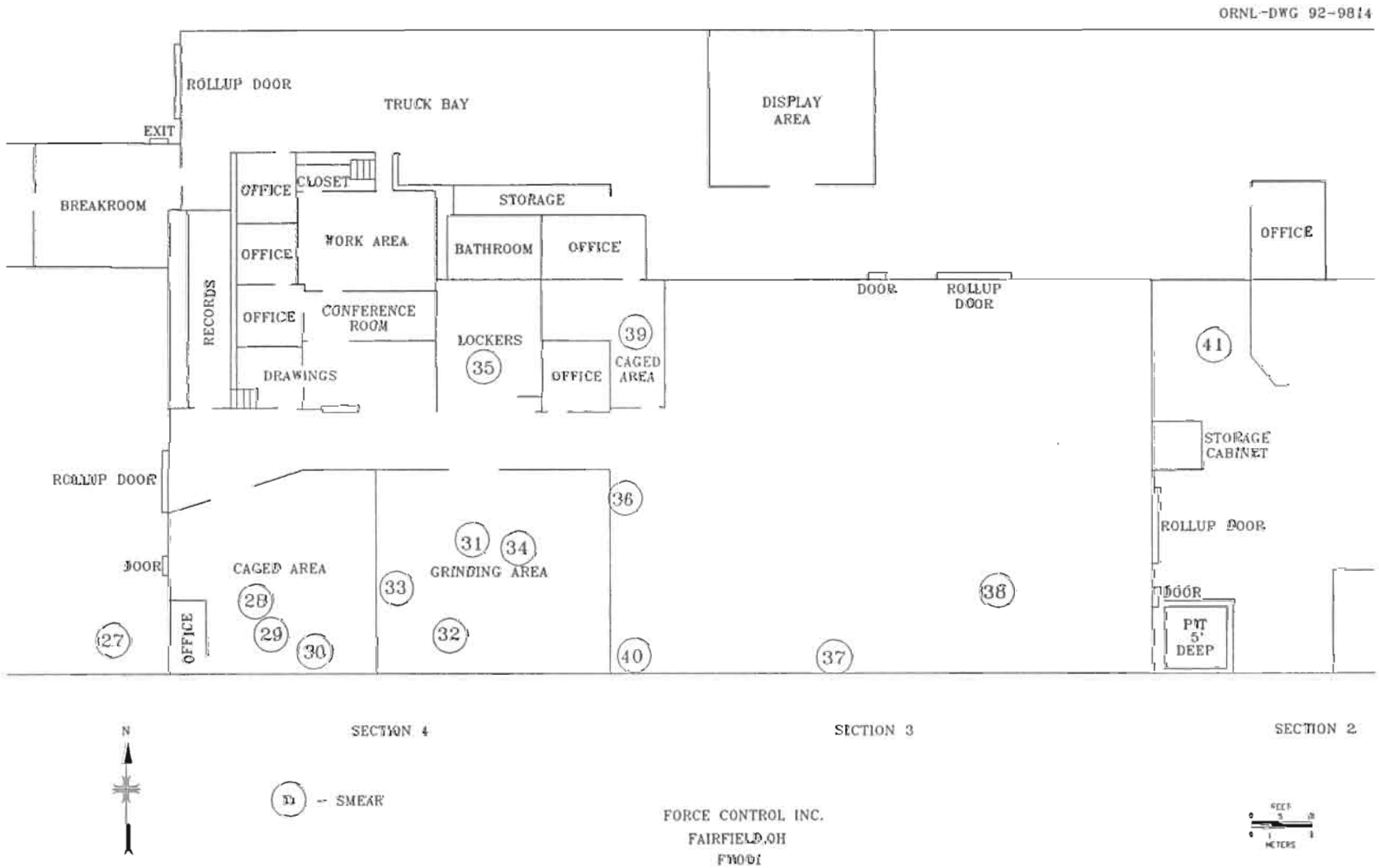

Fig. 12. Diagram showing locations of smears taken on equipment and structural surfaces near floor level in the building at the former Associate Aircraft site.

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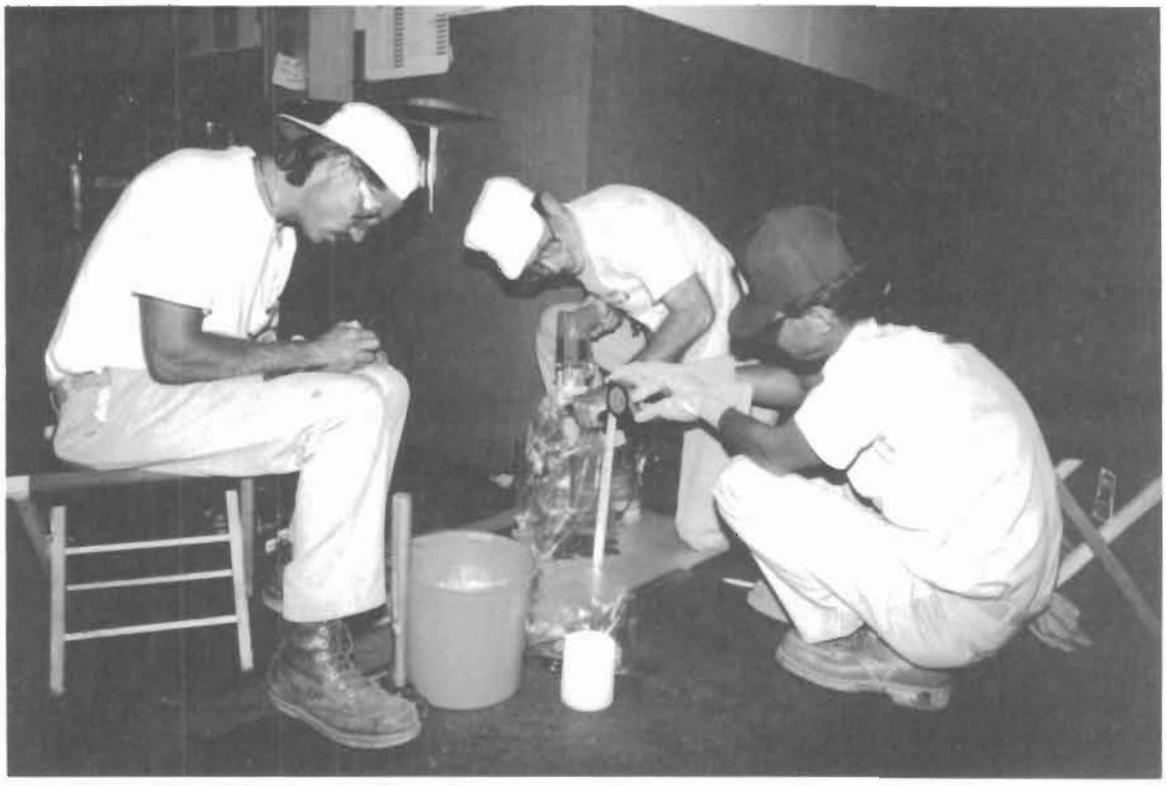

Fig. 13. Photograph of survey team accessing the floor seam in Section 4 to collect samples M3 and M4.

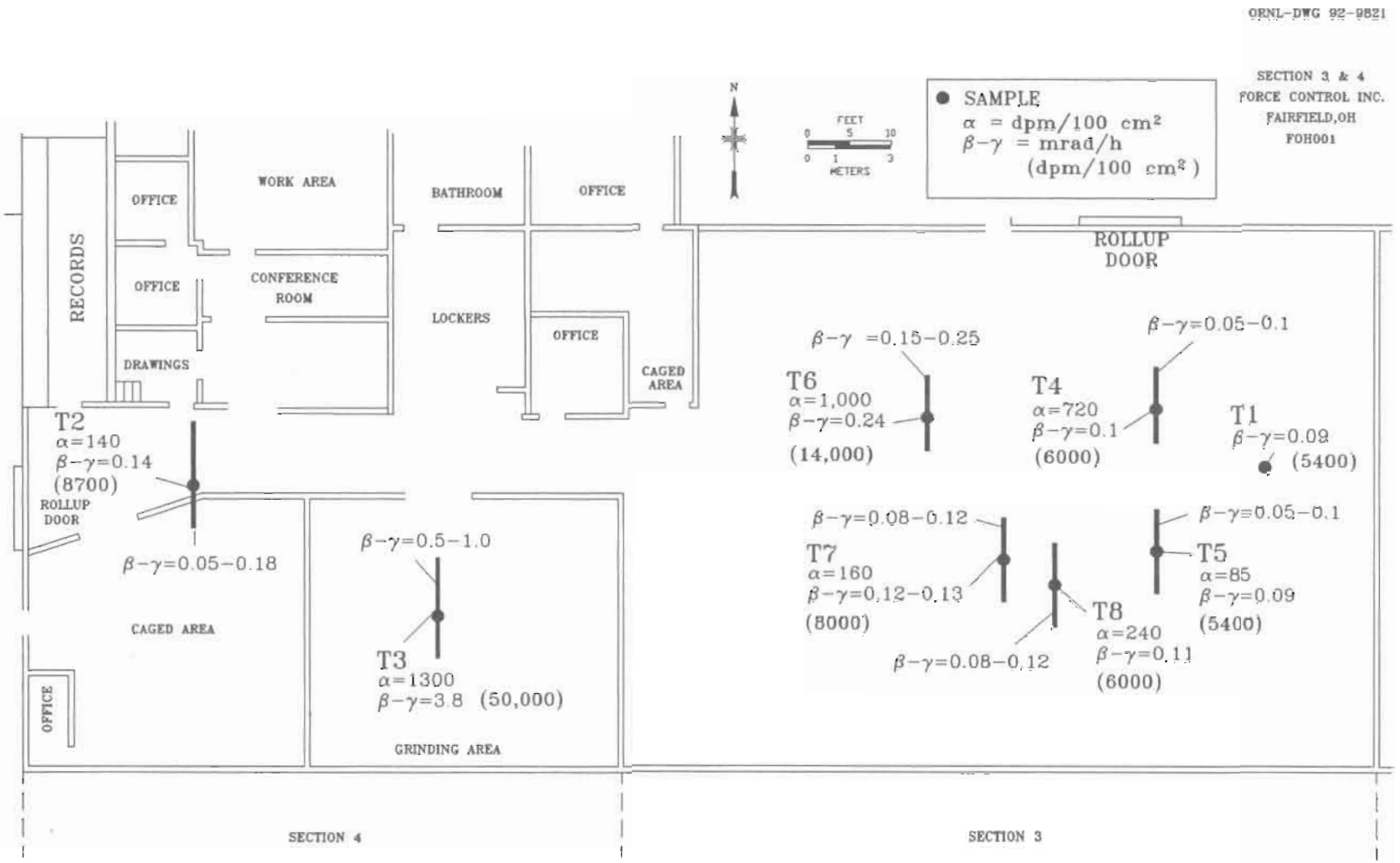

Fig. 14. Diagram showing directly measured radiation levels and locations of samples on overhead structures in the building at the former Associate Aircraft site.

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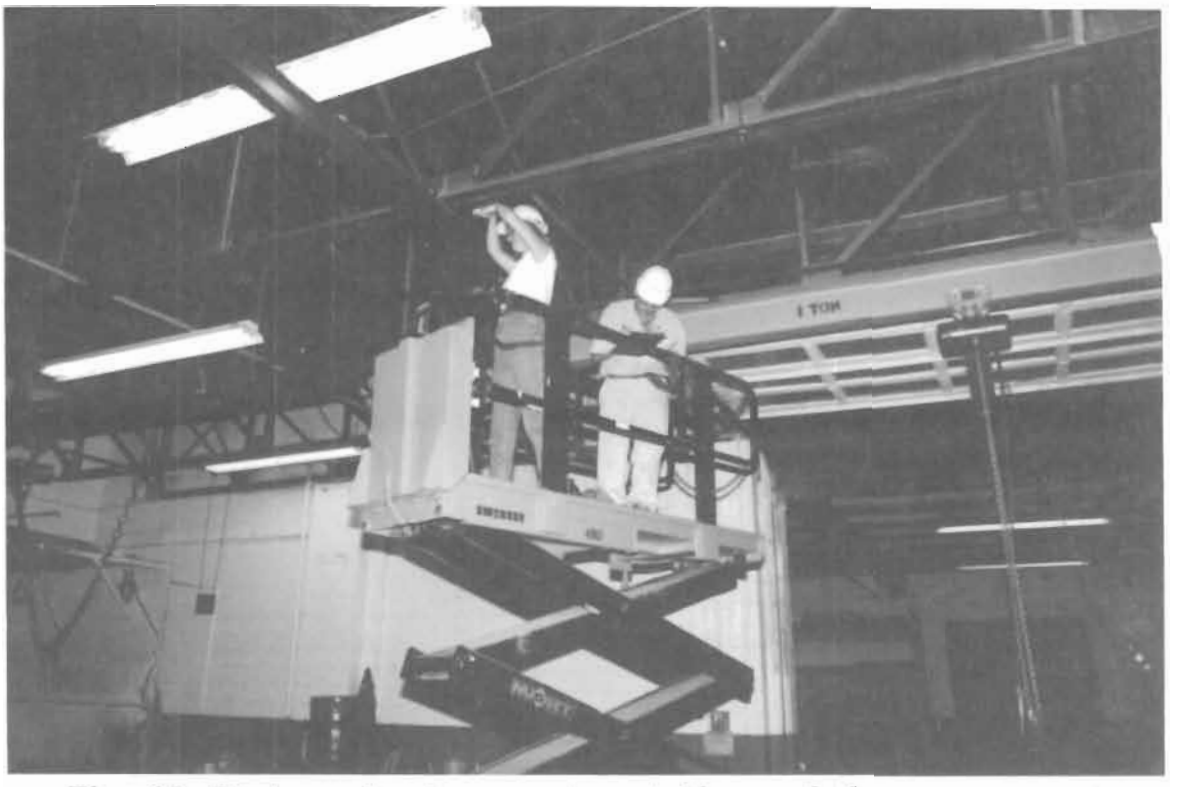

Fig. 15. Photograph of survey team taking radiation measurements on overhead beams.

Table 1. Applicable guidelines for protection against radiation
(Limits for uncontrolled areas)

Mode of exposure	Exposure conditions	Guideline value
Gamma radiation	Indoor gamma radiation level (above background)	20 μR/h[a]
Total residual surface contamination[b]	^{238}U, ^{235}U, U-natural (alpha emitters)	
	or	
	Beta-gamma emitters[c]	
	Fixed and removable	15,000 dpm/100 cm^2
	Average	5,000 dpm/100 cm^2
	Removable	1,000 dpm/100 cm^2
	^{232}Th, Th-natural (alpha emitters)	
	or	
	^{90}Sr (beta-gamma emitter)	
	Fixed and removable	3,000 dpm/100 cm^2
	Average	1,000 dpm/100 cm^2
	Removable	200 dpm/100 cm^2
	^{226}Ra, ^{230}Th, transuranics	
	Fixed and removable	300 dpm/100 cm^2
	Average	100 dpm/100 cm^2
	Removable	20 dpm/100 cm^2
Beta-gamma dose rates	Surface dose rate averaged over not more than 1 m^2	0.20 mrad/h
	Maximum dose rate in any 100-cm^2 area	1.0 mrad/h
Radionuclide concentrations in soil (generic)	Maximum permissible concentration of the following radionuclides in soil above background levels, averaged over a 100-m^2 area	5 pCi/g averaged over the first 15 cm of soil below the surface; 15 pCi/g when averaged over 15-cm-thick soil layers more than 15 cm below the surface
	^{226}Ra	
	^{232}Th	
	^{230}Th	

Table 1 (continued)

Mode of exposure	Exposure conditions	Guideline value
Derived concentrations	^{238}U	Site specific[d]

[a]The 20 μR/h shall comply with the basic dose limit (100 mrem/yr) when an appropriate-use scenario is considered.

[b]DOE surface contamination guidelines are consistent with *NRC Guidelines for Decontamination at Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for By-Product, Source, or Special Nuclear Material*, May 1987.

[c]Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except ^{90}Sr, ^{228}Ra, ^{223}Ra, ^{227}Ac, ^{133}I, ^{129}I, ^{126}I, ^{125}I.

[d]DOE guidelines for uranium are derived on a site-specific basis. Guidelines of 30-40 pCi/g have been applied at other FUSRAP sites. *Sources*: R. E. Rodriguez, et al., *Results of the Radiological Survey at the Town of Tonawanda Landfill, Tonawanda, New York (TNY001)*, ORNL/RASA-92/12, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., October 1992; B. A. Berven et al., *Radiological Survey of the Former Kellex Research Facility, Jersey City, New Jersey*, DOE/EV-0005/29, ORNL-5734, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., February 1982.

Sources: Adapted from U.S. Department of Energy, *Radiation Protection of the Public and the Environment*, DOE Order 5400.5, April 1990 and U.S. Department of Energy, *Guidelines for Residual Radioactive Material at FUSRAP and Remote SFMP Sites*, Rev. 2, March 1987; and *U. S. Department of Energy Radiological Control Manual*, DOE N 5480.6 (DOE/EH-256T), June 1992.

Table 2. Background radiation levels and concentrations of selected radionuclides in soil in the Fairfield, Ohio, area

Type of radiation measurement or sample	Radiation level or radionuclide concentration
Gamma exposure rate at 1 m above ground surface (μR/h)[a]	
Average	7
Range	3–11
Concentration of radionuclides in soil (pCi/g)[a]	
^{232}Th	0.9
^{226}Ra	1.5
^{238}U	1.3

[a]Values obtained from three locations between Columbus and Cincinnati.

Source: T. E. Myrick, B. A. Berven, and F. F. Haywood, *State Background Radiation Levels: Results of Measurements Taken During 1975-1979*, ORNL/TM-7343, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., November 1981.

Table 3. Concentrations of radionuclides in soil samples collected outdoors at the former Associate Aircraft Facility, Fairfield, Ohio

Sample I.D.[c]	Depth (cm)	Gamma exposure rate (μR/h)[a]		Radionuclide concentration (pCi/g dry wt)[b]		
		Upper	Lower	^{226}Ra	^{232}Th	^{238}U
			Systematic samples[d]			
S1A	0–15	8	9	0.96 ± 0.08	0.74 ± 0.1	1.8 ± 0.5
S1B	15–30	8	10	0.87 ± 0.09	0.63 ± 0.1	1.3 ± 0.4
S1C	30–45	10	9	0.89 ± 0.07	0.57 ± 0.08	1.1 ± 0.4
S2A	0–15	7	7	0.85 ± 0.06	0.58 ± 0.09	1.3 ± 0.3
S2B	15–30	7	9	0.75 ± 0.08	0.40 ± 0.1	1.4 ± 0.2
S2C	30–45	9	9	0.89 ± 0.06	0.52 ± 0.09	1.4 ± 0.4
S3A	0–15	8	9	1.04 ± 0.08	0.76 ± 0.1	1.1 ± 0.5
S3B	15–30	9	10	1.1 ± 0.02	0.76 ± 0.04	1.1 ± 0.3
S3C	30–45	10	12	1.1 ± 0.02	0.74 ± 0.03	2.2 ± 0.5
S4	0–15	6	7	0.45 ± 0.01	0.25 ± 0.02	1.2 ± 0.5
S5	0–15	5	5	0.37 ± 0.04	0.25 ± 0.06	0.90 ± 0.2
S6	0–15	5		0.44 ± 0.05	0.26 ± 0.07	1.2 ± 0.3
S7	0–15	6	8	1.1 ± 0.1	0.91 ± 0.2	1.5 ± 0.4
S8A	0–15	8	10	1.0 ± 0.02	0.71 ± 0.03	13 ± 2.0
S8B	15–30	10	10	1.0 ± 0.08	0.68 ± 0.1	4.0 ± 1.0
S8C	30–45	10	10	1.0 ± 0.02	0.62 ± 0.02	1.6 ± 0.5
S9A	0–15	6	9	1.0 ± 0.09	0.76 ± 0.1	1.3 ± 0.5
S9B	15–30	*e*	11	1.1 ± 0.1	0.92 ± 0.2	1.8 ± 0.7
S9C	30–45	*e*	10	1.1 ± 0.08	0.74 ± 0.1	1.5 ± 0.4
S10A	0–15	5	6	0.59 ± 0.08	0.39 ± 0.1	0.68 ± 0.2
S10B	15–30	6	6	0.57 ± 0.01	0.30 ± 0.02	0.70 ± 0.32
			Biased samples[f]			
B1A	0–15	24	30	1.2 ± 0.1	0.92 ± 0.2	360 ± 90
B2A	0–15	15	26	1.2 ± 0.09	0.81 ± 0.1	160 ± 35
B2B	15–30	26	26	1.3 ± 0.1	0.77 ± 0.2	88 ± 11
B3A	0–15	16	100	<1.5	0.40 ± 0.3	2900 ± 600
B3B	15–30	100	48	0.65 ± 0.1	<0.28	450 ± 100
B4A	0–15	13	20	5.2 ± 0.2	3.3 ± 0.2	4.3 ± 0.5
B4B	15–30	20	15	2.0 ± 0.09	1.1 ± 0.2	2.0 ± 0.3
B5A	0–15	6	8	1.0 ± 0.07	0.71 ± 0.1	1.3 ± 0.6
B5B	15–30	*e*	9	0.98 ± 0.1	0.59 ± 0.1	1.8 ± 0.8
B6A	0–15	8	10	0.92 ± 0.02	0.59 ± 0.03	2.4 ± 0.5
B6B	15–30	*e*	11	1.0 ± 0.08	0.72 ± 0.1	1.4 ± 0.4

[a]Gamma radiation levels measured in the field on contact with the soil surface above and below the sample ("upper" and "lower", respectively).

[b]Indicated counting error is at the 95% confidence level ($\pm 2\sigma$).

[c]Locations are shown on Figs. 6 and 7.

[d]Systematic samples are taken at locations irrespective of gamma exposure rates.

[e]No measurement taken.

[f]Biased samples are taken from areas shown to have elevated gamma exposure rates.

Table 4. Concentrations of radionuclides in floor drain and seam samples collected from Section 4 of the building at the former Associate Aircraft site

Sample I.D.[a]	Depth (cm)	Radionuclide concentration (pCi/g dry wt)[b]		
		^{226}Ra	^{232}Th	^{238}U
M3	*c*	<3.2	<4.8	16000 ± 100
M4A	*c*	<3.5	<4.9	45000 ± 1000
M4B	*c*	<3.0	<4.6	42000 ± 10000
M4C	0–13	<3.1	<3.4	2500 ± 500
M4D	0–13	<3.5	<4.7	2000 ± 1000
M5A	*c*	<1.5	<1.1	13000 ± 4000
M5B	*c*	<3.0	<4.5	48000 ± 10000
M5C	*c*	<4.0	<5.4	62000 ± 5000
M5D	*c*	<4.0	<5.4	60000 ± 5000
M6A	2–5	<2.6	<2.7	10 ± 1.0
M6B	5–8	<0.85	<0.55	3.0 ± 0.7
M6C	8–10	<0.70	<0.33	1.2 ± 0.4
M6D	10–13	0.58 ± 0.1	0.30 ± 0.2	5.9 ± 1.2
M6E	13–15	<0.71	<0.32	1.3 ± 0.5
M6F	15–18	<0.45	<0.41	4.9 ± 1.0
M6G	18–20	<0.50	<0.24	1.5 ± 0.3
M6H	10–22	<2.0	<1.1	5.1 ± 1.4

[a]Locations are shown on Fig. 9.
[b]Indicated counting error is at the 95% confidence level ($\pm 2\sigma$).
[c]Not applicable.

Table 5. Total and removable alpha and beta-gamma activity levels and radionuclide concentrations in dust samples from selected locations on overhead beams at the former Associate Aircraft site

Sample I.D.[a]	Directly measured activity levels (dpm/100 cm²)[b]		Removable activity levels (dpm/100 cm²)[c]		Derived beta-gamma activity levels (dpm/100 cm²)[d]	^{238}U (pCi/g dry wt)[e]	Weight (gm)	Location[f]
	Alpha	Beta-gamma	Alpha	Beta-gamma				
T1A/B	<MDA	5400	6	<MDA	1060	115 ± 15	4.19	Sect. 3 -15 ft W of E roll-up door
T2A/B	140	8700	10	<MDA	700	400 ± 100	0.79	Sect. 4 - 15 ft E of W wall; 20 ft N of E center
T3A/B	1300	50,000	90	<MDA	3800	1900 ± 300	0.92	Sect. 4 - 35 ft E of W wall, near center
T4A/B	720	5900	4	<MDA	800	150 ± 20	2.46	Sect. 3 - 27 ft W of E wall, 36 ft N of S wall main work bay
T5A/B	85	5400	10	<MDA	1400	140 ± 10	4.62	Sect. 3 - 27 ft W of E wall, 15 ft N of S wall main work bay
T6A/B	1000	14,000	<3	<MDA	2800	350 ± 40	3.57	Sect. 3 - 52 ft W of E wall, 39 ft N of S wall, main work bay
T7A/B	160	8000	6	<MDA	1900	290 ± 10	3.0	Sect. 3 - 45 ft W of E wall, 15 ft N of S wall main work bay
T8A/B	240	6500	<3	<MDA	840	200 ± 10	1.9	Sect. 3 - 39 ft W of E wall, 12 ft N of S wall main work bay

[a]TnA samples are the smear samples for which removable activity levels are reported. TnB samples are the dust/debris collected after directly measured activity levels were determined. TnB samples were analyzed for radionuclide concentrations.

[b]Results of analysis of smears (A sample) collected from the surface from which the dust sample (B) was removed.

[c]Directly measured alpha and beta-gamma activity levels over the selected area prior to sampling and smearing.

[d]Derived surface contamination levels (dpm/100 cm²) were calculated from the uranium concentration (pCi/g), the sample weight, and the area from which the samples were taken.

[e]Indicated counting error is at the 95% confidence level ($\pm 2\sigma$).

[f]Location is shown on Fig. 14.

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