Prepared by
Oak Ridge Associated Universities

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RADIOLOGICAL MEASUREMENTS AT INTERNATIONAL NUTRONICS, INC. DOVER, NEW JERSEY

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

FINAL REPORT

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AT
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INTRODUCTION

In 1970, International Nutronics, Inc., began conducting process gamma irradiations at their site in Dover, New Jersey. The gamma radiation field was provided by a cylindrical array of Co-60 sources. During nonoperational periods, the sources were stored in a water tank, which provided both radiation shielding and cooling. Because of small leaks in the sealed sources the water in the tank became contaminated with Co-60. In 1982, while attempting to decontaminate water in the shield tank, a leak occurred in the transfer line. An estimated 5700 liters of contaminated water was released onto the irradiator building floor. This water, following the slope of the floor, ran towards the north and west walls. Some of the water passed through floor and wall mortar joints, contaminating the soil beneath the building and immediately adjacent to the outside walls. Irradiator operations have ceased and the International Nutronics staff is in the process of decontaminating and decommissioning the facility.

At the request of the Nuclear Regulatory Commission's (NRC) Region I Office, the Radiological Site Assessment Program of Oak Ridge Associated Universities (ORAU), Oak Ridge, Tennessee, conducted radiological measurements at the International Nutronics site. The purpose of these measurements was to determine the extent and levels of Co-60 contamination beneath and around the irradiator building.

SITE DESCRIPTION

International Nutronics, Inc., occupies two buildings on Rt. 46 in Dover, New Jersey. One of the buildings houses administrative operations; the other building contains the Co-60 irradiator unit. Figure 1 is a floor plan of the irradiator facility. The facility is located inside a concrete block building, approximately 15 m x 24 m with a 5 m high ceiling. The floor is slightly reinforced concrete, estimated to be 10-15 cm thick; there are several expansion joints in the floor slab. A 1.3 m diameter, 5 m high tank, located inside a concrete shield wall, contains sealed sources having an activity of approximately 50 kCi of Co-60. The tank is below floor level and filled with contaminated water. This building also houses a second (newer) irradiator facility. This second irradiator presently contains no sources, but the labyrinth shield is being used to store containers of radioactive waste. In the southeast corner of the building there is a small office, restrooms, and a contamination control/change line area.

SURVEY PROCEDURES

This section describes the monitoring and sampling performed by ORAU during a scoping visit on November 4, 1983, and a site survey during November 30 - December 2, 1983. Information from ORAU activities was supplemented by analysis of subsurface samples collected November 4 - 8, 1983, by Storch Engineering, under contract to International Nutronics.

November 4, 1983

1. Radiation scans were performed around the outside of the irradiator building using a NaI(Tl) gamma scintillation detector and ratemeter. Relative radiation levels at the ground surface adjacent to the building and at distances up to 1 m from the building were noted. Levels were also monitored at varying heights above the ground surface.
2. Subsurface gamma monitoring was performed in one of the boreholes (borehole B3) as it was drilled by Storch Engineering. The pattern of levels with increasing depth was noted.

November 30 - December 2, 1983

1. Radiation scans were performed inside the irradiator building to identify locations of maximum direct radiation levels and to define the boundaries of subfloor and surface contamination. Because of the high radiation levels and contamination potential, these scans were not conducted inside the controlled areas established around each of the irradiator facilities.

2. At eleven locations, 15 cm diameter holes were cut through the floor using a concrete coring drill. These locations are shown on Figure 2.
3. Samples of the soil immediately beneath the floor were collected. In holes where direct radiation monitoring did not indicate soil contamination, the initial sample was 0-15 cm; where soil contamination was indicated, samples were collected at 0-5 cm and 5-15 cm.
4. Deeper samples were collected from the core holes using a manually-operated bucket auger. Samples were collected at 30-40 cm below the soil-floor interface and at approximately 50 cm intervals below that depth.
5. A gamma scintillation detector was lowered into each hole and count rates noted at various depths to determine the radiation profile.
6. Soil samples were returned to Oak Ridge, Tennessee, for analysis of Co-60 concentrations.

Additional Investigations

Storch Engineering provided ORAU with soil samples, collected November 4-8, 1983, from four boreholes drilled outside the north and west walls of the irradiator building (refer to Figure 2). ORAU analyzed these samples for Co-60 content.

Equipment And Analytical Procedures

Appendix A contains a listing of the major items of equipment used by ORAU in performing this survey. Additional information concerning analytical procedures is provided in Appendix B.

RESULTS

Radiation scans around the outside of the building indicate that contamination is limited to the north and west walls. Approximately two-thirds of the length of each of these walls produces elevated radiation levels, suggesting contamination. The maximum levels were noted along the west wall, several meters south of the side door. At a short distance (30 cm) from the wall and with increasing height above the ground the radiation levels decrease considerably, indicating that the contamination is primarily limited to the surface soil immediately adjacent to the building.

Radiation scans inside the building provided a pattern of distribution, similar to that noted from the outside surveys. However, the radiation levels inside were higher and the area of contamination appeared to extend about 1 m from the wall/floor intersection. No locations of significantly higher direct levels were noted in floor expansion joints, stress cracks, or depressions. It should be noted that surveys could not be performed along the eastern section of the north wall, because of the irradiator shielding and waste storage in that area.

The concentrations of Co-60 measured in samples from beneath the building floor are presented in Table 1. The highest concentration was 3850 pCi/g from 5-15 cm deep at core location 5 along the west wall. (This location corresponds to the area of maximum direct radiation identified by the scans.) In the 0-5 cm depth sample from this location, the concentration was 3760 pCi/g. The highest concentration along the north wall was 716 pCi/g at the subfloor soil surface in core hole 9. Concentrations decreased with depth at each of the core locations along the north and west walls, with the exception of location 8. At this location, which, according to direct measurements, was outside the region of contamination, the concentration was a maximum of 7.58 pCi/g at 80-90 cm deep - the depth of the building footer. It is suspected that contaminated water reached this location by flowing along the footer from areas of higher contamination along the west wall.

At core locations 1 and 2, along the east and south walls, no significant Co-60 concentrations were measured. Location 3 contained only a slightly elevated concentration of 1.46 pCi/g, immediately below the flooring. Concentrations of Co-60 at core location 4 did not follow the depth distribution pattern observed at other locations. In this hole the concentration decreased from 20.7 pCi/g at 0-15 cm to 5.62 pCi/g at 80-90 cm, then increased to 48.2 pCi/g at 180-190 cm. Further sampling was not possible at this and several other locations because of debris or large rocks encountered within the upper 2 m of fill. At core locations near the walls the foundation footer prevented sampling below 0.6 m (location 11) to 1.2 m (locations 5, 6, 7, and 9). It should be noted that small amounts of water were encountered approximately 1.0 to 1.5 m below the floor in all of the coring locations. The quantity of water available was not sufficient to permit sampling. Radiation profiles, obtained by lowering a gamma detector into the core holes, revealed a pattern consistent with the subsurface soil concentrations.

Concentrations of Co-60 in samples from outside boreholes are presented in Table 2. The soil from boreholes B1 and B2, north of the building did not contain elevated Co-60 levels. Borehole B4 has an elevated level of 6.33 pCi/g on the surface; at 0.6-1.2 and 1.8-2.4 m the concentrations are 1.73 and 1.76 pCi/g, respectively. Borehole B3 provided the only subsurface sample containing a high concentration of Co-60. In this borehole the sample from 0.6-1.2 m contained 274 pCi/g. Samples from above and below that depth were considerably lower, i.e. 2.27 and 4.72 pCi/g. This is consistent with the results of direct measurements in this borehole that indicated a high gamma intensity at approximately 1 m below the ground surface.

DISCUSSION AND SUMMARY

The results of direct measurements and sample analysis performed in connection with this survey confirm that Co-60 contamination is present beneath the building floor and adjacent to the building along the west and north walls. The estimated distribution of contamination is shown on Figure 3. This distribution is consistent with the available information regarding the water release incident and indicates that the water carried the contamination through cracks at the wall/floor joint. After reaching the floor/soil interface it probably followed the path of least resistance, flowing into depressions and voids beneath the floor and along the foundation. A small amount of leakage to the outside through wall mortar joints also apparently occurred. A larger than usual leakage path may explain the high concentration of Co-60 at about 1 m deep in borehole B3 along the west wall. The depth distribution of the contamination inside the facility suggests that the radionuclide is in a relatively insoluble form.

The distribution of contamination at coring location 4 is inconsistent with the pattern observed at other locations. One possible explanation may be the presence of additional leakage paths within the irradiator facility, i.e. other floor joints and stress cracks or around the water tank. If additional paths exist, substantially larger subfloor areas may be contaminated. Removal of the sources and dismantling of the irradiator shield will be required before such a determination can be made.

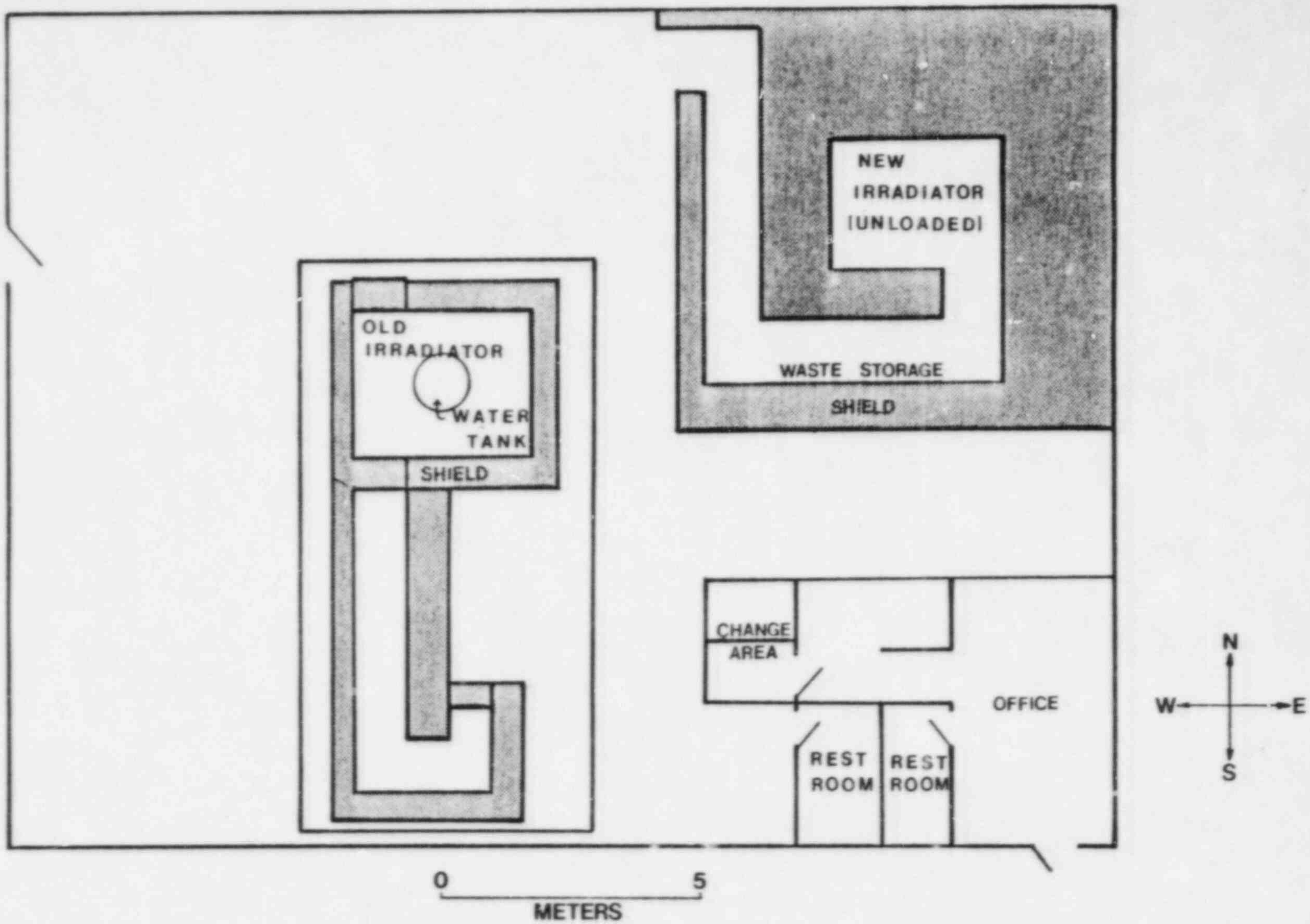

FIGURE 1: Floor Plan of the Irradiator Building.

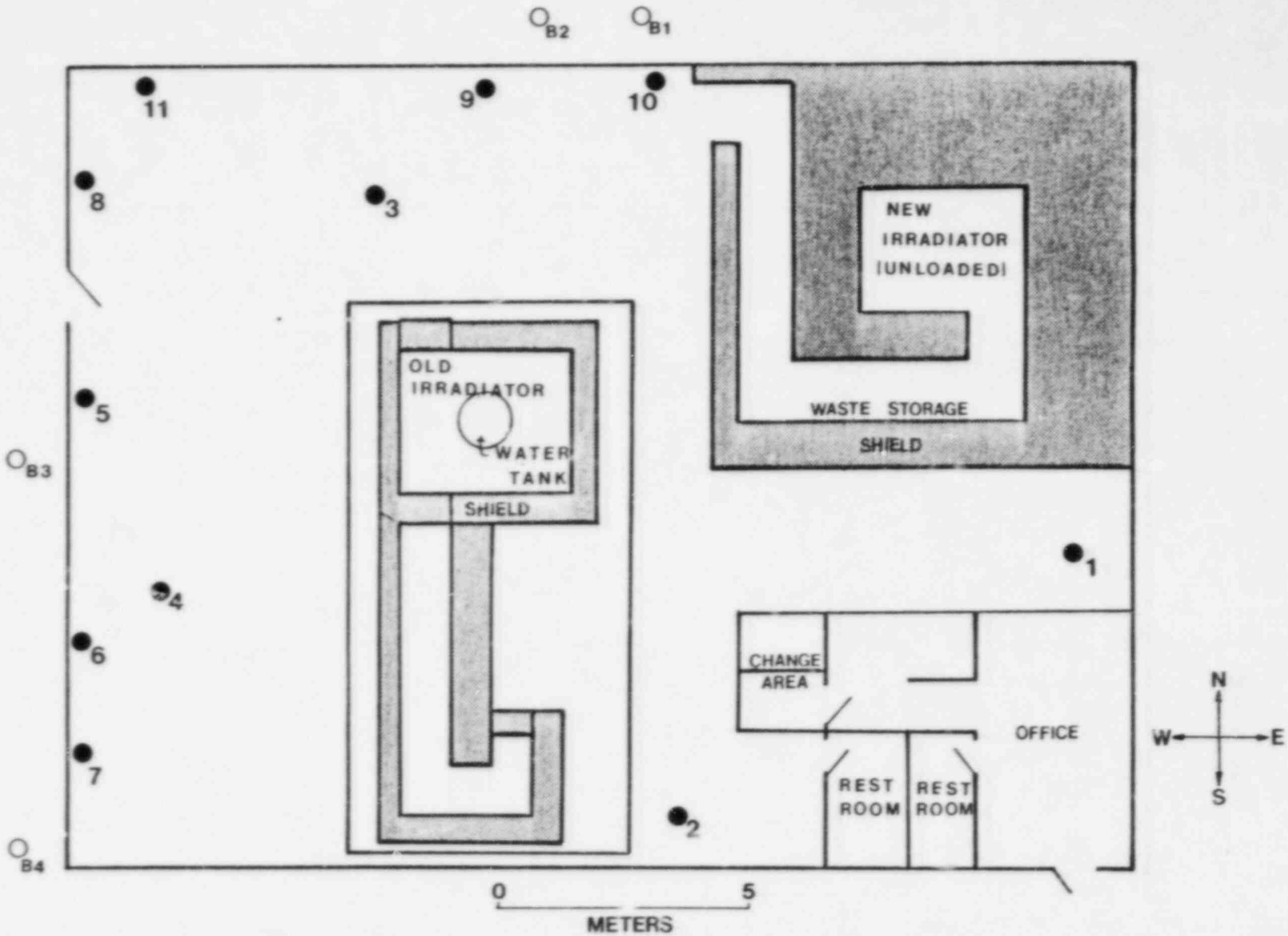

FIGURE 2. Locations of Floor Coring (1-11) and Boreholes (B1-B4) for Subsurface Investigations.

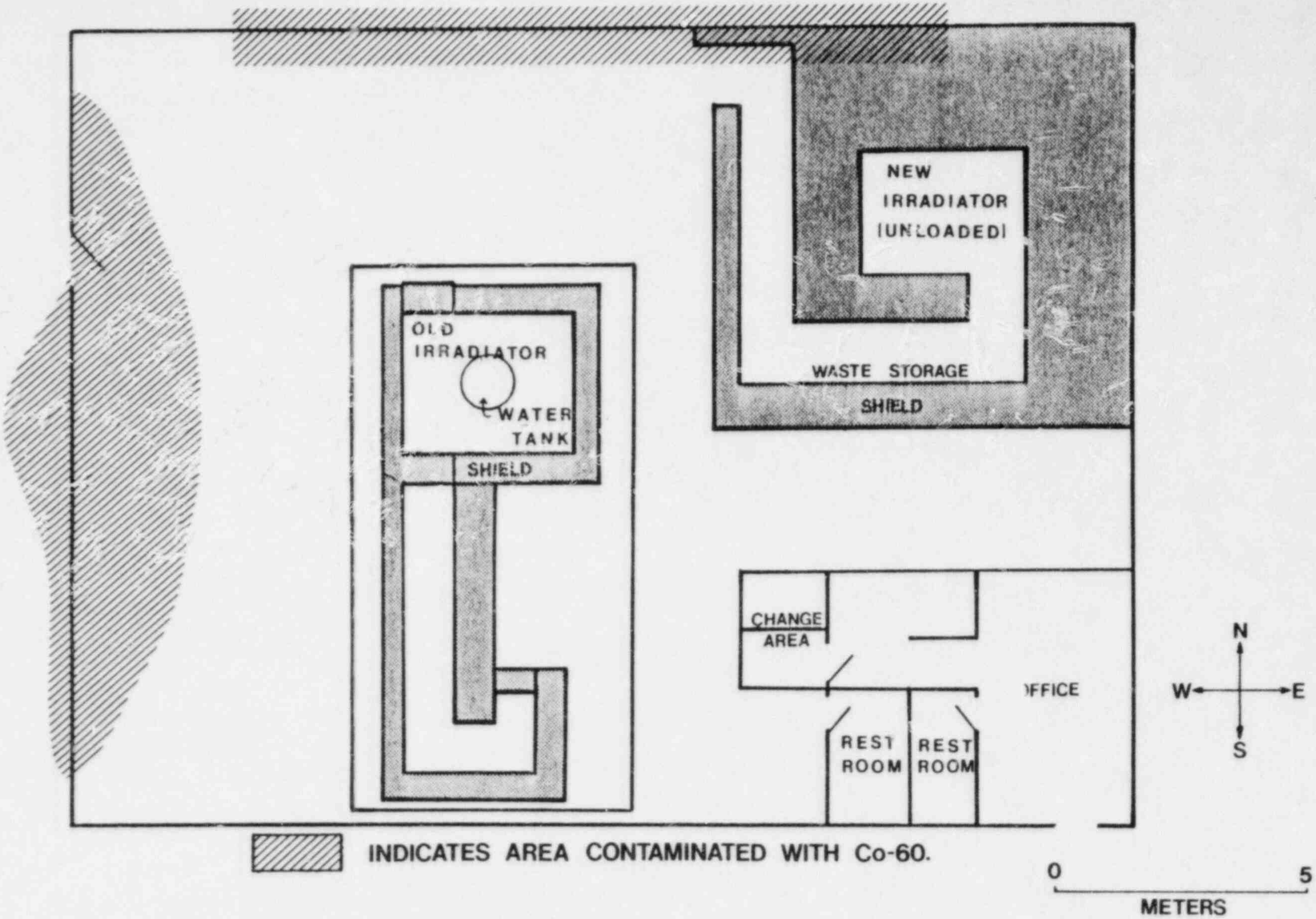

FIGURE 3. Floor Plan of the Irradiator Building, Indicating Areas of Subfloor and Outside Soil Contamination.

TABLE 1

COBALT-60 CONCENTRATIONS IN SOIL SAMPLES FROM BENEATH THE IRRADIATOR BUILDING FLOOR

Coring[a] Location	Sampling Depth[b] (cm)	Co-60 Concentrations (pCi/g)
1	0-15	<0.05
	30-40	0.05 ± 0.07[c]
2	0-15	0.02 ± 0.01
	30-40	0.11 ± 0.05
	80-90	0.18 ± 0.10
	130-140	0.09 ± 0.05
3	0-5	1.46 ± 0.18
	5-15	0.45 ± 0.15
	30-40	0.11 ± 0.14
	80-90	<0.03
	130-140	0.20 ± 0.06
4	0-15	20.7 ± 0.6
	30-40	10.2 ± 0.5
	80-90	5.62 ± 0.36
	130-140	24.9 ± 0.7
	180-190	48.2 ± 1.0
5	0-5	3760 ± 43
	5-15	3850 ± 44
	30-40	89.6 ± 1.2
	80-90	59.3 ± 1.0
	110-120	20.7 ± 0.7
6	0-5	2110 ± 27
	5-15	1140 ± 19
	30-40	256 ± 4
	80-90	11.6 ± 0.5
	110-120	3.21 ± 0.23
7	0-5	1680 ± 25
	5-15	814 ± 16
	30-40	120 ± 2
	80-90	31.0 ± 0.8
	110-120	9.28 ± 0.45
8	0-5	0.65 ± 0.11
	5-15	0.35 ± 0.11
	30-40	4.40 ± 0.31
	80-90	7.58 ± 0.39

TABLE 1, cont.

COBALT-60 CONCENTRATIONS IN SOIL SAMPLES
FROM BENEATH THE IRRADIATOR BUILDING FLOOR

Coring Location	Sampling Depth (cm)	Co-60 Concentrations (pCi/g)
9	0-5	716 ± 4
	5-15	708 ± 7
	30-40	19.7 ± 0.7
	80-90	13.3 ± 0.5
	110-120	4.35 ± 0.27
10	0-5	496 ± 5
	5-15	301 ± 3
	30-40	56.9 ± 1.2
	80-90	28.1 ± 0.7
11	0-5	0.71 ± 0.15
	5-15	0.37 ± 0.13
	30-40	0.13 ± 0.08
	50-60	0.13 ± 0.11

[a] Refer to Figure 2.
[b] Depth below floor/soil interface.
[c] Errors are 2σ based on counting statistics.

TABLE 2

COBALT-60 CONCENTRATIONS IN SOIL SAMPLES
COLLECTED FROM BOREHOLES OUTSIDE THE IRRADIATOR BUILDING

Location[a]	Depth (m)	Co-60 Concentrations (pCi/g)
B1	0-0.6	<0.06
	1.2-1.8	<0.06
	2.4-3.0	<0.04
	3.6-4.2	<0.11
	4.6-5.2	<0.06
B2	0-0.6	<0.15
	0.6-1.2	<0.04
	2.4-3.0	<0.10
	3.6-4.2	<0.10
	4.6-5.2	<0.07
B3	0-0.6	2.27 ± 0.36[b]
	0.6-1.2	274 ± 9
	1.2-1.8	4.72 ± 0.50
	1.8-2.4	1.20 ± 0.30
	2.4-3.0	0.16 ± 0.13
	3.0-3.3	0.24 ± 0.18
	3.6-3.8	0.22 ± 0.19
	4.2-4.7	<0.09
B4	0-0.6	6.33 ± 0.95
	0.6-1.2	1.73 ± 0.45
	1.2-1.8	<0.11
	1.8-2.4	1.76 ± 0.42
	2.4-3.0	0.16 ± 0.11
	3.0-3.6	0.14 ± 0.13
	3.6-4.2	<0.10
	4.6-5.2	0.13 ± 0.08

[a] Refer to Figure 2.
[b] Errors are 2σ based on counting statistics.

APPENDIX A

MAJOR SAMPLING AND ANALYTICAL EQUIPMENT

APPENDIX A

Major Sampling and Analytical Equipment

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

A. Direct Radiation Measurements

Model PRM-6 Ratemeter
(Eberline Instrument Corp., Santa Fe, NM)

NaI Scintillation Probe, Model 489-55
(Victoreen, Inc., Cleveland, OH)

B. Sampling

Diamond-bit Concrete Corer
(Black and Decker)

Soil Coring and Sampling Kit
Model 41007-1
(Acker Drill Co., Inc., Scranton, PA)

C. Laboratory Analysis

Ge(Li) and Intrinsic Germanium Detectors
(Princeton Gamma Tech, Princeton, NJ, and EG&G ORTEC, Oak Ridge, TN)

Pulse Height Analyzer, ND680
ND66 Analyzer Model 88-0629 with ND11 Computer package
(Nuclear Data, Inc., Schaumburg, IL)

APPENDIX B

ANALYTICAL PROCEDURES

APPENDIX B

Analytical Procedures

Soil Sample Analysis

Soil samples were dried at 120° C, ground, mixed, and a portion placed in a 0.5 l Marinelli beaker. The quantity placed in each beaker was chosen to reproduce the calibrated counting geometry and ranged from 500 to 800 g of soil. The beakers were capped but not sealed. Net soil weights were determined and the samples counted using Ge(Li) or intrinsic germanium detectors coupled to a Nuclear Data ND680 pulse height analyzer system. The 1.17 MeV and 1.33 MeV energy peaks were used for identification and determination of Co-60. Background and Compton stripping, peak search, peak identification, and concentration calculations were performed using the computer capabilities inherent in the analyzer system.

Calibration and Quality Assurance

All survey and laboratory instruments were calibrated with NBS-traceable standards. Quality control procedures on all instruments included daily background and check-source measurements to confirm operation within the limits of expected statistical deviation. The ORAU laboratory participates in the EPA Quality Assurance Program.