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Formerly Utilized MED/AEC Sites Remedial Action Program

Radiological Survey of the Former GSA 39th Street Warehouse 1716 Pershing Road, Chicago, Illinois

January 1979

Final Report

Prepared for:

U.S. Department of Energy
Assistant Secretary for Environment
Division of Environmental Control Technology

DISCLAIMER

DOE/EV-0005/9
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PREFACE

This is one of a series of reports resulting from a program initiated in 1974 by the Atomic Energy Commission (AEC) for determination of the condition of sites formerly utilized by the Manhattan Engineer District (MED) and the AEC for work involving the handling of radioactive materials. Since the early 1940's, the control of over 100 sites that were no longer required for nuclear programs has been returned to private industry or the public for unrestricted use. A search of MED and AEC records indicated that for some of these sites, documentation was insufficient to determine whether or not the decontamination work done at the time nuclear activities ceased is adequate by current guidelines.

This report contains the results of surveys of the current radiological condition of the Former GSA 39th Street Warehouse, 1716 West Pershing Road, Chicago, Illinois. Findings of this survey indicate there is no identifiable residual activity remaining at this facility from operations conducted by the MED and AEC during the period 1946 through 1953.

This survey was performed by the following Health Physics personnel of the Occupational Health and Safety Division, Argonne National Laboratory, Argonne, Illinois: R. A. Wynveen, W. H. Smith, C. J. Mayes, P. C. Gray, D. W. Reilly.

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CONTENTS

RADIOLOGICAL SURVEY OF THE FORMER GSA 39th STREET WAREHOUSE, 1716 WEST PERSHING ROAD, CHICAGO, ILLINOIS

INTRODUCTION

During the Manhattan Engineer District/Atomic Energy Commission (MED/AEC) Era, the building located at 1716 West Pershing Road, Chicago, Illinois, was used for storage of government materials. This building was referred to as the 39th Street Warehouse.

Personnel involved with the facility recall that this building was used, at least in part, for storage of radioactive materials. Records indicate that some contaminated animal cages were stored outside behind the building. Records of survey performed in 1949 indicate that contamination was found in the building, the yard and on equipment remaining in the building. These records indicate that contaminated items were removed, but no records concerning the decontamination of the building could be found.

Due to the uncertainty of the decontamination of the facility, a radiation survey of the building was undertaken from July 11 to July 14, 1977. The purpose of this survey was to determine if any detectable contamination remains as a result of any MED/AEC occupancy.

In recent years, the structure was used as an office and warehouse facility by RESCO, and air conditioning, refrigeration, and heating firm; the north end of the building was used for storage while the south end was occupied as office space. At the time of the survey, RESCO was in the process of moving their equipment and operations to a new location. The building is now owned by a private individual.

SURVEY TECHNIQUES

General

All accessible original walls were surveyed to a height of seven feet and all accessible floor areas were surveyed (Table 1). In many areas, the floors and walls had been carpeted or painted. Even though these were not the original surfaces, these areas were surveyed since the capability of detection was adequate to see activity on the original structures underneath. A representative selective survey of overheads such as ducts and beams was performed in areas where the original structures were available. See Table 1 and Figure 1A and 1B for locations of accessible areas surveyed. Figure 1C shows the site location.

Instrumentation

Three types of survey instruments were used (Table 2). An Eberline FM-4G having a detection area of 325 cm^2, utilizing the Eberline PAC-4G-3 electronics, was used to survey the floors. A PAC-4G-3 with a hand-held detector, 51 cm^2 in sensitive area, was used to survey the walls and other accessible areas. Double aluminized mylar (~0.85 mg/cm^2) windows were used in both detectors. This allows for low energy detection and greater instrument sensitivity. Both of these instruments were initially used in the beta mode. In this mode, the detector responds to a wide energy range of electromagnetic and particulate radiations. When areas were found which indicated a higher count rate than the average instrument background, the instrument was then switched to the alpha mode and a reading of the alpha activity was obtained.

An End Window Geiger-Mueller (G-M) Detector, Eberline Model E-530 with an Eberline HP-190 probe, held three feet above the floor, was used to determine general background radiation levels throughout the surveyed area. If an area was found that had an elevated count rate, a contact reading was obtained.

The End Window G-M Detector was calibrated using the gamma emissions from a Radium-226 calibration source. The PAC-4G-3 instruments were calibrated in the alpha mode using a flat plate infinitely thin Plutonium-239 standard and in the beta mode with a flat plate infinitely thin Strontium-90-Yttrium-90 standard. The instruments were calibrated to an apparent 50% geometry.

It must be realized that the numerous isotopes that could be encountered will exhibit emission energies differing from that of Plutonium-239 and Strontium-90-Yttrium-90 utilized in the calibration. When detecting known isotopes that emit alpha and beta energies differing from that of the standards, a conversion factor would be developed to determine the appropriate yield.

Smear Surveys

Smears were taken throughout the office and warehouse areas (Figure 1A and 1B). Only original structures and components such as walls, floors, pipes and vents were smeared. All smears were taken with No. 1 Whatman filter paper, 4.25 cm in diameter. Smears of one square foot were normally taken. If an area was found which had a higher than normal background, a smear of 100 cm^2 was taken. A smear of 100 cm^2 was also taken if an area indicated excessive dirt loading. The smears were counted in groups of ten using the 10-Wire Flat Plate Gas Proportional Dectector, developed at Argonne National Laboratory (ANL), utilizing an Eberline Mini Scaler Model MS-2. One smear of each group was removed and counted in a Nuclear Measurement Corporation Proportional Counter-5 (PC-5) 2π Internal Gas Flow Counter using a mylar spun top. This procedure was used as an additional means of checking the smear samples. In addition, any smears indicating elevated amounts in the 10-Wire Assembly, were also counted in the more sensitive PC-5 counter. Smears were counted in both detectors for alpha and beta activity. Appendix 1 includes the instrumentation and smear count conversion factors used.

Table 1 includes the room survey readings while the maps in Figure 2 indicate the location of the smears. A number, n, indicates the location of the smear in the room. A number, ⓝ, indicates a smear of an overhead structure.

Air Samples

Air samples were collected using a Filter Queen Air sampling device. The air samples were taken at a flow rate of 40 m^3/hr on a 200 cm^2 sheet of Hollingsworth-Vose (HV-70-9 mil) filter media which collected the particulates present in the air. A 10% portion, 5 cm in diameter, was removed from the filter media and counted in the PC-5 2π Internal Gas Flow Counter, utilizing a mylar spun top for both alpha and beta activity. Sampling results were used to determine radon concentrations and the presence of any long-lived activity. Air sample data is presented in Appendix 2A through 2C.

Soil Samples

In addition to the survey inside the building, a soil coring was taken at a selected location outside the warehouse to determine the deposition, if any, of isotopes that could have been spilled or released from the facility. Radiochemical (fluorometric) and gamma spectrum analyses were conducted on these soil samples.

The coring was effected using a four (4) inch in diameter by six (6) inch in length right circular cylinder; commonly called a hole cutter. This device is normally used for cutting holes for the cups in golf courses.

The core was 1 foot in length and divided into four (4) segments. starting from the surface, three (3) separate two (2) inch segments are cut, bagged, and marked A, B and C respectively; the final segment, a six (6) inch section, was marked D.

The reason for the segmented coring is to determine what, if any, contaminant migration has occurred, to reduce the dilution of lower level soil with the upper level segments in respect to the surface deposition of the contaminants or vice versa, and to reveal any overburden or back fill that may have occurred over the years.

One soil coring was taken from the grounds adjacent to the north end of the building. Figure 1A indicates the soil sample location.

Background data for the soil sample analysis (Table 7) was obtained from a number of soil samples taken from the Chicago area. This information was obtained from the Environmental Monitoring Section of the Occupational Health and Safety (OHS) Division of ANL.

The soil samples were processed at ANL (Figure 2) and shipped to a commercial laboratory (LFE Environmental Analysis Laboratories) for radiochemical (fluorometric) and gamma spectrum analysis. Their soil analysis procedure is described in Appendix 3.

Sample preparation consisted of weighing the samples in their entirety and then drying for approximately 24 hours at 80° Centigrade. All samples were then reweighed, put into mill jars (2.3 gallon) and milled until a sufficient amount of the soil sample would pass a No. 30 standard sieve. At no point were the rocks and heavy material ground or pulverized since this material would act as a diluent and hence lower the concentration per unit volume of deposited material.

After sufficient milling, the material was sieved using a No. 30, 600 micron (μ) standard stainless sieve. The rocks and dross vs. sieved material (< 600 μ) was segregated, bagged, and weighed separately. Soil sample weights are given in Table 5.

Aliquots of the sieved material were then loaded into screw top plastic containers. The amount varied according to the type of analysis to be performed; 100 grams for gamma and radiochemical (fluorometric) analysis and 10 grams for radiochemical (fluorometric) only. Every effort was made throughout the sample preparation operations to reduce or eliminate cross contamination. Soil samples which were suspected of containing elevated amounts of radioactivity were processed in equipment separate from the soil samples considered to contain background levels. All items of equipment were scrubbed and air dried prior to the introduction of the next sample.

ANALYSIS OF SURVEY RESULTS

General

All data, including diagrams of survey locations, are attached to this report. This section discusses the results of the survey and the findings therein. Instrument readings and smear results were normalized to units of disintegrations per minute per one hundred square centimeters (dpm/100 cm^2). (See Appendix 1 for the conversion factors used.) All data is reported in net counts, i.e., the background counts have been subtracted from the gross counts prior to converting from counts per minute per one hundred square centimeters (cpm/100 cm^2) to dpm/100 cm^2. The beta mode readings are compensated for any alpha contribution. The room background levels varied somewhat due to the construction materials in them. Table 3 provides an average background reading for all modes of the different instruments used.

The areas accessible for survey varied from area to area. Areas accessible for survey are presented in Table 1. The average percent of the total accessible areas was 70% for the floors and 60% for the walls.

Instrument Surveys

All indicated areas were surveyed and no radioactivity above background levels could be detected.

Smear Surveys

No contamination above background levels was detected on any smears.

Air Samples

The air sampling results are presented in Table 4. The variation of the data results do not appear to be a result of any MED/AEC operation, but rather the variation reflects the differences in the construction materials used throughout the facility. Other factors such as the ventilation of the room can cause the radon concentrations to vary. All radon concentrations determined are below the Maximum Permissible Concentration (MPC) for an uncontrolled area as listed in "Standard for Protection Against Radiation," Code of Federal Regulations, Title 10, Part 20, Appendix B (April 30, 1975), (10 CFR 20). These concentrations are found to be within the normal expected levels of radon.

Soil Samples

Results submitted by LFE Environmental Analysis Laboratories, as listed in Table 6, are reported in picocuries per gram (pCi/g) for the Germanium (Lithium) [Ge(Li)] spectral analysis and in micrograms per gram (µg/g) for the uranium fluorometric analysis. The latter concentrations were converted to pCi/g by means of the example calculation as shown in Appendix 4.

The background soil data is presented in Table 7. The background samples indicate normal uranium concentrations ranging from 0.3 to 2.0 pCi/g. Results of soil samples taken at the Former 39th Street Warehouse indicate a normal uranium background concentration in the soil.

FINDINGS

The survey results show that no radioactivity above background was detected throughout the Former GSA 39th Street Warehouse. Air sampling results indicate normal radon concentration levels. The results of the soil sample analysis shows no elevated readings above the natural background levels present in the soil from this region.

TABLE 1
DATA SHEET SHOWING ROOM SURVEY RESULTS

Room or Area No.	Percent of Area Accessible for Survey		Air Sample (pCi/l)	Beta Mode[1] Direct Readings (dpm/100cm²)				Alpha Mode Direct Readings (dpm/100cm²)				End Window (mR/hr)		Smear Results (dpm/100cm²)	Comments
	Floor	Wall		Floors	Walls	Overhead	Other	Floors	Walls	Overhead	Other	Contact	3 feet		
1	95	95	NS[2]	BKGD[3]	BKGD	OSU[4]	NE[5]	NA[6]	NA	NA	NA	NN[7]	BKGD	BKGD	
2	100	95	NS	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
3	85	90	NS	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
4	90	90	NS	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
5	95	95	NS	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
6	60	50	NS	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
7	60	50	NS	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
8	50	50	NS	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
9	60	45	NS	BKGD	BKGD	BKGD	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
10	50	35	NS	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
11	85	80	0.42	BKGD	BKGD	BKGD	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
12	50	50	NS	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
13	55	50	NS	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
14	45	50	NS	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
15	40	40	NS	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
16	50	50	NS	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
17														NST[8]	This is the company safe; no survey was taken here.

[1] Beta Mode detects both electromagnetic and particulate radiation. The beta mode readings are compensated for any alpha contribution.

[2] NS-(Not Selected) Air sample locations were chosen on a selected basis throughout the areas surveyed.

[3] BKGD (Background) Instrument Background Readings

	Beta Mode	Alpha Mode
Floor Monitor FM-4G	1500-2300 cpm/325cm²	0-50 cpm/325cm²
PAC-4G-3	150-200 cpm/51cm²	0-50 cpm/51cm²
PC-5	40 BKGD	0.3 BKGD
10 Wire	500 cpm	10 cpm

G-M End Window Detector read <0.03 mR/hr at 3 feet above floor.

[4] OSU (Overhead Structure Unavailable) Floor and wall survey indicates no necessity to demolish structures to reach original overhead surfaces.

[5] NE (Non-Existant) The locations did not contain structural items classified as "other" such as the following: ducts, louves, pipes and vents.

[6] NA (Not Applicable) No activity detected above background in the beta mode; therefore, no alpha mode survey was necessary.

[7] NN (Not Necessary) No activity was detected; therefore, no contact G-M End Window Survey was necessary.

[8] NST (No Smear Taken)

TABLE 1
DATA SHEET SHOWING ROOM SURVEY RESULTS

Room or Area No.	Percent of Area Accessible for Survey		Air Sample (pCi/ℓ)	Beta Mode[1] Direct Readings (dpm/100cm²)				Alpha Mode Direct Readings (dpm/100cm²)				End Window (mR/hr)		Smear Results (dpm/100cm²)	Comments
	Floor	Wall		Floors	Walls	Overhead	Other	Floors	Walls	Overhead	Other	Contact	3 feet		
18	80	95	NS	BKGD	BKGD	BKGD	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
19	60	60	NS	BKGD	BKGD	BKGD	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
20	40	45	NS	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
21	100	100	NS	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD	BKGD	
22	80	80	NS	BKGD	BKGD	OSU	NE	NA	NA	NA	NA	NN	BKGD	NST	Restroom
Warehouse	55	55	0.37	BKGD	BKGD	BKGD	NE	NA	NA	NA	NA	NN	BKGD	BKGD	Air sample taken at south end.
			0.21												Air sample taken at north end.

(1) Beta Mode detects both electromagnetic and particulate radiation. The beta mode readings are compensated for any alpha contribution.

(2) NS - (Not Selected) Air sample locations were chosen on a selected basis throughout the areas surveyed.

(3) BKGD (Background) Instrument Background Readings

	Beta Mode	Alpha Mode
Floor Monitor FM-4G	1500-2000 cpm/325cm²	0-50 cpm/325cm²
PAC-4G-3	150-200 cpm/51cm²	0-50 cmp/51cm²
PC-5	40 BKGD	0.3 BKGD
10 Wire	500 cpm	10 cpm

G-M End Window Detector read <0.03 mR/hr at 3 feet above floor.

(4) OSU (Overhead Structure Unavailable) Floor and wall survey indicate no necessity to demolish structures to reach original overhead surfaces.

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(6) NA (Not Applicable) No activity detected above background in the beta mode; therefore, no alpha mode survey was necessary.

(7) NN (Not Necessary) No activity was detected; therefore, no contact G-M End Window Survey was necessary.

FIGURE 1A

SURVEY LOCATIONS OF OFFICE AREA AND SOIL SAMPLE LOCATIONS

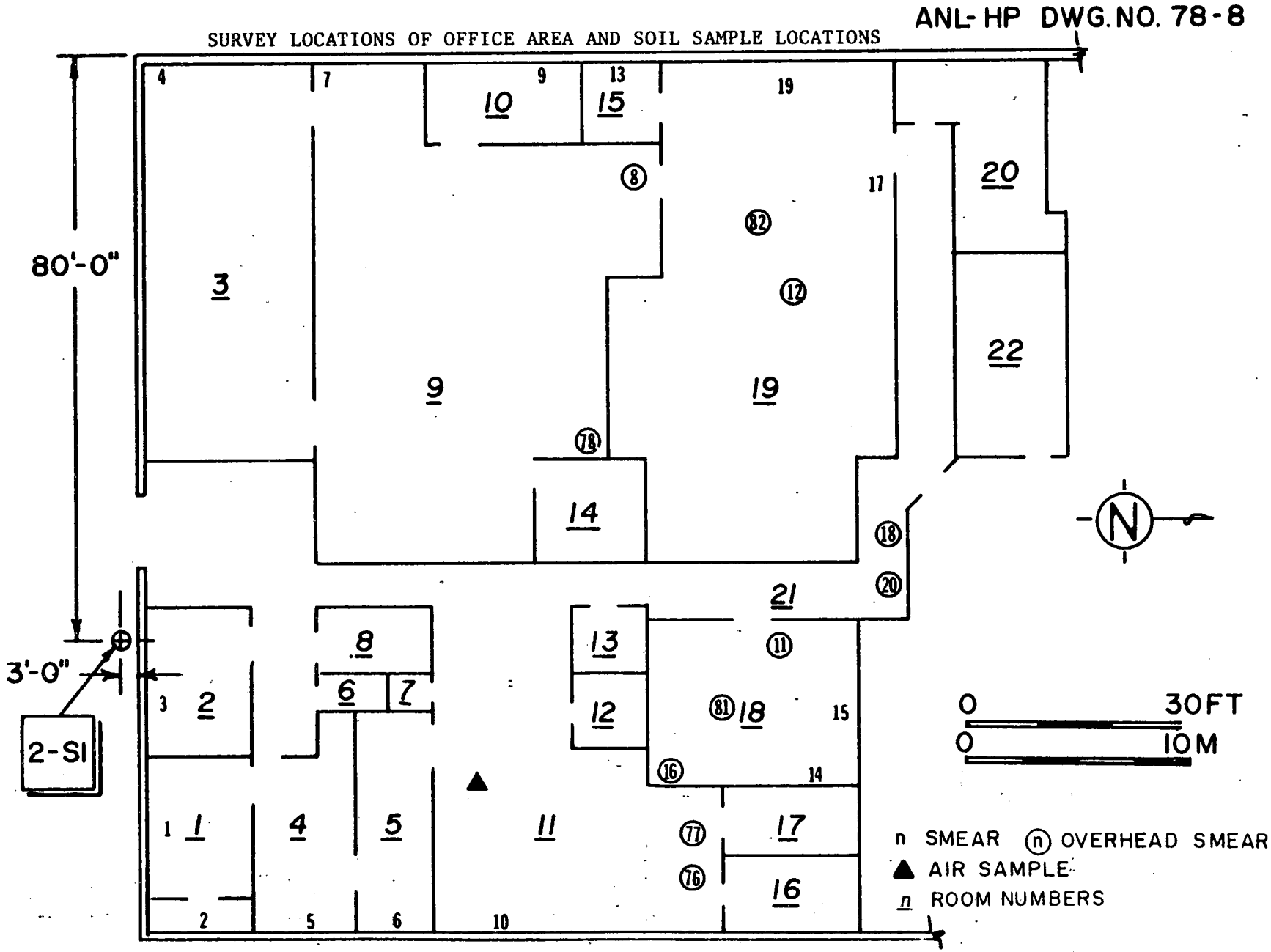
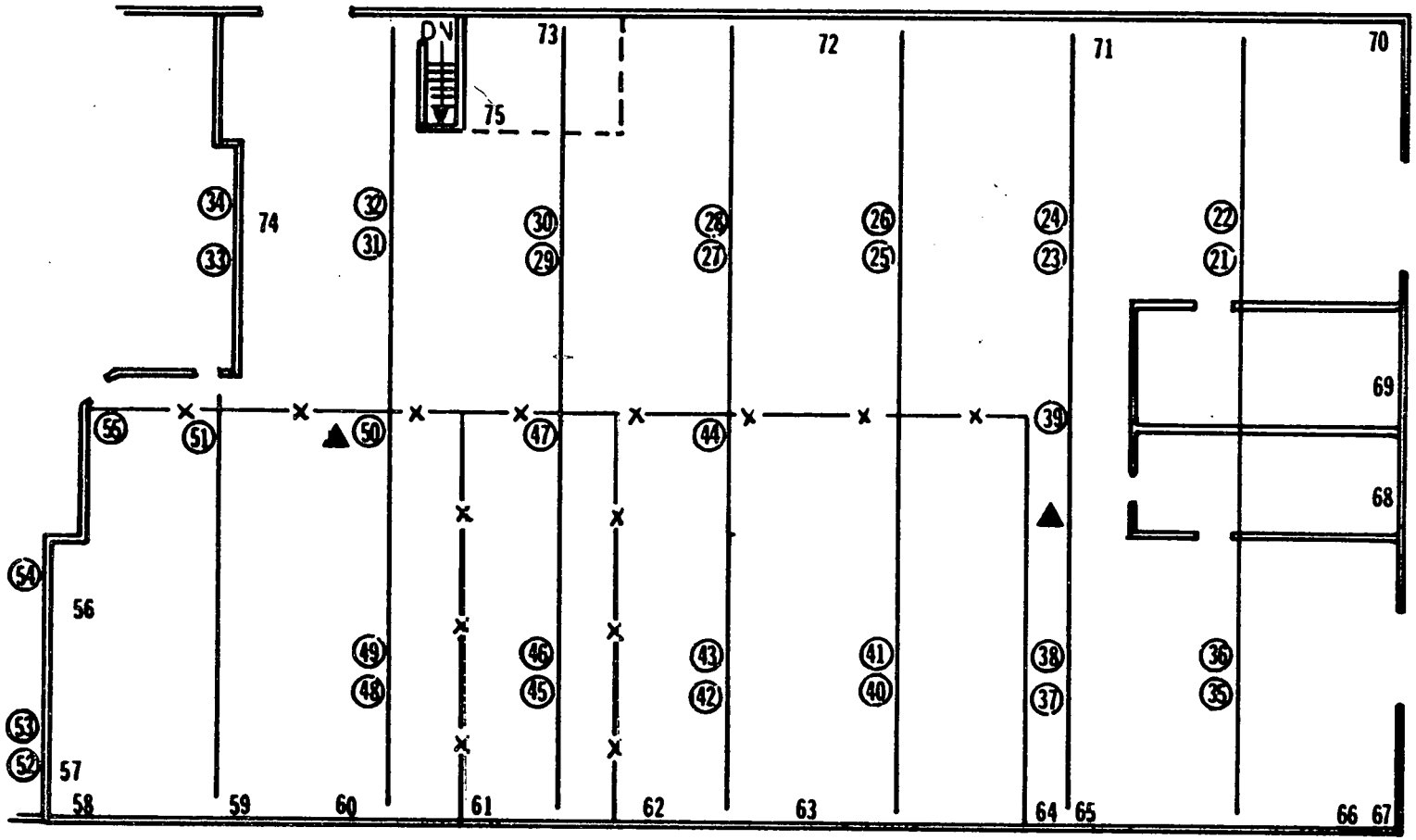


FIGURE 1B

SURVEY LOCATIONS OF WAREHOUSE AREA

ANL-HP DWG. NO. 78-9



ANL-HP DWG. NO. 78-44

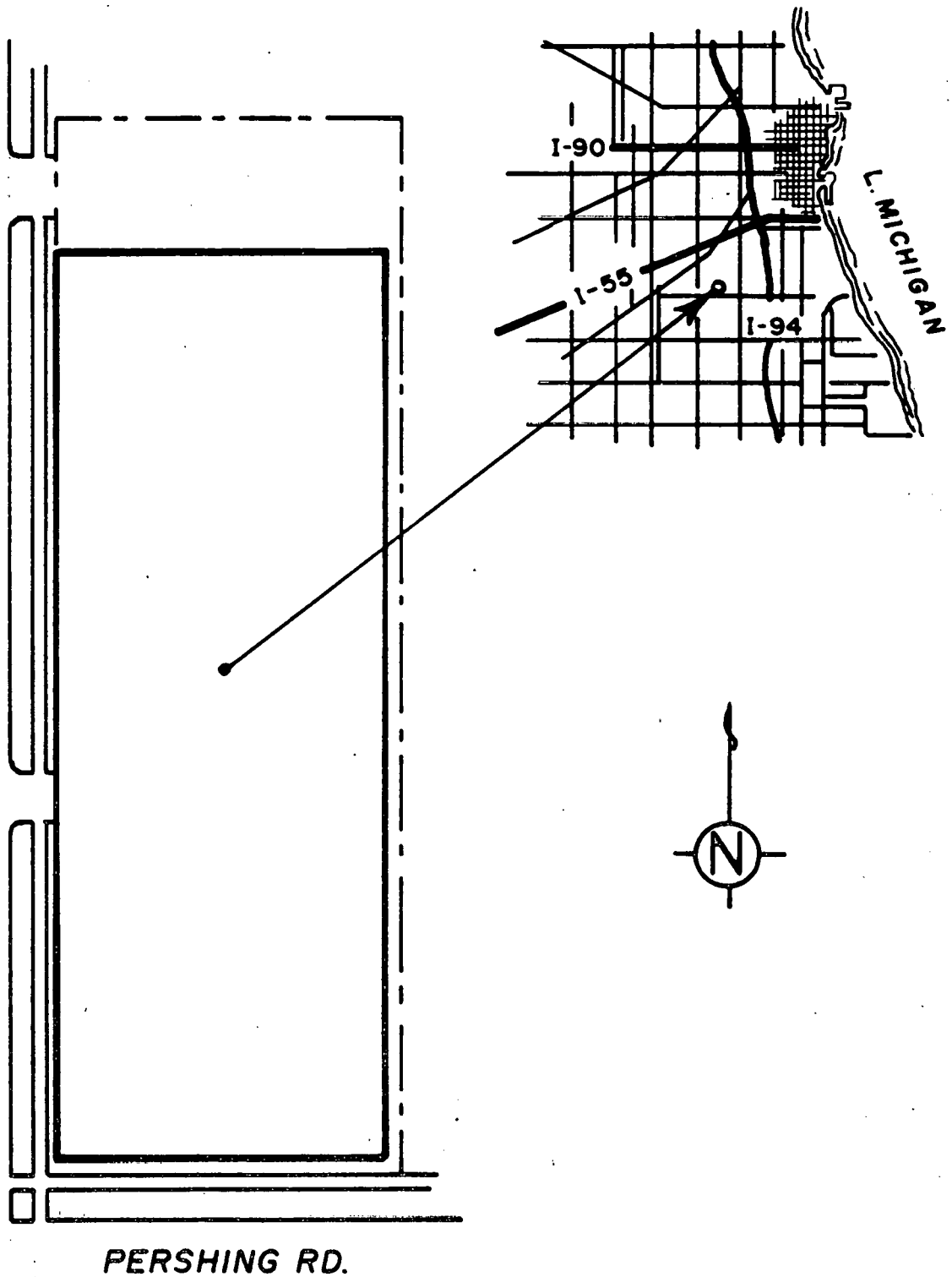


FIGURE 1C
SITE LOCATION

TABLE 2

INSTRUMENTATION USED IN SURVEY

Type	Inventory Number	Probe Area	Window
Eberline Floor Monitor FM-4G utilizing a PAC-4G-3	183412	325 cm^2	0.85 mg/cm^2
Eberline Floor Monitor FM-4G utilizing a PAC-4G-3	183414	325 cm^2	0.85 mg/cm^2
Eberline Floor Monitor FM-4G utilizing a PAC-4G-3	183415	325 cm^2	0.85 mg/cm^2
Eberline PAC-4G-3	183413	51 cm^2	0.85 mg/cm^2
Eberline PAC-4G-3	184339	51 cm^2	0.85 mg/cm^2
Eberline PAC-4G-3	184340	51 cm^2	0.85 mg/cm^2
Eberline PAC-4G-3	184341	51 cm^2	0.85 mg/cm^2
Eberline E-530 with HP-190 Beta-Gamma End Window	184575	-	1.4 - mg/cm^2
Nuclear Measurement Corporation PC-5 2π Internal Gas Flow Counter	184065	-	0.85 mg/cm^2
Argonne National Laboratory Filter Queen Air Sampler using HV-70 filter media	-	-	-
Argonne National Laboratory 10-Wire Flat Plate Gas Proportional Detector with Eberline Mini Scaler MS-2	184343	400 cm^2	0.85 mg/cm^2

TABLE 3

INSTRUMENT BACKGROUND READINGS

Instrument	Readings* Alpha Mode (cpm)	(Beta Mode (cpm)	3 Feet above floor mR/hr
Eberline Floor Monitor FM-4G using PAC-4G-3			
#183412	0 - 50	1500 - 2000	
#183414	0 - 50	1500 - 2000	
#183415	0 - 50	1500 - 2000	
Eberline PAC-4G-3			
#183413	0 - 50	150 - 200	
#184339	0 - 50	150 - 200	
#184340	0 - 50	150 - 200	
#184341	0 - 50	150 - 200	
Eberline E-530 with HP-190 Beta-Gamma End Window			< 0.03
Nuclear Measurement Corporation PC-5 2π Internal Gas Flow Counter	0.3	40	
Argonne National Laboratory 10-Wire Flat Plate Gas Proportional Detector with Eberline Mini Scaler MS-2	10	500	

*Background readings were initially taken in the mobile laboratory and rechecked throughout the various areas inside the Pershing Road Warehouse while surveying.

TABLE 4

RADON CONCENTRATION DETERMINATIONS

Location	dpm/m^3	pCi/ℓ	% of MPC*
Area 11	935	0.42	14.0
Area 22 South End	818	0.37	12.3
Area 22 North End	474	0.21	7.0

*The 10 CFR 20 MPC for Radon-222 for an uncontrolled area is 3×10^{-9} µCi/cc which equals 3 pCi/ℓ.

Example Calculation - Area 11

$$935 \text{ dpm/m}^3 \times \frac{1 \text{ pCi}}{2.22 \text{ dpm}} \quad \frac{\text{m}^3}{10^3 \ell} = 0.42 \text{ pCi/}\ell$$

FIGURE 2
SOIL SAMPLING PROCEDURE AND PROCESSING DIAGRAM

ANL-HP-DWG. 78-2

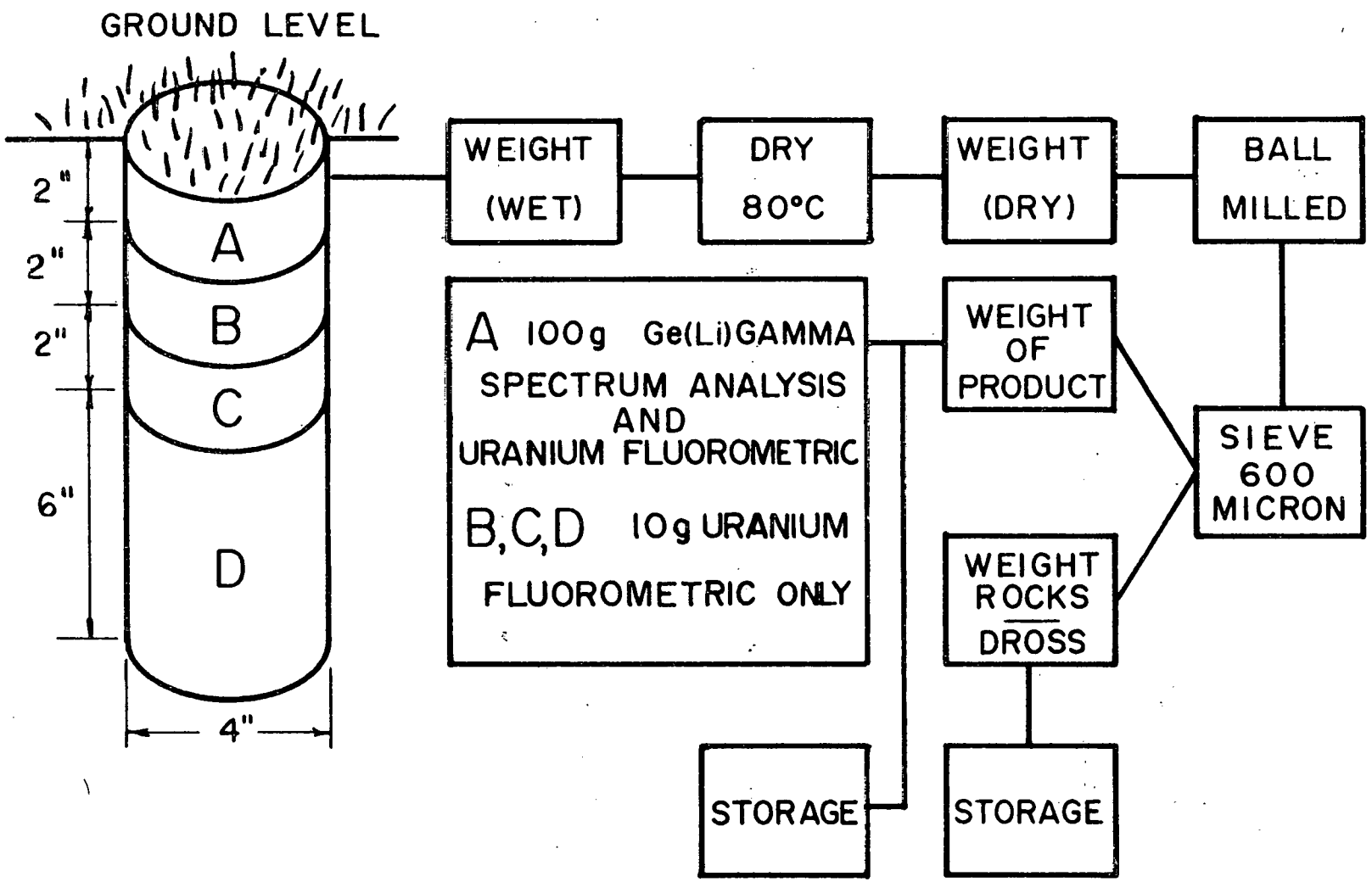


TABLE 5

SOIL SAMPLE WEIGHTS

Sample No.	Wet Weight (grams)	Dry Weight (grams)	Sieved Weight (grams)	Calculated Rocks and Dross Weight (grams)*
2-S1-A	636.8	596.7	86.7	510.0
2-S1-B	634.0	598.3	87.2	511.1
2-S1-C	1175.8	1055.6	404.5	651.1
2-S1-D	2207.8	1902.4	860.1	1042.3

*Calculated Rocks and Dross Weight = Dry Weight - Sieved Weight.

TABLE 6

Ge(Li) SPECTRUM AND URANIUM FLUOROMETRIC ANALYSIS RESULTS

Sample No.	Ge(Li) Spectra pCi/g received wt ± σ(1) ^{137}Cs	^{232}Th Decay Chain	^{226}Ra Decay Chain	Uranium µg/g ± σ(2)	Uranium pCi/g ± σ(3)
2-S1-A	0.66 ± 0.05	0.0 ± 0.37	0.69 ± 0.08	2.7 ± 0.3	1.9 ± 0.2
2-S1-B				2.2 ± 0.4	1.5 ± 0.3
2-S1-C				2.5 ± 0.6	1.7 ± 0.4
2-S1-D				2.6 ± 0.6	1.8 ± 0.4

(1) One standard deviation due to counting statistics.

(2) Data results from LFE.

(3) ANL Conversion from Appendix 3.

TABLE 7

BACKGROUND SOIL SAMPLE DATA*

Cesium-137, Thorium, and Uranium in Soil 1976

Concentrations in pCi/g

Date Collected	Locations	Cesium-137	Thorium-232	Uranium
July 22	Argonne Area.	0.3 ± 0.1	0.21 ± 0.04	1.3 ± 0.1
July 22	Argonne Area	0.1 ± 0.1	0.49 ± 0.04	2.0 ± 0.1
July 22	Argonne Area	0.3 ± 0.1	0.48 ± 0.04	1.5 ± 0.1
October 18	Argonne Area	0.1 ± 0.1	0.65 ± 0.07	1.5 ± 0.1
October 18	Argonne Area	0.3 ± 0.1	0.43 ± 0.04	1.4 ± 0.1
October 18	Argonne Area	0.4 ± 0.1	0.39 ± 0.04	1.3 ± 0.1
	Average	0.2 ± 0.1	0.44 ± 0.14	1.5 ± 0.3
	Off-Site			
June 22	McKinley Woods State Park, IL	0.4 ± 0.1	0.16 ± 0.02	0.9 ± 0.1
June 23	McCormick Woods Brookfield, IL	0.3 ± 0.1	0.22 ± 0.02	1.2 ± 0.1
June 23	Bemis Woods Hinsdale, IL	0.4 ± 0.1	0.18 ± 0.01	1.6 ± 0.1
October 12	St. Joseph, MI	0.4 ± 0.1	0.20 ± 0.02	0.3 ± 0.1
October 13	Willow Springs IL	0.5 ± 0.2	-	1.0 ± 0.1
October 14	Dresden Lock & Dam, IL	0.4 ± 0.1	0.45 ± 0.03	1.6 ± 0.1
	Average	0.4 ± 0.1	0.24 ± 0.14	1.1 ± 0.5

*These results are transcribed from "Environmental Monitoring at Argonne National Laboratory Annual Report for 1976" (ANL-77-13) by N. W. Golchert, T. L. Duffy and J. Sedlet. These measurements are presented in Table 13, on page 47 of the report.

APPENDIX 1

CONVERSION FACTORS

INSTRUMENTATION

Below are the conversion factors used to obtain the readings in units of disintegrations per minute per 100 cm^2 (dpm/100 cm^2).

I Conversion Factors

	Floor Monitor (FM-4G)	PAC-4G-3
To 100 cm^2	0.31	1.96
cpm to dpm (alpha)	2	2
cpm to dpm (beta)	2	2

II Deriviation of Conversion Factors

Floor Monitor (FM-4G)

Window Area: ~325 cm^2

Conversion to 100 cm^2 = .31 times floor monitoring reading

PAC-4G-3

Window Area: ~51 cm^2

Conversion to 100 cm^2 = 1.96 times PAC reading

2π Internal Gas Flow Counter, PC-5

Geometry: Mylar Spun Top - 0.43

Mylar Spun Top Counting (window double aluminized mylar ~0.85 mg/cm^2) utilizes the well of the PC-5 and is a method developed and used by the Argonne National Laboratory Health Physics Section for negating the dielectric effect in counting samples on non-conducting media.

APPENDIX 1 (contd)

SMEAR COUNT

The conversion factors for cpm/100 cm^2 to dpm/100 cm^2 are given below.

I CONVERSION EQUATION (ALPHA)

$$\frac{\text{cpm-Bkgd}}{\text{g x bf x sa x waf}} = \text{dpm Alpha}$$

A geometry (g) of 0.43 is standard for all flat plate counting.

A backscatter factor (bf) of 1.0 is used when determining alpha activity on a filter media.

The self-absorption (sa) was assumed to be 1 unless otherwise determined.

If the energies of the isotope were known, the appropriate window air factor (waf) was used; if the energies of the isotopes were unknown the waf of Plutonium-239 which is .713, was used.

II CONVERSION EQUATION (BETA)

$$\frac{\text{cpm - (Beta Bkgd + Alpha cpm)}}{\text{g x bf x sa x waf}} = \text{dpm Beta}$$

A geometry (g) of 0.43 is standard for all flat plate counting.

A backscatter factor (bf) of 1.1 is used when determining beta activity on a filter media.

The self-absorption (sa) was assumed to be 1 unless otherwise determined.

If the energies of the isotopes were known, the appropriate window air factor (waf) was used; if the energies of the isotopes were unknown, the waf of Strontium-90-Yttrium-90, which is 0.85 was used.

APPENDIX 1 (contd)

RADON DETERMINATION

This appendix summarizes the air sampling calculations for samples collected using Argonne National Laboratory designed air sampler with HV-70 filter media. The appendix includes the basic assumptions and calculations used to derive the air concentrations.

I. Radon Concentrations Based on RaC' Results

The following postulates are assumed in deriving the Radon-222 concentrations as based on the RaC' alpha count results.

1. RaA, RaB, RaC, RaC', are in equilibrium.
2. RaA is evident only in the first count and not after the 100 minute decay.
3. That one-half of the radon progeny is not adhered to airborne particulate, and therefore, not evident on the filter media.
4. The geometry factor (g) is 0.43 for both the alpha and beta activity.
5. The backscatter factor (bf) of 1.0 is used for the alpha activity which is determined from RaC'.
6. The sample absorption factor (sa) for RaC' is 0.77.
7. The window air factor (waf) for RaC' is 0.8.
8. RaB and RaC being beta emitters, are not counted in the alpha mode.
9. The half life of the radon progeny is approximately 36 minutes, based on the combined RaB and RaC half lives.
10. No long-lived alpha emitters are present as evidenced by the final recount.
11. For all practical purposes, RaC' decays at the rate of the composite of RaB and RaC which is approximately 36 minutes.

APPENDIX 1 (contd)

RADON DETERMINATION (contd)

II. Equations Used to Derive Air Concentrations

$$N_o = \frac{N}{e^{-\lambda t}}$$

Where: N_o = Activity present at the end of the sampling period

N = Activity at some time interval, after end of sampling

t = Time interval N_o to N (minutes)

$\lambda = \frac{.693}{t_{\frac{1}{2}}}$

$t_{\frac{1}{2}}$ = Half life of isotope (minutes)

$$C = \frac{A\,\lambda}{f} \quad \frac{1}{(1-e^{-\lambda t_1})}$$

Where: C = Concentration per unit volume

A = Activity of filter media at end of sampling period (N_o from previous equation)

f = Sampling rate (m^3/minute)

t_1 = Time sample was taken (minutes)

$\lambda = \frac{.693}{t_{\frac{1}{2}}}$

$t_{\frac{1}{2}}$ = Half life of isotope or controlling parent

APPENDIX 1 (contd)

RADON DETERMINATION (contd)

III. Example Calculation - Office Area as given in Appendix 2C.

$$N_o = \frac{1268 \text{ dpm}}{e^{-\frac{.693 \times 100}{36}}} = 8692 \text{ dpm}$$

$$C = \frac{8692 \times \frac{.693}{36}}{40/60} \quad \frac{1}{1-e^{-\frac{.693 \times 40}{36}}} = 467 \text{ dpm/m}^3 \times 2 = 935 \text{ dpm/m}^3$$

APPENDIX 2A

AIR SAMPLE DATA

LOCATION: 1716 W. Pershing Road

South End of Warehouse Area

SAMPLE COLLECTION DATE: 7/12/77

TIME OF COLLECTION: 1040

SUSPECTED ISOTOPE: Unidentified

LENGTH OF RUN: TIME STOPPED 1120 MINUS TIME STARTED 1040 TOTAL TIME 40 MINUTES

VOLUME: COLLECTION RATE $\frac{40}{60}$ M^3/hr X TOTAL TIME 40 MINUTES = VOLUME 26.6 M^3

DATE AND TIME OF COUNT		GROSS COUNTS: TOTAL COUNTS	GROSS COUNTS: COUNT TIME Min.	GROSS COUNTS: COUNTS / MIN.	BKGD: COUNTS / MIN.	NET: COUNTS / MIN.	GEOMETRY	BACKSCATTER FACTOR	SAMPLE ABSORPTION	WINDOW AIR FACTOR	DISINTEGRATIONS PER MINUTE *	$d/m/M^3$	TYPE OF ACTIVITY	DECAY TIME
7/12	1123	283	2	141.5	0.1	141.0	.43	1	.77	.8	5340	200	α	3 min
7/12	1300	59	2	29.5	0.1	29.4	.43	1	.77	.8	1110	41	α	100 min
10/3		0	2	0.0	0.4	BKGD	.43	1	.77	.8	BKGD	BKGD	α	86 days
7/12	1125	1458	2	729.0	141 ± 41	547.0	.43	1.1	1	.95	12180	457	β	5 min
7/11	1302	276	2	138.0	29 ± 41	68.0	.43	1.1	1	.95	1510	56	β	102 min
10/3		99	2	49.5	45.9	3.6	.43	1.1	1	.95	BKGD	BKGD	β	86 days

ALPHA: $\frac{\text{cpm - Bkdg}}{\text{g x bf x sa x waf}}$ = dpm Alpha

BETA: Pure Beta emitters $\frac{\text{cpm - Bkgd}}{\text{g x bf x sa x waf}}$ = dpm Beta

COMPOSITE: Beta determination $\frac{\text{cpm - Beta Bkgd + Alpha cpm}}{\text{g x bf x sa x waf}}$ = dpm Beta

REMARKS: *10% of sample counted in PC-5 with mylar spun top (0.85 mg/cm^2)

APPENDIX 2B

AIR SAMPLE DATA

LOCATION: 1716 W. Pershing Road

North End of Warehouse Area

SAMPLE COLLECTION DATE: 7/12/77

TIME OF COLLECTION: 1050

SUSPECTED ISOTOPE: Unidentified

LENGTH OF RUN: TIME STOPPED 1130 MINUS TIME STARTED 1050 TOTAL TIME 40 MINUTES

VOLUME: $\frac{\text{COLLECTION RATE } 40 \text{ } M^3/hr}{60} \times \text{TOTAL TIME } 40 \text{ MINUTES} = \text{VOLUME } 26.6 \text{ } M^3$

DATE AND TIME OF COUNT	GROSS COUNTS: TOTAL COUNTS	GROSS COUNTS: COUNT TIME Min.	GROSS COUNTS: COUNTS / MIN.	BKGD: COUNTS / MIN.	NET: COUNTS / MIN.	GEOMETRY	BACKSCATTER FACTOR	SAMPLE ABSORPTION	WINDOW AIR FACTOR	DISINTEGRATIONS PER MINUTE *	$d/m/M^3$	TYPE OF ACTIVITY	DECAY TIME
7/12 1131	223	2	111.0	0.1	111.0	.43	1	.77	.8	4204	158	α	1 min
9/12 1310	34	2	17.0	0.1	17.0	.43	1	.77	.8	643	24	α	100 min
10/3	0	2	0.0	0.4	0.0	.43	1	.77	.8	BKGD	BKGD	α	86 days
9/12 1133	1133	2	566.5	41.0 +111.0	414.0	.43	1.1	1	.95	9213	346	β	3 min
9/12 1312	193	2	96.5	41.0 + 17.0	38.0	.43	1.1	1	.95	845	31	β	102 min
10/3	99	2	49.5	49.5	3.6	.43	1.1	1	.95	BKGD	BKGD	β	86 days

ALPHA: $\frac{\text{cpm} - \text{Bkdg}}{g \times bf \times sa \times waf} = \text{dpm Alpha}$

BETA: Pure Beta emitters $\frac{\text{cpm} - \text{Bkgd}}{g \times bf \times sa \times waf} = \text{dpm Beta}$

COMPOSITE: Beta determination $\frac{\text{cpm} - \text{Beta Bkgd} + \text{Alpha cpm}}{g \times bf \times sa \times waf} = \text{dpm Beta}$

REMARKS: *10% of sample counted in PC-5 with mylar spun top (0.85 mg/cm^2)

APPENDIX 2C

AIR SAMPLE DATA

LOCATION: 1716 W. Pershing Road

Office Area

SAMPLE COLLECTION DATE: 7/12/77

TIME OF COLLECTION: 1025

SUSPECTED ISOTOPE: Unidentified

LENGTH OF RUN: TIME STOPPED 1105 MINUS TIME STARTED 1025 TOTAL TIME 40 MINUTES

VOLUME: COLLECTION RATE $\frac{40}{60}$ M^3/hr X TOTAL TIME 40 MINUTES = VOLUME 26.6 M^3

DATE AND TIME OF COUNT	GROSS COUNTS: TOTAL COUNTS	GROSS COUNTS: COUNT TIME Min.	GROSS COUNTS: COUNTS / MIN.	BKGD: COUNTS / MIN.	NET: COUNTS / MIN.	GEOMETRY	BACKSCATTER FACTOR	SAMPLE ABSORPTION	WINDOW AIR FACTOR	DISINTEGRATIONS PER MINUTE *	$d/m/M^3$	TYPE OF ACTIVITY	DECAY TIME
7/12 1109	384	2	192.0	0.1	192.0	.43	.	.77	.8	7290	274	α	4 min
7/12 1249	67	2	33.5	0.1	33.5	.43	1	.77	.8	1268	47	α	100 min
10/3	0	2	0	0.4	BKGD	.43	1	.77	.8	BKGD	BKGD	α	86 days
7/12 1111	1893	2	946.5	41 +192	713.0	.43	1.1	1	.95	15867	596	β	6 min
7/12 1251	385	2	192.5	33.5 + 41.0	118.0	.43	1.1	1	.95	2628	98	β	102 min
10/3	90	2	45.0	45.9	BKGD	.43	1.1	1	.95	BKGD	BKGD	β	86 days

ALPHA: $\frac{\text{cpm - Bkdg}}{\text{g x bf x sa x waf}}$ = dpm Alpha

BETA: Pure Beta emitters $\frac{\text{cpm - Bkgd}}{\text{g x bf x sa x waf}}$ = dpm Beta

COMPOSITE: Beta determination $\frac{\text{cpm - Beta Bkgd + Alpha cpm}}{\text{g x bf x sa x waf}}$ = dpm Beta

REMARKS: *10% of sample counted in PC-5 with mylar spun top (0.85 mg/cm^2)

APPENDIX 3

LFE SOIL ANALYSIS PROCEDURE FOR TOTAL URANIUM AND GAMMA-EMITTING NUCLIDES

Summary of Methods

A 60-milliliter volume of the received soil was counted in a petri dish for 500 minutes on a Ge(Li) detector over the energy range 0 - 1.5 MeV. This corresponded to between 60 to 100 g of soil, depending upon bulk soil density. Positive photopeaks above instrument background were converted to dpm using a line efficiency curve based upon a National Bureau of Standards Multi-Gamma standard. The natural Thorium-232 and Radium-226 decay chains were calculated using the 0.910 MeV Actinium-228 and 0.609 MeV Bismuth-214 photopeaks respectively. Cesium-137 is reported for each sample as a representative gamma emitter. Potassium-40 was observed on all soil samples, as expected, but was not calculated or reported.

One gram of the soil sample was ashed and dissolved in $HF-HNO_3$ for the total uranium analysis. A 100-λ aliquot of the dissolved sample was fused with 98% NaF-2% LiF and the fluorescence determined using a Jarrell-Ash fluorometer. A quenching factor was determined for each sample by using an internal spike.

APPENDIX 4

NATURAL URANIUM CALCULATIONS

Radioactive half lives of ^{234}U, ^{235}U and ^{238}U as well as the percent abundance for each isotope were obtained as current best values from the "Table of Isotopes - 6th Edition" by C. M. Lederer, J. M. Hollander and I. Perlman, 1967. The following values used are:

^{234}U half life	2.47×10^5 years
^{235}U half life	7.1×10^8 years
^{238}U half life	4.51×10^9 years
^{234}U percent abundance	0.0057
^{235}U percent abundance	0.7196
^{238}U percent abundance	99.2760

Is should be noted that the abundance totals 100.0013%. Since it cannot be determined which isotope(s) are in error, the calculations are made with the .0013% error not accounted for.

Avagadro's Number used - 6.025×10^{23}

$SpA = \lambda N$

$$SpA\ ^{234}U = \frac{.693 \times 6.025 \times 10^{23}}{2.47 \times 10^5 \times 5.256 \times 10^5 \times 2.34 \times 10^2} = 1.374 \times 10^{10} \text{ dpm/gram}$$

$= 1.374 \times 10^4$ dpm/μgram $\times$ 5.70×10^{-5} = .783 dpm/μgram of natural uranium

$$SpA\ ^{235}U = \frac{.693 \times 6.025 \times 10^{23}}{7.1 \times 10^8 \times 5.256 \times 10^5 \times 2.35 \times 10^2} = 4.76 \times 10^6 \text{ dpm/gram}$$

$= 4.76$ dpm/μgram x 7.196×10^{-3} = .034 dpm/μgram of natural uranium

APPENDIX 4 (contd)

NATURAL URANIUM CALCULATIONS

$$\text{SpA } ^{238}U = \frac{.693 \times 6.025 \times 10^{23}}{4.51 \times 10^{9} \times 5.256 \times 10^{5} \times 2.38 \times 10^{2}} = 7.4 \times 10^{5} \text{ dpm/gram}$$

$$= .74 \text{ dpm/}\mu\text{gram} \times 9.9276 \times 10^{-1} = .735 \text{ dpm/}\mu\text{gram of natural uranium}$$

Therefore, 1 μgram of natural uranium contains

$$.783 \text{ dpm } ^{234}U + .034 \text{ dpm } ^{235}U + .735 \text{ dpm } ^{238}U = 1.552 \text{ dpm/}\mu\text{gram}$$

$$= \frac{1.552 \text{ dpm/}\mu\text{gram}}{2.22 \text{ dpm/pCi}} = .6991 \text{ pCi/}\mu\text{gram natural uranium}$$

Conversion of μg/gm to pCi/g

Example Calculation - 2-S1-A given in Table 6

$$2.7 \pm 0.3 \text{ μgram/gram} \times 0.6991 \text{ pCi/μgram} = 1.9 \pm 0.2 \text{ pCi/gram}$$

* U.S. GOVERNMENT PRINTING OFFICE: 1979 281-704/1017 1-3