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Formerly Utilized Sites Remedial Action Program (FUSRAP)
Contract No. DE-AC05-81OR20722

POST-REMEDIAL ACTION REPORT FOR LODI RESIDENTIAL PROPERTIES - 1985

Lodi, New Jersey

August 1986

Bechtel National, Inc.
Advanced Technology

039580

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OAK RIDGE OPERATIONS OFFICE

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By

Bechtel National, Inc.

Advanced Technology

Oak Ridge, Tennessee

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ABBREVIATIONS

cm	centimeter
cm^2	square centimeter
dpm	**disintegrations per minute***
ft	foot
m^2	square meter
MeV	million electron volts
mg/cm^2	milligrams per square centimeter
mrad/h	**millirad per hour**
mrem	**millirem**
mrem/yr	**millirem per year**
pCi/g	**picocuries per gram**
WL	**working level**

*Words appearing in boldfaced print are explained in the glossary.

1.0 INTRODUCTION

Bechtel National, Inc. (BNI) removed radioactive contamination from residential properties on Trudy Drive, Hancock Street, Avenue F, and Avenue C in Lodi, Jersey as part of work being conducted under the U.S. Department of Energy (DOE) Formerly Utilized Sites Remedial Action Program (FUSRAP). The purpose of this report is to document post-remedial action sampling performed by BNI at these properties near the Stepan Company plant located in Maywood. This report briefly describes the origin of the radioactive **contamination** on the properties, the methods used to determine the extent of it, and the types of **remedial action** performed. It 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 each property.

Background

From about 1916 until 1956, Maywood Chemical Works extracted **thorium** compounds and **rare earths** from a natural, sand-like ore called **monazite** (Ref. 1). The thorium was used to manufacture a number of products, including mantles for gas lanterns. Stepan Company acquired the site in 1959. In 1984, Congress directed DOE to initiate a research and development decontamination project for this site and properties in in vicinity. These properties, including the Lodi residential properties, were assigned by DOE to FUSRAP, a DOE effort to identify, decontaminate, or otherwise control sites where low-level radioactive contamination (exceeding current guidelines) remains from the early days of the nation's atomic energy program. Although the contamination in Maywood and Lodi did not result from the atomic energy program, the site was added to FUSRAP by Congress. FUSRAP is currently being managed by the DOE Oak Ridge Operations office. BNI is the Project Management Contractor and acts as the DOE representative in planning, managing, and implementing FUSRAP.

It is not known for certain how the Trudy Drive, Hancock Street, Avenue F, and Avenue C properties became contaminated, but one possibility is that the contamination may have been the result of using residues from the Maywood Chemical Works as fill. Another theory is that the contamination migrated along a drainage ditch originating on the Maywood Chemical Works property. The ditch has since been

replaced by a culvert. This theory is credible because the contamination in Lodi follows the path of the drainage ditch. It is also possible that the contamination results from both the use of fill dirt and migration via the drainage ditch.

In June 1984 Oak Ridge National Laboratory (ORNL) conducted a "drive by" survey of Lodi using its scanning van. Although the survey was not comprehensive, it indicated areas requiring further investigation (Ref. 2). Followup surveys conducted by ORNL in areas where further investigation was deemed necessary identified four residences where elevated levels of thorium were present (Refs. 3-6). Because of the possibility that contamination extended across property boundaries, six additional properties were surveyed by BNI, four of which were designated for remedial action by DOE (Refs. 7-10). Additional radiological measurements were made by BNI on the four properties (58, 59, and 61 Trudy Drive and 59 Avenue C) initially surveyed by ORNL. These additional data were provided to DOE as part of the remedial action design process (Ref. 11).

2.0 REMEDIAL ACTION GUIDELINES

The radioactive contamination on the Lodi properties consisted primarily of thorium-232, with lower levels of radium-226 and uranium. Table 1 (Ref. 12) lists DOE residual contamination guidelines. DOE implemented these guidelines on the basis of their compatibility with the criteria used by the Environmental Protection Agency (Ref. 13). If these guidelines are exceeded, contaminated soil is removed from the property until concentrations are within guidelines. Once the guidelines have been met, the property can be released for unrestricted use.

3.0 REMEDIAL ACTION

After a property was determined to be contaminated based on the preliminary radiological surveys, DOE designated it for remedial action. This means that the property was contaminated in excess of DOE guidelines and that remedial action would be undertaken. The residents were notified, and BNI began the engineering design and related activities to hire local subcontractors to perform the cleanup work (Ref. 14).

Cleanup/Decontamination Activities

When the design work had been completed and permission (a construction access agreement) received from the property owner to perform the remedial action, drawings showing the extent of contamination in the soil on each property were given to the excavation subcontractor. The shaded areas on Figures 1 through 8 show the areas of excavation. The subcontractor removed the soil in accordance with the engineering drawings, placed it in watertight dump trucks, and transported it to the storage pile on the Maywood Interim Storage Site (MISS), which is adjacent to the Stepan Company plant. The soil will be stored at the MISS until a permanent disposal site is selected for this material.

After the radioactively contaminated soil was removed, the property was restored to its original condition. This included backfilling the excavation, followed by sodding and/or seeding. If shrubbery or trees were removed during the cleanup, they were replaced or alternative arrangements were made with the individual property owners. In some cases, removing the contamination necessitated alterations to buildings, fences, or pavement. If this occurred, the affected structures were also restored to their original condition. Figures 1 through 8 show what types of remedial action were required on each property.

Contamination Control During the Cleanup

During the cleanup, several measures were implemented to control the radioactive materials being removed from the properties. These measures were designed to protect workers and residents from exposure to radiation in excess of the standards during cleanup.

The primary pathway by which residents could be exposed to radiation was dust released during the excavation. To prevent such exposure, the subcontractor was required to keep all excavations and work areas free from dust by keeping the soil moistened.

To keep uncontaminated areas clean during excavation work, trucks were draped with tarpaulins before they were loaded. This kept the contaminated dirt from getting on the truck exterior and later falling off on clean property. If the truck was parked on a

clean area while it was being loaded, the ground was also covered with a tarpaulin and the truck pulled onto it before loading. If contaminated soil was spilled during the loading of the truck, the tarpaulin prevented the contamination of clean ground. Finally, the radioactive soil loaded on the trucks was covered before the soil was hauled away. This also prevented soil from falling out of the truck onto clean ground. The combination of these measures resulted in control of the contamination and prevented its spread onto areas accessible to the general public.

4.0 POST-REMEDIAL ACTION SAMPLING

After the radioactively contaminated soil was removed from each property, another radiological survey was conducted to ensure that the property was indeed clean (no radionuclide concentrations in excess of DOE guidelines). This survey used several techniques, as described below.

Surface Gamma Radiation Scans

Two types of gamma radiation scans were conducted to determine whether all radioactively contaminated soil had been removed. The first was a walkover scan. In conducting this type of survey, the surveyor holds the radiation detector a few inches above the ground surface and slowly moves it over the ground as he walks over the excavated area. This type of survey is performed to detect areas of residual contamination. The advantage of the walkover survey is that the detector quickly scans the area as the excavation proceeds.

The second gamma radiation scan was performed after all contamination detected by the walkover scan was removed. This survey used a lead-shielded detector to ensure that the only radiation detected was that coming from the ground under the detector. Measurements were made on each property at 10-ft intervals in the excavated areas to ensure that the property had been cleaned of radioactively contaminated soils.

If either of these gamma radiation scans detected contamination in excess of the DOE guidelines, additional soil was removed, and the survey process was repeated until DOE guidelines were met.

Soil Sampling

The primary method of ensuring that the DOE cleanup guidelines were met was to collect soil samples. These samples were analyzed in a laboratory to determine the concentration of thorium-232, radium-226, and uranium-238. Soil sampling locations and depths are shown in Figures 1 through 8.

Exposure Rate Measurements

Pressurized ionization chamber (PIC) readings were taken to measure the gamma radiation exposure rate after removal of the contamination. The PIC was set up at the locations shown in Figures 1 through 8. The measured gamma radiation exposure rates are reported in Tables 2, 4, 6, 8, 10, 12, 14, and 16. For comparison, the DOE radiation protection standard is 100 mrem/yr above the background radiation level. The values in the tables were calculated from the measured exposure rates and assume continuous exposure. A background contribution of 100 mrem has been subtracted from these values.

5.0 POST-REMEDIAL ACTION STATUS

As shown in Tables 3, 5, 7, 9, 11, 13, 15, and 17, the soil samples taken after removing the radioactive materials show that there is no area in which radioactive contamination remains in excess of the DOE remedial action guidelines. An independent assessment of the remedial action at the Lodi properties was conducted by ORNL Radiological Survey Activities Group. The purpose of the assessment was to verify the BNI data supporting the adequacy of the remedial action and to confirm that radiological conditions at each property comply with remedial action guidelines.

Based on all data collected, these properties conform to all applicable radiological guidelines established for release of the properties for unrestricted use (Refs. 15 and 16).

In addition to the surveys performed on behalf of DOE, measures have been taken by the NJDEP to monitor remedial action activities. These measures include observing on-site operations and procedures, and analyzing archived soil samples.

TABLE 1

SUMMARY OF RESIDUAL CONTAMINATION GUIDELINES

FOR THE MAYWOOD SITE

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 (MAXIMUM LIMITS FOR UNRESTRICTED USE)

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 (MAXIMUM LIMITS FOR UNRESTRICTED USE)

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 are intended for unrestricted 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 to be released for unrestricted use shall not exceed the background level by more than 20 uR/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	220

TABLE I

(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 α	15,000 α	1,000 α
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above	5,000 $\beta-\gamma$	15,000 $\beta-\gamma$	1,000 $\beta-\gamma$

[a] In the event of occurrence of mixture of radionuclides, the fraction contributed by each radionuclide to its limit shall be determined, and the sum of these fractions shall not exceed 1.

[b] These guidelines represent unrestricted-use 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.

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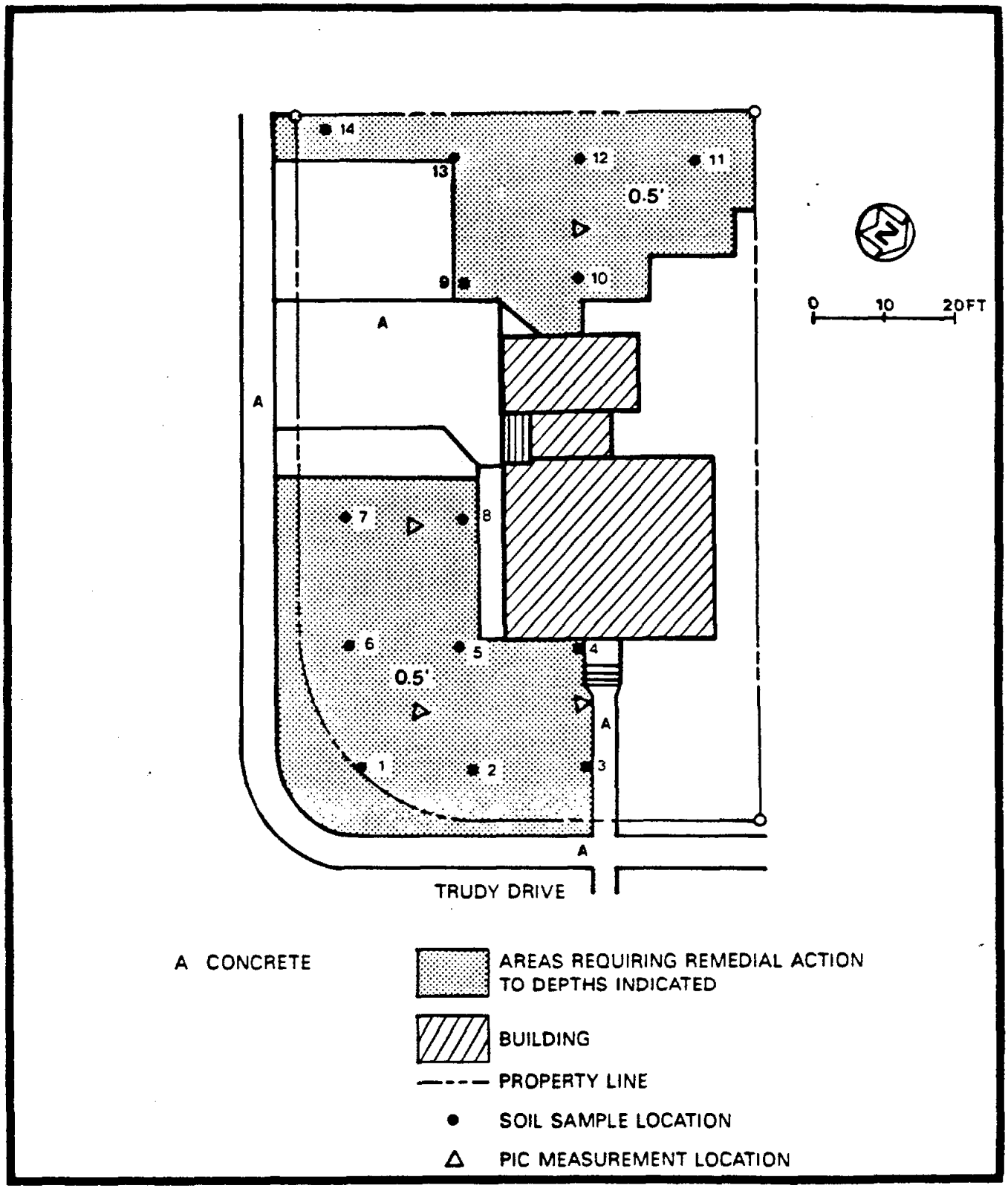

FIGURE 1 REMEDIAL ACTION AT 58 TRUDY DRIVE

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TABLE 2

GAMMA RADIATION EXPOSURE RATE MEASUREMENTS

FOR 58 TRUDY DRIVE

Unit	Number of Measurements	Average*	Range*	DOE Guideline**
mrem/yr	4	1.1	0-4.4	100

*Calculated from exposure rate measurements assuming continuous occupancy at point of measurement. The natural background radiation of 100 mrem/yr has been subtracted.

**DOE guidelines are specified to be "above natural background values."

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TABLE 3

POST-REMEDIAL ACTION SAMPLING RESULTS

58 TRUDY DRIVE

Sample Number	Concentrations (pCi/g +/- 1 sigma) Uranium-238	Radium-226	Thorium-232
1	<2.5	0.9 ± 0.3	2.5 ± 0.6
2	3.2 ± 1.8	0.9 ± 0.2	3.3 ± 1.1
3	<1.2	0.7 ± 0.1	1.1 ± 0.3
4	2.8 ± 0.3	1.2 ± 0.1	4.5 ± 0.1
5	<1.1	0.6 ± 0.1	1.2 ± 0.3
6	1.4 ± 1.3	0.8 ± 0.2	1.9 ± 0.2
7	1.4 ± 1.8	1.0 ± 0.2	3.1 ± 0.8
8	<1.4	0.6 ± 0.3	1.2 ± 0.4
9	2.1 ± 1.2	0.7 ± 0.3	1.6 ± 0.3
10	<1.1	0.8 ± 0.1	2.0 ± 0.4
11	1.2 ± 0.1	0.7 ± 0.2	1.3 ± 0.4
12	3.7 ± 2.5	2.5 ± 0.3	9.1 ± 0.7
13	5.0 ± 1.2	2.0 ± 0.3	7.8 ± 1.2
14	2.5 ± 1.6	1.1 ± 0.2	2.4 ± 0.8

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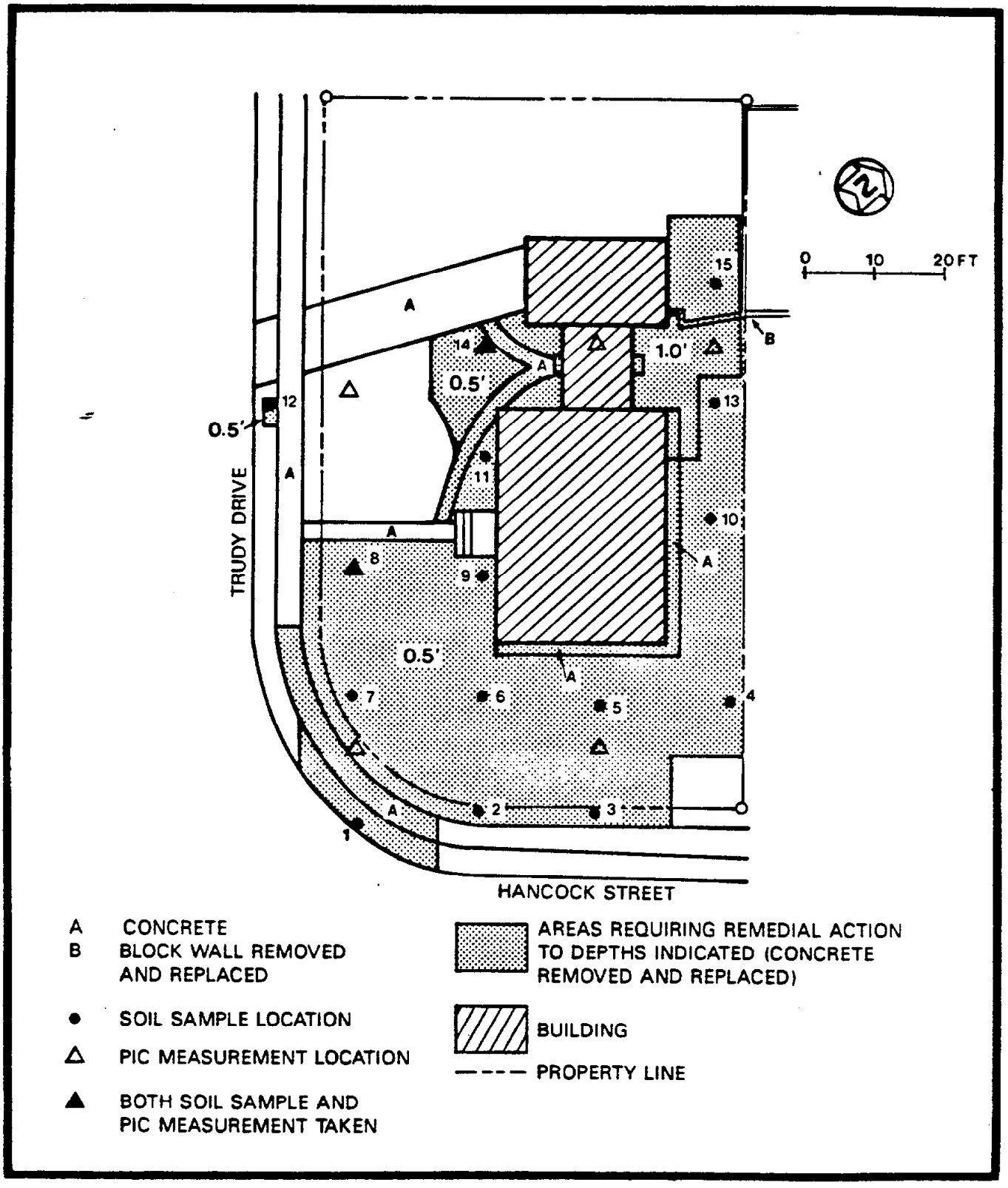

FIGURE 2 REMEDIAL ACTION AT 59 TRUDY DRIVE

TABLE 4

GAMMA RADIATION EXPOSURE RATE MEASUREMENTS

FOR 59 TRUDY DRIVE

Unit	Number of Measurements	Average*	Range*	DOE Guideline**
mrem/yr	7	2.6	0-8.8	100

*Calculated from exposure rate measurements assuming continuous occupancy at point of measurement. The natural background radiation of 100 mrem/yr has been subtracted.

**DOE guidelines are specified to be "above natural background values."

TABLE 5

POST-REMEDIAL ACTION SAMPLING RESULTS

59 TRUDY DRIVE

Sample Number	Concentrations (pCi/g +/- 1 sigma)		
	Uranium-238	Radium-226	Thorium-232
1	3.3 ± 2.3	2.0 ± 0.3	8.4 ± 2.2
2	<1.4	1.3 ± 0.5	3.5 ± 0.4
3	3.5 ± 1.2	1.1 ± 0.4	3.4 ± 0.4
4	<1.5	0.7 ± 0.3	1.3 ± 0.3
5	1.1 ± 1.2	1.0 ± 0.2	2.4 ± 0.9
6	<1.3	0.8 ± 0.1	1.4 ± 0.3
7	1.3 ± 1.2	0.7 ± 0.1	1.7 ± 0.8
8	<1.4	0.6 ± 0.2	1.4 ± 0.7
9	2.4 ± 0.1	0.8 ± 0.2	2.1 ± 0.4
10	<1.0	0.6 ± 0.1	1.2 ± 0.3
11	1.2 ± 1.1	0.7 ± 0.1	1.6 ± 0.3
12	2.4 ± 1.4	1.2 ± 0.3	3.6 ± 1.3
13	<0.9	0.8 ± 0.2	2.4 ± 0.3
14	<1.3	0.5 ± 0.2	0.9 ± 0.4
15	<1.0	0.8 ± 0.3	2.7 ± 0.7

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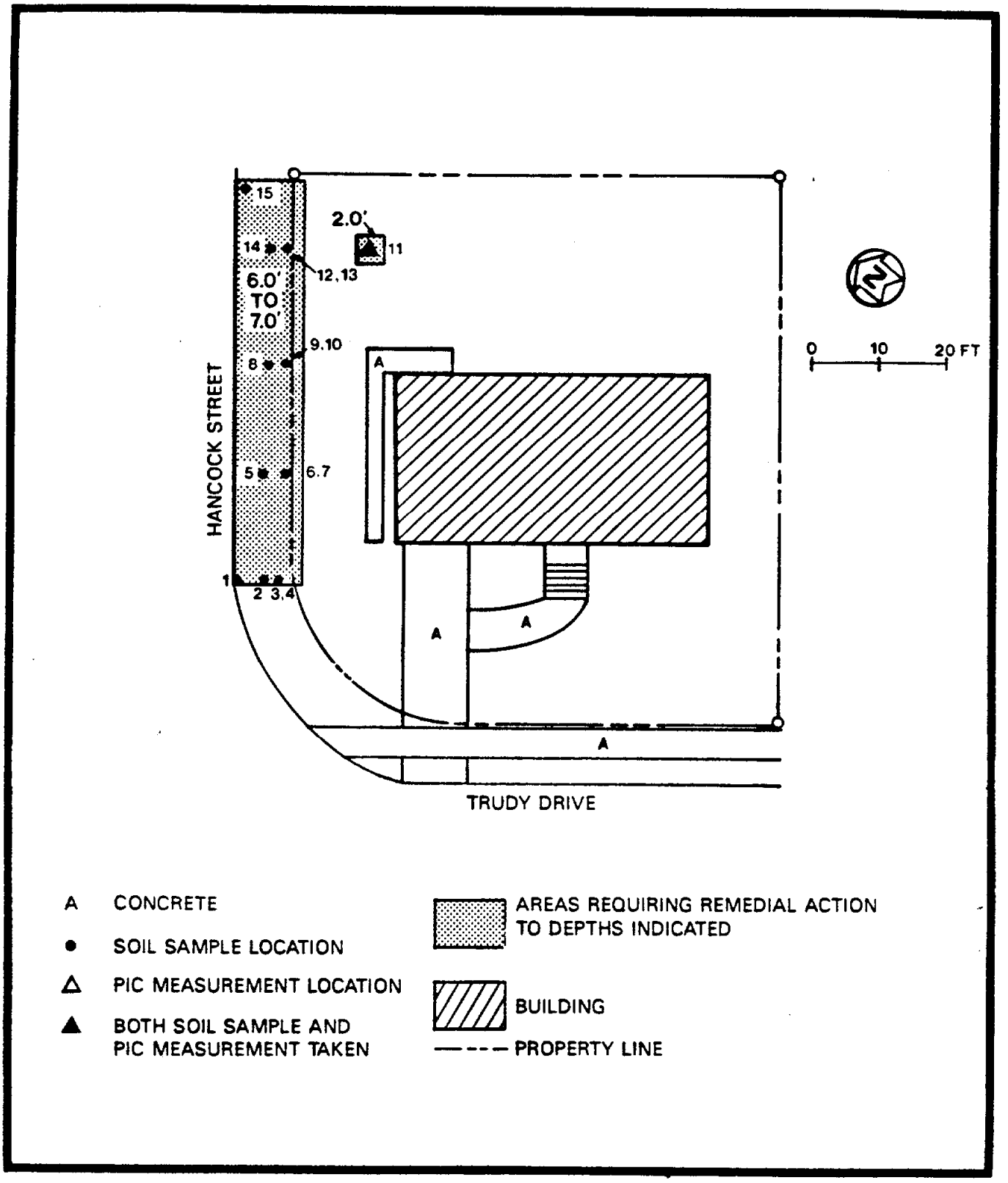

FIGURE 3 REMEDIAL ACTION AT 61 TRUDY DRIVE

TABLE 6

GAMMA RADIATION EXPOSURE RATE MEASUREMENTS

FOR 61 TRUDY DRIVE

Unit	Number of Measurements	Average*	Range*	DOE Guideline**
mrem/yr	1	17.5	17.5	100

*Calculated from exposure rate measurements assuming continuous occupancy at point of measurement. The natural background radiation of 100 mrem/yr has been subtracted.

**DOE guidelines are specified to be "above natural background values."

TABLE 7

POST-REMEDIAL ACTION SAMPLING RESULTS

61 TRUDY DRIVE

Sample Number	Concentrations (pCi/g +/- 1 sigma)		
	Uranium-238	Radium-226	Thorium-232
1	2.5 ± 1.3	1.8 ± 0.3	1.8 ± 0.4
2	2.6 ± 1.3	1.6 ± 0.1	1.9 ± 0.9
3	<1.2	1.3 ± 0.1	3.5 ± 0.9
4	1.9 ± 1.2	1.8 ± 0.3	1.5 ± 0.6
5	2.1 ± 0.6	1.7 ± 0.3	1.6 ± 0.2
6	2.0 ± 1.3	2.0 ± 0.3	1.8 ± 0.5
7	2.9 ± 1.4	1.7 ± 0.1	1.7 ± 0.4
8	1.6 ± 1.1	1.7 ± 0.4	1.6 ± 0.6
9	1.5 ± 1.4	1.8 ± 0.1	1.5 ± 0.3
10	2.1 ± 0.9	1.7 ± 0.6	1.6 ± 0.2
11	<1.5	0.4 ± 0.1	0.7 ± 0.2
12	1.8 ± 1.1	2.2 ± 0.3	1.7 ± 0.5
13	1.4 ± 2.2	1.5 ± 0.2	5.4 ± 1.0
14	2.6 ± 1.5	1.8 ± 0.2	2.7 ± 0.4
15	2.4 ± 1.0	1.8 ± 0.3	1.3 ± 0.4

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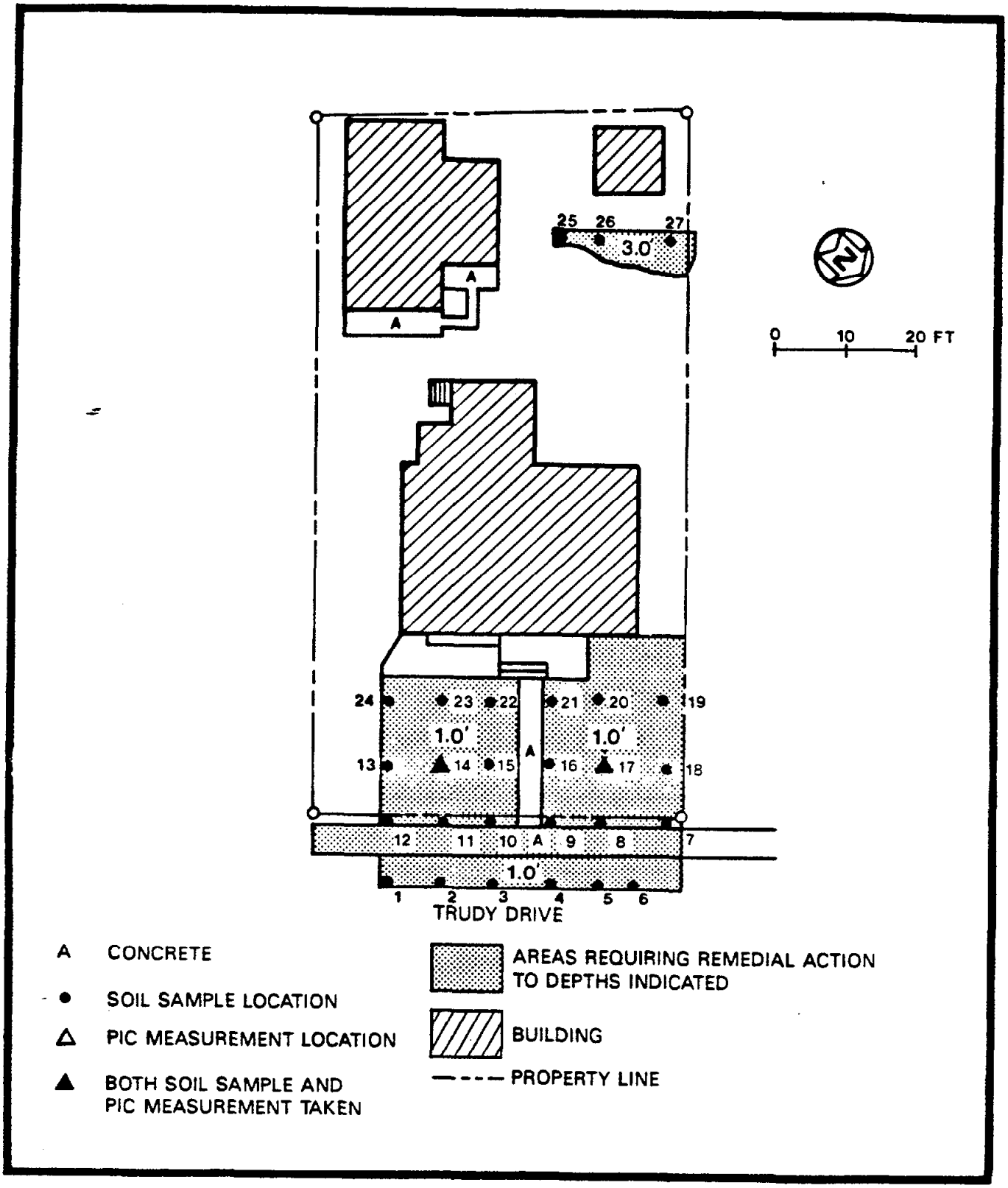

FIGURE 4 REMEDIAL ACTION AT 64 TRUDY DRIVE

TABLE 8

GAMMA RADIATION EXPOSURE RATE MEASUREMENTS

FOR 64 TRUDY DRIVE

Unit	Number of Measurements	Average*	Range*	DOE Guideline**
mrem/yr	2	8.8	8.8	100

*Calculated from exposure rate measurements assuming continuous occupancy at point of measurement. The natural background radiation of 100 mrem/yr has been subtracted.

**DOE guidelines are specified to be "above natural background values."

TABLE 9

POST-REMEDIAL ACTION SAMPLING RESULTS

64 TRUDY DRIVE

Sample Number	Concentrations (pCi/g +/- 1 sigma) Uranium-238	Radium-226	Thorium-232
1	<1.9	0.6 ± 0.1	1.2 ± 0.3
2	2.9 ± 1.6	1.3 ± 0.2	4.4 ± 0.6
3	2.9 ± 0.3	1.3 ± 0.3	6.7 ± 2.0
4	1.9 ± 0.5	0.9 ± 0.3	3.8 ± 0.4
5	0.9 ± 1.1	0.7 ± 0.2	1.9 ± 0.6
6	<2.1	1.1 ± 0.2	9.3 ± 0.9
7	2.2 ± 1.5	0.8 ± 0.2	2.4 ± 0.7
8	<1.3	1.1 ± 0.2	2.2 ± 0.4
9	<1.3	0.6 ± 0.1	0.9 ± 0.2
10	4.7 ± 2.1	1.3 ± 0.2	6.1 ± 0.9
11	<2.7	0.6 ± 0.1	0.8 ± 0.2
12	<1.1	0.6 ± 0.1	1.3 ± 0.4
13	1.1 ± 1.0	0.6 ± 0.2	1.4 ± 0.3
14	1.2 ± 0.8	0.6 ± 0.2	1.0 ± 0.2
15	1.1 ± 1.1	0.7 ± 0.2	1.6 ± 0.4
16	1.0 ± 1.0	0.6 ± 0.1	1.2 ± 0.3
17	1.2 ± 1.5	1.5 ± 0.2	3.0 ± 0.4
18	1.9 ± 1.3	0.8 ± 0.1	1.5 ± 0.9
19	2.3 ± 1.6	1.1 ± 0.1	2.1 ± 0.1
20	1.1 ± 1.4	1.4 ± 0.2	2.9 ± 0.4
21	2.2 ± 0.2	1.1 ± 0.2	2.6 ± 0.7
22	1.5 ± 1.1	0.7 ± 0.1	1.2 ± 0.4
23	<1.5	0.6 ± 0.1	1.2 ± 0.5
24	1.8 ± 1.2	0.6 ± 0.1	1.2 ± 0.2
25	5.2 ± 1.7	1.3 ± 0.2	3.2 ± 1.4
26	<2.0	0.6 ± 0.1	0.8 ± 0.2
27	<2.5	0.7 ± 0.2	2.0 ± 0.4

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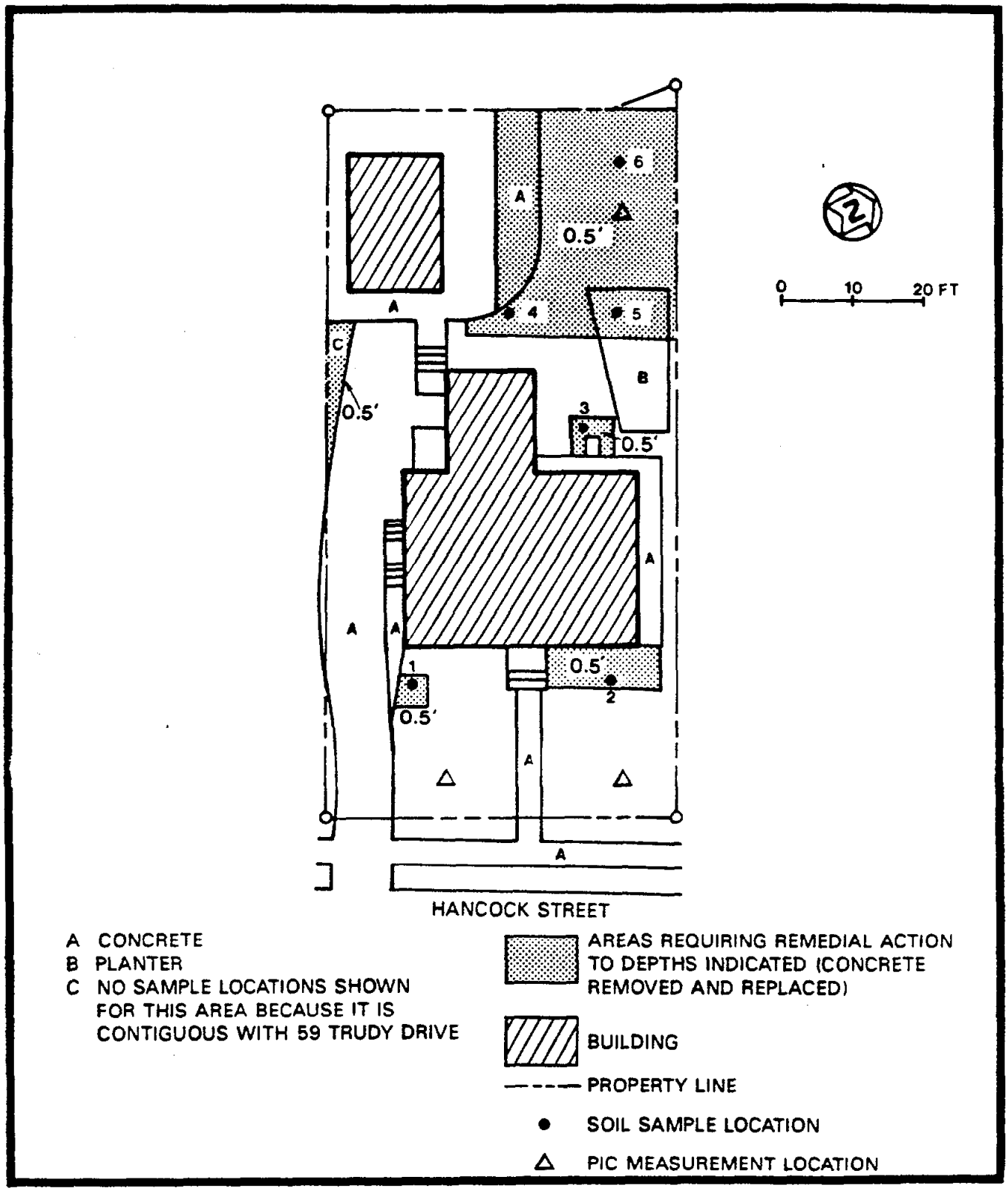

FIGURE 5 REMEDIAL ACTION AT 3 HANCOCK STREET

TABLE 10

GAMMA RADIATION EXPOSURE RATE MEASUREMENTS

FOR 3 HANCOCK STREET

Unit	Number of Measurements	Average*	Range*	DOE Guideline**
mrem/yr	3	2.9	0-8.8	100

*Calculated from exposure rate measurements assuming continuous occupancy at point of measurement. The natural background radiation of 100 mrem/yr has been subtracted.

**DOE guidelines are specified to be "above natural background values."

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TABLE 11

POST-REMEDIAL ACTION SAMPLING RESULTS

3 HANCOCK STREET

Sample Number	Concentrations (pCi/g +/- 1 sigma)		
	Uranium-238	Radium-226	Thorium-232
1	1.6 ± 1.3	0.7 ± 0.3	1.9 ± 0.5
2	1.0 ± 1.0	0.7 ± 0.2	1.3 ± 0.6
3	<1.3	0.6 ± 0.1	1.5 ± 0.3
4	<1.0	0.7 ± 0.1	1.6 ± 0.3
5	0.6 ± 0.2	0.7 ± 0.1	1.9 ± 0.3
6	<1.2	0.6 ± 0.1	2.2 ± 0.7

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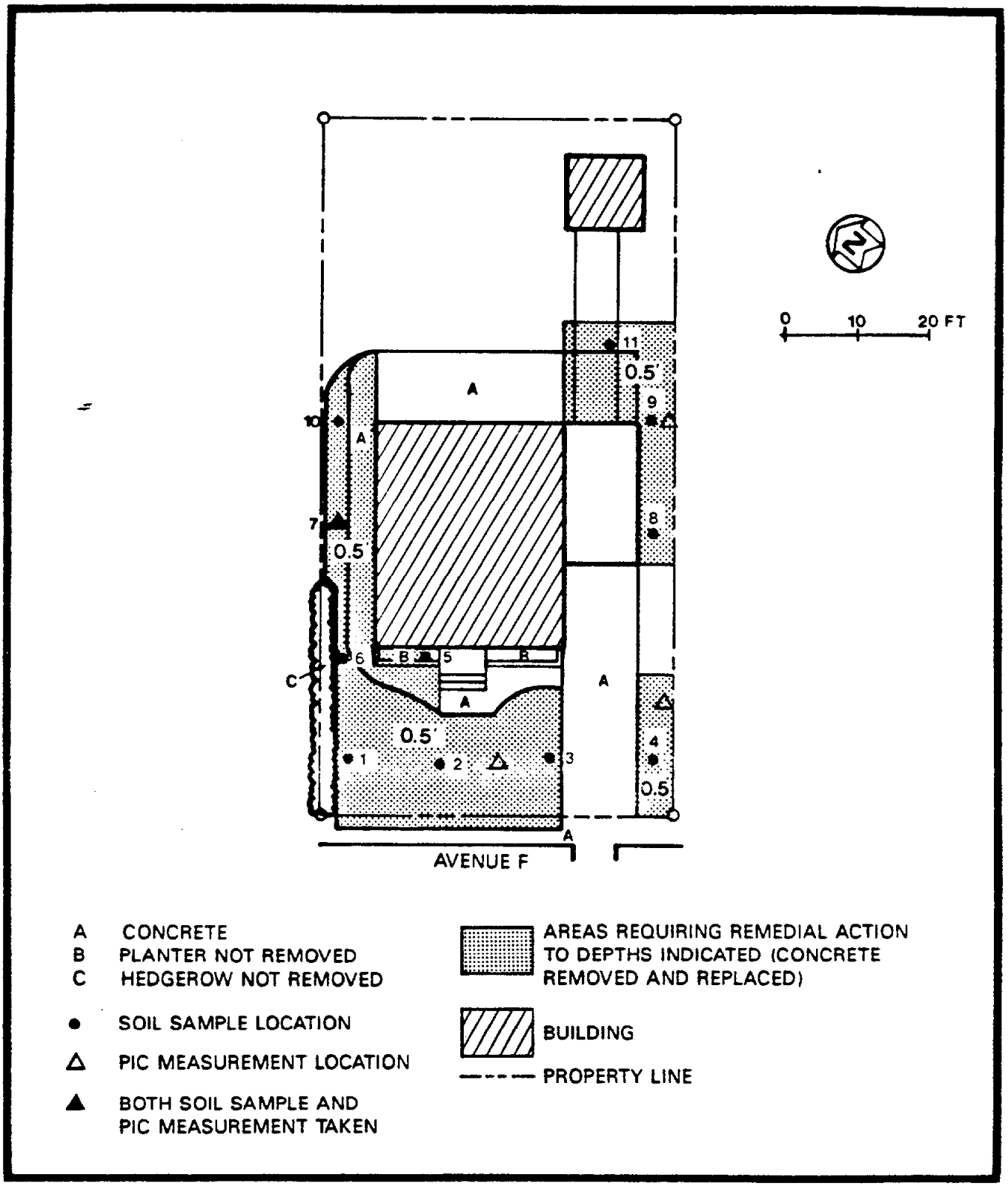

FIGURE 6 REMEDIAL ACTION AT 121 AVENUE F

TABLE 12

GAMMA RADIATION EXPOSURE RATE MEASUREMENTS

FOR 121 AVENUE F

Unit	Number of Measurements	Average*	Range*	DOE Guideline**
mrem/yr	4	4.4	0-8.8	100

*Calculated from exposure rate measurements assuming continuous occupancy at point of measurement. The natural background radiation of 100 mrem/yr has been subtracted.

**DOE guidelines are specified to be "above natural background values."

TABLE 13

POST-REMEDIAL ACTION SAMPLING RESULTS

121 AVENUE F

Sample Number	Concentrations (pCi/g +/- 1 sigma)		
	Uranium-238	Radium-226	Thorium-232
1	<2.4	0.8 ± 0.2	1.3 ± 0.9
2	<1.0	0.6 ± 0.2	1.0 ± 0.2
3	<1.1	0.7 ± 0.1	1.1 ± 0.2
4	<1.4	0.6 ± 0.2	0.8 ± 0.3
5	<1.4	0.7 ± 0.1	1.3 ± 0.2
6	2.3 ± 1.5	1.1 ± 0.3	2.5 ± 0.8
7	1.8 ± 0.9	1.2 ± 0.2	2.7 ± 0.6
8	0.7 ± 1.1	0.8 ± 0.2	1.5 ± 0.3
9	1.4 ± 1.1	0.6 ± 0.2	1.7 ± 0.3
10	<1.1	1.1 ± 0.4	2.2 ± 0.6
11	2.9 ± 1.7	1.1 ± 0.7	3.0 ± 0.5

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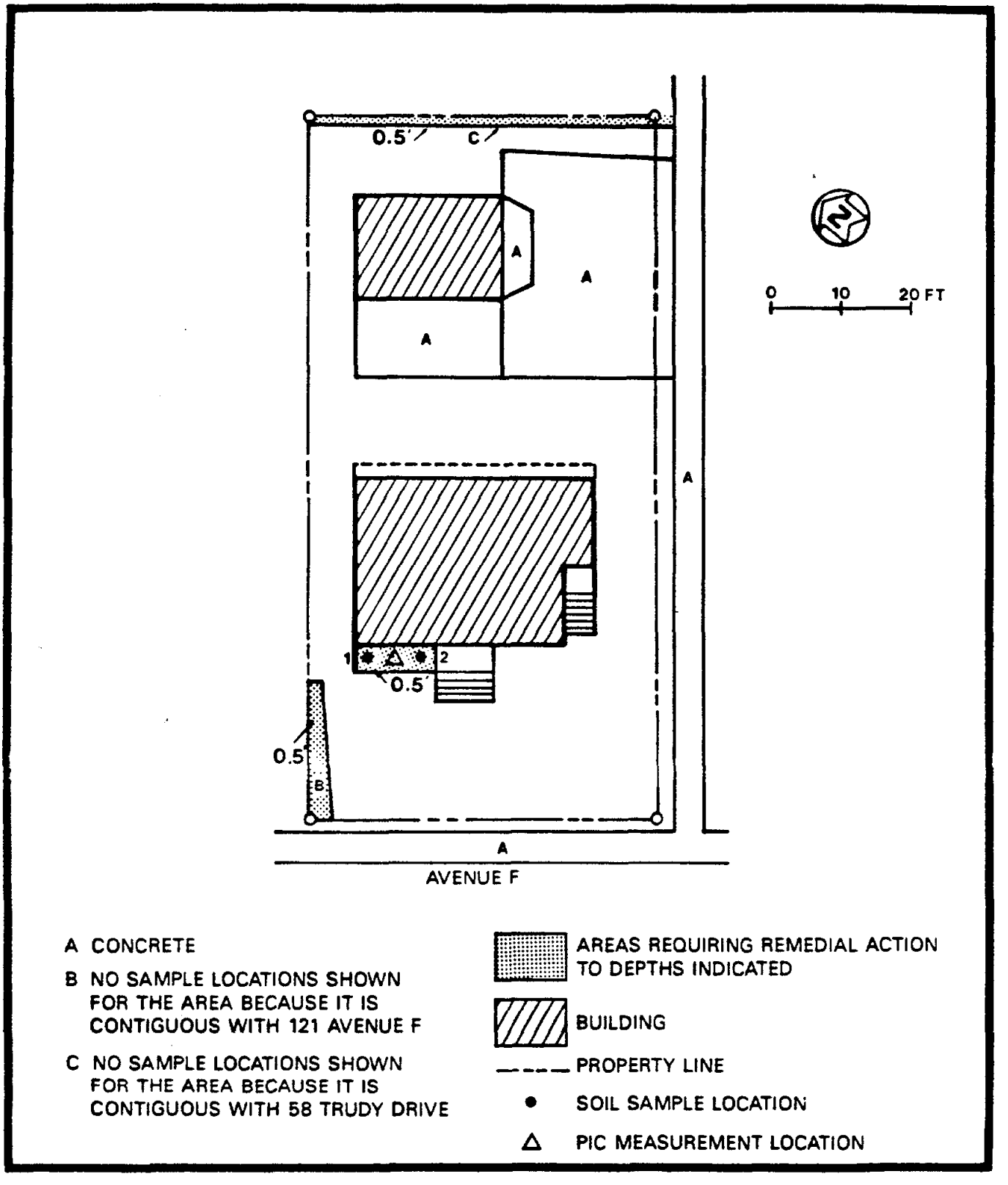

FIGURE 7 REMEDIAL ACTION AT 123 AVENUE F

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TABLE 14

GAMMA RADIATION EXPOSURE RATE MEASUREMENTS

FOR 123 AVENUE F

Unit	Number of Measurements	Average*	Range*	DOE Guideline**
mrem/yr	1	0	0	100

*Calculated from exposure rate measurements assuming continuous occupancy at point of measurement. The natural background radiation of 100 mrem/yr has been subtracted.

**DOE guidelines are specified to be "above natural background values."

TABLE 15

POST-REMEDIAL ACTION SAMPLING RESULTS

123 AVENUE F

Sample Number	Concentrations (pCi/g +/- 1 sigma)		
	Uranium-238	Radium-226	Thorium-232
1	1.8 ± 0.3	0.6 ± 0.2	2.0 ± 0.4
2	2.5 ± 1.4	0.8 ± 0.2	2.7 ± 0.3

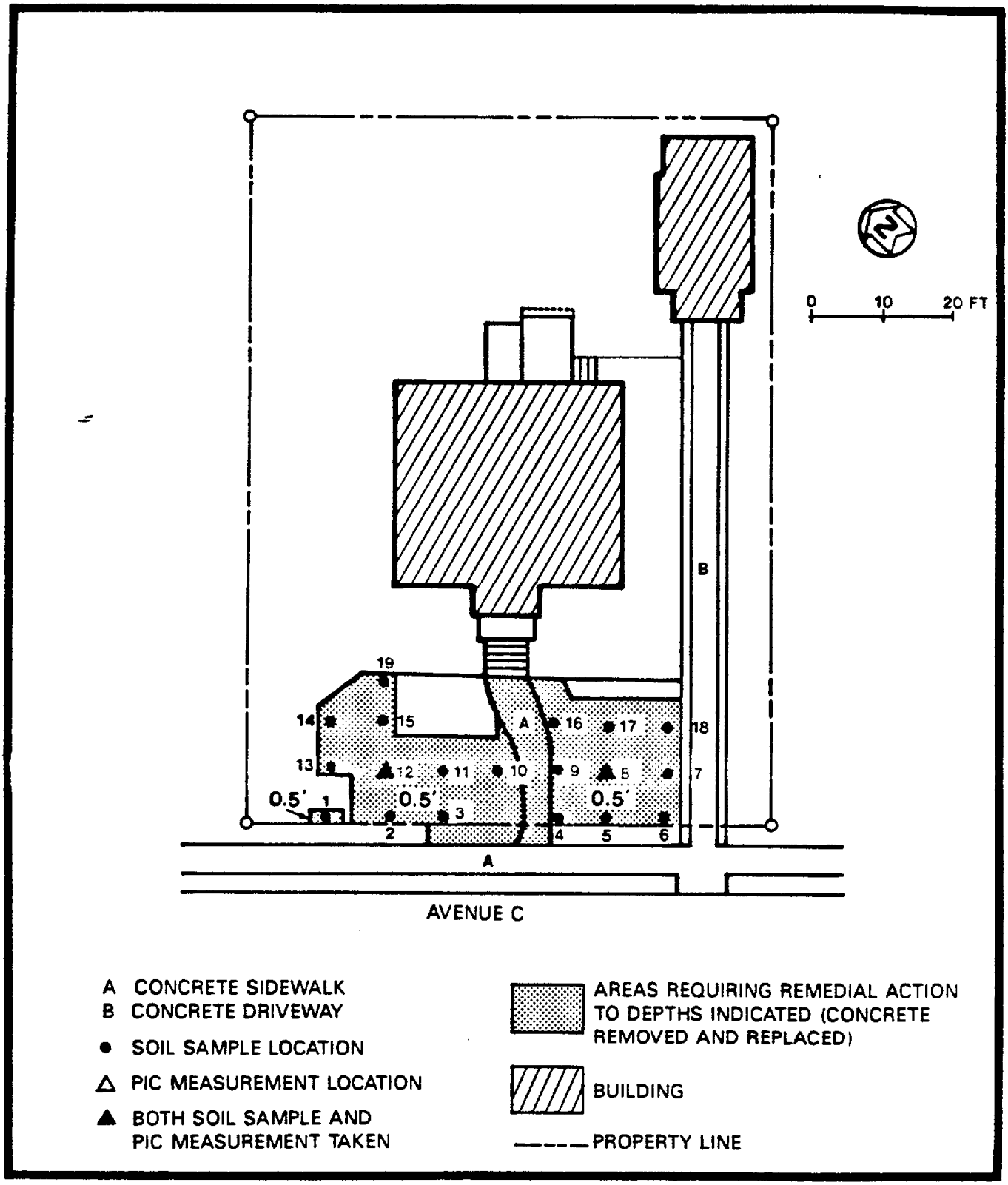

FIGURE 8 REMEDIAL ACTION AT 59 AVENUE C

TABLE 16

GAMMA RADIATION EXPOSURE RATE MEASUREMENTS

FOR 59 AVENUE C

Unit	Number of Measurements	Average*	Range*	DOE Guideline**
mrem/yr	2	13.1	8.8-17.5	100

*Calculated from exposure rate measurements assuming continuous occupancy at point of measurement. The natural background radiation of 100 mrem/yr has been subtracted.

**DOE guidelines are specified to be "above natural background values."

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TABLE 17

POST-REMEDIAL ACTION SAMPLING RESULTS

59 AVENUE C

Sample Number	Concentrations (pCi/g +/- 1 sigma)		
	Uranium-238	Radium-226	Thorium-232
1	<1.0	0.6 ± 0.1	2.0 ± 1.0
2	<2.5	0.8 ± 0.1	3.1 ± 0.9
3	<1.0	0.7 ± 0.2	1.0 ± 0.3
4	<1.0	0.4 ± 0.1	0.9 ± 0.3
5	2.4 ± 1.4	0.6 ± 0.2	1.7 ± 0.3
6	2.0 ± 1.6	1.0 ± 0.4	5.0 ± 0.8
7	<1.4	0.6 ± 0.1	2.0 ± 0.4
8	<1.6	0.5 ± 0.1	0.7 ± 0.2
9	<1.2	0.8 ± 0.1	1.6 ± 0.4
10	<1.8	0.7 ± 0.2	1.9 ± 0.6
11	<1.1	0.7 ± 0.1	2.3 ± 0.6
12	<1.3	0.7 ± 0.1	1.6 ± 0.4
13	<2.0	0.8 ± 0.2	2.3 ± 0.4
14	<2.0	1.0 ± 0.1	4.9 ± 0.8
15	<1.3	0.7 ± 0.2	2.5 ± 0.6
16	<0.9	0.5 ± 0.4	0.9 ± 0.3
17	<1.8	0.6 ± 0.2	1.1 ± 0.2
18	<1.7	0.5 ± 0.2	0.8 ± 0.2

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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.

Beta-gamma-emitting - See radiation.

Contamination - Contamination means a concentration of radioactive materials in the soil exceeding that permitted by DOE 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 for more information.

Exposure rate - Exposure rate is the rate at which radiation imparts energy to the air. Exposure is typically measured in microroentgens (uR) and the exposure rate is typically given as uR/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 uR/h for 168 hours per week (continuous exposure) for 52 weeks per year, the whole-body dose would be 170 mrem.

Gamma radiation - See radiation.

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

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

Millirad - Millirad is a measure of the amount of energy imparted by radiation to a unit of mass. It is generally expressed in terms of a rate per hour, i.e., mrad/h.

Millirem - 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. For comparison, a typical chest x-ray is about 40 mrem. 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.

Monazite - Monazite is a mineral that contains unusually high concentrations of thorium and rare earth metals. Monazite is often found in sand and gravel deposits.

Picocurie - A picocurie is the unit of measure for radioactivity just as an ounce is a unit to measure weight. One picocurie means that one radioactive particle is released on the average of every 27 seconds.

Radiation - There are three primary types of radiation: alpha, beta, and gamma. Alpha radiation travels less than an inch in air before it stops. Alpha radiation 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. For radioactive material external to the body, gamma radiation is the principal concern. For radioactive material that enters the body by ingestion or inhalation, alpha and beta radiation are also of concern.

Radionuclide - A radionuclide is another word meaning a particular radioactive element. For example, radium-226 is a radionuclide, uranium-238 is another, thorium-232 another, and so on.

Rare earths - Rare earths refers to various types of metals present in the monazite sands. These were extracted from the monazite for their value. Rare earth metals include cerium, lanthanum, praeseodymium, and neodymium.

Remedial action - Remedial action is a general term typically used to mean "cleanup of contamination." It referes to any action required so that a property can b released for unrestricted use as noncontaminated. In practice, this may mean removing grass and soil, cutting trees, removing asphalt, etc.

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 preparation 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.

Unrestricted Use - Unrestricted use means that a property can be used for any purpose without regard to the radioactivity that used to be on the property. These uses could include anything -- farming, a residence, a playground, etc.

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 (as it exists in Lodi) 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 for use with uranium mine workers and has become the accepted unit for environmental measurements.