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RESULTS OF THE RADIOLOGICAL SURVEY AT 80 INDUSTRIAL ROAD, LODI, NEW JERSEY (LJ061)

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ABSTRACT

Maywood Chemical Works (MCW) of Maywood, New Jersey, generated process wastes and residues associated with the production and refining of thorium and thorium compounds from monazite ores from 1916 to 1956. MCW supplied rare earth metals and thorium compounds to the Atomic Energy Commission and various other government agencies from the late 1940s to the mid–1950s. Area residents used the sandlike waste from this thorium extraction process mixed with tea and cocoa leaves as mulch in their yards. Some of these contaminated wastes were also eroded from the site into Lodi Brook. At the request of the U.S. Department of Energy (DOE), a group from Oak Ridge National Laboratory conducts investigative radiological surveys of properties in the vicinity of MCW to determine whether a property is contaminated with radioactive residues, principally ^{232}Th, derived from the MCW site. The survey typically includes direct measurement of gamma radiation levels and soil sampling for radionuclide analyses. The survey of this site, 80 Industrial Road, Lodi, New Jersey (LJ061), was conducted during 1985 and 1986.

Results of the survey demonstrated radionuclide concentrations in excess of DOE remedial action criteria, primarily from the ^{232}Th decay chain, with some contamination from ^{226}Ra. The radionuclide distributions are typical of the type of material originating from the MCW site.

RESULTS OF THE RADIOLOGICAL SURVEY AT 80 INDUSTRIAL ROAD, LODI, NEW JERSEY (LJ061)*

INTRODUCTION

From 1916 to 1956, process wastes and residues associated with the production and refining of thorium and thorium compounds from monazite ores were generated by the Maywood Chemical Works (MCW), Maywood, New Jersey. During the latter part of this period, MCW supplied rare earth metals and thorium compounds to various government agencies. In the 1940s and 1950s, MCW produced thorium and lithium, under contract, for the Atomic Energy Commission (AEC). These activities ceased in 1956, and approximately three years later, the 30-acre real estate was purchased by the Stepan Company. The property is located at 100 Hunter Avenue in a highly developed area in Maywood and Rochelle Park, Bergen County, New Jersey.

During the early years of operation, MCW stored wastes and residues in low-lying areas west of the processing facilities. In the early 1930s, these areas were separated from the rest of the property by the construction of New Jersey State Highway 17. The Stepan property, the interim storage facility, and several vicinity properties have been designated for remedial action by the Department of Energy (DOE).

The waste produced by the thorium extraction process was a sandlike material containing residual amounts of thorium and its decay products, with smaller quantities of uranium and its decay products. During the years 1928 and 1944 to 1946, area residents used these process wastes mixed with tea and cocoa leaves as mulch in their lawns and gardens. In addition, some of the contaminated wastes were apparently eroded from the site into Lodi Brook and carried downstream.

Lodi Brook is a small stream flowing south from Maywood with its headwaters near the Stepan waste storage site. Approximately 150 ft after passing under State Route 17, the stream has been diverted underground through concrete or steel culverts until it merges with the Saddle River in Lodi, New Jersey. Only a small section near Interstate 80 remains uncovered. From the 1940s to the 1970s when the stream was being diverted underground, its course was altered several times. Some of these changes resulted in the movement of contaminated soil to the surface of a few properties, where it is still in evidence. In other instances, the contaminated soil was covered over or mixed with clean fill, leaving no immediate evidence on the surface. Therefore, properties in question may be drilled in search of former stream bed material, even in the absence of surface contamination.

As a result of the Energy and Water Appropriations Act of Fiscal Year 1984, the property discussed in this report and properties in its vicinity contaminated

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

with residues from the former MCW, were included as a decontamination research and development project under the DOE Formerly Utilized Sites Remedial Action Program. As part of this project, DOE is conducting radiological surveys in the vicinity of the site to identify properties contaminated with residues derived from the MCW. The principal radionuclide of concern is thorium-232. The radiological survey discussed in this report is part of that effort and was conducted, at the request of DOE, by members of the Measurement and Applications Development Group of the Oak Ridge National Laboratory.

A radiological survey of the commercial property at 80 Industrial Road, Lodi, New Jersey, was conducted during 1986. The survey and sampling of the ground surface, as well as the subsurface investigation, were carried out on September 19, 1986.

SURVEY METHODS

The radiological survey of the property included: (1) a gamma scan of the entire property outdoors, (2) collection of surface and subsurface soil samples, and (3) gamma profiles of auger holes. No indoor survey measurements were performed.

Using a portable gamma scintillation meter, ranges of measurements were recorded for areas of the property surface. Systematic soil samples were then obtained at randomly selected locations irrespective of gamma exposure rates. In addition, biased soil samples were collected in areas of elevated gamma levels. To define the extent of possible subsurface soil contamination, auger holes were drilled to depths of approximately 2.9 m. A plastic pipe was placed in each hole, and a NaI scintillation probe was lowered inside the pipe. The probe was encased in a lead shield with a horizontal row of collimating slits on the side. This collimation allows measurement of gamma radiation intensities resulting from contamination within small fractions of the hole depth. Measurements were made at 15–, 20–, or 30–cm intervals. If the gamma readings in the hole were elevated, a soil sample was scraped from the wall of the auger hole at the point showing the highest gamma radiation level. The auger hole loggings were used to select locations where further soil sampling would be useful. A split-spoon sampler was used to collect subsurface samples at known depths. In some auger holes, a combination of split-spoon sampling and side-wall scraping was used to collect samples. These survey methods followed the plan outlined in Reference 1. A comprehensive description of the survey methods and instrumentation has been presented in another report.[2]

SURVEY RESULTS

Applicable DOE guidelines are summarized in Table 1.[3] The normal background radiation levels for the northern New Jersey area are presented in Table 2. These data are provided for comparison with survey results presented in this section. All direct measurement results presented in this report are gross readings; background radiation levels have not been subtracted. Similarly, background concentrations have not been subtracted from radionuclide concentrations measured in environmental samples.

Surface Gamma Radiation Levels

Gamma radiation levels measured during a gamma scan of the surface of the property are given in Fig. 1. Gamma exposure rates over the major portion of the property ranged from 5 to 13 μR/h. The three areas indicated by shading on the drawing represent locations of elevated gamma levels. Gamma measurements in the large area at the south end of the property ranged from 7 to 21 μR/h. Two smaller areas had gamma measurements of 13 to 17 μR/h and 13 to 21 μR/h.

Systematic and Biased Soil Samples

Two systematic soil samples and twelve biased soil samples, taken from four soil sample locations, were collected for radionuclide analyses. Locations of the samples are shown in Fig. 2, with results of laboratory analyses provided in Table 3. Concentrations of ^{226}Ra and ^{232}Th in the systematic samples were 0.59 and 0.64 pCi/g and 0.84 and 0.83 pCi/g, respectively. Biased samples were found to have 0.67 to 4.9 pCi/g ^{226}Ra and 1.6 to 45 pCi/g ^{232}Th. The DOE guideline for ^{232}Th concentration in surface soil is exceeded in samples B1A and B4A. The criterion for subsurface thorium-232 is exceeded in sample B1B. Radium-226 concentrations in biased samples were generally slightly elevated above background for the northern New Jersey area but below guidelines (Table 2).

Auger Hole Soil Samples and Gamma Logging

Auger holes were drilled at 25 locations as indicated in Fig. 2. Varying thicknesses of subsurface soil were sampled from depths of 0 to 290 cm in nine selected auger holes where gamma measurements indicated possible elevated concentrations of radionuclides. Although gamma levels were low in hole 1, one sample was collected at 45 to 75 cm because an obstruction prohibited drilling below 75 cm. The results of analyses of these samples are given in Table 3 (A1A-A25M). Concentrations of ^{226}Ra and ^{232}Th in the soil samples ranged from 0.44 to 3.6 and 0.59 to 64 pCi/g, respectively. Thorium-232 concentrations in samples A25I, A25J, and A25K were above the DOE criterion (Table 1) for subsurface soil with levels of 48, 50, and 64 pCi/g, respectively. The elevated concentrations were found between 215 and 255 cm below the surface. Radium-226 concentrations were above background in several samples but well below the applicable guidelines.

Gamma logging was performed in nine auger holes to characterize and further define the extent of possible contamination. The logging technique used here is not radionuclide specific. However, logging data, in conjunction with soil analyses data, may be used to estimate regions of elevated radionuclide concentrations in auger holes when compared with background levels for the area. Following a comparison of these data, it appears that any shielded scintillator readings of 1,000 counts per minute (cpm) or greater generally indicate the presence of elevated concentrations of ^{226}Ra and/or ^{232}Th. Data from the gamma profiles of the logged auger holes are graphically represented in Figs. 3 through 11. Holes 6, 7, 10, 11, and 13 through 23 were not logged with the shielded probe because no elevated gamma levels were detected using an unshielded probe.

No readings above 800 cpm were detected in holes 1, 3, and 5. Readings at depths between 76 and 140 cm were greater than 1,000 cpm in auger hole 2, with a maximum reading of 2,600 cpm at 100 cm. Elevated readings were between the surface and 60 cm in hole 4 with a maximum of 2,400 cpm at 15 cm. In hole 8, elevated readings were between 46 and 61 cm, with a maximum of 1,600 cpm at 61 cm. A maximum of 2,500 cpm was measured at 61 cm in hole 9 with elevated gamma between 30 and 76 cm. Readings above 1,000 were found between 1.5 and 2 m in hole 12 with a maximum of 2,200 cpm at 1.7 m. Hole 24 was logged and found to contain contamination at approximately 2.3 m which is too deep to allow sampling of the side-walls. The maximum reading obtained in hole 24 was 13,000 cpm. Hole 25, drilled adjacent to hole 24, was sampled by the split-spoon method down to 2.9 m. The maximum gamma measurement in hole 25 was 9,000 cpm. The areas of highest gamma readings correspond to the greatest concentrations of radionuclides shown in Table 3.

SIGNIFICANCE OF FINDINGS

Measurements taken at 80 Industrial Road indicate that the property contained radioactive contamination primarily from the ^{232}Th decay chain, with some contamination from ^{226}Ra. These radionuclide distributions are typical of the type of material originating from the processing operations at MCW. The concentration and extent of ^{232}Th on this property were in excess of the applicable DOE criteria (Table 1). Guidelines are exceeded in samples B1, B4, and A25 collected at the locations shown in Fig. 2. Based on the results of this radiological assessment, it is recommended that this site be considered for inclusion in the DOE remedial action program.

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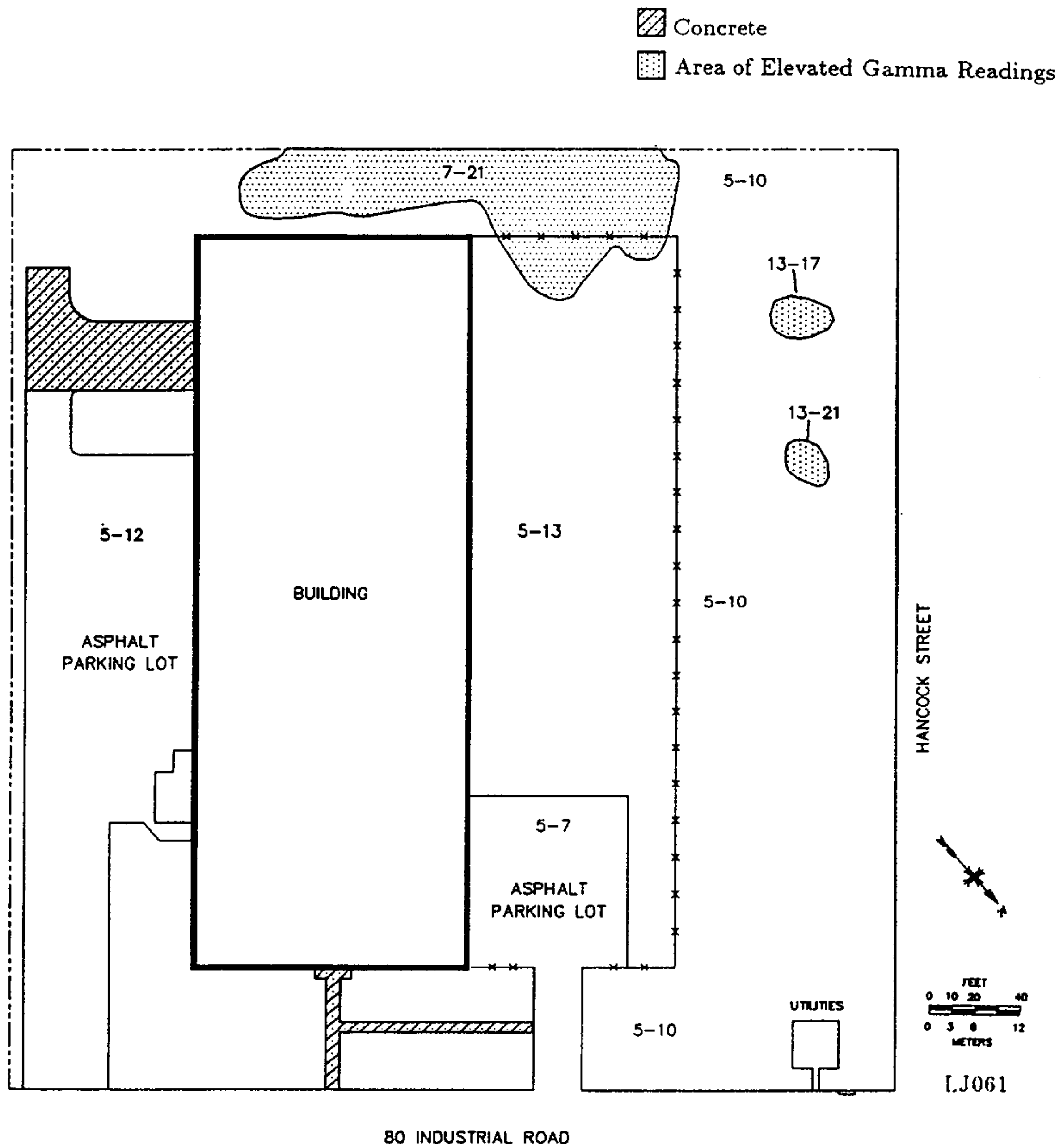

Fig. 1. Gamma radiation levels (μR/h) measured on the surface at 80 Industrial Road, Lodi, New Jersey (LJ061).

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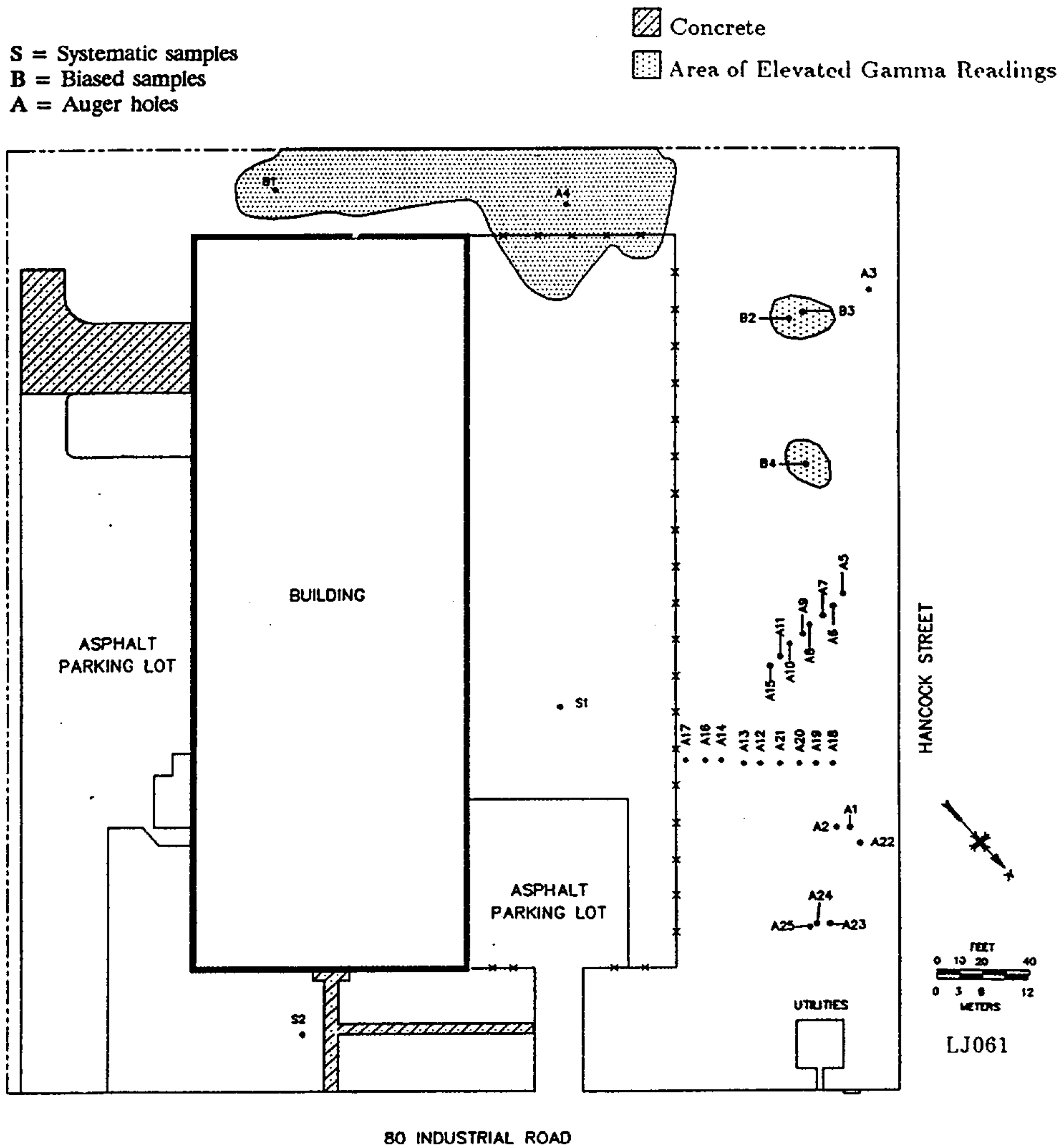

Fig. 2. Diagram showing locations of soil samples taken at 80 Industrial Road, Lodi, New Jersey (LJ061).

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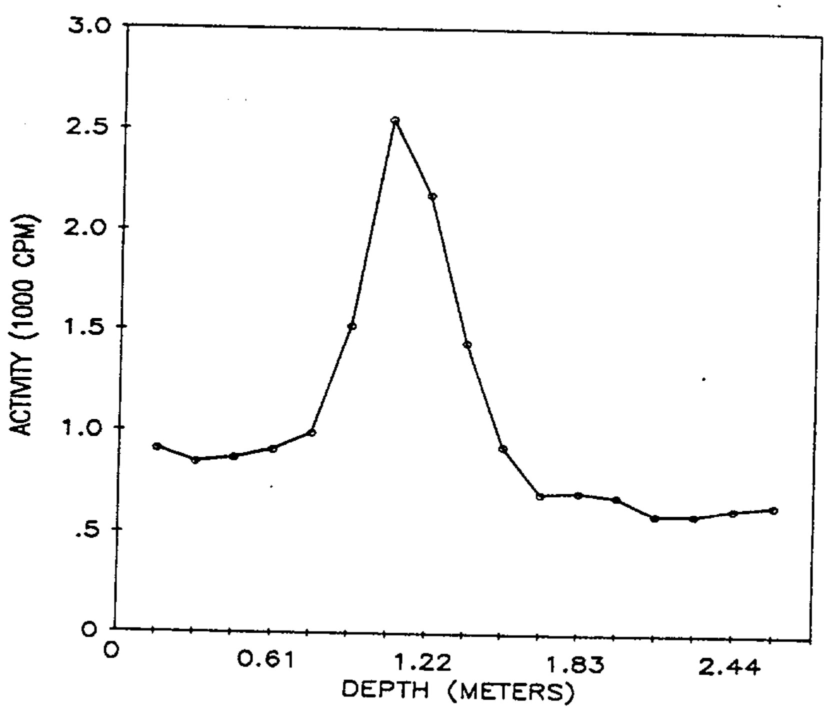

Fig. 3. Gamma profile for auger hole 2 (LJ061A2) at 80 Industrial Road, Lodi, New Jersey.

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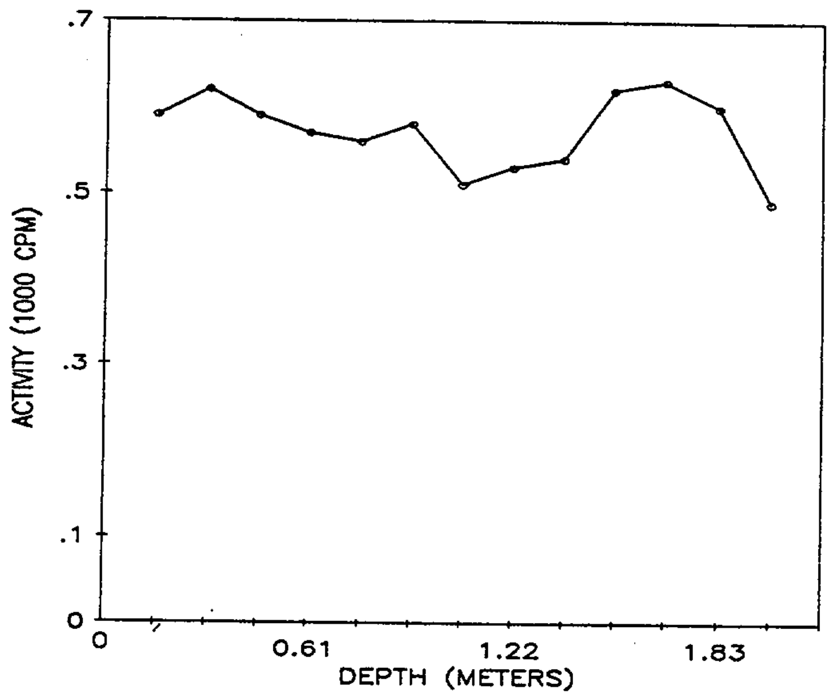

Fig. 4. Gamma profile for auger hole 3 (LJ061A3) at 80 Industrial Road, Lodi, New Jersey.

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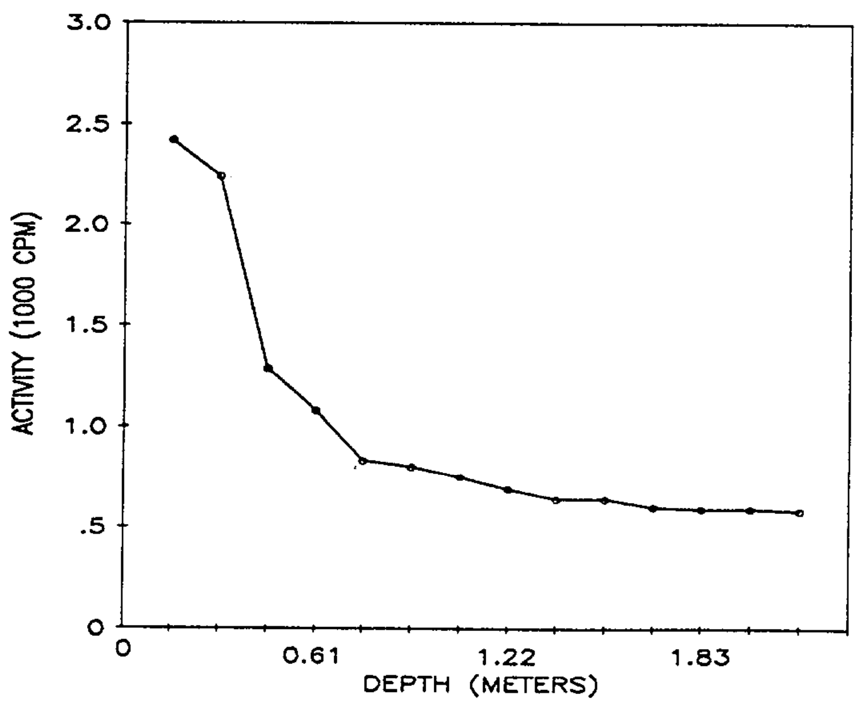

Fig. 5. Gamma profile for auger hole 4 (LJ061A4) at 80 Industrial Road, Lodi, New Jersey.

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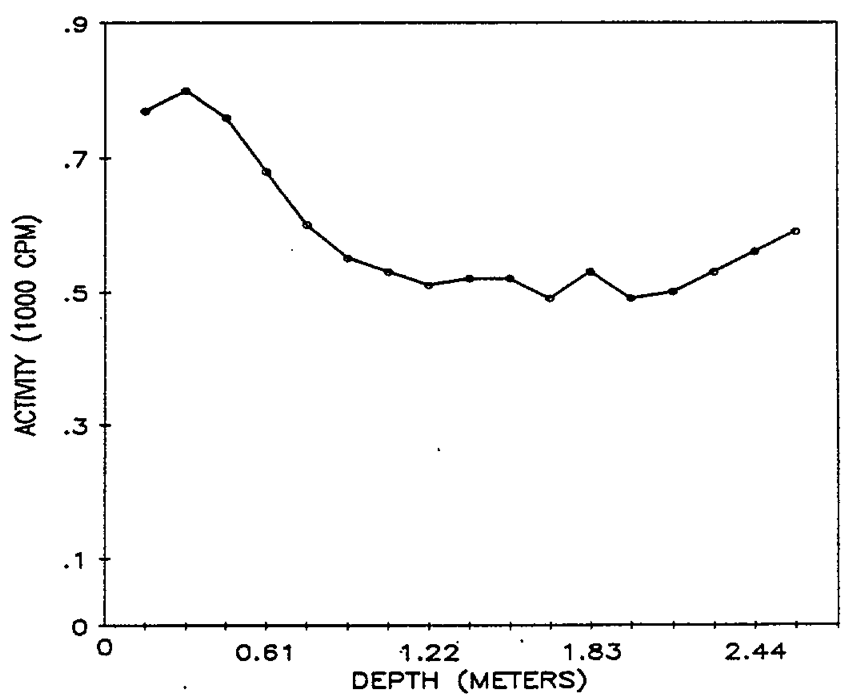

Fig. 6. Gamma profile for auger hole 5 (LJ061A5) at 80 Industrial Road, Lodi, New Jersey.

ORNL-DWG 89-10688

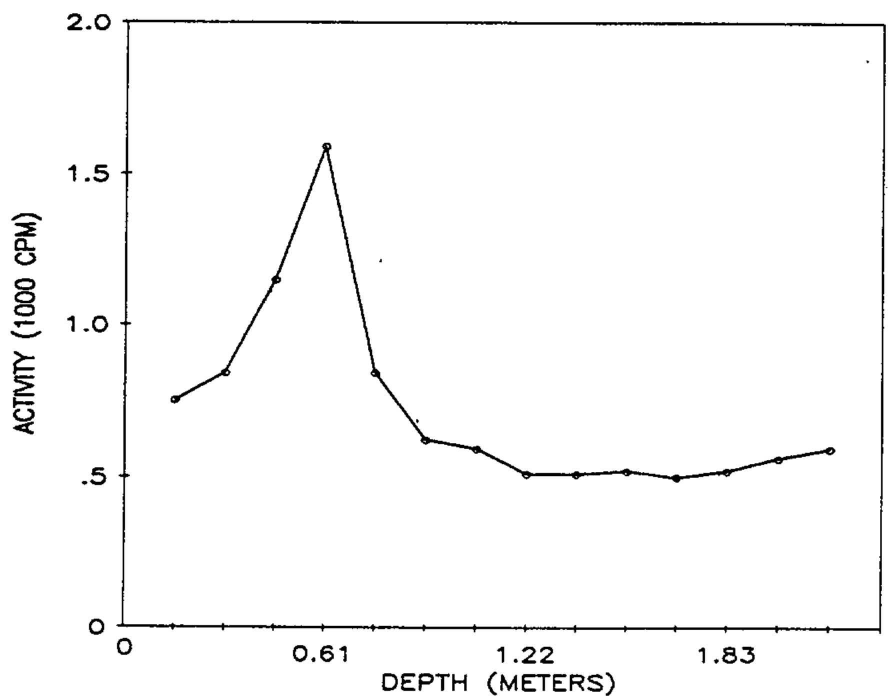

Fig. 7. Gamma profile for auger hole 8 (LJ061A8) at 80 Industrial Road, Lodi, New Jersey.

ORNL-DWG 89-10689

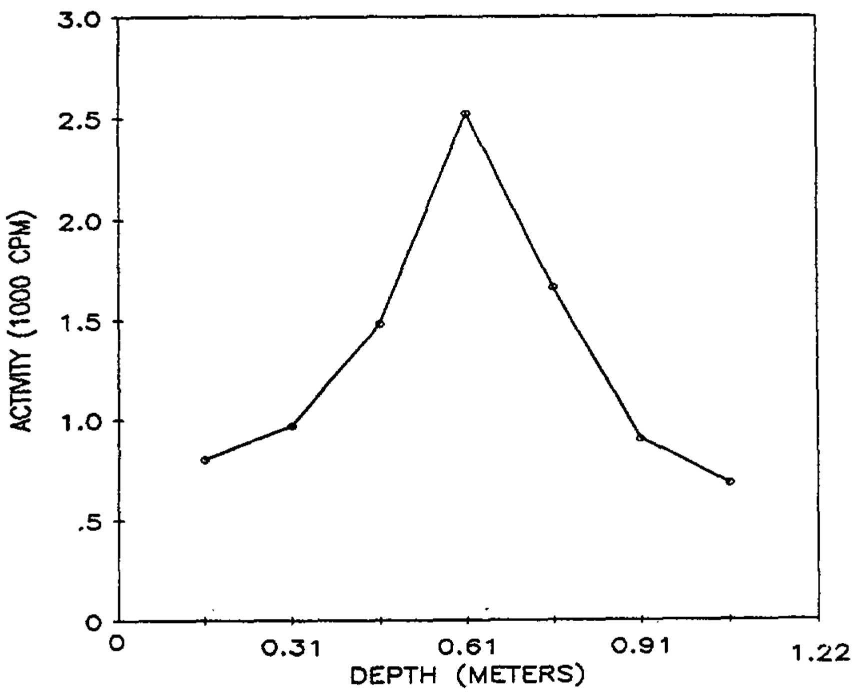

Fig. 8. Gamma profile for auger hole 9 (LJ061A9) at 80 Industrial Road, Lodi, New Jersey.

ORNL-DWG 89-10690

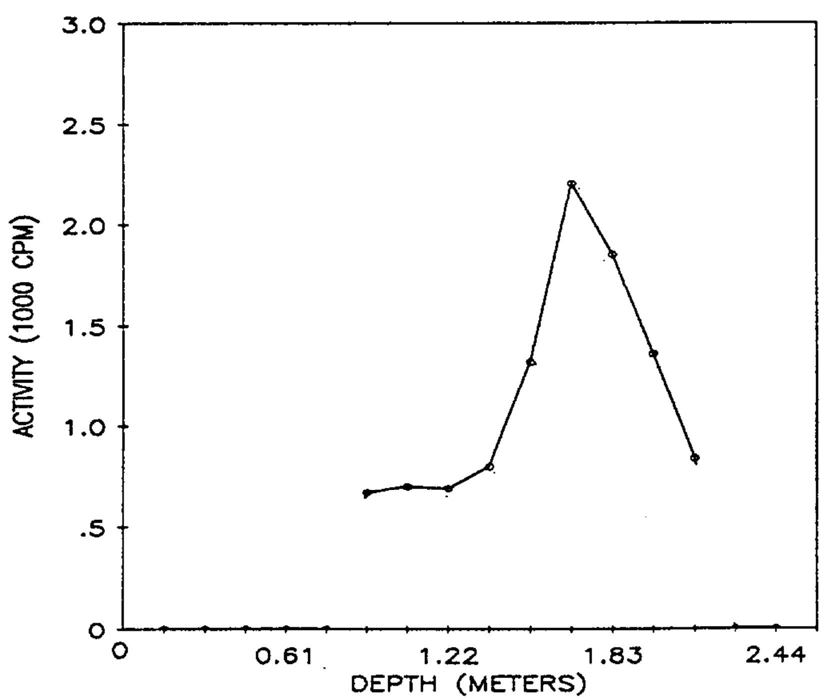

Fig. 9. Gamma profile for auger hole 12 (LJ061A12) at 80 Industrial Road, Lodi, New Jersey.

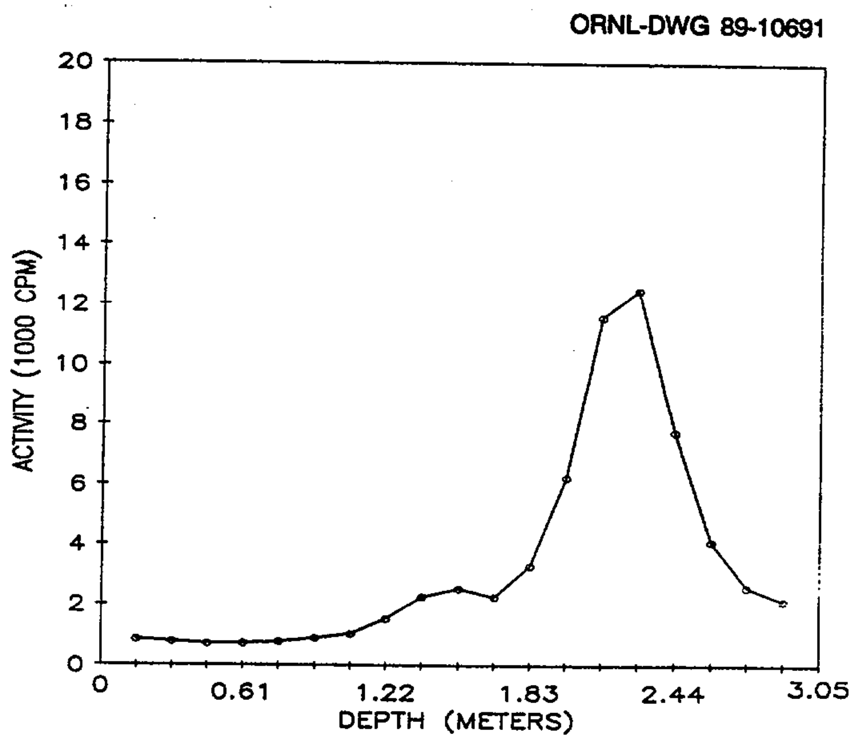

Fig. 10. Gamma profile for auger hole 24 (LJ061A24) at 80 Industrial Road, Lodi, New Jersey.

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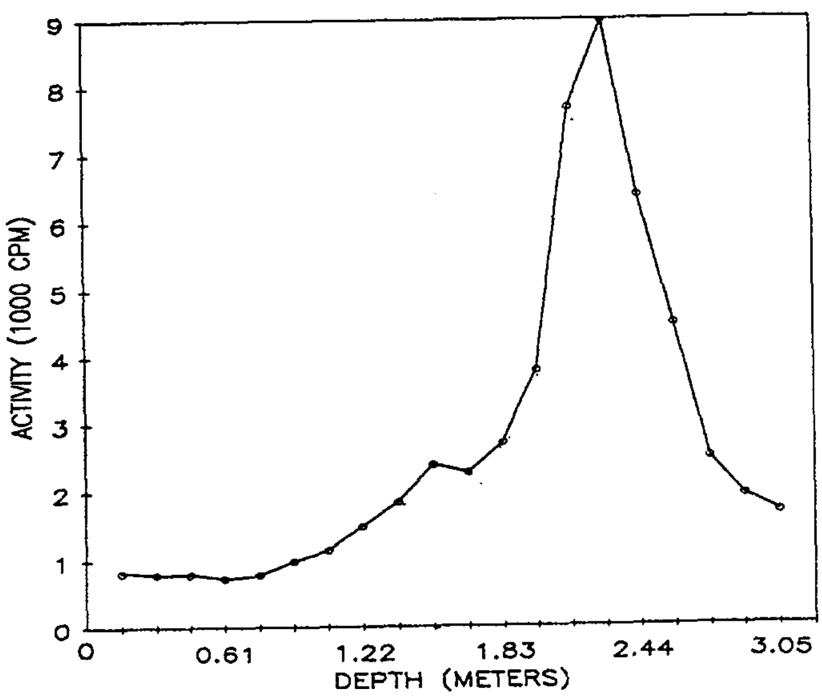

Fig. 11. Gamma profile for auger hole 25 (LJ061A25) at 80 Industrial Road, Lodi, New Jersey.

Table 1. Applicable guidelines for protection against radiation[a]

Mode of exposure	Exposure conditions	Guideline value
Radionuclide concentrations in soil	Maximum permissible concentration of the following radionuclides in soil above background levels averaged over 100 m^2 area ^{232}Th ^{230}Th ^{228}Ra ^{226}Ra	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

[a]Reference 3.

Table 2. Background radiation levels for the northern New Jersey area

Type of radiation measurement or sample	Radiation level or radionuclide concentration
Gamma exposure at 1 m above ground surface (μR/h)[a]	8
Concentrations of radionuclides in soil (pCi/g)[b]	
^{232}Th	0.9
^{238}U	0.9
^{226}Ra	0.9

[a]Reference 4.
[b]Reference 5.

Table 3. Concentrations of radionuclides in soil at 80 Industrial Road, Lodi, New Jersey (LJ061)

Sample[a]	Depth (cm)	Radionuclide concentration (pCi/g)	
		^{226}Ra[b]	^{232}Th[b]
		Systematic samples	
S1	0–15	0.59 ± 0.03	0.84 ± 0.2
S2	0–15	0.64 ± 0.1	0.83 ± 0.2
		Biased samples[c]	
B1A	0–15	3.6 ± 0.3	34 ± 0.6
B1B	15–30	4.9 ± 0.5	45 ± 0.5
B1C	30–45	1.8 ± 0.2	11 ± 0.4
B2A	0–15	1.2 ± 0.6	5.0 ± 0.4
B2B	15–30	1.2 ± 0.2	5.3 ± 0.2
B2C	30–45	0.76 ± 0.05	2.3 ± 0.07
B3A	0–15	1.0 ± 0.1	3.9 ± 0.7
B3B	15–30	1.0 ± 0.07	4.1 ± 0.2
B3C	30–45	0.67 ± 0.2	1.6 ± 0.07
B4A	0–15	1.5 ± 0.2	8.0 ± 0.4
B4B	15–30	1.6 ± 0.4	8.8 ± 0.9
B4C	30–45	1.4 ± 0.1	6.9 ± 0.7
		Auger samples[d]	
A1A	45–75	0.77 ± 0.3	0.96 ± 0.1
A2A	60–90	0.65 ± 0.1	0.84 ± 0.06
A2B	90–120	1.6 ± 0.1	11 ± 0.4
A2C	120–150	0.73 ± 0.05	0.94 ± 0.1
A3A	0–30	0.44 ± 0.1	0.59 ± 0.06
A3B	120–150	0.51 ± 0.1	0.69 ± 0.06
A4A	0–30	1.4 ± 0.2	6.7 ± 0.5
A4B	30–60	0.82 ± 0.06	1.5 ± 0.1
A4C	60–90	0.65 ± 0.1	0.84 ± 0.1
A4D	120–140	0.55 ± 0.05	1.0 ± 0.2
A5A	60–75	0.70 ± 0.2	1.0 ± 0.2
A5B	90–105	0.63 ± 0.09	0.81 ± 0.09
A5C	150–165	0.62 ± 0.1	0.67 ± 0.05
A5D	165–185	0.64 ± 0.1	0.68 ± 0.2
A5E	185–195	0.66 ± 0.03	0.74 ± 0.1
A5F	195–215	0.64 ± 0.05	0.73 ± 0.09
A5G	215–225	0.67 ± 0.2	0.89 ± 0.2
A5H	225–245	0.67 ± 0.08	0.87 ± 0.2
A8A	30–45	0.65 ± 0.09	1.0 ± 0.2
A8B	45–60	0.83 ± 0.2	3.6 ± 0.5
A8C	60–75	0.95 ± 0.3	4.4 ± 0.3
A8D	75–90	0.67 ± 0.04	0.74 ± 0.1
A9A	30–45	0.70 ± 0.1	1.1 ± 0.2
A9B	45–60	0.70 ± 0.03	1.2 ± 0.3

Table 3 (continued)

Sample[a]	Depth (cm)	Radionuclide concentration (pCi/g)	
		^{226}Ra[b]	^{232}Th[b]
		Auger samples[d]	
A9C	60–75	2.3 ± 0.2	7.8 ± 0.5
A9D	75–90	1.9 ± 0.05	7.6 ± 0.3
A12A	135–150	0.65 ± 0.09	0.87 ± 0.1
A12B	150–165	0.94 ± 0.1	3.5 ± 0.3
A12C	165–185	0.80 ± 0.08	2.8 ± 0.2
A12D	185–195	0.88 ± 0.1	3.4 ± 0.7
A12E	195–215	0.75 ± 0.4	2.4 ± 0.09
A25A	90–105	0.79 ± 0.06	3.0 ± 0.2
A25B	105–120	0.85 ± 0.2	4.3 ± 0.3
A25C	120–135	0.94 ± 0.2	8.1 ± 0.8
A25D	135–150	1.2 ± 0.1	11 ± 0.1
A25E	150–165	1.3 ± 0.08	5.3 ± 0.2
A25F	165–185	1.0 ± 0.2	2.5 ± 0.2
A25G	185–195	1.0 ± 0.08	8.0 ± 0.7
A25H	195–215	1.1 ± 0.04	14 ± 0.5
A25I	215–225	1.8 ± 0.3	48 ± 2
A25J	225–245	3.6 ± 0.6	50 ± 3
A25K	245–255	3.0 ± 0.3	64 ± 2
A25L	255–275	0.98 ± 0.2	8.6 ± 0.8
A25M	275–290	0.74 ± 0.04	2.5 ± 0.05

[a]Locations of soil samples are shown on Fig. 2.

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

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

[d]Auger samples are taken from holes drilled to further define the depth and extent of radioactive material. Holes are drilled where the surface may or may not be contaminated.

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