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RADIOLOGICAL SURVEY AT THE NAVAL EXPLOSIVE ORDNANCE DISPOSAL TECHNOLOGY CENTER, INDIAN HEAD, MARYLAND

W. D. Cottrell
R. F. Carrier

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HEALTH AND SAFETY RESEARCH DIVISION

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RADIOLOGICAL SURVEY AT THE NAVAL EXPLOSIVE ORDNANCE DISPOSAL TECHNOLOGY CENTER, INDIAN HEAD, MARYLAND

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ABSTRACT

At the request of the Department of the Navy, a radiological survey of Buildings 2083 and 2084 at the Naval Explosive Ordnance Technical Center (Indian Head, Charles County, Maryland) was performed by members of a survey team from Oak Ridge National Laboratory. Practical training in radiological emergencies, conducted for many years in the buildings, had resulted in possible radioactive contamination, which would require remedial action prior to implementation of planned structural changes. The survey included: gamma scanning of all accessible areas; sampling of surface soil and gravel; sampling of subsurface soil from auger holes; gamma logging of auger holes; sampling of drain outfall and sewer sediments; and measuring of alpha and beta-gamma activity on wall, structural, and overhead surfaces.

Radioactive contamination attributable to ^{232}Th and ^{238}U residuals was found in Bays 1, 3, 5, 51, 55, and 57 of Building 2083 and Bays 44, 50, and 56 of Building 2084. Remediation was conducted in several areas by Naval personnel subsequent to identification of localized contamination associated with scrap or visible residues. Gamma exposure rates throughout the site following cleanup were 5 to 130 μR/h with contamination remaining in Bays 1, 3, 51, 55, and 57. The maximum concentration of ^{238}U, 3800 pCi/g, occurred in surface soil collected from Bay 55. This value exceeds the average background value for the Charles County area by a factor of $\sim$4100. The maximum concentration of ^{232}Th, 95 pCi/g, was found in a surface soil sample from Bay 1. This concentration exceeded the DOE guideline of 5 pCi/g by a factor of $\sim$18. Analysis of drain outfall and sewer sediment samples revealed no evidence of the migration of significant levels of radionuclides. Structural surfaces were found to have no significant contamination by alpha and beta-gamma emitters.

INTRODUCTION

Practical training in radiological emergencies was conducted for many years in Buildings 2083 and 2084 at the Naval Explosive Ordnance Technical Center (NAVEOD-TECHCEN) located at Indian Head in Charles County, Maryland (Fig. 1). Simulations of explosive ordnance accidents typically involved depleted uranium and thorium. Planned structural changes necessitated characterization to determine the extent of radioactive contamination in unmodified areas of the buildings. At the request of the Department of the Navy, a radiological survey was conducted by Oak Ridge National Laboratory (ORNL) to identify, locate, and describe the contamination. Additionally, the findings of the survey were to be compared with levels typical for the geographic area, providing a basis on which to plan for possible remediation activities. The survey was conducted between July 21 and 27, 1986, with the assistance of Naval personnel. During the survey, these personnel conducted limited remediation procedures involving several distinct, localized regions of elevated measurements that were amenable to immediate and thorough cleanup. This report describes the results of the radiological survey in detail.

The property consists of two open metal buildings connected by an asphalt driveway. The buildings, each ~600 x 40 ft, are designated 2083 (north) and 2084 (south) and comprise sixty 20 x 40 ft bays. Many of the bays are open to each other and to the driveway. Some of the bays, and some portions of some bays, have been enclosed to form rooms over concrete pads or have been partitioned off in anticipation of future enclosure. There are variously sized concrete pads in scattered locations. Bay floors not concreted are surfaced with pea gravel over soil. In those regions, it was apparent that a clay-like material differing from the surrounding soil had been used as fill beneath the buildings. The roofs of the buildings are connected over the driveway by heavy metal wire mesh. The roofs slope from the flat mesh to a height of ~15 ft along the sides of the buildings. The roof from the west end to bays 13/14 is higher than the others. There are automatic roll-up doors at each end of the driveway. A scaled drawing of the layout of the two buildings and the grid network established for measurements is shown in Fig. 2. Figures 3 through 7 present various views of the interior of the buildings, including some of the bays in which contamination was verified.

SURVEY METHODS

The radiological survey of this property included the following: (1) gamma exposure rate measurements throughout the entire site; (2) alpha and beta-gamma activity measurements on wall, structure, driveway, and overhead surfaces; (3) radionuclide analysis of surface soil and gravel, and subsurface soil; (4) logging of gamma radiation levels at vari-

ous depths in auger holes; and (5) radionuclide analysis of drain outfall and sewer sediment samples.

The concrete pads located in various areas of the buildings, as well as the enclosures used for classes, meetings, offices, and storage, were newly constructed of uncontaminated materials. Therefore, this survey was limited to soil– and gravel–covered areas and to the walls and overhead regions surrounding these areas. In regions disclosing no elevated gamma exposure rates, the gravel was moved aside to access the soil surface for further monitoring and soil sampling. Additionally, surface measurements were obtained in Bay 40 inside a small wooden structure used for storage and containing radiation survey instruments and associated radioactive check sources.

The size of the survey blocks, which were 20–ft square, was determined by the size of the buildings and bays. These survey blocks were further subdivided for measurements in bays having elevated gamma exposure rates. A comprehensive description of survey methods and instrumentation is given in a separate report.[1]

SURVEY RESULTS

Typical background radiation levels and radionuclide concentrations in soil in the Charles County, Maryland, area are listed in Table 1. Department of Energy (DOE) guidelines for the release of property for unrestricted use are provided in Table 2. Although these guidelines are not directly applicable to this site, they may be useful as a general reference in evaluating contamination levels. Site–specific criteria will be determined by the Department of the Navy.

All direct measurements 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.

GAMMA EXPOSURE RATE MEASUREMENTS

Each accessible survey block was scanned with a portable gamma scintillation detector, and the range of gamma radiation levels was recorded. Scanning in areas showing no elevated gamma levels was performed over the surface of the undisturbed gravel as well as over the soil surface after the gravel was moved aside. At center points, after gravel removal, gamma exposure rates were determined at 1 m above the surface and at the surface. In bays disclosing elevated gamma levels, gravel was moved aside only at center points in each 10– or 20–ft grid block. A final scan of each bay was performed after the gravel was replaced.

Elevated gamma levels ranging from 15 to 500 μR/h were found in Bays 1, 3, 5, 51, 55, and 57 of Building 2083 and Bays 44, 50, and 56 of Building 2084 during the initial scan. The contaminated bays are discussed individually in the following text. The loca-

tions of the contaminated regions in Building 2083 and the measured exposure rates are shown on Figs. 8 and 9. The elevated gamma measurements noted in Building 2084 were associated with localized contamination, which was immediately remediated. Table 3 lists the gamma exposure rates measured in the buildings for each bay before (A) and after (B) the gravel was moved aside. Scan data do not include the maximum values associated with material remediated during the survey nor are the results of the final scan of remediated and uncontaminated bays tabulated. Each listing represents multiple measurements, the readings for each grid block having been averaged for center point data. Table 4 provides the gamma data for the driveway.

Gamma levels for the driveway were comparable to the typical background value of 8 μR/h for Charles County, ranging from 3 to 8 μR/h. However, gamma exposure rates over undisturbed gravel and beneath it in both buildings were slightly above the background levels for Charles County, averaging 9 μR/h at 1 m and 10 μR/h at the surface at grid block center points. With the exception of gamma levels measured over contaminated areas, these levels are quite uniform. The fill material, a finely divided, silty clay, exhibited slightly elevated gamma exposure rates when compared with local background soil.

Building 2083

Exposure rates in bays where no elevated levels were found were 5 to 13 μR/h over the gravel, ranging from 7 to 13 μR/h beneath it. An exception was noted where gamma levels on top of the gravel ranged from 5 to 15 μR/h throughout Bay 53. Exposure rates there were 7 to 12 μR/h at the soil surface. Elevated gamma levels ranging from 17 to 150 μR/h were found in Bays 1, 3, 5, 51, 55, and 57.

> ***Bays 1, 3, and 5***: Elevated gamma exposure rates in these bays ranged from 17 to 120 μR/h with the maximum level occurring at the western-most edge of a hole in Bay 3 at location 0+21, 44L. The hole was the focal point of a region having an area of ~15 m^2 and extending into Bay 1 where exposure rates were as high as 67 μR/h. Gamma levels decreased to 17 μR/h around the circumference of the area. Views of these bays, including the hole in Bay 3, are shown in Figs. 4 and 5. The gamma exposure rate measurements are indicated in Fig. 8. In Bay 1 were also two localized spots with exposure rates of 20 and 50 μR/h at grid locations 0+09, 31L and 0+13, 37L. In addition to the area centering around the hole, there were four smaller spots in Bay 3 ranging from <0.1 to 0.4 m^2 with gamma exposure rates of 20 to 50 μR/h. The area showing a gamma level of 50 μR/h was adjacent to a region in Bay 5 measuring ~0.5 m^2 and having an exposure rate of 67 μR/h. At grid location 0+40, 45L in Bay 5, three small pieces of metal gave a reading of 120 μR/h. Their removal resulted in a gamma scan range of 6 to 10 μR/h in that grid block.
>
> ***Bay 51***: Figure 9 details the gamma exposure rates measured in Bays 51, 55, and 57. Contamination was evidenced by an exposure rate of 23 μR/h within a hole located in grid block 5+00, 50L in Bay 51 (Fig. 6). Gamma levels decreased to 13 μR/h around the edge of the hole, which was ~2.5 m^2 in area. There was also a region at 5+12, 28L, ~0.3 m^2, which averaged 15 μR/h.

Bays 55 and 57: In Bay 55, grid block 5+50, 50L, two areas of ~0.4 m^2 each and one of ~0.8 m^2 exhibited gamma levels from 34 to 130 μR/h. One region extended into Bay 57 at grid point 5+60, 40L, where a measurement of 40 μR/h was detected beneath the gravel. Gamma levels rapidly decreased to 13 μR/h with increasing distance from the region. At 5+42, 41L, a small area of dark, powdery material was sampled where exposure rates were 150 μR/h (see discussion of surface soil results for Bay 55). Following remediation at this grid location, gamma levels were 5 to 130 μR/h in Bay 55.

Gamma exposure rates following gravel replacement in uncontaminated bays in this building ranged from 5 to 10 μR/h.

Building 2084

In bays disclosing no elevated gamma levels, readings ranged from 5 to 13 μR/h both before and after the gravel was moved aside. The scan showed measurements of 5 to 16 μR/h in Bay 6 prior to gravel removal, 5 to 13 μR/h after, and 7 to 10 μR/h following gravel replacement. Elevated gamma measurements noted in Bays 44, 50, and 56 were associated with localized contamination, which was removed upon discovery. Data provided in Table 3 for these bays are post-remediation values.

Bay 44: A small piece of metal at location 4+23, 15R gave a gamma exposure rate of 500 μR/h. Following its removal, gamma levels in the entire bay were 5 to 10 μR/h over the gravel and 7 to 11 μR/h beneath it.

Bay 50: At grid location 4+90, 25R, exposure rates of 84 μR/h were found in association with two small areas of gray powdery material. After remediation, gamma levels in the bay were 5 to 15 μR/h over and 10 to 13 μR/h beneath the gravel.

Bay 56: Yellowish material reading 45 μR/h was observed as an apparent coating on the surface of the gravel at grid point 5+42, 12R over an area measuring ~0.5 m in diameter. Cleanup was also performed at this location, resulting in gamma levels of 5 to 12 μR/h over the gravel and 8 to 15 μR/h beneath it.

Subsequent to remediation, Bays 44, 50, and 56 were treated as uncontaminated; that is, the gravel was moved aside for scan and center point measurements. Following cleanup and replacement of the gravel, a final scan over the surface in all bays showed a range of 5 to 10 μR/h.

SURFACE SOIL AND GRAVEL SAMPLES

Gravel and soil samples were collected from the surface at systematic locations to provide representative sampling of the site. The thickness of gravel samples varied from ~8 to 15 cm because the layer of pea gravel varied in thickness from bay to bay and from area to area within the bays. Soil samples were usually collected to depths of 8, 10, or 15

cm. However, in some cases, for further definition of contamination, sampling was extended to a depth of 85 cm.

In addition to systematic sampling, samples were collected from selected locations showing elevated gamma radiation levels and are designated as "biased" samples. In several contaminated regions, resampling was conducted to substantiate remediation to more acceptable radionuclide concentrations.

The ranges and averages calculated for systematic surface soil samples included the results for auger hole samples collected at a depth of 0 to 15 cm. Sample locations are shown in Figs. 10 and 11, with results of sample analyses detailed in Tables 5 and 6.

In bays where gamma levels indicated little or no contamination, concentrations of ^{226}Ra in systematic surface samples ranged from 0.07 to 1.2 pCi/g, averaging 0.18 pCi/g in gravel and 0.99 pCi/g in soil. These concentrations are comparable to background values found in the Charles County area. Uranium–238 concentrations ranged from 0.10 to 5 pCi/g, averaging 0.44 and 2.0 pCi/g in gravel and soil, respectively. Concentrations of ^{232}Th in gravel and soil ranged from <0.05 to 1.4 pCi/g with respective averages of 0.23 and 1.1 pCi/g. Average concentrations of all three radionuclides in gravel samples were lower than background soil values. In soil samples, ^{226}Ra concentrations approximated background values while ^{232}Th and ^{238}U concentrations were slightly higher. Radionuclide concentrations in contaminated bays are discussed below.

Building 2083

Bay 1: Concentrations of ^{226}Ra, ^{232}Th, and ^{238}U in surface soil (0–15 cm) ranged from 0.85 to 1.1 pCi/g, 0.99 to 95 pCi/g, and 1.1 to <2.5 pCi/g, respectively. The maximum concentration of ^{232}Th (95 pCi/g) was found in a sample obtained during a previous preliminary survey conducted on April 9, 1986. (This location was not resampled during the later survey). The highest concentration of ^{232}Th measured in surface soil in this bay during this survey was 12 pCi/g (auger hole sample 37A).

Bay 3: Concentrations of ^{226}Ra, ^{232}Th, and ^{238}U in surface soil ranged from 0.05 to 1.1 pCi/g, 0.44 to 12 pCi/g, and 0.11 to 2.4 pCi/g, respectively. The maximum concentration of ^{232}Th was found in the top 5 cm of soil on the grid line at 0+40, 23L (biased sample 2) and is also representative of the ^{232}Th concentration in surface soil at that grid point in Bay 5. A biased sample (13), taken at a depth of 35 to 45 cm from within the hole at grid location 0+23, 44L was found to contain 44 pCi/g ^{232}Th.

Bay 5: In this bay, radionuclide concentrations ranged from 0.84 to 1.1 pCi/g, 1.0 to 12 pCi/g, and 0.97 to 2.2 pCi/g for ^{226}Ra, ^{232}Th, and ^{238}U, respectively. As previously noted, the maximum concentration of ^{232}Th was found in biased sample 2 at the grid line shared by Bays 3 and 5. Elsewhere in Bay 5, ^{232}Th concentrations were comparatively low, ranging from 1.0 to 1.2 pCi/g.

Bay 51: Respective concentrations of ^{226}Ra, ^{232}Th, and ^{238}U in surface soil samples collected in this bay were 0.18 to 1.1 pCi/g, 0.13 to 1.3 pCi/g, and 0.60 to 2.7 pCi/g. Analyses of soil from the bottom of the hole in grid block 5+00, 50L indicate concentrations of radionuclides at or near background levels. However, soil samples were not obtained from the sides of the hole to substantiate the elevated gamma exposure rates found within it.

Bay 55: Ranges for ^{226}Ra, ^{232}Th, and ^{238}U in surface soil from this bay were 0.28 to 1.1 pCi/g, 1.1 to 1.2 pCi/g, and 1.8 to 3800 pCi/g, respectively. The maximum concentration of ^{238}U found on the site (3800 pCi/g) was identified in biased sample 8A. It was composed largely of gravel and was collected in an area containing a dark, powdery material at the edge of the concrete pad in this bay. Following cleanup in that region, resampling at a depth of 8 to 23 cm showed the ^{238}U content reduced to 2.5 pCi/g (8B).

Bay 57: Respective ranges for ^{226}Ra, ^{232}Th, and ^{238}U in this bay were 0.07 to 0.33 pCi/g, <0.08 to 0.42 pCi/g, and 0.43 to 93 pCi/g. Uranium–238 at a concentration of 93 pCi/g was found in a biased soil sample (9) collected from a depth of 0 to 8 cm in an area of elevated gamma levels at grid point 5+60, 40L near contamination noted in Bay 55.

Building 2084

Bay 44: The respective ranges of concentrations for ^{226}Ra, ^{232}Th, and ^{238}U in surface soil were 0.33 to 0.96 pCi/g, 0.30 to 1.1 pCi/g, and 1.2 to 350 pCi/g. Contamination by ^{238}U was evidenced by an analysis result of 350 pCi/g at grid location 4+23, 15R, where a piece of metal having elevated gamma levels had been observed and removed.

Bay 50: Concentrations of ^{226}Ra, ^{232}Th, and ^{238}U in surface soil were 0.11 to 1.1 pCi/g, 0.99 to 27 pCi/g, and 0.53 to 2.2 pCi/g. At the location where a gray, powdery substance showed elevated gamma exposure rates, soil sampling showed an initial ^{232}Th content of 27 pCi/g, which was reduced to 0.99 pCi/g by remediation (biased samples 4 and 4A).

Bay 56: Ranges of concentrations of ^{226}Ra, ^{232}Th, and ^{238}U in surface soil were 0.62 to 1.1 pCi/g, <0.15 to 1.3 pCi/g, and 1.4 to 1800 pCi/g, respectively. Sampling of surface soil where the gravel appeared to be coated with a yellowish substance showed the concentration of ^{238}U reduced from 1800 pCi/g ^{238}U to 17 pCi/g subsequent to remediation.

SUBSURFACE SOIL SAMPLES AND GAMMA LOGGING OF AUGER HOLES

Holes were augered at locations shown in Fig. 11. One or more soil samples were collected from each hole at depths from 0 to 0.9 m. The sampling depths were chosen with respect to the degree and type of contamination as evidenced by the gamma exposure

rates. At selected locations, split-spoon samplers were used to collect subsurface samples at known depths. Concentrations of ^{226}Ra, ^{232}Th, and ^{238}U in each subsurface soil sample are given in Table 6. The reported ranges and averages are drawn from samples collected at depths of 15 cm and below and include the data from both contaminated and uncontaminated bays.

The amount of ^{226}Ra in subsurface soil was comparable to background, ranging from 0.16 to 1.2 pCi/g and averaging 1.0 pCi/g. Thorium-232 analysis showed a range of 0.16 to 1.5 pCi/g and an average of 1.2 pCi/g. Concentrations of ^{238}U ranged from 0.70 to 3.4 pCi/g with an average concentration of 1.5 pCi/g. As found for surface soil, ^{232}Th and ^{238}U values slightly exceeded the background ranges.

Each of the auger holes was "logged" using a gamma scintillation detector. A plastic pipe (PVC Schedule 40) with a 4-in. inside diameter was placed in the 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 hole depth. Measurements were usually made at 15- or 30-cm intervals. Logging of the auger holes was done at depths of 0 to ~1.7 m to determine if the contamination found during the gamma survey extended to the subsurface strata. Profiles of gamma intensity as a function of depth are presented in the Appendix.

The logging technique used here is not radionuclide-specific. However, logging data, in conjunction with soil analysis data, may be used to estimate the region of contamination in auger holes. It appears from a comparison of these data that a reading of 1000 cpm or greater using the shielded scintillator indicates the presence of elevated concentrations of ^{226}Ra, ^{232}Th, and/or ^{238}U. Consequently, soil giving rise to 1000 cpm or greater on the scintillator or containing radionuclide concentrations above criteria (Table 2) as determined from soil analysis is considered as contaminated soil. Using these criteria, it may be seen that the contamination observed at this site is surficial and does not penetrate below the upper 30 cm of soil except within the large hole in Bay 3. Concentrations of ^{232}Th as high as 44 pCi/g were observed at depths of 35-45 cm in this hole. No indication of significant subsurface contamination was observed using the "logging" and sampling procedures employed on this site.

OUTFALL AND SEWER SAMPLES

Samples were obtained from the soil surface next to the exterior walls of the buildings where outfall from roof drains was deposited. Additionally, sediment samples were taken from three storm sewer drains located down the center of the driveway and from the storm sewer outfall near its entry into the river (Fig. 2). One of the drains (location shown on Fig. 2) is visible in Fig. 3. Table 7 lists the concentrations of ^{226}Ra, ^{232}Th, and ^{238}U found in these samples.

Radionuclide analysis of roof drain outfall samples indicated ^{226}Ra in concentrations ranging from 0.29 to 0.86 pCi/g, averaging 0.63 pCi/g. Concentrations of ^{232}Th were 0.19 to 1.0 pCi/g with an average of 0.69 pCi/g. Uranium-238 was found in amounts ranging from 0.05 to 3.2 pCi/g and averaging 1.0 pCi/g.

In sediment samples from storm sewers, the content of ^{226}Ra was determined to range from 0.17 to 0.53 pCi/g, averaging 0.36 pCi/g. Thorium-232 values encompassed a range of 0.3 to 0.9 pCi/g, with an average of 0.5 pCi/g. An average ^{238}U concentration of 1.7 pCi/g was calculated from a range of 0.70 to 3.3 pCi/g. The maximum concentration of ^{238}U, 3.3 pCi/g, was collected in a sample from the storm sewer outfall near the river. For both roof drain outfalls and sewer samples, concentrations of ^{226}Ra and ^{232}Th were within the range of soil background values for the Charles County area (Table 1) while the average concentration of ^{238}U was above the background average (0.93 pCi/g).

ALPHA AND BETA-GAMMA MEASUREMENTS

Walls and Overhead Surfaces

For the survey of wall and overhead surfaces, measurements of direct alpha and beta-gamma levels were made at numerous points as uniformly spaced as practicable. Beta-gamma dose rates were measured at 1 cm above the surface with an end window Geiger-Mueller tube. In addition, smears were obtained from overhead structures at frequent intervals to establish transferable alpha and beta-gamma levels. All results were averaged by bay. The walls were surveyed throughout their entire height (~15 ft); overhead surface measurements were made beneath the roof as well as on support beams. Figure 7 shows these structures and the personnel lift used to obtain overhead measurements.

Table 8 lists measurements of direct alpha and beta-gamma contamination levels made on wall surfaces. The range of direct alpha activity in both buildings was 0 to 100 dpm/100 cm^2, the average levels by bay varying from 4 to 45 dpm/100 cm^2. The maximum activity was detected on the back walls of contaminated Bays 1 and 3. Beta-gamma dose rates in the buildings ranged from <0.01 to 0.03 mrad/h, averaging (by bay) <0.01 to 0.02 mrad/h.

Fixed alpha and beta-gamma activity levels measured on surfaces beneath the roof and on supporting beams are presented in Table 9. Direct alpha levels ranged from 0 to 160 dpm/100 cm^2 in both buildings and on the driveway with corresponding averages by bay ranging from <1 to 70 dpm/100 cm^2. Beta-gamma dose rates ranged from <0.01 to 0.02 mrad/h with bay-averaged arithmetic means of 0.01 to 0.02 mrad/h. All measurements of removable alpha and beta-gamma activity were below minimum detectable levels (20 and 200 dpm/100 cm^2, respectively).

Wooden Structure, Bay 40

Measurements of fixed alpha contamination levels were determined on floor, wall, and shelf surfaces inside this building as well as on the exterior surface of the case containing a radioactive check source. The location of directly determined alpha measurements is shown in Fig. 12. Alpha activity levels ranged from 60 to 250 dpm/100 cm^2 and averaged 120 dpm/100 cm^2. Transferable alpha and beta-gamma measurements were all below the respective minimum detectable activity levels of 20 and 200 dpm/100 cm^2.

SIGNIFICANCE OF FINDINGS

Radioactive contamination was found in several regions in both buildings and was attributable to the presence of ^{232}Th and/or ^{238}U residuals. Limited remediation of contamination was carried out at the time of the survey in Bays 5 and 55 (one spot in each bay, others remain) of Building 2083 and in Bays 44, 50, and 56 of Building 2084, lowering gamma exposure rates and soil radionuclide concentrations in the remediated areas to levels comparable to those found in uncontaminated areas. Regions of elevated measurements in Bays 1, 3, 51, and 57 were left undisturbed.

In general, gamma exposure rates in both buildings exceeded typical background levels for the Charles County area (8 μR/h), averaging 9 μR/h at 1 m above the surface and 10 μR/h at the surface. These values, however, are well below the DOE guideline of 20 μR/h above background for indoor radiation levels in habitable structures. Measurements in uncontaminated and remediated regions were 5 to 10 μR/h subsequent to the replacement of gravel. The maximum exposure rate detected on the site (500 μR/h) was associated with removable metallic material in Bay 44. Remediation in most cases was possible due to the localization of contamination on or in metallic scrap (Bays 5 and 44), gravel coated with apparent oxidized material (Bay 50), or visible residues (Bays 55 and 56). The range of gamma levels was 15 to 130 μR/h in the contaminated regions remaining in Bays 1, 3, 5, 51, 55, and 57.

The results of radionuclide analyses of soil and gravel samples taken from uncontaminated bays are summarized in Table 10. Background values found in soil collected from locations on the NAVEODTECHCEN site but removed from the area of interest are provided for comparison. Average concentrations of ^{232}Th and ^{238}U in surface soil (1.1 and 2.0 pCi/g, respectively) and subsurface soil (1.2 and 1.5 pCi/g, respectively) were consistently, though only slightly, above typical background (0.98 and 1.2 pCi/g, respectively). Concentrations of ^{226}Ra in all gravel samples and in soil samples from uncontaminated areas approximated background.

In contaminated bays, the maximum concentration of ^{232}Th found in soil was 95 pCi/g in a biased surface sample obtained from Bay 1. That amount exceeds the average background value by 125 times and the DOE criterion for surface soil (5 pCi/g) by a factor of 18. The maximum amount of ^{238}U in a biased sample, 3800 pCi/g, was ~4100 times the average level. The region of maximum ^{238}U concentration was remediated during the survey with the resulting final maximum being 93 pCi/g ^{238}U (Bay 57) in surface soil. Concentrations of both ^{226}Ra and ^{232}Th in sediment samples from drains and outfalls were below average soil background values. Average concentrations of ^{238}U in both types of samples were within the range of background.

No significant surface contamination was found on wall, overhead, driveway, or structural surfaces (wooden storage building, Bay 40) at this site. All measurements of surface contamination levels were well below the more restrictive (^{232}Th) DOE guideline values of 1000 dpm/100 cm^2 and 0.2 mrad/h for fixed alpha and beta–gamma activity, and 200 dpm/100 cm^2 and 1000 dpm/100 cm^2 for transferable alpha and beta–gamma activity, respectively.

In summary, regions of elevated gamma exposure rates were found in Bays 1, 3, 5, 51, 55, and 57 of Building 2083, and Bays 44, 50, and 56 of Building 2084. The results of radionuclide analysis established that the contamination was due to the presence of ^{232}Th and/or ^{238}U residuals in soil. The contamination was confined to the soil surface at depths of 0 to 30 cm with the exception of localized subsurface contamination in Bay 3. Remediation conducted in Bays 44, 50, and 56 at the time of the survey lowered gamma exposure rates and soil radionuclide concentrations to levels below the appropriate guidelines. Limited cleanup activities were also conducted in Bays 5 and 55. Maximum concentrations of ^{232}Th and ^{238}U in remaining surface soil samples were 1.2 and 1.9 pCi/g, respectively (Bay 5), and 1.2 and 3.3 pCi/g, respectively (Bay 55). Maximum concentrations of ^{232}Th and ^{238}U remaining in Building 2083 where no cleanup was performed were 95 and <2.5 pCi/g, respectively (Bay 1); 12 and 2.4 pCi/g, respectively (Bay 3); 1.3 and 2.7 pCi/g, respectively (Bay 51); and 0.42 and 93 pCi/g, respectively (Bay 57). Gamma levels in contaminated regions remaining in Bays 1, 3, 5, 51, 55, and 57 ranged from 15 to 130 μR/h.

Maximum concentrations of ^{232}Th and ^{238}U in surface soil following remediation were 95 pCi/g (Bay 1) and 93 pCi/g (Bay 57), respectively. The maximum concentration of ^{232}Th remaining in subsurface soil and exceeding the guideline value was 44 pCi/g in Bay 3. Uranium-238 values remaining in subsurface soil were below the guideline.

Wall, overhead, driveway, and structural surfaces were found to be free of significant contamination. Radionuclide concentrations in sediments from driveway drains and in outfall from roof drains were within the range of typical Charles County background values.

REFERENCES

1. T. E. Myrick, B. A. Berven, W. D. Cottrell, W. A. Goldsmith, and F. F. Haywood, *Procedures Manual for the ORNL Radiological Survey Activities (RASA) Program*, Oak Ridge National Laboratory, ORNL/TM-8600 (April 1987).

ORNL-DWG 87-16441

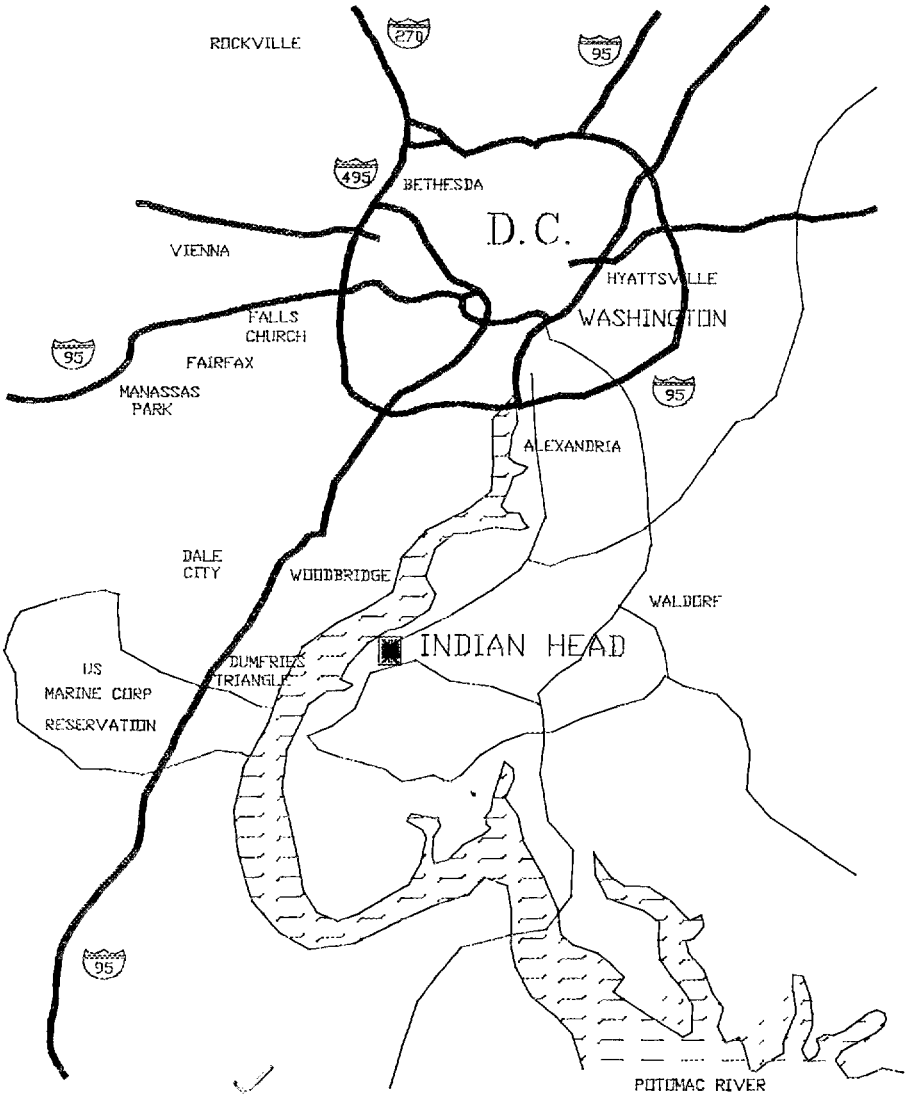

Fig. 1. Diagram showing general location of the NAVEODTECHCEN site, Indian Head, Maryland.

ORNL-DWG 87-16442

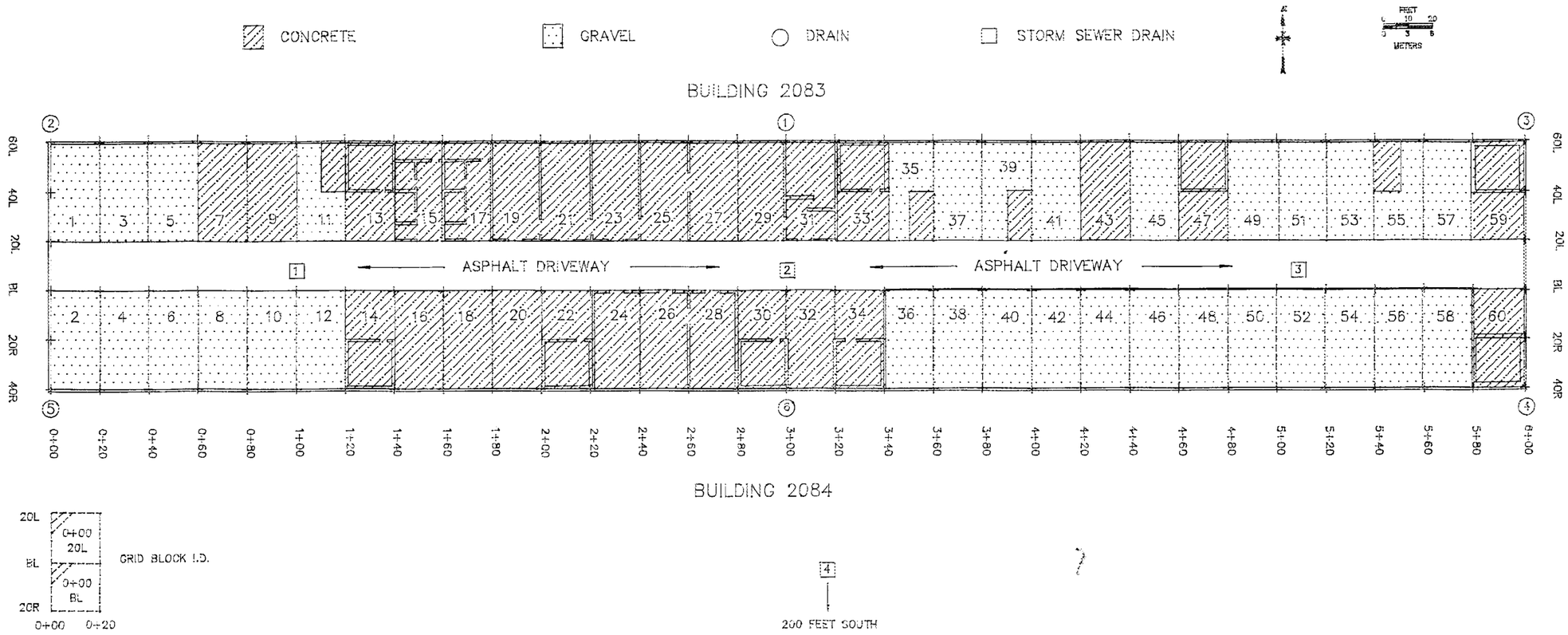

Fig. 2. Scaled drawing of the buildings and grid system used in the survey.

ORNL-PHOTO 6808-87

Fig. 3. View of the buildings and driveway looking east.

ORNL-PHOTO 6809-87

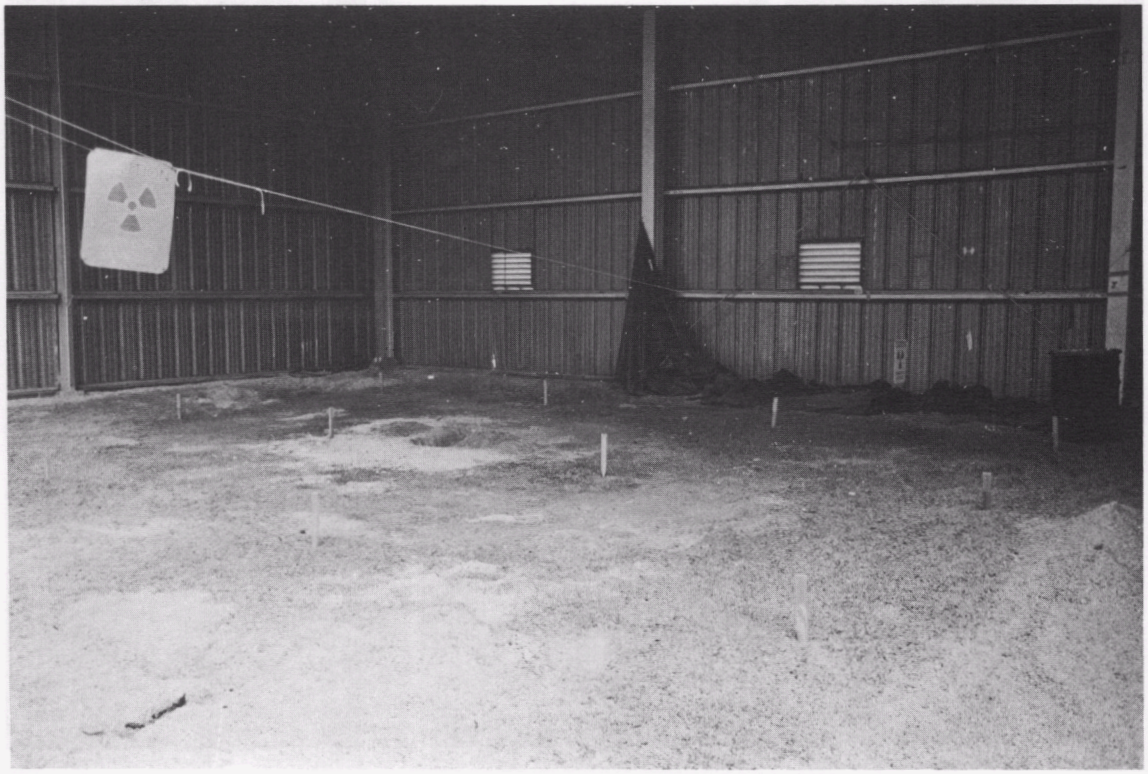

Fig. 4. View of Bays 1 and 3, looking northwest toward the contaminated hole in Bay 3.

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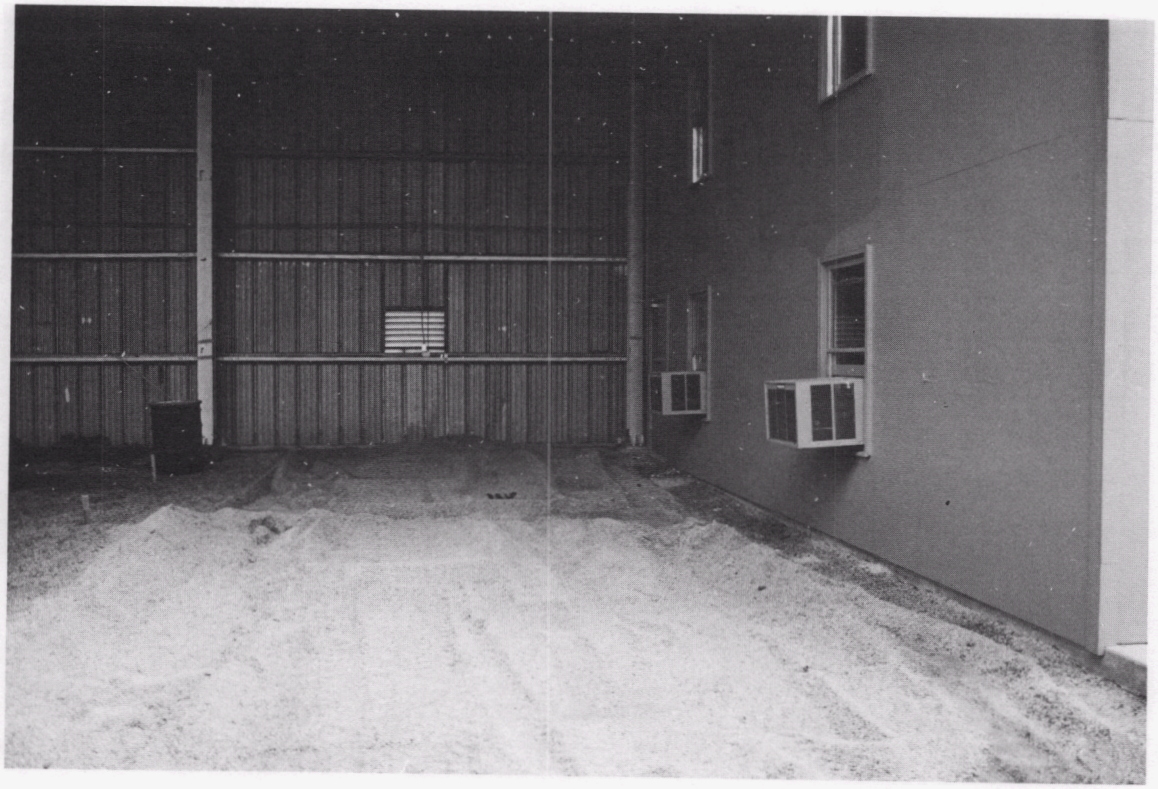

Fig. 5. View into Bay 5, looking north.

ORNL-PHOTO 68011-87

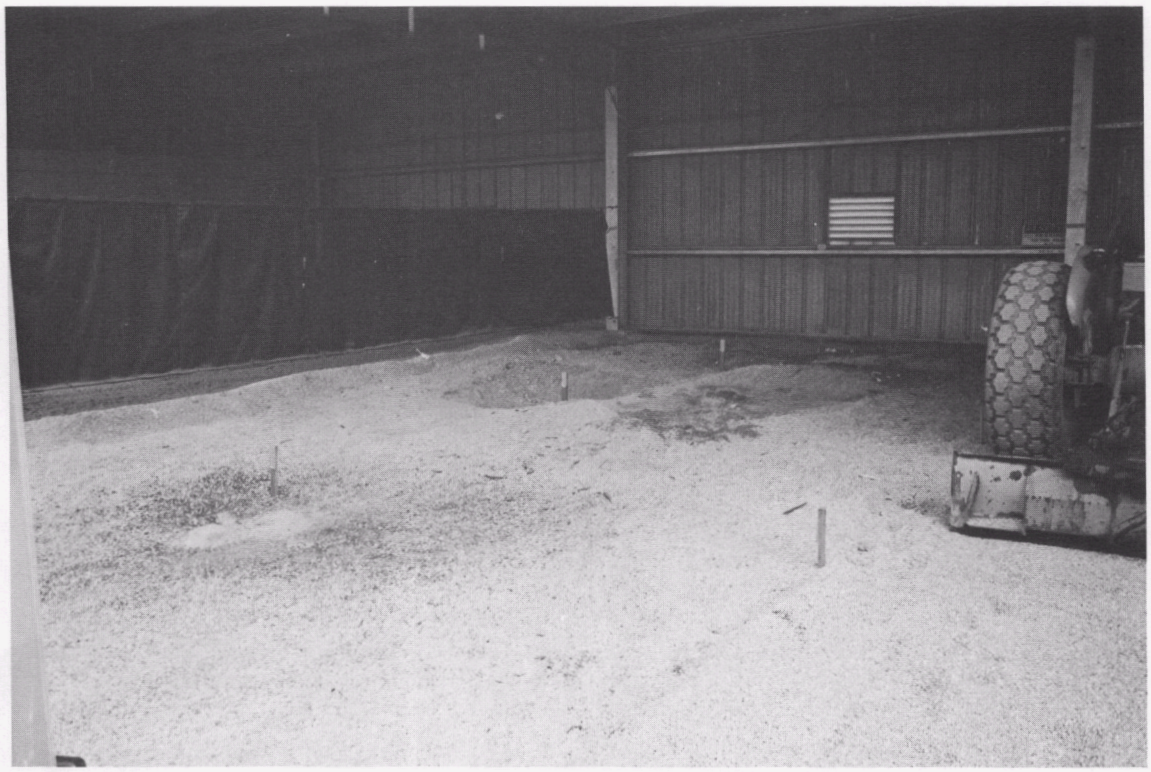

Fig. 6. View of Bay 51, looking northwest at contaminated hole.

ORNL-PHOTO 68012-87

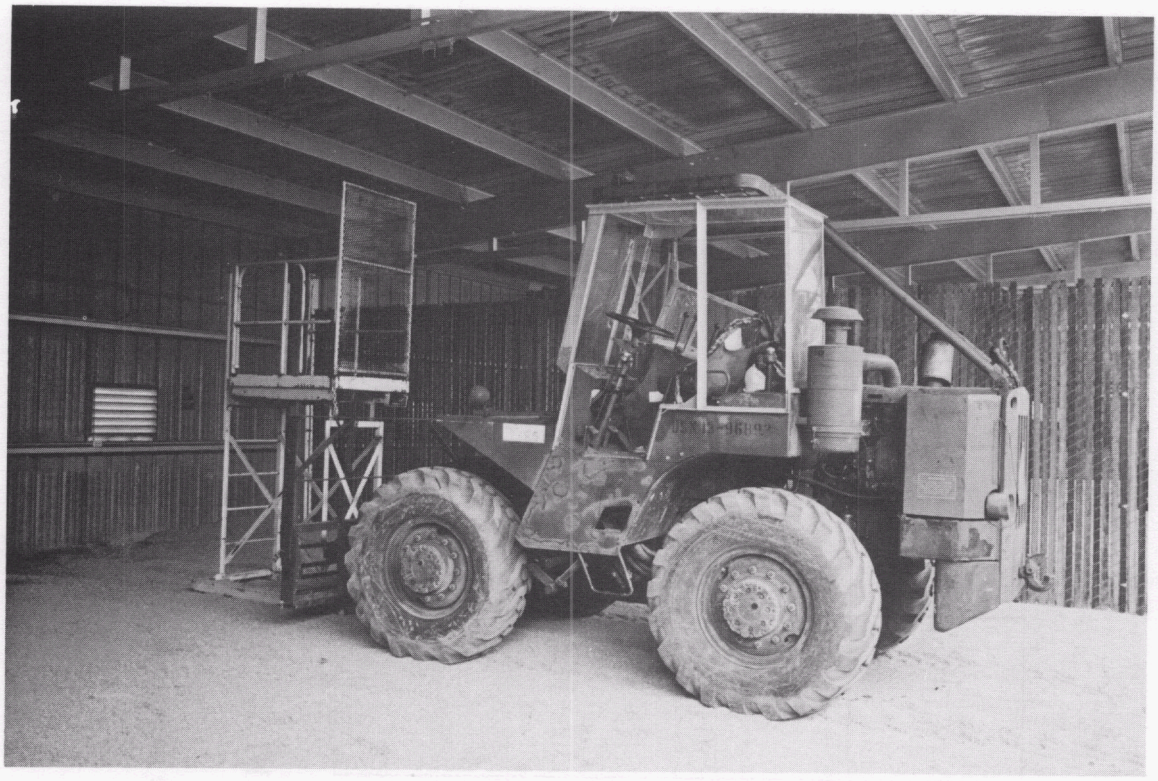

Fig. 7. View of overhead structures and personnel lift.

ORNL-DWG 87-16443

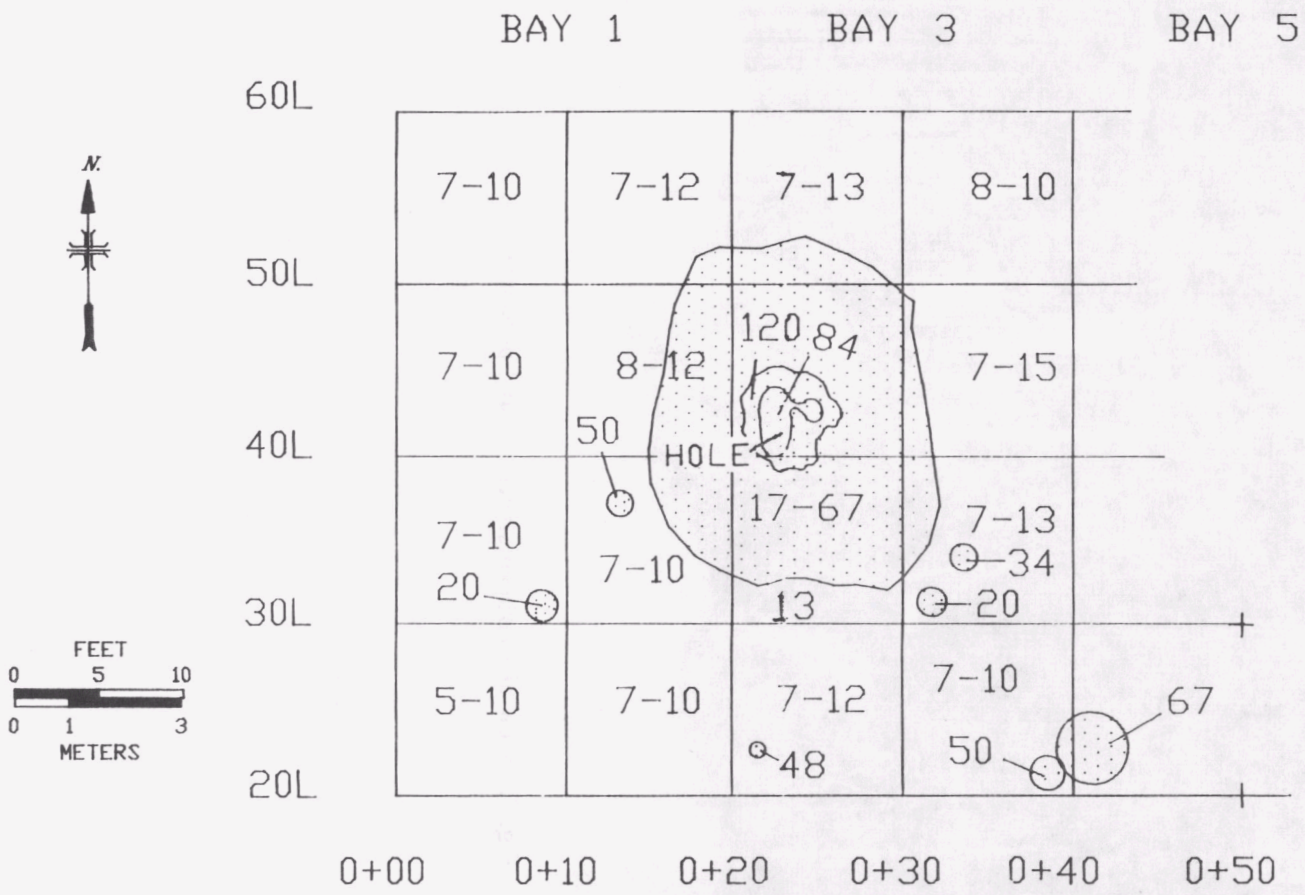

Fig. 8. Gamma exposure rate measurements (μR/h) in Bays 1, 3, and 5.

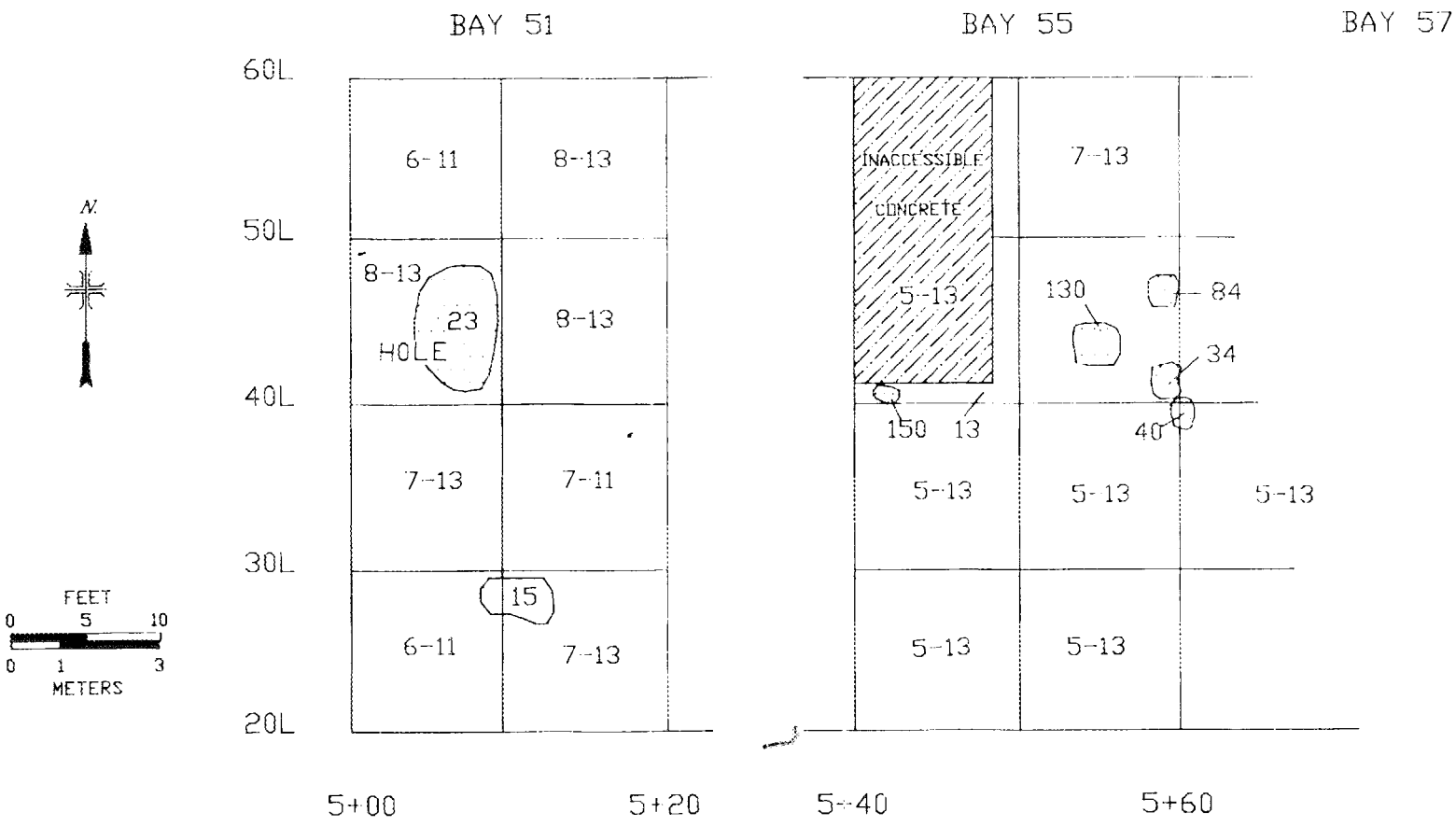

Fig. 9. Gamma exposure rate measurements (μR/h) in Bays 51, 55, and 57.

ORNL-DWG 87-16445

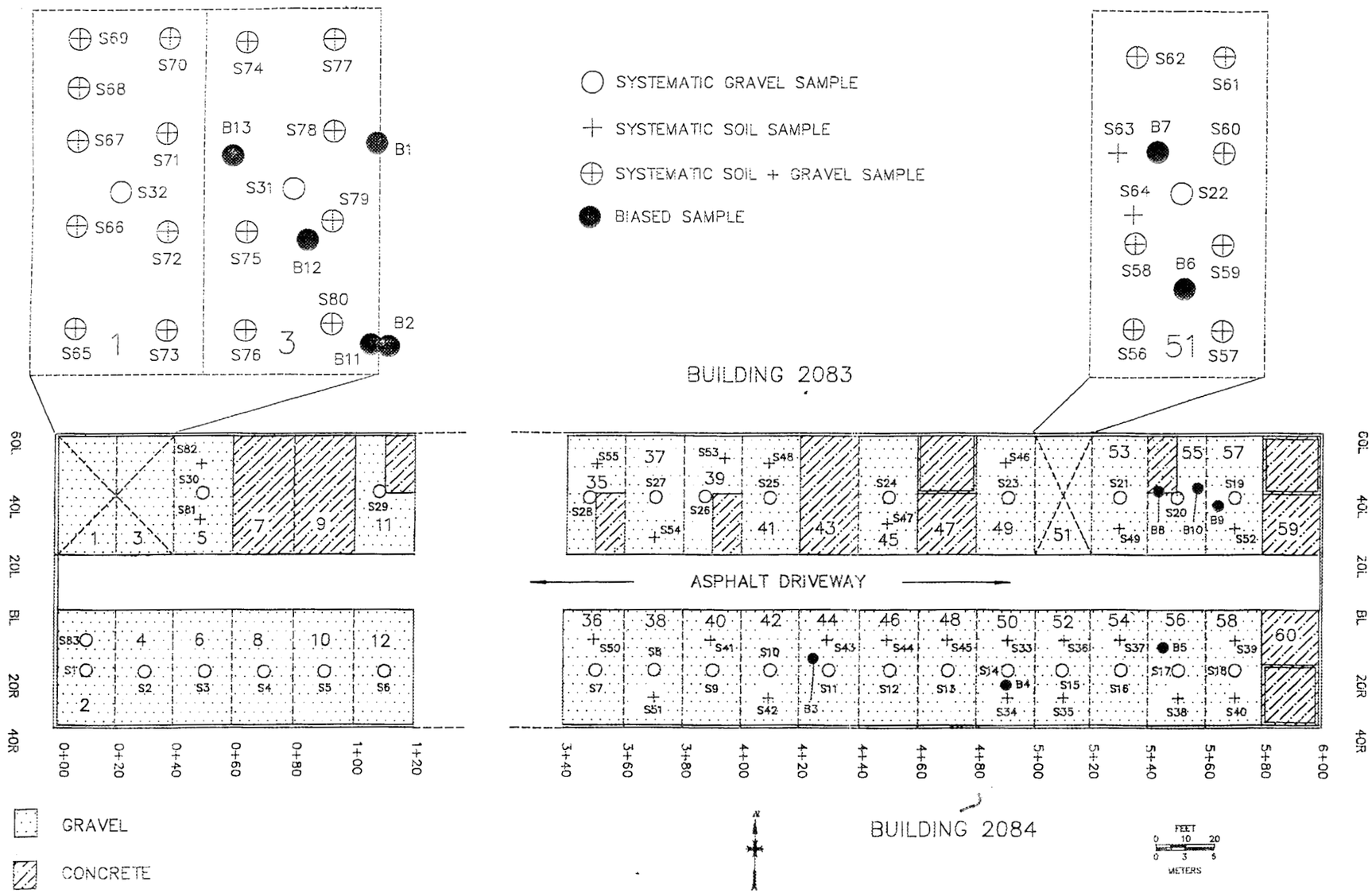

Fig. 10. Location of surface soil and gravel samples.

ORNL-DWG 87-16446

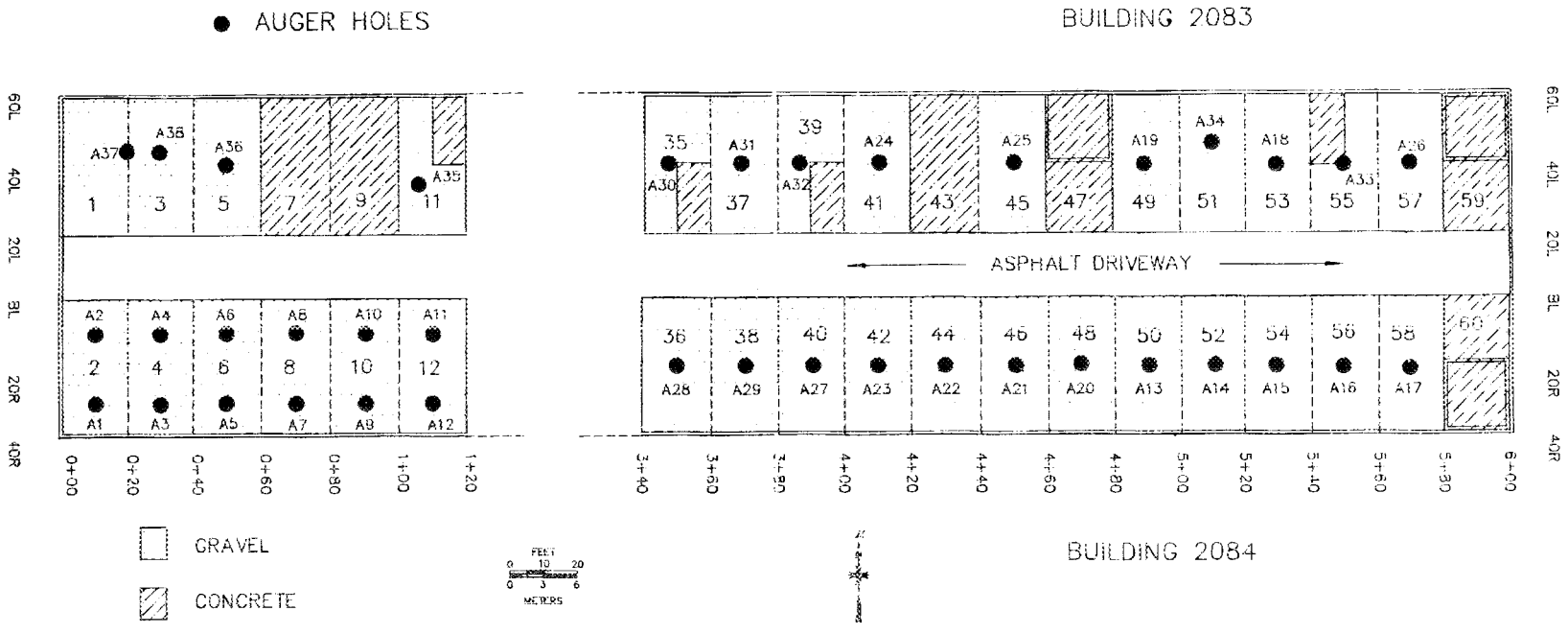

Fig. 11. Location of auger holes and subsurface soil samples.

ORNL-DWG 87-16447

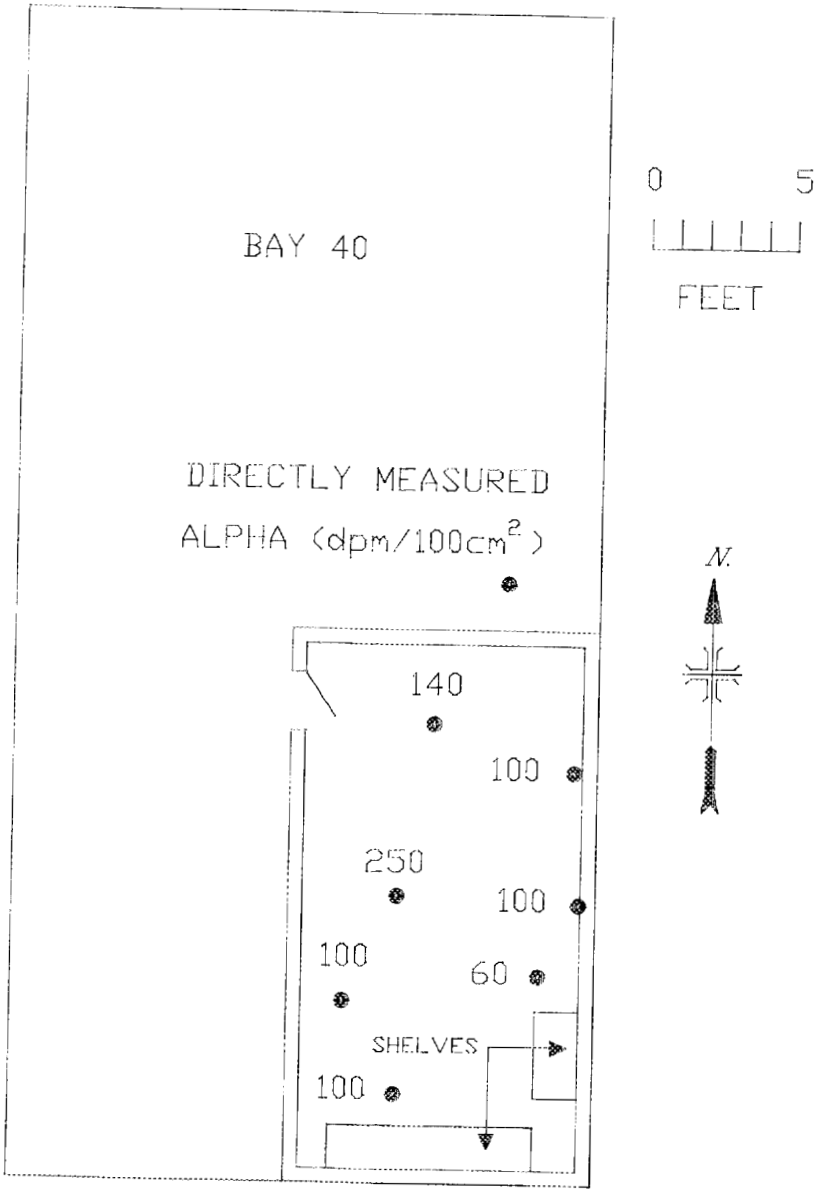

Fig. 12. Directly measured alpha contamination levels in wooden structure, Bay 40.

Table 1. Background radiation levels in the Charles County, Maryland, area

Type of radiation measurement or sample	Radiation level or radionuclide concentration	
	Range	Average
Gamma exposure rate at 1 m above floor or ground surface (μR/h)[a]	–	8
Concentration of radionuclides in soil (pCi/g)[b]		
^{238}U	0.8–1.2	0.93
^{226}Ra	0.65–1.1	0.78
^{232}Th	0.62–0.98	0.74

[a]Values obtained from two locations in Charles County, Maryland. Both measurements were 8 μR/h.

[b]Values obtained from the two Charles County locations and three uncontaminated offsite regions at the naval base.

Table 2. Applicable guidelines for protection against radiation[a]

Mode of exposure	Exposure conditions	Guideline value
Gamma radiation	Indoor gamma radiation level (above background)	20 μR/h
Surface alpha contamination	^{232}Th contamination fixed on surfaces	1000 dpm/100 cm^2
	Removable ^{232}Th contamination	200 dpm/100 cm^2
	^{238}U contamination fixed on surfaces	5000 dpm/100 cm^2
	Removable ^{238}U contamination	1000 dpm/100 cm^2
Surface beta contamination	Removable beta–gamma emitters[b]	1000 dpm/100 cm^2
Beta–gamma dose rates	Surface dose rate averaged over not more than 1 m^2	0.20 mrad/h
	Maximum dose rate in any 100 cm^2 area	1.0 mrad/h
Radionuclide concentrations in soil	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]U.S. Department of Energy Guidelines for Residual Radioactivity at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites (July 1985).

[b]Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except ^{90}Sr, ^{228}Ra, ^{223}Ra, ^{227}Ac, ^{133}I, ^{131}I, ^{129}I, and ^{125}I.

Table 3. Gamma exposure rate measurements in Buildings 2083 and 2084

Location[a]	Surface status[b]	Center point measurements[c]		Range of gamma exposure rates during scan of grid block[d] (μR/h)
		Gamma exposure rate at 1 m (μR/h)	Gamma exposure rate at surface (μR/h)	
		Building 2083		
Bay				
1	A	11	12	5–67
	B	e	13	e
3	A	14	15	7–120
	B	e	11	e
5	A	9	9	5–67
	B	e	8	e
11	A	6	6	5–8
	B	7	10	7–12
35	A	7	8	5–10
	B	8	9	7–12
37	A	7	7	5–7
	B	8	9	7–12
39	A	8	8	5–8
	B	f	f	5–10
41	A	7	7	5–7
	B	8	8	7–10
45	A	7	7	5–8
	B	8	11	7–13
49	A	8	9	5–10
	B	9	10	7–10
51	A	10	11	6–23
	B	7	10	e
53	A	10	11	5–15
	B	f	f	7–12
55	A	9	10	5–130
	B	12	23	e
57	A	7	7	5–8
	B	f	f	5–40
		Building 2084		
Bay				
2	A	10	11	5–12
	B	g	g	5–12
4	A	11	12	5–12
	B	g	g	5–13
6	A	10	12	5–16
	B	g	g	5–13
8	A	11	12	5–12
	B	g	g	5–13

Table 3 (continued)

Location[a]	Surface status[b]	Center point measurements[c]		Range of gamma exposure rates during scan of grid block[d] (μR/h)
		Gamma exposure rate at 1 m (μR/h)	Gamma exposure rate at surface (μR/h)	
10	A	9	10	5–11
	B	g	g	5–13
12	A	10	12	5–12
	B	g	g	6–13
36	A	8	9	5–12
	B	8	10	7–12
38	A	7	7	5–8
	B	7	9	7–12
40	A	8	9	5–13
	B	9	11	8–12
42	A	7	7	5–11
	B	9	11	7–12
44	A	8	10	5–10
	B	9	10	7–11
46	A	8	10	7–10
	B	10	11	8–12
48	A	9	9	5–10
	B	8	10	7–12
50	A	9	9	5–15
	B	g	g	10–13
52	A	11	12	5–12
	B	g	g	7–13
54	A	10	11	5–12
	B	g	g	10–13
56	A	11	12	5–12
	B	g	g	8–15
58	A	10	11	5–12
	B	g	g	8–12

[a]Location shown in Fig. 2.

[b]Measurements listed under "A" were taken on top of undisturbed gravel. Those listed under "B" were recorded over soil after the gravel was moved aside.

[c]Center point measurements are discrete measurements at the center of each grid block. Multiple center point measurements recorded in each bay were averaged to obtain these data.

[d]Grid block measurements encompass the range of gamma readings obtained by scanning the entire bay.

[e]Gravel was moved aside only at center points in bays having elevated gamma levels.

[f]Inaccessible.

[g]No measurement taken.

Table 4. Radiological measurements on the driveway between Buildings 2083 and 2084

Bay	Grid block[a]	Center point measurements[b]		Range of gamma exposure rates during scan of grid block[c] (μR/h)	Direct alpha (dpm/100 cm²)[d]
		Gamma exposure rate at 1 m (μR/h)	Gamma exposure rate at surface (μR/h)		
1–2	0+00, 20L	3	3	3–7	30
3–4	0+20, 20L	3	3	3–7	30
5–6	0+40, 20L	3	3	3–7	30
7–8	0+60, 20L	3	4	3–7	60
9–10	0+80, 20L	3	4	3–7	30
11–12	1+00, 20L	3	4	3–7	40
13–14	1+20, 20L	4	4	3–7	30
15–16	1+40, 20L	3	3	3–7	0
17–18	1+60, 20L	3	3	3–7	40
19–20	1+80, 20L	3	4	3–8	30
21–22	2+00, 20L	3	3	3–7	30
23–24	2+20, 20L	3	3	3–7	30
25–26	2+40, 20L	4	5	3–7	30
27–28	2+60, 20L	5	5	3–7	30
29–30	2+80, 20L	5	5	3–7	40
31–32	3+00, 20L	4	4	3–7	60
33–34	3+20, 20L	3	3	3–7	30
35–36	3+40, 20L	4	4	3–7	0
37–38	3+60, 20L	4	4	3–8	60
39–40	3+80, 20L	4	4	3–7	0
41–42	4+00, 20L	4	3	3–7	0
43–44	4+20, 20L	4	4	3–7	0
45–46	4+40, 20L	4	4	3–7	0
47–48	4+60, 20L	4	4	3–7	0
49–50	4+80, 20L	4	4	3–7	0
51–52	5+00, 20L	4	4	3–7	0
53–54	5+20, 20L	3	4	3–7	0
55–56	5+40, 20L	3	4	3–7	40
57–58	5+60, 20L	3	4	3–7	0
59–60	5+80, 20L	5	6	3–7	40

[a]Location shown on Fig. 2.

[b]Center point measurements are discrete measurements at the center of each grid block.

[c]Grid block measurements are obtained by a gamma scan of the entire block.

[d]Measurements of transferable contamination levels were less than the minimum detectable activity (MDA) at the 95% confidence level of 20 dpm/100 cm² for alpha and 200 dpm/100 cm² for beta–gamma in each grid block.

Table 5. Concentration of radionuclides in systematic and biased soil and gravel samples

Bay	Grid location[a]	Sample[b]	Depth (cm)	Radionuclide concentration[c] (pCi/g)		
				^{226}Ra[d]	^{232}Th[d]	^{238}U[e]
			Systematic Samples[f]			
			Pea gravel			
2	0+10, 10R	83	0–10	0.89 ± 0.1	1.1 ± 0.1	0.97
	0+10, 20R	1	0–10	0.12 ± 0.01	0.09 ± 0.09	0.40
4	0+30, 20R	2	0–10	0.10 ± 0.04	<0.06	1.2
6	0+50, 20R	3	0–10	0.07 ± 0.02	0.09 ± 0.07	0.25
8	0+70, 20R	4	0–10	0.09 ± 0.04	0.09 ± 0.06	0.22
10	0+90, 20R	5	0–10	0.07 ± 0.03	0.08 ± 0.04	0.50
12	1+10, 20R	6	0–10	0.08 ± 0.03	<0.06	0.16
36	3+50, 20R	7	0–10	0.09 ± 0.02	<0.07	<0.73
38	3+70, 20R	8	0–10	0.09 ± 0.02	0.08 ± 0.05	<0.73
40	3+90, 20R	9	0–10	0.19 ± 0.04	1.3 ± 0.21	<0.80
42	4+10, 20R	10	0–10	0.11 ± 0.02	0.11 ± 0.05	1.5
44	4+30, 20R	11	0–10	0.33 ± 0.1	0.32 ± 0.07	0.19
46	4+50, 20R	12	0–10	0.15 ± 0.03	0.14 ± 0.08	0.20
48	4+70, 20R	13	0–10	0.13 ± 0.01	0.15 ± 0.03	0.21
50	4+90, 20R	14	0–10	0.08 ± 0.04	<0.07	<0.15
	Composite[g]	86	0–10	0.10 ± 0.02	0.16 ± 0.06	0.43
52*	5+10, 20R	15	0–10	0.07 ± 0.02	<0.05	0.27
54*	5+30, 20R	16	0–10	0.09 ± 0.02	0.07 ± 0.06	0.16
56*	5+50, 20R	17	0–10	0.10 ± 0.05	0.08 ± 0.09	0.16
58*	5+70, 20R	18	0–10	0.08 ± 0.01	0.07 ± 0.03	0.16
*	Composite[g]	84	0–10	0.09 ± 0.02	0.10 ± 0.05	<0.2
1	0+05, 25L	65A	0–10	0.08 ± 0.03	0.72 ± 0.1	0.32
	0+15, 25L	73A	0–10	0.09 ± 0.04	0.12 ± 0.07	0.09
	0+05, 35L	66A	0–10	0.09 ± 0.05	0.11 ± 0.03	0.14
	0+15, 35L	72A	0–10	0.10 ± 0.03	0.42 ± 0.09	0.21
	0+10, 40L	32	0–10	0.10 ± 0.01	0.75 ± 0.07	0.16
	0+05, 45L	67A	0–10	0.10 ± 0.01	0.09 ± 0.08	<0.17
	0+15, 45L	71A	0–10	0.09 ± 0.03	0.69 ± 0.1	0.14
	0+05, 50L	68A	0–10	0.15 ± 0.03	0.14 ± 0.07	0.16
	0+05, 55L	69A	0–10	0.10 ± 0.04	0.09 ± 0.05	0.10
	0+15, 55L	70A	0–10	0.08 ± 0.01	0.13 ± 0.06	0.13
3	0+25, 25L	76A	0–10	0.07 ± 0.01	0.11 ± 0.07	0.11
	0+35, 25L	80A	0–10	0.08 ± 0.04	0.18 ± 0.06	0.14
	0+25, 35L	75A	0–10	0.28 ± 0.1	6.9 ± 0.3	0.30
	0+35, 35L	79A	0–10	0.09 ± 0.05	0.45 ± 0.1	0.14
	0+30, 40L	31	0–10	0.20 ± 0.07	11 ± 0.71	0.10
	0+35, 45L	78A	0–10	0.07 ± 0.02	0.43 ± 0.1	0.12
	0+25, 55L	74A	0–10	0.06 ± 0.03	2.0 ± 0.1	0.18
	0+35, 55L	77A	0–10	0.10 ± 0.03	0.14 ± 0.05	0.13
5	0+50, 40L	30	0–10	0.19 ± 0.04	0.17 ± 0.04	0.17
	Composite[g]	85	0–10	0.10 ± 0.02	0.11 ± 0.06	<0.17

Table 5 (continued)

Bay	Grid location[a]	Sample[b]	Depth (cm)	Radionuclide concentration[c] (pCi/g)		
				^{226}Ra[d]	^{232}Th[d]	^{238}U[e]
11	1+10, 40L	29	0–10	0.09 ± 0.02	<0.05	0.10
35	3+50, 40L	28	0–10	0.21 ± 0.03	0.22 ± 0.1	0.24
37	3+70, 40L	27	0–10	0.19 ± 0.02	0.20 ± 0.10	0.15
39	3+90, 40L	26	0–10	0.26 ± 0.04	0.28 ± 0.05	0.19
41	4+10, 40L	25	0–10	0.14 ± 0.01	0.14 ± 0.03	0.26
45	4+50, 40L	24	0–10	0.19 ± 0.02	0.23 ± 0.1	0.18
49	4+90, 40L	23	0–10	0.22 ± 0.02	0.23 ± 0.03	0.16
51	5+05, 25L	56A	0–8	0.09 ± 0.02	0.07 ± 0.04	0.13
	5+15, 25L	57A	0–8	0.09 ± 0.03	<0.06	0.70
	5+05, 35L	58A	0–8	0.11 ± 0.03	0.08 ± 0.07	0.22
	5+15, 35L	59A	0–8	0.09 ± 0.01	0.10 ± 0.01	0.16
	5+10, 40L	22	0–10	0.92 ± 0.1	1.1 ± 0.2	0.97
	5+15, 45L	60A	0–8	0.11 ± 0.06	0.11 ± 0.07	<0.22
	5+15, 55L	61A	0–8	0.10 ± 0.01	0.09 ± 0.05	0.14
	5+05, 55L	62A	0–8	0.11 ± 0.04	0.11 ± 0.06	0.12
53	5+30, 40L	21	0–10	0.66 ± 0.1	0.66 ± 0.14	0.70
55	5+50, 40L	20	0–10	0.34 ± 0.06	0.38 ± 0.08	0.80
57	5+70, 40L	19	0–10	0.10 ± 0.04	0.11 ± 0.04	0.10
			Soil			
36	3+50, 10R	50	0–10	0.83 ± 0.1	1.0 ± 0.1	1.2
38	3+70, 30R	51	0–10	0.87 ± 0.05	1.0 ± 0.04	1.1
40	3+90, 10R	41	0–10	0.84 ± 0.1	0.95 ± 0.2	0.95
42	4+10, 30R	42	0–10	0.85 ± 0.2	0.95 ± 0.2	1.4
44	4+30, 10R	43	0–10	0.91 ± 0.06	0.96 ± 0.09	1.2
46	4+50, 10R	44	0–10	1.0 ± 0.08	1.2 ± 0.2	5.0
48	4+70, 10R	45	0–10	1.1 ± 0.1	1.2 ± 0.1	1.2
50	4+90, 10R	33	0–10	1.1 ± 0.06	1.3 ± 0.33	1.5
	4+90, 30R	34	0–10	1.1 ± 0.07	1.1 ± 0.2	2.2
52	5+10, 30R	35	0–10	0.76 ± 0.1	0.83 ± 0.1	1.1
	5+10, 10R	36	0–10	1.1 ± 0.08	1.3 ± 0.3	1.9
54	5+30, 10R	37	0–10	1.1 ± 0.1	1.3 ± 0.04	1.2
56	5+50, 30R	38	0–10	1.1 ± 0.1	1.2 ± 0.1	1.8
58	5+70, 10R	39	0–10	1.1 ± 0.05	1.3 ± 0.1	1.3
	5+70, 30R	40A	0–15	1.1 ± 0.1	1.2 ± 0.3	2.9
		40B	25–35	1.1 ± 0.08	1.2 ± 0.3	1.7
1	0+05, 25L	65B	0–15	0.92 ± 0.08	1.3 ± 0.3	<2.5
	0+15, 25L	73B	0–15	0.85 ± 0.1	0.99 ± 0.06	1.1
	0+05, 35L	66B	0–15	0.98 ± 0.1	1.1 ± 0.2	1.6
	0+15, 35L	72B	0–15	0.94 ± 0.1	1.1 ± 0.2	<2.3
	0+05, 45L	67B	0–15	1.0 ± 0.07	1.2 ± 0.3	1.9
	0+15, 45L	71B	0–15	1.0 ± 0.09	1.2 ± 0.4	<2.4
	0+00, 50L	68B	0–15	1.1 ± 0.07	1.3 ± 0.2	1.7
	0+05, 55L	69B	0–15	1.0 ± 0.2	1.2 ± 0.1	1.4
	0+15, 55L	70B	0–15	1.1 ± 0.1	1.4 ± 0.4	1.6

Table 5 (continued)

Bay	Grid location[a]	Sample[b]	Depth (cm)	Radionuclide concentration[c] (pCi/g)		
				^{226}Ra[d]	^{232}Th[d]	^{238}U[e]
3	0+25, 25L	76B	0–15	0.99 ± 0.05	1.2 ± 0.1	1.3
	0+35, 25L	80B	0–15	0.96 ± 0.2	1.2 ± 0.1	<2.7
	0+25, 35L	75B	0–15	0.99 ± 0.1	1.3 ± 0.2	2.2
	0+35, 35L	79B	0–15	1.0 ± 0.1	1.3 ± 0.4	2.0
	0+35, 45L	78B	0–15	1.1 ± 0.2	1.2 ± 0.2	0.93
	0+25, 55L	74B	0–15	1.1 ± 0.06	1.4 ± 0.1	1.4
	0+35, 55L	77B	0–15	1.1 ± 0.1	1.2 ± 0.3	1.8
5	0+50, 30L	81	0–15	0.84 ± 0.1	1.0 ± 0.2	2.2
	0+50, 50L	82	0–15	1.1 ± 0.07	1.2 ± 0.2	1.9
35	3+50, 50L	55	0–15	0.91 ± 0.07	0.94 ± 0.05	0.90
37	3+70, 30L	54	0–15	0.82 ± 0.06	0.89 ± 0.09	1.0
39	3+95, 50L	53	0–15	0.64 ± 0.1	0.76 ± 0.2	0.69
41	4+10, 50L	48	0–15	0.89 ± 0.05	0.93 ± 0.06	2.8
45	4+50, 30L	47	0–15	0.98 ± 0.2	1.1 ± 0.3	1.6
49	4+90, 50L	46	0–15	1.1 ± 0.07	1.1 ± 0.1	1.4
51	5+05, 25L	56B	0–8	1.0 ± 0.1	1.2 ± 0.1	2.3
	5+15, 25L	57B	0–8	1.1 ± 0.1	1.1 ± 0.2	1.1
	5+05, 35L	58B	0–8	1.0 ± 0.2	1.2 ± 0.06	1.6
	5+15, 35L	59B	0–8	1.1 ± 0.2	1.1 ± 0.2	2.7
	5+05, 38L	64	30–45	0.94 ± 0.1	1.2 ± 0.3	1.1
	5+05, 45L	63	30–45	0.96 ± 0.2	1.1 ± 0.2	0.90
	5+15, 45L	60B	0–8	1.0 ± 0.05	1.1 ± 0.2	1.3
	5+05, 55L	62B	0–8	1.1 ± 0.05	1.3 ± 0.1	1.0
	5+15, 55L	61B	0–8	1.0 ± 0.1	1.1 ± 0.3	1.1
53	5+30, 30L	49	0–15	1.1 ± 0.07	1.2 ± 0.2	2.0
57	5+70, 30L	52	0–15	0.26 ± 0.04	0.38 ± 0.09	<1.0
			Biased samples[h]			
1	i	14	0–15	0.61 ± 0.07	95 ± 6.3	2.4
3	0+39, 23L	11A	0–15	0.05 ± 0.02	1.9 ± 0.2	0.11
		11B	15–30	1.0 ± 0.09	3.5 ± 0.8	1.5
		11C	75–85	0.99 ± 0.08	1.2 ± 0.1	<2.7
	0+40, 23L	2	0–5	0.10 ± 0.06	12 ± 0.85	0.30
	0+32, 35L	12	0–15	1.0 ± 0.1	4.1 ± 0.5	2.0
	0+23, 44L	13	35–45	1.1 ± 0.3	44 ± 2.0	2.5
	0+40, 45L	1	0–5	0.34 ± 0.06	0.44 ± 0.08	0.47
44	4+23, 15R	3	0–5	0.33 ± 0.1	0.30 ± 0.11	350
50	4+90, 25R	4	0–5	0.11 ± 0.03	27 ± 2.3	0.53
		4A	0–5	0.86 ± 0.09	0.99 ± 0.17	1.0
51	5+10, 30L	6A	0–5	0.18 ± 0.02	0.13 ± 0.09	0.60
		6B	5–15	1.1 ± 0.1	1.2 ± 0.3	1.6
	5+07, 45L	7	60–75	1.2 ± 0.05	1.4 ± 0.3	1.3

Table 5 (continued)

Bay	Grid location[a]	Sample[b]	Depth (cm)	Radionuclide concentration[c] (pCi/g)		
				^{226}Ra[d]	^{232}Th[d]	^{238}U[e]
55	5+42, 41L	8A	0–8	0.28 ± 0.6	1.2 ± 0.1	3800
		8B	8–23	1.1 ± 0.1	1.2 ± 0.4	2.5
	5+59, 45L	10	0–15	1.1 ± 0.1	1.2 ± 0.3	3.3
56	5+42, 12R	5	0–5	0.68 ± 0.1	<0.15	1800
		5A	0–5	0.62 ± 0.04	0.66 ± 0.09	17
57	5+61, 39L	9	0–8	0.07 ± 0.06	<0.08	93

[a]Locations of soil samples are shown on Fig. 10.

[b]An "A" sample was collected from the surface (0–15 cm). A "B" sample was taken from the same grid location as an "A" sample and may be either surface soil (from beneath an "A" gravel sample) or subsurface soil (from beneath an "A" surface soil sample).

[c]A value preceded by a "<" sign is the minimum detectable activity (MDA) at the 95% confidence level.

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

[e]Analytical error of measurement results is less than ±5% (95% confidence level).

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

[g]Composite samples consist of aliquots taken from more than one grid location. Composite sample 84(*) contains aliquots from Bays 52, 54, 56, and 58.

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

[i]Sample collected in Bay 1 during a preliminary survey conducted on April 9, 1986, to establish the need for site characterization.

Table 6. Concentration of radionuclides in subsurface soil samples

Bay	Grid location[a]	Sample	Depth (cm)	Radionuclide concentration[b] (pCi/g)		
				^{226}Ra[c]	^{232}Th[c]	^{238}U[d]
			Auger Samples[e]			
2	0+10, 30R	1A	0–15	1.0 ± 0.04	1.1 ± 0.2	1.7
		1B	15–30	1.0 ± 0.2	1.2 ± 0.2	1.0
	0+10, 10R	2A	0–15	1.0 ± 0.08	1.1 ± 0.2	<3.2
		2B	15–30	1.0 ± 0.03	1.1 ± 0.2	1.9
4	0+30, 30R	3A	0–15	0.95 ± 0.2	1.0 ± 0.04	1.6
		3B	15–30	0.98 ± 0.04	1.1 ± 0.2	1.0
	0+30, 10R	4A	0–15	1.0 ± 0.1	1.2 ± 0.3	3.7
		4B	15–30	0.93 ± 0.08	1.0 ± 0.3	2.3
6	0+50, 30R	5A	0–15	1.1 ± 0.09	1.1 ± 0.07	2.0
		5B	15–30	1.1 ± 0.09	1.1 ± 0.2	2.7
	0+50, 10R	6A	0–15	0.93 ± 0.09	1.1 ± 0.1	1.0
		6B	15–30	1.0 ± 0.09	1.2 ± 0.1	0.87
8	0+70, 30R	7A	0–15	1.1 ± 0.08	1.1 ± 0.2	2.0
		7B	15–30	1.1 ± 0.09	1.3 ± 0.2	<3.0
	0+70, 10R	8A	0–15	1.0 ± 0.06	1.3 ± 0.2	1.6
		8B	15–30	1.0 ± 0.2	1.3 ± 0.3	1.4
10	0+90, 30R	9A	0–15	1.0 ± 0.2	1.2 ± 0.2	3.2
		9B	15–30	1.1 ± 0.02	1.3 ± 0.06	1.2
	0+90, 10R	10A	0–15	1.1 ± 0.2	1.4 ± 0.4	3.1
		10B	15–30	1.2 ± 0.07	1.4 ± 0.1	0.93
12	1+10, 10R	11A	0–15	1.1 ± 0.2	1.4 ± 0.2	3.0
		11B	15–30	1.1 ± 0.1	1.4 ± 0.3	2.0
	1+10, 30R	12A	0–15	1.1 ± 0.07	1.3 ± 0.09	0.97
		12B	15–30	1.2 ± 0.2	1.5 ± 0.3	1.2
36	3+50, 20R	28A	0–15	0.97 ± 0.1	1.0 ± 0.1	1.4
		28B	15–30	1.1 ± 0.2	1.1 ± 0.13	<3.2
38	3+70, 20R	29A	0–15	0.85 ± 0.06	0.97 ± 0.08	2.2
		29B	15–30	0.97 ± 0.1	1.2 ± 0.2	1.6
40	3+90, 20R	27A	0–15	0.87 ± 0.04	0.97 ± 0.06	2.2
		27B	15–30	1.1 ± 0.04	1.2 ± 0.09	1.5
42	4+10, 20R	23A	0–15	0.96 ± 0.1	1.1 ± 0.2	2.6
		23B	15–30	1.1 ± 0.06	1.2 ± 0.06	1.2
44	4+30, 20R	22A	0–15	0.96 ± 0.1	1.1 ± 0.2	1.3
		22B	15–30	1.2 ± 0.1	1.4 ± 0.3	1.4
46	4+50, 20R	21A	0–15	1.1 ± 0.1	1.3 ± 0.4	<3.4
		21B	15–30	1.1 ± 0.07	1.3 ± 0.4	1.4
48	4+70, 20R	20A	0–15	1.2 ± 0.08	1.4 ± 0.2	1.3
		20B	15–30	1.2 ± 0.07	1.3 ± 0.07	2.7

Table 6 (continued)

Bay	Grid location[a]	Sample	Depth (cm)	Radionuclide concentration[b] (pCi/g)		
				^{226}Ra[c]	^{232}Th[c]	^{238}U[d]
50	4+90, 20R	13A	0–15	1.0 ± 0.2	1.2 ± 0.2	1.6
		13B	15–30	1.1 ± 0.08	1.3 ± 0.3	1.3
		13C	30–60	1.1 ± 0.06	1.3 ± 0.3	3.4
		13D	60–90	0.77 ± 0.1	0.86 ± 0.2	1.7
52	5+10, 20R	14A	0–15	1.1 ± 0.09	1.2 ± 0.3	2.9
		14B	15–30	0.95 ± 0.2	1.1 ± 0.1	2.0
54	5+30, 20R	15A	0–15	1.1 ± 0.08	1.2 ± 0.06	1.2
		15B	15–30	1.1 ± 0.1	1.3 ± 0.2	0.87
56	5+50, 20R	16A	0–15	1.1 ± 0.05	1.3 ± 0.2	1.4
		16B	15–30	1.1 ± 0.06	1.4 ± 0.4	1.7
58	5+70, 20R	17A	0–15	0.85 ± 0.2	0.97 ± 0.22	1.4
		17B	15–30	1.0 ± 0.2	1.1 ± 0.18	1.2
1	0+20, 43L	37A	0–15	0.91 ± 0.1	12 ± 2	1.5
		37B	15–30	0.97 ± 0.06	1.7 ± 0.5	0.70
		37C	30–60	1.1 ± 0.07	1.2 ± 0.1	1.0
		37D	60–90	1.1 ± 0.09	1.2 ± 0.3	2.2
3	0+26, 42L	38A	0–15	1.0 ± 0.09	3.7 ± 0.2	1.4
		38B	15–30	1.1 ± 0.1	3.1 ± 0.3	0.93
		38C	30–60	1.1 ± 0.1	1.3 ± 0.1	<2.6
		38D	60–90	1.0 ± 0.08	1.1 ± 0.1	2.8
5	0+50, 40L	36A	0–15	1.0 ± 0.07	1.1 ± 0.2	0.97
		36B	15–30	1.1 ± 0.08	1.1 ± 0.2	1.1
11	1+06, 34L	35A	0–15	1.0 ± 0.06	1.2 ± 0.2	1.0
		35B	15–30	1.1 ± 0.08	1.4 ± 0.2	0.87
35	3+50, 40L	30A	0–15	0.92 ± 0.05	0.96 ± 0.2	1.6
		30B	15–30	1.1 ± 0.04	1.2 ± 0.2	1.7
37	3+70, 40L	31A	0–15	1.1 ± 0.09	1.1 ± 0.08	2.0
		31B	15–30	0.92 ± 0.2	1.0 ± 0.21	0.70
39	3+90, 40L	32A	0–15	0.96 ± 0.05	1.0 ± 0.21	2.2
		32B	15–30	1.1 ± 0.05	1.2 ± 0.2	0.87
41	4+10, 40L	24A	0–15	0.90 ± 0.1	1.1 ± 0.2	<3.7
		24B	15–30	1.1 ± 0.1	1.2 ± 0.1	1.4
45	4+50, 40L	25A	0–15	0.93 ± 0.06	1.1 ± 0.07	1.6
		25B	15–30	1.1 ± 0.04	1.2 ± 0.1	1.6
49	4+90, 40L	19A	0–15	1.2 ± 0.03	1.3 ± 0.05	3.2
		19B	15–30	1.2 ± 0.1	1.3 ± 0.2	1.1
51	5+10, 45L	34A	0–15	1.1 ± 0.07	1.2 ± 0.1	1.3
		34B	15–30	1.2 ± 0.09	1.3 ± 0.2	1.5
		34C	30–60	1.2 ± 0.06	1.3 ± 0.4	1.3
		34D	60–90	1.1 ± 0.05	1.2 ± 0.1	1.0

Table 6 (continued)

Bay	Grid location[a]	Sample	Depth (cm)	Radionuclide concentration[b] (pCi/g)		
				^{226}Ra[c]	^{232}Th[c]	^{238}U[d]
53	5+30, 40L	18A	0–15	1.1 ± 0.08	1.1 ± 0.3	1.8
		18B	15–30	1.1 ± 0.05	1.3 ± 0.1	1.1
55	5+50, 40L	33A	0–15	1.1 ± 0.05	1.1 ± 0.2	1.8
		33B	15–30	1.1 ± 0.1	1.3 ± 0.2	1.0
		33D	60–90	1.0 ± 0.1	1.2 ± 0.2	1.0
57	5+70, 40L	26A	0–15	0.33 ± 0.06	0.42 ± 0.09	0.43
		26B	15–30	0.16 ± 0.03	0.16 ± 0.1	0.87

[a]Location shown on Fig. 11.

[b]A value preceded by a "<" sign is the minimum detectable activity (MDA) at the 95% confidence level.

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

[d]Analytical error of measurement results is less than ±5% (95% confidence level).

[e]Auger samples are those taken from holes drilled to further define the depth and extent of contaminated material. Holes may be drilled in either contaminated or uncontaminated regions.

Table 7. Concentrations of radionuclides in sediments and soil samples from drains and drain outfalls

Sample	Location[a]	Radionuclide concentration (pCi/g)		
		^{226}Ra[b]	^{232}Th[b]	^{238}U[c]
		Roof drain outfall[d]		
	Bldg. 2083			
1	N	0.63 ± 0.06	0.69 ± 0.06	3.2
2	NW	0.29 ± 0.07	0.19 ± 0.17	0.8
3	NE	0.5 ± 0.08	0.55 ± 0.17	0.57
	Bldg. 2084			
4	SE	0.86 ± 0.06	1.0 ± 0.28	0.97
5	SW	0.82 ± 0.08	0.95 ± 0.07	0.05
6	S	0.72 ± 0.61	0.81 ± 0.10	0.67
		Sewer drain sediment[e]		
1	1+00, 10L	0.53 ± 0.05	0.6 ± 0.2	0.73
2	3+00, 16L	0.31 ± 0.09	0.3 ± 0.1	0.70
3	5+04, 10L	0.17 ± 0.05	0.3 ± 0.04	2.1
4	f	0.44 ± 0.18	0.88 ± 0.18	3.3 ± 2.7

[a]Location shown on Fig. 2.

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

[c]Total error of measurement results is less than ± 3% (95% confidence level).

[d]Roof drain outfall was sampled from the ground surface (0–15 cm) at drains emptying outside the buildings.

[e]Samples were collected from storm sewers draining runoff from the driveway.

[f]Storm sewer located ~200 ft south of Building 2084 (Fig. 2).

Table 8. Directly measured alpha and beta–gamma activity on wall surfaces

Location[a]	Alpha (dpm/100 cm^2) Average	Alpha (dpm/100 cm^2) Range	Beta–gamma (mrad/h)[b] Average	Beta–gamma (mrad/h)[b] Range
		Building 2083		
Bay				
1	40	0–100	0.02	0.01–0.02
3	45	20–100	0.02	0.01–0.02
5	14	0–40	0.02	0.01–0.02
11	7	0–40	0.02	0.01–0.02
35	18	0–60	0.02	0.01–0.02
37	16	0–60	0.02	0.01–0.02
39	9	0–40	0.02	0.01–0.02
41	8	0–50	0.02	–
45	9	0–20	0.02	–
49	5	0–40	0.02	–
51	4	0–40	0.02	–
53	7	0–20	0.02	–
55	4	0–30	0.02	–
57	9	0–50	0.02	–
		Building 2084		
Bay				
2	17	0–60	0.02	<0.01–0.03
4	15	0–40	<0.01	–
6	29	0–60	<0.01	–
8	12	0–40	<0.01	–
10	7	0–20	<0.01	–
12	15	0–30	0.02	0.01–0.02
36	21	0–60	0.02	0.01–0.02
38	18	0–40	0.02	–
40	12	0–40	0.02	0.01–0.02
42	9	0–40	0.01	0.01–0.02
44	6	0–20	0.02	–
46	20	0–40	0.02	–
48	8	0–40	0.02	0.02–0.03
50	19	0–80	0.01	–
52	37	0–60	0.02	–
54	25	0–80	0.02	–
56	6	0–40	0.02	–
58	13	0–40	0.02	0.01–0.02

[a]Location shown on Fig. 2.

[b]A value preceded by "<" sign is the minimum detectable activity (MDA) at the 95% confidence level.

Table 9. Alpha and beta–gamma measurements on overhead surfaces

	Directly measured contamination[b]			
	Alpha (dpm/100 cm^2)		Beta–gamma dose rate at 1 cm (mrad/h)	
Location[a]	Average	Range	Average	Range
		Building 2083		
Bay				
1	5	0–20	0.01	<0.01–0.02
3	6	0–60	0.01	<0.01–0.02
5	8	0–40	0.02	<0.01–0.02
11	4	0–20	0.01	<0.01–0.02
33	70	0–120	0.01	<0.01–0.02
35	50	0–140	0.01	0.01–0.02
37	31	0–160	0.01	<0.01–0.02
39	<1	0–40	0.01	<0.01–0.02
41	<1	0–40	0.01	<0.01–0.02
43	17	0–40	0.01	<0.01–0.02
45	11	0–40	0.01	<0.01–0.02
49	13	0–20	0.01	<0.01–0.02
51	<1	0–40	0.01	<0.01–0.02
53	67	0–110	0.01	0.01–0.02
55	85	0–130	0.01	<0.01–0.02
57	51	0–150	0.01	0.01–0.02
Driveway	10	0–50	0.01	<0.01–0.02
		Building 2084		
Bay				
2	24	10–60	0.02	<0.01–0.02
4	20	0–80	0.02	0.01–0.02
6	20	0–60	0.01	0.01–0.02
8	11	0–20	0.02	0.01–0.02
10	9	0–20	0.02	0.01–0.02
12	17	0–40	0.01	0.01–0.02
14	8	0–60	0.01	<0.01–0.02
36	3	0–20	0.02	0.01–0.02
38	31	0–80	0.01	<0.01–0.02
40	9	0–40	0.01	<0.01–0.02
42	7	0–20	0.01	<0.01–0.02
44	23	0–60	0.01	0.01–0.02
46	38	0–80	0.01	<0.01–0.02
48	63	0–120	0.01	0.01–0.02
50	17	0–40	0.01	<0.01–0.02

Table 9 (continued)

	Directly measured contamination[b]			
	Alpha (dpm/100 cm^2)		Beta–gamma dose rate at 1 cm (mrad/h)[c]	
Location[a]	Average	Range	Average	Range
52	50	0-120	0.01	0.01-0.02
54	9	0-60	0.01	<0.01-0.02
56	11	0-40	0.01	0.01-0.02
58	17	0-40	0.01	0.01-0.02
60	27	20-60	0.01	<0.01-0.02

[a]Location shown on Fig. 2.

[b]Measurements of transferable contamination levels were less than the minimum detectable activity (MDA) of 20 dpm/100 cm^2 for alpha and 200 dpm/100 cm^2 for beta–gamma in each bay and the driveway.

[c]A value preceded by "<" sign is the MDA at the 95% confidence level.

Table 10. Summarized results of radionuclide analysis of soil and gravel samples in uncontaminated bays[a]

Radionuclide	Number of samples	Range (pCi/g)	Mean (pCi/g)
		Background Soil Samples[b]	
^{226}Ra	3	0.65–1.1	0.83
^{232}Th	3	0.62–0.98	0.76
^{238}U	3	0.90–1.2	1.0
		Systematic Gravel Samples[c]	
^{226}Ra	24	0.07–0.89	0.18
^{232}Th	24	<0.05–1.3	0.23
^{238}U	24	0.10–1.5	0.44
		Systematic Soil Samples[c]	
^{226}Ra	49	0.64–1.2	0.99
^{232}Th	49	0.76–1.4	1.1
^{238}U	49	0.69–5.0	2.0
		Subsurface Soil Samples[d]	
^{226}Ra	29	0.92–1.2	1.0
^{232}Th	29	1.0–1.5	1.2
^{238}U	29	0.70–3.2	1.5

[a]Contaminated bays are 1, 3, 5, 51, 55, and 57 (Building 2083) and 44, 50, and 56 (Building 2084).

[b]Background samples, Table 1.

[c]Systematic samples, Table 5.

[d]Auger hole samples, Table 6.

APPENDIX

GAMMA PROFILE GRAPHS OF AUGER HOLES AT THE NAVEODTECHCEN SITE, INDIAN HEAD, MARYLAND

ORNL-DWG 87-16448

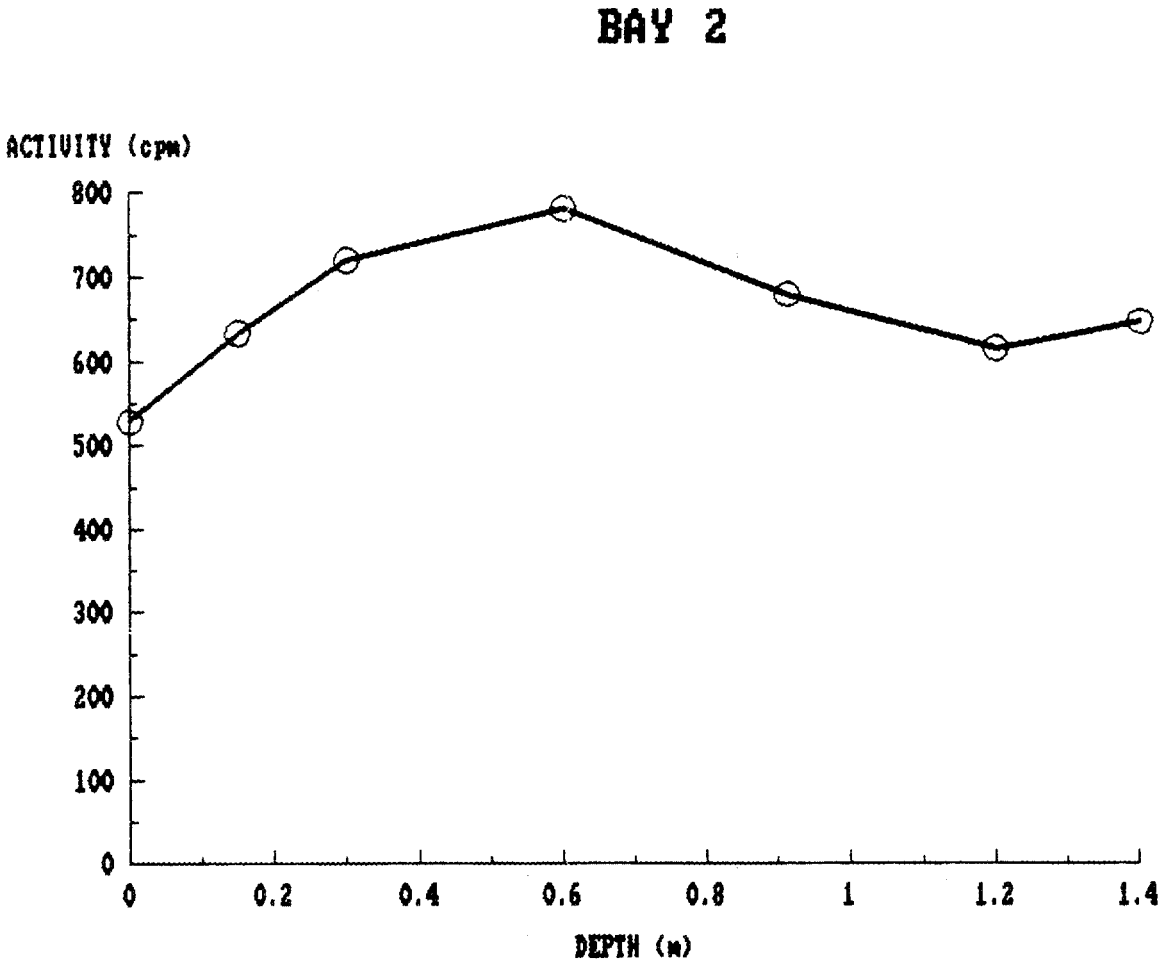

Fig. A.1. Gamma profile of auger hole 1.

ORNL-DWG 87-16449

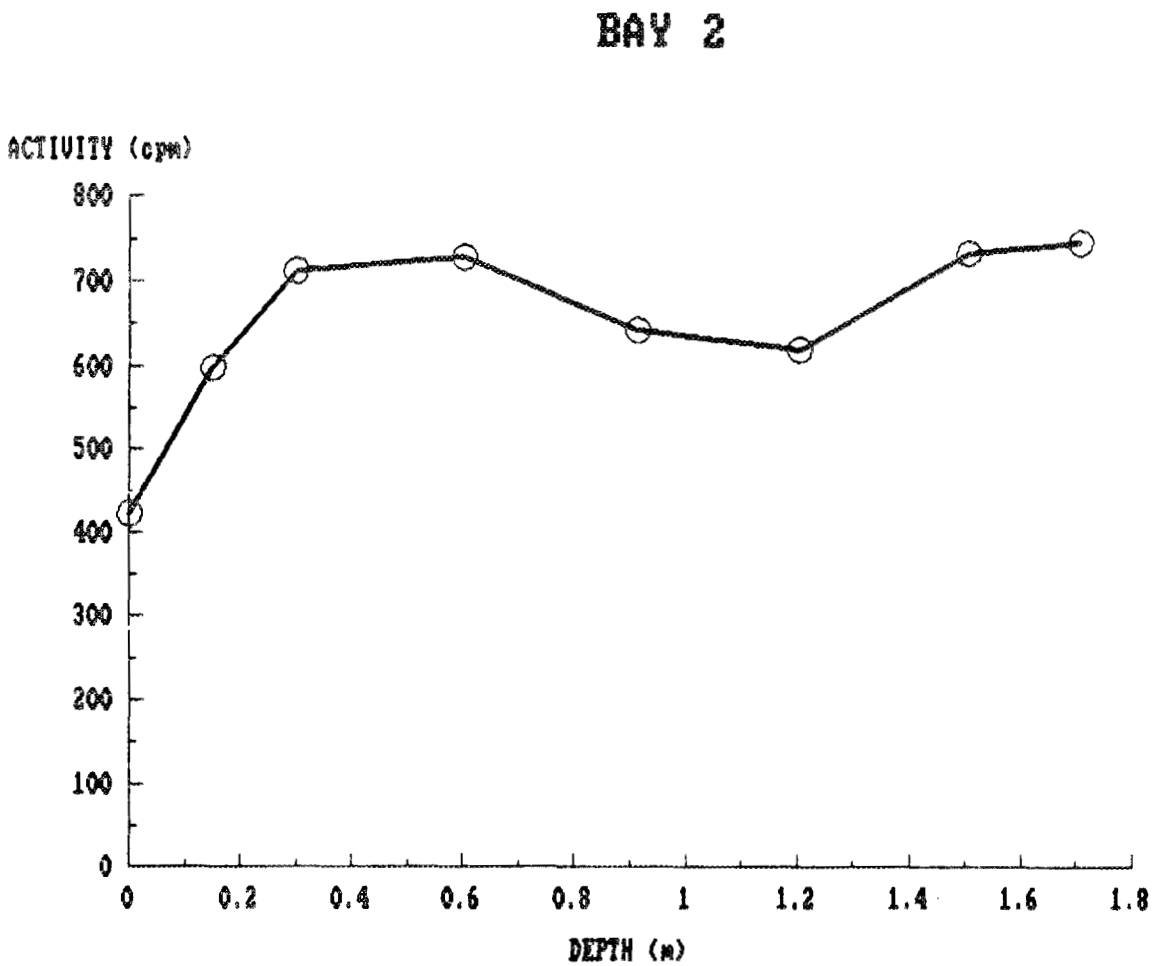

Fig. A.2. Gamma profile of auger hole 2.

ORNL-DWG 87-16450

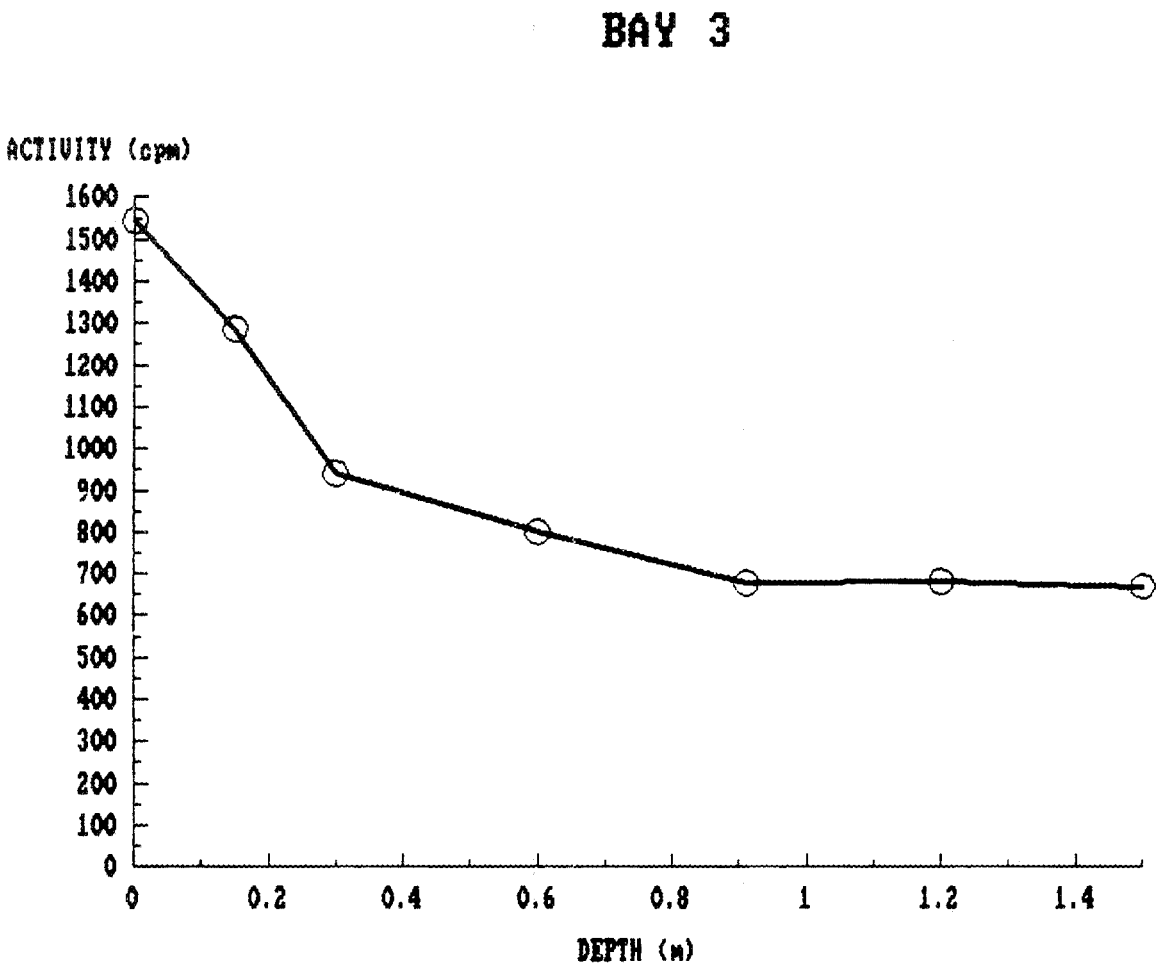

Fig. A.3. Gamma profile of auger hole 37.

ORNL-DWG 87-16451

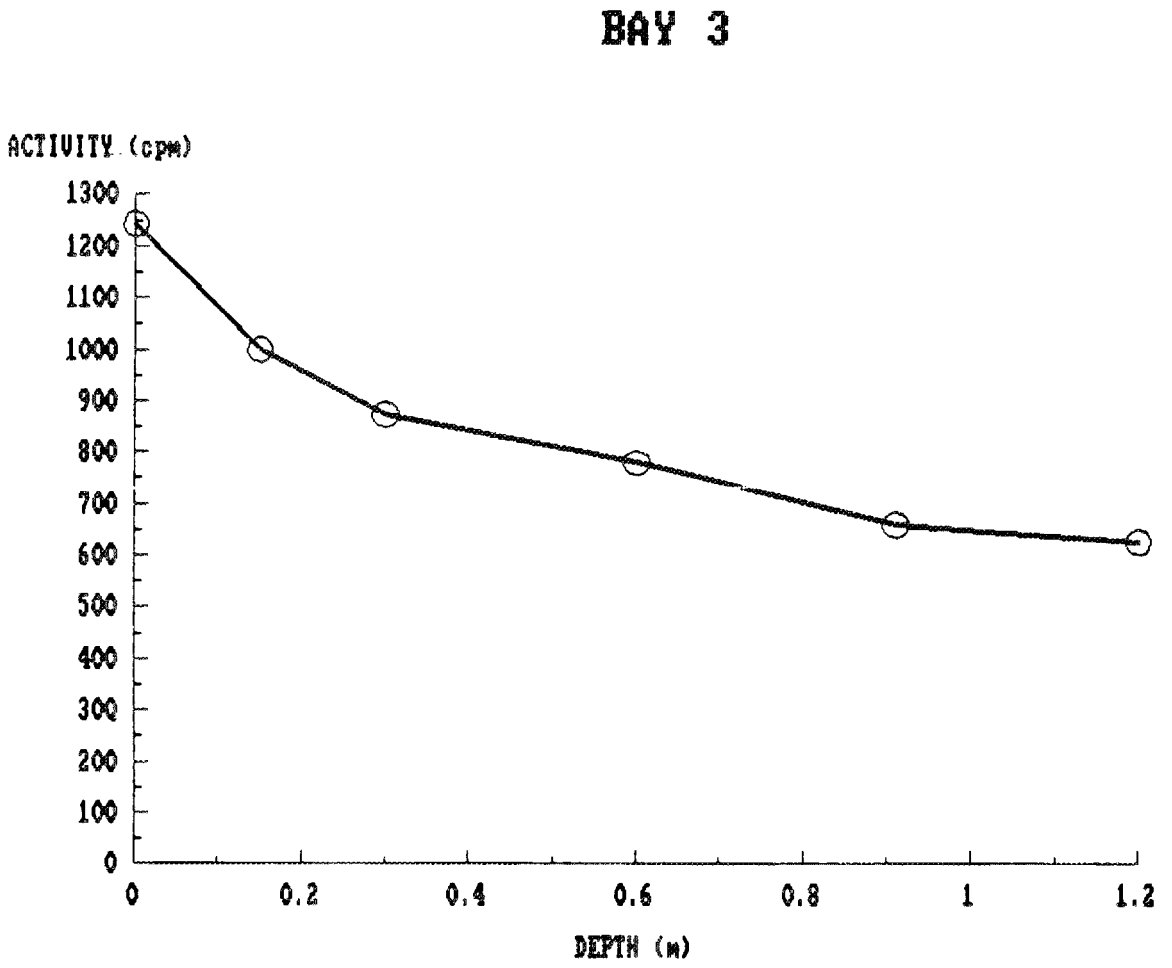

Fig. A.4. Gamma profile of auger hole 38.

ORNL-DWG 87-16452

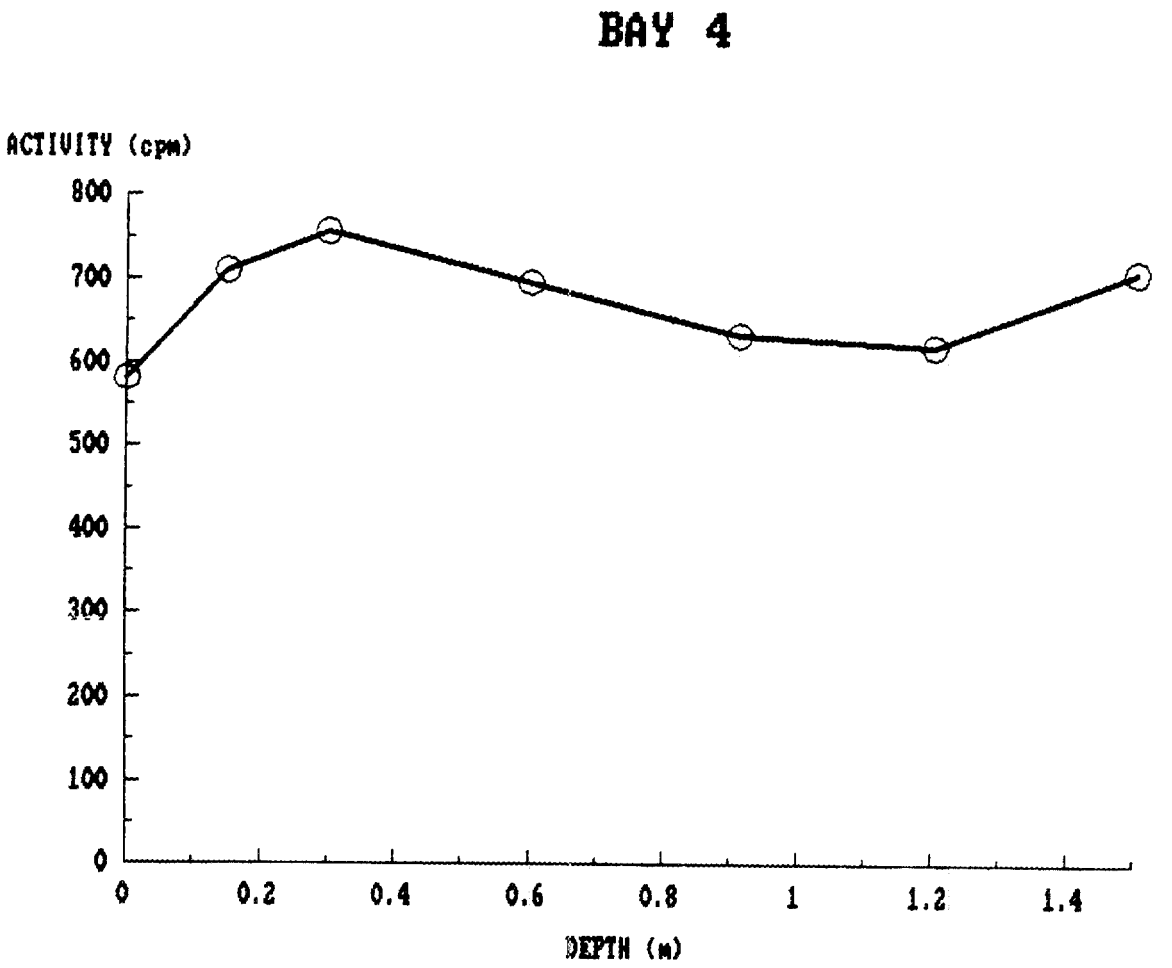

Fig. A.5. Gamma profile of auger hole 3.

ORNL-DWG 87-16453

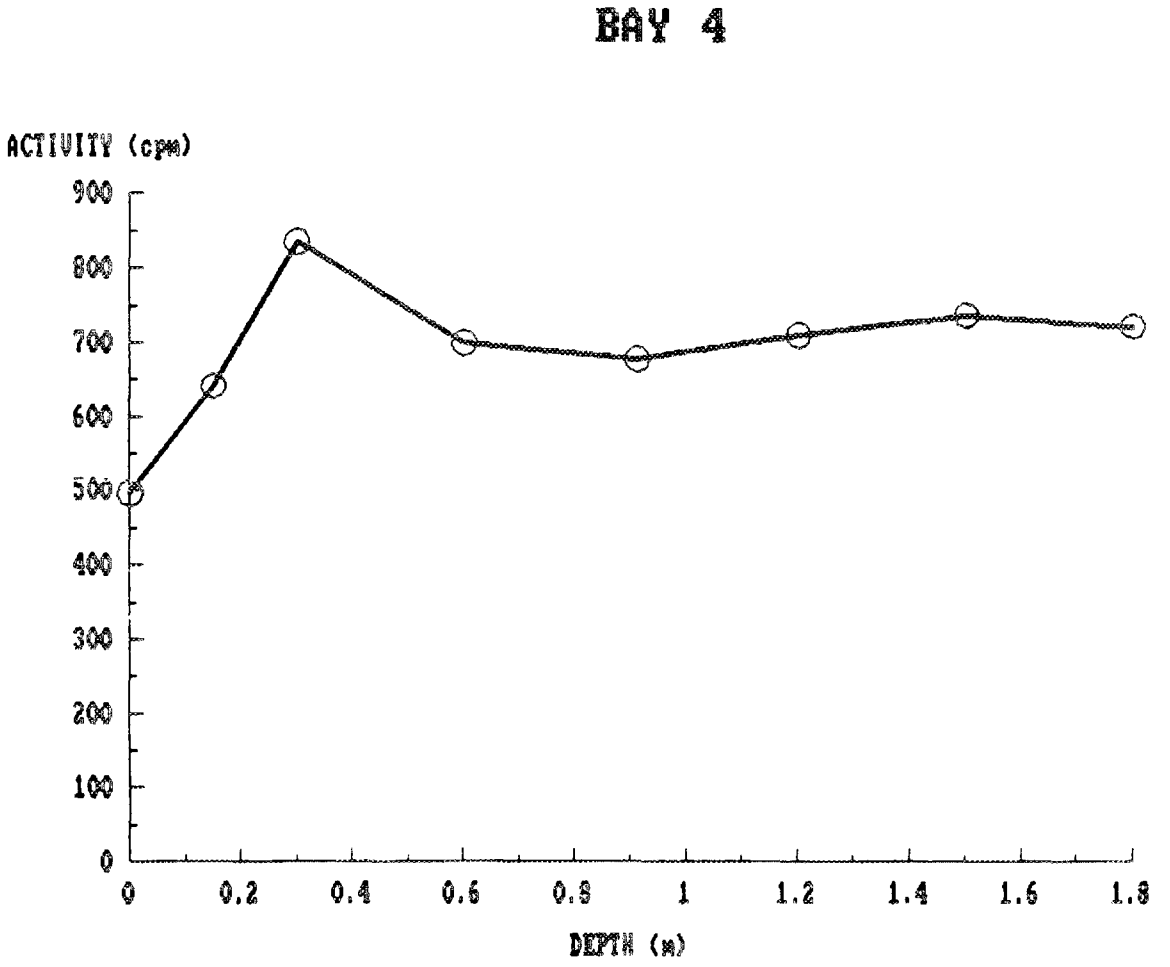

Fig. A.6. Gamma profile of auger hole 4.

ORNL-DWG 87-16454

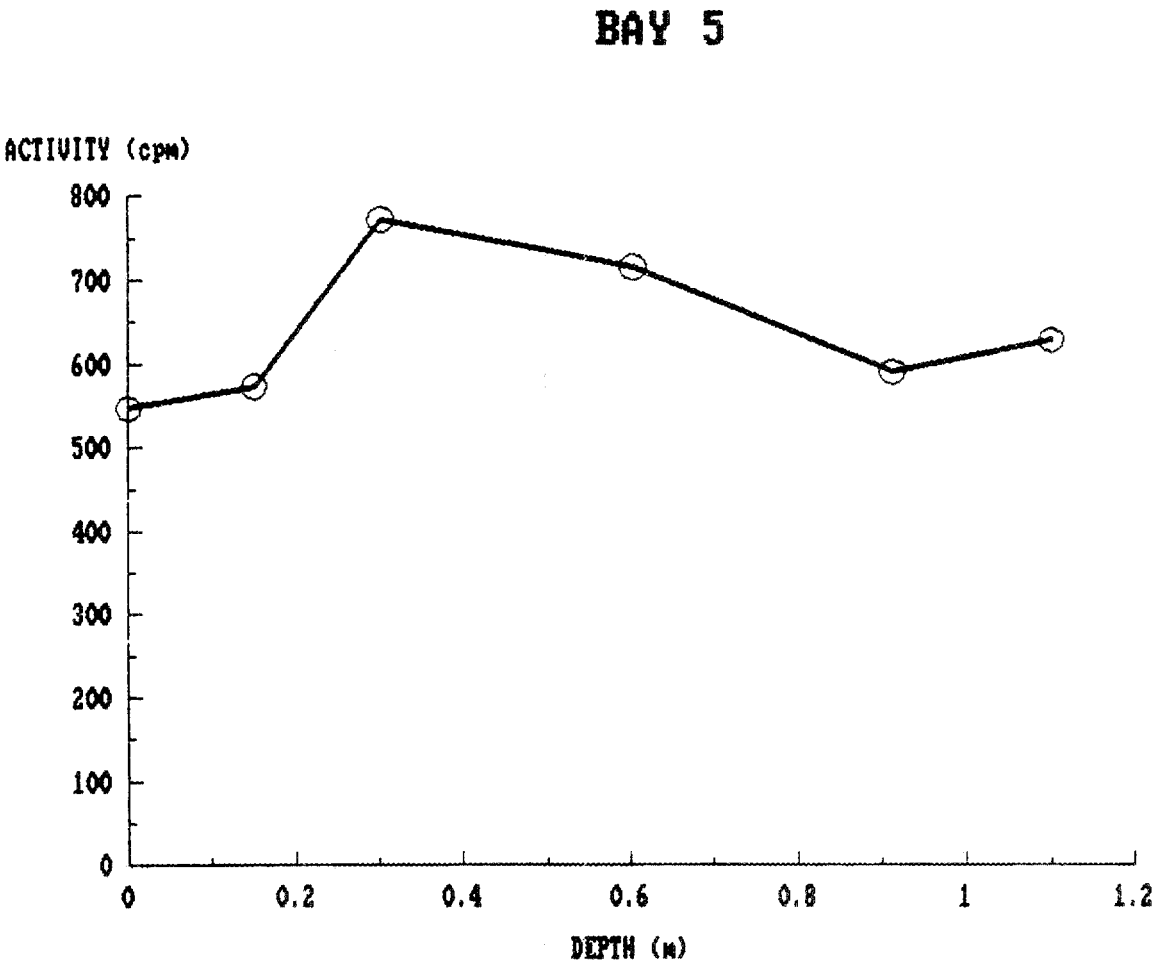

Fig. A.7. Gamma profile of auger hole 36.

ORNL-DWG 87-16455

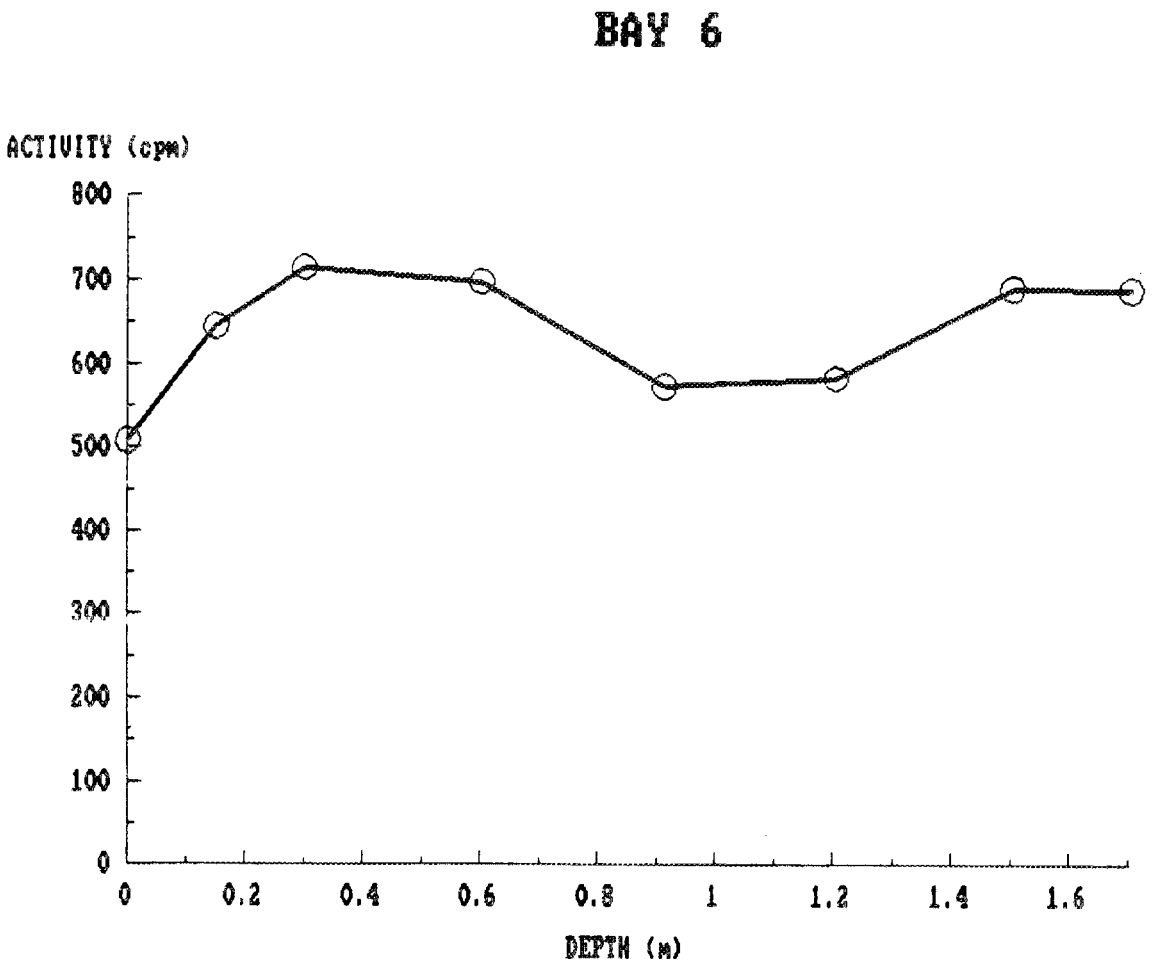

Fig. A.8. Gamma profile of auger hole 5.

ORNL-DWG 87-16456

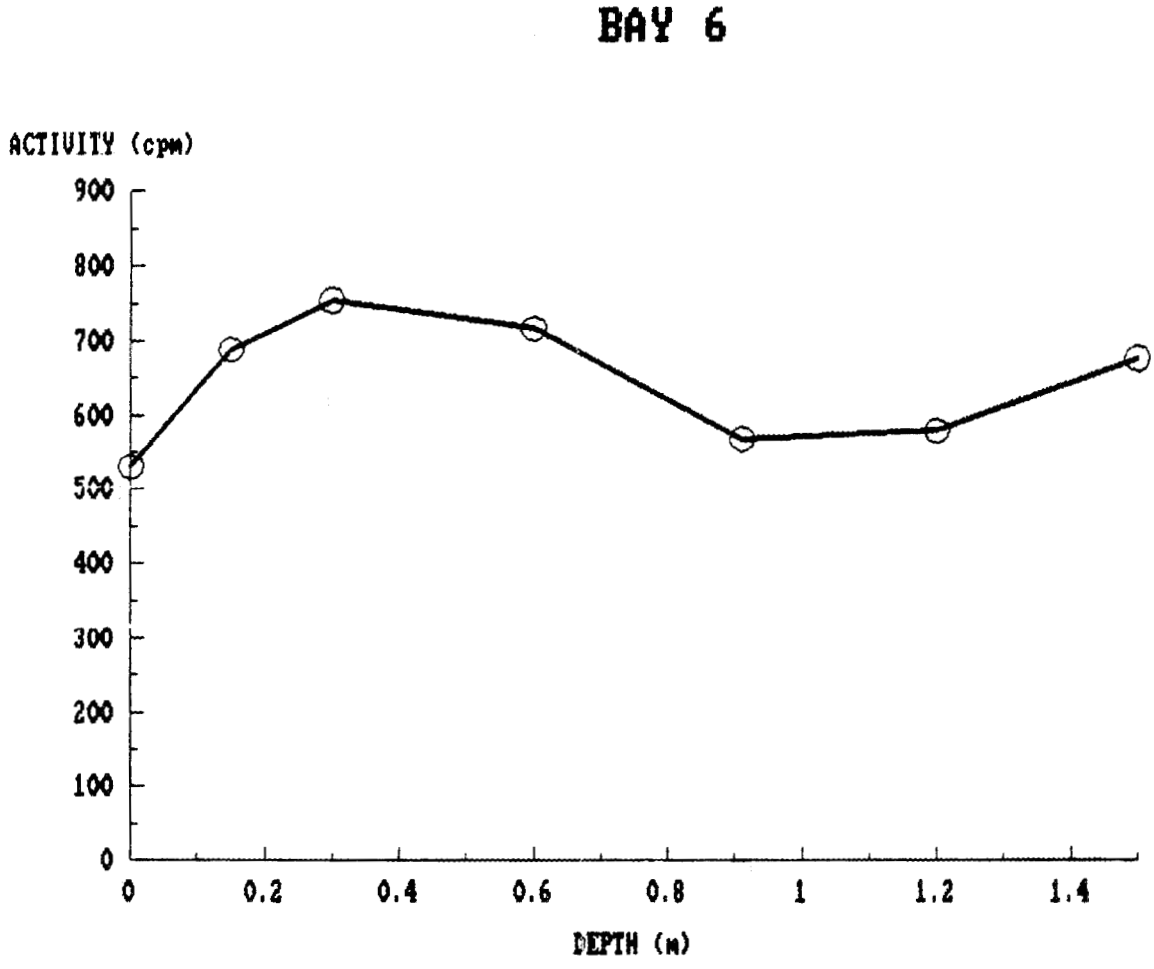

Fig. A.9. Gamma profile of auger hole 6.

ORNL-DWG 87-16457

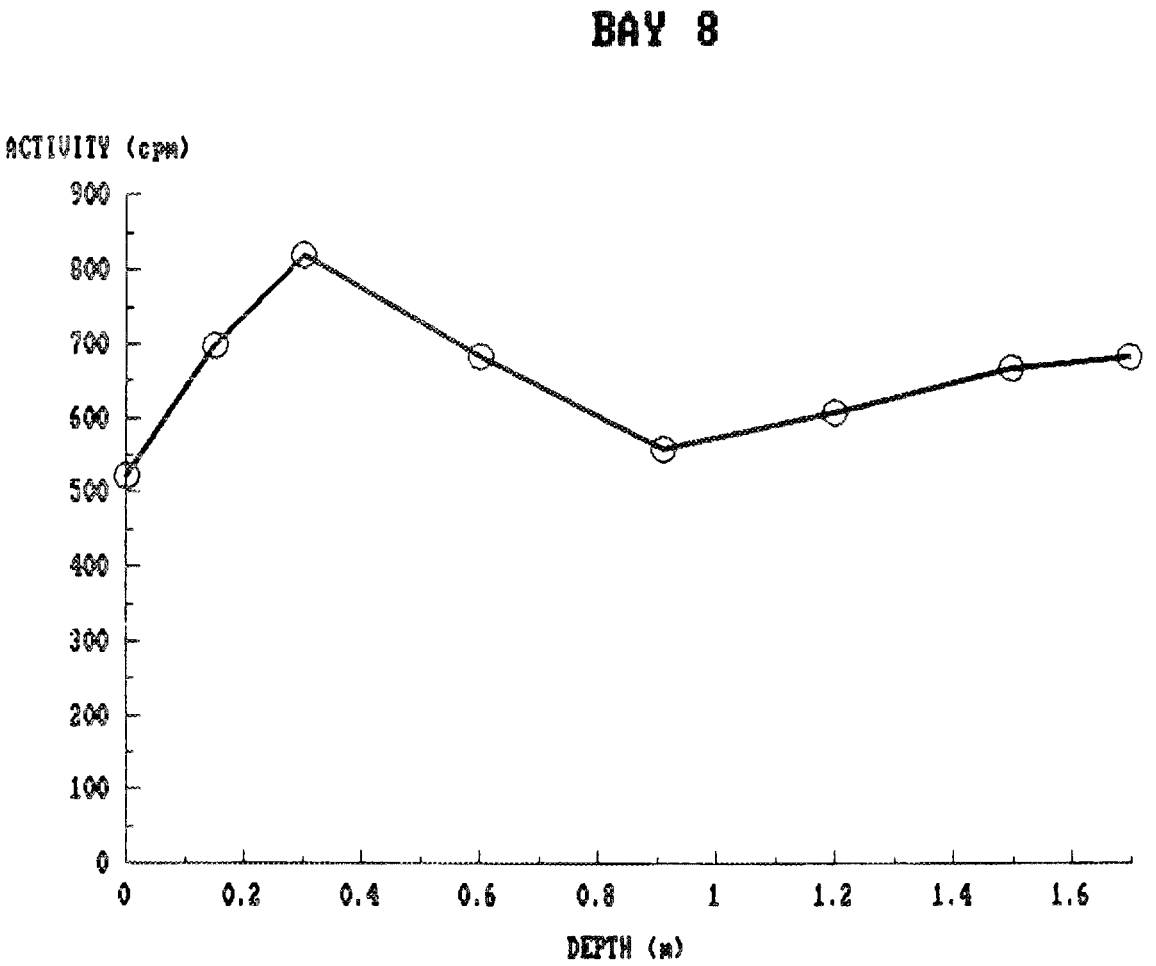

Fig. A.10. Gamma profile of auger hole 8.

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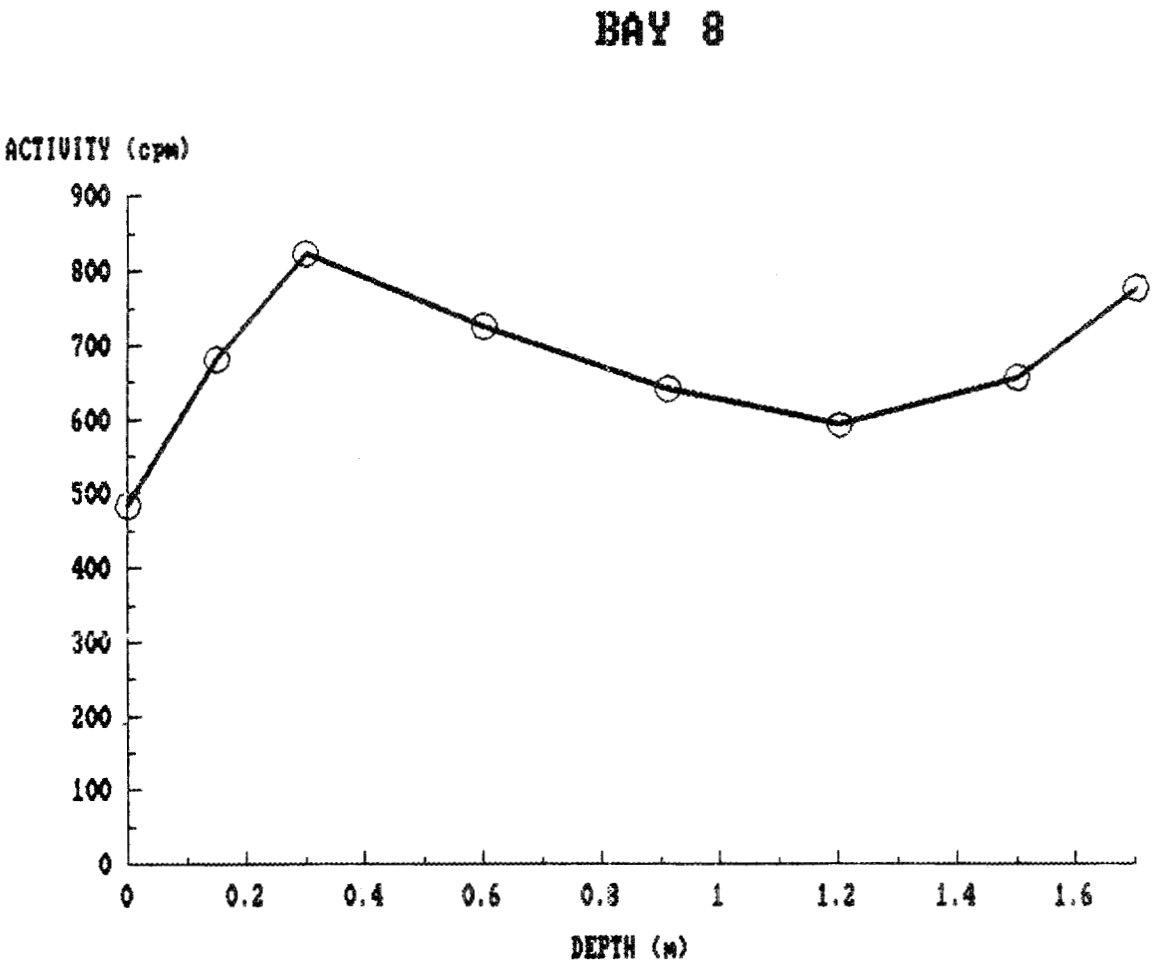

Fig. A.11. Gamma profile of auger hole 7.

ORNL-DWG 87-16459

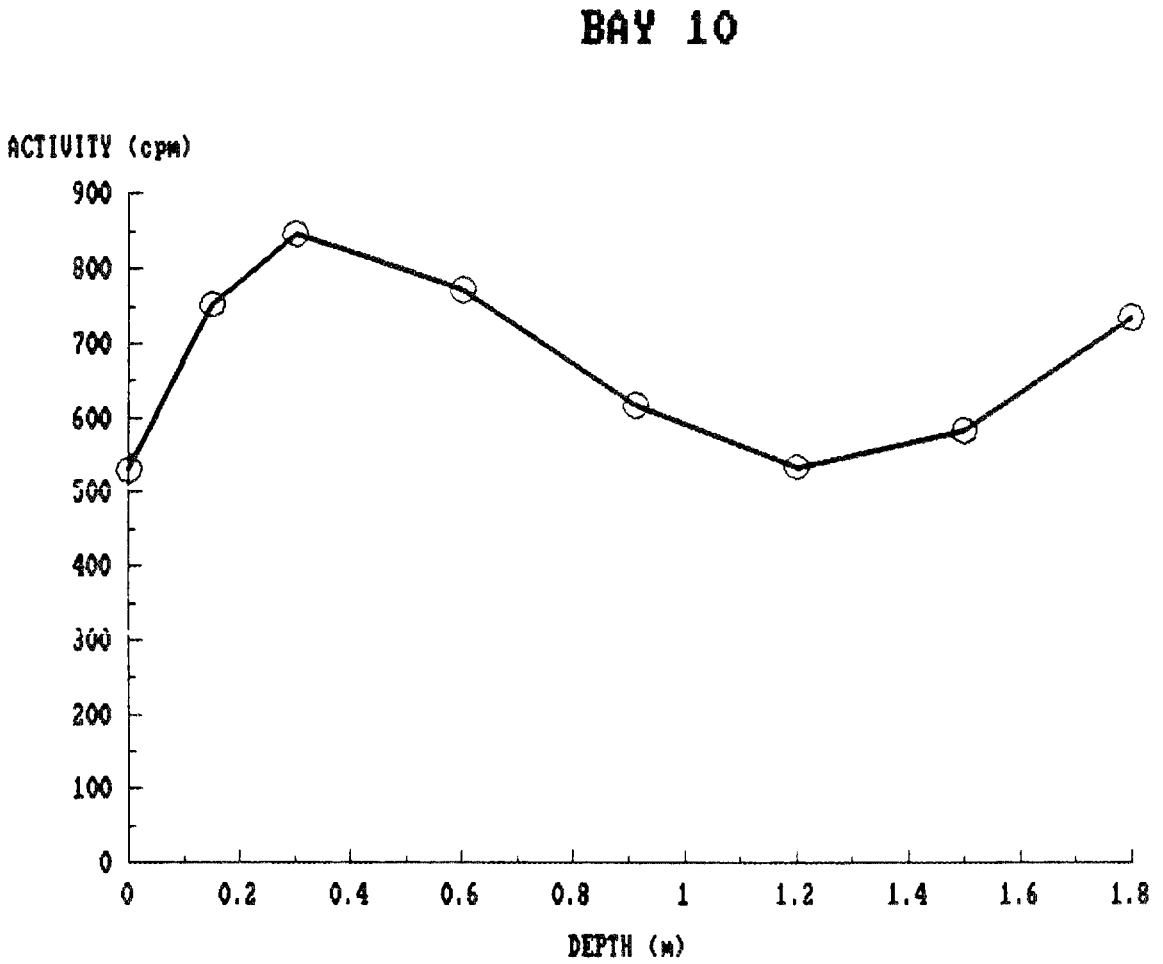

Fig. A.12. Gamma profile of auger hole 9.

ORNL-DWG 87-16460

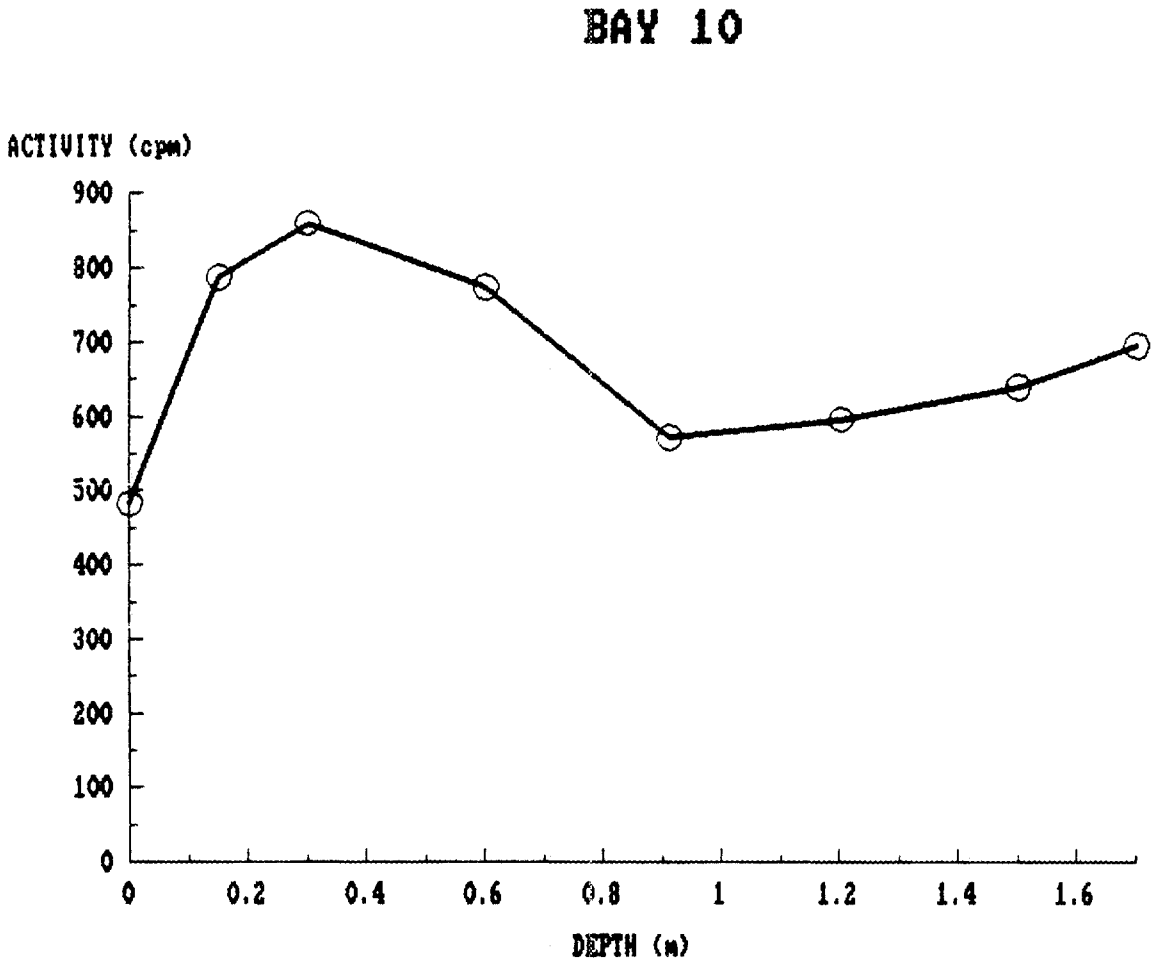

Fig. A.13. Gamma profile of auger hole 10.

ORNL-DWG 87-16461

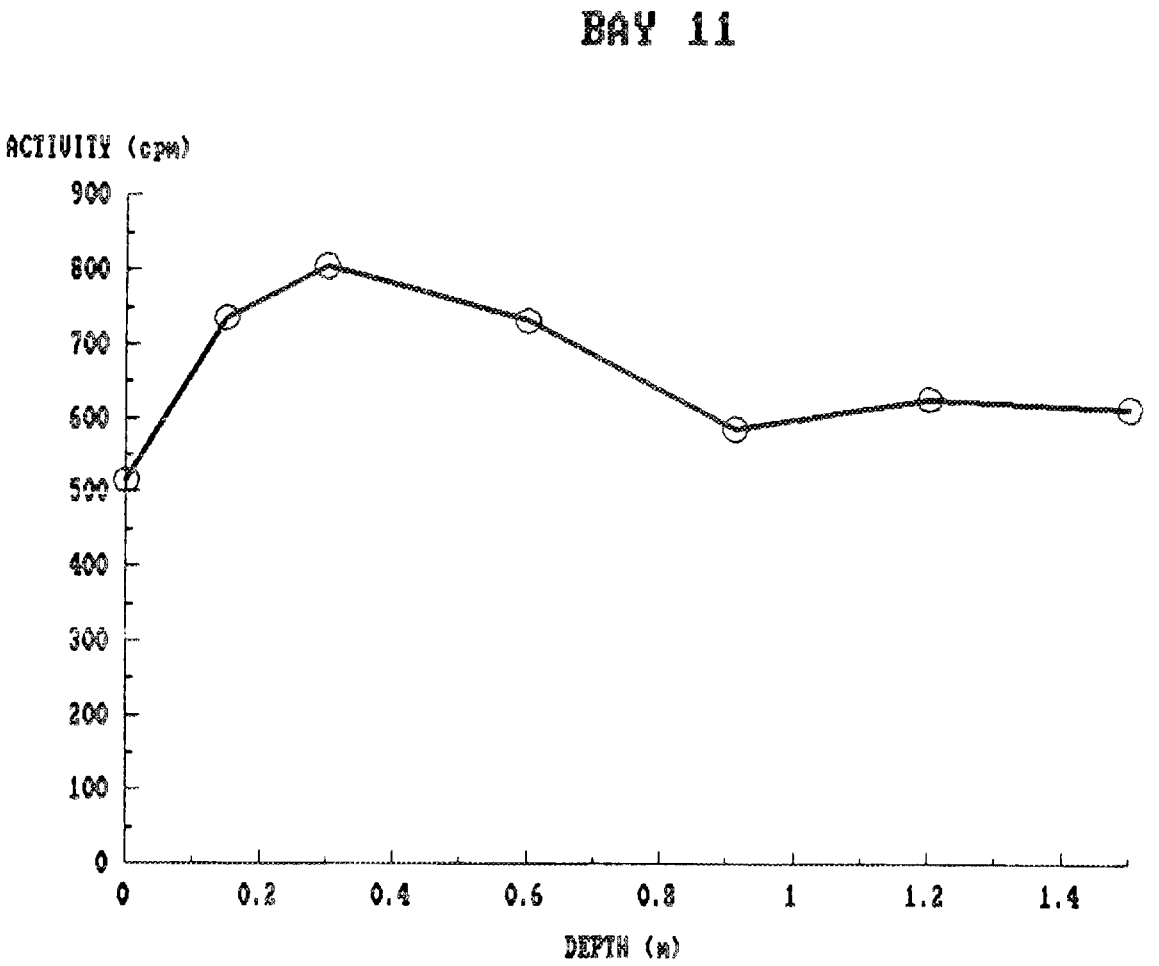

Fig. A.14. Gamma profile of auger hole 35.

ORNL-DWG 87-16462

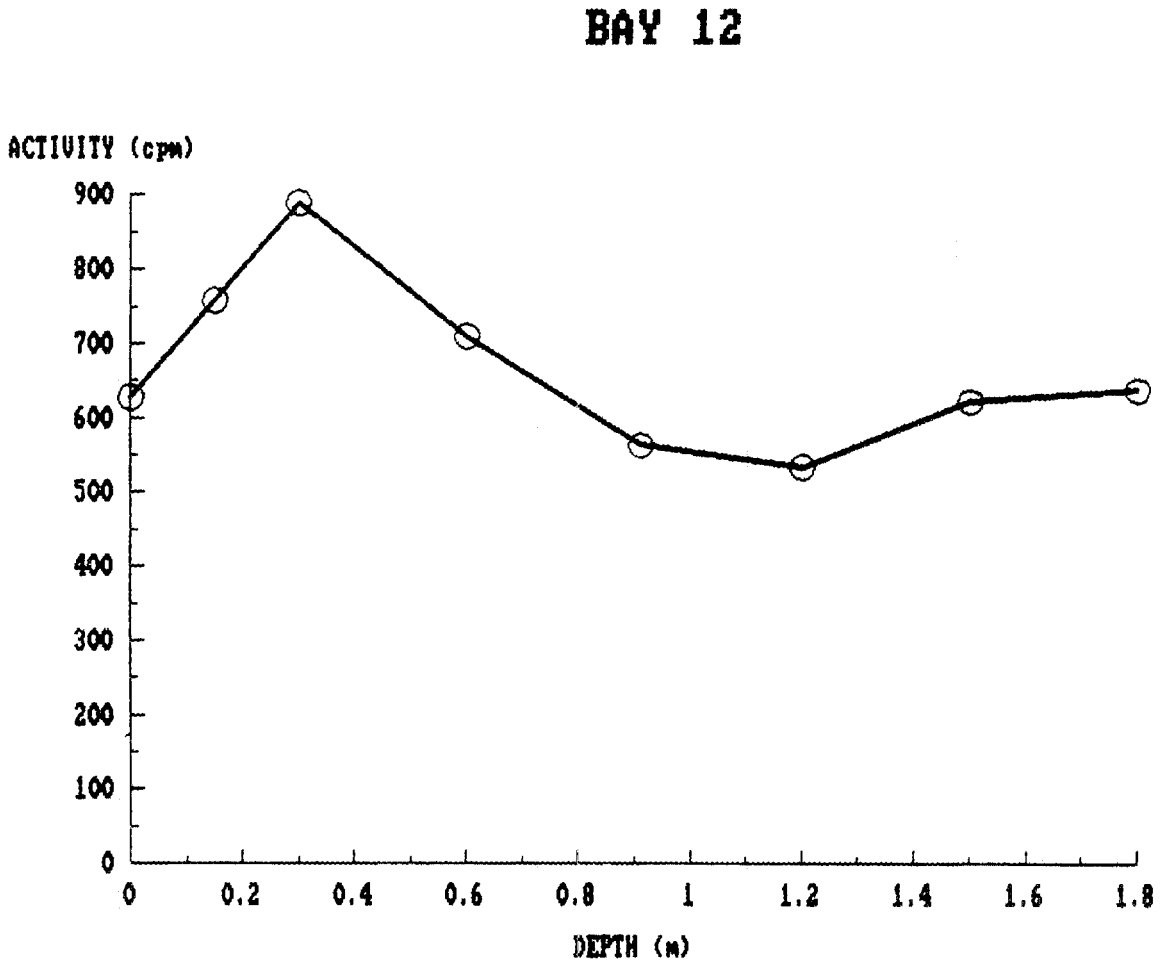

Fig. A.15. Gamma profile of auger hole 11.

ORNL-DWG 87-16463

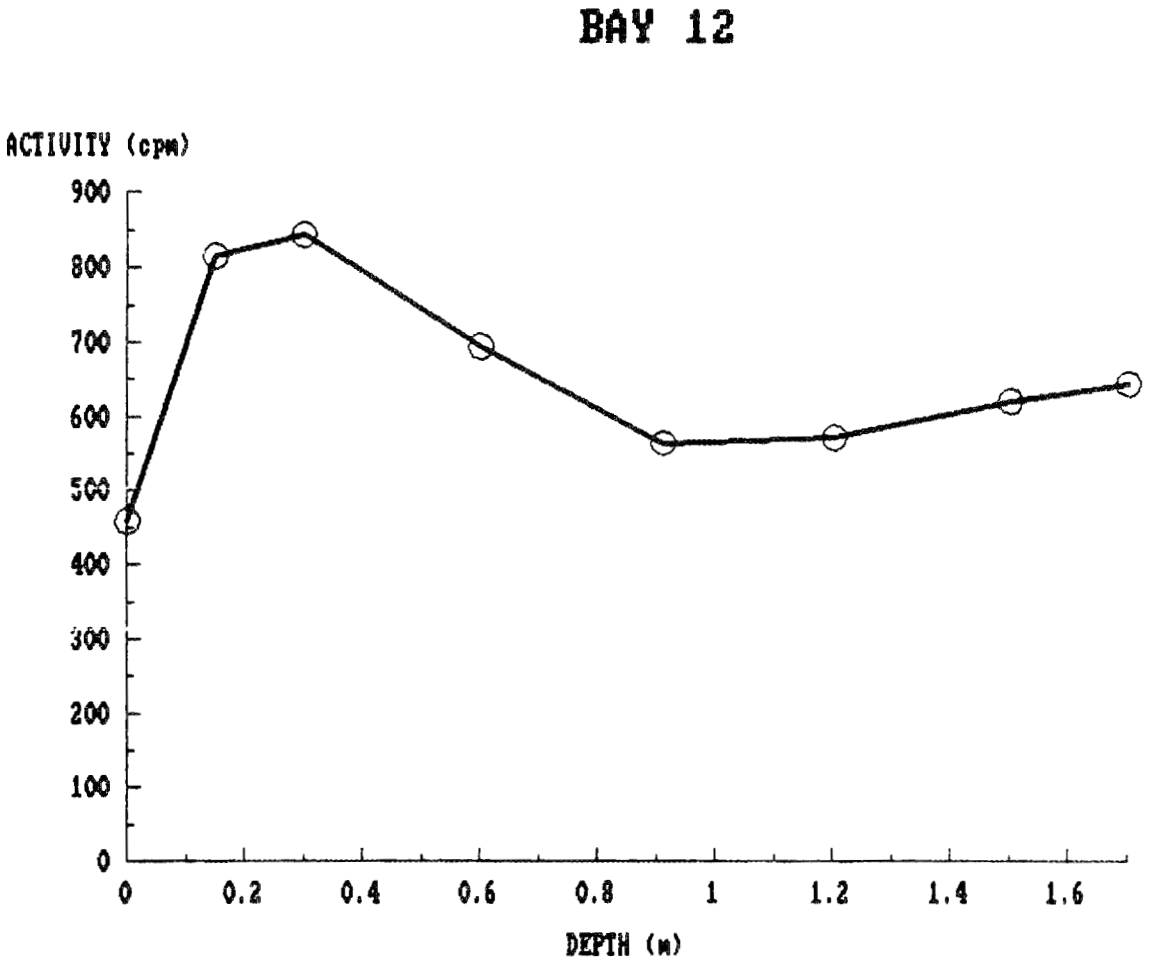

Fig. A.16. Gamma profile of auger hole 12.

ORNL-DWG 87-16464

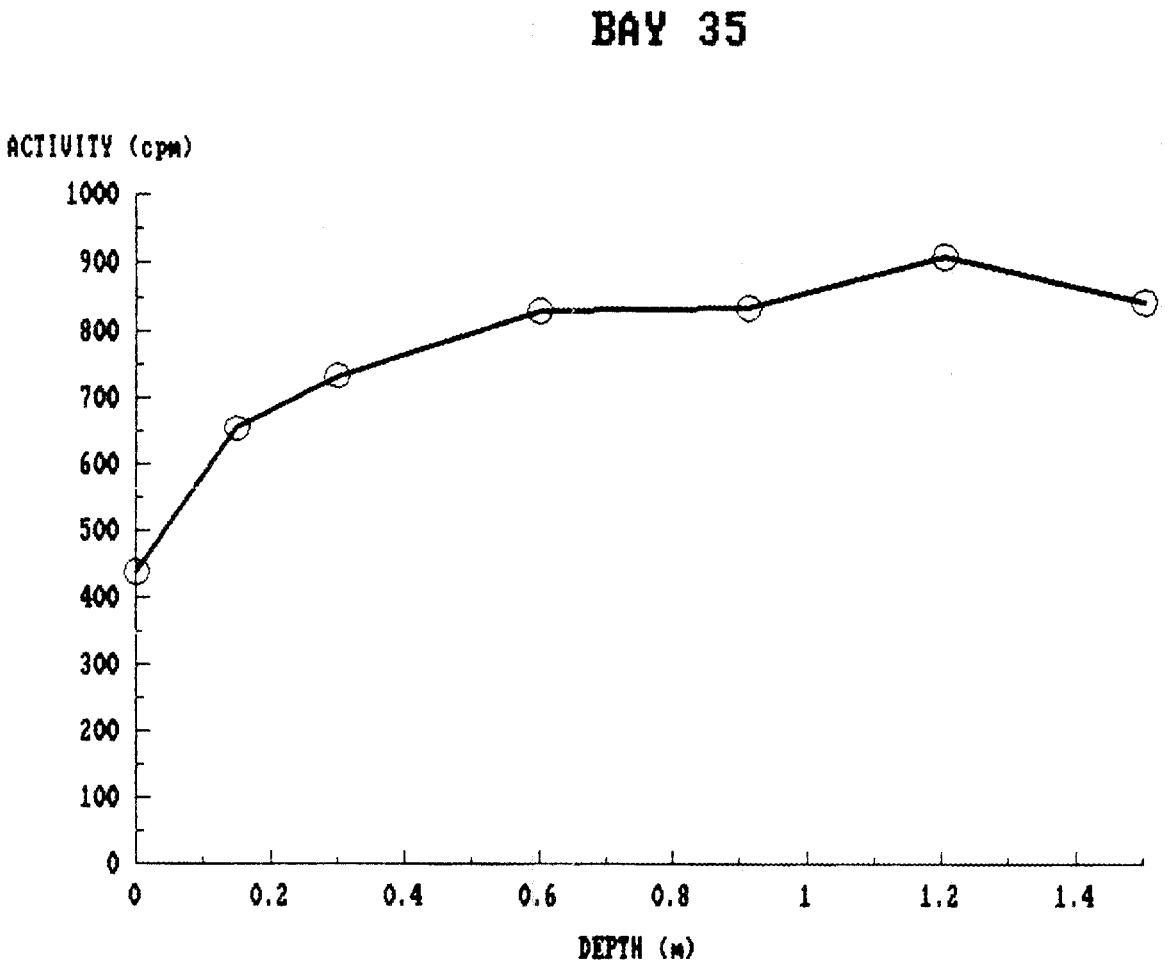

Fig. A.17. Gamma profile of auger hole 30.

ORNL-DWG 87-16465

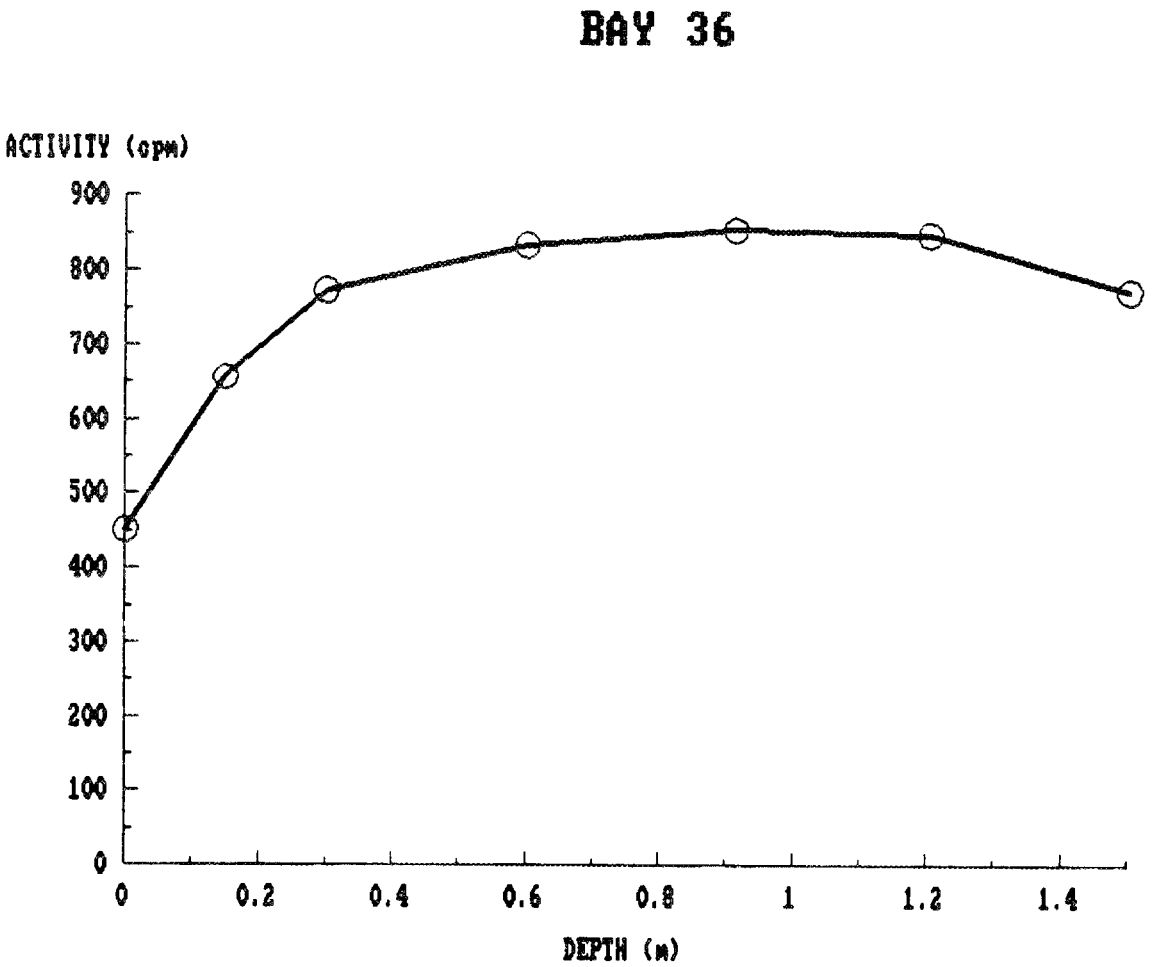

Fig. A.18. Gamma profile of auger hole 28.

ORNL-DWG 87-16466

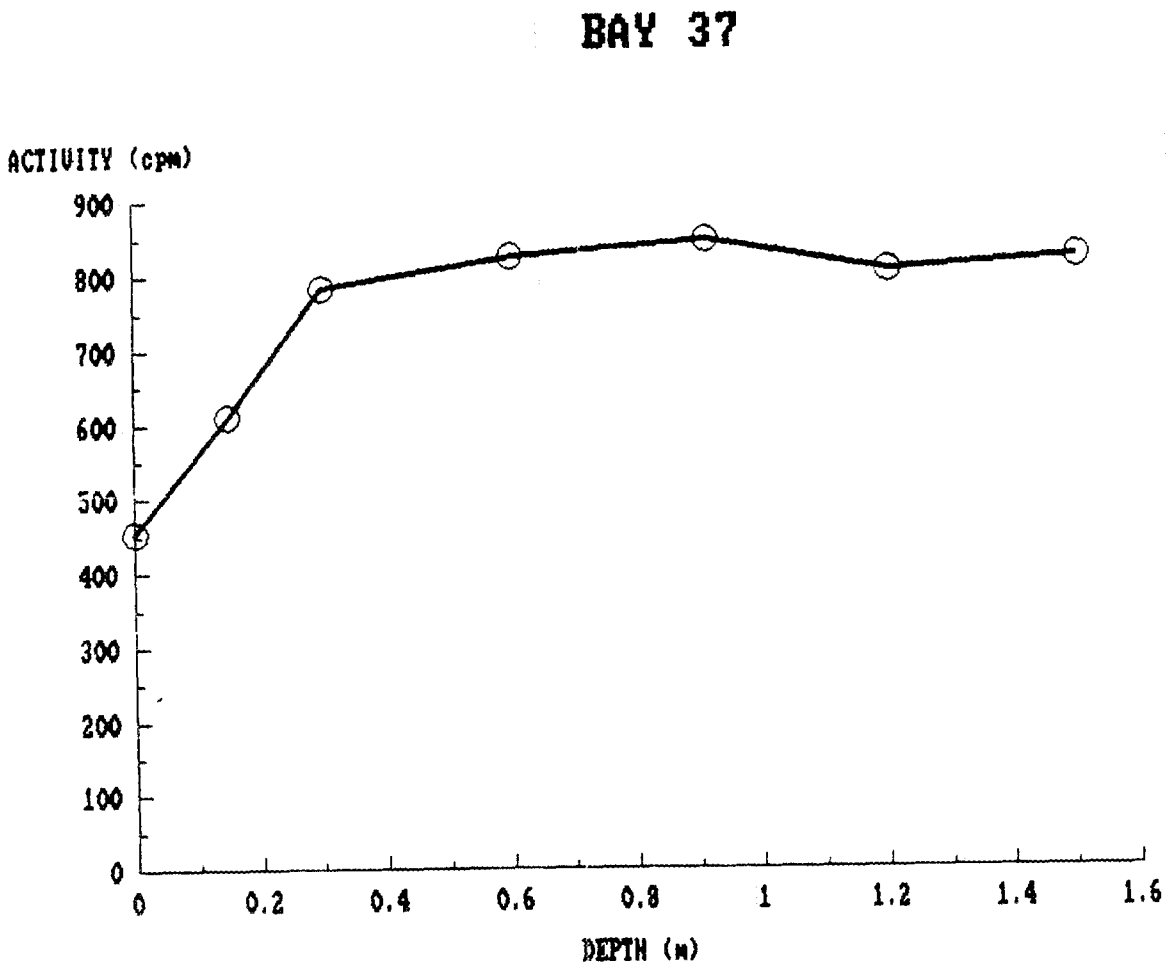

Fig. A.19. Gamma profile of auger hole 31.

ORNL-DWG 87-16467

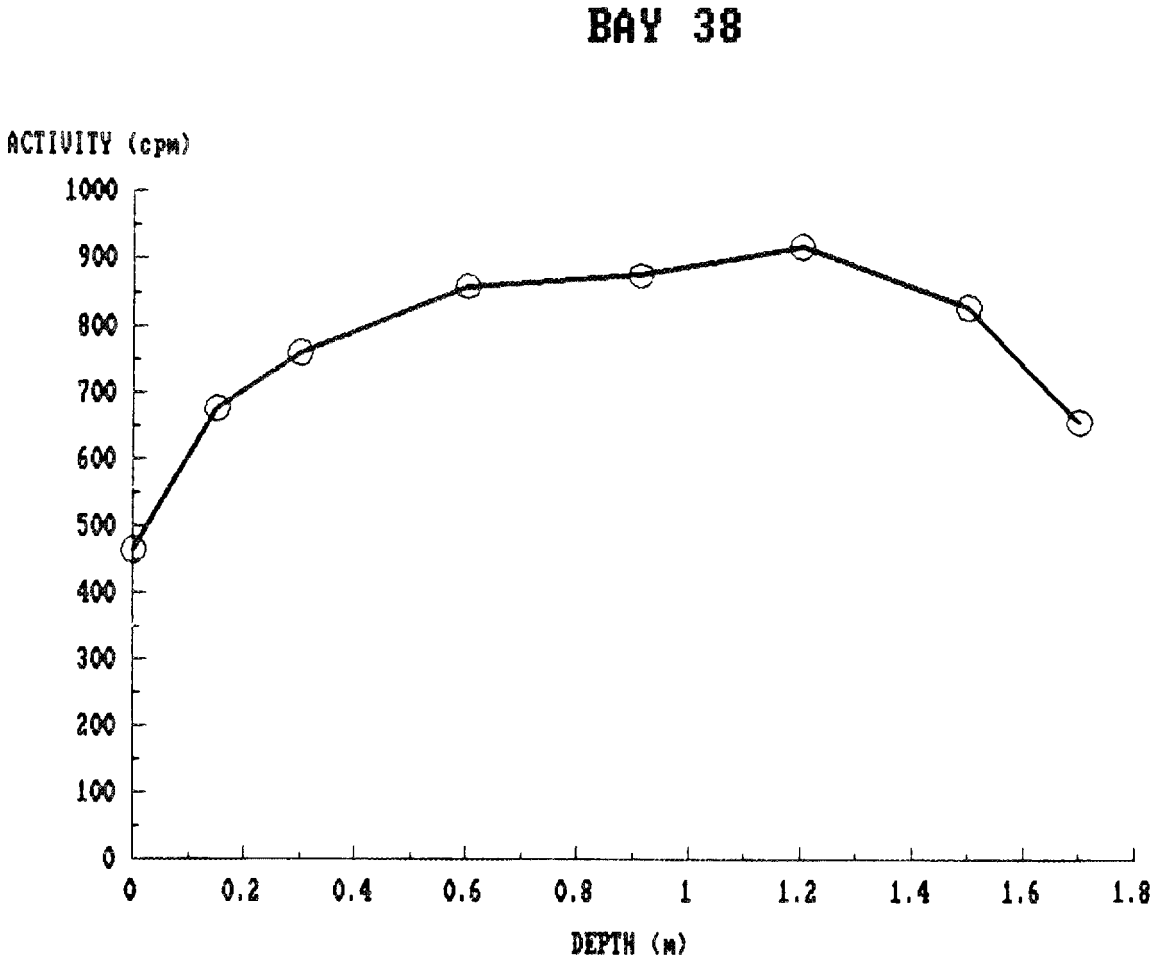

Fig. A.20. Gamma profile of auger hole 29.

ORNL-DWG 87-16468

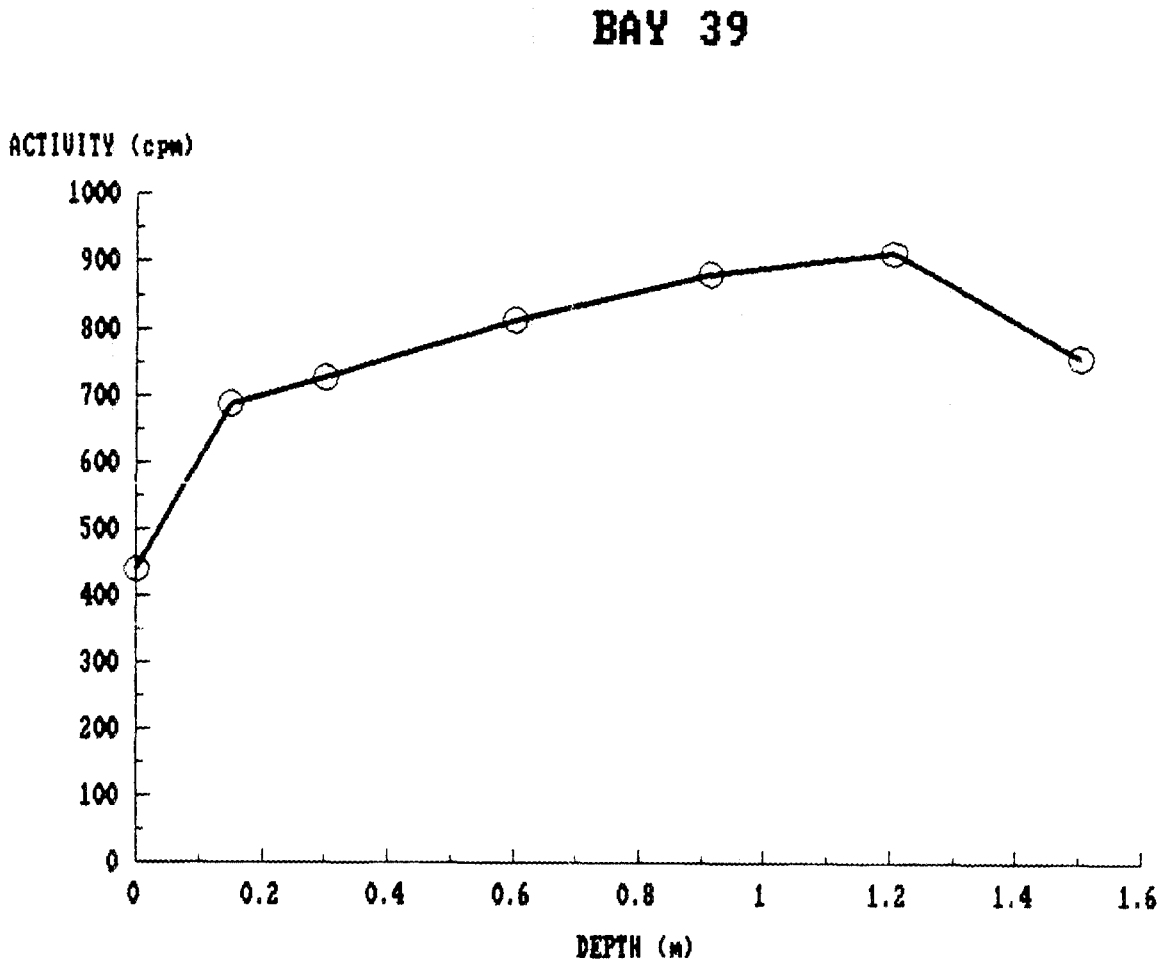

Fig. A.21. Gamma profile of auger hole 32.

ORNL-DWG 87-16469

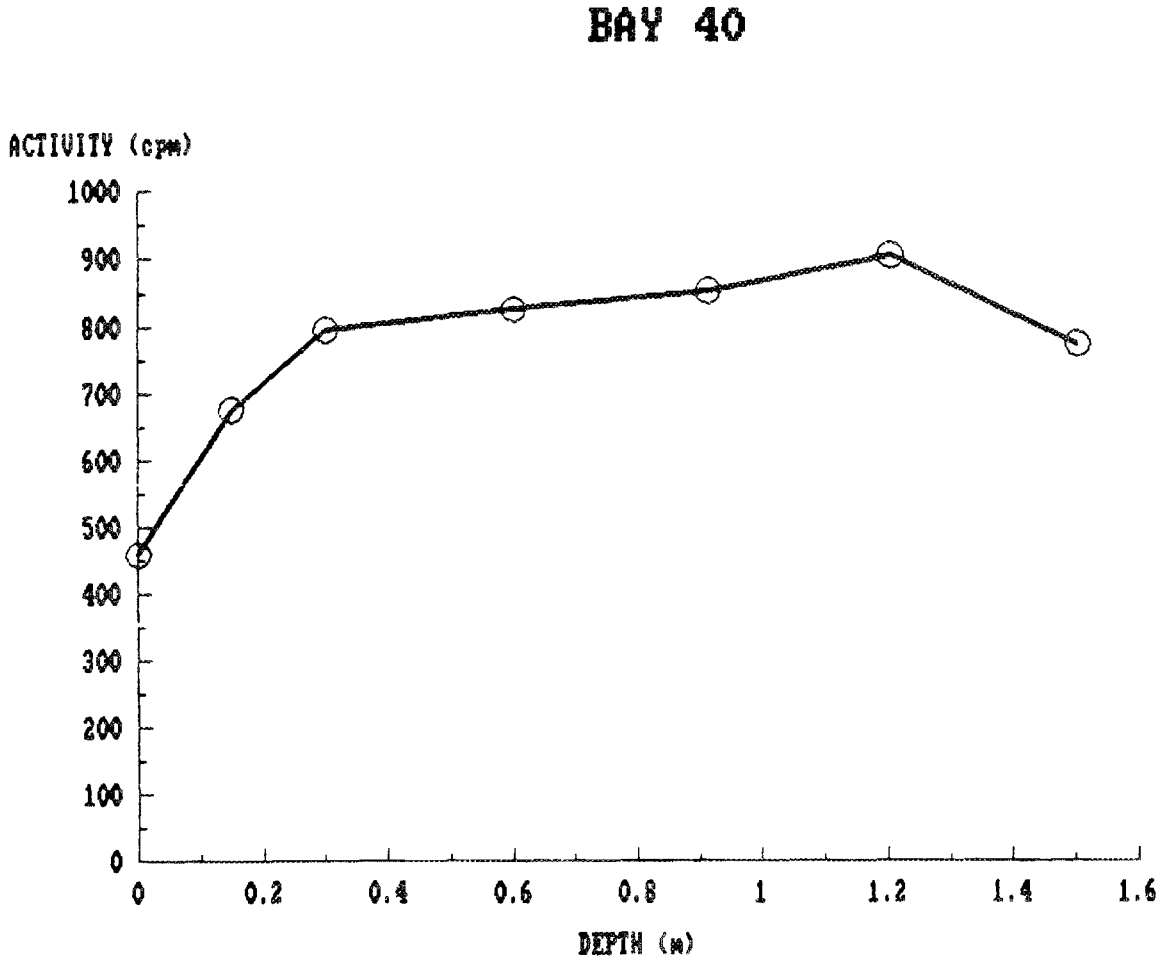

Fig. A.22. Gamma profile of auger hole 27.

ORNL-DWG 87-16470

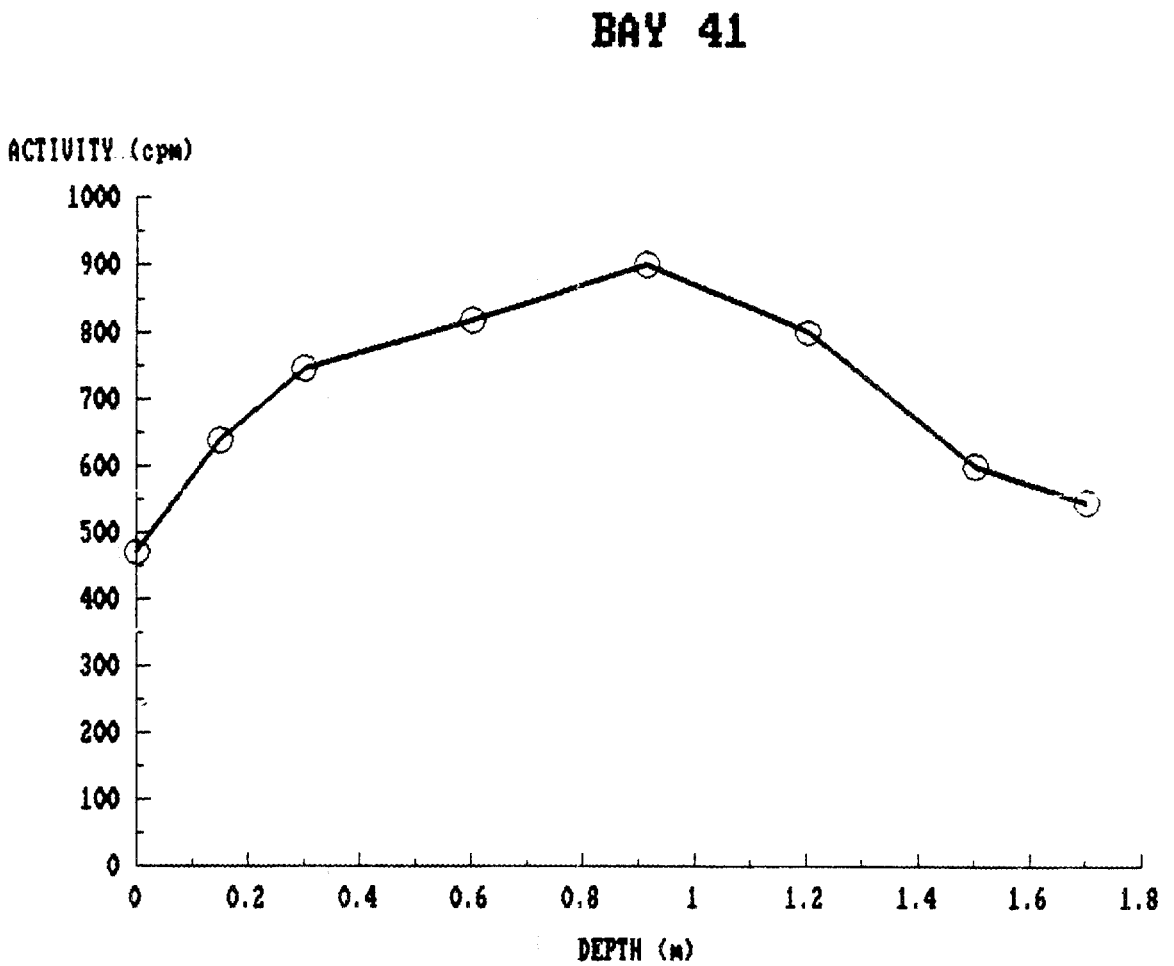

Fig. A.23. Gamma profile of auger hole 24.

ORNL-DWG 87-16471

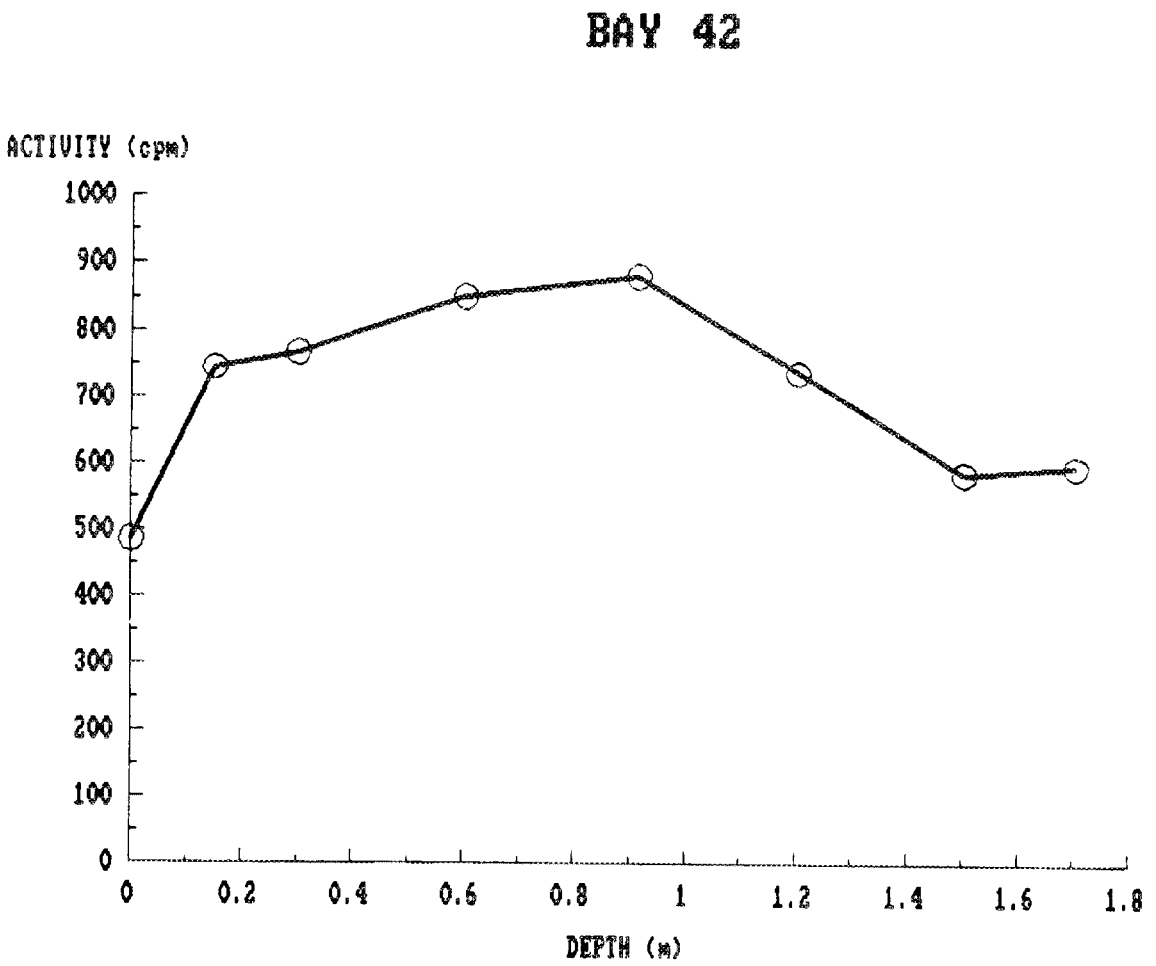

Fig. A.24. Gamma profile of auger hole 35.

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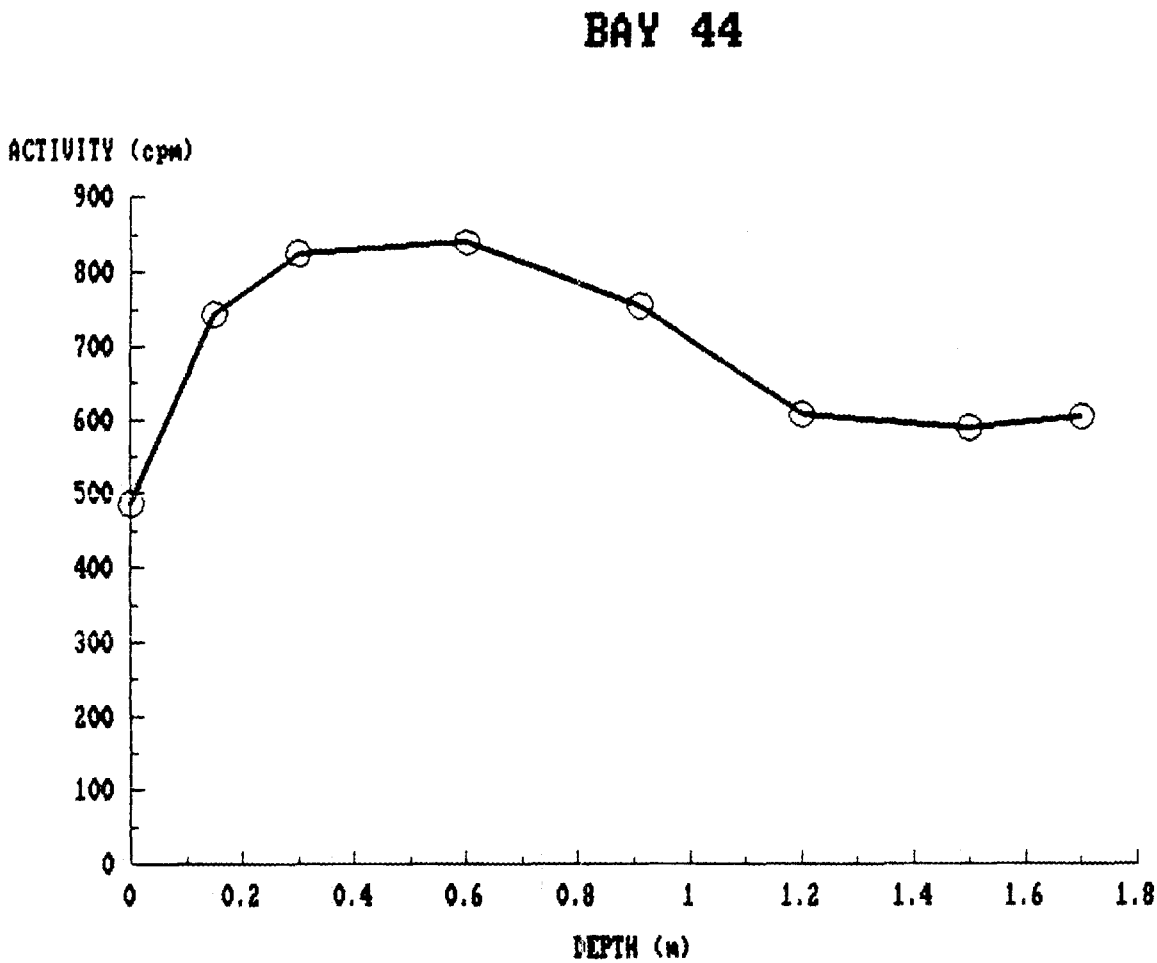

Fig. A.25. Gamma profile of auger hole 22.

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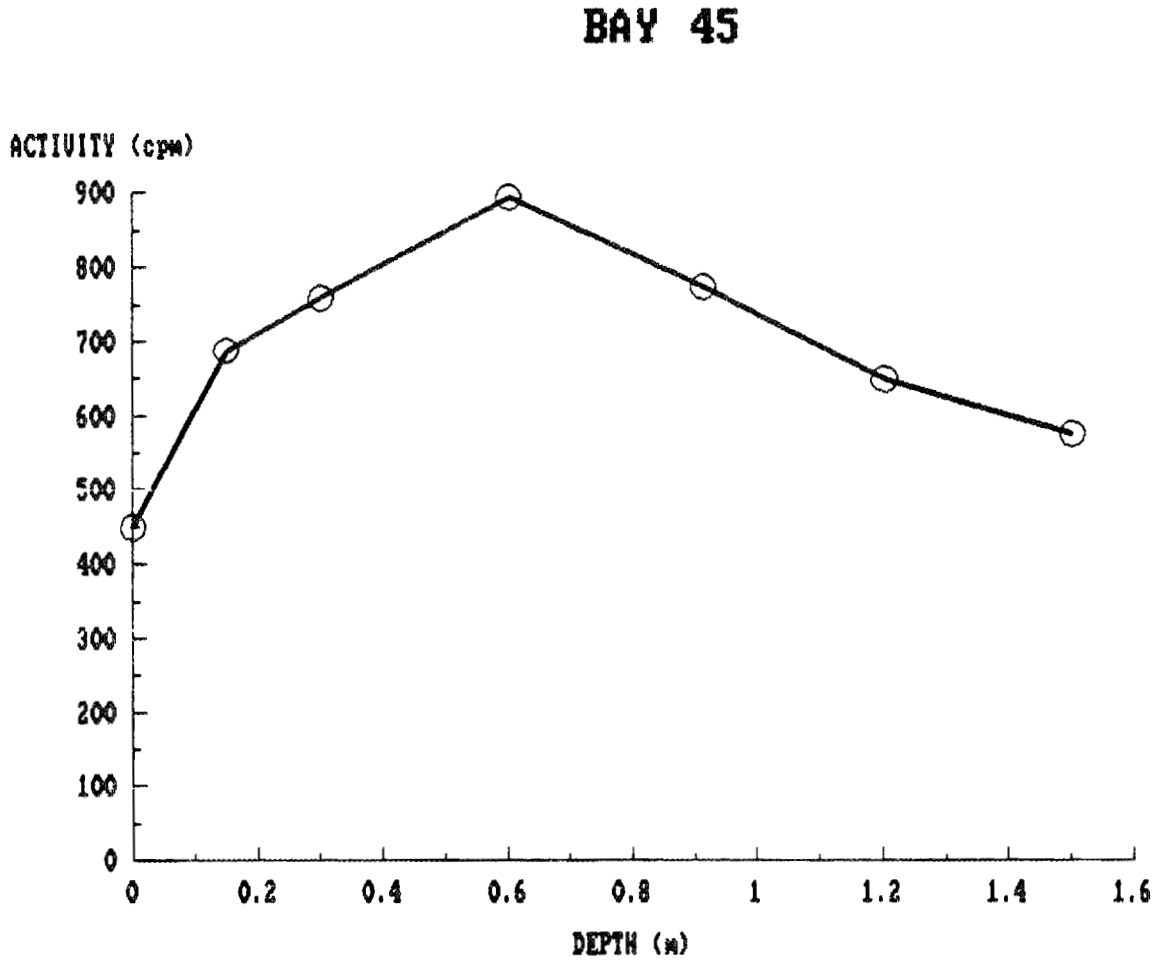

Fig. A.26. Gamma profile of auger hole 25.

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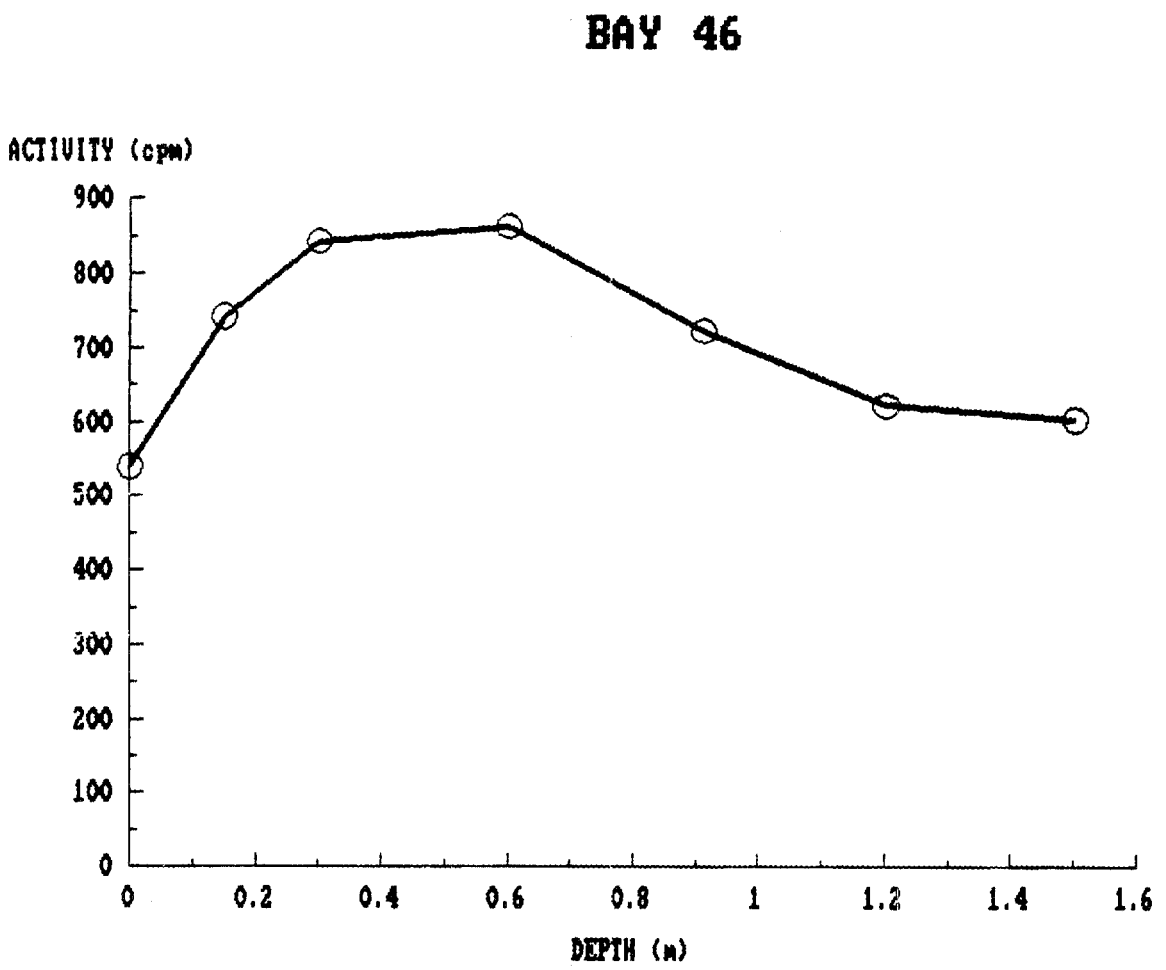

Fig. A.27. Gamma profile of auger hole 21.

ORNL-DWG 87-16475

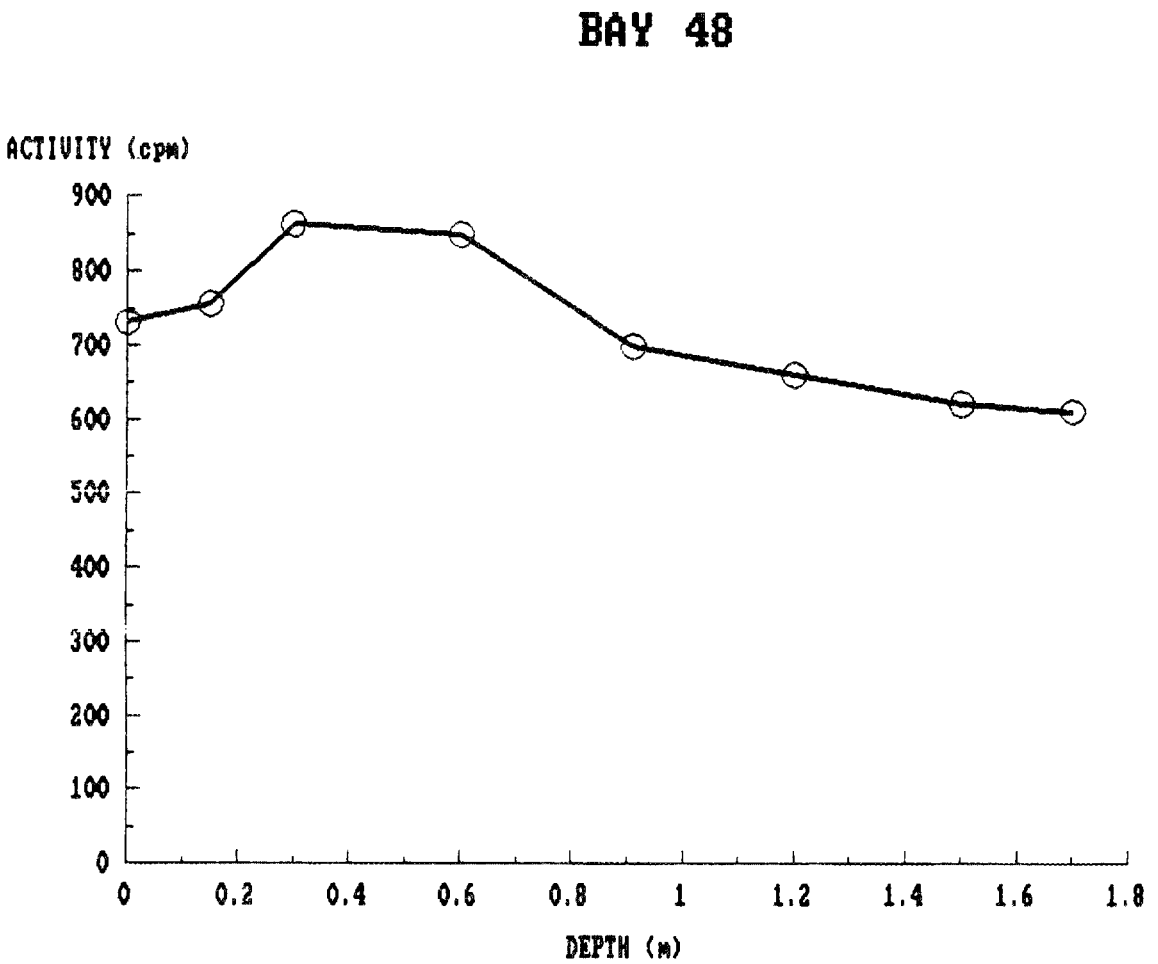

Fig. A.28. Gamma profile of auger hole 20.

ORNL-DWG 87-16476

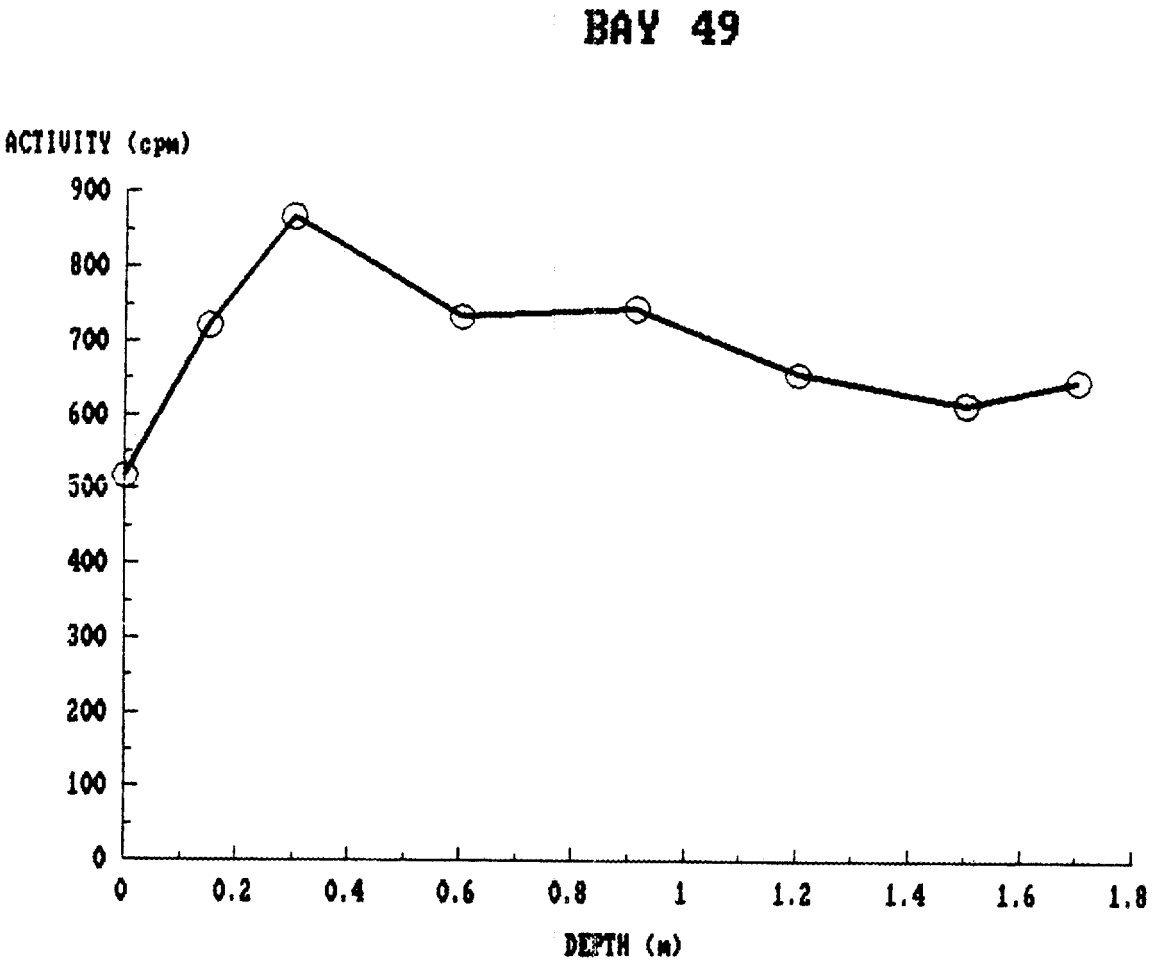

Fig. A.29. Gamma profile of auger hole 19.

ORNL-DWG 87-16477

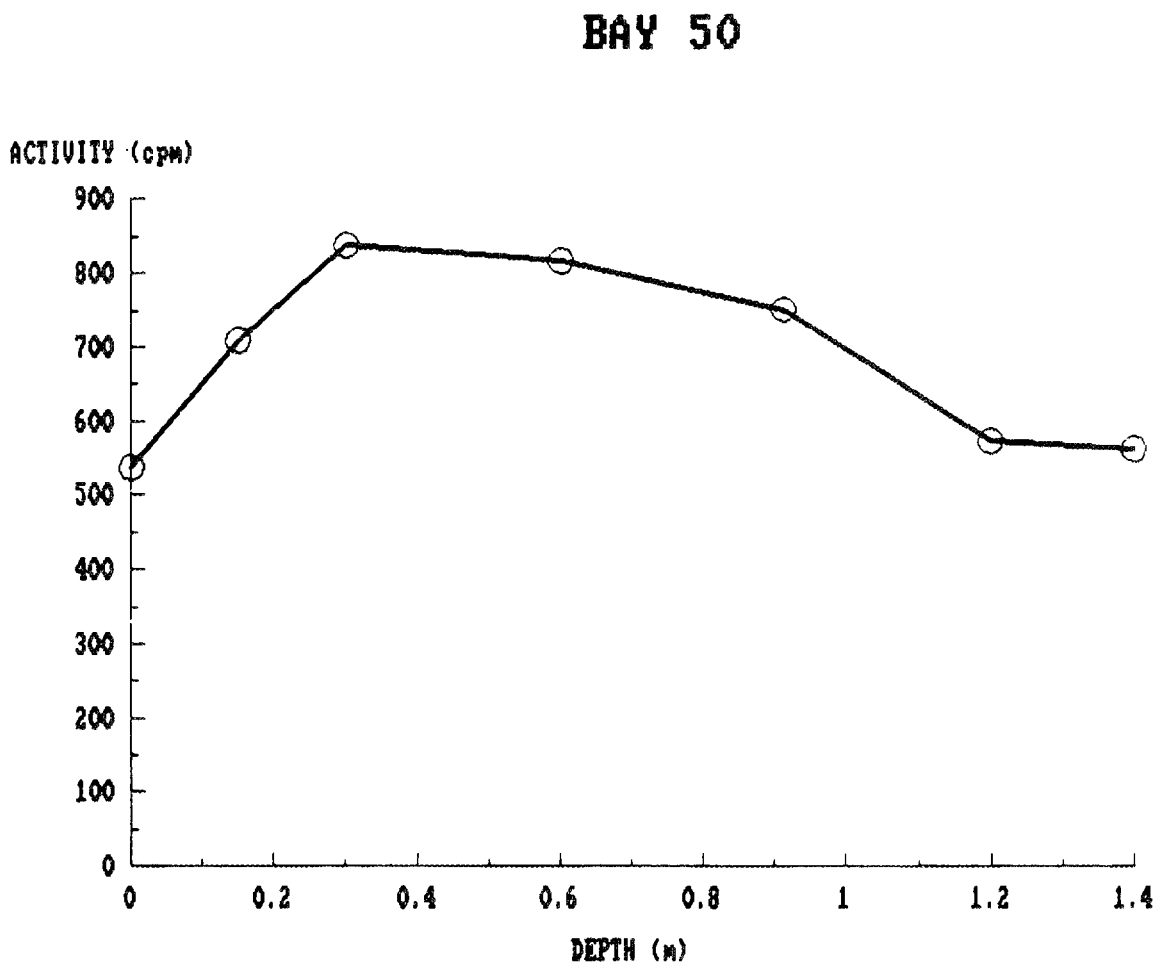

Fig. A.30. Gamma profile of auger hole 13.

ORNL-DWG 87-16478

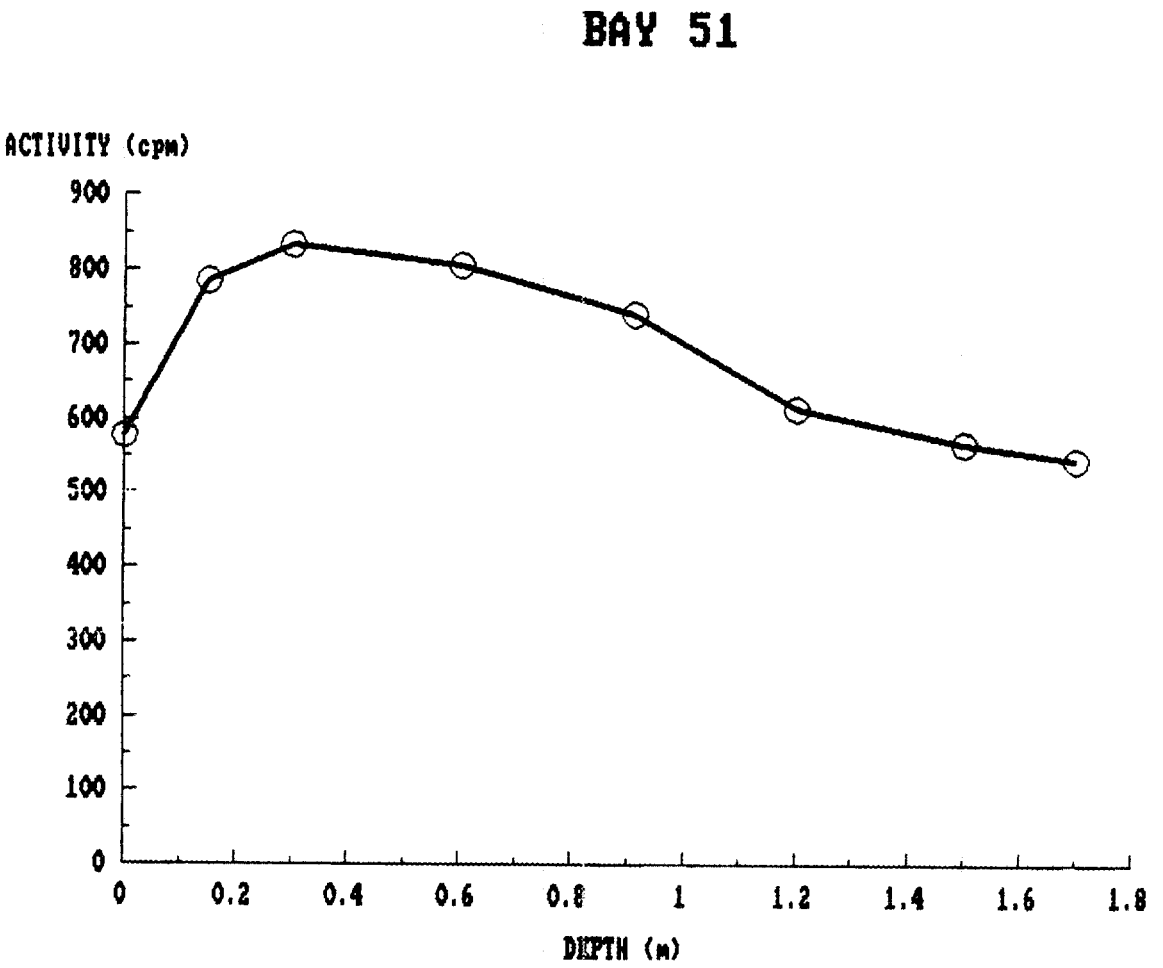

Fig. A.31. Gamma profile of auger hole 34.

ORNL-DWG 87-16479

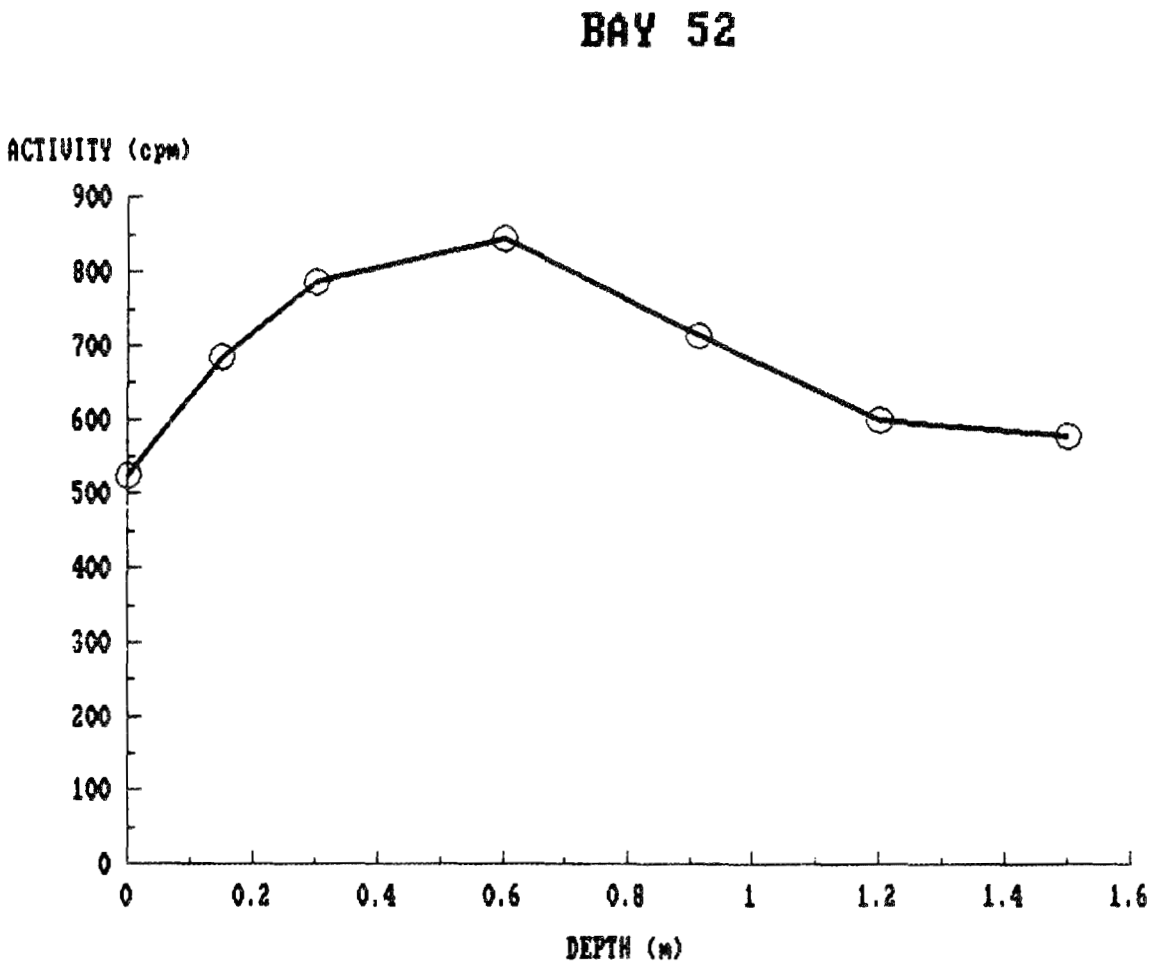

Fig. A.32. Gamma profile of auger hole 14.

ORNL-DWG 87-16480

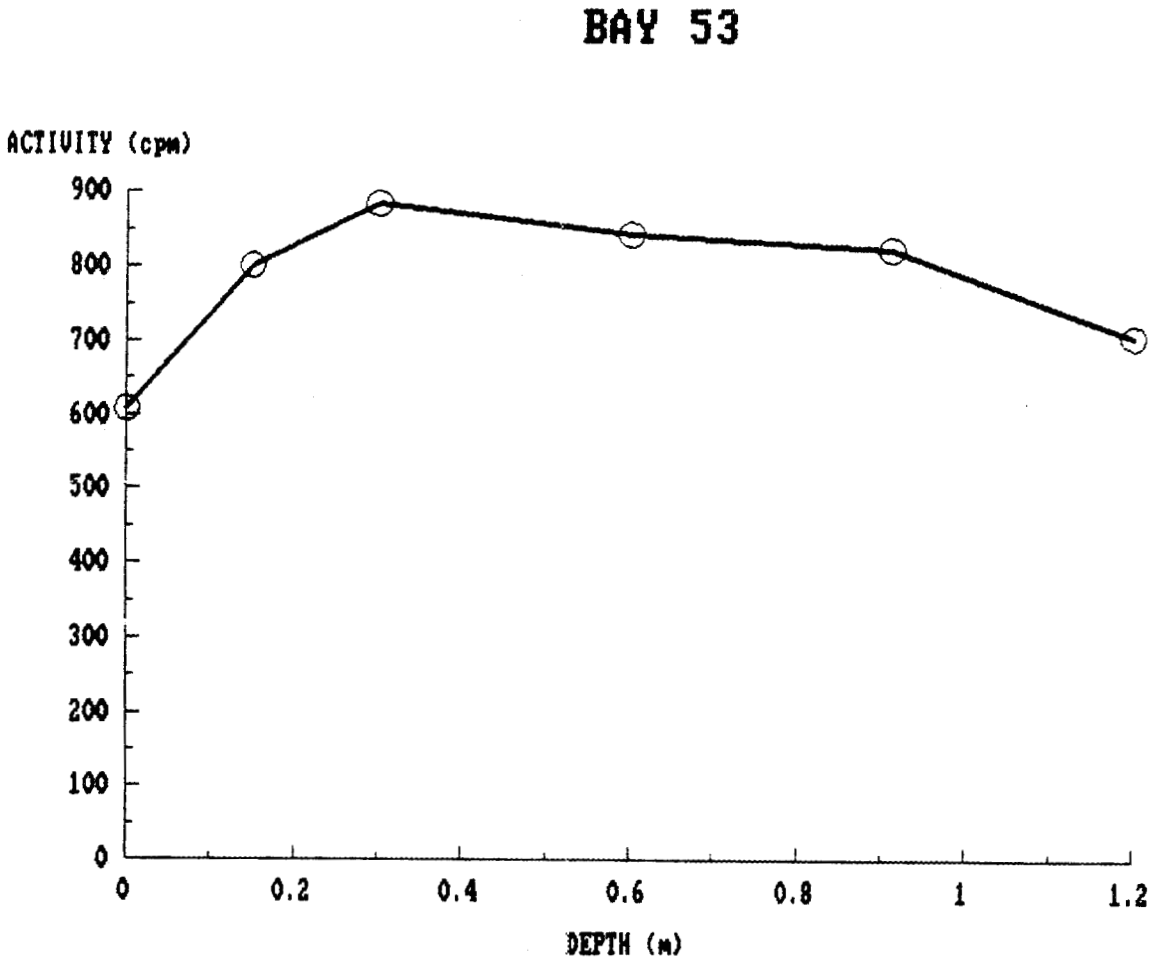

Fig. A.33. Gamma profile of auger hole 18.

ORNL-DWG 87-16481

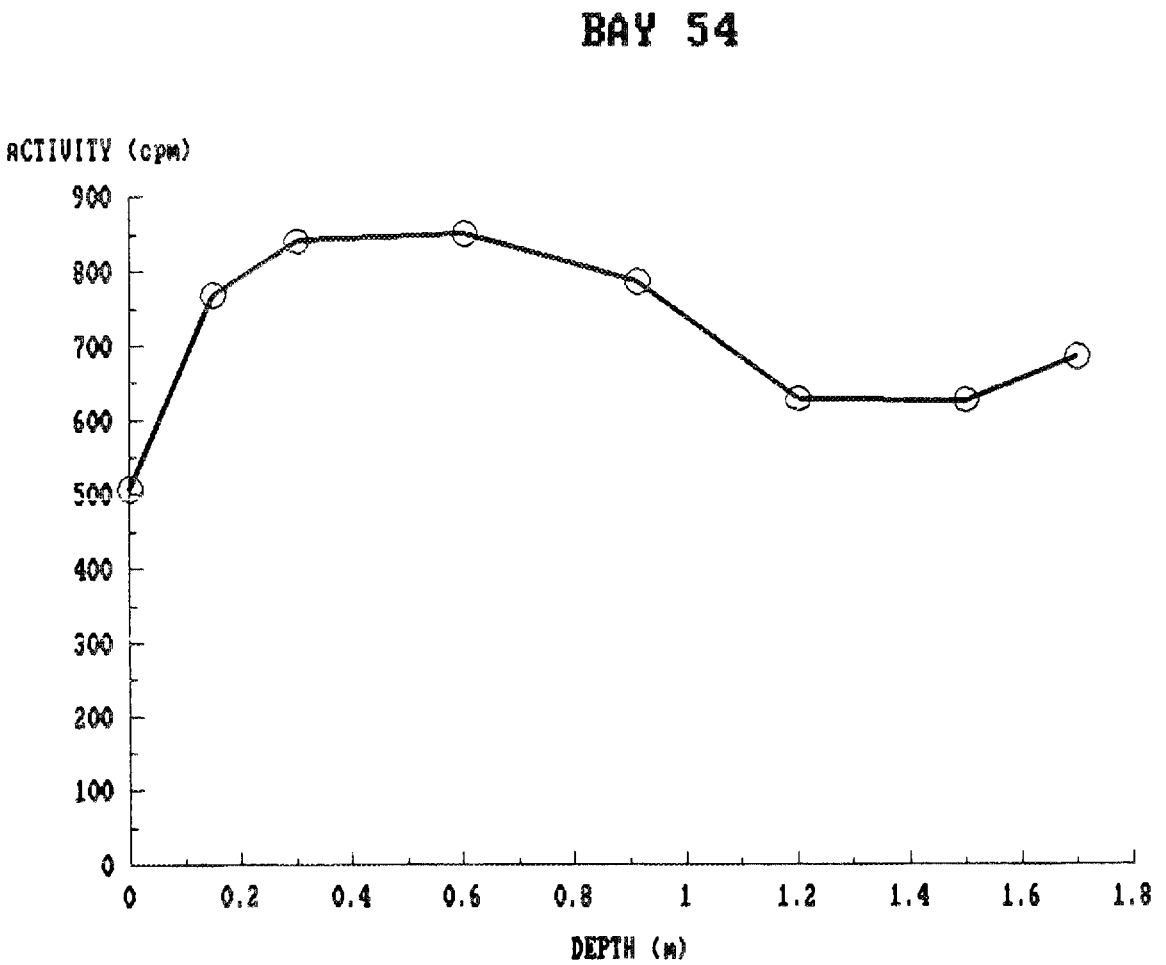

Fig. A.34. Gamma profile of auger hole 15.

ORNL-DWG 87-16482

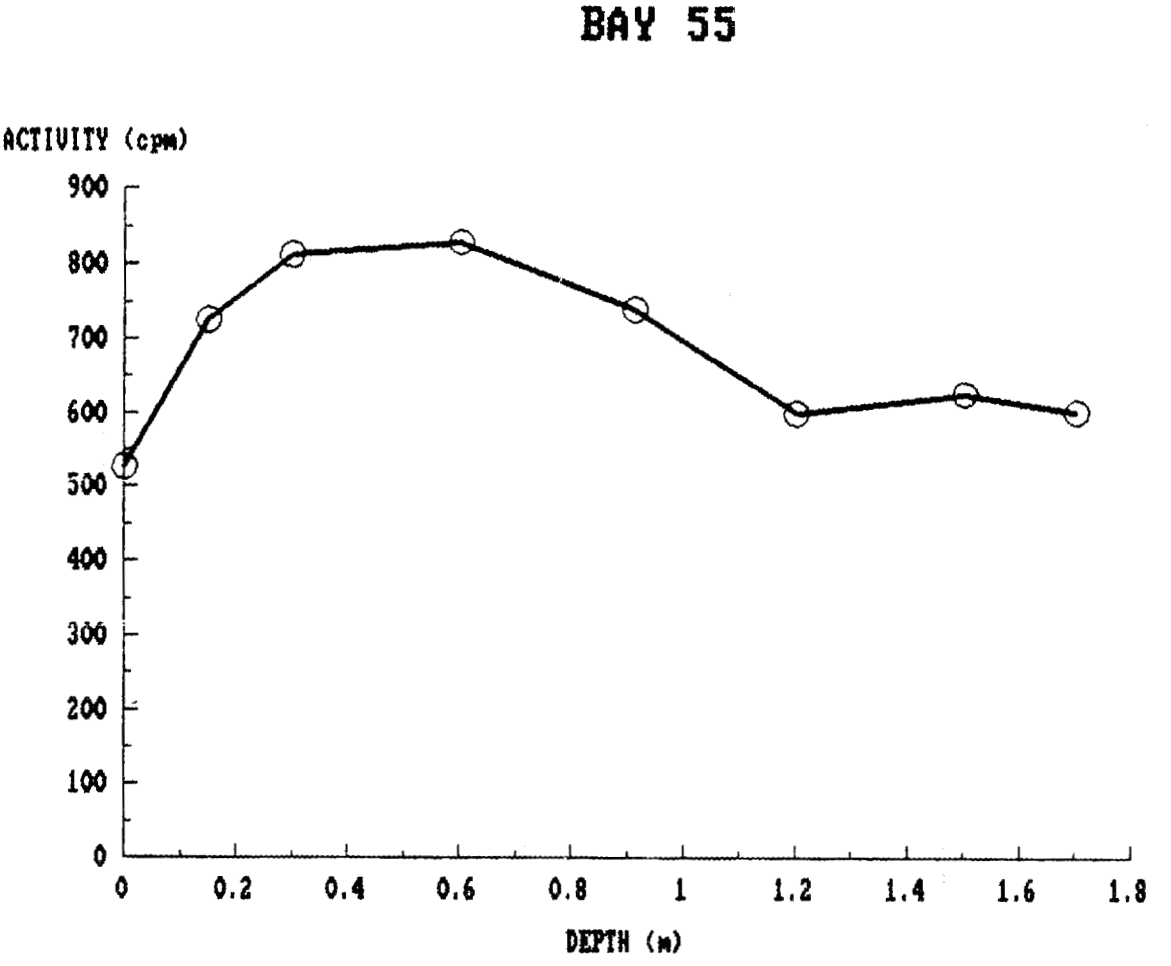

Fig. A.35. Gamma profile of auger hole 33.

ORNL-DWG 87-16483

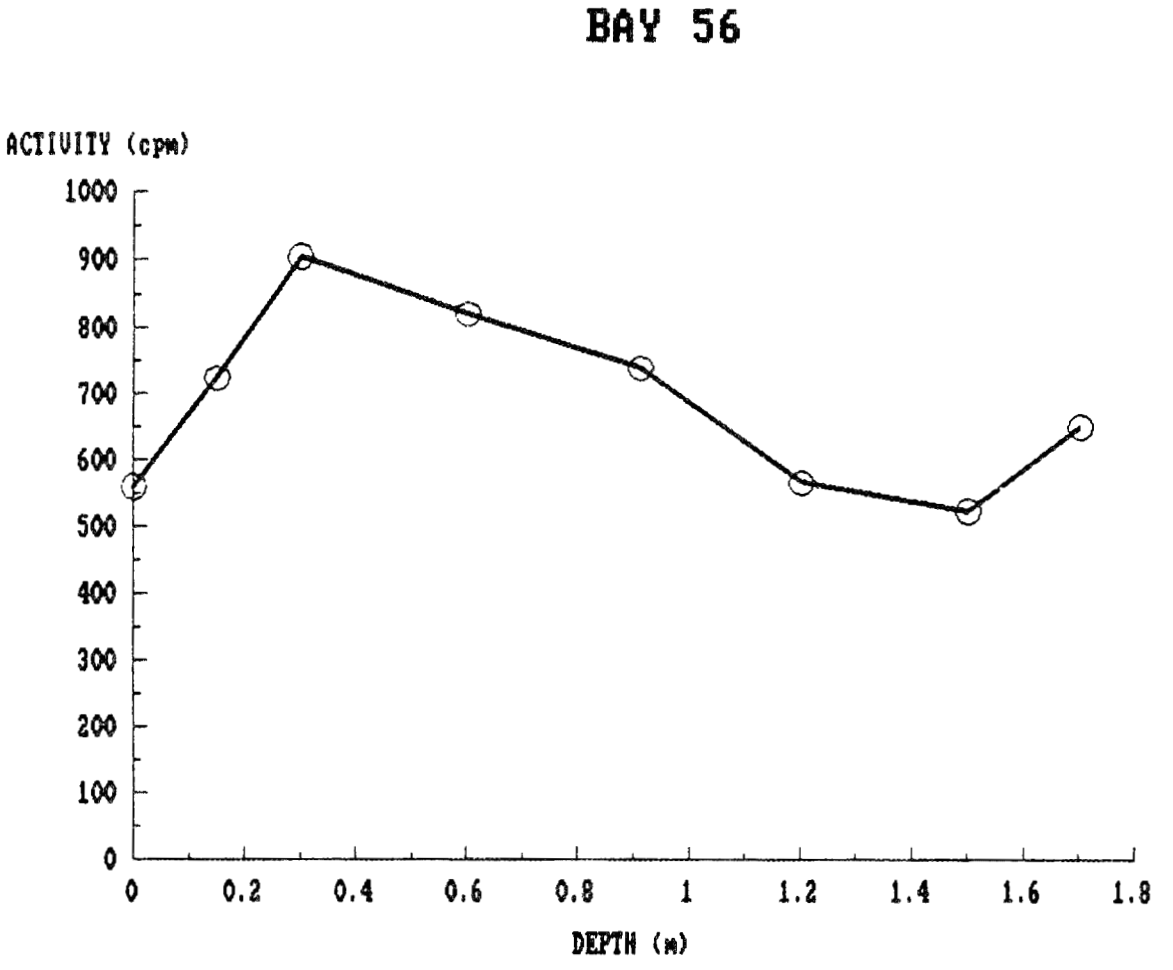

Fig. A.36. Gamma profile of auger hole 16.

ORNL-DWG 87-16484

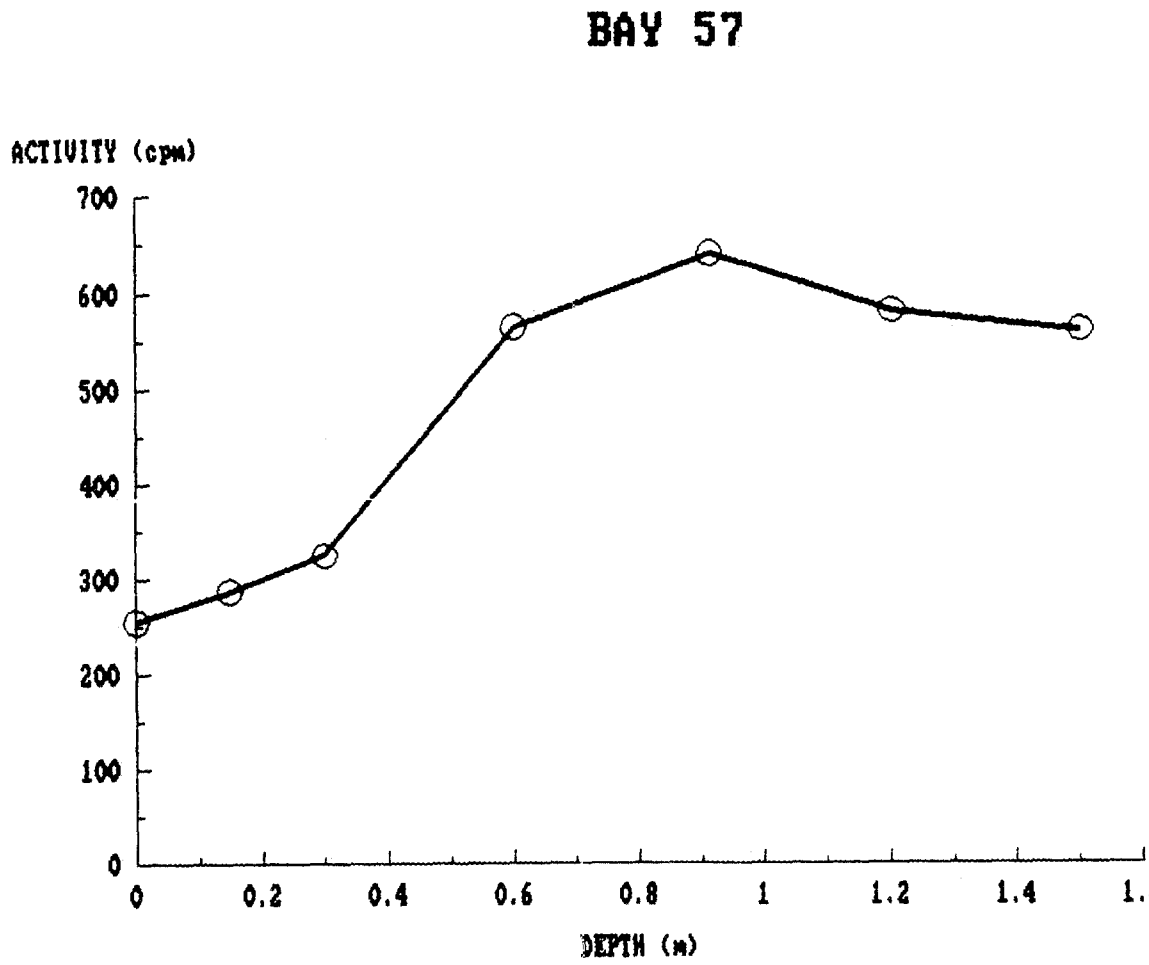

Fig. A.37. Gamma profile of auger hole 26.

ORNL-DWG 87-16485

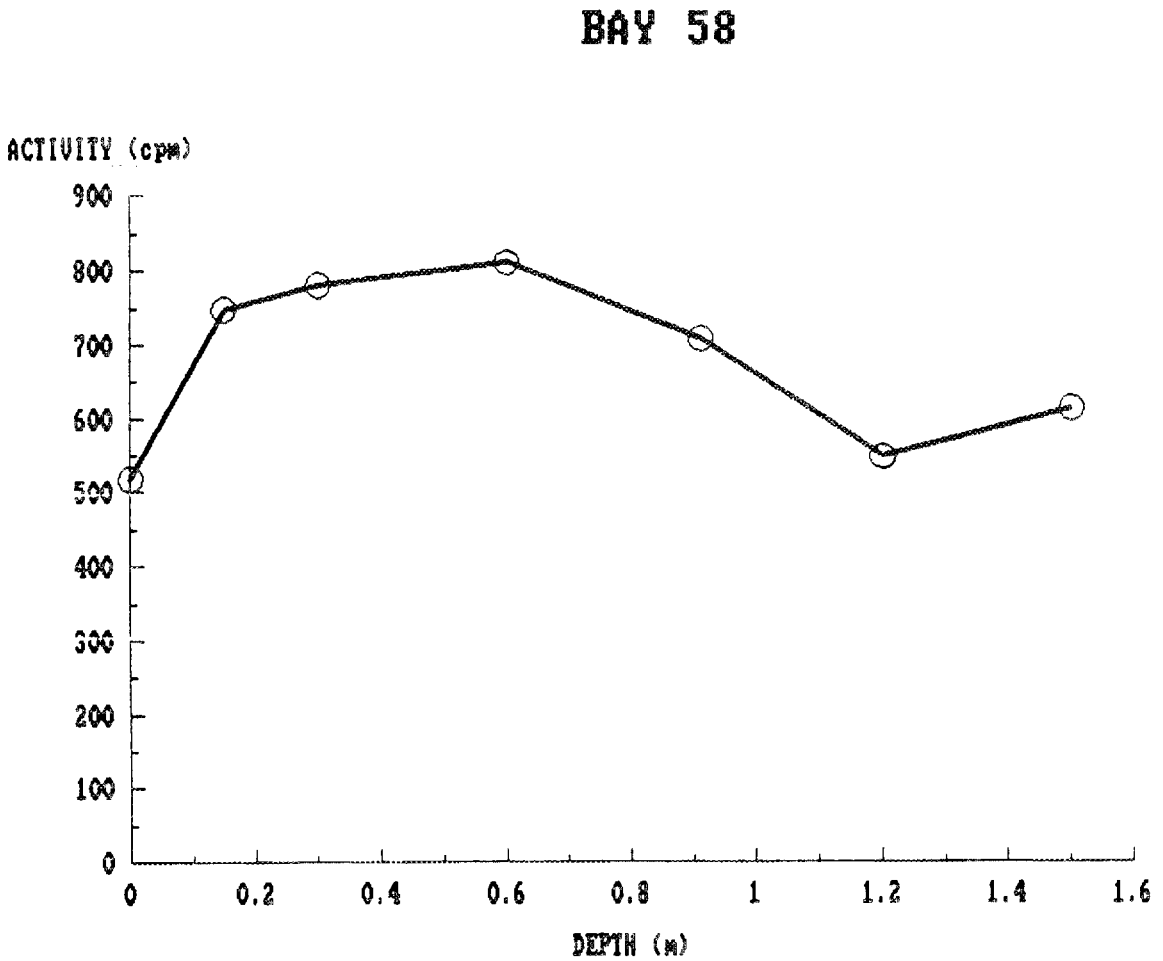

Fig. A.38. Gamma profile of auger hole 17.

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