COMPREHENSIVE RADIOLOGICAL SURVEY

OFF-SITE PROPERTY N′-NORTH
NIAGARA FALLS STORAGE SITE
LEWISTON, NEW YORK

Prepared for

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INTRODUCTION

Beginning in 1944, the Manhattan Engineer District and its successor, the Atomic Energy Commission (AEC), used portions of the Lake Ontario Ordnance Works (presently referred to as the Niagara Falls Storage Site (NFSS) and off-site properties), approximately 3 km northeast of Lewiston, New York, for storage of radioactive wastes. These wastes were primarily residues from uranium processing operations; however, they also included: contaminated rubble and scrap from decommissioning activities, biological and miscellaneous wastes from the University of Rochester, and low-level fission-product waste from contaminated-liquid evaporators at the Knolls Atomic Power Laboratory (KAPL). Receipt of radioactive waste was discontinued in 1954, and, following cleanup activities by Hooker Chemical Co., 525 hectares of the original 612-hectare site were declared surplus. This property was eventually sold by the General Services Administration to various private, commercial, and governmental agencies.[1]

Modern Landfill, Inc., is the current owner of a tract from the NFSS, identified as off-site property N′-North (see Figure 1). A radiological survey of that tract, conducted September-October 1983, is the subject of this report.

SITE DESCRIPTION

Figure 2 is a plot plan of off-site property N′-North. This property, bounded by Track Street and South Track Street, occupies approximately 2.6 hectares. An out-of-service railroad track passes through the center of the site. A drainage ditch, portions of which contain debris and building rubble, parallels the track on the north side. The property is presently unused and there are no structures on the site. There are numerous small piles of building rubble, crushed rock and gravel, and miscellaneous metal, rubber, and wood scrap. Light brush and small trees cover the area.

Radiological History

The N′-North area was used during the early 1950′s for temporary storage and classification of contaminated scrap from dismantled MED/AEC facilities.[1] Much of this material was removed during the 1950′s; however, the 1971-72 AEC survey identified a large portion of the area as having elevated direct radiation levels.[2] Although additional cleanup was conducted following the AEC survey, areas exceeding 20 μR/h remained. The 1980 ORNL mobile scan confirmed elevated radiation levels throughout the property bounded by Track Street and South Track Street.

SURVEY PROCEDURES

The comprehensive survey of off-site property N′-North was performed by the Radiological Site Assessment Program of Oak Ridge Associated Universities (ORAU), during September and October 1983. The survey was in accordance with a plan dated March 18, 1983, approved by the Department of Energy′s Office of Nuclear Energy. The objective and procedures from that plan are presented in this section.

Objective

The objective of the survey was to provide a comprehensive assessment of the radiological conditions and associated potential health effects, if any, on property N′-North. Radiological information collected included:

1. direct gamma exposure rates and surface beta-gamma dose rates,
2. locations of contaminated surface areas, and
3. concentrations of radionuclides in surface and subsurface soil.

Procedures

1. Brush and weeds were cleared as needed to provide access for gridding and surveying. This operation was performed by Modern Disposal, Inc., of Model City, NY, under subcontract.

2. Under subcontract, McIntosh and McIntosh of Lockport, NY, established a 10 m grid system. This grid is shown on Figure 3.

3. Gamma exposure rate measurements were made at the surface and at 1 m above the surface at 10 m grid intervals. Measurements were performed using portable gamma NaI(Tl) scintillation survey meters. Conversion of these measurements to exposure rates in microroentgens per hour (μR/h) was in accordance with cross calibration with a pressurized ionization chamber.

4. Beta-gamma dose rate measurements were performed 1 cm above the surface at 10 m grid intervals. These measurements were conducted using thin-window (<7 mg/cm^2) G-M detectors and portable scaler/ratemeters. Measurements were also obtained with the detector shielded to evaluate contributions of nonpenetrating beta and low-energy gamma radiations. Meter readings were converted to dose rates in microrads per hour (μrad/h) based on cross calibration with a thin-window ionization chamber.

5. Surface (0-15 cm) soil samples of approximately 1 kg each were collected at 10 m grid intervals.

6. Walkover surface scans were conducted at 1-2 m intervals over the property. Locations of elevated contact radiation levels were noted.

7. At selected locations of elevated surface radiation levels, beta-gamma dose rates at 1 cm above the surface and exposure rates at 1 m above the surface were also measured. Surface soil samples were obtained from these locations and, following sampling, the surface exposure levels were remeasured to evaluate the effectiveness of shallow sampling on removal of the radiation source.

8. Detection Sciences Group of Carlisle, MA, performed ground-penetrating radar surveys to identify evidence of subsurface targets which might indicate buried waste. Radar scans were also performed at locations of proposed subsurface investigations to identify the presence of underground piping or utilities which would preclude borehole drilling.

9. Boreholes were drilled to provide a mechanism for logging subsurface direct radiation profiles and collecting subsurface soil and water samples. Boreholes were drilled by Site Engineers, Inc., of Cherry Hill, NJ, and Earth Dimensions, of Aurora, NY, using truck mounted 20 cm diameter hollow-stem augers. A total of fifteen boreholes were drilled; the locations of these boreholes are shown on Figure 4.

   A gamma scan of the boreholes was performed to identify elevated radiation levels, which would indicate subsurface residues. Radiation profiles in the boreholes were determined by measuring gamma radiation at 15-30 cm intervals between the surface and the hole bottom. A collimated gamma scintillation detector and portable scaler were used for these measurements.

   Soil samples of approximately 1 kg each were collected from various depths in the holes by scraping the sides of each borehole with an ORAU designed sampling tool. Water was either not encountered in these boreholes or was present as a result of surface water in the area. There were therefore no subsurface water samples collected.

10. Twenty soil samples and seven water samples were collected from the Lewiston area (but not on the NFSS or associated off-site properties) to provide baseline concentrations of radionuclides for comparison purposes. Direct background radiation levels were measured at locations where baseline soil samples were collected. The locations of the baseline samples and background measurements are shown on Figure 5.

Sample Analysis and Interpretation of Results

Soil samples were analyzed by gamma spectrometry. Radium-226 was the major radionuclide of concern, although spectra were reviewed for U-235, U-238, Cs-137, Th-232, and other gamma emitters.

Additional information concerning analytical equipment and procedures is contained in Appendix A.

Results of this survey were compared to the applicable guidelines for formerly utilized radioactive materials handling sites, which are presented in Appendix B.

RESULTS

Background Levels and Baseline Concentrations

Background exposure rates and baseline radionuclide concentrations in soil, determined for 20 locations (Figure 5) in the vicinity of the NFSS, are presented in Table 1-A. Exposure rates ranged from 6.8 to 8.8 μR/h (typical levels for this area of New York). Concentrations of radionuclides in soil were: Ra-226, <0.09 to 1.22 pCi/g (picocuries per gram); U-235, <0.14 to 0.46 pCi/g; U-238, <2.20 to 6.26 pCi/g; Th-232, 0.32 to 1.18 pCi/g; and Cs-137, <0.02 to 1.05 pCi/g. These concentrations are typical of the radionuclide levels normally encountered in surface soils.

Radioactivity levels in baseline water samples are presented in Table 1-B. The gross alpha and gross beta concentrations ranged from 0.55 to 1.87 pCi/l (picocuries per liter) and <0.63 to 14.3 pCi/l, respectively. These are typical of concentrations normally occurring in surface water.

Direct Radiation Levels

Direct radiation levels, systematically measured at 10 m grid intervals, are presented in Table 2. The gamma exposure rates at 1 m above the surface ranged from 6 to 23 μR/h (average 11 μR/h). At surface contact, the rates ranged from 6 to 27 μR/h (average 11 μR/h). Beta-gamma dose rates ranged from 6 to 220 μrad/h (average 40 μrad/h). Measurements performed with the detector shielded averaged approximately 20% less than those with the unshielded detector. This indicates only a small portion of the surface dose rate is due to nonpenetrating beta or low-energy photon radiations. The highest exposure rates were at grid location 130N, 960E; the highest dose rate was at 120N, 940E. Direct radiation levels were generally higher in the vicinity of the railroad tracks and piles of rock ballast.

The walkover survey identified several small general areas and numerous isolated spots having elevated surface radiation levels. Their locations are indicated on Figure 6 and associated direct radiation levels are presented in Table 3. The maximum contact exposure rate was 520 μR/h at grid lcoation 28N, 772E. The exposure rate at 1 m above the surface at this location was 16 μR/h and the surface dose rate was 10,000 μrad/h. The maximum surface dose rate measured was 50,000 μrad/h at grid coordinate 124N, 953E. Elevated areas of direct radiation were primarily located north of the railroad tracks; many were in or adjacent to the drainage ditch. At a few of the isolated spots, sampling was effective in reducing the radiation levels. In other locations the levels were unchanged or increased as a result of surface sampling.

Radionuclide Concentrations in Surface Soil

Table 4 lists the concentrations of radionuclides measured in surface soil from 10 m grid intervals. These samples contained Ra-226 concentrations ranging from <0.20 to 29.9 pCi/g. Seventy percent of the samples had Ra-226 levels above this baseline range; approximately 13% contained more than 5 pCi/g above the average baseline concentration.

These samples also contained elevated levels of other radionuclides. The highest concentrations were U-238, 125 pCi/g; Cs-137, 4.40 pCi/g; and Th-232, 2.47 pCi/g.

Samples from locations of elevated contact radiation levels contained Ra-226 concentrations ranging from 6.45 to 4290 pCi/g (refer to Table 5). The highest level was obtained at grid location 132N, 950E. Ten of the samples were found to contain small white chips, which were the source of the Ra-226 activity. These chips were evaluated individually and their contents, ranging from 0.13 to 4.21 µCi, are presented in Table 6. Some of these samples also contained elevated U-238 levels. For example, B29 had a U-238 concentration of 9430 pCi/g; B28, 1500 pCi/g; B10, 365 pCi/g; and B22, 320 pCi/g. Small yellow chips (possibly yellowcake) were observed in samples B22 and B29. Sample B4 contained 160 pCi/g of Cs-137. Other samples did not contain significant levels of Cs-137 or Th-232.

Ground-Penetrating Radar Findings

The subcontractor's report summarizing ground-penetrating radar survey results for property N'-North is provided in Appendix C. Scans, performed in general areas where elevated surface radiation levels were noted, identified targets at 0.6 to 1.0 m deep. Signals indicate some of these targets are metallic and suggest the presence of shallow buried material scattered throughout the areas.

Borehole Gamma-Logging Measurements

Gamma scintillation measurements performed in boreholes indicated that contamination was limited to the upper 15-30 cm of soil. Gamma-logging data was not used to quantify radionuclide concentrations in the subsurface soil because of the varying ratios of Ra-226, U-235, U-238, Cs-137, and Th-232 occurring in soils from this site.

Radionuclide Concentrations in Subsurface Soil

Table 7 presents the radionuclide concentrations measured in soil samples from boreholes. All of these boreholes were at locations of surface contamination identified by the walkover scan or in the vicinity of subsurface targets indicated by ground-penetrating radar. Although several of the subsurface samples contained radionuclide concentrations slightly above baseline levels, none of the concentrations exceeded guideline levels.

COMPARISON OF SURVEY RESULTS WITH GUIDELINES

The guidelines applicable to cleanup of the off-site properties at NFSS are presented in Appendix B. The maximum exposure rate at 1 m above the ground surface on property N′-North is 27 μR/h and the average is 11 μR/h. These levels are well below the 60 μR/h criteria for open land areas.

Areas of surface contamination, identified by the walkover scan, contain Ra-226 concentrations in excess of 5 pCi/g. Several areas contain U-238 levels in excess of 150 pCi/g, and one area has a Cs-137 concentration above 80 pCi/g. Some of these areas are small and isolated and contamination levels would satisfy guideline criteria if averaged over an area of 100 m^2. There are three larger areas containing multiple regions of contaminated soil and radionuclide concentrations well above the guideline concentrations; averaging over 100 m^2 would not be sufficient to reduce concentrations in these areas to within the appropriate criteria. Locations of areas exceeding guideline levels are summarized in Table 8 and indicated on Figure 7. No subsurface soil samples exceeded cleanup criteria.

SUMMARY

A comprehensive survey of off-site property N′-North at the Niagara Falls Storage Site was conducted during September and October 1983. The survey included surface radiation scans, measurements of direct radiation

levels, ground-penetrating radar scans for buried material, and analyses of radionuclide concentrations in surface and subsurface soil.

The survey identified areas of surface Ra-226 and U-238 contamination exceeding guidelines for unrestricted use. These areas are in the form of small isolated pieces of material and several larger regions of general surface contamination. No subsurface contamination exceeding guideline levels was detected.

Although there are small areas of contaminated residues on portions of this property, the contaminants do not pose potential health risks. There is no evidence of migration of the radioactive materials to adjacent properties.

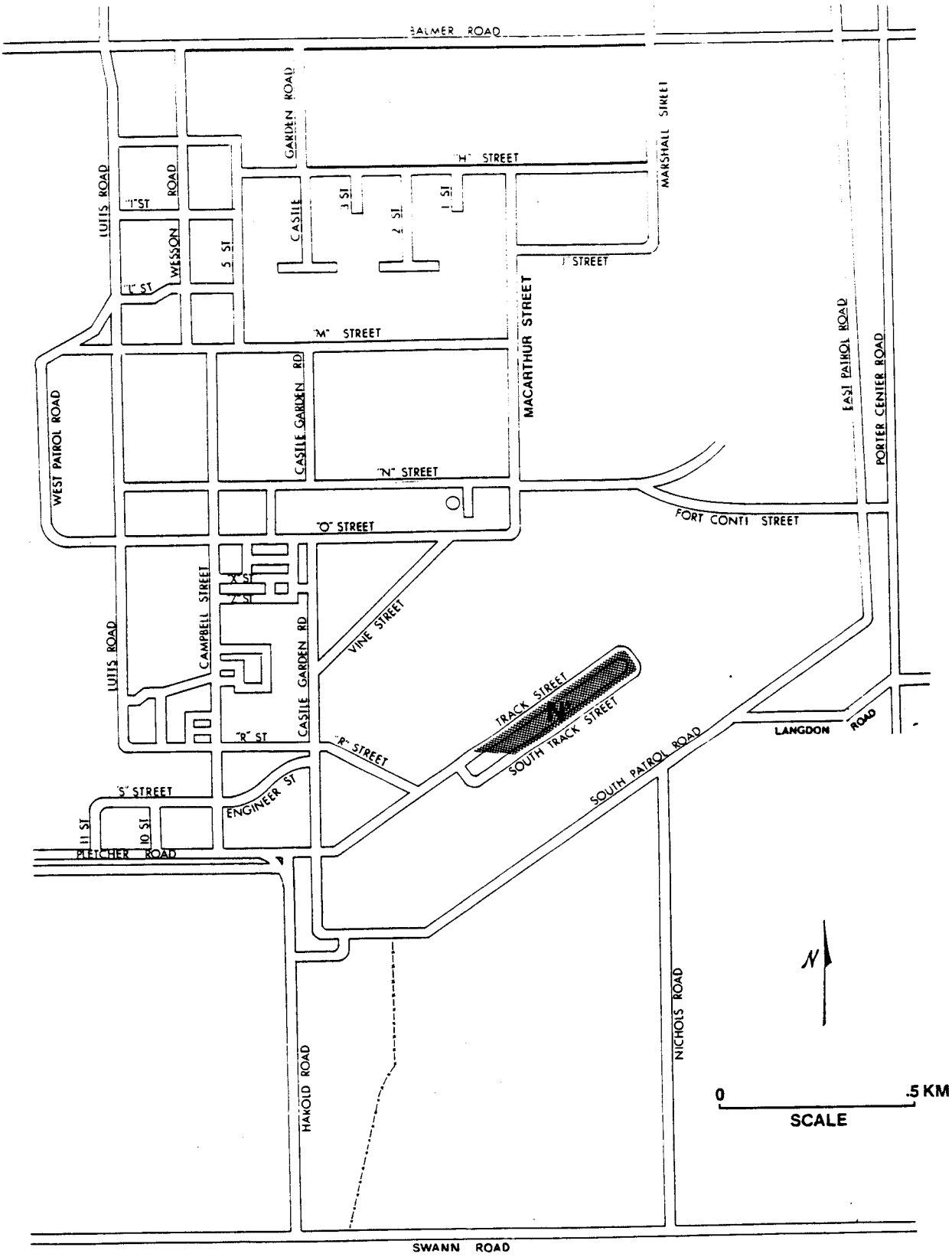

FIGURE 1. Map of Niagara Falls Storage Site and Off-Site Properties, Lewiston, New York, Indicating the Location of Off-Site Property N'-North.

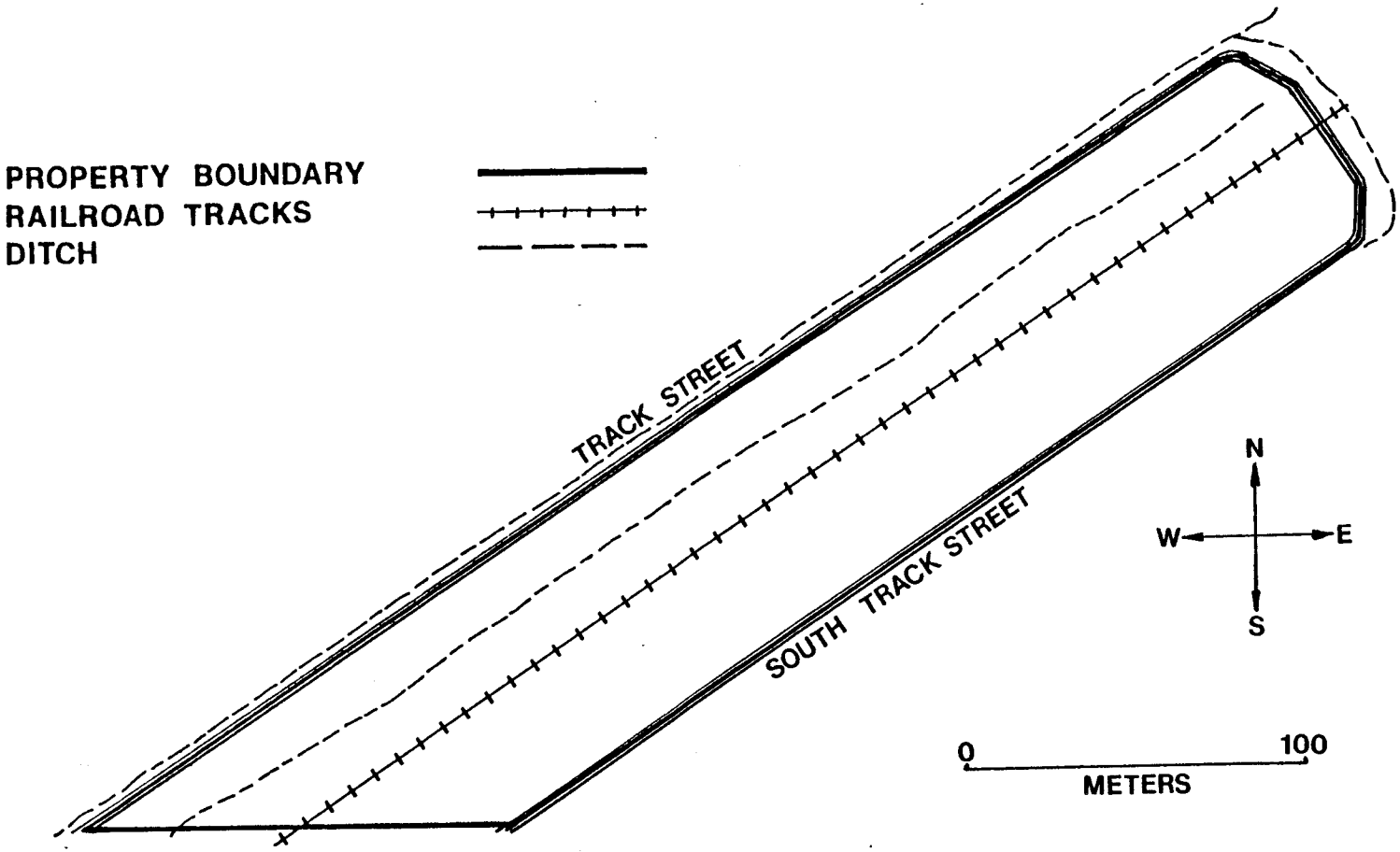

FIGURE 2. Plan View of NFSS Off-Site Property N'-North Indicating Prominent Surface Features.

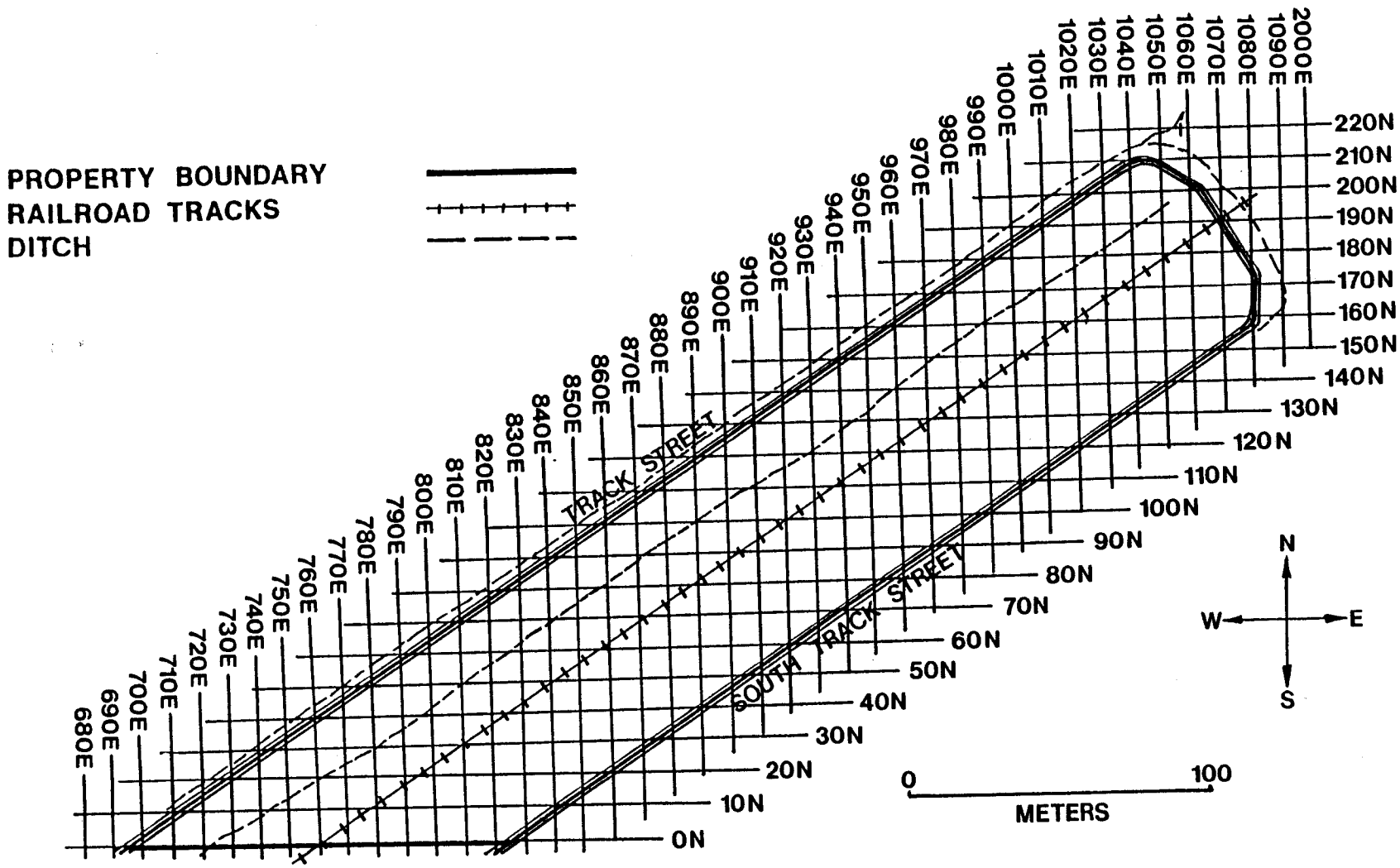

FIGURE 3. Plan View of NFSS Off-Site Property N'-North Indicating the Grid System Established for Survey Reference.

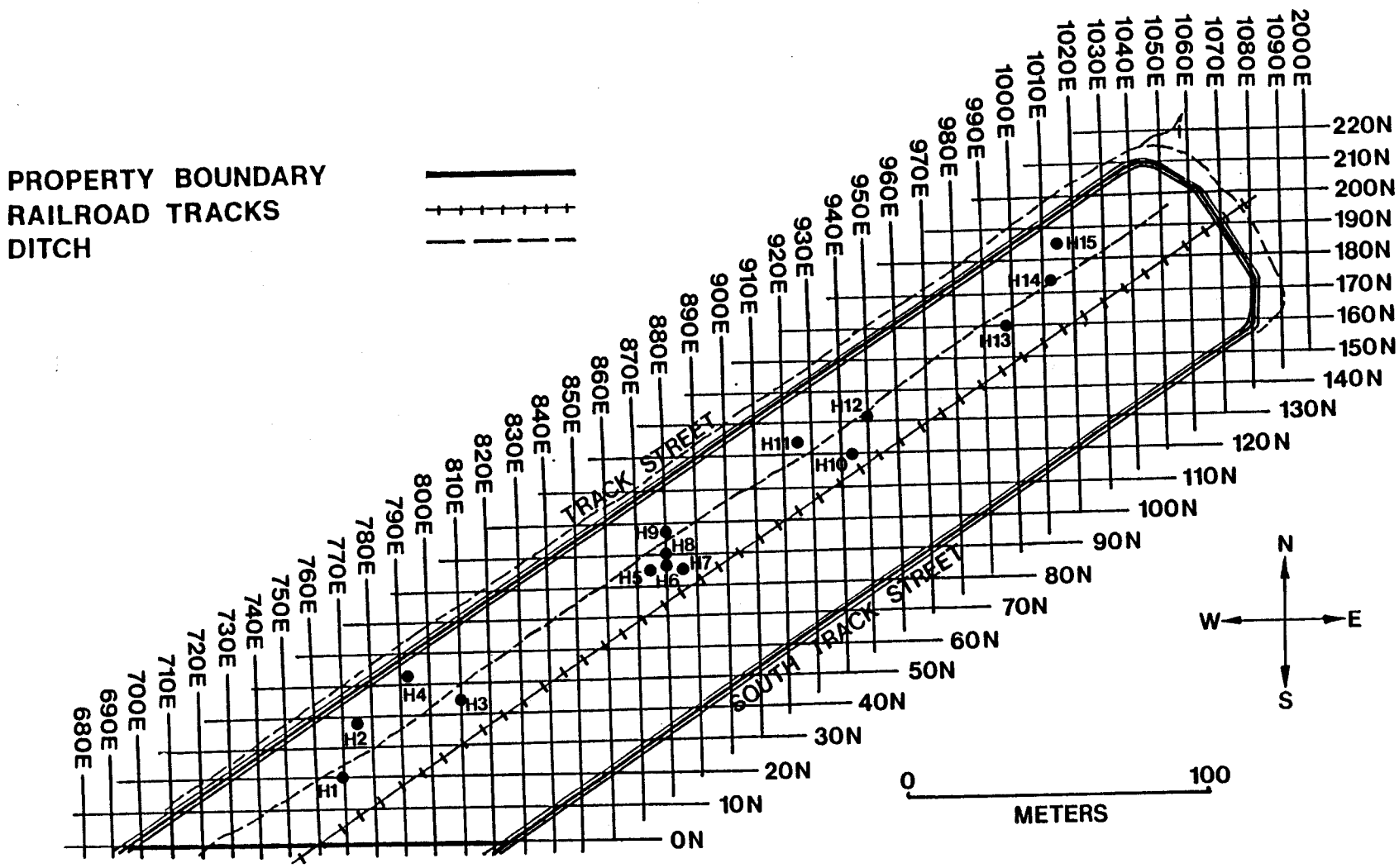

FIGURE 4. Locations of Borholes for Subsurface Investigations.

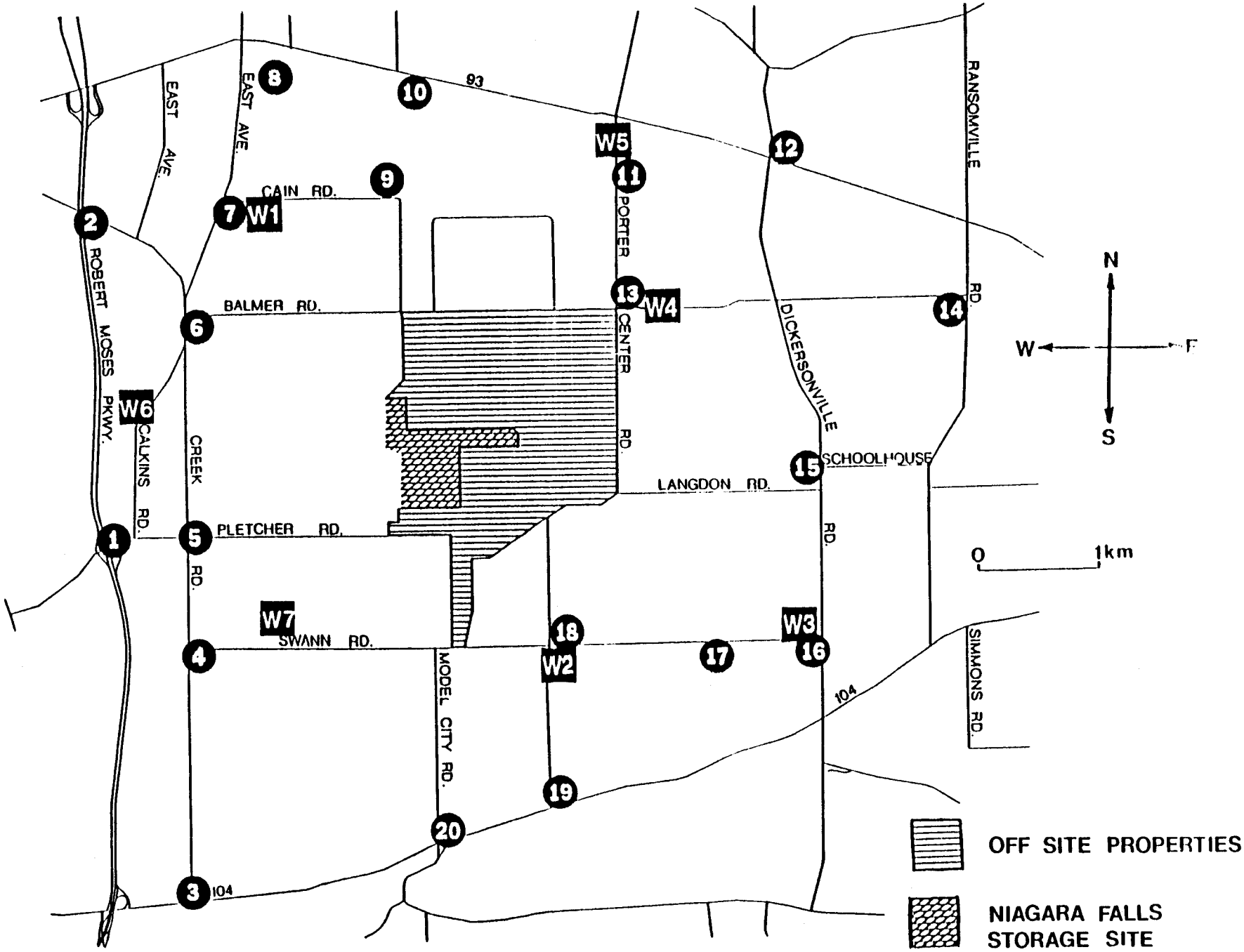

FIGURE 5. Map of Northern Niagara County, New York, Showing Locations of Background Measurements and Baseline Samples. (#1-20: soil samples and direct measurements; W1-W7: water samples.)

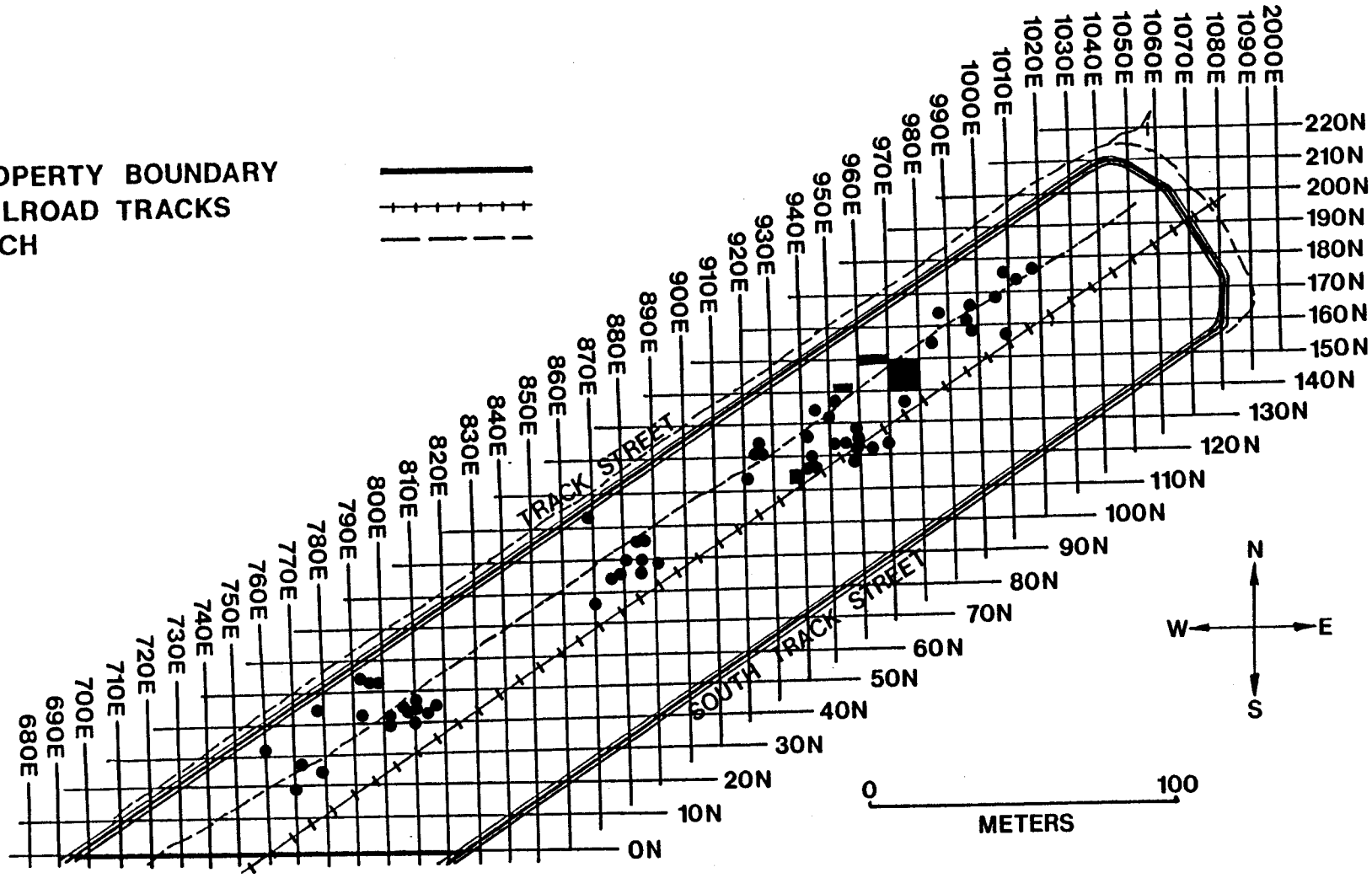

FIGURE 6. Locations of Areas of Elevated Direct Radiation.

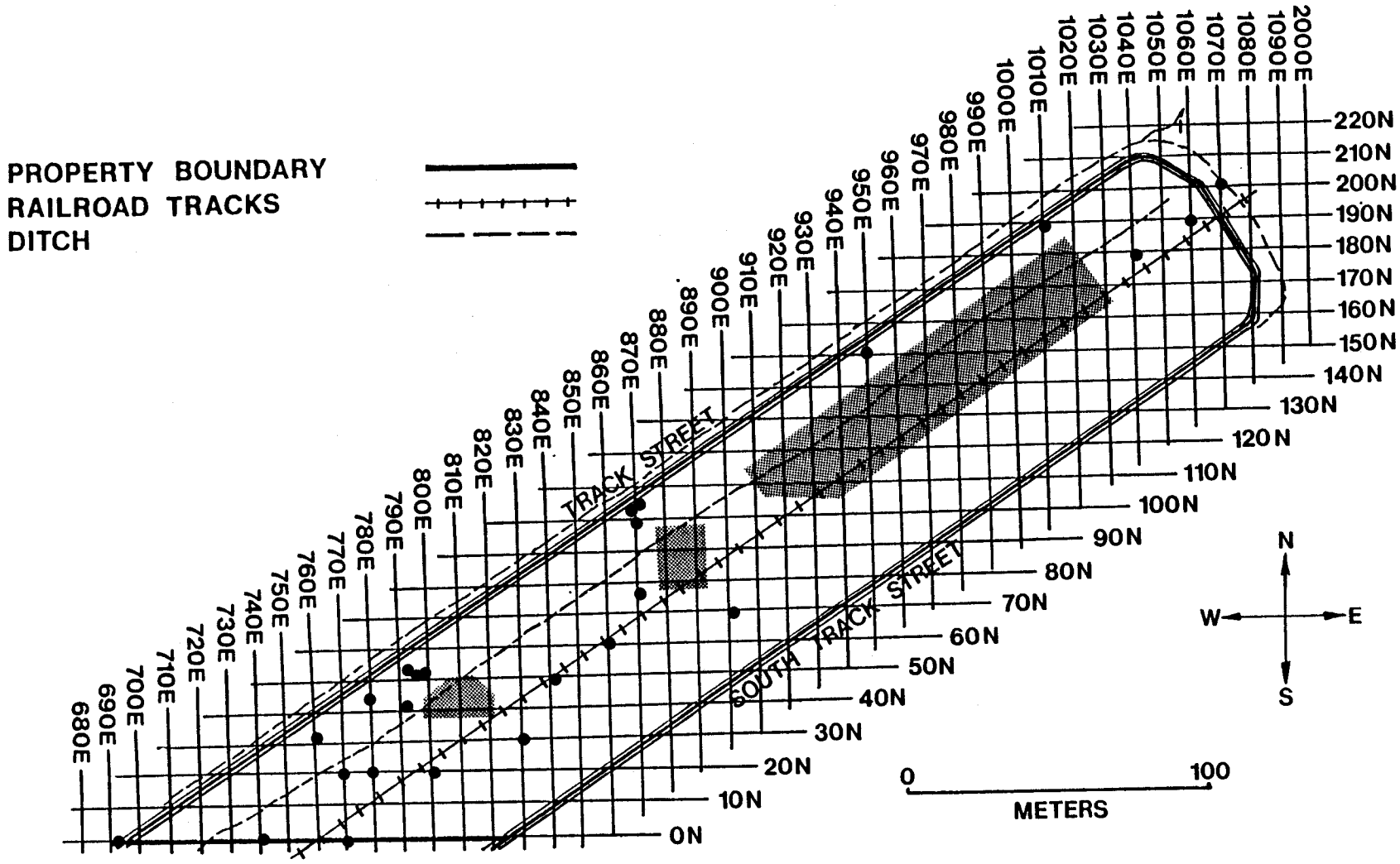

FIGURE 7. Map of NFSS Off-Site Property N'-North Indicating Areas Where Radionuclide Concentrations in Soil Exceed Guideline Levels.

TABLE 1-A

BACKGROUND EXPOSURE RATES
AND
RADIONUCLIDE CONCENTRATIONS IN BASELINE SOIL SAMPLES

Location[a]	Exposure Rate[b] (μR/h)	Radionuclide Concentrations (pCi/g)				
		Ra-226	U-235	U-238	Th-232	Cs-137
1	6.8	0.74 ± 0.16[c]	<0.19	<2.89	0.70 ± 0.46	0.29 ± 0.08
2	6.8	0.75 ± 0.19	<0.19	<3.35	0.86 ± 0.24	0.24 ± 0.08
3	8.3	0.71 ± 0.18	0.46 ± 0.41	<3.72	0.88 ± 0.33	0.34 ± 0.09
4	7.9	0.67 ± 0.18	<0.22	<4.10	1.18 ± 0.35	0.12 ± 0.07
5	7.3	0.70 ± 0.16	<0.17	<3.34	0.68 ± 0.24	0.14 ± 0.07
6	7.7	0.50 ± 0.15	<0.16	<2.33	0.52 ± 0.38	0.17 ± 0.09
7	7.7	0.63 ± 0.13	<0.17	<2.73	0.83 ± 0.24	0.35 ± 0.08
8	7.6	0.59 ± 0.12	<0.14	<2.20	0.54 ± 0.23	<0.02
9	7.1	0.63 ± 0.20	<0.23	<4.16	0.83 ± 0.38	0.69 ± 0.11
10	7.1	0.70 ± 0.16	<0.19	<2.98	0.59 ± 0.25	0.69 ± 0.10
11	6.7	<0.09	<0.19	<2.83	0.49 ± 0.31	0.48 ± 0.14
12	7.1	0.48 ± 0.13	<0.16	<2.84	0.65 ± 0.26	0.68 ± 0.10
13	6.7	0.57 ± 0.14	<0.17	<2.36	0.49 ± 0.26	0.41 ± 0.08
14	6.8	0.68 ± 0.17	<0.19	<3.24	0.67 ± 0.25	0.70 ± 0.10
15	8.2	0.65 ± 0.14	<0.17	<3.20	0.72 ± 0.35	0.23 ± 0.08
16	7.4	0.91 ± 0.17	<0.71	<3.58	0.83 ± 0.28	0.61 ± 0.09
17	7.0	0.48 ± 0.14	<0.16	<2.73	0.32 ± 0.22	0.38 ± 0.08
18	7.7	0.73 ± 0.16	<0.18	6.26 ± 9.23	1.01 ± 0.44	0.32 ± 0.12
19	8.8	1.22 ± 0.22	<0.23	<3.79	1.08 ± 0.49	1.05 ± 0.13
20	8.6	0.83 ± 0.17	<0.21	<3.59	0.84 ± 0.29	0.08 ± 0.07
Range	6.8 to 8.8	<0.09 to 1.22	<0.14 to 0.46	<2.20 to 6.26	0.32 to 1.18	<0.02 to 1.05

[a] Refer to Figure 5.
[b] Measured at 1 m above the surface.
[c] Errors are 2σ based on counting statistics.

TABLE 1-B

RADIONUCLIDE CONCENTRATIONS IN BASELINE WATER SAMPLES

Location[a]	Radionuclide Concentrations (pCi/l)	
	Gross Alpha	Gross Beta
W1	0.95 ± 0.93 [b]	4.79 ± 1.15
W2	0.95 ± 0.94	9.17 ± 1.31
W3	0.55 ± 0.78	2.73 ± 1.05
W4	0.63 ± 0.89	5.37 ± 1.17
W5	0.73 ± 0.68	<0.64
W6	1.87 ± 1.84	14.3 ± 2.4
W7	1.16 ± 0.66	<0.63
Range	0.55 to 1.87	<0.63 to 14.3

[a] Refer to Figure 5.
[b] Errors are 2σ based on counting statistics.

TABLE 2

DIRECT RADIATION LEVELS MEASURED
AT 10 M GRID INTERVALS

Grid Location N	Grid Location E	Gamma Exposure Rates at 1 m Above the Surface (μR/h)	Gamma Exposure Rates at the Surface (μR/h)	Beta-Gamma Dose Rates at 1 cm Above the Surface (μrad/h)
0	690	8	8	28
0	700	10	10	21
0	710	11	10	19
0	720	12	10	24
0	730	12	11	44
0	740	13	14	31
0	750	14	15	44
0	760	13	13	60
0	770	12	13	48
0	780	12	11	38
0	790	12	12	35
0	800	12	12	49
0	810	9	10	21
0	820	8	8	25
0	830	8	9	16
10	700	10	9	29
10	710	10	9	28
10	720	10	10	32
10	730	11	10	32
10	740	13	13	59
10	750	12	12	32
10	760	12	14	34
10	770	13	14	63
10	780	12	12	49
10	790	13	14	47
10	800	12	12	55
10	810	12	14	45
10	820	10	10	21
10	830	9	10	30
10	840	8	7	7
20	720	8	10	26
20	730	9	9	28
20	740	11	11	40
20	750	11	13	51
20	760	11	12	25
20	770	12	27	150
20	780	12	12	55
20	790	12	14	41
20	800	13	12	25
20	810	13	12	43

TABLE 2, cont.

DIRECT RADIATION LEVELS MEASURED
AT 10 M GRID INTERVALS

Grid Location N	Grid Location E	Gamma Exposure Rates at 1 m Above the Surface (μR/h)	Gamma Exposure Rates at the Surface (μR/h)	Beta-Gamma Dose Rates at 1 cm Above the Surface (μrad/h)
20	820	12	12	50
20	830	14	13	51
20	840	11	11	24
20	850	8	9	25
20	860	7	7	17
30	740	9	8	8
30	750	11	10	27
30	760	11	9	15
30	770	13	14	45
30	780	12	12	34
30	790	12	12	43
30	800	13	13	46
30	810	13	13	72
30	820	13	14	71
30	830	12	13	53
30	840	12	13	41
30	850	12	13	29
30	860	9	9	29
30	870	7	7	7
30	880	9	9	38
40	750	10	10	40
40	760	10	12	39
40	770	10	8	41
40	780	11	12	46
40	790	12	14	41
40	800	14	18	120
40	810	14	13	47
40	820	13	13	35
40	830	12	13	50
40	840	13	13	39
40	850	12	13	44
40	860	12	13	47
40	870	9	9	25
40	880	9	9	28
40	890	8	7	7
50	770	9	8	15
50	780	10	10	21
50	790	12	12	38

TABLE 2, cont.

DIRECT RADIATION LEVELS MEASURED
AT 10 M GRID INTERVALS

Grid Location N	Grid Location E	Gamma Exposure Rates at 1 m Above the Surface (μR/h)	Gamma Exposure Rates at the Surface (μR/h)	Beta-Gamma Dose Rates at 1 cm Above the Surface (μrad/h)
50	800	12	13	59
50	810	13	13	63
50	820	14	20	190
50	830	13	13	47
50	840	12	12	43
50	850	12	12	34
50	860	13	14	48
50	870	12	12	48
50	880	10	11	38
50	890	9	10	17
50	900	8	8	24
50	910	8	9	32
60	790	9	8	28
60	800	12	12	25
60	810	14	21	110
60	820	12	12	62
60	830	12	11	58
60	840	12	12	31
60	850	13	13	57
60	860	13	14	64
60	870	12	12	38
60	880	11	12	31
60	890	12	14	52
60	900	12	11	33
60	910	11	12	26
58	920	7	7	28
70	800	9	9	25
70	810	9	9	39
70	820	9	10	34
70	830	12	12	28
70	840	12	12	54
70	850	12	12	19
70	860	13	14	41
70	870	12	13	56
70	880	12	13	23
70	890	13	13	29
70	900	12	13	40
70	910	13	13	29
70	920	12	12	43

TABLE 2, cont.

DIRECT RADIATION LEVELS MEASURED
AT 10 M GRID INTERVALS

Grid Location N	Grid Location E	Gamma Exposure Rates at 1 m Above the Surface (μR/h)	Gamma Exposure Rates at the Surface (μR/h)	Beta-Gamma Dose Rates at 1 cm Above the Surface (μrad/h)
70	930	10	12	43
70	940	8	7	14
78	810	8	9	19
80	820	8	8	34
80	830	9	9	26
80	840	10	9	13
80	850	10	12	28
80	860	12	12	42
80	870	12	12	41
80	880	13	13	50
80	890	13	13	30
80	900	11	10	39
80	910	12	12	52
80	920	13	13	44
80	930	10	9	26
80	940	10	10	29
80	950	8	8	12
80	960	8	10	36
90	830	9	9	28
90	840	8	7	8
90	850	9	9	28
90	860	10	10	36
90	870	10	10	41
90	880	13	17	200
90	890	17	22	130
90	900	13	14	52
90	910	12	12	41
90	920	12	12	36
90	930	13	14	52
90	940	12	12	45
90	950	10	10	39
90	960	9	9	39
90	970	7	7	7
90	980	9	9	39
97	840	8	9	22
100	850	8	8	39
100	860	9	9	19
100	870	10	10	16

TABLE 2, cont.

DIRECT RADIATION LEVELS MEASURED
AT 10 M GRID INTERVALS

Grid Location N	Grid Location E	Gamma Exposure Rates at 1 m Above the Surface (μR/h)	Gamma Exposure Rates at the Surface (μR/h)	Beta-Gamma Dose Rates at 1 cm Above the Surface (μrad/h)
100	880	10	12	32
100	890	12	13	33
100	900	13	12	49
100	910	13	13	57
100	920	12	13	44
100	930	12	12	38
100	940	13	14	47
100	950	12	12	39
100	960	9	10	17
100	970	9	10	20
100	980	9	9	19
100	990	7	7	23
110	860	8	9	31
110	870	8	8	28
110	880	9	9	38
110	890	9	9	33
110	900	12	12	29
110	910	14	17	81
110	920	14	14	110
110	930	14	17	86
110	940	12	14	52
110	950	13	13	63
110	960	12	13	32
110	970	9	10	41
110	980	9	10	26
110	990	9	9	47
110	1000	7	7	9
110	1010	8	9	45
120	880	8	9	36
120	890	8	8	22
120	900	9	9	10
120	910	10	11	37
120	920	14	16	60
120	930	13	14	93
120	940	17	17	220
120	950	14	18	140
120	960	18	18	78
120	970	14	14	61
120	980	12	13	37

TABLE 2, cont.

DIRECT RADIATION LEVELS MEASURED
AT 10 M GRID INTERVALS

Grid Location N	Grid Location E	Gamma Exposure Rates at 1 m Above the Surface (μR/h)	Gamma Exposure Rates at the Surface (μR/h)	Beta-Gamma Dose Rates at 1 cm Above the Surface (μrad/h)
120	990	9	9	23
120	1000	10	12	32
120	1010	8	9	26
120	1020	7	6	6
120	1030	7	8	31
130	900	8	8	19
130	910	9	9	28
130	920	10	10	41
130	930	12	12	42
130	940	14	14	47
130	950	18	20	84
130	960	23	27	120
130	970	13	13	66
130	980	12	13	55
130	990	12	13	40
130	1000	10	12	41
130	1010	9	9	43
130	1020	9	9	29
130	1030	7	8	10
130	1040	7	7	20
140	910	9	9	39
140	920	8	7	11
140	930	10	10	29
140	940	13	13	55
140	950	14	13	63
140	960	13	13	30
140	970	14	14	44
140	980	14	20	99
140	990	14	16	49
140	1000	12	12	35
140	1010	10	11	33
140	1020	9	9	23
140	1030	10	9	31
140	1040	9	8	38
140	1050	7	7	18
140	1060	9	9	20
150	930	8	9	28
150	940	9	10	16

TABLE 2, cont.

DIRECT RADIATION LEVELS MEASURED
AT 10 M GRID INTERVALS

Grid Location N	Grid Location E	Gamma Exposure Rates at 1 m Above the Surface (μR/h)	Gamma Exposure Rates at the Surface (μR/h)	Beta-Gamma Dose Rates at 1 cm Above the Surface (μrad/h)
150	950	13	14	57
150	960	14	16	77
150	970	20	20	74
150	980	14	17	46
150	990	13	14	53
150	1000	13	13	49
150	1010	12	13	37
150	1020	9	10	36
150	1030	9	10	30
150	1040	9	9	23
150	1050	8	9	26
150	1060	7	8	8
150	1070	6	6	15
160	940	9	9	15
160	950	8	7	13
160	960	10	10	20
160	970	16	17	67
160	980	14	12	23
160	990	16	17	71
160	1000	14	14	56
160	1010	17	20	69
160	1020	11	12	43
160	1030	9	10	20
160	1040	9	9	26
160	1050	9	9	39
160	1060	9	9	26
160	1070	8	9	15
160	1080	7	7	17
170	960	9	9	28
170	970	12	12	41
170	980	12	12	35
170	990	13	13	36
170	1000	17	17	47
170	1010	14	14	45
170	1020	16	17	80
170	1030	12	13	73
170	1040	10	10	23
170	1050	8	8	24
170	1060	9	9	18

TABLE 2, cont.

DIRECT RADIATION LEVELS MEASURED
AT 10 M GRID INTERVALS

Grid Location N	Grid Location E	Gamma Exposure Rates at 1 m Above the Surface (μR/h)	Gamma Exposure Rates at the Surface (μR/h)	Beta-Gamma Dose Rates at 1 cm Above the Surface (μrad/h)
170	1070	8	8	24
170	1080	7	7	13
170	1090	9	9	40
180	980	7	8	15
180	990	10	10	21
180	1000	10	10	21
180	1010	10	8	25
180	1020	14	12	56
180	1030	12	13	77
180	1040	13	14	43
180	1050	12	12	41
180	1060	9	9	26
180	1070	9	9	33
180	1080	7	8	12
180	1090	8	8	32
190	1000	7	7	14
190	1010	10	12	25
190	1020	9	9	23
190	1030	9	9	13
190	1040	12	13	77
190	1050	13	14	51
190	1060	14	15	54
190	1070	12	12	34
190	1080	8	9	22
200	1010	8	8	17
200	1020	7	7	11
200	1030	9	9	43
200	1040	9	9	33
200	1050	9	9	10
200	1060	13	14	57
200	1070	11	12	21
210	1060	9	9	33
210	1070	8	9	33
220	1060	9	10	23

TABLE 3

DIRECT RADIATION LEVELS AT LOCATIONS IDENTIFIED BY THE WALKOVER SURFACE SCAN

Grid Location[a] N	Grid Location[a] E	Exposure Rate (μR/h) Contact	Exposure Rate (μR/h) 1 m Above Surface	Surface Dose Rate (μrad/h)	Sample Identification[b]	Contact Exposure Rate After Sample Removal (μR/h)
20	770	56	14	160	B1	47
26	779	85	16	250	B2	18
28	772	520	16	10,000	B3	17
31	760	33	13	130	B4	27
40	801	37	17	130	B5, A&B	27
40	810	85	14	26,000	B6	17
41	802	31	---[c]	---	---	---
42	792	50	14	230	B7	47
43	814	67	14	340	B8	29
44	779	20	14	66	B9	21
44	808	36	---	---	---	---
44	811	32	16	180	B10	29
45	808	43	14	320	B11	17
46	817	27	---	---	---	---
47	810	310	20	21,500	B12	35
53	796	29	---	---	---	---
53	797	190	17	6,410	B13	39
54	793	58	14	160	B14	40
78	870	20	14	50	B15	20
85	875	56	17	350	B16	18
86	876	44	18	290	B17	44
86	880	58	20	660	B18	46
86	885	31	20	---	B19	31
90	880	130	12	12,800	B20	14
90	885	45	---	---	---	---
90	890	20	---	---	---	---
96	885	45	---	---	---	---
96	886	23	---	---	---	---
105-107	868-870	29-58	---	---	---	---
106	869	58	14	84	B21	50
112-116	936-939	20-66	---	---	---	---
115	938	66	17	11,500	B22	58
115	921	22	20	183	B23	40
116-118	940-946	20-35	---	---	---	---
117	940	35	21	340	B24	66
119	959	---	---	---	---	---
120	942	66	23	240	B25	33
120	959	85	22	1,420	B26	85

TABLE 3, cont.

DIRECT RADIATION LEVELS AT LOCATIONS IDENTIFIED BY THE WALKOVER SURFACE SCAN

Grid Location N	Grid Location E	Exposure Rate (μR/h) Contact	Exposure Rate (μR/h) 1 m Above Surface	Surface Dose Rate (μrad/h)	Sample Identification	Contact Exposure Rate After Sample Removal (μR/h)
121	925	120	16	18,600	B27 A&B	27
121	959	67	---	---	---	---
122	964	34	---	---	---	---
124	924	210	23	450	B28	230
124	952	155	23	1,560	---	---
124	953	110	27	50,000	B29	38
124	970	34	---	---	---	---
127	941	85	17	440	B30	22
127	959	92	---	---	---	---
128	959	85	22	870	B31	66
132	950	210	21	1,000	B32	130
135	945	29	---	---	---	---
138	975	190	27	9,890	B33	500
139	951	67	17	420	B34	27
140-150	970-980	20-29	---	---	---	---
141-142	952-958	20-29	---	---	---	---
141	955	29	---	---	---	---
148-151	962-970	20-75	---	---	---	---
148	967	75	23	180	B35	150
155	984	340	20	8,430	B36	210
158	1009	33	20	58	B37	57
160	998	44	17	100	B38	35
161	998	38	---	---	---	---
166	987	38	---	---	---	---
166	998	29	---	---	---	---
169	1005	23	---	---	---	---
173	1012	40	20	213	B39	43
176	1009	50	---	---	---	---
176	1016	55	21	200	B40	80

[a] Refer to Figure 6.
[b] Radionuclide concentrations are presented in Table 5.
[c] Dash indicates measurement or sampling not performed.

TABLE 4

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES FROM 10 M GRID INTERVALS

Grid Location N	Grid Location E	Radionuclide Concentrations (pCi/g) Ra-226	U-235	U-238	Cs-137	Th-232
0	689	9.53 ± 0.55[a]	<0.48	<1.30	1.43 ± 0.15	<0.21
0	700	2.58 ± 0.36	<0.26	3.01 ± 2.10	0.37 ± 0.09	0.72 ± 0.31
0	710	2.49 ± 0.35	0.78 ± 0.49	2.88 ± 1.21	0.28 ± 0.09	1.00 ± 0.44
0	720	2.35 ± 0.39	<0.24	1.63 ± 1.42	0.34 ± 0.12	0.57 ± 0.38
0	730	2.46 ± 0.36	<0.35	8.14 ± 2.33	0.52 ± 0.10	1.06 ± 0.54
0	740	6.10 ± 0.61	0.49 ± 0.88	5.18 ± 2.47	0.60 ± 0.16	0.97 ± 0.51
0	750	1.84 ± 0.38	<0.40	1.02 ± 2.47	0.87 ± 0.17	1.23 ± 0.50
0	760	4.11 ± 0.35	<0.22	4.24 ± 0.90	0.06 ± 0.04	1.26 ± 0.26
0	770	6.21 ± 0.51	<0.34	4.58 ± 2.07	0.62 ± 0.14	0.76 ± 0.41
0	780	3.93 ± 0.35	<0.38	2.86 ± 0.99	0.46 ± 0.10	1.22 ± 0.33
0	790	3.66 ± 0.50	<0.35	3.50 ± 1.90	0.64 ± 0.11	0.97 ± 0.39
0	800	2.69 ± 0.38	<0.39	<1.22	1.02 ± 0.17	0.46 ± 0.25
0	810	1.50 ± 0.29	0.38 ± 0.60	0.76 ± 0.80	0.70 ± 0.13	1.09 ± 0.38
0	820	0.80 ± 0.34	<0.27	0.87 ± 1.48	0.59 ± 0.12	1.13 ± 0.27
0	830	0.69 ± 0.19	<0.18	3.34 ± 1.34	0.32 ± 0.07	0.64 ± 0.41
10	720	1.41 ± 0.26	0.15 ± 0.54	1.61 ± 1.28	0.13 ± 0.05	0.59 ± 0.22
10	730	1.33 ± 0.20	<0.26	4.39 ± 1.71	0.32 ± 0.08	0.58 ± 0.22
10	740	5.69 ± 0.74	<0.52	3.08 ± 3.62	<0.08	0.74 ± 0.85
10	750	2.29 ± 0.34	<0.25	3.74 ± 1.13	0.61 ± 0.12	0.73 ± 0.31
10	760	2.16 ± 0.40	<0.38	2.78 ± 2.09	0.81 ± 0.16	1.00 ± 0.46
10	770	5.04 ± 0.40	0.76 ± 0.65	4.60 ± 1.16	<0.05	0.90 ± 0.38
10	780	4.61 ± 0.49	<0.54	5.50 ± 2.48	1.16 ± 0.19	1.32 ± 0.51
10	790	5.08 ± 0.55	<0.39	2.50 ± 2.29	<0.14	1.24 ± 0.47
10	800	2.41 ± 0.38	<0.39	3.31 ± 1.25	0.83 ± 0.12	1.41 ± 0.41
10	810	3.39 ± 0.45	<0.37	2.78 ± 2.20	1.29 ± 0.23	0.97 ± 0.61
10	820	0.73 ± 0.26	<0.41	4.20 ± 1.73	1.01 ± 0.22	1.54 ± 0.55
10	830	1.86 ± 0.39	<0.29	1.94 ± 1.80	0.84 ± 0.21	0.93 ± 0.40
6	840	0.99 ± 0.28	<0.34	<1.15	0.52 ± 0.15	1.06 ± 0.42
22	720	1.60 ± 0.28	<0.38	3.01 ± 2.49	0.66 ± 0.12	0.99 ± 0.50
20	730	1.40 ± 0.28	<0.16	1.51 ± 1.13	0.33 ± 0.10	0.81 ± 0.36
20	740	1.86 ± 0.30	0.37 ± 0.66	8.41 ± 1.46	0.25 ± 0.08	0.88 ± 0.47
20	750	2.04 ± 0.43	<0.35	2.44 ± 2.71	0.28 ± 0.10	0.85 ± 0.42
20	760	2.80 ± 0.35	0.40 ± 0.51	2.71 ± 0.65	0.34 ± 0.09	0.80 ± 0.40
20	770	12.0 ± 0.8	0.81 ± 0.03	17.2 ± 4.2	0.27 ± 0.09	2.47 ± 0.74
20	780	12.9 ± 0.8	<0.03	4.00 ± 1.20	0.32 ± 0.10	1.18 ± 0.63
20	790	2.35 ± 0.36	<0.37	7.91 ± 2.04	<0.06	1.45 ± 0.66
20	800	6.69 ± 1.11	<0.59	3.51 ± 2.01	0.37 ± 0.31	1.06 ± 0.55
20	810	3.94 ± 0.44	<0.23	1.99 ± 0.80	0.62 ± 0.12	0.91 ± 0.65

TABLE 4, cont.

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES
FROM 10 M GRID INTERVALS

Grid Location		Radionuclide Concentrations (pCi/g)				
N	E	Ra-226	U-235	U-238	Cs-137	Th-232
20	820	2.21 ± 0.40	0.36 ± 0.44	2.00 ± 0.97	0.78 ± 0.12	1.08 ± 0.45
20	830	3.69 ± 0.41	0.51 ± 0.76	4.07 ± 1.21	0.78 ± 0.15	1.52 ± 0.35
20	840	0.99 ± 0.27	<0.18	1.88 ± 0.67	0.57 ± 0.13	0.90 ± 0.58
20	850	0.84 ± 0.41	<0.39	<1.36	0.94 ± 0.18	1.53 ± 0.57
20	860	0.76 ± 0.30	<0.18	<0.49	0.67 ± 0.16	0.97 ± 0.38
20	870	0.90 ± 0.46	<0.31	<1.05	0.29 ± 0.10	1.47 ± 0.48
30	740	1.29 ± 0.25	<0.15	0.92 ± 0.76	0.36 ± 0.13	0.67 ± 0.36
30	750	1.31 ± 0.27	<0.30	<0.97	0.24 ± 0.10	0.92 ± 0.65
30	760	1.39 ± 0.31	<0.30	2.30 ± 1.82	0.16 ± 0.14	0.97 ± 0.49
30	770	5.51 ± 0.59	<0.32	7.42 ± 1.25	3.56 ± 0.31	0.93 ± 0.39
30	780	2.23 ± 0.36	0.81 ± 0.54	4.83 ± 0.95	0.24 ± 0.08	1.06 ± 0.33
30	790	1.82 ± 0.32	<0.37	5.86 ± 1.98	1.18 ± 0.06	1.37 ± 0.43
30	800	3.60 ± 0.74	<0.49	3.03 ± 4.35	<0.08	0.92 ± 0.82
30	810	5.94 ± 0.81	<0.54	3.66 ± 3.34	<0.09	1.32 ± 0.84
30	820	5.01 ± 0.42	0.30 ± 0.68	3.37 ± 1.23	0.66 ± 0.11	0.76 ± 0.28
30	830	6.74 ± 0.92	<0.57	3.80 ± 3.16	0.28 ± 0.18	0.53 ± 0.42
30	840	4.15 ± 0.54	<0.36	3.32 ± 2.15	0.40 ± 0.12	0.84 ± 0.49
30	850	1.72 ± 0.33	<0.41	1.17 ± 2.15	0.90 ± 0.17	1.51 ± 0.60
30	860	0.80 ± 0.33	<0.23	0.68 ± 1.05	0.65 ± 0.19	0.81 ± 0.77
30	870	0.50 ± 0.16	<0.22	0.68 ± 1.20	0.82 ± 0.12	0.56 ± 0.19
30	880	1.02 ± 0.32	<0.34	2.09 ± 2.11	0.79 ± 0.16	1.04 ± 0.43
40	750	1.94 ± 0.29	<0.33	2.12 ± 1.61	0.81 ± 0.13	0.93 ± 0.42
40	760	3.50 ± 0.40	0.72 ± 0.72	1.74 ± 1.72	0.88 ± 0.18	0.76 ± 0.50
40	770	1.87 ± 0.30	<0.32	3.10 ± 1.49	0.53 ± 0.12	0.72 ± 0.37
40	780	1.18 ± 0.34	<0.18	1.08 ± 0.91	0.38 ± 0.12	0.84 ± 0.36
40	790	1.89 ± 0.40	2.73 ± 0.76	7.31 ± 2.81	0.22 ± 0.13	0.90 ± 0.52
40	800	8.71 ± 0.73	2.88 ± 1.19	43.4 ± 3.7	3.27 ± 0.29	1.65 ± 0.56
40	810	0.71 ± 0.26	<0.16	2.36 ± 0.64	<0.03	0.92 ± 0.38
40	820	6.18 ± 0.91	<0.54	6.52 ± 2.25	0.19 ± 0.17	1.16 ± 0.74
40	830	4.78 ± 0.50	0.86 ± 0.78	7.73 ± 4.18	0.62 ± 0.12	1.04 ± 0.46
40	840	4.84 ± 0.40	1.06 ± 0.74	5.69 ± 2.22	0.61 ± 0.11	1.16 ± 0.52
40	850	3.82 ± 0.39	0.38 ± 0.49	2.41 ± 0.72	0.59 ± 0.10	1.01 ± 0.69
40	860	3.75 ± 0.40	0.53 ± 0.71	8.50 ± 1.66	0.69 ± 0.14	1.26 ± 0.44
40	870	0.96 ± 0.26	<0.32	<1.05	0.77 ± 0.12	0.93 ± 0.39
40	880	1.39 ± 0.42	<0.42	4.78 ± 1.43	0.57 ± 0.18	1.22 ± 0.49
40	890	0.93 ± 0.26	<0.15	0.57 ± 0.85	0.55 ± 0.12	0.94 ± 0.48
44	900	1.26 ± 0.28	<0.33	5.97 ± 2.18	0.56 ± 0.14	1.57 ± 0.39

TABLE 4, cont.

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES
FROM 10 M GRID INTERVALS

Grid Location		Radionuclide Concentrations (pCi/g)				
N	E	Ra-226	U-235	U-238	Cs-137	Th-232
47	760	2.03 ± 0.40	<0.31	4.47 ± 1.38	0.88 ± 0.13	0.85 ± 0.34
53	770	0.91 ± 0.22	<0.15	1.13 ± 0.86	0.15 ± 0.07	0.67 ± 0.31
50	780	2.90 ± 0.40	<0.41	<1.21	1.18 ± 0.19	0.87 ± 0.39
50	790	2.26 ± 0.35	0.58 ± 0.57	3.39 ± 0.91	3.39 ± 0.28	0.74 ± 0.46
50	800	4.80 ± 0.53	<0.55	1.01 ± 3.20	4.40 ± 0.35	1.27 ± 0.36
50	810	6.89 ± 0.63	1.69 ± 1.16	46.7 ± 3.8	1.49 ± 0.23	1.58 ± 0.60
50	820	5.11 ± 0.44	3.18 ± 0.71	56.1 ± 2.2	0.62 ± 0.11	1.03 ± 0.44
50	830	3.53 ± 0.39	0.88 ± 0.61	8.37 ± 1.60	0.45 ± 0.15	0.78 ± 0.37
50	840	7.18 ± 0.97	<0.60	4.87 ± 2.25	0.52 ± 0.34	2.05 ± 0.76
50	850	4.12 ± 0.37	0.65 ± 0.51	2.75 ± 0.82	0.76 ± 0.14	0.81 ± 0.37
50	860	4.26 ± 0.37	<0.45	8.90 ± 1.89	0.57 ± 0.12	1.67 ± 0.43
50	870	4.16 ± 0.41	<0.23	2.76 ± 0.73	0.54 ± 0.09	1.16 ± 0.44
50	880	3.00 ± 0.37	<0.38	1.53 ± 2.31	0.72 ± 0.14	1.21 ± 0.43
50	890	0.82 ± 0.31	<0.16	1.50 ± 1.08	0.71 ± 0.13	0.53 ± 0.25
50	900	1.02 ± 0.26	<0.29	<0.97	0.99 ± 0.14	1.48 ± 0.43
50	910	0.70 ± 0.19	<0.17	0.79 ± 0.56	0.59 ± 0.13	1.01 ± 0.38
60	800	2.25 ± 0.39	<0.29	3.35 ± 1.27	1.16 ± 0.18	0.76 ± 0.36
60	810	2.43 ± 0.40	<0.32	1.87 ± 2.91	0.19 ± 0.13	0.53 ± 0.28
60	820	2.84 ± 0.37	1.37 ± 0.73	13.5 ± 3.26	0.43 ± 0.13	1.18 ± 0.39
60	830	2.88 ± 0.36	<0.43	9.97 ± 1.70	0.83 ± 0.14	1.30 ± 0.41
60	840	3.31 ± 0.63	<0.50	2.25 ± 1.53	0.21 ± 0.19	1.23 ± 0.78
60	850	4.86 ± 0.76	<0.52	1.56 ± 3.34	0.18 ± 0.18	1.07 ± 0.45
60	860	7.85 ± 0.90	1.55 ± 0.96	4.76 ± 2.85	<0.06	1.31 ± 0.83
60	870	1.98 ± 0.33	0.49 ± 0.44	1.09 ± 0.93	0.44 ± 0.11	0.89 ± 0.48
60	880	2.55 ± 0.39	<0.29	1.72 ± 1.91	0.62 ± 0.15	0.93 ± 0.41
60	890	2.98 ± 0.42	0.40 ± 0.89	3.55 ± 3.84	0.99 ± 0.18	1.14 ± 0.49
60	900	1.14 ± 0.27	<0.20	1.29 ± 1.34	0.81 ± 0.16	1.07 ± 0.49
60	910	2.60 ± 0.44	<0.28	1.78 ± 2.34	0.79 ± 0.14	0.86 ± 0.33
58	920	0.86 ± 0.20	<0.18	0.87 ± 0.89	0.36 ± 0.11	0.77 ± 0.38
72	800	1.40 ± 0.37	<0.35	<1.17	0.60 ± 0.13	0.91 ± 0.60
70	810	1.60 ± 0.29	<0.17	1.21 ± 0.54	0.37 ± 0.08	0.72 ± 0.28
70	820	0.97 ± 0.34	<0.41	7.62 ± 2.38	0.93 ± 0.16	0.80 ± 0.54
70	830	0.89 ± 0.21	<0.15	1.41 ± 0.81	0.15 ± 0.08	0.66 ± 0.25
70	840	1.53 ± 0.31	<0.39	<1.11	0.38 ± 0.12	<0.32
70	850	2.96 ± 0.37	0.26 ± 0.44	1.98 ± 0.72	0.64 ± 0.14	1.04 ± 0.36
70	860	5.58 ± 0.47	0.64 ± 0.66	14.0 ± 1.8	0.34 ± 0.13	0.93 ± 0.39
70	870	4.08 ± 0.93	<0.53	4.57 ± 3.43	<0.14	1.87 ± 0.82

TABLE 4, cont.

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES
FROM 10 M GRID INTERVALS

Grid Location		Radionuclide Concentrations (pCi/g)				
N	E	Ra-226	U-235	U-238	Cs-137	Th-232
70	880	2.65 ± 0.35	<0.22	2.17 ± 0.79	0.71 ± 0.15	0.99 ± 0.38
70	890	3.99 ± 0.43	<0.45	7.81 ± 1.72	0.77 ± 0.16	1.42 ± 0.62
70	900	14.1 ± 0.7	<0.62	2.25 ± 1.94	0.72 ± 0.10	0.92 ± 0.40
70	910	4.42 ± 0.45	<0.46	6.92 ± 1.43	0.76 ± 0.14	1.35 ± 0.46
70	920	1.39 ± 0.38	<0.21	1.07 ± 0.65	0.79 ± 0.14	1.14 ± 0.33
70	930	1.84 ± 0.31	0.35 ± 0.80	<1.26	0.84 ± 0.15	1.24 ± 0.36
70	940	0.79 ± 0.23	0.40 ± 0.30	0.78 ± 1.06	0.45 ± 0.12	1.03 ± 0.35
84	820	1.04 ± 0.30	<0.28	3.21 ± 1.59	0.39 ± 0.11	1.31 ± 0.36
80	830	0.83 ± 0.17	<0.12	1.04 ± 0.48	0.51 ± 0.12	0.69 ± 0.31
80	840	0.89 ± 0.22	<0.12	0.86 ± 0.47	0.25 ± 0.06	0.86 ± 0.26
80	850	1.69 ± 0.32	<0.32	2.06 ± 1.00	0.57 ± 0.14	0.99 ± 0.31
80	860	2.57 ± 0.30	<0.26	4.38 ± 1.61	0.35 ± 0.08	1.41 ± 0.36
80	870	3.39 ± 0.53	<0.30	2.18 ± 1.06	0.76 ± 0.17	1.02 ± 0.46
80	880	4.28 ± 0.47	<0.29	2.94 ± 1.83	0.42 ± 0.09	0.84 ± 0.42
80	890	14.2 ± 0.9	2.60 ± 0.94	25.0 ± 1.9	0.34 ± 0.09	1.17 ± 0.53
80	900	1.31 ± 0.29	<0.27	1.75 ± 1.27	0.24 ± 0.11	0.94 ± 0.37
80	910	3.44 ± 0.37	<0.20	2.28 ± 0.63	0.43 ± 0.12	0.61 ± 0.42
80	920	4.54 ± 0.50	<0.34	2.15 ± 2.06	0.63 ± 0.13	1.04 ± 0.41
80	930	0.83 ± 0.32	<0.24	2.21 ± 1.61	0.74 ± 0.13	1.34 ± 0.47
80	940	<0.20	<0.31	1.24 ± 0.78	0.62 ± 0.17	1.05 ± 0.38
80	950	0.85 ± 0.21	<0.15	<0.42	0.70 ± 0.13	0.85 ± 0.36
80	960	0.83 ± 0.25	<0.23	1.21 ± 1.31	0.85 ± 0.14	0.98 ± 0.37
90	830	2.03 ± 0.29	<0.34	1.99 ± 1.33	0.60 ± 0.10	1.23 ± 0.45
90	840	1.21 ± 0.27	<0.18	1.28 ± 0.95	0.43 ± 0.10	1.10 ± 0.30
90	850	0.62 ± 0.29	<0.19	<0.62	0.48 ± 0.10	0.80 ± 0.37
90	860	0.94 ± 0.23	<0.19	<0.74	0.28 ± 0.10	0.91 ± 0.31
90	870	1.19 ± 0.25	<0.29	1.88 ± 1.81	0.11 ± 0.08	1.37 ± 0.57
90	880	2.54 ± 0.34	<0.39	8.69 ± 2.35	0.92 ± 0.18	0.88 ± 0.49
90	890	6.79 ± 1.22	<0.68	7.91 ± 2.51	0.11 ± 0.11	1.36 ± 0.61
90	900	5.18 ± 0.99	<0.60	5.40 ± 4.75	0.55 ± 0.20	1.00 ± 0.76
90	910	2.78 ± 0.39	<0.29	3.07 ± 1.98	0.38 ± 0.10	1.23 ± 0.52
86	920	1.11 ± 0.32	<0.32	2.68 ± 2.16	0.19 ± 0.09	1.50 ± 0.42
90	930	4.01 ± 0.46	0.27 ± 0.53	2.07 ± 0.77	0.93 ± 0.13	1.31 ± 0.47
90	940	0.88 ± 0.26	<0.18	1.15 ± 1.16	0.51 ± 0.11	0.83 ± 0.39
90	950	0.78 ± 0.18	<0.18	<0.61	0.34 ± 0.10	0.90 ± 0.35
90	960	0.93 ± 0.24	<0.25	<0.86	0.55 ± 0.11	1.34 ± 0.36
90	970	1.92 ± 0.33	0.38 ± 0.63	1.95 ± 1.89	0.71 ± 0.23	<0.32
90	980	0.65 ± 0.20	<0.13	0.47 ± 0.68	0.54 ± 0.09	0.72 ± 0.27

TABLE 4, cont.

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES
FROM 10 M GRID INTERVALS

Grid Location		Radionuclide Concentrations (pCi/g)				
N	E	Ra-226	U-235	U-238	Cs-137	Th-232
100	820	1.56 ± 0.31	<0.43	1.65 ± 1.26	1.27 ± 0.22	0.91 ± 0.58
97	840	0.89 ± 0.25	<0.15	0.87 ± 0.48	0.44 ± 0.10	0.84 ± 0.32
103	850	1.02 ± 0.25	<0.22	2.06 ± 1.90	0.53 ± 0.12	0.87 ± 0.32
100	860	1.28 ± 0.34	<0.31	2.08 ± 1.59	0.69 ± 0.18	1.01 ± 0.41
100	870	6.40 ± 0.51	<0.48	<1.42	1.70 ± 0.18	<0.22
100	880	0.85 ± 0.24	<0.16	1.28 ± 0.51	0.11 ± 0.09	0.66 ± 0.43
100	890	2.61 ± 0.50	<0.31	3.30 ± 2.38	0.72 ± 0.14	0.84 ± 0.40
100	900	3.45 ± 0.41	<0.31	4.18 ± 1.37	0.34 ± 0.14	1.20 ± 0.31
100	910	3.12 ± 0.39	0.44 ± 0.39	4.67 ± 1.96	0.27 ± 0.11	1.87 ± 0.74
100	920	5.25 ± 1.10	<0.63	7.63 ± 4.21	0.49 ± 0.32	1.23 ± 0.71
100	930	2.60 ± 0.33	<0.22	0.92 ± 1.11	0.55 ± 0.13	0.93 ± 0.31
100	940	4.09 ± 0.58	<0.33	3.73 ± 1.32	1.12 ± 0.17	1.60 ± 0.48
100	950	3.64 ± 0.48	<0.24	1.99 ± 0.79	0.56 ± 0.11	0.81 ± 0.39
100	960	1.11 ± 0.34	<0.38	3.20 ± 1.36	1.06 ± 0.22	1.18 ± 0.49
100	970	1.11 ± 0.30	<0.19	0.92 ± 0.67	0.68 ± 0.14	0.86 ± 0.36
100	980	1.13 ± 0.35	<0.39	<1.15	0.99 ± 0.17	1.58 ± 0.40
100	990	0.64 ± 0.23	<0.15	0.65 ± 0.45	0.93 ± 0.14	0.48 ± 0.26
105	1000	1.17 ± 0.40	<0.30	<1.03	0.93 ± 0.20	1.14 ± 0.47
110	860	1.36 ± 0.50	<0.38	1.34 ± 2.31	0.57 ± 0.13	1.44 ± 0.49
110	880	1.03 ± 0.27	<0.13	0.34 ± 0.64	0.56 ± 0.11	0.25 ± 0.20
110	890	1.39 ± 0.36	<0.28	1.62 ± 1.50	0.61 ± 0.16	1.46 ± 0.57
110	900	1.74 ± 0.35	0.57 ± 0.75	4.72 ± 3.23	0.63 ± 0.14	1.01 ± 0.33
110	910	14.3 ± 0.8	3.50 ± 1.31	35.1 ± 3.2	0.84 ± 0.14	1.43 ± 0.63
110	920	6.32 ± 0.54	1.11 ± 1.04	11.2 ± 4.0	0.14 ± 0.07	2.04 ± 0.58
110	930	9.16 ± 1.05	1.39 ± 1.54	3.67 ± 4.35	0.15 ± 0.22	2.00 ± 0.78
110	940	3.17 ± 0.92	<0.58	4.70 ± 3.47	0.36 ± 0.20	0.83 ± 0.73
110	950	4.39 ± 0.45	<0.25	3.15 ± 0.79	0.71 ± 0.14	1.01 ± 0.36
110	960	2.89 ± 0.65	<0.43	2.52 ± 4.44	0.28 ± 0.13	1.10 ± 0.66
110	970	1.17 ± 0.37	<0.19	1.43 ± 1.07	0.17 ± 0.06	1.22 ± 0.69
110	980	1.20 ± 0.39	<0.29	1.41 ± 1.99	0.41 ± 0.17	1.20 ± 0.46
110	990	1.39 ± 0.36	<0.28	1.62 ± 1.50	0.61 ± 0.16	1.46 ± 0.57
110	1000	0.27 ± 0.13	<0.10	0.49 ± 0.47	0.56 ± 0.10	0.24 ± 0.15
110	1010	1.04 ± 0.43	0.28 ± 0.96	<0.94	0.66 ± 0.15	0.82 ± 0.43
120	880	0.92 ± 0.25	<0.27	<0.79	0.70 ± 0.14	0.88 ± 0.46
120	890	1.35 ± 0.33	<0.31	<1.04	0.79 ± 0.13	1.22 ± 0.34
120	900	0.94 ± 0.29	<0.21	1.36 ± 1.40	0.89 ± 0.15	0.83 ± 0.61
120	910	1.21 ± 0.28	0.79 ± 0.76	7.25 ± 1.92	0.31 ± 0.09	0.78 ± 0.55

TABLE 4, cont.

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES
FROM 10 M GRID INTERVALS

Grid Location		Radionuclide Concentrations (pCi/g)				
N	E	Ra-226	U-235	U-238	Cs-137	Th-232
120	920	6.75 ± 0.85	<0.56	6.12 ± 2.56	0.14 ± 0.17	<0.38
120	930	5.14 ± 0.54	0.56 ± 0.69	9.68 ± 1.28	0.13 ± 0.18	1.37 ± 0.55
120	940	5.62 ± 0.54	0.69 ± 0.82	7.93 ± 1.81	<0.06	0.62 ± 0.34
120	950	8.15 ± 0.91	<0.56	3.32 ± 2.08	<0.10	0.87 ± 0.79
120	960	9.22 ± 0.96	<0.62	7.00 ± 2.43	0.19 ± 0.19	1.32 ± 0.65
120	970	5.33 ± 0.79	0.67 ± 1.08	4.44 ± 1.95	0.29 ± 0.19	0.71 ± 0.49
120	980	5.02 ± 0.75	<0.48	3.14 ± 3.11	0.08 ± 0.08	<0.35
120	990	0.88 ± 0.39	<0.28	2.49 ± 1.95	0.67 ± 0.17	0.82 ± 0.55
120	1000	2.04 ± 0.38	<0.28	1.13 ± 2.59	0.25 ± 0.11	1.10 ± 0.44
120	1010	1.34 ± 0.44	<0.38	<1.18	0.90 ± 0.18	1.04 ± 0.49
118	1020	1.22 ± 0.37	<0.19	1.04 ± 1.00	0.50 ± 0.13	0.84 ± 0.40
123	1030	1.43 ± 0.33	<0.37	1.28 ± 2.19	0.69 ± 0.14	0.99 ± 0.35
126	890	0.99 ± 0.52	<0.27	1.65 ± 2.23	0.63 ± 0.19	1.18 ± 0.40
132	900	0.95 ± 0.30	<0.24	1.82 ± 1.09	0.39 ± 0.10	0.90 ± 0.31
130	910	1.16 ± 0.30	<0.18	1.36 ± 0.91	0.57 ± 0.11	0.94 ± 0.31
130	920	1.17 ± 0.24	<0.21	3.82 ± 0.80	0.36 ± 0.10	0.95 ± 0.34
130	930	1.32 ± 0.39	0.77 ± 0.97	14.9 ± 4.0	0.48 ± 0.15	0.84 ± 0.54
130	940	1.90 ± 0.37	<0.39	9.84 ± 2.59	<0.06	1.22 ± 0.48
130	950	11.8 ± 0.7	0.51 ± 0.77	9.25 ± 1.30	<0.06	0.89 ± 0.53
130	960	19.3 ± 1.1	7.71 ± 1.79	125 ± 7	0.54 ± 0.14	1.49 ± 0.72
130	970	5.39 ± 1.07	<0.79	3.24 ± 5.85	0.39 ± 0.21	<0.76
130	980	3.80 ± 0.42	<0.44	<1.25	0.49 ± 0.15	1.79 ± 0.43
130	990	3.22 ± 0.43	<0.23	1.93 ± 0.75	0.88 ± 0.12	1.10 ± 0.47
130	1000	4.73 ± 0.56	<0.31	2.27 ± 2.02	0.43 ± 0.11	0.72 ± 0.47
130	1010	1.29 ± 0.44	<0.36	1.43 ± 2.42	0.59 ± 0.12	1.06 ± 0.43
130	1020	1.13 ± 0.26	<0.19	0.48 ± 0.57	0.59 ± 0.11	1.15 ± 0.36
130	1030	b	b	b	b	b
130	1040	1.29 ± 0.33	<0.26	2.62 ± 1.11	0.48 ± 0.18	1.04 ± 0.43
130	1050	b	b	b	b	b
130	1060	1.25 ± 0.28	<0.36	4.96 ± 1.58	0.47 ± 0.11	1.67 ± 0.48
140	910	0.83 ± 0.34	<0.16	1.94 ± 0.92	0.43 ± 0.12	0.88 ± 0.29
140	920	3.06 ± 0.56	<0.24	<0.73	1.17 ± 0.16	<0.16
140	930	1.40 ± 0.30	1.36 ± 0.65	15.3 ± 3.1	1.11 ± 0.23	1.88 ± 0.54
140	940	1.65 ± 0.28	0.82 ± 0.50	16.2 ± 1.3	0.67 ± 0.13	0.99 ± 0.69
140	950	6.54 ± 0.70	1.58 ± 0.71	<2.27	1.15 ± 0.17	0.96 ± 0.43
140	960	6.25 ± 0.54	<0.51	14.7 ± 2.4	<0.06	1.37 ± 0.45
140	970	8.26 ± 0.63	<0.30	2.69 ± 1.51	<0.05	1.17 ± 0.48

TABLE 4, cont.

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES FROM 10 M GRID INTERVALS

Grid Location		Radionuclide Concentrations (pCi/g)				
N	E	Ra-226	U-235	U-238	Cs-137	Th-232
140	980	10.3 ± 1.3	<0.73	3.79 ± 3.72	0.42 ± 0.25	2.14 ± 0.94
140	990	7.54 ± 0.88	<0.55	1.07 ± 2.86	<0.10	0.95 ± 0.67
140	1000	4.65 ± 0.50	<0.33	2.10 ± 1.77	0.63 ± 0.16	1.49 ± 0.43
140	1010	2.12 ± 0.39	0.77 ± 0.72	<1.28	0.93 ± 0.17	0.86 ± 0.80
140	1020	1.08 ± 0.24	<0.16	0.29 ± 0.40	0.25 ± 0.07	1.05 ± 0.42
140	1030	1.55 ± 0.38	<0.25	1.25 ± 1.67	0.76 ± 0.19	1.26 ± 0.38
140	1040	1.44 ± 0.29	<0.32	1.08 ± 0.96	0.46 ± 0.10	0.59 ± 0.26
140	1050	0.25 ± 0.25	<0.20	<0.65	0.61 ± 0.16	<0.20
140	1060	1.06 ± 0.31	<0.18	1.15 ± 1.09	0.74 ± 0.14	0.89 ± 0.38
145	920	0.83 ± 0.30	<0.21	1.23 ± 1.54	<0.04	0.65 ± 0.31
150	930	1.52 ± 0.59	<0.41	3.12 ± 1.40	0.78 ± 0.19	1.72 ± 0.47
150	940	1.30 ± 0.36	<0.19	4.10 ± 0.82	1.12 ± 0.14	0.68 ± 0.37
150	950	9.04 ± 0.85	1.05 ± 1.01	16.0 ± 2.3	0.90 ± 0.16	1.82 ± 0.65
150	960	2.47 ± 0.42	3.03 ± 0.79	29.7 ± 2.5	<0.06	1.63 ± 0.40
150	970	6.03 ± 0.61	0.54 ± 0.65	4.56 ± 1.06	<0.05	1.00 ± 0.55
150	980	8.24 ± 0.65	1.29 ± 1.02	9.20 ± 3.43	0.16 ± 0.18	0.97 ± 0.36
150	990	7.46 ± 0.66	<0.52	3.15 ± 2.53	<0.08	1.24 ± 0.35
150	1000	4.91 ± 0.88	<0.55	2.76 ± 2.79	<0.08	0.90 ± 1.23
150	1010	4.72 ± 0.82	<0.47	3.25 ± 2.25	0.40 ± 0.15	1.84 ± 0.70
150	1020	1.97 ± 0.40	<0.29	<0.66	1.06 ± 0.19	1.08 ± 0.64
150	1030	0.71 ± 0.76	<0.40	1.27 ± 2.88	0.35 ± 0.18	0.77 ± 0.62
150	1040	1.25 ± 0.34	<0.26	1.68 ± 1.52	0.61 ± 0.20	1.23 ± 0.67
150	1050	1.14 ± 0.30	<0.35	2.92 ± 1.62	0.75 ± 0.15	2.01 ± 0.59
150	1060	1.19 ± 0.28	<0.18	1.25 ± 0.66	0.72 ± 0.18	1.26 ± 0.51
150	1070	0.68 ± 0.38	<0.18	1.60 ± 1.73	0.79 ± 0.14	0.36 ± 0.29
159	940	0.75 ± 0.28	<0.20	0.92 ± 1.87	0.25 ± 0.10	1.05 ± 0.34
160	950	4.02 ± 0.47	<0.36	<1.05	1.81 ± 0.17	<0.19
160	960	1.52 ± 0.30	<0.26	2.92 ± 2.14	0.61 ± 0.12	0.40 ± 0.54
160	970	2.86 ± 0.39	1.22 ± 0.84	17.6 ± 2.4	0.49 ± 0.22	1.07 ± 0.50
160	980	1.23 ± 0.29	<0.34	7.97 ± 1.62	<0.05	1.01 ± 0.36
160	990	29.9 ± 1.0	<0.46	<1.01	<0.06	0.92 ± 0.55
160	1000	8.38 ± 0.69	<0.39	1.55 ± 2.87	<0.06	1.05 ± 0.49
160	1010	10.9 ± 0.71	<0.62	<1.75	0.08 ± 0.07	2.15 ± 0.64
160	1020	6.17 ± 0.91	<0.61	<1.75	0.33 ± 0.30	1.98 ± 0.95
160	1030	1.52 ± 0.29	<0.21	1.48 ± 1.09	0.69 ± 0.18	1.74 ± 0.51
160	1040	1.50 ± 0.38	<0.26	1.07 ± 2.15	0.63 ± 0.13	0.65 ± 0.30
160	1050	0.97 ± 0.23	<0.19	1.04 ± 1.66	0.05 ± 0.05	1.01 ± 0.29

TABLE 4, cont.

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES
FROM 10 M GRID INTERVALS

Grid Location		Radionuclide Concentrations (pCi/g)				
N	E	Ra-226	U-235	U-238	Cs-137	Th-232
160	1060	0.82 ± 0.28	<0.26	1.76 ± 2.20	0.40 ± 0.09	0.76 ± 0.30
160	1070	0.78 ± 0.19	<0.16	0.75 ± 0.89	0.04 ± 0.07	0.67 ± 0.24
160	1080	0.42 ± 0.16	<0.15	<0.42	1.71 ± 0.16	0.24 ± 0.19
170	960	1.17 ± 0.25	0.52 ± 0.43	7.70 ± 1.37	0.71 ± 0.11	0.85 ± 0.33
170	970	5.32 ± 0.44	<0.22	<0.48	0.54 ± 0.09	0.62 ± 0.35
170	980	1.86 ± 0.29	<0.26	<0.79	0.74 ± 0.14	0.94 ± 0.36
170	990	1.30 ± 0.25	<0.30	1.92 ± 1.00	0.26 ± 0.09	1.02 ± 0.27
170	1000	1.76 ± 0.27	<0.17	1.08 ± 1.29	0.42 ± 0.09	0.83 ± 0.30
170	1010	3.52 ± 0.50	<0.31	3.53 ± 2.85	<0.06	0.60 ± 0.32
170	1020	3.92 ± 0.40	0.55 ± 0.62	4.90 ± 1.37	0.08 ± 0.05	0.80 ± 0.26
170	1030	5.35 ± 0.78	<0.52	3.48 ± 3.36	0.17 ± 0.21	1.24 ± 0.94
170	1040	1.18 ± 0.30	<0.16	0.76 ± 0.51	0.83 ± 0.12	0.60 ± 0.31
170	1050	1.24 ± 0.31	<0.25	2.72 ± 1.65	0.62 ± 0.12	0.89 ± 0.33
170	1060	0.92 ± 0.31	<0.25	1.24 ± 1.62	0.27 ± 0.12	0.74 ± 0.43
170	1070	1.10 ± 0.30	<0.28	1.26 ± 1.59	0.38 ± 0.11	1.16 ± 0.38
170	1080	0.69 ± 0.30	<0.13	0.49 ± 0.98	0.95 ± 0.14	0.56 ± 0.25
170	1090	0.93 ± 0.21	<0.22	0.89 ± 1.56	0.51 ± 0.12	1.32 ± 0.37
180	980	2.08 ± 0.34	<0.29	<0.83	0.85 ± 0.12	0.43 ± 0.31
180	990	1.78 ± 0.35	<0.18	2.34 ± 0.96	0.67 ± 0.11	1.20 ± 0.36
180	1000	1.93 ± 0.36	<0.27	<0.78	0.41 ± 0.17	0.36 ± 0.23
180	1010	1.49 ± 0.29	<0.31	1.47 ± 1.65	0.44 ± 0.12	0.90 ± 0.47
180	1020	1.60 ± 0.32	0.48 ± 0.66	6.98 ± 0.979	0.08 ± 0.06	1.05 ± 0.33
180	1030	3.18 ± 0.45	1.04 ± 0.84	11.0 ± 3.2	0.38 ± 0.15	1.36 ± 0.50
180	1040	6.91 ± 0.80	<0.52	4.35 ± 3.70	<0.09	1.61 ± 0.65
180	1050	3.55 ± 0.70	<0.38	1.89 ± 5.51	<0.08	1.22 ± 0.62
180	1060	1.38 ± 0.33	<0.37	0.50 ± 1.24	0.50 ± 0.13	1.47 ± 0.42
180	1070	1.56 ± 0.31	<0.20	1.58 ± 1.05	0.52 ± 0.13	0.84 ± 0.38
180	1080	0.92 ± 0.25	<0.22	0.83 ± 2.64	<0.05	0.84 ± 0.38
180	1090	1.11 ± 0.25	<0.37	1.91 ± 2.08	0.98 ± 0.17	1.17 ± 0.55
190	1000	1.42 ± 0.29	<0.24	<0.68	1.14 ± 0.13	0.47 ± 0.35
190	1010	8.75 ± 0.63	0.51 ± 0.56	0.81 ± 1.25	1.70 ± 0.18	<0.26
190	1020	1.46 ± 0.43	0.47 ± 0.84	1.10 ± 1.94	0.79 ± 0.18	1.34 ± 0.58
190	1030	1.17 ± 0.28	0.45 ± 0.37	1.44 ± 0.67	0.69 ± 0.15	0.72 ± 0.33
190	1040	5.45 ± 0.55	2.47 ± 1.21	17.8 ± 2.25	0.50 ± 0.20	1.13 ± 0.72
190	1050	2.56 ± 0.52	<0.42	1.22 ± 2.61	<0.07	1.24 ± 0.47
190	1060	6.60 ± 0.49	0.70 ± 0.55	3.71 ± 0.94	0.39 ± 0.08	0.98 ± 0.30
190	1070	1.39 ± 0.34	<0.23	<0.71	1.11 ± 0.18	0.51 ± 0.34

TABLE 4, cont.

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES
FROM 10 M GRID INTERVALS

Grid Location		Radionuclide Concentrations (pCi/g)				
N	E	Ra-226	U-235	U-238	Cs-137	Th-232
190	1080	1.06 ± 0.37	<0.37	1.14 ± 1.88	0.56 ± 0.15	1.07 ± 0.43
195	1000	2.00 ± 0.37	0.43 ± 0.70	2.35 ± 1.99	0.60 ± 0.14	1.30 ± 0.45
200	1010	1.03 ± 0.29	<0.24	<0.75	0.52 ± 0.14	0.39 ± 0.21
200	1020	1.45 ± 0.34	<0.25	1.89 ± 1.56	0.74 ± 0.14	0.78 ± 0.30
200	1030	1.32 ± 0.26	<0.30	3.91 ± 1.37	0.44 ± 0.15	1.38 ± 0.45
200	1040	1.22 ± 0.24	<0.17	1.11 ± 0.63	0.43 ± 0.11	1.24 ± 0.43
200	1050	2.06 ± 0.52	0.84 ± 0.62	2.73 ± 3.77	0.75 ± 0.16	0.89 ± 0.59
200	1060	1.34 ± 0.27	<0.22	<0.80	0.25 ± 0.12	1.13 ± 0.46
200	1070	22.5 ± 1.1	<0.88	<2.49	0.91 ± 0.16	1.69 ± 1.50
206	1020	0.82 ± 0.28	<0.17	1.29 ± 1.27	0.55 ± 0.12	0.42 ± 0.33
210	1030	1.01 ± 0.25	<0.30	2.70 ± 1.09	0.57 ± 0.13	1.12 ± 0.40
210	1040	0.80 ± 0.21	<0.14	0.31 ± 0.75	1.52 ± 0.17	<0.13
210	1050	0.93 ± 0.28	<0.22	1.37 ± 1.79	0.45 ± 0.10	0.95 ± 0.33
210	1060	0.89 ± 0.28	<0.28	1.37 ± 1.80	0.85 ± 0.18	1.05 ± 0.56
210	1070	1.30 ± 0.29	<0.39	<1.21	1.20 ± 0.19	1.11 ± 0.70

[a] Errors are 2σ based on counting statistics.
[b] Sample not collected.

TABLE 5

RADIONUCLIDE CONCENTRATIONS IN SURFACE SAMPLES
FROM LOCATIONS IDENTIFIED BY THE WALKOVER SCAN

Sample ID	Description	Grid Location N	Grid Location E	Radionuclide Concentrations (pCi/g)[a] Ra-226	U-235[b]	U-238[b]	Cs-137[b]	Th-232[b]
B1	White Chip	20	770	c	c	c	c	c
B2	White Chip	26	779	c	c	c	c	c
B3	White Chip	28	772	c	c	c	c	c
B4	Soil	31	760	6.45 ± 0.86[d]	2.57 ± 2.12	16.3 ± 5.8	160 ± 2	0.67 ± 0.33
B5A	Soil	40	801	950 ± 9	6.89 ± 8.33	<10.3	<0.64	<2.32
B5B	White Chip	40	801	c	c	c	c	c
B6	White Chip	40	810	c	c	c	c	c
B7	Soil	42	792	56.7 ± 2.2	5.07 ± 2.32	9.98 ± 6.68	0.32 ± 0.20	0.86 ± 1.27
B8	Soil	43	814	567 ± 5	6.51 ± 3.46	51.3 ± 4.6	0.91 ± 0.33	<1.26
B9	Soil	44	779	11.6 ± 0.7	0.60 ± 0.79	2.47 ± 1.42	2.27 ± 0.20	1.06 ± 0.50
B10	Soil	44	811	82.5 ± 2.0	19.4 ± 2.9	365 ± 9	0.71 ± 0.19	0.66 ± 1.36
B11	White Chip	45	808	c	c	c	c	c
B12	Soil	47	810	1980 ± 12	45.7 ± 13.6	<23.4	<1.19	<4.33
B13	White Chip	53	797	c	c	c	c	c
B14	Soil	54	793	85.9 ± 2.0	22.5 ± 3.2	<6.51	2.41 ± 0.27	1.34 ± 1.38
B15	Rock	78	870	7.50 ± 0.73	<0.43	7.47 ± 1.77	0.33 ± 0.16	1.19 ± 0.54
B16	Soil	85	875	650 ± 6	<0.31	<7.63	<0.47	<1.70
B17	Soil	86	876	34.7 ± 2.0	3.02 ± 2.44	14.5 ± 6.8	0.79 ± 0.25	0.64
B18	Soil	86	880	38.6 ± 2.1	<1.18	8.28 ± 6.45	<0.17	3.40 ± 2.49
B19	White Chip	86	885	c	c	c	c	c
B20	White Chip	90	880	c	c	c	c	c
B21	Soil	106	869	84.0 ± 2.1	2.79 ± 2.95	17.2 ± 4.6	<0.20	<0.73
B22	Yellow Chips	115	938	72.4 ± 1.8	16.3 ± 2.8	320 ± 9	0.71 ± 0.18	0.84 ± 1.16
B23	Soil	115	921	72.8 ± 1.6	8.15 ± 1.16	104 ± 4	0.28 ± 0.14	<0.15
B24	Soil	117	940	62.7 ± 1.6	6.81 ± 1.77	46.8 ± 3.0	0.55 ± 1.15	1.26 ± 0.96
B25	Soil	120	942	3700 ± 30	39.6 ± 25.7	<35.1	<2.10	<8.05
B26	Rocks	120	959	29.6 ± 1.7	5.10 ± 3.00	25.7 ± 7.6	0.35 ± 0.18	1.20 ± 1.45
B27A	Soil	121	925	670 ± 10	21.1 ± 10.2	34.8 ± 25.9	<0.68	<2.79
B27B	Soil	121	925	58.8 ± 2.4	<1.29	2.18 ± 7.94	<0.19	<0.78
B28	Soil	124	924	1130 ± 7	72.4 ± 8.8	1500 ± 28	<0.69	4.48 ± 3.66
B29	Yellow Chips	124	953	73.0 ± 2.5	510 ± 7	9430 ± 35	<0.44	<1.19
B30	White Chip	127	941	c	c	c	c	c
B31	Soil	128	959	7.07 ± 1.03	3.27 ± 1.71	67.1 ± 5.6	<0.09	1.43 ± 0.84
B32	Soil	132	950	4290 ± 21	93.8 ± 17.3	<26.6	<1.83	<6.48
B33	Rock	138	975	1100 ± 10	13.0 ± 9.8	96.5 ± 22.3	<0.66	<2.66
B34	Soil	139	951	930 ± 8	9.67 ± 8.18	<10.7	<0.51	<2.08
B35	Rocks	148	967	47.4 ± 1.7	1.42 ± 1.87	<2.45	<0.12	1.23 ± 0.98
B36	Soil & Rocks	155	984	970 ± 8	10.1 ± 7.6	14.4 ± 17.0	<0.54	<2.08
B37	Rocks	158	1009	52.8 ± 1.5	1.68 ± 1.20	<1.21	<0.10	0.80 ± 0.79
B38	Soil	160	998	130 ± 3	4.65 ± 2.85	<3.59	0.22 ± 0.20	1.76 ± 1.37
B39	Soil	173	1012	15.1 ± 0.9	0.60 ± 1.45	<2.30	<0.09	1.60 ± 0.56
B40	Soil & Rocks	176	1016	45.0 ± 2.1	2.51 ± 2.49	10.1 ± 6.0	<0.16	0.55 ± 1.83

[a] Refer to Table 3 for direct radiation levels.
[b] Relatively large errors and poor detection sensitivities are the result of high levels of Ra-226 or U-238 which cause increased continuum count rates.
[c] Small sample with high Ra-226 content; activity levels are presented in Table 6.
[d] Errors are 2σ based on counting statistics.

TABLE 6

RA-226 ACTIVITY IN SAMPLES FROM
LOCATIONS OF ELEVATED DIRECT RADIATION LEVELS

Sample	Grid Location N	Grid Location E	Nature of Sample	Ra-226 (μCi)
B1	20	770	White Chips	0.14
B2	26	779	" "	1.42
B3	28	772	" "	4.21
B5B	40	801	" "	0.49
B6	40	810	" "	0.26
B11	45	809	" "	0.13
B13	53	797	" "	0.97
B19	86	885	" "	0.25
B20	90	880	" "	0.57
B30	127	941	" "	0.59

TABLE 7

RADIONUCLIDE CONCENTRATIONS IN BOREHOLE SOIL SAMPLES

Borehole No.[a]	Grid Location N	Grid Location E	Depth (m)	Radionuclide Concentrations (pCi/g) Ra-226	U-235	U-238	Cs-137	Th-232
H1	20	770	Surface	97.1 ± 2.6[b]	4.61 ± 3.22	16.9 ± 8.3	<0.26	<0.92
			1	1.15 ± 0.22	<0.17	0.54 ± 1.68	<0.04	0.91 ± 0.33
			2	0.98 ± 0.32	<0.22	<0.70	<0.04	1.08 ± 0.37
H2	38	775	Surface	1.23 ± 0.37	<0.24	0.97 ± 1.58	0.40 ± 0.10	0.36 ± 0.36
			0.5	1.40 ± 0.37	<0.44	5.09 ± 1.60	0.23 ± 0.14	1.22 ± 0.80
			1	1.04 ± 0.26	<0.17	0.92 ± 0.89	<0.04	0.75 ± 0.41
H3	43	810	Surface	17.1 ± 1.1	5.85 ± 1.81	50.9 ± 3.8	0.35 ± 0.13	0.76 ± 0.71
			0.5	1.32 ± 0.38	0.29 ± 0.95	2.40 ± 2.42	<0.06	1.60 ± 0.59
			1	1.12 ± 0.30	<0.39	2.44 ± 2.20	<0.05	1.40 ± 0.57
H4	53	792	Surface	10.0 ± 0.8	1.79 ± 1.02	3.26 ± 1.58	4.32 ± 0.33	0.96 ± 0.80
			0.5	1.39 ± 0.37	<0.28	3.08 ± 1.90	<0.06	1.23 ± 0.55
			2	0.85 ± 0.25	<0.29	2.87 ± 2.03	0.09 ± 0.10	1.50 ± 0.56
H5	85	875	Surface	650 ± 6	<0.31	<7.63	<0.47	<1.07
			0.5	0.96 ± 0.28	<0.19	0.22 ± 0.82	<0.04	0.95 ± 0.30
			1	1.15 ± 0.33	<0.25	0.96 ± 1.04	<0.06	1.07 ± 0.64
H6	86	880	Surface	38.6 ± 2.1	<1.18	8.28 ± 6.45	<0.17	3.40 ± 2.49
			0.5	1.54 ± 0.32	<0.39	2.72 ± 1.39	<0.06	1.24 ± 0.50
			1	1.62 ± 0.26	<0.19	1.19 ± 1.05	<0.03	1.22 ± 0.45
H7	86	885	Surface	7.76 ± 0.78	<0.42	5.92 ± 2.76	0.08 ± 0.08	0.91 ± 0.56
			0.5	1.12 ± 0.29	<0.25	1.46 ± 1.93	<0.05	0.93 ± 0.37
			2	1.36 ± 0.34	<0.39	<1.17	<0.04	1.39 ± 0.69
H8	90	880	Surface	2.80 ± 0.44	<0.38	6.37 ± 1.72	0.57 ± 0.15	1.00 ± 0.51
			0.5	0.96 ± 0.31	<0.03	<0.09	<0.04	1.23 ± 0.35
			2	1.06 ± 0.30	<0.15	0.95 ± 0.54	<0.04	1.14 ± 0.39
H9	96	880	Surface	1.40 ± 0.31	<0.23	<0.83	0.53 ± 0.11	0.65 ± 0.28
			0.5	1.31 ± 0.30	<0.35	0.98 ± 0.99	0.15 ± 0.10	1.44 ± 0.38
			1	0.94 ± 0.19	<0.15	0.72 ± 0.88	<0.02	0.64 ± 0.33
H10	120	942	Surface	3700 ± 30	39.6 ± 25.7	<35.1	<2.10	<8.05
			0.5	1.19 ± 0.28	<0.29	<0.86	<0.04	1.25 ± 0.39
			2	1.61 ± 0.40	<0.35	1.93 ± 2.12	<0.05	0.57 ± 0.55
H11	124	924	Surface	1130 ± 7	72.4 ± 8.8	1500 ± 28	<0.69	4.48 ± 3.66
			0.5	1.20 ± 0.44	<0.29	1.86 ± 2.29	<0.03	1.18 ± 0.52
			1	1.56 ± 0.45	<0.30	1.99 ± 1.76	<0.04	1.34 ± 0.70

TABLE 7, cont.

RADIONUCLIDE CONCENTRATIONS IN BOREHOLE SOIL SAMPLES

Borehole No.	Grid Location N	Grid Location E	Depth (m)	Radionuclide Concentrations (pCi/g) Ra-226	U-235	U-238	Cs-137	Th-232
H12	132	950	Surface	4290 ± 21	93.8 ± 17.3	<26.6	<1.83	<6.48
			0.5	1.19 ± 0.27	<0.16	0.94 ± 1.17	<0.03	1.09 ± 0.40
			1	1.79 ± 0.38	<0.24	1.74 ± 0.99	<0.05	0.81 ± 0.46
H13	160	998	Surface	130 ± 3	4.65 ± 2.85	<3.59	0.22 ± 0.20	1.76 ± 1.37
			0.5	1.21 ± 0.26	<0.30	3.02 ± 1.18	<0.04	0.89 ± 0.28
			1	0.84 ± 0.26	0.24 ± 0.36	<0.49	<0.03	0.61 ± 0.40
H14	176	1012	Surface	70.2 ± 2.4	<1.18	<3.03	1.06 ± 0.27	1.18 ± 1.08
			0.5	1.22 ± 0.30	0.59 ± 0.54	1.48 ± 2.02	<0.04	1.13 ± 0.54
			1	1.05 ± 0.26	<0.38	2.71 ± 1.74	<0.05	1.39 ± 0.52
H15	183	1015	Surface	1.74 ± 0.33	<0.19	1.80 ± 0.69	0.39 ± 0.10	0.95 ± 0.35
			0.5	<0.20	<0.18	1.34 ± 2.20	<0.04	0.88 ± 0.36
			2	1.29 ± 0.29	<0.32	1.74 ± 2.00	<0.05	1.44 ± 0.54

[a] Refer to Figure 4.
[b] Errors are 2σ based on counting statistics.

TABLE 8

LISTING OF AREAS ON PROPERTY N′-NORTH WHERE RADIONUCLIDE CONCENTRATIONS EXCEED GUIDELINE CONTAMINATION LEVELS

Location[a]		Principal Radionuclides[b]	Estimated Quantities of Material Exceeding Guidelines: Area (m^2)	Avg. Depth (m)	Volume (m^3)	Remarks
Area 1		Ra-226, U-238	175	0.15	26	
Area 2		Ra-226, U-238	300	0.15	45	
Area 3		Ra-226, U-238	3250	0.15	488	
105-107N	868-870E	Ra-226	4	0.15	0.6	
0N	689E	Ra-226	---	---	---	Small isolated surface or near surface "hot spot" or individual piece of contaminated debris or material. Each of these locations involves less than 1 m^3 in volume.
0N	740E	Ra-226	---	---	---	
0N	770E	Ra-226	---	---	---	
20N	770E	Ra-226	---	---	---	
20N	780E	Ra-226	---	---	---	
20N	800E	Ra-226	---	---	---	
30N	830E	Ra-226	---	---	---	
31N	760E	Ra-226	---	---	---	
42N	792E	Ra-226	---	---	---	
44N	779E	Ra-226	---	---	---	
50N	830E	Ra-226	---	---	---	
53N	796E	Ra-226	---	---	---	
53N	797E	Ra-226	---	---	---	
54N	793E	Ra-226	---	---	---	
60N	860E	Ra-226	---	---	---	
70N	900E	Ra-226	---	---	---	
78N	870E	Ra-226	---	---	---	
100N	870E	Ra-226	---	---	---	
150N	950E	Ra-226	---	---	---	
180N	1040E	Ra-226	---	---	---	
190N	1010E	Ra-226	---	---	---	
190N	1060E	Ra-226	---	---	---	
200N	1070E	Ra-226	---	---	---	

[a] Refer to Figure 7.
[b] Based on sample analysis, direct radiation levels, location, and physical appearance.

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APPENDIX A

INSTRUMENTATION AND ANALYTICAL PROCEDURES

APPENDIX A

Instrumentation and Analytical Procedures

Gamma Scintillation Measurement

Walkover surface scans and measurements of gamma exposure rates were performed using Eberline Model PRM-6 portable ratemeters with Victoreen Model 489-55 gamma scintillation probes containing 3.2 cm x 3.8 cm NaI(Tl) scintillation crystals. Count rates were converted to exposure rates (μR/h) using factors determined by comparing the response of the scintillation detector with that of a Reuter Stokes model RSS-111 pressurized ionization chamber at several locations on the NFSS and off-site properties.

Beta-Gamma Dose Rate Measurements

Measurements were performed using Eberline "Rascal," Model PRS-1, portable scaler/ratemeters with Model HP-260 thin-window, pancake G-M, beta probes. Dose rates (μrad/h) were determined by comparison of the response of a Victoreen Model 440 ionization chamber survey meter to that of the G-M probes.

Borehole Logging

Borehole gamma radiation measurements were performed using a Victoreen Model 489-55 gamma scintillation probe, connected to a Ludlum Model 2200 portable scaler. The scintillation probe was shielded by a 1.25 cm thick lead shield with four 2.5 cm x 7 mm holes evenly spaced around the region of the scintillation crystal. The probe was lowered into each hole using a tripod holder with a small winch. Measurements were performed at 15-30 cm intervals in all holes. The logging data were used to identify regions of possible residues and guide the selection of subsurface soil sampling locations. Due to the varying ratios of Ra-226, U-235, U-238, Th-232, and Cs-137, there was no attempt to estimate soil radionuclide concentrations directly from the logging results.

Soil Sample Analysis

Gamma Spectrometry

Soil samples were dried, mixed, and a portion placed in a 0.5 l Marinelli beaker. The quantity placed in each beaker was chosen to reproduce the calibrated counting geometry and ranged from 600 to 800 g of soil. Net soil weights were determined and the samples counted using intrinsic germanium and Ge(Li) detectors coupled to a Nuclear Data Model ND-680 pulse height analyzer system. Background and Compton stripping, peak search, peak identification, and concentration calculations were performed using the computer capabilities inherent in the analyzer system. Energy peaks used for determination of radionuclides of concern were:

Ra-226 - 0.609 MeV from Bi-214 (corrected for equilibrium conditions)
U-235 - 0.143 MeV
U-238 - 0.094 MeV from Th-234 (secular equilibrium assumed)
Th-232 - 0.911 MeV from Ac-228 (secular equilibrium assumed)
Cs-137 - 0.662 MeV

Calibration and Quality Assurance

With the exception of the exposure and dose rate conversion factors for portable survey gamma and beta-gamma meters, all survey and laboratory instruments were calibrated with NBS-traceable standards. The calibration procedures for these portable instruments are described above.

Quality control procedures on all instruments included daily background and check-source measurements to confirm equipment performance was within acceptable statistical fluctuations. The ORAU laboratory participates in the EPA Quality Assurance Program.

APPENDIX B

SUMMARY OF RADIATION GUIDELINES APPLICABLE TO OFF-SITE PROPERTIES AT THE NIAGARA FALLS STORAGE SITE

U. S. DEPARTMENT OF ENERGY

RESIDUAL CONTAMINATION AND WASTE CONTROL CRITERIA FOR FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM (FUSRAP) AND REMOTE SURPLUS FACILITIES MANAGEMENT PROGRAM (SFMP) SITES

Presented here are the residual contamination cleanup and waste control criteria of general applicability to the FUSRAP project and remote SFMP sites[1/].

With the exception of limits for radium-226, the soil residual contamination criteria were developed on the basis of limiting maximum individual radiation exposure to DOE limits specified in DOE Order 5480.1A exclusive of exposure from natural background radiation or medical procedures. The aggregate of the contribution from all major pathways, based on scenarios for permanent intrusion, e.g., establishing residences on the site, has been assumed. In most circumstances, the probability is low that such an intrusion will occur. Also, conservative assumptions were used in deriving these criteria to ensure that a particular dose limit would not be exceeded. Use of these criteria is additionally conservative because the pathways considered in the derivation of the criteria assume all water intake and most food intake is from the site. Also, the sites often have limited agricultural capability and the contamination is generally not homogeneous. The combined effect of these factors is such that the probable radiation exposure to the average population on, or in the vicinity of, FUSRAP sites decontaminated to these criteria limits will not be appreciably different from that normally received from natural background radiation.

The residual contamination criteria for surface contamination of structures were developed from a proposed ANSI standard[2/] modified as appropriate to be consistent with DOE Order 5480.1A and the specific needs of FUSRAP for cost-effective, workable guidelines which provide an adequate safety margin. The waste control criteria are consistent with applicable DOE Orders and EPA's regulations for inactive uranium milling sites, 40 CFR 192.

1/ A remote SFMP site is one that is excess to DOE programmatic needs and is located outside a major operating DOE R&D or production area. Remote sites are more likely to be released to the public or excessed to other government agencies after decontamination than are sites located with major R&D or production areas.

2/ ANSI N13.12 (proposed) -- an adaptation to be applied, as appropriate.

A. RESIDUAL CONTAMINATION CRITERIA FOR FORMERLY UTILIZED SITES AND REMOTE SURPLUS FACILITIES MANAGEMENT PROGRAM SITES

The following criteria represent the maximum residual contamination limits for unrestricted use of land and structures contaminated with radionuclides related to the nuclear fuel cycle at FUSRAP and remote SFMP sites. It is the policy of DOE to decontaminate sites to contamination levels at or below the limits and in a manner consistent with DOE's as-low-as-is-reasonably-achievable (ALARA) policy. Residual contamination limits for other nuclides will be developed when required using the same methodology[1/] as was used for those represented here.

1. Soil (Land) Criteria (Maximum Limits for Unrestricted Use)

Radionuclide	Soil Criteria[2/,3/,4/] (pCi/g above background)
U-Natural[5/]	75
U-238[6/]	150
U-234[6/]	150
Th-230[7/]	15
Ra-226	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 and less than 1.5m below the surface.
U-235[6/]	140
Pa-231	40
Ac-227	190
Th-232	15
Am-241	20
Pu-241[8/]	800
Pu-238, 239, 240	100
Cs-137	80
Sr-90	100
H-3 (pCi/ml soil moisture)	5,200

1/ Described in ORO-831 and ORO-832.

2/ In the event of occurrence of mixtures of radionuclides, the fraction contributed by each radionuclide to its limit shall be determined, and the sum of these fractions shall not exceed 1. There are two special cases for which this rule must be modified:

(a) If Ra-226 is present, then the fraction for Ra-226 should not be included in the sum if the Ra-226 concentration is less than or equal to the Th-230 concentration. If the Ra-226 concentration exceeds the Th-230 concentration, then the sum shall be evaluated by replacing the Ra-226 concentration by the difference between the Ra-226 and Th-230 concentrations.

(b) If Ac-227 is present, then the same rule given in (a) for Ra-226 relative to Th-230 applies for Ac-227 relative to Pa-231.

3/ Except for Ra-226, these criteria 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. The same conditions prevail for Ra-226 except for soil layers beneath 1.5 m; beneath 1.5 m, the allowable Ra-226 concentration may be affected by site-specific conditions and must be evaluated accordingly.

4/ Localized concentrations in excess of these limits are allowable provided that the average over 100 m^2 is not exceeded.

5/ A curie of natural uranium means the sum of 3.7×10^{10} disintegrations per second (dis/s) from U-238 plus 3.7×10^{10} dis/s from U-234 plus 1.7×10^{5} dis/s from U-235. One curie of natural uranium is equivalent to 3,000 kilograms or 6,600 pounds of natural uranium.

6/ Assumes no other uranium isotopes are present.

7/ The Th-230 guideline is 15 pCi/g to account for ingrowth of Ra-226 as Th-230 decays. Ra-226 is a limiting radionuclide because its decay product is Rn-222 gas.

8/ The Pu-241 criterion was derived from the Am-241 concentration.

2. Structure Criteria (Maximum Limits for Unrestricted Use)

a. Indoor Radon Decay Products

A structure located on private property and intended for unrestricted use shall be subject to remedial action as necessary to ensure the annual average concentration of radon decay products is less than 0.03 WL within the structure.

b. Indoor Gamma Radiation

The indoor gamma radiation after decontamination shall not exceed 20 microroentgen per hour (20 μR/h) above background.

c. Indoor/Outdoor Structure Surface Contamination

Radionuclides	Allowable Surface Residual Contamination[1/] (dpm/100 cm^2) Total	Removable
Group 1:	100	20
Radionuclides for which the uncontrolled area concentration guide in air above background[2/] is 2×10^{-13} Ci/m^3 or less or for which the uncontrolled area concentration guide in water above background[2/] is 2×10^{-7} Ci/m^3 or less; includes Pa-231, Th-228, Th-230, Ac-227, Ra-226, Ra-228, and Pb-210.		
Group 2:	1,000	200
Radionuclides not in Group 1 for which the uncontrolled area concentration guide in air above background[2/] is 1×10^{-12} Ci/m^3 or less or for which the uncontrolled area concentration guide in water above background[2/] is 1×10^{-6} Ci/m^3 or less; includes U-232, U-238, Th-232, Ra-223, and Po-210.		
Group 3:	5,000	1,000
Those radionuclides not in Group 1 or Group 2; includes U-234, U-235, and Ra-224 and all other beta-gamma emitters.		

1/ The levels may be averaged over 1 m^2 provided the maximum activity in any area of 100 cm^2 is less than 3 times the limit value; dpm = disintegrations per minute. In the event of occurrence of mixtures of radionuclides, the fraction contributed by each radionuclide to its limit shall be determined, and the sum of these fractions shall not exceed 1.

2/ Given in Attachment 1 to Chapter XI, Table II, DOE Order 5480.1A.

B. CONTROL OF RADIOACTIVE WASTES AND RESIDUES FROM FUSRAP AND REMOTE SFMP SITES

Specified here are the control requirements (criteria) for radioactive wastes and residues related to the nuclear fuel cycle at FUSRAP and remote SFMP sites.

1. Interim Storage

All operational and control requirements specified in the following DOE Orders shall apply:

a. 5480.1A, Environmental Protection, Safety, and Health Protection Program for DOE Operations.

b. 5480.2, Hazardous and Radioactive Mixed Waste Management.

c. 5483.1, Occupational Safety and Health Program for Government-Owned Contractor-Operated Facilities.

d. 5484.1, Environmental Protection, Safety, and Health Protection Information Reporting Requirements.

e. 5484.2, Unusual Occurrence Reporting System.

f. Control and stabilization features will be designed to ensure, to the extent reasonably achievable, an effective life of 50 years, and in any case, at least 25 years.

g. Rn-222 concentrations in the atmosphere above facility surfaces or openings shall not (1) exceed 100 pCi/l at any given point, or an average concentration of 30 pCi/l for the facility site, or (2) exceed an average Rn-222 concentration at or above any location outside the facility site of 3.0 pCi/l (above background).

h. For water protection, use existing state and federal standards; apply site-specific measures where needed.

2. Long-Term Management

a. All operational requirements specified for Interim Storage Facilities (B.1) will apply.

b. Control and stabilization features will be designed to ensure to the extent reasonably achievable, an effective life of 1,000 years and, in any case, at least 200 years. Other disposal site design features shall conform with 40 CFR Part 192 performance guidelines/requirements.

c. Rn-222 emanation to the atmosphere from facility surfaces or opening shall not (1) exceed an average release rate of 20 $pCi/m^2/s$, or (2) increase the annual average Rn-222 concentration at or above any location outside the facility site by more than 0.5 pCi/l.

d. For water protection, use existing state and federal standards; apply site-specific measures where needed.

e. Prior to placement of any potentially biodegradable contaminated wastes in a Long-Term Management Facility, such wastes will be properly conditioned to (1) ensure that the generation and escape of biogenic gases will not cause the criteria in paragraph 2.c. to be exceeded, and (2) ensure that biodegradation within the facility will not result in premature structural failure not in accordance with the criteria in paragraph 2.b.. If biodegradable wastes are conditioned by incineration, incineration operations will be carried out in compliance with all applicable federal, state, and local air emission standards and requirements, including any standards for radionuclides established pursuant to 40 CFR Part 61, National Emission Standards for Hazardous Air Pollutants (NESHAPS).

C. EXCEPTIONS

1. Procedure -- Analysis of site-specific conditions.

2. Applicability -- Where health and safety would be endangered, or where cost clearly outweighs benefits.

D. CRITERIA SOURCE

Criteria	Source
Residual Contamination Criteria[1/]	
Soil Criteria	DOE Order 5480.1A, 40 CFR Part 192[2/]
Structure Criteria	40 CFR Part 192, proposed ANSI N13.12.
Control of Radioactive Wastes and Residues	
Interim Storage Long-Term Management	DOE Order 5480.1A 40 CFR Part 192

Exceptions

Procedure	40 CFR Part 192
Applicability	40 CFR Part 192

1/ The bases of the residual contamination criteria are developed in ORO-831 as supplemented and ORO-832.

2/ Based on limiting the concentration of radon-222 decay products to 0.03 WL within structures.

DETECTION SCIENCES GROUP

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FINAL REPORT

GROUND-PENETRATING RADAR SURVEY
AREA N-N' NORTH
FORMER LAKE ONTARIO ORDNANCE WORKS
LEWISTON, NEW YORK

Prepared for

OAK RIDGE ASSOCIATED UNIVERSITIES, INC.
Oak Ridge, Tennessee 37830

Purchase Order No. C-29943-008
Letter Release No. 8
Dated October 11, 1983

Report No. J165-83

October, 1983

DETECTION SCIENCES GROUP

INTRODUCTION AND SUMMARY

On October 11-14 and October 17, 1983, Detection Sciences Group performed a ground-penetrating radar survey of Property **N-N' North** at the former Lake Ontario Ordnance Works, Lewiston, New York. The survey was performed in accordance with Oak Ridge Associated Universities, Inc. Purchase Order No. C-29932-008, Letter Release No. 8, dated October 11, 1983. The survey work was conducted under the field direction and instructions of O.R.A.U. personnel.

On October 11 and 12, four grid-surveys were made in Area **N-N' North**. The first area to be surveyed ran from 10N to 72N, covering 5 meter intervals from 770E to 810E. The results of this grid survey are listed in **Table I**, and are illustrated in **Figure 1**.

The second area to be surveyed ran from 74N to 126N, covering 5 meter intervals from 870E to 890E. The results of this grid survey are listed in **Table II**, and are illustrated in **Figure 2**.

The third area to be surveyed ran from 105N to 154N, covering 5 meter intervals from 920E to 960E. The results of this grid survey are listed in **Table III**, and are illustrated in **Figure 3**.

The fourth area to be surveyed ran from 153N to 190N, covering 5 meter intervals from 1000E to 1020E. The results of this grid survey are listed in **Table IV**, and are illustrated in **Figure 4**.

With the exception of **Figure 4**, it will be noted that the radar anomalies tend to be clustered along an orientation that is parallel to the railroad tracks, and parallel to the associated access roads along the tracks. This is particularly evident in **Figures 1** and **2**. This radar evidence indicates that the former use of the site was closely linked to the existence of the railroad.

On October 13, 14 and 17, 1983, a total of 11 systematic borings were inspected on Property **N-N' North**. (This procedure has been described in detail in the **Final Report** on Property **G**, dated August, 1983, and will not be iterated here.) Potential drilling obstacles were found at 2 of the 11 locations. The proposed locations for the 11 borings and the final locations of the borings are listed in **Table V**.

The designations of the borings, N1 through N11 for the systematic borings, are designations assigned by **Detection Sciences Group** in accordance with the sequence in which the borings were inspected, and are not designations assigned by O.R.A.U.

A separate binding, titled "Radar Graphic Charts, Area N-N' North, Systematic Borings", contains all of the radar charts of borings inspected in Area **N-N' North**. The proposed location for the boring is the centerpoint of each chart, shown by a pair of vertical dashed lines. The final location of each boring is shown by the arrow at the top of each chart. The vertical scale for all of the boring inspection charts is 1 inch = 1 foot. A separate binding titled "Radar Graphic Charts, Area N-N' North, Grid Surveys" shows the vertical profiles and the anomalies along each grid line. The vertical scale of these charts is 1" = 2 feet.

TABLE I

GRID SURVEY ANOMALLIES

AREA N-N' NORTH

Chart Number	Radar Line	Location (Meters)	Depth (Cm.)	Comments
1	770E	10N to 13N	0' to 5.0'	Wet Area
		35N to 40N	0' to 5.5'	Wet Saturated Area
2	775E	32N to 41N	0' to 4.0'	Wet Area
		51.5N		Metal
		51N to 54.5N	0' to 3.0'	Wet Area
3	780E	36N to 38N	0' to 4.5'	Wet Depressed Area
4	785E	38N to 43N	3.5'	Buried Material
		48.5N to 51N	3.0'	Buried Material
5	790E	42N to 47N	3.5'	Filled Pit w/Ionic Material
6	795E	44N to 47N	3.0'	Ionic Material
		52N to 53.5N	3.5'	Buried Crushed Metal
7	800E	29N to 31N	3.0'	Ionic Material
		38N	2.5'	Pipe
		47N to 52N	2.0'	Ionic Material
8	805E	51N to 53N	3.0'	Buried Material
9	810E	35N to 38N	0' to 6'	Wet Area
		44N	2.3'	Buried Crushed Metal
		48N	2.3'	Buried Object
		53N to 56N	2.0'	Ionic Material

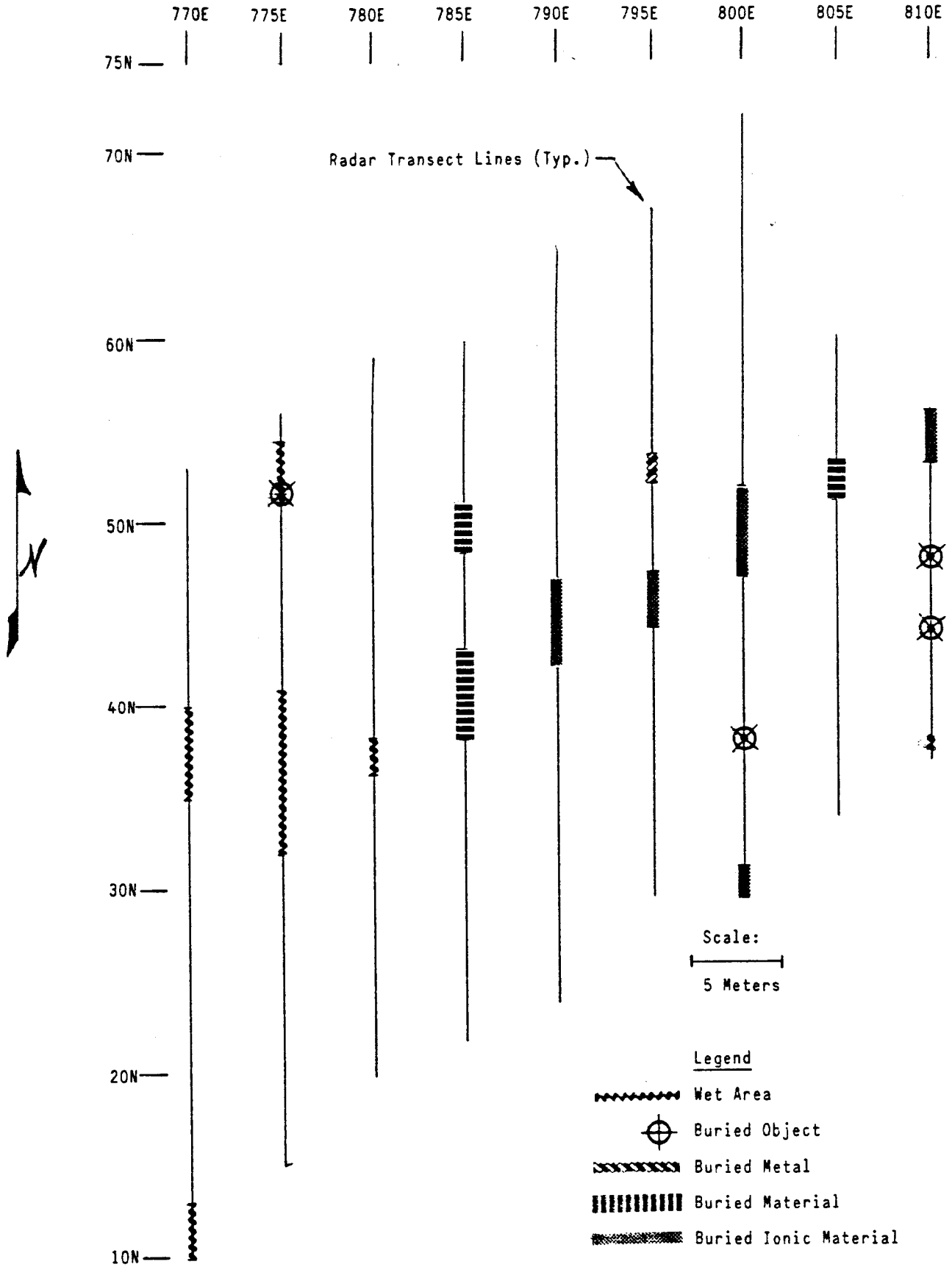

Figure 1. AREA N/N' North RADAR ANOMALIES

TABLE II

GRID SURVEY ANOMALLIES

AREA N-N' NORTH

Chart Number	Radar Line	Location (Meters)	Depth (Cm.)	Comments
10	870E	81N to 82.N	2.3'	Buried Crushed Metal
		92N	2.0'	Buried Objects
		94N	3.0'	Buried Objects
		85N to 86N	3.0'	Buried Object
11	875N	84N to 94N		Wet Saturated Area
		87N to 88N	2.5'	Buried Crushed Metal
12	880E	85N to 86N	3.5'	Crushed Metal
		89N to 90N	4.5'	Crushed Metal
		91N	3.0'	Metal Object
		93N to 100N		Wet Saturated Area
13	885E	93.5N	3.0'	Buried Object
		85.5N	3.0'	Buried Object
		83N	2.5'	Buried Object
		113N to 115N	3.5'	Crushed Metal
14	890E	99N	3.8'	Buried Object
		101.5N to 104N		Buried Material

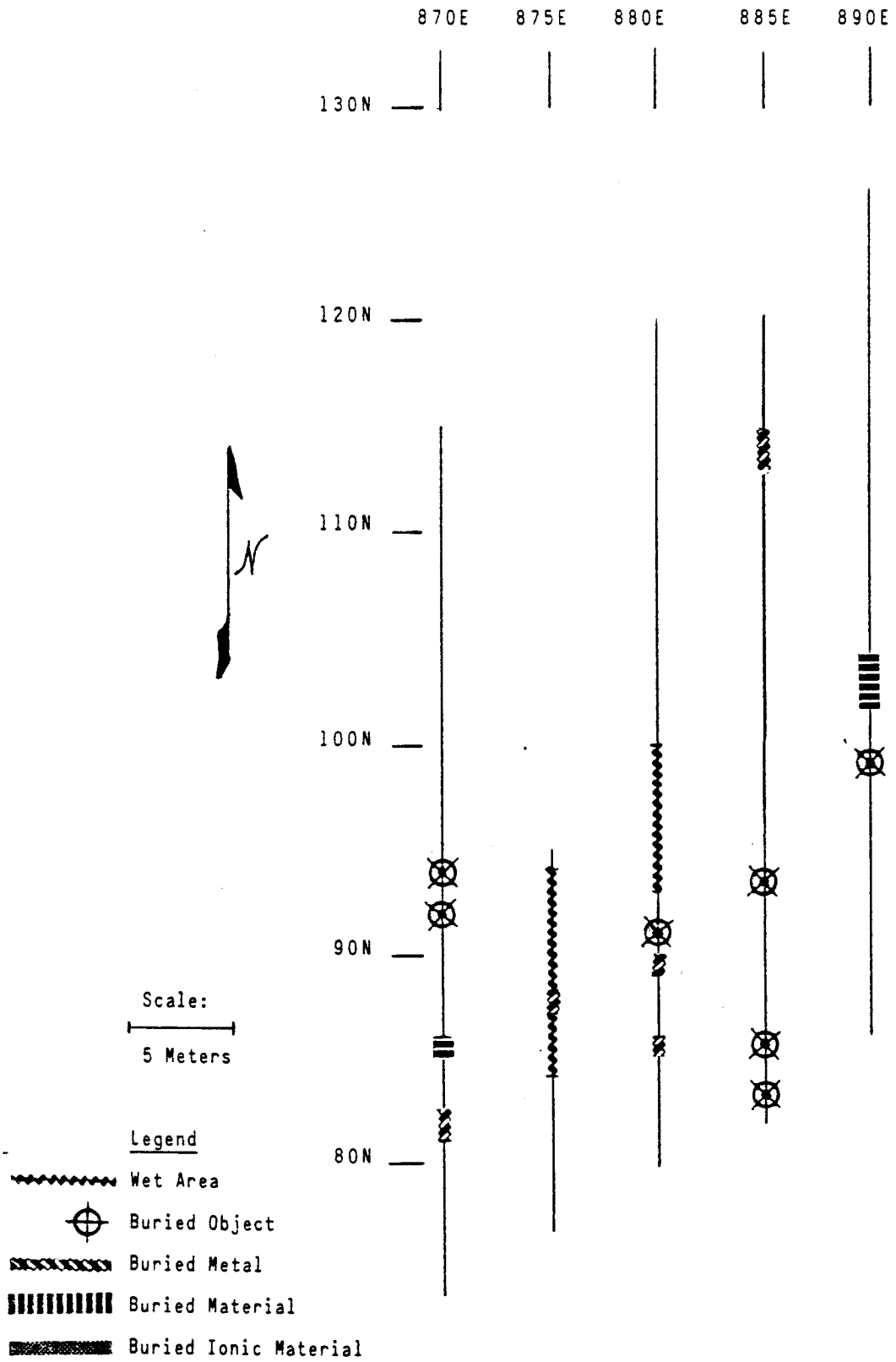

Figure 2. AREA N/N' North RADAR ANOMALIES

TABLE III

GRID SURVEY ANOMALLIES

AREA N-N' NORTH

Chart Number	Radar Line	Location (Meters)	Depth (Cm.)	Comments
15	920E	121.5N	3.7'	Pipe
		125N to 127N	2.0'	Buried Material
16	925E	121N to 122N	2.2'	Buried Material
		124N	3.0'	Buried Object
17	930E	127N to 129N	3.3'	Buried Debris
		133N to 134N	2.2'	Buried Debris
21	950E	139.5N	2.0'	Buried Object
22	955E	145N	2.5'	Buried Debris
23	960E	136N to 137N	3.5'	Buried Debris
		133N to 135N	3.0'	Ionic Material

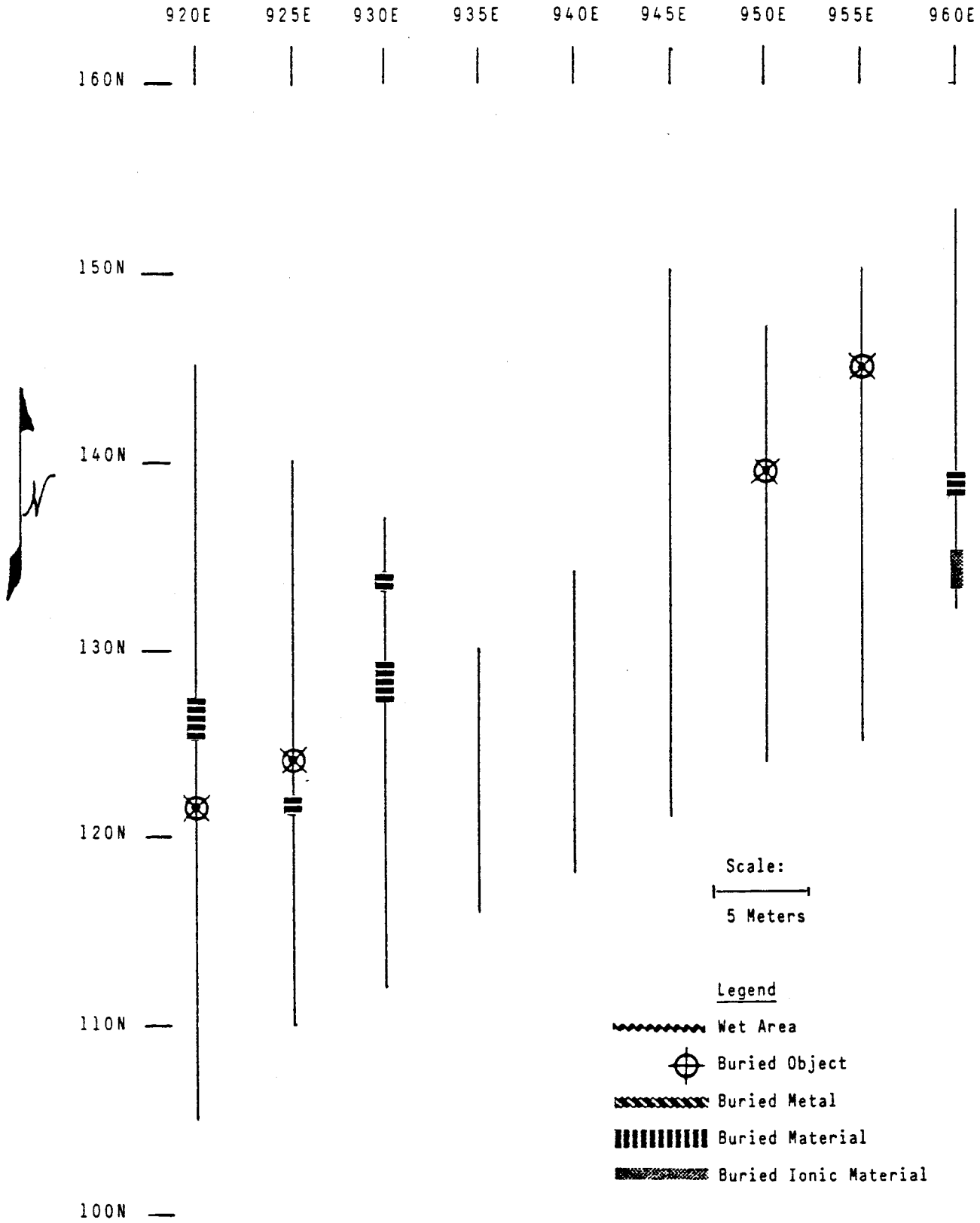

Figure 3. AREA N/N' North RADAR ANOMALIES

APPENDIX C

REPORT OF GROUND-PENETRATING RADAR SURVEY OF OFF-SITE PROPERTY N′-NORTH AT THE NIAGARA FALLS STORAGE SITE

DETECTION SCIENCES GROUP

FINAL REPORT

GROUND-PENETRATING RADAR SURVEY

AREA N-N' NORTH

FORMER LAKE ONTARIO ORDNANCE WORKS

LEWISTON, NEW YORK

TABLE IV

GRID SURVEY ANOMALLIES

AREA N-N' NORTH

Chart Number	Radar Line	Location (Meters)	Depth (Cm.)	Comments
24	1000E	164N to 167N	3.0' Ave.	Buried Material
25	1005E	161N to 162.5N	2.7'	Buried Material
26	1010E	176.5N	2.5'	Crushed Metal
		179N to 181N	1.5'	Filled Excavation

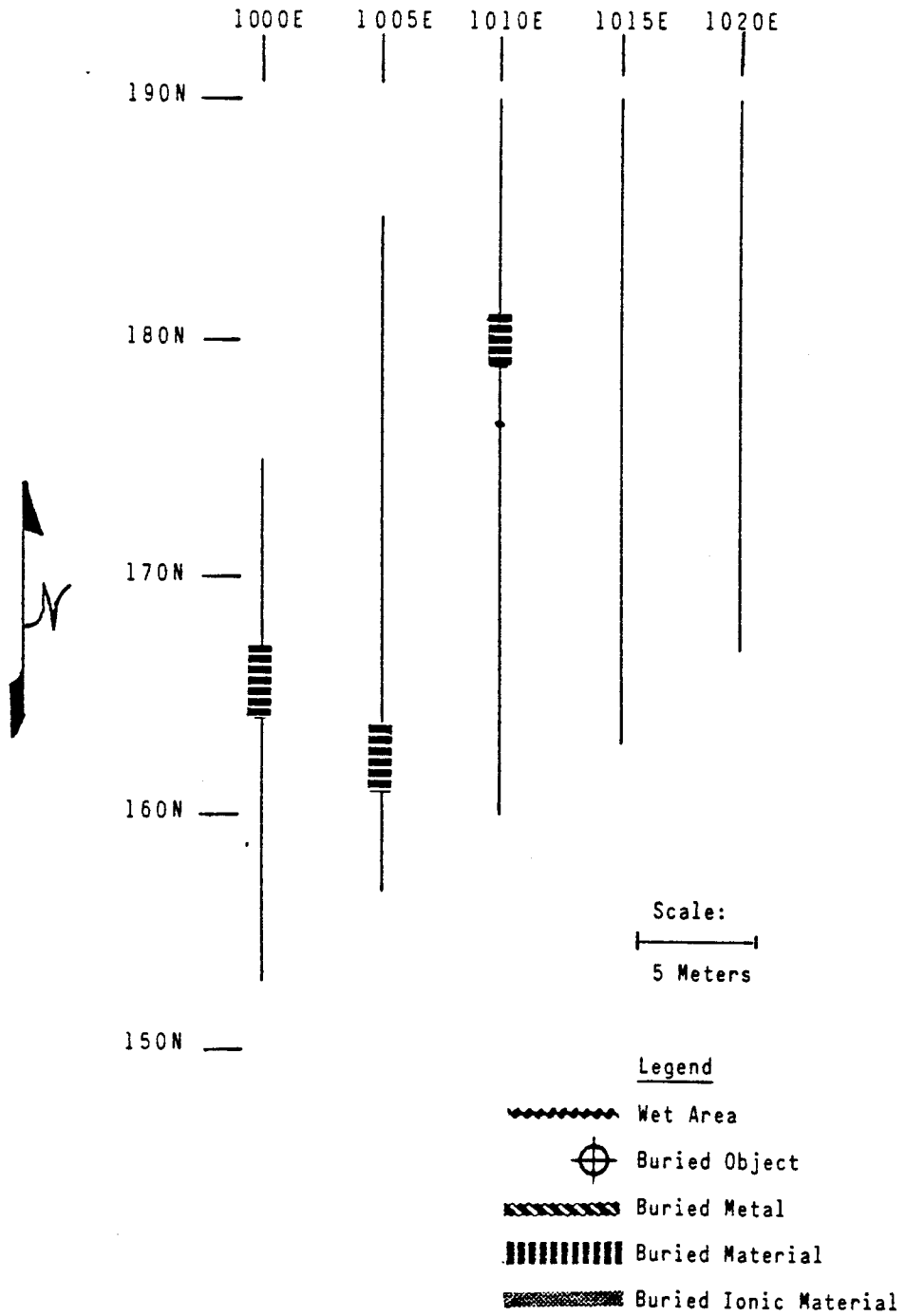

Figure 4. AREA N/N' North RADAR ANOMAL

TABLE V

BORING LOCATIONS DETERMINED BY RADAR

AREA N-N' NORTH - SYSTEMATIC BORINGS

Boring Number	Direction of Relocation	Proposed Location	Final Location
N1	-	ØN, 101E	ØN, 101E
N2	-	ØN, 480E	ØN, 480E
N3	Move 3m North	ØN, 820E	3N, 820E
N4	Move 1m East	ØN, 1300E	ØN, 1301E
N5	-	140N, 1540E	140N, 1540E
N6	-	300N, 1825E	300N, 1825E
N7	-	420N, 1000E	420N, 1000E
N8	-	180N, 1080E	180N, 1080E
N9	-	280N, 420E	280N, 420E
N10	-	334N, 1380E	334N, 1380E
N11	-	240N, 105E	240N, 105E