

COMPREHENSIVE RADILOGICAL SURVEY

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

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COMPREHENSIVE RADIOLGICAL SURVEY

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

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 uR/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 (μ R/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 ($<7 \text{ mg/cm}^2$) 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 ($\mu\text{rad/h}$) 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 $\mu\text{R/h}$ (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 $\mu\text{R}/\text{h}$ (average 11 $\mu\text{R}/\text{h}$). At surface contact, the rates ranged from 6 to 27 $\mu\text{R}/\text{h}$ (average 11 $\mu\text{R}/\text{h}$). Beta-gamma dose rates ranged from 6 to 220 $\mu\text{rad}/\text{h}$ (average 40 $\mu\text{rad}/\text{h}$). 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 $\mu\text{R}/\text{h}$ at grid location 28N, 772E. The exposure rate at 1 m above the surface at this location was 16 $\mu\text{R}/\text{h}$ and the surface dose rate was 10,000 $\mu\text{rad}/\text{h}$. The maximum surface dose rate measured was 50,000 $\mu\text{rad}/\text{h}$ 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 pCi, 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 $\mu\text{R}/\text{h}$ and the average is 11 $\mu\text{R}/\text{h}$. These levels are well below the 50 $\mu\text{R}/\text{h}$ 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.

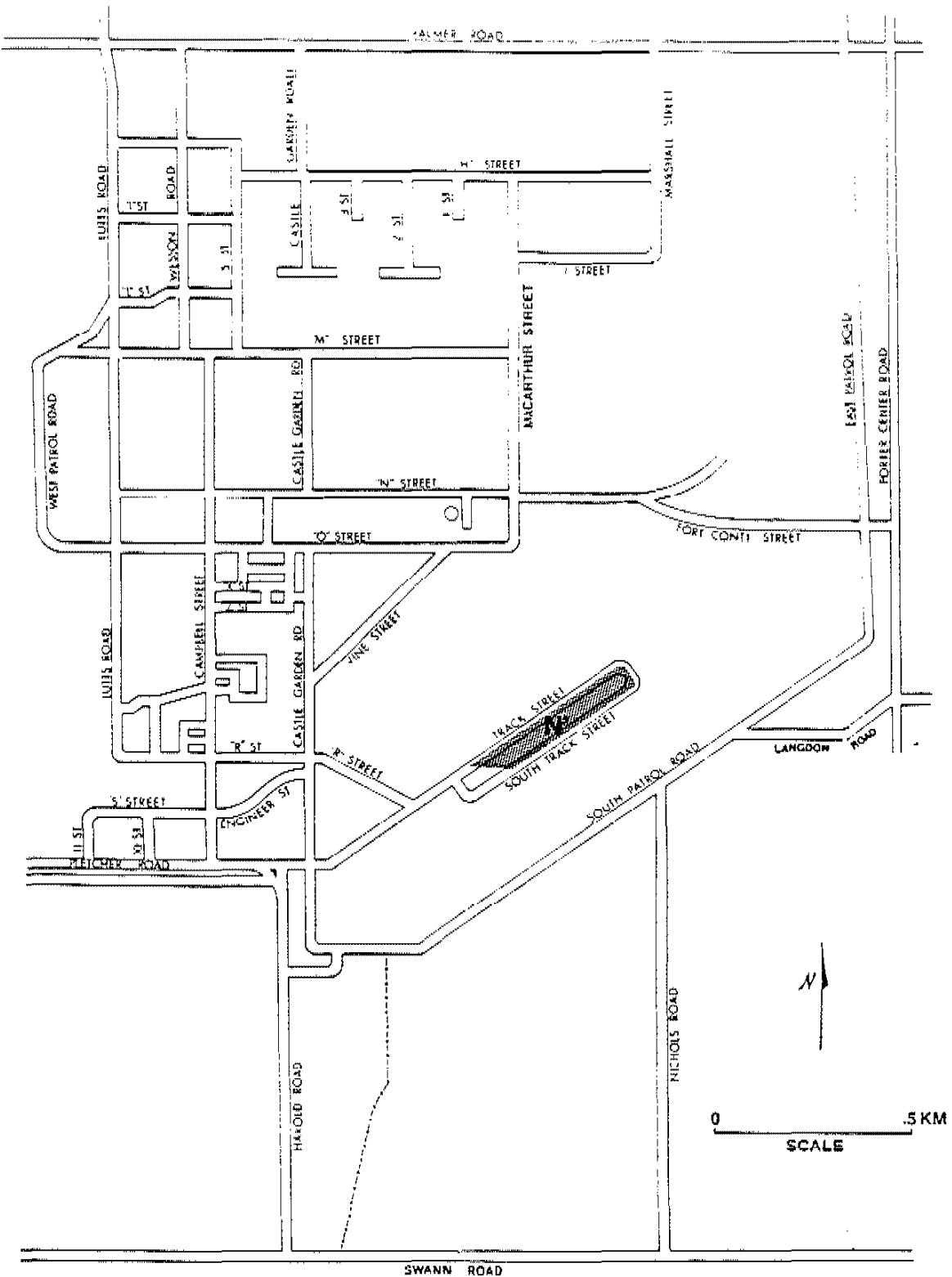


FIGURE 1. Map of Niagara Falls Storage Site and Off-Site Properties, Lewiston, New York, Indicating the Location of Off-Site Property N'-North.

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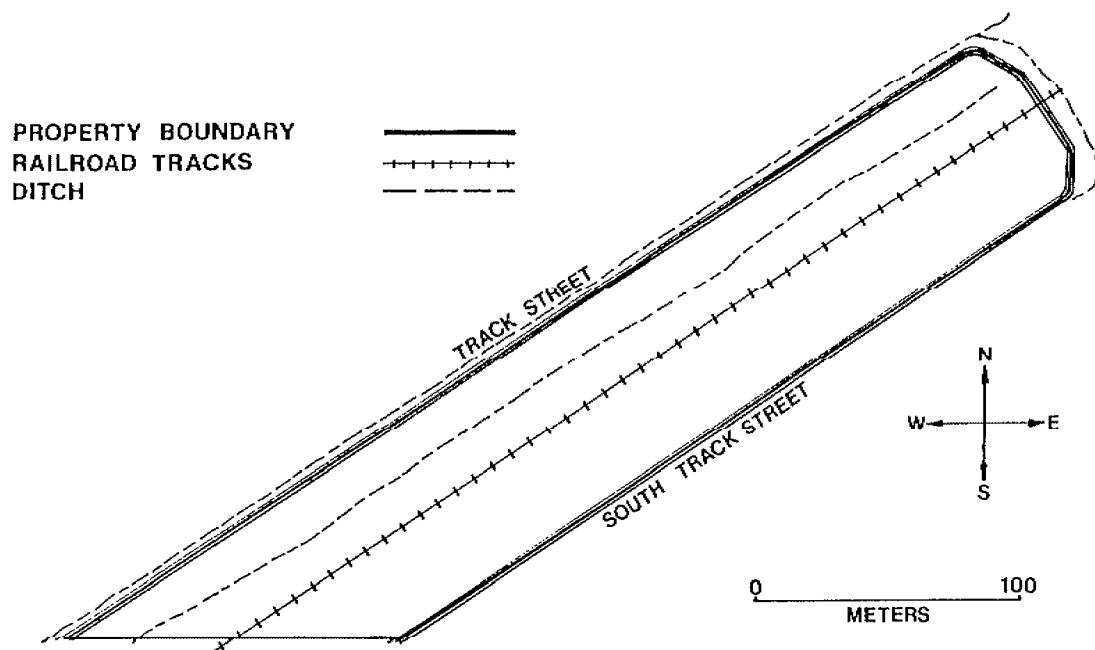


FIGURE 2. Plan View of NFSS Off-Site Property N'-North Indicating Prominent Surface Features.

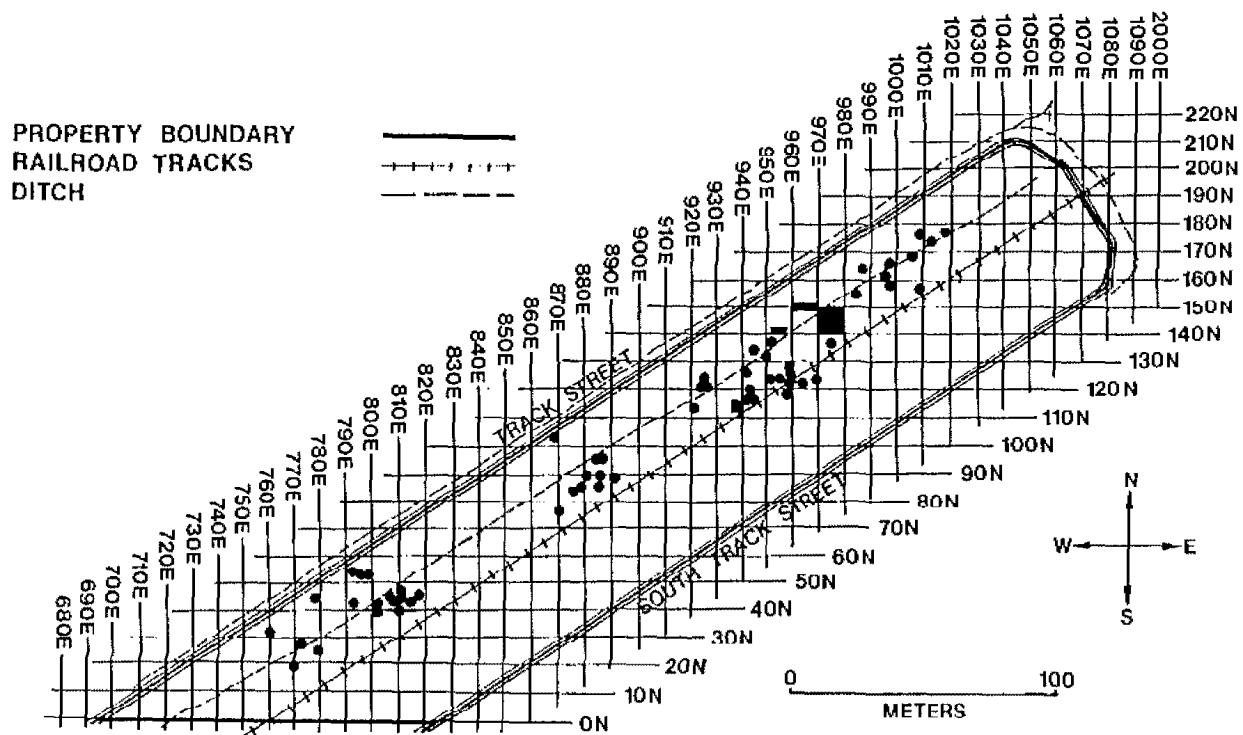


FIGURE 6. Locations of Areas of Elevated Direct Radiation.

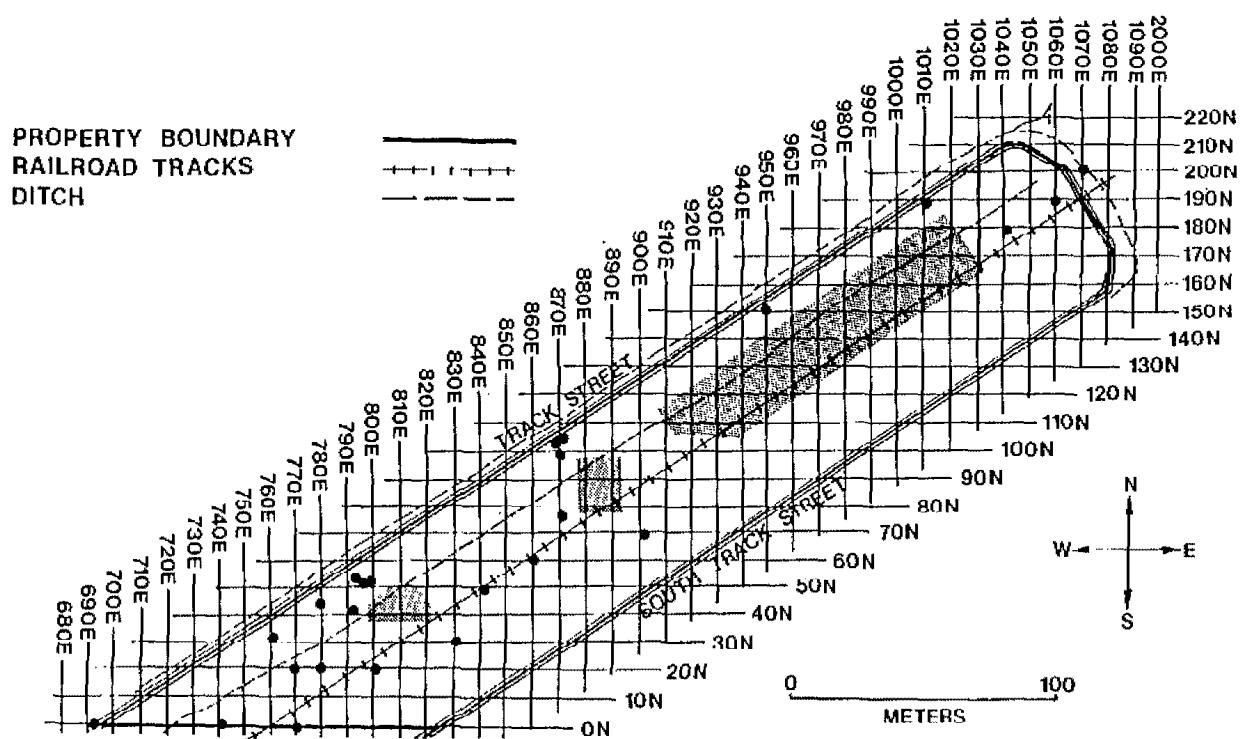


FIGURE 7. Map of NFSS Off-Site Property N'-North Indicating Areas Where Radionuclide Concentrations in Soil Exceed Guideline Levels.

TABLE 1-A
 BACKGROUND EXPOSURE RATES
 AND
 RADIONUCLIDE CONCENTRATIONS IN BASELINE SOIL SAMPLES

Location ^a	Exposure Rate ^b (μ R/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 ± 0.20	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 2 σ based on counting statistics.

TABLE I-B
RADIONUCLIDE CONCENTRATIONS IN BASELINE WATER SAMPLES

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

^a Refer to Figure 5.

^b Errors are 2 σ based on counting statistics.

TABLE 2
DIRECT RADIATION LEVELS MEASURED
AT 10 M GRID INTERVALS

<u>Grid</u>	<u>Location</u>	Gamma Exposure	Gamma Exposure	Beta-Gamma
N	E	Rates at 1 m Above the Surface ($\mu\text{R}/\text{h}$)	Rates at the Surface ($\mu\text{R}/\text{h}$)	Dose Rates at 1 cm Above the Surface ($\mu\text{rad}/\text{h}$)
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		Gamma Exposure Rates at 1 m Above the Surface (μ R/h)	Gamma Exposure Rates at the Surface (μ R/h)	Beta-Gamma Dose Rates at 1 cm Above the Surface (μ rad/h)
N	E			
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
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		Gamma Exposure Rates at 1 m Above the Surface ($\mu\text{R}/\text{h}$)	Gamma Exposure Rates at the Surface ($\mu\text{R}/\text{h}$)	Beta-Gamma Dose Rates at 1 cm Above the Surface ($\mu\text{rad}/\text{h}$)
N	E			
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		Gamma Exposure Rates at 1 m Above the Surface ($\mu\text{R/h}$)	Gamma Exposure Rates at the Surface ($\mu\text{R/h}$)	Beta-Gamma Dose Rates at 1 cm Above the Surface ($\mu\text{rad/h}$)
N	E			
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		Gamma Exposure Rates at 1 m Above the Surface ($\mu\text{R/h}$)	Gamma Exposure Rates at the Surface ($\mu\text{R/h}$)	Beta-Gamma Dose Rates at 1 cm Above the Surface ($\mu\text{rad/h}$)
N	E			
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		Gamma Exposure Rates at 1 m Above the Surface (μ R/h)	Gamma Exposure Rates at the Surface (μ R/h)	Beta-Gamma Dose Rates at 1 cm Above the Surface (μ rad/h)
N	E			
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

<u>Grid</u> <u>Location</u>	<u>Gamma Exposure</u>	<u>Gamma Exposure</u>	<u>Beta-Gamma</u>
<u>N</u> <u>E</u>	<u>Rates at 1 m Above</u> <u>the Surface</u> ($\mu\text{R}/\text{h}$)	<u>Rates at the</u> <u>Surface</u> ($\mu\text{R}/\text{h}$)	<u>Dose Rates at 1 cm</u> <u>Above the Surface</u> ($\mu\text{rad}/\text{h}$)
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 E	Gamma Exposure Rates at 1 m Above the Surface ($\mu\text{R}/\text{h}$)	Gamma Exposure Rates at the Surface ($\mu\text{R}/\text{h}$)	Beta-Gamma Dose Rates at 1 cm Above the Surface ($\mu\text{rad}/\text{h}$)
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 E	Exposure Rate ($\mu\text{R}/\text{h}$) Contact	Exposure Rate ($\mu\text{R}/\text{h}$) 1 m Above Surface	Surface Dose Rate ($\mu\text{rad}/\text{h}$)	Sample Identification ^b	Contact Exposure Rate ($\mu\text{R}/\text{h}$) After Sample Removal
20 770	56	14	160	B1	47
76 779	85	16	250	B2	18
28 772	520	16	10,000	B3	17
31 760	33	13	130	B4	27
40 801	17	17	130	B5, A&E	27
40 810	65	14	26,000	B6	17
41 802	31	---	---	---	---
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	160	B10	29
45 690	43	14	320	B11	17
46 817	27	---	---	---	---
47 810	110	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
88 860	58	20	660	B18	46
88 865	31	20	---	B19	31
90 880	130	12	12,800	B20	14
90 885	45	---	---	---	---
90 890	20	---	---	---	---
96 885	45	---	---	---	---
96 896	23	---	---	---	---
105-107	86.8-87.0	29-58	---	---	---
106	86.9	58	14	B21	50
112-116	93.6-93.9	20-66	---	---	---
115	93.8	66	17	11,500	58
115	97.1	22	10	B22	40
116-118	94.0-94.6	20-35	---	B23	40
117	94.0	35	21	340	66
119	95.9	---	---	---	---
120	92.2	66	23	240	33
120	95.9	85	22	1,420	85

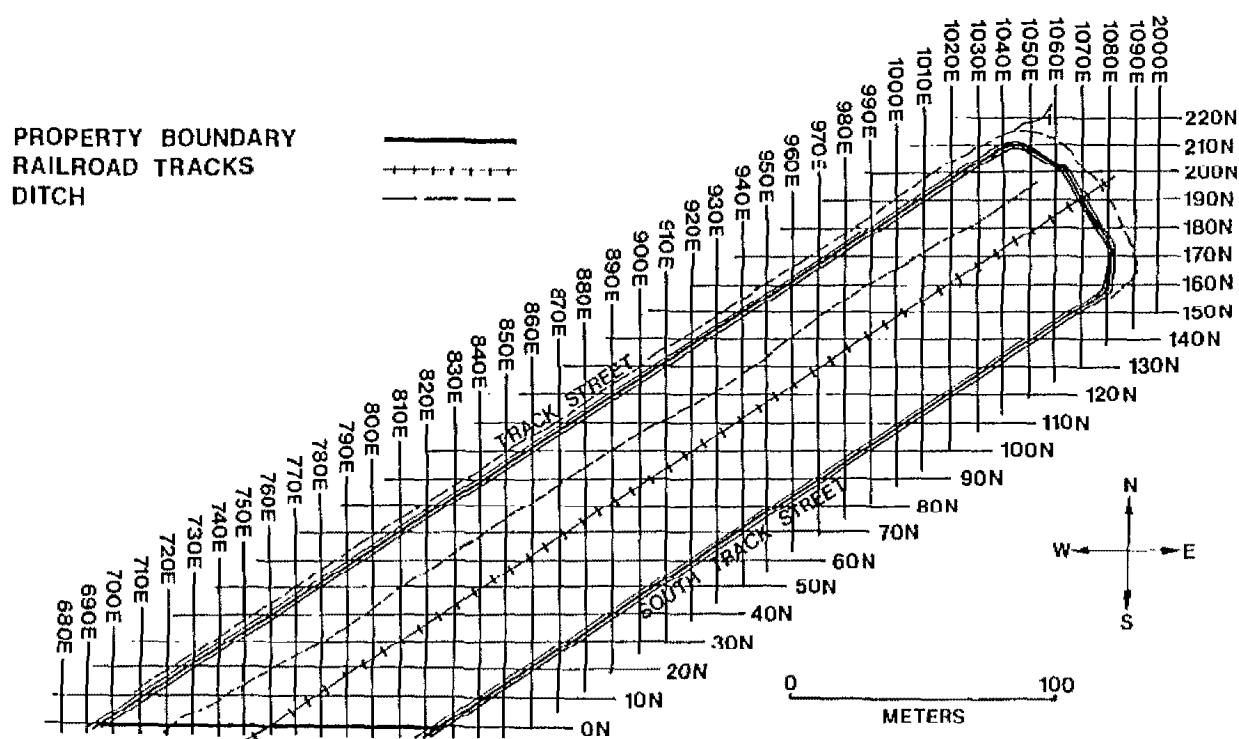


FIGURE 3. Plan View of NFSS Off-Site Property N'-North Indicating the Grid System Established for Survey Reference.

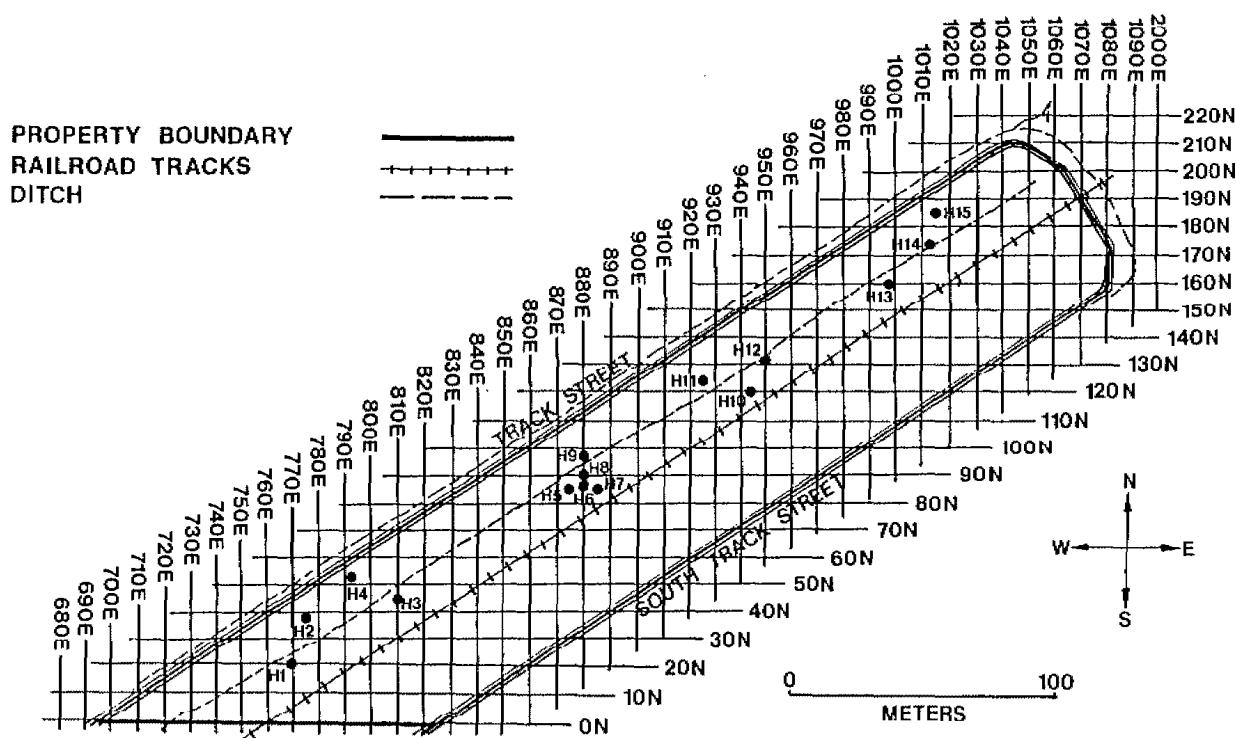


FIGURE 4. Locations of Borholes for Subsurface Investigations.

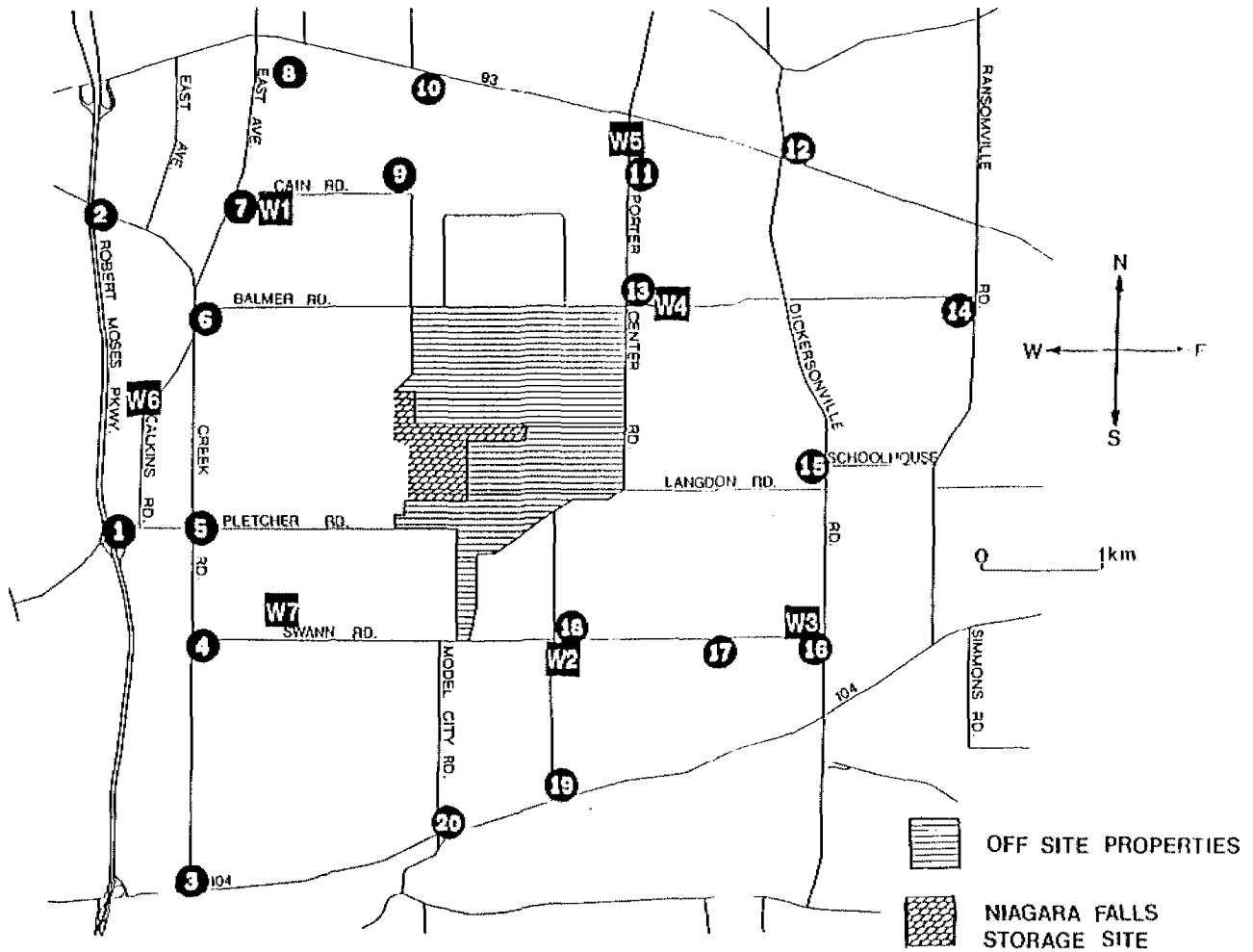


FIGURE 5. Map of Northern Niagara County, New York, Showing Locations of Background Measurements and Baseline Samples. (#1-20: soil samples and direct measurements; W1-W7: water samples.)

TABLE 3, cont.

DIRECT RADIATION LEVELS AT LOCATIONS IDENTIFIED
BY THE WALKOVER SURFACE SCAN

Grid location N E	Exposure Rate (μR/h) Contact "F" m Above Surface*	Surface Dose Rate (μrad/h)	Sample Identification	Contact Exposure Rate After Sample Removal (μR/h)
121 925	120	16	B27 ASN	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
133 945	29	---	---	---
138 975	190	27	9,490	B33 500
139 951	67	17	420	B34 27
140-150 970-980	20-29	---	---	---
141-142 932-938	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	---	---	---
166 967	20	---	---	---
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 E	Ra-226	Radionuclide Concentrations (pCi/g)			
		U-235	P-238	Cs-137	Tb-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	0.51 ± 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 ± 0.18	<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	0.70 ± 0.80	0.70 ± 0.13	1.09 ± 0.30
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	<0.30	2.78 ± 2.09	0.01 ± 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
0 840	0.99 ± 0.20	<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	1.00 ± 0.30	0.37 ± 0.66	6.41 ± 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	0.33 ± 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.

RADIOMUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES
FROM 10 M GRID INTERVALS

Grid Location	N	E	Ra-226	Radiomuclide Concentrations (pCi/g)			
				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	1.31 ± 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	0.60 ± 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	2.08 ± 1.19	49.4 ± 3.7	0.27 ± 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	4.04 ± 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	4.28 ± 1.43	0.57 ± 0.18	1.22 ± 0.69	
40	890	0.93 ± 0.26	<0.15	0.52 ± 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 N	E	Ra-226	Radionuclide Concentrations (in Ci/g)			
			U-235	U-238	Cs-137	Th-232
47	760	2.03 ± 0.40	<0.31	4.42 ± 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
59	780	2.90 ± 0.40	<0.41	<1.21	1.18 ± 0.19	0.87 ± 0.39
59	790	7.76 ± 0.35	0.58 ± 0.57	3.39 ± 0.91	3.39 ± 0.28	0.74 ± 0.46
59	800	4.80 ± 0.33	<0.55	1.01 ± 3.20	4.40 ± 0.35	1.27 ± 0.36
59	810	6.89 ± 0.63	1.69 ± 1.16	46.7 ± 3.8	1.49 ± 0.23	1.58 ± 0.60
59	820	5.11 ± 0.44	3.18 ± 0.71	56.1 ± 2.2	0.62 ± 0.11	1.03 ± 0.44
59	830	3.53 ± 0.39	0.88 ± 0.61	8.37 ± 1.60	0.45 ± 0.15	0.78 ± 0.37
59	840	7.18 ± 0.97	<0.60	4.87 ± 2.25	0.52 ± 0.34	2.05 ± 0.76
59	850	4.12 ± 0.37	0.65 ± 0.51	2.75 ± 0.82	0.76 ± 0.14	0.81 ± 0.37
59	860	4.26 ± 0.37	<0.45	8.90 ± 1.89	0.57 ± 0.12	1.67 ± 0.43
59	870	4.18 ± 0.41	<0.23	2.76 ± 0.73	0.54 ± 0.09	1.16 ± 0.44
59	880	3.00 ± 0.37	<0.38	1.51 ± 2.31	0.72 ± 0.14	1.21 ± 0.43
59	890	0.82 ± 0.31	<0.16	1.50 ± 1.08	0.71 ± 0.13	0.53 ± 0.25
59	900	1.02 ± 0.26	<0.29	<0.97	0.99 ± 0.14	1.48 ± 0.43
59	910	0.70 ± 0.19	<0.17	0.79 ± 0.56	0.59 ± 0.13	1.01 ± 0.38
60	600	2.25 ± 0.39	<0.29	3.50 ± 1.27	1.10 ± 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	1.33 ± 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	2.22 ± 1.53	0.21 ± 0.19	1.71 ± 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	1.77 ± 1.91	0.62 ± 0.13	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 ± 0.21	<0.10	1.29 ± 1.34	0.81 ± 0.36	1.01 ± 0.49
60	910	2.60 ± 0.44	<0.28	1.78 ± 2.34	0.79 ± 0.14	0.86 ± 0.33
59	920	0.86 ± 0.20	<0.18	0.67 ± 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
72	810	1.60 ± 0.29	<0.17	1.21 ± 0.54	0.37 ± 0.08	0.72 ± 0.28
72	820	0.92 ± 0.34	<0.41	7.62 ± 2.38	0.93 ± 0.16	0.80 ± 0.54
72	830	0.89 ± 0.21	<0.15	1.41 ± 0.81	0.15 ± 0.08	0.66 ± 0.25
72	840	1.53 ± 0.31	<0.39	<1.11	0.38 ± 0.12	<0.32
72	850	2.96 ± 0.37	0.26 ± 0.44	1.98 ± 0.72	0.64 ± 0.14	1.04 ± 0.36
72	860	5.58 ± 0.42	0.64 ± 0.66	14.0 ± 1.8	0.34 ± 0.13	0.93 ± 0.39
72	870	4.08 ± 0.93	<0.53	4.57 ± 3.43	<0.14	1.81 ± 0.82

TABLE 4, cont.

**RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES
FROM 10 M GRID INTERVALS**

Grid Location	N	E	Radionuclide Concentrations (pCi/g)			
			Ra-226	U-235	U-238	Cs-137
70	830	2.65 ± 0.35	<0.22	2.17 ± 0.79	0.71 ± 0.15	0.99 ± 0.38
70	840	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	0.99 ± 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
80	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	0.31 ± 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	4.36 ± 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 ± 0.67	<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	0.63 ± 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	0.02 ± 0.29	<0.19	<0.62	0.46 ± 0.10	0.08 ± 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	0.79 ± 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
90	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	0.53 ± 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	1.99 ± 0.33	0.38 ± 0.63	1.95 ± 1.09	0.71 ± 0.23	2.02 ± 0.52
90	980	0.65 ± 0.20	<0.13	0.47 ± 0.68	0.54 ± 0.09	0.72 ± 0.21

TABLE 4, cont.

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES
FROM 10 M GRID INTERVALS

Grid Location N E	Ra-226	Radionuclide Concentrations ($\mu\text{Ci}/\text{kg}$)			
		U-235	U-238	Cs-137	Th-232
100 820	1.56 \pm 0.31	<0.43	1.65 \pm 1.26	1.77 \pm 0.22	0.91 \pm 0.36
97 840	0.89 \pm 0.23	<0.15	0.87 \pm 0.48	0.44 \pm 0.10	0.84 \pm 0.32
103 850	1.02 \pm 0.25	<0.22	2.06 \pm 1.90	0.53 \pm 0.12	0.87 \pm 0.32
100 860	1.28 \pm 0.34	<0.31	2.08 \pm 1.59	0.69 \pm 0.18	1.01 \pm 0.41
100 870	6.40 \pm 0.51	<0.48	<1.49	1.70 \pm 0.18	<0.22
100 880	0.85 \pm 0.24	<0.16	1.28 \pm 0.51	0.11 \pm 0.09	0.66 \pm 0.43
100 890	2.61 \pm 0.50	<0.31	3.30 \pm 2.38	0.72 \pm 0.14	0.84 \pm 0.40
100 900	3.45 \pm 0.41	<0.31	4.18 \pm 1.37	0.34 \pm 0.14	1.20 \pm 0.31
100 910	3.12 \pm 0.39	0.44 \pm 0.39	4.67 \pm 1.96	0.27 \pm 0.11	1.87 \pm 0.74
100 920	5.25 \pm 1.10	<0.63	7.63 \pm 4.21	0.49 \pm 0.32	1.23 \pm 0.71
100 930	2.60 \pm 0.33	<0.22	0.92 \pm 1.11	0.55 \pm 0.13	0.93 \pm 0.31
100 940	4.09 \pm 0.58	<0.33	3.73 \pm 1.32	1.12 \pm 0.17	1.60 \pm 0.48
100 950	3.64 \pm 0.48	<0.24	1.99 \pm 0.79	0.56 \pm 0.11	0.81 \pm 0.39
100 960	1.11 \pm 0.34	<0.38	3.20 \pm 1.16	1.06 \pm 0.22	1.18 \pm 0.49
100 970	1.11 \pm 0.30	<0.19	0.92 \pm 0.67	0.68 \pm 0.14	0.86 \pm 0.36
100 980	1.13 \pm 0.35	<0.39	<1.15	0.99 \pm 0.17	1.58 \pm 0.50
100 990	0.64 \pm 0.23	<0.15	0.65 \pm 0.45	0.93 \pm 0.14	0.48 \pm 0.26
105 1000	1.17 \pm 0.40	<0.30	<1.03	0.93 \pm 0.20	1.14 \pm 0.47
110 860	1.36 \pm 0.50	<0.38	1.34 \pm 2.31	0.57 \pm 0.13	1.44 \pm 0.49
110 880	1.03 \pm 0.27	<0.13	0.76 \pm 0.66	0.56 \pm 0.11	0.25 \pm 0.20
110 890	1.39 \pm 0.36	<0.28	1.62 \pm 1.50	0.61 \pm 0.16	1.46 \pm 0.57
110 900	1.74 \pm 0.35	0.57 \pm 0.75	4.72 \pm 3.23	0.63 \pm 0.14	1.01 \pm 0.33
110 910	14.3 \pm 0.8	3.50 \pm 1.31	35.1 \pm 3.2	0.84 \pm 0.14	1.43 \pm 0.63
110 920	6.32 \pm 0.54	1.11 \pm 1.04	11.2 \pm 4.0	0.14 \pm 0.07	2.06 \pm 0.58
110 930	9.16 \pm 1.05	1.39 \pm 1.54	3.67 \pm 4.35	0.15 \pm 0.22	2.00 \pm 0.78
110 940	3.17 \pm 0.92	<0.58	4.70 \pm 1.47	0.36 \pm 0.20	0.83 \pm 0.73
110 950	4.39 \pm 0.45	<0.25	3.15 \pm 0.79	0.71 \pm 0.14	1.01 \pm 0.36
110 960	2.89 \pm 0.65	<0.43	2.52 \pm 4.44	0.28 \pm 0.13	1.10 \pm 0.66
110 970	1.17 \pm 0.37	<0.19	1.43 \pm 1.07	0.17 \pm 0.06	1.22 \pm 0.69
110 980	1.20 \pm 0.39	<0.29	1.41 \pm 1.99	0.41 \pm 0.17	1.20 \pm 0.46
110 990	1.39 \pm 0.36	<0.28	1.62 \pm 1.50	0.61 \pm 0.16	1.46 \pm 0.57
110 1000	0.27 \pm 0.13	<0.10	0.49 \pm 0.47	0.56 \pm 0.10	0.24 \pm 0.15
110 1010	1.04 \pm 0.43	0.28 \pm 0.96	<0.94	0.66 \pm 0.15	0.82 \pm 0.43
120 880	0.92 \pm 0.25	<0.27	<0.79	0.70 \pm 0.14	0.88 \pm 0.46
120 890	1.35 \pm 0.33	<0.31	<1.04	0.79 \pm 0.13	1.22 \pm 0.34
120 900	0.94 \pm 0.29	<0.21	1.36 \pm 1.40	0.89 \pm 0.15	0.83 \pm 0.61
120 910	1.21 \pm 0.28	0.79 \pm 0.76	7.25 \pm 1.92	0.31 \pm 0.09	0.78 \pm 0.55

TABLE 4, cont.

**RADIOMUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES
FROM 10 M GRID INTERVALS**

Grid Location N E	Ra-226	Radiomuclide Concentrations (pCi/g)			
		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	0.86 ± 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 ± 0.13	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 ± 0.32	<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	0.96 ± 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	0.88 ± 0.54
130 940	1.90 ± 0.37	<0.39	9.64 ± 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 ± 3.03	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 N E	Ra-226	Radionuclide Concentrations (pCi/g)			
		U-235	U-238	Ce-137	Th-232
140 980	10.3 ± 1.3	<0.73	3.79 ± 3.77	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	6.10 ± 0.82	1.12 ± 0.14	0.68 ± 0.37
150 950	9.04 ± 0.85	1.05 ± 1.01	16.0 ± 2.1	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	7.92 ± 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	6.38 ± 0.69	<0.39	1.55 ± 2.67	<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	0.63 ± 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 N	E	Ra-226	Radionuclide Concentrations (pCi/g)			
			U-235	B-238	Cs-137	Tl-205
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	
170 950	1.37 ± 0.25	0.52 ± 0.13	7.70 ± 1.37	0.71 ± 0.11	0.85 ± 0.23	
170 960	5.32 ± 0.46	<0.22	<0.48	0.54 ± 0.09	0.62 ± 0.35	
170 970	1.86 ± 0.29	<0.26	<0.79	0.74 ± 0.14	0.94 ± 0.36	
170 980	1.30 ± 0.25	<0.30	1.92 ± 1.00	0.26 ± 0.09	1.02 ± 0.27	
170 990	1.76 ± 0.27	<0.17	1.08 ± 1.20	0.42 ± 0.09	0.83 ± 0.30	
170 1000	3.52 ± 0.50	<0.31	3.53 ± 2.85	<0.06	0.60 ± 0.32	
170 1010	3.92 ± 0.40	0.55 ± 0.62	4.90 ± 1.37	0.08 ± 0.05	0.80 ± 0.26	
170 1020	5.35 ± 0.78	<0.52	3.48 ± 3.36	0.17 ± 0.21	1.24 ± 0.94	
170 1030	1.18 ± 0.30	<0.16	0.76 ± 0.51	0.81 ± 0.12	0.60 ± 0.31	
170 1040	1.24 ± 0.31	<0.25	2.72 ± 1.65	0.62 ± 0.12	0.89 ± 0.33	
170 1050	0.92 ± 0.31	<0.25	1.24 ± 1.62	0.27 ± 0.12	0.74 ± 0.43	
170 1060	1.10 ± 0.30	<0.28	1.26 ± 1.59	0.38 ± 0.11	1.16 ± 0.38	
170 1070	0.69 ± 0.30	<0.13	0.49 ± 0.98	0.95 ± 0.14	0.56 ± 0.25	
170 1080	0.93 ± 0.21	<0.22	0.89 ± 1.56	0.51 ± 0.12	1.32 ± 0.37	
180 950	2.08 ± 0.34	<0.29	<0.83	0.85 ± 0.12	0.43 ± 0.31	
180 960	1.78 ± 0.35	<0.18	2.34 ± 0.96	0.67 ± 0.11	1.20 ± 0.36	
180 970	1.99 ± 0.36	<0.27	<0.78	0.41 ± 0.17	0.36 ± 0.23	
180 980	1.49 ± 0.29	<0.31	1.47 ± 1.65	0.44 ± 0.12	0.90 ± 0.47	
180 990	1.60 ± 0.32	0.48 ± 0.66	6.98 ± 0.979	0.08 ± 0.06	1.05 ± 0.33	
180 1000	3.18 ± 0.45	1.04 ± 0.84	11.0 ± 3.2	0.38 ± 0.15	1.36 ± 0.50	
180 1010	6.91 ± 0.80	<0.52	4.35 ± 3.70	<0.09	1.61 ± 0.65	
180 1020	3.55 ± 0.70	<0.38	1.89 ± 5.51	<0.06	1.22 ± 0.62	
180 1030	1.38 ± 0.33	<0.37	0.50 ± 1.24	0.50 ± 0.13	1.47 ± 0.42	
180 1040	1.56 ± 0.31	<0.20	1.58 ± 1.05	0.52 ± 0.13	0.84 ± 0.38	
180 1050	0.92 ± 0.25	<0.22	0.83 ± 2.64	<0.05	0.84 ± 0.38	
180 1060	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	0.67 ± 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 ± 0.41	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 N	E	Ra-226	Radionuclide Concentrations ($\mu\text{Ci/g}$)			
			U-235	U-238	Cs-137	Th-232
190 1080		1.06 \pm 0.37	<0.37	1.14 \pm 1.88	0.56 \pm 0.15	1.67 \pm 0.43
195 1000		2.00 \pm 0.37	0.43 \pm 0.70	2.35 \pm 1.99	0.60 \pm 0.14	1.30 \pm 0.45
200 1010		1.03 \pm 0.29	<0.24	<0.75	0.52 \pm 0.14	0.39 \pm 0.21
200 1020		1.45 \pm 0.34	<0.25	1.89 \pm 1.56	0.74 \pm 0.14	0.78 \pm 0.30
200 1030		1.32 \pm 0.26	<0.30	3.91 \pm 1.37	0.44 \pm 0.15	1.38 \pm 0.45
200 1040		1.22 \pm 0.24	<0.17	1.11 \pm 0.63	0.43 \pm 0.11	1.24 \pm 0.43
200 1050		2.06 \pm 0.52	0.84 \pm 0.62	2.73 \pm 3.77	0.75 \pm 0.16	0.89 \pm 0.59
200 1060		1.34 \pm 0.27	<0.22	<0.80	0.25 \pm 0.12	1.13 \pm 0.46
200 1070		27.5 \pm 1.1	<0.88	<2.49	0.91 \pm 0.16	1.65 \pm 1.50
205 1020		0.82 \pm 0.28	<0.17	1.29 \pm 1.27	0.55 \pm 0.12	0.42 \pm 0.31
210 1030		1.01 \pm 0.25	<0.30	2.70 \pm 1.09	0.57 \pm 0.13	1.12 \pm 0.40
210 1040		0.80 \pm 0.21	<0.14	0.31 \pm 0.75	1.52 \pm 0.17	<0.13
210 1050		0.93 \pm 0.28	<0.22	1.37 \pm 1.79	0.45 \pm 0.10	0.93 \pm 0.33
210 1060		0.89 \pm 0.28	<0.28	1.37 \pm 1.80	0.85 \pm 0.18	1.05 \pm 0.56
210 1070		1.30 \pm 0.29	<0.39	<1.21	1.20 \pm 0.19	1.11 \pm 0.70

^a Errors are 2 σ 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 E	Ra-226	Radionuclide Concentrations (pCi/g) ^a					
				U-238	U-238b	Cs-137b	Th-232b		
B1	White Chip	20 770	c	c	c	c	c	c	c
B2	White Chip	26 779	c	c	c	c	c	c	c
B3	White Chip	28 772	c	c	c	c	c	c	c
B4	Soil	31 760	6.45 ± 0.86d	2.57 ± 2.12	16.3 ± 5.8	160 ± 2	0.67 ± 0.33	<2.32	
B5A	Soil	40 801	950 ± 9	6.89 ± 8.33	<10.3	<0.64			
B5B	White Chip	40 801	c	c	c	c	c	c	c
B6	White Chip	40 810	c	c	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	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	c	c
B14	Soil	54 793	85.9 ± 2.0	22.5 ± 3.2	<6.51	2.01 ± 0.27	1.36 ± 1.38		
B15	Rock	78 870	7.50 ± 0.73	<0.43	7.47 ± 1.77	0.33 ± 0.16	1.19 ± 0.14		
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	c	c
B20	White Chip	90 880	c	c	c	c	c	c	c
B21	Soil	106 869	85.0 ± 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	124 933	73.0 ± 2.5	310 ± 7	9430 ± 35	<0.44	<1.19		
B30	White Chip	127 941	c	c	c	c	c	c	c
B31	Soil	128 959	1.07 ± 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	136 975	1100 ± 10	13.0 ± 9.0	96.5 ± 22.3	<0.60	<2.66		
B34	Soil	139 951	910 ± 8	9.67 ± 8.18	<10.7	<0.51	<2.08		
B35	Rocks	148 967	47.4 ± 1.7	1.42 ± 1.87	<7.45	<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	0.00 ± 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 ± 1.81		

^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	<u>Grid Location</u>		Nature of Sample	Ra-226 (μ Ci)
	N	E		
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.	Grid Location N E	Depth (m)	Ra-226	Radionuclide Concentrations.(ppi/g)			
				U-235	U-238	Ce-137	Tl-232
B1	20 770	Surface	97.1 ± 2.6b	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
B2	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 ± 0.09	<0.04	0.73 ± 0.41
B3	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 ± 2.62	<0.06	1.60 ± 0.59
		1	1.12 ± 0.30	<0.30	2.44 ± 2.20	<0.05	1.40 ± 0.57
B4	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 ± 2.63	0.09 ± 0.10	1.50 ± 0.56
B5	85 875	Surface	650 ± 6	<0.31	<1.63	<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
B6	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
B7	86 865	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
B8	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 ± 0.19
B9	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 ± 0.68	<0.02	0.64 ± 0.17
B10	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	0.97 ± 0.55
B11	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 N	Location E	Depth (m)	Ra-226	Radionuclide Concentrations (pCi/g)			
					U-235	U-238	Cs-137	Tl-232
B12	132	950	Surface	4290 \pm 21	93.8 \pm 17.3	<76.6	<1.83	<6.48
			0.5	1.19 \pm 0.27	<0.16	0.94 \pm 1.17	<0.03	1.09 \pm 0.40
			1	1.79 \pm 0.38	<0.24	1.74 \pm 0.99	<0.05	0.81 \pm 0.46
B13	160	998	Surface	130 \pm 3	4.65 \pm 2.85	<3.59	0.22 \pm 0.20	1.76 \pm 1.37
			0.5	1.21 \pm 0.26	<0.30	3.02 \pm 1.18	<0.04	0.89 \pm 0.28
			1	0.84 \pm 0.26	0.24 \pm 0.36	<0.49	<0.03	0.61 \pm 0.40
B14	176	1012	Surface	70.2 \pm 2.4	<1.18	<3.03	1.06 \pm 0.27	1.18 \pm 1.08
			0.5	1.22 \pm 0.30	0.59 \pm 0.54	1.48 \pm 2.02	<0.04	1.13 \pm 0.54
			1	1.05 \pm 0.26	<0.38	2.71 \pm 1.74	<0.05	1.39 \pm 0.52
B15	183	1015	Surface	1.74 \pm 0.33	<0.19	1.80 \pm 0.69	0.39 \pm 0.10	0.95 \pm 0.35
			0.5	<0.20	<0.18	1.34 \pm 2.20	<0.04	0.88 \pm 0.36
			2	1.29 \pm 0.29	<0.32	1.74 \pm 2.00	<0.05	1.44 \pm 0.54

a Refer to Figure 4.

b Errors are 2 σ 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			Remarks
		Area (m ²)	Avg. Depth (m)	Volume (m ³)	
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 86.8-87.0E	Ra-226	4	0.15	0.6	
ON 689E	Ra-226	---	---	---	
ON 740E	Ra-226	---	---	---	
ON 771E	Ra-226	---	---	---	
20N 770E	Ra-226	---	---	---	
20N 780E	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 86.0E	Ra-226	---	---	---	
70N 90.0E	Ra-226	---	---	---	
7.8N 87.0E	Ra-226	---	---	---	
100N 87.0E	Ra-226	---	---	---	
150N 95.0E	Ra-226	---	---	---	
180N 104.0E	Ra-226	---	---	---	
190N 101.0E	Ra-226	---	---	---	
190N 106.0E	Ra-226	---	---	---	
200N 107.0E	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 ($\mu\text{R/h}$) 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 ($\mu\text{rad/h}$) 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 methodology¹, as was used for those represented here.

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

<u>Radionuclide</u>	<u>Soil Criteria^{2/,3/,4/} (pCi/g above background)</u>
U-Natural ^{5/}	75
U-238 ^{5/}	150
U-234 ^{5/}	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 ^{8/}	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 m² 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 m² 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 1.7×10^3 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 ($20 \mu\text{R}/\text{h}$) above background.

c. Indoor/Outdoor Structure Surface Contamination

<u>Radionuclides</u>	<u>Allowable Surface Residual Contamination^{1/} (dpm/100 cm²)</u>
<u>Total</u>	<u>Removable</u>
<u>Group 1:</u>	100 20
Radionuclides for which the uncontrolled area concentration guide in air above background ^{2/} is 2×10^{-15} Ci/m ³ or less or for which the uncontrolled area concentration guide in water above background ^{2/} is 2×10^{-6} Ci/m ³ or less; includes Pa-231, Th-228, Th-230, Ac-227, Ra-226, Ra-228, and Pb-210.	
<u>Group 2:</u>	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.	
<u>Group 3:</u>	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 m² provided the maximum activity in any area of 100 cm² 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.

E. 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 openings shall not (1) exceed an average release rate of 20 pCi/m²/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

<u>Criteria</u>	<u>Source</u>
<u>Residual Contamination Criteria</u> ^{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	DOE Order 5480.1A
Long-Term Management	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.

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 \circ NORTH
FORMER LAKE ONTARIO ORDNANCE WORKS
LEWISTON, NEW YORK

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
DAK 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, NI 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.

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TABLE I
GRID SURVEY ANOMALIES
AREA N-N' NORTH

<u>Chart Number</u>	<u>Radar Line</u>	<u>Location (Meters)</u>	<u>Depth (Cm.)</u>	<u>Comments</u>
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
3	780E	36N to 38N	0' to 4.5'	Wet Depressed Area
		38N to 43N	3.5'	Buried Material
4	785E	48.5N to 51N	3.0'	Buried Material
		42N to 47N	3.5'	Filled Pit w/Ionic Material
5	790E	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
8	805E	47N to 52N	2.0'	Ionic Material
		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

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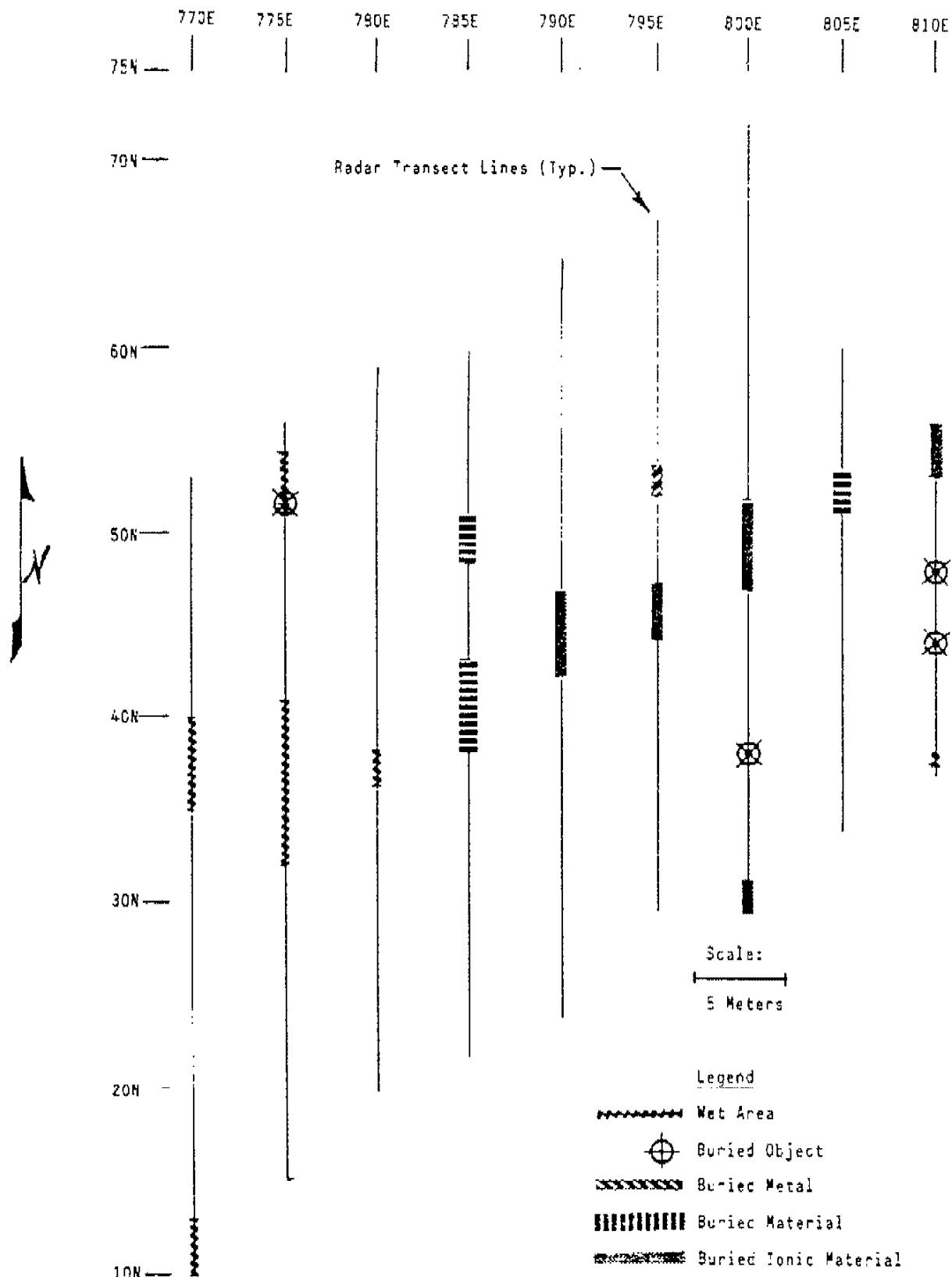


Figure 1. AREA N/N' North RADAR ANOMALIES

DETECTION SCIENCES GROUP

TABLE II
GRID SURVEY ANOMALIES
AREA N-N' NORTH

<u>Chart Number</u>	<u>Radar Line</u>	<u>Location (Meters)</u>	<u>Depth (Cm.)</u>	<u>Comments</u>
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
		93.5N	3.0'	Buried Object
13	885E	85.5N	3.0'	Buried Object
		83N	2.5'	Buried Object
		113N to 115N	3.5'	Crushed Metal
		99N	3.8'	Buried Object
14	890E	101.5N to 104N		Buried Material

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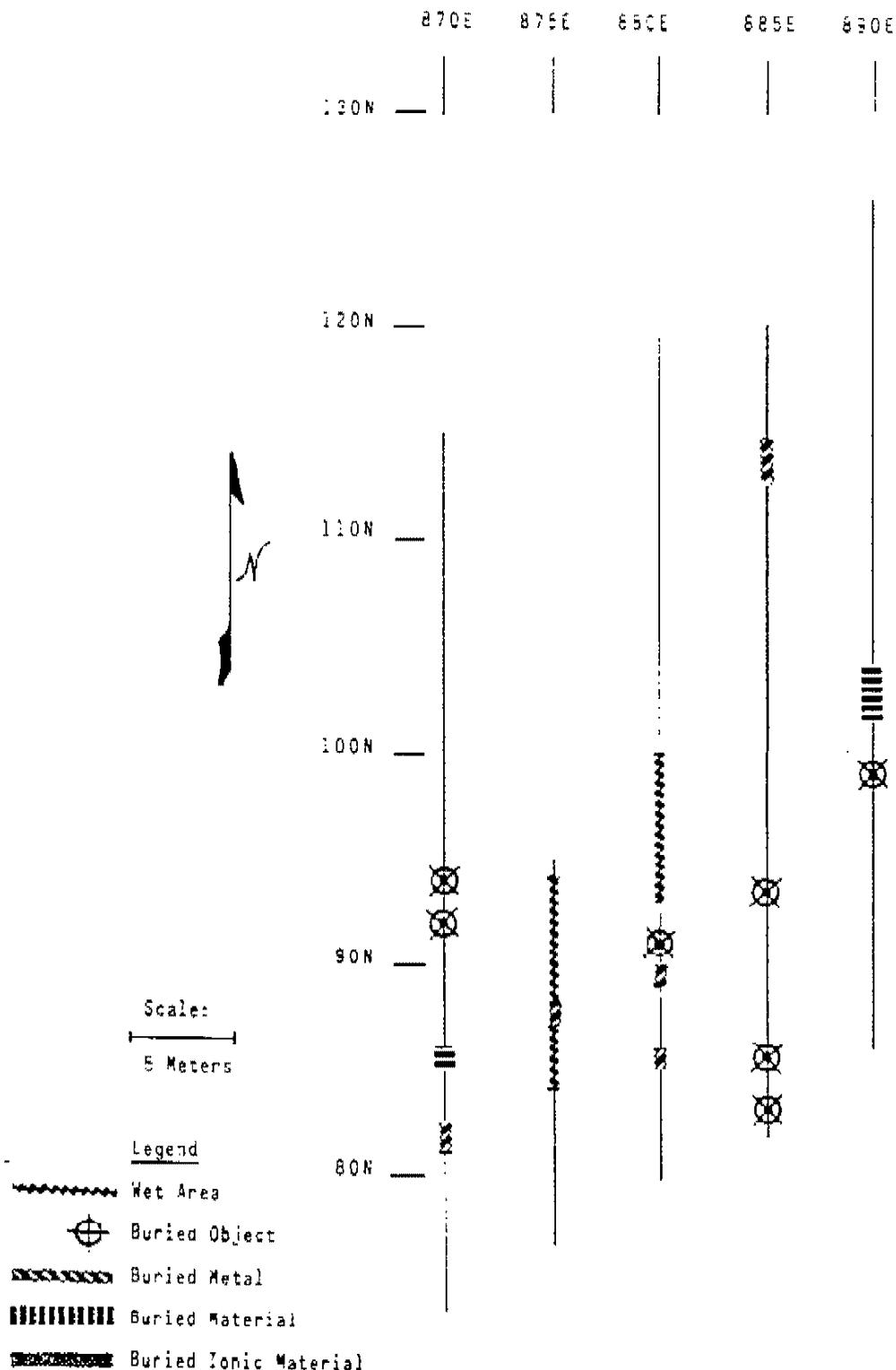


Figure 2. AREA N/N' North RADAR ANOMALIES

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TABLE III
GRID SURVEY ANOMALIES
AREA N-N' NORTH

<u>Chart Number</u>	<u>Radar Line</u>	<u>Location (Meters)</u>	<u>Depth (Cm.)</u>	<u>Comments</u>
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	135N to 137N	3.5'	Buried Debris
		133N to 135N	3.0'	Ionic Material

DETECTION SCIENCES GROUP

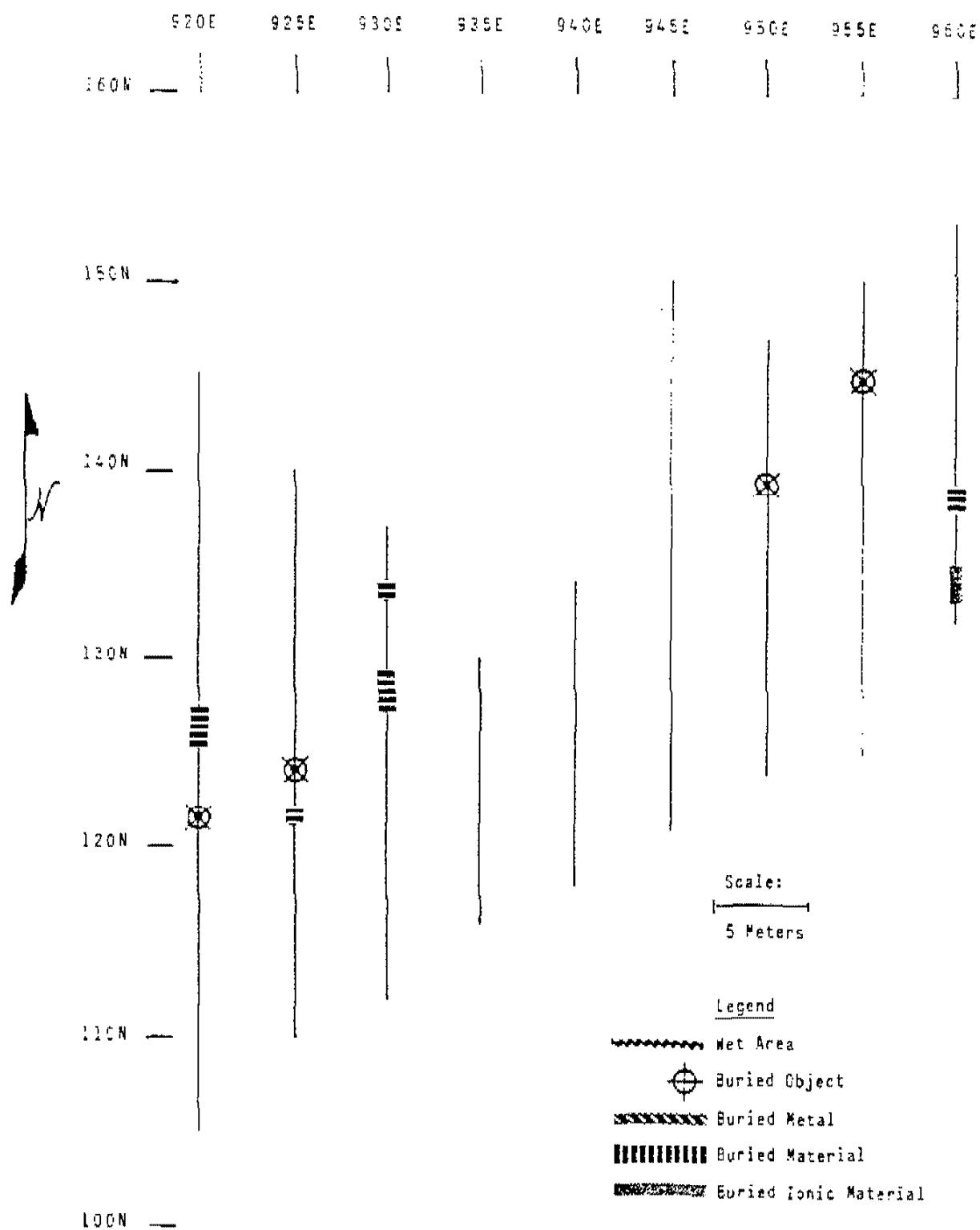


Figure 3. AREA N/N' North RADAR ANOMALIES

DETECTION SCIENCES GROUP

TABLE IV
GRID SURVEY ANOMALIES
AREA N-N' NORTE

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

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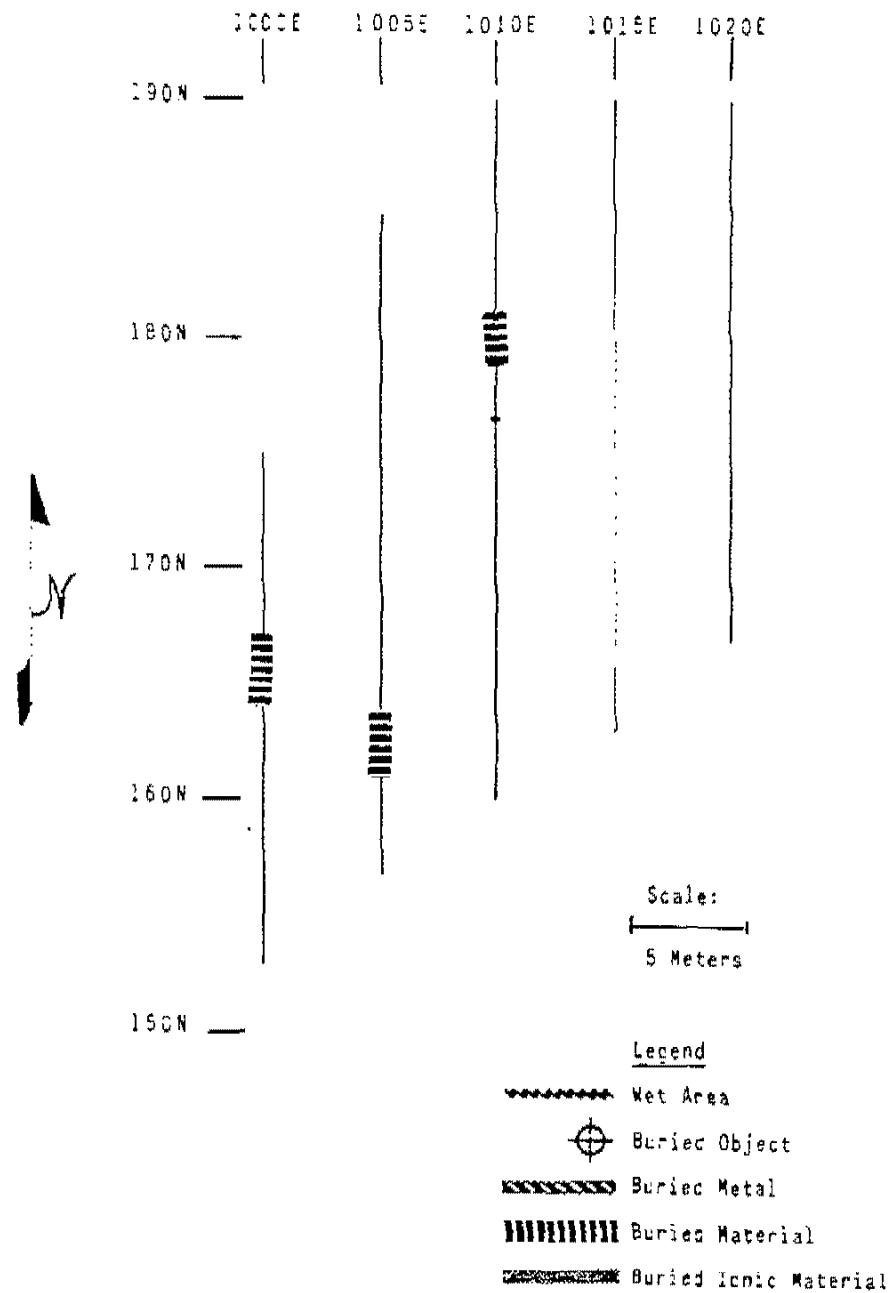


Figure 4. AREA N/N' North RADAR ANOMAL

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TABLE V

BORING LOCATIONS DETERMINED BY RADAR

AREA N-N' NORTH - SYSTEMATIC BORINGS

Boring Number	Direction of Relocation	Proposed Location	Final Location
N1	-	0N, 101E	0N, 101E
N2	-	0N, 480E	0N, 480E
N3	Move 3m North	0N, 820E	3N, 820E
N4	Move 1m East	0N, 1300E	0N, 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