

COMPREHENSIVE RADIOLOGICAL SURVEY

BECHTEL - OAK RIDGE  
LIBRARY

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

Prepared for

U.S. Department of Energy  
as part of the  
Formerly Utilized Sites -- Remedial Action Program

A. J. Boerner

Project Staff

J.D. Berger	W.O. Helton
R.D. Condra	T.J. Sowell
P.W. Frame	C.F. Weaver
R.C. Gosslee	B.S. Zacharek

Prepared by

Radiological Site Assessment Program  
Manpower Education, Research, and Training Division  
Oak Ridge Associated Universities  
Oak Ridge, Tennessee 37831-0117

FINAL REPORT

May 1984

This report is based on work performed under contract number  
DE-AC05-76OR00033 with the Department of Energy.

## TABLE OF CONTENTS

	<u>Page</u>
List of Figures . . . . .	ii
List of Tables. . . . .	iii
Introduction. . . . .	1
Site Description. . . . .	1
Survey Procedures . . . . .	3
Results . . . . .	7
Comparison of Survey Results with Guidelines . . . . .	10
Summary . . . . .	11
References. . . . .	36
Appendices	
Appendix A: Instrumentation and Analytical Procedures	
Appendix B: Summary of Radiation Guidelines Applicable to Off-Site Properties at the Niagara Falls Storage Site	

## LIST OF FIGURES

	<u>Page</u>
FIGURE 1. Map of Niagara Falls Storage Site and Off-Site Properties, Lewiston, New York, Indicating the Location of Off-Site Property N-North . . . . .	12
FIGURE 2. Plan View of NFSS Off-Site Property N-North Indicating Prominent Surface Features . . . . .	13
FIGURE 3. Plan View of NFSS Off-Site Property N-North Indicating the Grid System Established for Survey Reference. . . . .	14
FIGURE 4. Locations of Boreholes for Subsurface Investigations . . . . .	15
FIGURE 5. Locations of Surface Water and Sediment Samples . . . . .	16
FIGURE 6. Map of Northern Niagara County, New York, Showing Locations of Background Measurements and Baseline Samples . . . . .	17
FIGURE 7. Isopleths of 20, 30, and 40 $\mu$ R/h on the North-Central Portion of Property N-North . . . . .	18
FIGURE 8. Locations of Areas of Elevated Direct Radiation. . . . .	19
FIGURE 9. Map of NFSS Off-Site Property N-North Indicating Areas Where Radionuclide Concentrations in Soil Exceed Criteria Levels . . . . .	20

# LIST OF TABLES

	<u>Page</u>
TABLE 1-A: Background Exposure Rates and Radionuclide Concentrations in Baseline Soil Samples . . . . .	21
TABLE 1-B: Radionuclide Concentrations in Baseline Water Samples . . . . .	22
TABLE 2: Direct Radiation Levels Measured at Intersections of the Major Grid Lines . . . . .	23
TABLE 3: Direct Radiation Levels at Locations Identified by the Walkover Surface Scan. . . . .	27
TABLE 4: Radionuclide Concentrations in Surface Soil Samples Collected at Intersections of the Major Grid Lines . .	28
TABLE 5: Radionuclide Concentrations in Surface Samples from Locations Identified by the Walkover Scan . . . . .	31
TABLE 6: Radionuclide Concentrations in Borehole Soil Samples. . . . .	32
TABLE 7: Radionuclide Concentrations in Water Samples. . . . .	33
TABLE 8: Radionuclide Concentrations in Sediment Samples from Drainage Ditches . . . . .	34
TABLE 9: Listing of Areas on Property N-North Which Exceed Residual Contamination Criteria . . . . .	35

# COMPREHENSIVE RADIOLOGICAL 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 (now known as the Niagara Falls Storage Site (NFSS) and associated 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.<sup>1</sup>

Modern Landfill, Inc., is the current owner of a tract identified as off-site property N-North (see Figure 1). A 6.5-hectare tract on the northwest corner was previously surveyed and remedial action was performed to remove residues. An additional 45-hectare section in the western portion of the site has also been surveyed by an independent organization. A survey to confirm the results of the independent organization's findings and to assess the radiological status of the remaining areas of property N-North, conducted in September through November 1983, is the subject of this report.

### SITE DESCRIPTION

Figure 2 is a plot plan of off-site property N-North. The property is approximately 1220 m long and varies in width from 630 m to 668 m. Included in this area is a small (2.6 hectare) section, bounded by Track

Street and designated as area N'-North; this area is the subject of a separate report. The remaining area occupies approximately 78.4 hectares. The west boundary is 15 m (50 ft.) east of the centerline of Castle Garden Road. Part of the north boundary is 15 m (50 ft.) south of the centerline of "O" Street. Security fences (actually on DOE property) parallel both of these boundaries. The east portion of the northern boundary is a partially demolished railroad track; the east boundary is a security fence. No particular features delineate the south boundary between Modern Landfill property and that belonging to the Department of Labor. Aside from Track Street and South Track Street, which form the boundary of area N'-North, only unimproved haul roads exist on the site. Out-of-service railroad tracks cross the northeast corner, parallel the eastern boundary, and then turn toward the southwest, into the Track Street area. There are a number of drainage ditches throughout the property and a swampy region in the northeast corner has been designated by the State of New York as a "wetlands" area.

The west portion of the property is being used as a sanitary landfill and contains several capped and open disposal trenches. Offices for the landfill operation are located in a temporary building (trailer), near the southwest corner. There are no additional structures on the property and the areas not involved in landfill activities are heavily overgrown with brush and trees.

#### Radiological History

Handling and storage of radium bearing K-65 residues occurred on the northwestern corner of the property, particularly along "O" Street, Castle Garden Road, and Vine Street (this latter road no longer exists).<sup>1</sup> These roads and the triangular area bounded by them were surveyed by Oak Ridge National Laboratory (ORNL) in early 1981 and elevated direct radiation levels and Ra-226 and Cs-137 concentrations in soil were identified.<sup>2</sup> Cleanup of this small area was conducted in mid-1981 and a post remedial action survey was performed by Oak Ridge Associated Universities (ORAU).<sup>3</sup> An additional 45 hectares in the western portion of the site was surveyed in late 1981 and early 1982 by Eberline Instrument Corporation under an

arrangement with the property owner. No radionuclide contamination exceeding the guidelines was identified by this survey; however, elevated direct radiation levels were measured in the extreme north-central portion and in the vicinity of Track Street.<sup>4,5</sup> These radiation levels are apparently the result of residues located on the adjacent properties. The north-central portion is in close proximity to the storage tower on the NFSS, and contamination, as a result of previous scrap handling operations in the Track Street area, was noted by the 1971-72 AEC survey and the 1980 ORNL mobile scan.<sup>6,7</sup> These previous surveys did not identify potential contamination on other portions of property N-North.

### SURVEY PROCEDURES

The comprehensive survey of NFSS off-site property N-North was performed by the Radiological Site Assessment Program of Oak Ridge Associated Universities, during September-November 1983. The survey was in accordance with a plan dated March 18, 1983, approved by the Department of 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 on property N-North. Radiological information collected included:

1. direct radiation exposure rates and surface beta-gamma dose rates,
2. locations of contaminated surface areas,
3. concentrations of radionuclides in surface and subsurface soil,
4. concentrations of radionuclides in surface water, and
5. concentrations of radionuclides in sediment samples from drainage ditches.

## Procedures

1. Trees, brush, and weeds were cleared, as needed, to provide access for gridding and surveying. This operation was performed by Modern Disposal Co. of Model City, NY, under subcontract.
2. The firm of McIntosh and McIntosh of Lockport, NY, established a reference grid system on the property. A nominal 80 m grid spacing was specified; however, actual gridding intervals varied slightly in some areas to make use of access paths previously cleared during the Eberline surveys. Use of these paths avoided unnecessary clearing expenses and also minimized further damage to trees and other vegetative ground cover. The grid system is indicated on Figure 3.
3. Walkover surface scans were conducted over all accessible areas of the property. Traverses were at 5-10 m intervals on those areas that were relatively inaccessible and had no history of radioactive material use. Scanning intervals were 1-2 m along roads, the north boundary, and in other areas where direct radiation measurements suggested possible contaminated residues. Portable gamma NaI(Tl) scintillation survey meters were used for the scans. Locations of elevated contact radiation levels were noted.
4. Gamma exposure rate measurements were made at the surface and at 1 m above the surface at intersections of the major grid lines. Measurements were performed using portable gamma NaI(Tl) scintillation survey meters. Conversion of these measurements to exposure rates in microroentgens per hour ( $\mu\text{R/h}$ ) was in accordance with cross calibration with a pressurized ionization chamber.
5. Beta-gamma dose rate measurements were performed 1 cm above the surface at major grid line intersections. 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.

6. Surface (0-15 cm) soil samples of approximately 1 kg each were collected at intersections of the major grid lines.
7. At 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 for comparison with presampling levels.
8. Detection Sciences Group of Carlisle, MA, performed ground-penetrating radar surveys at proposed borehole locations to assure that subsurface piping and utilities were not damaged during drilling. In some cases, boreholes were relocated slightly.
9. Boreholes were drilled to provide a mechanism for logging subsurface direct radiation profiles and collecting subsurface soil and water samples. Five 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. The locations of these boreholes are shown on Figure 4.

Gamma radiation scans were performed in the boreholes to identify the locations of elevated direct radiation levels which might indicate subsurface residues. Radiation profiles in the boreholes were determined by measuring gamma radiation at 15-30 cm intervals between the surface and ground water or 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 boreholes by scraping the sides of the hole with an ORAU designed sampling tool.

10. Three water samples were collected from areas of standing (surface) water (see Figure 5).
11. Three sediment samples were collected from ditches located near the periphery and eastern section of the property (refer to Figure 5).
12. Twenty soil samples and seven water samples were collected from the Lewiston area (but not on 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 6.

#### Sample Analyses 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, Th-232, Cs-137, and other gamma emitters. Water samples were analyzed for gross alpha and gross beta concentrations.

Additional information concerning analytical equipment and procedures is 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 6) 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, measured at major grid line intersections, are presented in Table 2. The gamma exposure rates at 1 m above the surface at these grid points ranged from 6 to 43  $\mu\text{R/h}$  (average 9  $\mu\text{R/h}$ ). Surface contact gamma exposure rates and beta-gamma dose rates were 7 to 41  $\mu\text{R/h}$  (average 9  $\mu\text{R/h}$ ) and 7 to 61  $\mu\text{rad/h}$  (average 21  $\mu\text{rad/h}$ ), respectively. At most locations, 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 direct radiation levels were recorded in the north-central portion of the property and were due to the proximity of the stored K-65 residues on the adjacent DOE property. Figure 7 shows the 20, 30, and 40  $\mu\text{R/h}$  isopleths on the N-North site.

The walkover survey identified a few isolated spots of elevated contact radiation levels. These locations are indicated on Figure 8 and

associated radiation levels are presented in Table 3. Surface contact gamma exposure rates ranged from 13-200  $\mu$ R/h; the maximum was measured at grid point 664N, 980E. Exposure rates at 1 m above the surface ranged from 9 to 17  $\mu$ R/h. Beta-gamma dose rates ranged from 43-79,000  $\mu$ rad/h. The maximum dose rate was also recorded at grid coordinate 664N, 980E. Contact exposure and beta-gamma dose rates were reduced by soil sampling at many of these locations; this indicates that most of the contamination is in small, discrete pieces of material rather than diffused throughout a larger area of soil.

The walkover surface scan also identified two additional areas of generally elevated radiation levels. Readings along the length of the railroad track at the northeastern boundary and along a drainage ditch (grid location 490-520N, 980-1060E) averaged 12 to 14  $\mu$ R/h - slightly higher than background-for the area.

#### Radionuclide Concentrations in Surface Soil

Table 4 lists the concentrations of radionuclides measured in surface soil from intersections of the major grid lines. These samples contained Ra-226 concentrations ranging from 0.35 to 7.23 pCi/g. The highest level was in the sample collected along a railroad track at grid point 668N, 1060E. This sample was primarily rock ballast and also contained a U-238 level comparable to the Ra-226 concentration. A few additional samples contained Ra-226 concentrations exceeding those in the baseline soil, but none exceeded 5 pCi/g above the baseline level. Several samples also contained slightly elevated U-238 and Th-232 concentrations; the highest levels measured were 7.48 pCi/g of U-238 and 1.88 pCi/g of Th-232. Levels of U-235 and Cs-137 were not significantly different from those in baseline samples. No other gamma emitting radionuclides were noted in concentrations exceeding those normally present in surface soil.

Radionuclide concentrations in samples from locations of elevated contact radiation levels are presented in Table 5. Concentrations of Ra-226 in these samples ranged from <1.75 to 210 pCi/g; the maximum concentration was measured in a rock (sample B1) collected at grid point

30N, 156E. Sample B4 was a piece of yellowcake and contained 21,000 pCi/g of U-238. Although sampling at this location removed visible contamination, the contact exposure rate of 70  $\mu$ R/h recorded after sampling indicates that small pieces of residue still remain.

#### Borehole Gamma-Logging Measurements

The results of gamma scintillation measurements in boreholes indicate no subsurface contamination. Based on previous subsurface investigations gamma count rates determined by the borehole measurements are reliable indicators of elevated subsurface radionuclide levels. However, the gamma logging data was not useful in quantifying radionuclide concentrations in the subsurface soil, because of the varying ratios of Ra-226, U-235, U-238, Th-232, and Cs-137 occurring in soils from this site.

#### Radionuclide Concentrations in Borehole Soil Samples

Table 6 presents the radionuclide concentrations measured in soil samples from boreholes. The five boreholes (H1-H5), located to provide a representative coverage of the property, contained radionuclide concentrations in the ranges of baseline samples. Inaccessibility of portions of this property precluded additional systematic boreholes. The effectiveness of surface sampling in removing the source of elevated contact radiation levels indicated that subsurface investigations at these locations were not warranted.

#### Radionuclide Concentrations in Water

Samples W1-W3 from areas of standing water on property N-North (refer to Table 7) contained gross alpha concentrations ranging from 2.37 to 7.16 pCi/l. Gross beta concentrations ranged from 6.00 to 7.33 pCi/l. The gross alpha levels are higher than the baseline range but within EPA Interim Drinking Water limits of 15 pCi/l; the gross beta levels are within the range of baseline concentrations.

## Radionuclide Concentrations in Drainage Ditch Sediments

Concentrations in sediment samples, collected from drainage ditches, are presented in Table 8. Samples SD1 and SD3 contained Ra-226 and Cs-137 concentrations above baseline levels. Sample SD3 also contained 62.6 pCi/g of U-238 - well above the baseline concentration. Levels were, however, within cleanup guidelines established for formerly utilized sites.

### COMPARISON OF SURVEY RESULTS WITH GUIDELINES

The guidelines applicable to cleanup of off-site properties at the Niagara Falls Storage Site are presented in Appendix B. Radiation levels and radionuclide concentrations, at small, isolated spots of surface or near-surface contamination, exceed these guideline values.

The exposure rates in contact with isolated areas of surface contamination do not exceed the guideline of 60  $\mu$ R/h for open land areas accessible by the general public, with the exception of grid location 664N, 980E where a contact exposure rate of 70  $\mu$ R/h remained after sample collection. Average exposure rates at 1 m above the surface (9  $\mu$ R/h) are well within the 60  $\mu$ R/h guideline. Higher gamma radiation levels in the north-central portion of the property are the result of residues on the adjacent DOE property. Elevated levels along the railroad tracks are probably due to the natural radionuclide concentrations in the ballast.

Areas of surface contamination, identified by the walkover scan, contained Ra-226 concentrations in excess of 5 pCi/g; two of the samples also contained U-238 concentrations above the 150 pCi/g criterion. These areas are summarized in Table 9 and indicated on Figure 9. Sample B4 (664N, 980E) consisted mainly of yellowcake (21,000 pCi/g), most of which was removed by sample collection. Most of these areas of contamination were small and isolated, and concentrations would be below the guidelines, when averaged over an area of 100 m<sup>2</sup>. Borehole measurements and samples did not identify subsurface levels differing from those in baseline samples.

Surface water contained radionuclide concentrations below the EPA limits of 15 pCi/l, gross alpha and 50 pCi/l, gross beta.

Radionuclide concentrations in sediment samples from drainage ditches were well within the cleanup guidelines established for formerly utilized sites.

#### SUMMARY

A comprehensive survey of off-site property N-North at the Niagara Falls Storage Site was conducted during September-November 1983. A portion of the property in the northwest corner is an active landfill and was inaccessible for surveying. This area, however, had been previously surveyed. The Track Street area (Property N'-North) will be discussed in a separate report. The survey included surface radiation scans, measurements of direct radiation levels, and analyses for radionuclide concentrations in soil samples, both surface and subsurface, and in surface water samples. Analyses of sediment samples, collected at three locations, were also performed. Ground-penetrating radar was used to identify subsurface utilities which might preclude borehole drilling.

The results of the survey indicate a few, small, isolated areas of elevated direct radiation and surface soil contamination. Elevated gamma radiation levels are present primarily in the north-central portion of the property in close proximity to the K-65 storage tower. The major soil contaminants are Ra-226 and U-238. Sampling removed most of the contamination; remaining contamination would meet cleanup criteria when averaged over an area of 100 m<sup>2</sup>.

Gross alpha and beta levels from surface water were within EPA guidelines. No subsurface contamination was identified through borehole measurements and sampling.

Although the contaminated residues and elevated direct radiation levels are present on small portions of this property, the contaminants do not pose potential health risks to the public or site workers.

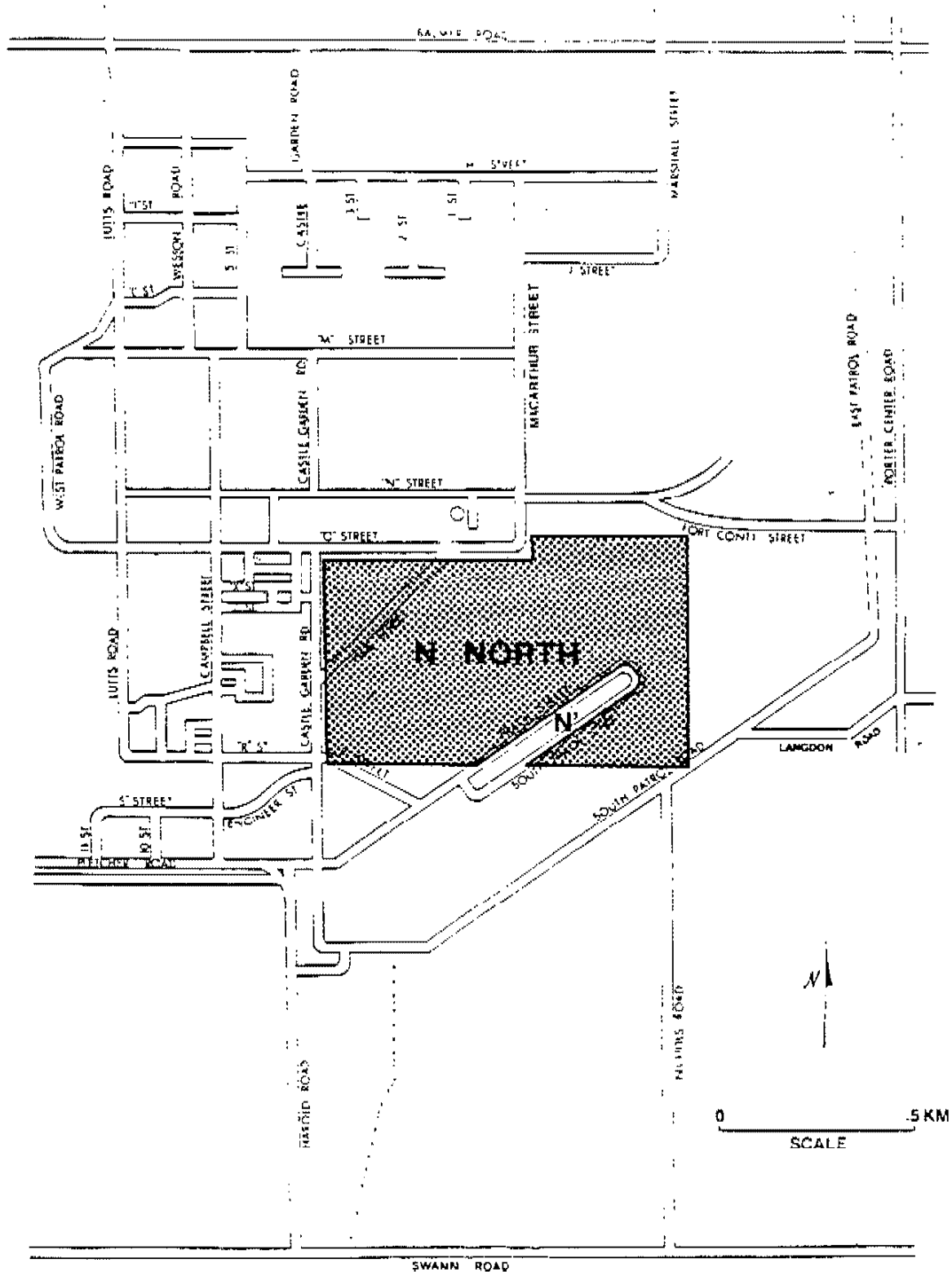


FIGURE 1. Map of Niagara Falls Storage Site and Off-Site Properties, Lewiston, New York, Indicating the Location of Off-Site Property N-North.



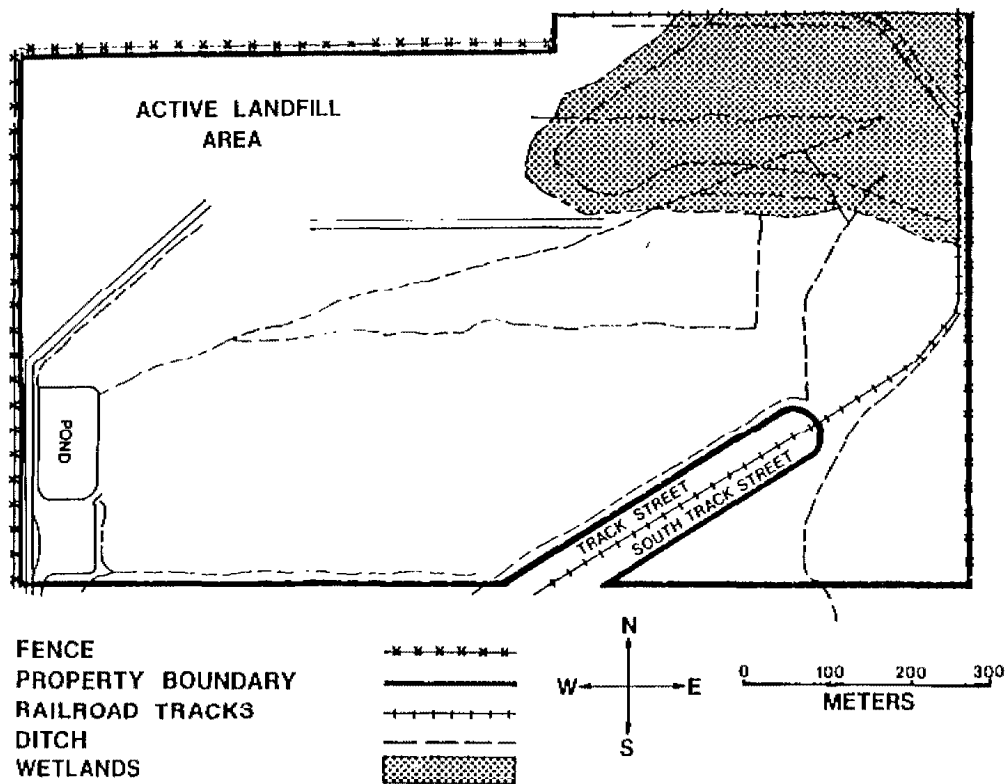


FIGURE 2. Plan View of NFSS Off-Site Property N-North Indicating Prominent Surface Features.

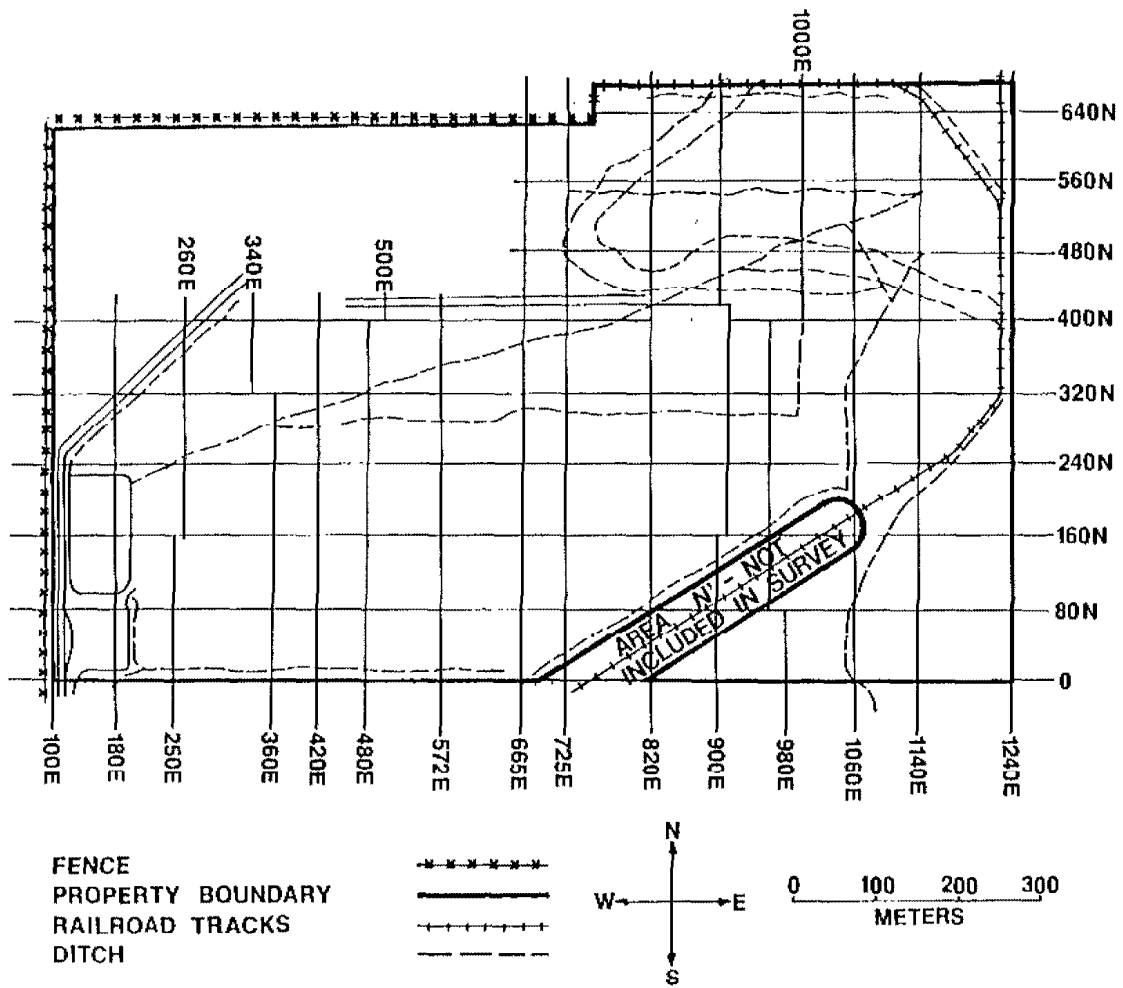


FIGURE 3. Plan View of NFSS Off-Site Property N-North Indicating the Grid System Established for Survey Reference.

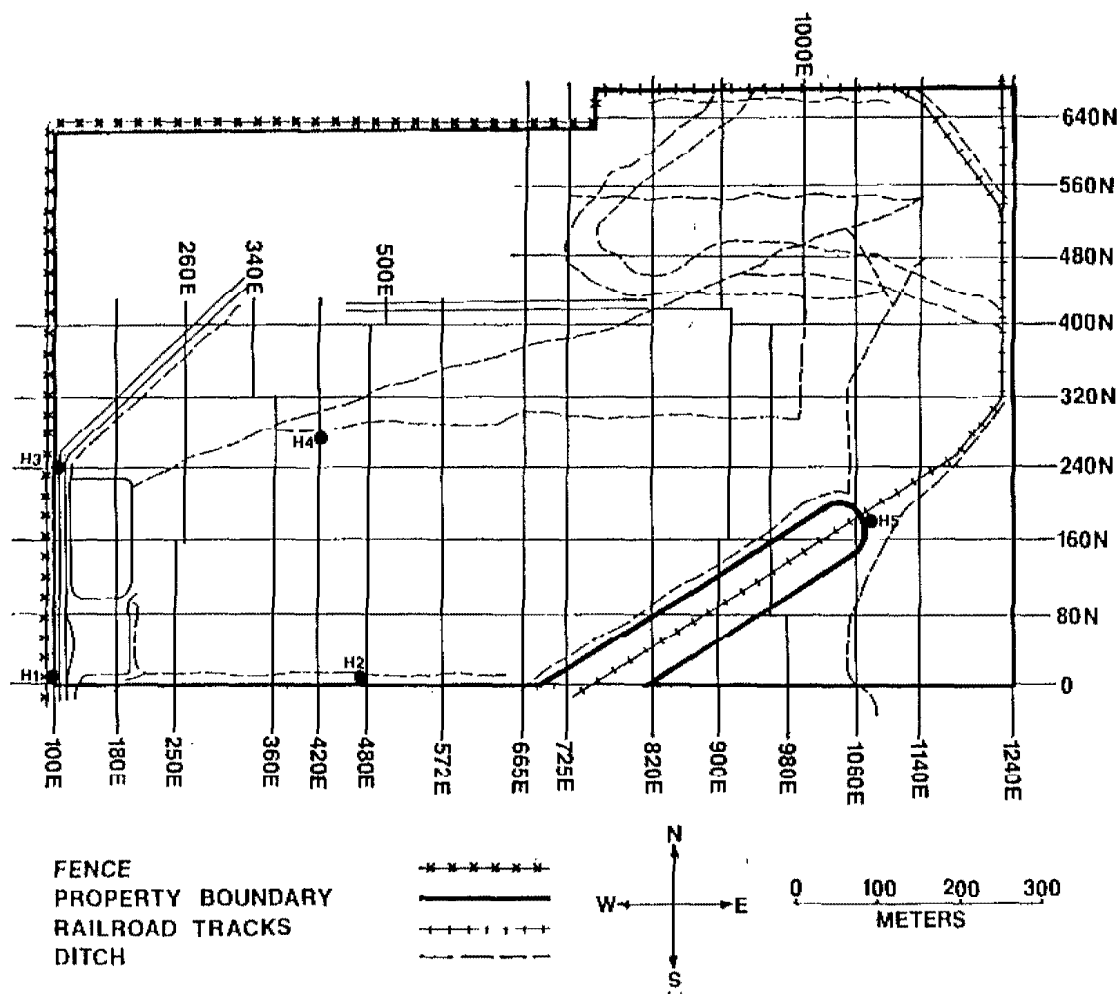


FIGURE 4. Locations of Boreholes for Subsurface Investigations.

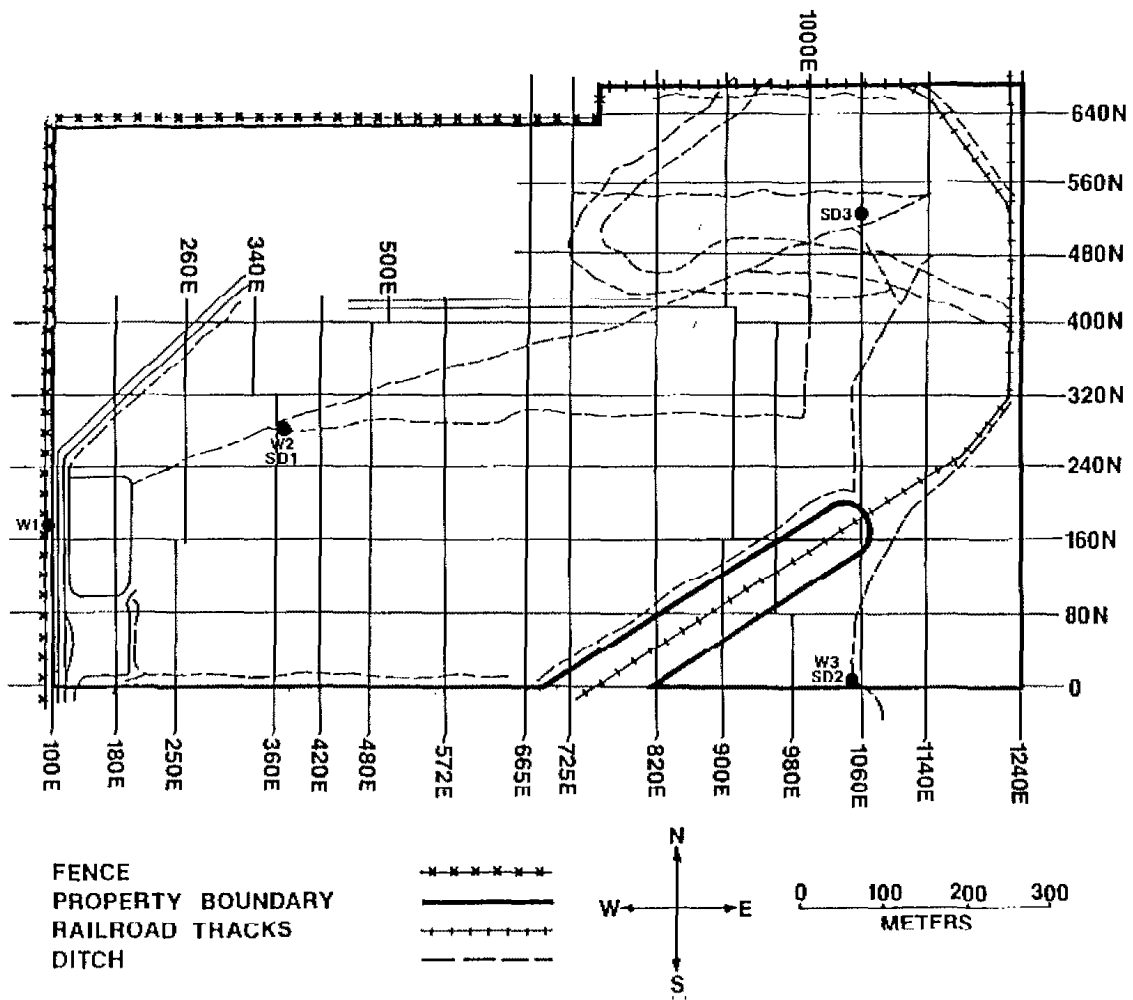


FIGURE 5. Locations of Surface Water and Sediment Samples.

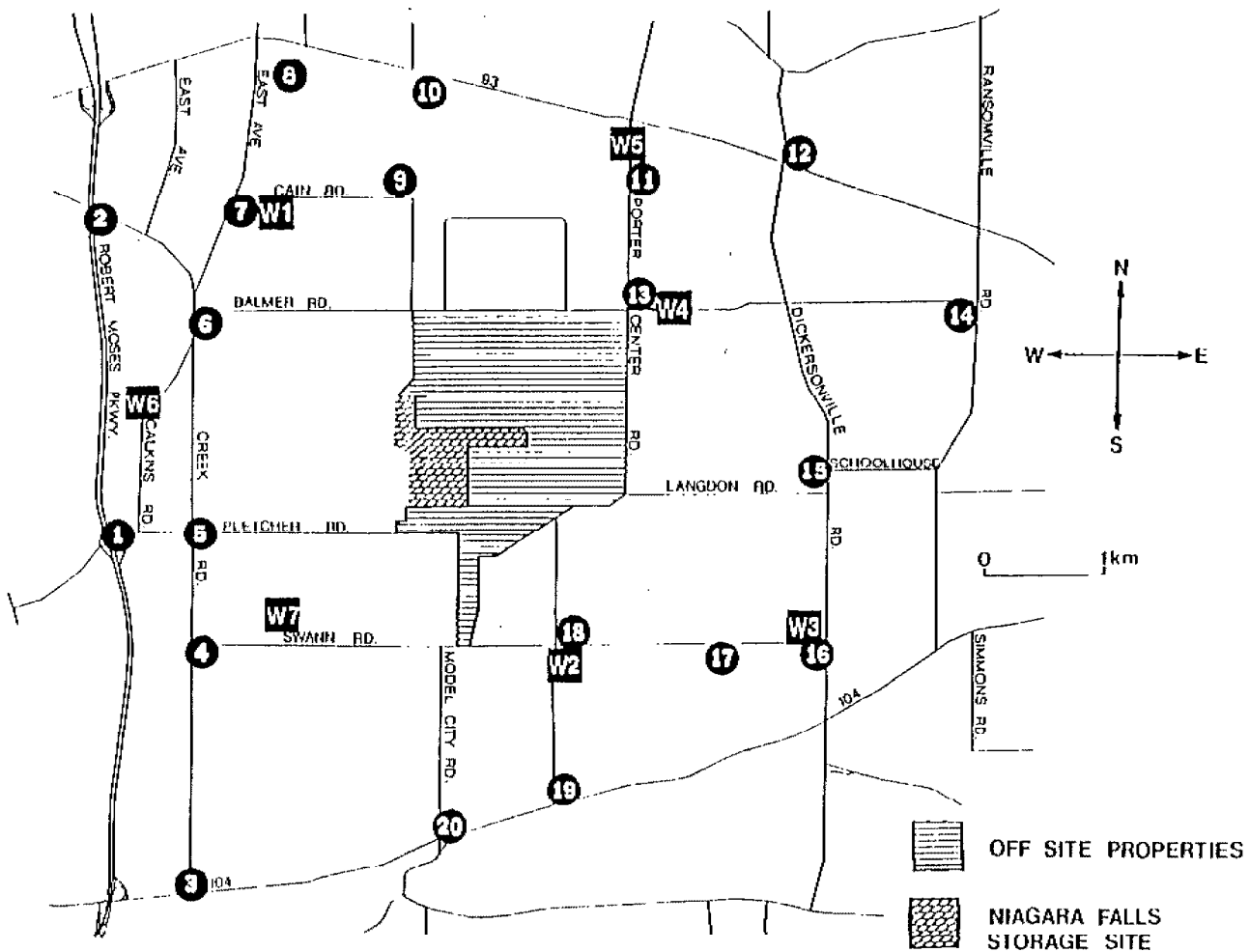


FIGURE 6. Map of Northern Niagara County, New York, Showing Locations of Background Measurements and Baseline Samples. (#1-20: Soil Samples and Direct Measurements; W1-W7: Water Samples.)

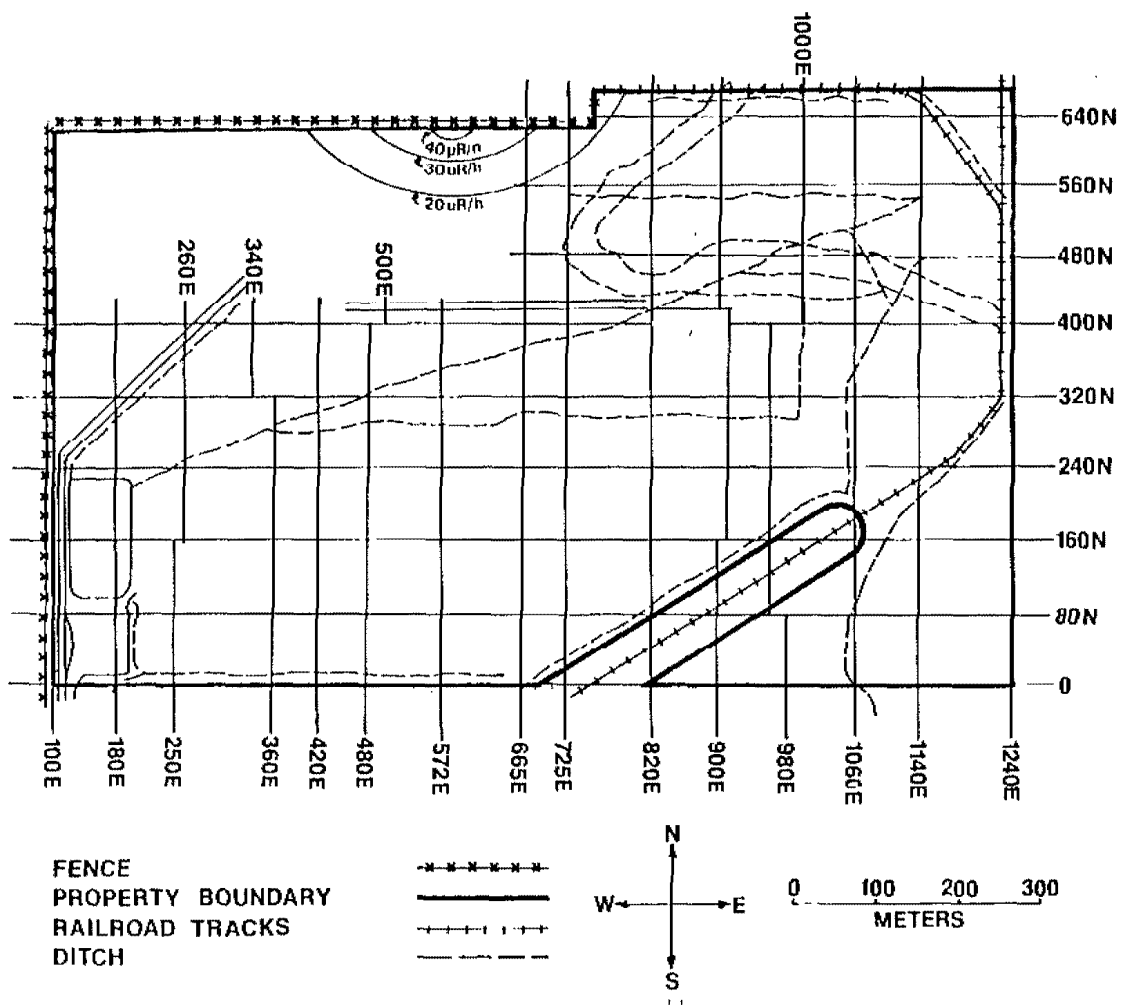


FIGURE 7. Isopleths of 20, 30, and 40 µR/h on the North-Central Portion of Property N-North.

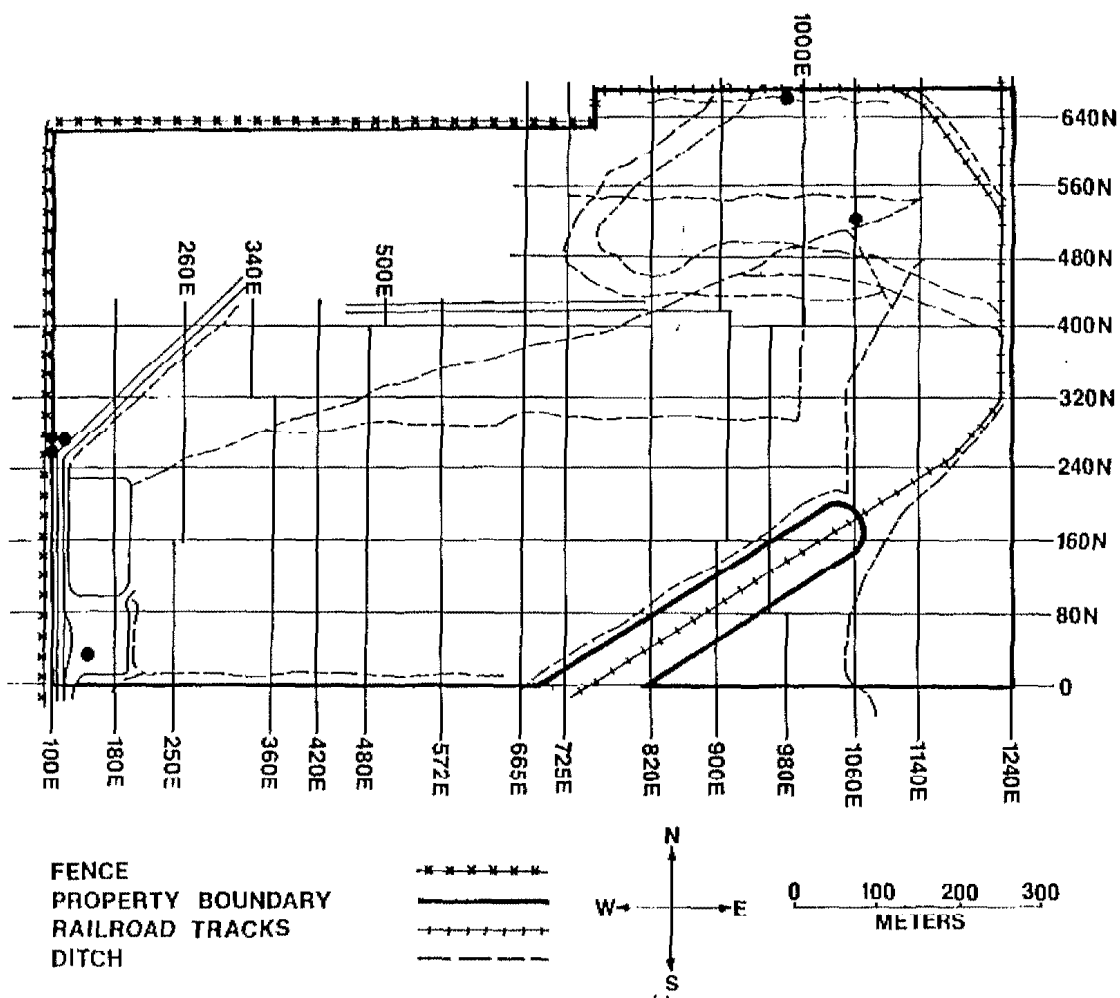


FIGURE 8. Locations of Areas of Elevated Direct Radiation.

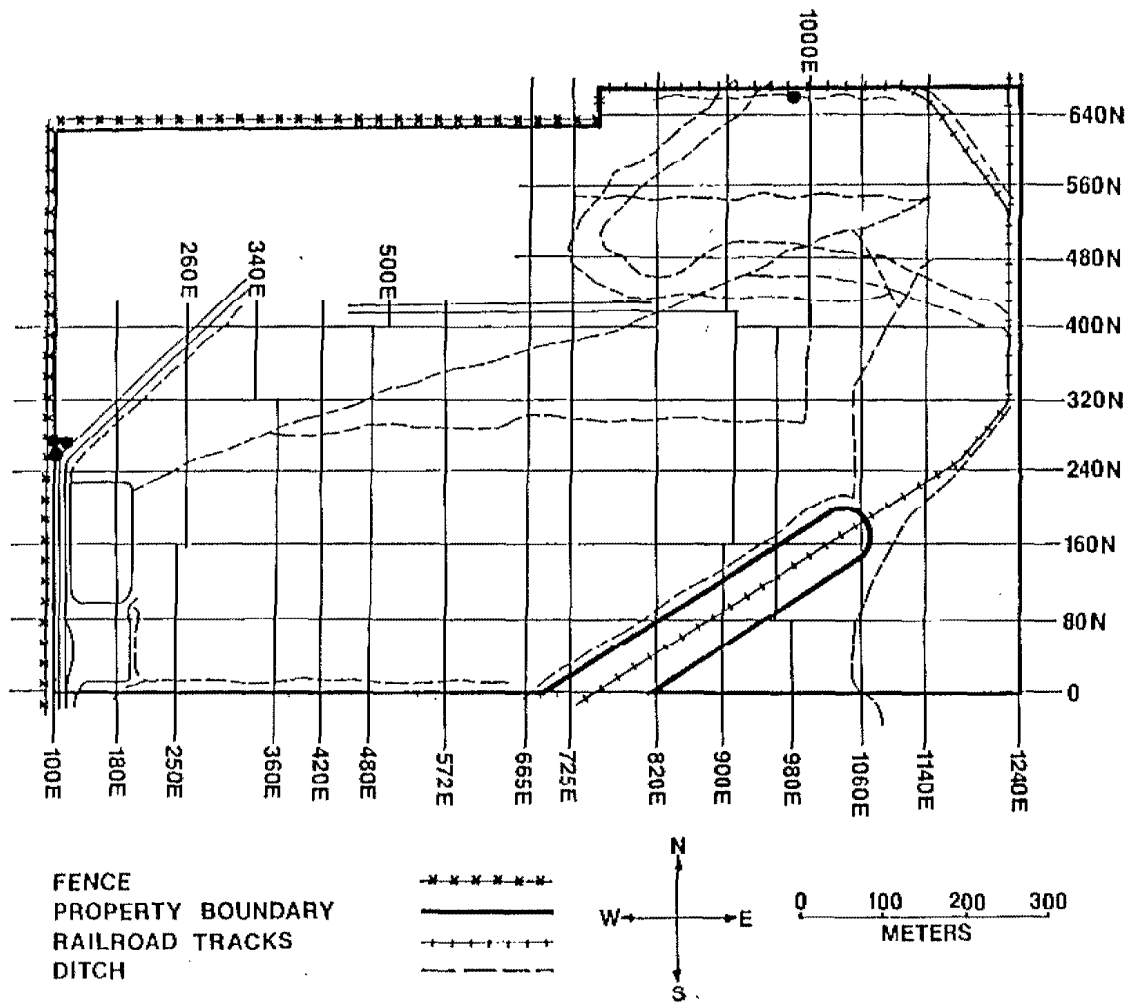


FIGURE 9. Map of NFSS Off-Site Property N-North Indicating Areas Where Radionuclide Concentrations in Soil Exceed Criteria Levels.



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

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

<sup>a</sup> Refer to Figure 6.

<sup>b</sup> Measured at 1 m above the surface.

<sup>c</sup> Errors are 2 $\sigma$  based on counting statistics.

TABLE 1-B  
RADIONUCLIDE CONCENTRATIONS IN BASELINE WATER SAMPLES

Location <sup>a</sup>	Radionuclide Concentrations (pCi/l)	
	Gross Alpha	Gross Beta
W1	0.95 ± 0.93 <sup>b</sup>	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

<sup>a</sup> Refer to Figure 6.

<sup>b</sup> Errors are 2σ based on counting statistics.

TABLE 2  
DIRECT RADIATION LEVELS  
MEASURED AT INTERSECTIONS OF THE  
MAJOR GRID LINES

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			
0	100	6	7	30
0	180	7	7	23
0	250	6	7	34
0	360	6	7	30
0	420	6	7	16
0	480	7	7	29
0	572	8	8	14
0	665	9	10	19
0	725	11 <sup>a</sup>	12 <sup>a</sup>	35 <sup>a</sup>
0	820	7 <sup>a</sup>	7 <sup>a</sup>	8 <sup>a</sup>
0	900	8	9	39
0	980	8	8	19
0	1060	8	8	19
0	1140	7	7	7
0	1240	8	8	25
80	100	7	8	18
80	180	7	7	30
80	250	7	8	27
80	360	7	7	16
80	420	7	7	20
80	480	7	8	21
80	572	8	8	35
80	665	9	9	32
80	725	9	9	18
80	820	8 <sup>a</sup>	8 <sup>a</sup>	8 <sup>a</sup>
80	900	11 <sup>a</sup>	10 <sup>a</sup>	39 <sup>a</sup>
80	980	8	8	18
80	1060	8	8	22
80	1140	7	7	16
80	1240	7	8	17
160	100	7	7	9
160	180	8	8	38
160	260	b	b	b
160	360	6	7	29
160	420	7	7	7
160	480	7	7	30
160	572	9	9	26
160	665	9	9	13
160	725	8	9	29

TABLE 2, cont.

DIRECT RADIATION LEVELS  
MEASURED AT INTERSECTIONS OF THE  
MAJOR GRID LINES

Grid Location		Gamma Exposure Rates at 1 m Above the Surface ( $\mu$ R/h)	Gamma Exposure Rates at the Surface ( $\mu$ R/h)	Beta-Gamma Dose Rates at 1 cm Above the Surface ( $\mu$ rad/h)
N	E			
160	820	9	9	26
160	910	10	10	23
160	970	8 <sup>a</sup>	8 <sup>a</sup>	8 <sup>a</sup>
160	1000	10 <sup>a</sup>	10 <sup>a</sup>	36 <sup>a</sup>
160	1060	8 <sup>a</sup>	8 <sup>a</sup>	28 <sup>a</sup>
160	1140	7	8	19
160	1240	7	8	8
240	100	b	b	b
240	180	7	7	7
240	260	b	b	b
240	360	7	8	24
240	420	7	7	18
240	480	7	7	18
240	572	9	9	11
240	665	9	9	20
240	725	8	9	9
240	820	9	9	35
240	910	9	9	25
240	970	7	8	9
240	1000	8	8	10
240	1060	8	8	30
240	1140	10	10	43
240	1240	7	7	24
320	100	b	b	b
320	180	7	7	18
320	260	b	b	b
320	340	b	b	b
320	420	b	b	b
320	480	7	8	14
320	572	10	10	21
320	665	9	9	15
320	725	9	9	26
320	820	9	9	29
320	910	9	10	24
320	970	8	8	14
320	1000	8	8	15
320	1060	8	8	10
320	1140	8	8	19
320	1240	9	9	16

TABLE 2, cont.

DIRECT RADIATION LEVELS  
MEASURED AT INTERSECTIONS OF THE  
MAJOR GRID LINES

Grid Location		Gamma Exposure Rates at 1 m Above the Surface ( $\mu$ R/h)	Gamma Exposure Rates at the Surface ( $\mu$ R/h)	Beta-Gamma Dose Rates at 1 cm Above the Surface ( $\mu$ rad/h)
N	E			
400	100	b	b	b
400	180	b	b	b
400	260	b	b	b
400	340	b	b	b
400	420	b	b	b
400	480	8	7	9
400	572	11	11	21
400	665	10	10	11
400	725	9	10	24
400	820	9	10	21
423	820	10	10	20
423	910	9	10	17
400	970	8	8	45
400	1000	8	8	8
400	1060	8	8	12
400	1140	8	8	27
400	1240	b	b	b
480	120	b	b	b
480	180	b	b	b
480	260	b	b	b
480	340	b	b	b
480	420	sb	b	b
480	500	b	b	b
480	572	14	14	54
480	665	13	13	20
480	725	11	12	12
480	820	11	12	14
480	900	9	9	15
480	1000	8	8	17
480	1060	8	8	17
480	1140	8	8	14
480	1240	b	b	b
560	100	b	b	b
560	180	b	b	b
560	260	b	b	b
560	340	b	b	b
560	420	b	b	b
560	500	b	b	b
560	572	20	17	50
560	665	17	19	39

TABLE 2, cont.

DIRECT RADIATION LEVELS  
MEASURED AT INTERSECTIONS OF THE  
MAJOR GRID LINES

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			
560	725	14	14	25
560	820	12	13	29
560	900	9	9	13
560	1000	7	8	17
560	1060	8	8	25
560	1140	8	8	28
560	1240	b	b	b
635	100	b	b	b
635	180	b	b	b
635	260	b	b	b
635	340	b	b	b
635	420	b	b	b
635	500	b	b	b
635	572	43	41	50
635	660	30	29	29
635	745	20	20	39
640	820	14	14	18
640	900	12	12	29
640	1000	8	8	19
640	1060	8	9	28
640	1140	8	8	15
640	1240	b	b	b
668	745	b	b	b
668	820	16	16	61
668	900	b	b	b
668	1000	9	9	33
668	1060	10	10	12
668	1140	8	9	19
668	1240	b	b	b

<sup>a</sup> Grid point is on N'-North property.

<sup>b</sup> Measurement not performed due to presence of active landfill, surface water or other obstruction.

TABLE 3  
DIRECT RADIATION LEVELS AT LOCATIONS  
IDENTIFIED BY THE WALKOVER SURFACE SCAN

Grid Location		Exposure Rate ( $\mu$ R/h)		Surface Dose Rate ( $\mu$ rad/h)	Sample Identification <sup>b</sup>	Contact Exposure Rate After Sample Removal ( $\mu$ R/h)
N	E	Contact	1 m Above Surface			
30	156	27	12	960	B1	9
250	101	36	14	80	B2	36
259	107	35	14	61	---	---
260	100	26	13	43	---	---
516	1060	13	9	50	B3	13
664	980	200	17	79,000	B4	70

<sup>a</sup> Refer to Figure 8.

<sup>b</sup> Radionuclide analyses are presented in Table 5.

<sup>c</sup> Dash indicates measurement or sampling not performed.

TABLE 4

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES  
COLLECTED AT INTERSECTIONS OF THE MAJOR GRID LINES

Grid Location		Radionuclide Concentrations (pCi/g)				
N	E	Ra-226	U-235	U-238	Cs-137	Th-232
0	100	1.03 ± 0.40 <sup>a</sup>	<0.22	1.49 ± 1.71	<0.04	0.76 ± 0.38
0	180	0.80 ± 0.29	<0.22	<0.87	0.11 ± 0.02	1.24 ± 0.43
0	250	0.73 ± 0.28	0.44 ± 0.38	0.87 ± 0.63	0.42 ± 0.13	0.85 ± 0.29
0	360	0.76 ± 0.31	<0.22	2.31 ± 1.78	<0.06	1.12 ± 0.62
0	420	0.98 ± 0.25	<0.35	<1.13	<0.06	1.22 ± 0.56
0	480	0.68 ± 0.34	<0.26	1.20 ± 1.62	0.23 ± 0.11	1.35 ± 0.45
0	572	0.69 ± 0.30	<0.22	1.14 ± 2.32	0.17 ± 0.14	1.11 ± 0.43
0	665	0.86 ± 0.24	<0.19	1.05 ± 0.62	0.20 ± 0.13	0.88 ± 0.40
0	725	b	b	b	b	b
0	820	b	b	b	b	b
0	900	0.85 ± 0.35	<0.34	3.02 ± 2.10	0.25 ± 0.13	0.83 ± 0.54
0	980	1.34 ± 0.36	<0.44	2.38 ± 1.66	0.23 ± 0.18	1.35 ± 0.54
0	1060	0.58 ± 0.26	<0.18	1.08 ± 0.85	0.20 ± 0.09	1.00 ± 0.31
0	1140	0.80 ± 0.30	<0.28	3.58 ± 1.73	0.32 ± 0.09	1.22 ± 0.51
0	1240	0.70 ± 0.21	<0.16	1.70 ± 0.98	0.25 ± 0.09	0.58 ± 0.24
80	100	0.91 ± 0.33	<0.22	<0.85	<0.05	1.49 ± 1.00
80	160	1.09 ± 0.36	<0.21	1.14 ± 1.47	0.14 ± 0.06	0.77 ± 0.34
80	250	0.88 ± 0.48	<0.39	1.38 ± 1.19	0.07 ± 0.09	1.54 ± 0.51
80	420	1.03 ± 0.30	<0.20	<0.80	0.09 ± 0.07	0.25 ± 0.53
80	480	1.00 ± 0.29	<0.30	2.06 ± 1.58	1.28 ± 0.18	1.07 ± 0.44
80	572	0.84 ± 0.45	<0.25	<0.84	0.18 ± 0.13	0.74 ± 0.55
80	665	1.23 ± 0.31	<0.36	<1.18	0.36 ± 0.13	1.14 ± 0.41
80	725	0.83 ± 0.35	<0.25	1.15 ± 2.91	0.22 ± 0.11	0.53 ± 0.45
80	820	b	b	b	b	b
80	900	b	b	b	b	b
80	980	0.94 ± 0.36	<0.37	1.57 ± 2.36	0.86 ± 0.18	1.07 ± 0.51
80	1060	0.83 ± 0.31	<0.21	1.19 ± 1.00	0.67 ± 0.16	0.88 ± 0.30
80	1140	0.64 ± 0.45	<0.25	3.69 ± 1.68	0.45 ± 0.12	1.00 ± 0.37
80	1240	0.58 ± 0.23	<0.22	<0.65	0.66 ± 0.31	1.03 ± 0.31
160	100	0.83 ± 0.33	<0.19	1.24 ± 1.74	<0.04	0.78 ± 0.33
160	160	0.68 ± 0.30	<0.23	1.71 ± 1.27	<0.03	1.06 ± 0.36
160	250	0.81 ± 0.34	<0.19	1.76 ± 1.60	<0.04	0.85 ± 0.27
160	360	0.55 ± 0.29	<0.22	2.81 ± 1.47	0.31 ± 0.09	0.51 ± 0.23
160	420	0.75 ± 0.30	<0.23	<0.74	0.70 ± 0.16	0.93 ± 0.41
160	480	0.96 ± 0.39	0.50 ± 0.67	1.24 ± 1.77	0.68 ± 0.16	1.04 ± 0.41
160	572	0.81 ± 0.30	0.44 ± 0.61	1.28 ± 1.65	0.40 ± 0.15	1.25 ± 0.50
160	665	0.73 ± 0.31	<0.20	2.04 ± 1.63	0.33 ± 0.15	0.69 ± 0.31
160	725	0.78 ± 0.24	<0.18	1.89 ± 0.60	0.37 ± 0.14	0.73 ± 0.43
160	820	0.23 ± 0.51	<0.35	1.40 ± 2.13	0.85 ± 0.14	1.11 ± 0.40
160	910	0.46 ± 0.23	<0.16	<0.56	0.67 ± 0.14	1.05 ± 0.33
160	980	b	b	b	b	b



TABLE 4, cont.

**RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES  
COLLECTED AT INTERSECTIONS OF THE MAJOR GRID LINES**

Grid Location		Radionuclide Concentrations (pCi/g)				
N	E	Ra-226	U-235	U-238	Cs-137	Th-232
160	1060	b	b	b	b	b
160	1140	0.35 ± 0.29	<0.24	2.31 ± 1.80	0.37 ± 0.09	1.30 ± 0.42
160	1240	<0.19	<0.33	2.53 ± 1.18	1.14 ± 0.15	0.78 ± 0.33
240	100	0.65 ± 0.19	<0.15	0.51 ± 0.36	<0.03	0.88 ± 0.39
240	180	0.96 ± 0.79	<0.21	1.40 ± 1.32	0.11 ± 0.06	0.64 ± 0.46
240	250	0.86 ± 0.24	<0.20	1.10 ± 1.48	0.17 ± 0.08	0.67 ± 0.34
240	360	1.49 ± 0.29	<0.24	3.91 ± 1.79	0.22 ± 0.12	1.04 ± 0.56
240	420	0.74 ± 0.33	<0.29	2.76 ± 1.05	0.36 ± 0.12	1.13 ± 0.32
240	480	0.88 ± 0.29	<0.19	2.14 ± 0.74	0.48 ± 0.10	1.24 ± 0.38
240	572	0.76 ± 0.36	<0.22	2.60 ± 1.06	0.62 ± 0.14	0.87 ± 0.48
240	665	0.96 ± 0.40	0.27 ± 0.70	2.31 ± 1.46	0.41 ± 0.12	1.07 ± 0.38
240	725	1.25 ± 0.30	<0.35	3.86 ± 1.61	0.58 ± 0.17	1.57 ± 0.55
240	820	0.59 ± 0.21	<0.18	1.84 ± 0.63	0.06 ± 0.05	0.45 ± 0.38
240	910	0.48 ± 0.35	<0.26	<0.89	0.64 ± 0.15	0.47 ± 0.27
240	970	0.76 ± 0.30	<0.26	3.32 ± 1.30	0.53 ± 0.15	0.52 ± 0.82
240	1060	0.84 ± 0.29	<0.31	4.48 ± 1.45	0.30 ± 0.11	1.14 ± 0.41
240	1140	1.60 ± 0.34	<0.21	1.07 ± 0.62	0.67 ± 0.12	1.11 ± 0.34
240	1240	1.23 ± 0.26	<0.28	4.21 ± 1.75	1.01 ± 0.17	0.90 ± 0.38
280	100	1.65 ± 0.33	<0.33	2.83 ± 1.02	<0.05	1.46 ± 0.52
280	180	1.11 ± 0.26	0.42 ± 0.27	0.99 ± 1.46	<0.04	0.66 ± 0.27
280	250	0.73 ± 0.30	<0.23	1.63 ± 1.40	0.26 ± 0.11	1.08 ± 0.37
280	360	0.91 ± 0.25	0.32 ± 0.78	0.79 ± 1.84	0.68 ± 0.13	0.70 ± 0.41
280	420	1.25 ± 0.30	<0.33	7.48 ± 1.59	0.30 ± 0.12	1.54 ± 0.77
320	480	0.74 ± 0.25	<0.18	<0.46	0.67 ± 0.12	0.83 ± 0.29
320	573	0.95 ± 0.21	<0.12	2.08 ± 0.71	0.45 ± 0.10	0.98 ± 0.29
320	665	1.05 ± 0.26	0.43 ± 0.70	3.38 ± 1.96	0.52 ± 0.12	1.43 ± 0.45
320	725	0.74 ± 0.23	<0.23	1.82 ± 2.21	0.37 ± 0.18	1.12 ± 0.35
320	820	0.83 ± 0.23	0.71 ± 0.58	6.37 ± 1.76	0.67 ± 0.16	1.34 ± 0.41
320	910	0.64 ± 0.20	<0.18	1.01 ± 0.64	0.50 ± 0.12	0.84 ± 0.30
320	970	0.71 ± 0.20	<0.25	1.54 ± 2.48	0.52 ± 0.13	0.80 ± 0.39
320	1060	0.78 ± 0.26	<0.31	2.20 ± 1.89	0.59 ± 0.15	0.97 ± 0.39
320	1140	0.73 ± 0.21	<0.71	1.15 ± 0.68	0.67 ± 0.13	1.38 ± 0.57
320	1240	0.79 ± 0.26	0.44 ± 0.35	1.80 ± 0.66	0.22 ± 0.07	0.93 ± 0.50
400	480	1.09 ± 0.34	<0.28	2.55 ± 2.79	0.70 ± 0.16	0.68 ± 0.69
400	572	0.88 ± 0.24	<0.27	1.68 ± 2.21	0.78 ± 0.19	1.50 ± 0.56
400	665	0.68 ± 0.25	<0.37	2.19 ± 1.76	0.70 ± 0.14	1.78 ± 0.60
400	725	0.63 ± 0.25	<0.21	1.78 ± 1.61	0.28 ± 0.21	0.95 ± 0.39
400	820	0.85 ± 0.34	<0.20	1.95 ± 0.95	0.33 ± 0.12	0.95 ± 0.39
400	910	0.69 ± 0.29	<0.20	1.64 ± 1.06	0.46 ± 0.15	0.85 ± 0.38
400	970	0.80 ± 0.31	<0.25	1.41 ± 1.94	0.60 ± 0.13	1.11 ± 0.44

TABLE 4, cont.

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES  
COLLECTED AT INTERSECTIONS OF THE MAJOR GRID LINES

Grid Locations		Radionuclide Concentrations (pCi/g)				
N	E	Ra-226	U-235	U-238	Cs-137	Th-232
400	1060	0.79 ± 0.18	<0.29	2.63 ± 1.55	0.30 ± 0.08	1.12 ± 0.36
400	1140	0.65 ± 0.24	<0.18	1.37 ± 1.83	0.51 ± 0.13	0.62 ± 0.36
400	1220	c	c	c	c	c
480	480	0.88 ± 0.30	<0.21	<0.69	0.08 ± 0.07	0.62 ± 0.26
480	572	1.00 ± 0.31	<0.28	2.95 ± 3.08	0.34 ± 0.13	1.27 ± 0.47
480	665	1.23 ± 0.36	<0.38	5.57 ± 1.70	<0.08	0.99 ± 0.64
480	725	1.01 ± 0.35	<0.26	3.65 ± 1.41	0.31 ± 0.20	0.73 ± 0.49
480	820	1.31 ± 0.38	<0.39	6.80 ± 2.80	0.65 ± 0.14	1.57 ± 0.66
480	900	0.86 ± 0.25	<0.17	0.94 ± 0.56	0.61 ± 0.11	0.96 ± 0.33
480	980	1.08 ± 0.38	<0.28	2.99 ± 2.31	0.74 ± 0.29	1.13 ± 0.62
480	1060	1.01 ± 0.30	0.31 ± 0.45	<0.92	0.69 ± 0.15	0.87 ± 0.91
480	1140	0.56 ± 0.39	1.06 ± 0.68	1.59 ± 2.03	0.73 ± 0.15	0.78 ± 0.43
480	1220	c	c	c	c	c
560	480	0.86 ± 0.30	<0.22	0.73 ± 2.03	<0.05	0.90 ± 0.38
560	572	0.76 ± 0.21	<0.22	1.20 ± 1.50	<0.04	0.82 ± 0.46
560	665	1.01 ± 0.49	<0.28	3.15 ± 1.89	0.36 ± 0.19	0.93 ± 0.55
560	725	0.88 ± 0.23	<0.34	4.88 ± 1.31	0.22 ± 0.10	1.47 ± 0.44
560	820	0.86 ± 0.28	<0.18	2.58 ± 1.54	0.54 ± 0.16	0.85 ± 0.43
560	900	0.88 ± 0.26	0.59 ± 0.38	1.59 ± 2.50	0.64 ± 0.19	1.13 ± 0.46
560	980	0.59 ± 0.21	<0.28	2.99 ± 2.12	0.74 ± 0.16	0.89 ± 0.36
560	1060	1.39 ± 0.33	<0.37	4.81 ± 2.77	0.59 ± 0.13	1.18 ± 0.72
560	1140	0.85 ± 0.28	<0.20	2.61 ± 0.84	0.98 ± 0.17	0.97 ± 0.15
560	1220	c	c	c	c	c
635	480	1.00 ± 0.35	<0.33	<1.07	0.18 ± 0.09	1.63 ± 0.43
635	572	0.76 ± 0.23	<0.17	0.63 ± 1.08	<0.04	0.81 ± 0.40
635	665	1.16 ± 0.53	<0.29	1.66 ± 1.20	<0.06	1.01 ± 0.69
635	725	0.88 ± 0.29	<0.22	<0.72	0.09 ± 0.11	0.96 ± 0.32
640	820	0.88 ± 0.25	<0.28	1.51 ± 1.17	0.74 ± 0.16	0.85 ± 0.48
640	900	0.63 ± 0.23	<0.36	3.93 ± 1.40	0.56 ± 0.11	1.23 ± 0.43
640	980	0.79 ± 0.21	<0.20	1.04 ± 1.31	0.82 ± 0.13	0.68 ± 0.46
640	1060	0.94 ± 0.30	<0.21	2.70 ± 1.65	0.75 ± 0.13	1.07 ± 0.30
640	1140	0.80 ± 0.33	<0.22	1.50 ± 2.00	<0.07	0.71 ± 0.42
640	1220	c	c	c	c	c
668	900	1.36 ± 0.25	<0.31	3.29 ± 1.15	0.06 ± 0.05	1.69 ± 0.49
668	980	5.74 ± 0.93	<0.53	5.15 ± 5.68	0.34 ± 0.23	1.88 ± 0.82
668	1060	1.23 ± 1.05	<0.66	6.65 ± 3.14	0.27 ± 0.30	<0.52
668	1140	1.05 ± 0.29	<0.23	4.24 ± 0.94	0.90 ± 0.19	0.99 ± 0.34
668	1220	c	c	c	c	c

<sup>a</sup> Errors are 2σ based on counting statistics.<sup>b</sup> Grid point location is on property N'-North; sample results are included in the report on that property.<sup>c</sup> No sample collected due to presence of surface water or other obstruction.

TABLE 5

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

Sample No.	Sample ID	Grid Location <sup>a</sup>		Radionuclide Concentrations (pCi/g) <sup>b</sup>					
				Ra-226	U-235	U-238	Ce-137	Th-232	
B1	Rock	30	156	210 ± 14 <sup>c</sup>	40.1 ± 14.3	540 ± 32	<1.07	76.3 ± 11.1	
B2	Soil	250	101	29.8 ± 1.9	<1.00	1.46 ± 4.36	<0.16	<0.55	
B3	Soil	516	1060	2.73 ± 0.76	3.71 ± 1.50	62.6 ± 5.5	1.78 ± 0.33	0.70 ± 0.72	
B4	Soil (yellowcake)	664	900	<1.75	310 ± 13	21,000 ± 60	<0.70	<1.80	

<sup>a</sup> Refer to Figure 8.

<sup>b</sup> Refer to Table 3 for direct radiation levels.

<sup>c</sup> Errors are 2σ based on counting statistics.

TABLE 6  
RADIONUCLIDE CONCENTRATIONS IN BOREHOLE SOIL SAMPLES

Borehole No. <sup>a</sup>	Grid Location		Depth (m)	Radionuclide Concentrations (pCi/g)				
	N	E		Ra-226	U-235	U-238	Cs-137	Th-232
H1	0	101	Surface	0.72 ± 0.24 <sup>b</sup>	<0.19	<0.66	<0.04	0.94 ± 0.39
			0.5	1.05 ± 0.44	<0.33	0.86 ± 2.82	0.08 ± 0.10	1.20 ± 0.37
			2	1.08 ± 0.42	<0.21	1.11 ± 1.46	<0.04	0.82 ± 0.46
H2	1	480	Surface	1.15 ± 0.33	<0.28	1.15 ± 2.35	0.37 ± 0.16	1.47 ± 0.45
			0.5	1.08 ± 0.41	<0.31	<0.99	<0.06	1.27 ± 0.86
			1	1.22 ± 0.31	<0.36	<1.10	0.16 ± 0.09	0.88 ± 0.34
H3	240	107	Surface	1.23 ± 0.21	<0.21	1.64 ± 0.49	0.10 ± 0.08	0.73 ± 0.23
			0.5	1.23 ± 0.36	<0.26	1.57 ± 1.60	<0.06	0.97 ± 0.54
			1	1.02 ± 0.25	<0.24	1.57 ± 1.87	<0.03	1.40 ± 0.40
			6.4	1.62 ± 0.38	<0.44	2.94 ± 2.12	<0.06	1.73 ± 0.50
H4	280	420	Surface	1.01 ± 0.28	<0.19	3.33 ± 1.09	0.37 ± 0.14	1.49 ± 0.40
			0.5	0.63 ± 0.19	0.24 ± 0.53	1.64 ± 1.19	<0.03	0.91 ± 0.41
			1	1.00 ± 0.25	<0.40	<1.22	<0.05	1.52 ± 0.53
H5	180	1082	Surface	0.59 ± 0.22	<0.13	<0.31	1.33 ± 0.18	0.22 ± 0.31
			0.5	0.71 ± 0.31	<0.20	1.41 ± 1.76	<0.03	0.82 ± 0.35
			1	0.89 ± 0.21	<0.21	2.05 ± 1.46	<0.03	0.84 ± 0.29
			2	0.97 ± 0.25	<0.29	0.34 ± 1.68	<0.03	1.04 ± 0.28

<sup>a</sup> Refer to Figure 4.

<sup>b</sup> Errors are 2σ based on counting statistics.

TABLE 7  
RADIONUCLIDE CONCENTRATIONS IN WATER SAMPLES

Sample No.	Sample Type	Grid Location		Radionuclide Concentrations (pCi/l)	
		N	E	Gross Alpha	Gross Beta
W1	Surface <sup>a</sup>	183	100	6.34 $\pm$ 1.65 <sup>b</sup>	6.37 $\pm$ 1.35
W2	Surface <sup>a</sup>	288	360	7.16 $\pm$ 1.98	7.33 $\pm$ 1.63
W3	Surface <sup>a</sup>	0	1057	2.37 $\pm$ 1.30	6.00 $\pm$ 1.58

<sup>a</sup> Refer to Figure 5.

<sup>b</sup> Errors are 2 $\sigma$  based on counting statistics.

TABLE 8

RADIONUCLIDE CONCENTRATIONS IN SEDIMENT SAMPLES  
FROM DRAINAGE DITCHES

Sample No.	Grid Location <sup>a</sup>		Radionuclide Concentrations (pCi/g)				
	N	E	Ra-226	U-235	U-238	Cs-137	Th-232
SD1	288	360	$1.96 \pm 0.44^b$	<0.37	$3.37 \pm 2.84$	$2.36 \pm 0.31$	$1.42 \pm 0.71$
SD2	0	1057	$0.95 \pm 0.28$	<0.23	<0.81	$0.26 \pm 0.08$	$1.58 \pm 0.45$
SD3	516	1060	$2.73 \pm 0.76$	$3.71 \pm 1.50$	$62.6 \pm 5.5$	$1.78 \pm 0.33$	$0.70 \pm 0.72$

<sup>a</sup> Refer to Figure 5.

<sup>b</sup> Errors are  $2\sigma$  based on counting statistics.

TABLE 9

LISTING OF AREAS ON PROPERTY N-NORTH WHICH  
EXCEED RESIDUAL CONTAMINATION CRITERIA

Grid Location <sup>a</sup>		Radionuclides <sup>b</sup>	Estimated Quantities of Material Exceeding Guidelines			Remarks
N	E		Area (m <sup>2</sup> )	Depth (m)	Volume (m <sup>3</sup> )	
250	101	Ra-226, U-238	---	---	<1	Small isolated areas or individual pieces of contaminated material.
259	107	Ra-226, U-238	---	---	<1	
260	100	Ra-226, U-238	---	---	<1	
664	980	U-238	---	---	<1	

<sup>a</sup> Refer to Figure 9.

<sup>b</sup> Radionuclide identification is based on a combination of sample analyses, direct radiation levels, location, distribution, and physical characteristics.

## REFERENCES

1. E.A. Vierzba and A. Wallo, Background and Resurvey Recommendations for the Atomic Energy Commission Portion of the Lake Ontario Ordnance Works, Aerospace Corp., November 1982.
2. Health and Safety Research Division, Oak Ridge National Laboratory, Radiological Survey of a Portion of Property Owned by Modern Landfill, Inc. - Former LOOW Site - Summary Report, March 1981.
3. J.D. Berger, et al., Post Remedial Action Survey, Property of Modern Landfill, Inc., Former LOOW Site, Lewiston, New York - Final Report, Radiological Site Assessment Program, Manpower Education, Research, and Training Division, ORAU, Oak Ridge, TN, 1982.
4. F.F. Haywood, et al., Remedial Action and Radiological Surveys Conducted at Property Owned by Modern Landfill, Inc., Lewiston, New York - Formerly a Portion of the Lake Ontario Ordnance Works, Eberline Instrument Corporation, December 1981.
5. C. Begley, et al., Final Report on the Radiological Survey Conducted on Modern Landfill, Inc.'s Property in March 1982, Eberline Instrument Corporation, May 1982.
6. Oak Ridge Operations, U.S. Atomic Energy Commission, Radiation Survey and Decontamination Report of the Lake Ontario Ordnance Works Site, Oak Ridge, TN, January 1973.
7. T.E. Myrick, et al., Preliminary Results of the Ground-Level Gamma-Ray Scan Survey of the Former Lake Ontario Ordnance Works Site - Draft Report, ORNL, Oak Ridge, TN, 1981.



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 locations on the Niagara Falls Storage Site 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 was 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 and Sediment Sample Analysis

### Gamma Spectrometry

Soil and sediment 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

### Water Sample Analysis

Water samples were rough-filtered through Whatman No. 2 filter paper. Remaining suspended solids were removed by subsequent filtration through 0.45  $\mu$ m membrane filters. The filtrate was acidified by addition of 10 ml of concentrated nitric acid. A known volume of each sample was evaporated to dryness and counted for gross alpha and gross beta using a Tennelec Model LB 5100 low-background proportional counter.

### 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 operations 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

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

(Review Within DOE Continuing)

Presented here are the residual contamination cleanup and waste control guidelines of general applicability to the FUSRAP project and remote SFMP sites<sup>1/</sup>. A site-specific analysis will be prepared for each FUSRAP and remote SFMP site prior to determining residual contamination guidelines for a specific site. In addition, it is the policy of the DOE to decontaminate sites in a manner consistent with DOE's as-low-as-reasonably-achievable (ALARA) policy. ALARA will be considered in reducing levels of residual contamination below applicable dose limits. ALARA will be implemented using cost/benefit considerations, and applied on a site-specific basis.

The soil residual contamination guidelines 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 radium-226 and thorium-230 guidelines include an additional limitation for buildup of radon-222 decay products in buildings. The aggregate of the contribution from all major pathways, based on scenarios for permanent intrusion, e.g., establishing residences on the site, was assumed. In most circumstances, the probability is low that such an intrusion will occur. Also, conservative assumptions were used in deriving these guidelines to ensure that a particular dose limit would not be exceeded. Use of these guidelines is additionally conservative because the pathways considered in the derivation of the guidelines assume all water intake and most food intake is from the site. Also, the FUSRAP and remote SFMP 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 or remote SFMP sites decontaminated to these guidelines will not be appreciably different from that normally received from natural background radiation.

The residual contamination guidelines for surface contamination of structures were adapted from guidelines developed by the U. S. Nuclear Regulatory Commission (NRC) for decontamination of facilities and equipment prior to release for unrestricted use or termination of licenses for byproduct, source, or special nuclear material<sup>2/</sup>. The waste control guidelines are consistent with applicable DOE Orders and EPA's regulations for inactive uranium milling sites, 40 CFR Part 192.

---

<sup>1/</sup>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.

- <sup>2/</sup> U. S. Nuclear Regulatory Commission 1982 Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material. Division of Fuel Cycle and Material Safety, Washington, DC.

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

The following guidelines 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. A site-specific analysis will be prepared for each site prior to determining residual contamination guidelines for a specific site. 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 on a site-specific basis. Site-specific guidelines and ALARA policy will be determined by DOE on a site-specific basis and an ALARA report filed on completion of remedial action at a site. Existing state and federal standards will be applied for water protection. Residual contamination limits for other nuclides will be developed when required using the same methodology<sup>1/</sup> as was used for those represented here.

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

<u>Radionuclide</u>	<u>Soil Criteria<sup>2/,3/,4/</sup> (pCi/g above background)</u>
U-Natural <sup>5/</sup>	75
U-238 <sup>6/</sup>	150
U-234 <sup>6/</sup>	150
Th-230 <sup>7/</sup>	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 <sup>6/</sup>	140
Pa-231	40
Ac-227	190
Th-232	15
Am-241	60
Pu-241 <sup>8/</sup>	2400
Pu-238, 239, 240	300
Cs-137	80

Sr-90  
H-3 (pCi/ml soil moisture)

300  
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 guideline 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 guidelines represent unrestricted-use residual concentrations above background averaged across any 15 cm thick layer to any depth and over any contiguous 100 m<sup>2</sup> 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 guidelines are allowable provided that the average over 100 m<sup>2</sup> is not exceeded. However, DOE ALARA policy will be considered on a site-specific basis when dealing with elevated localized concentrations.

5/ A curie of natural uranium means the sum of  $3.7 \times 10^{10}$  disintegrations per second (dis/s) over any 15cm thick layers from U-238 plus  $3.7 \times 10^{10}$  dis/s from U-234 plus  $1.7 \times 10^9$  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 guideline was derived from the Am-241 concentration.

## 2. Structure Guidelines (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 R/h) above background in any occupied or habitable building.

c. Indoor/Outdoor Structure Surface Contamination

Radionuclides <sup>2/</sup>	Allowable Surface Residual Contamination <sup>+1</sup> (dpm/100 cm <sup>2</sup> )		
	Average <sup>3/,4/</sup>	Maximum <sup>4/,5/</sup>	Removable <sup>4/,6/</sup>
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100	300	20
U-Natural, Th-232, Sr-90, Fr-223, Ra-224, U-232, I-126, I-131, I-133	1,000	3,000	200
U-Natural, U-235, U-238, and associated decay products	5,000	15,000	1,000
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above	5,000	15,000	1,000

<sup>1/</sup> As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

<sup>2/</sup> Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides shall apply independently.

<sup>3/</sup> Measurements of average contaminant should not be averaged over more than 1 m<sup>2</sup>. For objects of less surface area, the average shall be derived for each such object.

<sup>4/</sup> The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should

not exceed 0.2 mrad/h at 1 cm and 1.0 mrad/h at 1 cm, respectively, measured through not more than 7 mg/cm<sup>2</sup> of total absorber.

5/ The maximum contamination level applies to an area of not more than 100 cm<sup>2</sup>.

6/ The amount of removable radioactive material per 100 cm<sup>2</sup> of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels shall be reduced proportionately and the entire surface shall be wiped.

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

Specified here are the control requirements for radioactive wastes and residues related to the nuclear fuel cycle at FUSRAP and remote SFMP sites. It is the policy of DOE to store radioactive wastes in a manner representing sound engineering practices consistent with DOE's ALARA policy.

### 1. Interim Storage

All operational and control requirements specified in the following DOE Orders and other items 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. 5820, Radioactive Waste Management.
- g. 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.
- h. 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).

1. 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<sup>2</sup>/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 requirement 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 requirements 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

Exceptions may be made to the guidelines presented herein following analysis of the site-specific aspects of a candidate site. Specific situations that warrant consideration for modifying these guidelines are:

1. Where remedial actions would pose a clear and present risk of injury to workers or members of the public, notwithstanding reasonable measures to avoid or reduce risk.
2. Where remedial actions would produce environmental harm that is clearly excessive compared to the health benefits to persons living on or near affected sites, now or in the future, notwithstanding reasonable measures to limit damage to the environment. A clear excess of environmental harm is harm that is long-term, manifest, and grossly disproportionate to health benefits that may reasonably be anticipated.

3. Where the cost of remedial actions for contaminated soil is unreasonably high relative to long-term benefits and the residual radioactive materials do not pose a clear present or future hazard. The likelihood that buildings will be erected or that people will spend long periods of time at such a site should be considered in evaluating this hazard. Remedial actions will generally not be necessary where residual radioactive materials have been placed semipermanently in a location where site-specific factors limit their hazard and from which they are costly or difficult to remove, or where only minor quantities of residual radioactive materials are involved. Examples are residual radioactive materials under hard surface public roads and sidewalks, around public sewer lines, or in fence-post foundations. Supplemental standards shall not be applied at such sites, however, if individuals are likely to be exposed for long periods of time to radiation from such materials at levels above those that would prevail in Subpart A.
4. Where the cost of cleanup of a contaminated building is clearly unreasonably high relative to the benefits. Factors that shall be included in this judgment are the anticipated period of occupancy, the incremental radiation level that would be affected by remedial actions, the residual useful lifetime of the building, the potential for future construction at the site, and the applicability of less costly remedial methods than removal of residual radioactive materials.
5. Where there is no known remedial action.

#### D. GUIDELINE SOURCE

<u>Guideline</u>	<u>Source</u>
<u>Residual Contamination Criteria<sup>1/</sup></u>	
Soil Guideline	DOE Order 5480.1A, 40 CFR Part 192 <sup>2/</sup>
Structure Guideline	40 CFR Part 192, NRC Guidelines for Decontamination of Facilities and Equip- ment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material (July 1982).
<u>Control of Radioactive Wastes and Residues</u>	
Interim Storage	DOE Order 5480.1A
Long-Term Management	40 CFR Part 192

---

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

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