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RESULTS OF RADIOLOGICAL MEASUREMENTS TAKEN IN THE NIAGARA FALLS, NEW YORK, AREA (NF002)

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MARTIN MARIETTA ENERGY SYSTEMS, INC.
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RESULTS OF RADIOLOGICAL MEASUREMENTS TAKEN IN THE NIAGARA FALLS, NEW YORK, AREA (NF002)

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CONTENTS

FIGURES v

TABLES vii

ACKNOWLEDGMENTS ix

ABSTRACT xi

INTRODUCTION 1

SURVEY METHODS 1

SURVEY RESULTS 1

GAMMA MEASUREMENTS 2

SOIL SAMPLING 3

SIGNIFICANCE OF FINDINGS 5

REFERENCES 9

FIGURES

1 Area surveyed during the mobile gamma scan of Niagara Falls, New York 11

2 Anomaly locations in the Lewiston–Lake Ontario Ordnance Works area 12

3 Anomaly locations in the Niagara Falls area 13

4 Anomaly locations in the Grand Island–Tonawanda area 14

5 Locations of soil samples in the Lewiston–Lake Ontario Ordnance Works area 15

6 Locations of soil samples in the Niagara Falls area 16

7 Locations of soil samples in the Grand Island–Tonawanda area 17

TABLES

1 Background radiation levels in the Niagara Falls area 19

2 Results of the gamma exposure rate measurements outdoors on the south side of Pletcher Road 20

3 Results of the gamma exposure rate measurements outdoors on the north side of Pletcher Road and south side of Old Pletcher Road 21

4 Results of the gamma exposure rate measurements outdoors in the Lewiston, New York, area 22

5 Results of the gamma exposure rate measurements outdoors northeast of Niagara Falls area 23

6 Results of the gamma exposure rate measurements outdoors in Grand Island–Tonawanda area 24

7 Results of the gamma exposure rate measurements outdoors Niagara Falls, New York 25

8 Results of biased soil sample analysis on the south side of Pletcher Road 27

9 Results of biased soil sample analysis on the north side of Pletcher Road and south side of Old Pletcher Road 28

10 Results of biased soil sample analysis in the Lewiston, New York, area 29

11 Results of biased soil sample analysis northeast of Niagara Falls area 30

12 Results of biased soil sample analysis in Grand Island–Tonawanda area 31

13 Results of biased soil sample analysis in Niagara Falls, New York 32

14 Summary of anomalies in the Niagara Falls, New York, area 34

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ABSTRACT

The results of a radiological survey of 100 elevated gamma radiation anomalies in the Niagara Falls, New York, area are presented in this report. These radiation anomalies were identified by a mobile gamma scanning survey during the period October 3-16, 1984, and were recommended for an onsite survey to determine if the elevated levels of radiation may be related to the transportation of radioactive waste material to the Lake Ontario Ordnance Works for storage. In this survey, radiological measurements included outdoor gamma exposure rates at 1 m above the surface; outdoor gamma exposure rates at the surface, range of gamma exposure rates during scan; and uranium, radium, and thorium concentrations in biased surface soil samples.

The results show 38 anomalies (35 located along Pletcher Road and 3 associated with other unrelated locations) were found to exceed Formerly Utilized Sites Remedial Action Program (FUSRAP) remedial action guidelines and were recommended for formal characterization surveys. (Since the time of this survey, remedial actions have been conducted on the 38 anomalies identified as exceeding FUSRAP guidelines, and the radioactive material above guidelines has been removed.) The remaining 62 anomalies are associated with asphalt driveways and parking lots, which used a phosphate slag material (previously identified as cyclowollastonite, synthetic $CaSiO_3$). This rocky-slag waste material was used for bedding under asphalt surfaces and in general gravel applications. Most of the contaminated soil and rock samples collected at the latter anomalies had approximately equal concentrations of ^{226}Ra and ^{238}U and, therefore, are not related to materials connected with the Niagara Falls Storage Site (NFSS), including material that was transported to the NFSS.

INTRODUCTION

A mobile gamma scanning survey was conducted of some streets in Niagara Falls, New York, and the surrounding area by the Radiological Survey Activities (RASA) group of Oak Ridge National Laboratory (ORNL) during the period October 3-16, 1984.[1] The area covered during the survey is shown in Fig. 1. The purpose of this mobile scanning survey was to identify all detectable gamma radiation anomalies that may be related to the transportation of radioactive waste material to the Lake Ontario Ordnance Works for storage. As a result of this activity, 100 anomalies in the Niagara Falls, New York, area were identified as having elevated levels of radiation and were recommended for onsite surveys. Three anomalies (#47, #51, and #87), located at the junction of Highways 18 and 104 (ORNL/RASA-85/40),[2] Highway 31 and Military Road (ORNL/RASA-85/42),[3] and Buffalo Avenue and Hyde Park Boulevard (ORNL/RASA-85/41),[4] respectively, have been previously reported to exceed U.S. Department of Energy (DOE) Formerly Utilized Sites Remedial Action Program (FUSRAP) remedial action guidelines.[5] The ORNL survey of both sides of Pletcher Road was only a confirmatory survey, as the area had been previously surveyed by Oak Ridge Associated Universities (ORAU).[6] Anomalies 1 through 23 (south side of Pletcher Road), 24 through 33 (north side of Pletcher Road), and 34 through 35 (south side of Old Pletcher Road) have been remediated.

Radiological surveys were performed at the 100 anomalies by members of the RASA group at ORNL during the period July 15-17, 1985. Anomaly locations are shown in Figs. 2, 3, and 4. The purpose of the radiological surveys at these anomalies is to determine if contaminated materials are present, and, if so, to determine if they are in excess of remedial action guidelines established for the Niagara Falls Storage Site (NFSS) in FUSRAP. This report provides the radiological survey results of the 100 anomalies identified by the mobile gamma scanning van.

SURVEY METHODS

Radiological surveys of these anomalies included: (1) gamma exposure rates, (2) a gamma scan of the entire ground surface outdoors, and (3) samples of outdoor soil. A comprehensive description of the survey methods and instrumentation has been presented in another report.[7]

SURVEY RESULTS

Typical background radiation levels for the Niagara Falls area are presented in Table 1. The data are provided for purposes of comparison with the survey results presented in this section.

All measurements presented in this report are gross readings; background radiation levels have not been subtracted. Similarly, background concentrations have not been subtracted from radionuclide concentrations in soil samples.

GAMMA MEASUREMENTS

South Side of Pletcher Road

Results of gamma exposure rate measurements taken at 23 anomalies on the south side of Pletcher Road are presented in Table 2. Generally, the gamma exposure rates scanned 23 to 86 μR/h (microroentgens* per hour) in a 3-ft (0.9-m) wide band along the edge of the pavement, and 11 to 17 μR/h along a 3-ft (0.9-m) wide band from the pavement to the ditch. Gamma exposure rates at 1 m above the ground surface ranged from 11 to 23 μR/h and averaged 16 μR/h. Gamma exposure rates at the ground surface ranged from 29 to 230 μR/h and averaged 59 μR/h. The maximum gamma exposure rate (230 μR/h) was measured at 8960 feet (2688 m), scanning east from Creek Road (anomaly #23).

North Side of Pletcher Road and South Side of Old Pletcher Road

Results of gamma exposure rate measurements taken at 12 anomalies on the north side of Pletcher Road and south side of Old Pletcher Road are presented in Table 3. Generally, the gamma exposure rates on the north side of Pletcher Road scanned 20 to 57 μR/h in a 2-ft (0.6-m) wide band along the edge of the pavement, and 9 to 17 μR/h along a 2-ft (0.6-m) wide band from the pavement to the ditch. Gamma exposure rates at 1 m above the ground surface ranged from 17 to 23 μR/h and averaged 19 μR/h. Gamma exposure rates at the ground surface ranged from 29 to 77 μR/h and averaged 41 μR/h. The maximum gamma exposure rate measured (77 μR/h) was found on the south side of Old Pletcher Road 570 feet (171 m) east of the KOA entrance (anomaly #35).

Lewiston, New York, Area

Gamma measurements were taken at 12 anomalies located in the Lewiston, New York, area as noted in Table 4. Gamma exposure rates at 1 m above the ground surface ranged from 11 to 200 μR/h and averaged 35 μR/h. Gamma exposure rates at the ground surface ranged from 29 to 710 μR/h and averaged 106 μR/h. The maximum gamma exposure rate measured (710 μR/h) was found in a small area approximately 10 ft wide (3 m) by 59 ft (18 m) in length along a ditch and gravel driveway at 738 Upper Mountain Road (anomaly #43).

Northeast of Niagara Falls Area

Results of gamma exposure rate measurements taken at 12 anomalies northeast of Niagara Falls are presented in Table 5. Gamma exposure rates at 1 m above the ground surface ranged from 16 to 49 μR/h and averaged 28 μR/h. Gamma exposure rates at the ground surface ranged from 26 to 140 μR/h and averaged 57 μR/h. The maximum gamma exposure rate, 140 μR/h, was found in the southwest corner of a residential asphalt driveway, averaging 10 ft wide (3 m) by 13 ft (4 m) in length, at 2924 Military Road (anomaly #52).

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*The roentgen (R) is a unit which was defined for radiation protection purposes for people exposed to penetrating x rays or gamma radiation. A microroentgen (μR) is one millionth of a roentgen. A milliroentgen (mR) is one thousandth of a roentgen or one thousand microroentgens.

Grand Island–Tonawanda Area

Results of gamma exposure rate measurements taken at six anomalies in the Grand Island–Tonawanda area are presented in Table 6. Gamma exposure rates at 1 m above the ground surface ranged from 9 to 34 μR/h and averaged 23 μR/h. Gamma exposure rates at the ground surface ranged from 17 to 140 μR/h and averaged 57 μR/h. The maximum gamma exposure rate (160 μR/h) was measured in a culvert northeast of 3060 Grand Island Boulevard (anomaly #63).

Niagara Falls, New York, Area

Gamma measurements were taken at 35 identified anomalies located in the Niagara Falls, New York, area as noted in Table 7. Gamma exposure rates at 1 m above the ground surface ranged from 9 to 86 μR/h and averaged 26 μR/h. Gamma exposure rates at the ground surface ranged from 17 to 160 μR/h and averaged 60 μR/h. The maximum gamma exposure rate (160 μR/h) was measured at the surface of a gravel driveway at 6901 Buffalo Avenue, region #4 (anomaly #81).

SOIL SAMPLING

Sixty soil samples were taken at 53 anomalies. These biased samples were selected from positions having elevated gamma exposure rates. The locations of the samples are shown in Figs. 5, 6, and 7, and the results of analysis are presented in Tables 8 through 14. Single soil samples were taken from the surface (0-15 cm) at areas of elevated gamma radiation. In many instances, a sample could not be taken because the ground was too dry and rocky or the anomaly was associated with asphalt pavement.

South Side of Pletcher Road

The concentration of ^{226}Ra in 13 soil samples taken on the south side of Pletcher Road ranged from 12 to 430 pCi/g (picocuries* per gram) and averaged 79 pCi/g. The maximum concentration of ^{226}Ra in soil (430 pCi/g) was sampled at anomaly #23, approximately 8960 ft (2688 m) east from Creek Road (NF002B1). Uranium concentrations in the soil ranged from 1.1 to 5.0 pCi/g and averaged 2.3 pCi/g. The maximum concentration of ^{238}U (5.0 pCi/g) was also found at anomaly #23 (NF002B1). Concentrations as high as 4.1 pCi of ^{232}Th per gram of soil were sampled at anomaly #23 (NF002B1).

North Side of Pletcher Road and South Side of Old Pletcher Road

The concentration of ^{226}Ra in seven soil samples taken on the north side of Pletcher Road and south side of Old Pletcher Road ranged from 23 to 120 pCi/g and averaged 47 pCi/g. The maximum concentration of ^{226}Ra in soil (120 pCi/g) was sampled at anomaly #35, south of Old Pletcher Road, approximately 570 ft (171 m) east of the KOA entrance

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*The curie is a unit used to define the radioactivity in a substance and equals that quantity of any radioactive isotope undergoing 2.2 x 10^{12} disintegrations per minute. The picocurie is one million-millionth of a curie, or that amount yielding 2.2 disintegrations per minute.

(NF002B5). Uranium concentrations in the soil ranged from 1.3 to 3.0 pCi/g and averaged 1.8 pCi/g. The maximum concentration of ^{238}U (3.0 pCi/g) was also found at anomaly #35 (NF002B5). Concentrations as high as 1.2 pCi of ^{232}Th per gram of soil were sampled at anomaly #26, north of Pletcher Road, approximately 1298 ft (389 m) west from Harold Road (NF002B4).

Lewiston, New York, Area

The concentration of ^{226}Ra in nine soil samples taken in the Lewiston, New York, area ranged from 6.0 to 180 pCi/g and averaged 42 pCi/g. The maximum concentration of ^{226}Ra in soil (180 pCi/g) was sampled at anomaly #47, at the junction of Highways 18 and 104 (ORNL/RASA-85/40)[2] (NF002B53). Uranium concentrations in the soil ranged from 1.0 to 70 pCi/g and averaged 18 pCi/g. The maximum concentration of ^{238}U (70 pCi/g) was found at anomaly #43, 738 Upper Mountain Road (NF002B55). Concentrations as high as 560 pCi of ^{232}Th per gram of soil were also sampled at anomaly #43 (NF002B55).

Northeast of Niagara Falls Area

The concentration of ^{226}Ra in 12 soil samples taken northeast of Niagara Falls ranged from 1.2 to 40 pCi/g and averaged 14 pCi/g. The maximum concentration of ^{226}Ra in soil (40 pCi/g) was sampled at anomaly #51, Military Road approximately 400 ft (120 m) north of Highway 31 (ORNL/RASA-85/42)[3] (NF002B33). Uranium concentrations in the soil ranged from 1.1 to 33 pCi/g and averaged 10 pCi/g. The maximum concentration of ^{238}U (33 pCi/g) was sampled at anomaly #54, Walter S. Kozdranski Co., Inc., 1865 3rd Avenue (NF002B48). Concentrations as high as 45 pCi of ^{232}Th per gram of soil were found at anomaly #52, 2924 Military Road (NF002B30).

Grand Island–Tonawanda Area

The concentration of ^{226}Ra in seven soil samples taken in the Grand Island–Tonawanda area ranged from 1.4 to 25 pCi/g and averaged 6.3 pCi/g. Uranium concentrations in the soil ranged from 1.2 to 26 pCi/g and averaged 6.3 pCi/g. The maximum concentrations of ^{226}Ra (25 pCi/g), ^{232}Th (39 pCi/g), and ^{238}U (26 pCi/g) in soil were sampled at anomaly #63, 3060 Grand Island Boulevard (NF002B43).

Niagara Falls, New York, Area

The concentration of ^{226}Ra in 12 soil samples taken in the Niagara Falls, New York, area ranged from 4.1 to 150 pCi/g and averaged 37 pCi/g. The maximum concentration of ^{226}Ra in soil (150 pCi/g) was sampled at anomaly #87, near the junction of Buffalo Avenue and Hyde Park Boulevard (ORNL/RASA-85/41)[4] (NF002B24). Uranium concentrations in the soil ranged from 3.7 to 52 pCi/g and averaged 22 pCi/g. The maximum concentration of ^{238}U (52 pCi/g) was sampled at anomaly #81, 6901 Buffalo Avenue (Region #1, NF002B25A). Concentrations as high as 20 pCi of ^{232}Th per gram of soil were found at anomaly #91, 2434 Willow Avenue (NF002B46).

SIGNIFICANCE OF FINDINGS

As a result of the ORNL onsite survey of 100 anomalies in the Niagara Falls, New York, area, three anomalies (#47, #51, and #87), located at the junctions of Highways 18 and 104 (ORNL/RASA-85/40),[2] Highway 31 and Military Road (ORNL/RASA-85/42),[3] and Buffalo Avenue and Hyde Park Boulevard (ORNL/RASA- 85/41),[4] were found to exceed FUSRAP remedial action guidelines and were recommended for formal radiological characterization surveys.[5] These anomalies, in addition to the 35 anomalies located along Pletcher Road, have been remediated.

The remaining 62 anomalies do not result from materials connected with NFSS. Contaminated rocks at several anomalies appeared to be a porous, slag material (previously identified as cyclowollastonite, CaSiO3).[8] This rocky-slag waste material was once involved in the electrochemical production of elemental phosphorous using uranium-bearing raw materials and reportedly originated from the former Oldbury Furnace in Niagara Falls, New York. Previous radiological surveys in the greater Niagara Falls, New York, area have revealed that this material was used for bedding under asphalt surfaces and for general gravel applications.[9]

Essentially all the contaminated soil and rock samples collected had approximately equal concentrations of ^{226}Ra and ^{238}U. This indicates that ^{226}Ra and ^{238}U are nearly in secular equilibrium and, furthermore, suggests that the rocks probably originated from a singular source. Thorium-232 in this latter slag or rock is believed (from previous analysis) to be tied up in monazite inclusions in the material.[10] The origin of this thorium-bearing material is unknown, but possibly was from some type of mineral extraction in the Niagara Falls area.[10] Five anomalies are attributable to slag material with elevated amounts of thorium: anomaly #42 (789 Upper Mt. Road), anomaly #43 (738 Upper Mt. Road), anomaly #52 (2924 Military Road), anomaly #63 (3060 Grand Island Blvd.), and anomaly #91 (2434 Willow Avenue).

SOUTH SIDE OF PLETCHER ROAD

Measurements of the gamma exposure levels outdoors at 23 anomalies determined that the exposure rate at 1 m above the ground surface ranged from 11 to 23 μR/h and averaged 16 μR/h. For comparison, the typical background for the Niagara Falls, New York, area is 9 μR/h, and the background for the state of New York[11,12] averages 9.5 μR/h and ranges from 6.8 to 13 μR/h (one standard deviation) based on 51 measurements. Thirteen soil samples taken from anomalies in this area had concentrations of ^{226}Ra in excess of 93 times average background levels, while the ^{238}U concentration was 2.4 times average background levels.

The ratio of ^{226}Ra to ^{238}U activity is consistent with contaminated material originating from the NFSS. The concentration of these nuclides at the identified anomalies was found to be in excess of relevant FUSRAP remedial action guidelines[5] (i.e., the weighted average in excess of 5 pCi/g of ^{226}Ra over 100 m^2 in the upper 15 cm of soil).

NORTH SIDE OF PLETCHER ROAD AND SOUTH SIDE OF OLD PLETCHER ROAD

Measurements of the gamma exposure levels outdoors at 12 anomalies determined that the exposure rate at 1 m above the ground surface ranged from 17 to 23 μR/h and averaged 19 μR/h. For comparison, the typical background for the Niagara Falls, New York, area is 9 μR/h, and the background for the state of New York[11,12] averages 9.5 μR/h and ranges from 6.8 to 13 μR/h (one standard deviation) based on 51 measurements. Seven soil samples taken from anomalies in this area had concentrations of ^{226}Ra in excess of 55 times average background levels, while the ^{238}U concentration was 1.9 times average background levels.

The ratio of ^{226}Ra to ^{238}U activity is consistent with contaminated material originating from the NFSS. The concentration of these nuclides at the identified anomalies were found to be in excess of relevant FUSRAP remedial action guidelines[5] (i.e., the weighted average in excess of 5 pCi/g of ^{226}Ra over 100 m^2 in the upper 15 cm of soil).

LEWISTON, NEW YORK, AREA

Measurements of the gamma exposure levels outdoors at 12 anomalies determined that the exposure rate at 1 m above the ground surface ranged from 11 to 200 μR/h and averaged 35 μR/h. For comparison, the typical background for the Niagara Falls, New York, area is 9 μR/h, and the background for the state of New York[11,12] averages 9.5 μR/h and ranges from 6.8 to 13 μR/h (one standard deviation) based on 51 measurements. Nine soil samples taken from anomalies in this area had concentrations of ^{226}Ra in excess of 49 times average background levels, while the ^{238}U concentration was 19 times average background levels.

With the exception of anomaly #47 (junction of Highways 18 and 104, ORNL/RASA-85/40),[2] which has been previously reported to exceed FUSRAP remedial action guidelines,[5] soil analyses indicate that ^{226}Ra and ^{238}U concentrations were approximately equal. The anomalies from this region are associated with phosphate slag material used as bedding for asphalt driveways and fill applications and are not related to materials connected with the NFSS, including material that was transported to the NFSS.

NORTHEAST OF NIAGARA FALLS AREA

Measurements of the gamma exposure levels outdoors at 12 anomalies determined that the exposure rate at 1 m above the ground surface ranged from 16 to 49 μR/h and averaged 28 μR/h. For comparison, the typical background for the Niagara Falls, New York, area is 9 μR/h, and the background for the state of New York[11,12] averages 9.5 μR/h and ranges from 6.8 to 13 μR/h (one standard deviation) based on 51 measurements. Twelve soil samples taken from anomalies in this area had concentrations of ^{226}Ra in excess of 16 times average background levels, while the ^{238}U concentration was 10 times average background levels.

With the exception of anomaly #51 (near junction of Highway 31 and Military Road, ORNL/RASA-85/42),[3] which has been previously reported to exceed FUSRAP remedial action guidelines,[5] soil analyses indicate that ^{226}Ra and ^{238}U concentrations were approximately equal. Anomalies from this area are associated with phosphate slag material used as bedding for asphalt driveways and fill applications and are not related to materials connected with the NFSS, including material that was transported to the NFSS.

GRAND ISLAND–TONAWANDA AREA

Measurements of the gamma exposure levels outdoors at six anomalies determined that the exposure rate at 1 m above the ground surface ranged from 9 to 34 μR/h and averaged 23 μR/h. For comparison, the typical background for the Niagara Falls, New York, area is 9 μR/h, and the background for the state of New York[11,12] averages 9.5 μR/h and ranges from 6.8 to 13 μR/h (one standard deviation) based on 51 measurements. Seven soil samples taken from anomalies in this area had concentrations of ^{226}Ra in excess of 7.4 times average background levels, while the ^{238}U concentration was 6.6 times average background levels.

Soil analyses indicate that ^{226}Ra and ^{238}U concentrations were approximately equal. Anomalies from this region are associated with phosphate slag material used as bedding for asphalt driveways and fill applications and are not related to materials connected with the NFSS, including material that was transported to the NFSS.

NIAGARA FALLS, NEW YORK, AREA

Measurements of the gamma exposure levels outdoors at 32 anomalies determined that the exposure rate at 1 m above the ground surface ranged from 9 to 86 μR/h and averaged 26 μR/h. For comparison, the typical background for the Niagara Falls, New York, area is 9 μR/h, and the background for the state of New York[11,12] averages 9.5 μR/h and ranges from 6.8 to 13 μR/h (one standard deviation) based on 51 measurements. Twelve soil samples taken from anomalies in this area had concentrations of ^{226}Ra in excess of 44 times average background levels, while the ^{238}U concentration was 23 times average background levels.

With the exception of anomaly #87 (near junction of Buffalo Avenue and Hyde Park Boulevard, ORNL/RASA-85/41),[4] which has been previously reported to exceed FUSRAP remedial action guidelines,[5] soil analyses indicate that ^{226}Ra and ^{238}U concentrations were approximately equal. The anomalies from this region are similarly associated with phosphate slag material used as bedding for asphalt driveways and fill applications and are not related to materials connected with the NFSS, including material that was transported to the NFSS.

NOTE: Since the time of this survey, remedial actions have been conducted on the 38 anomalies identified as exceeding FUSRAP guidelines, and the radioactive material above guidelines has been removed.

REFERENCES

1. W. H. Shinpaugh, B. A. Berven, and W. D. Cottrell, *Results of the Mobile Gamma Scanning Activities in Niagara Falls, New York Area,* Oak Ridge National Laboratory, ORNL/RASA-85/1 (August 1985).
2. B. A. Berven, *Results of Radiological Measurements Taken at Junction of Highways 18 and 104 in Niagara Falls, New York,* Oak Ridge National Laboratory, ORNL/RASA-85/40 (December 1985).
3. B. A. Berven, *Results of Radiological Measurements Taken near Junction of Highway 31 and Military Road in Niagara Falls, New York,* Oak Ridge National Laboratory, ORNL/RASA-85/42 (December 1985).
4. B. A. Berven, *Results of Radiological Measurements Taken near Junction of Buffalo Avenue and Hyde Park Blvd. in Niagara Falls, New York,* Oak Ridge National Laboratory, ORNL/RASA-85/41 (December 1985).
5. U.S. Department of Energy, *U.S. Department of Energy Guidelines for Residual Radioactivity at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites,* (Rev. 1, July 1985).
6. Personal communication, J. D. Berger, Oak Ridge Associated Universities, P. O. Box 117, Oak Ridge, TN 37831.
7. T. E. Myrick, B. A. Berven, W. D. Cottrell, W. A. Goldsmith, and F. F. Haywood, *Procedures Manual for the Remedial Action Survey and Certification Activities (RASCA) Program,* Oak Ridge National Laboratory, ORNL/TM-8600 (September 1982).
8. W. D. Cottrell, D. J. Christian, and F. F. Haywood, *Ground-Level Investigation of Anomalous Radiation Levels in Niagara Falls, New York,* Oak Ridge National Laboratory, unpublished report (June 1979).
9. W. D. Cottrell, T. E. Myrick, W. H. Shinpaugh, and F. F. Haywood, *Ground-Level Investigation of Anomalous Gamma Radiation Levels in the Tonawanda, New York, Area,* Oak Ridge National Laboratory, unpublished report (January 1980).
10. U.S. Department of Energy, *Exploratory Aerial and Ground Level Radiological Survey of the Niagara Falls Area, Niagara Falls, New York,* Formerly Utilized MED/AEC Sites Remedial Action Program, July 1979.
11. S. G. Levin, R. K. Stoms, E. Kuerze, and W. Huskisson, "Summary of Natural Environmental Gamma Radiation Using a Calibrated Portable Scintillation Counter," *Radiological Health Data Report* 9:679-695 (1968).
12. C. L. Lindekin, K. R. Peterson, D. E. Jones, and R. E. McMillen, "Geographic Variations in Environmental Radiation Background in the United States," *Proceedings of the Second International Symposium on the Natural Radiation Environment,* CONF-720805-P-1, pp. 317-331 (1972).
13. T. E. Myrick, B. A. Berven, and F. F. Haywood, *State Background Radiation Levels: Results of Measurements Taken During 1975-1959,* ORNL/TM-7343 (November 1981).

ORNL-DWG 86-11613

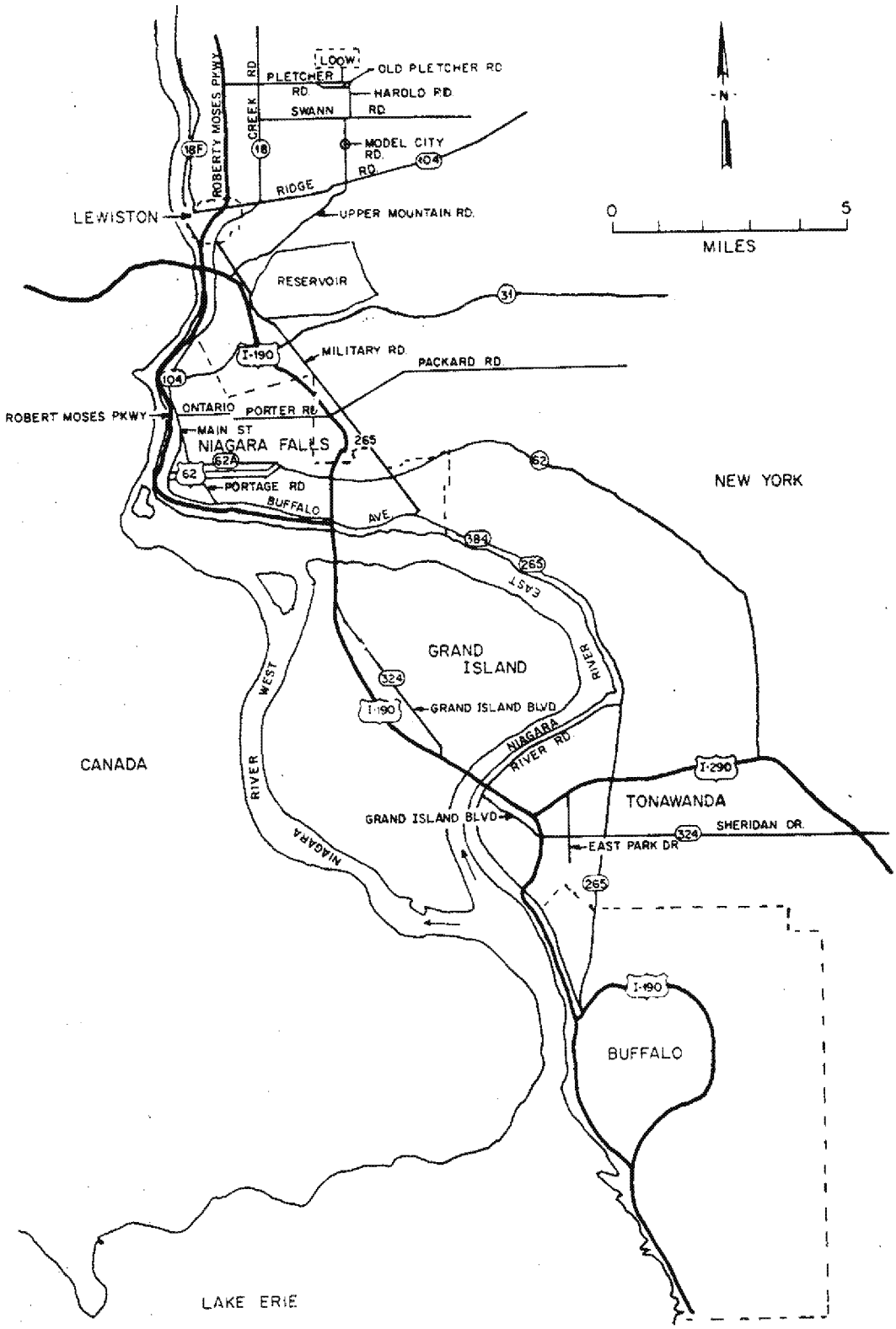

Fig. 1. Area surveyed during the mobile gamma scan of Niagara Falls, New York.

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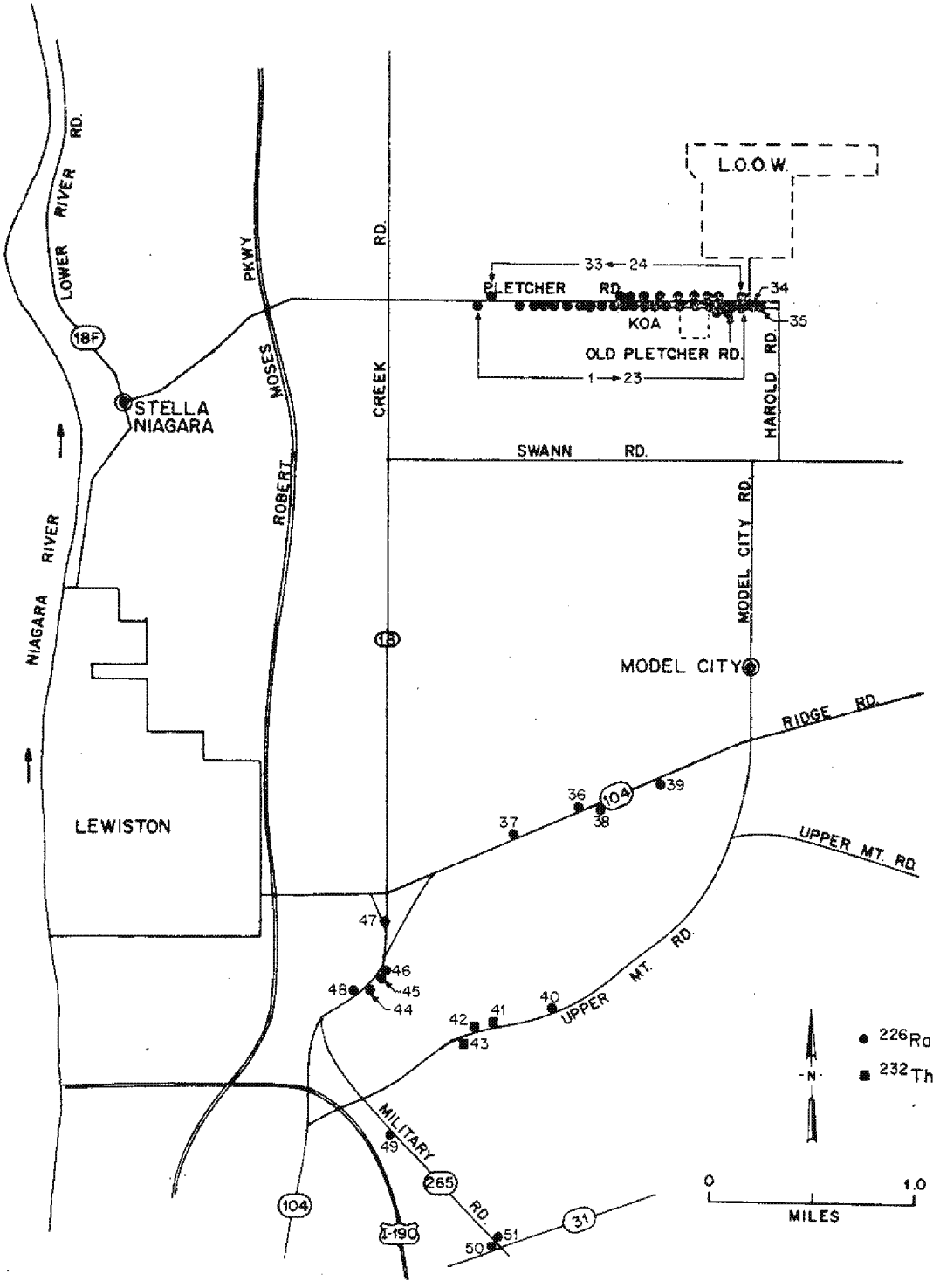

Fig. 2. Anomaly locations in the Lewiston–Lake Ontario Ordnance Works area.

ORNL-DWG 86-11615

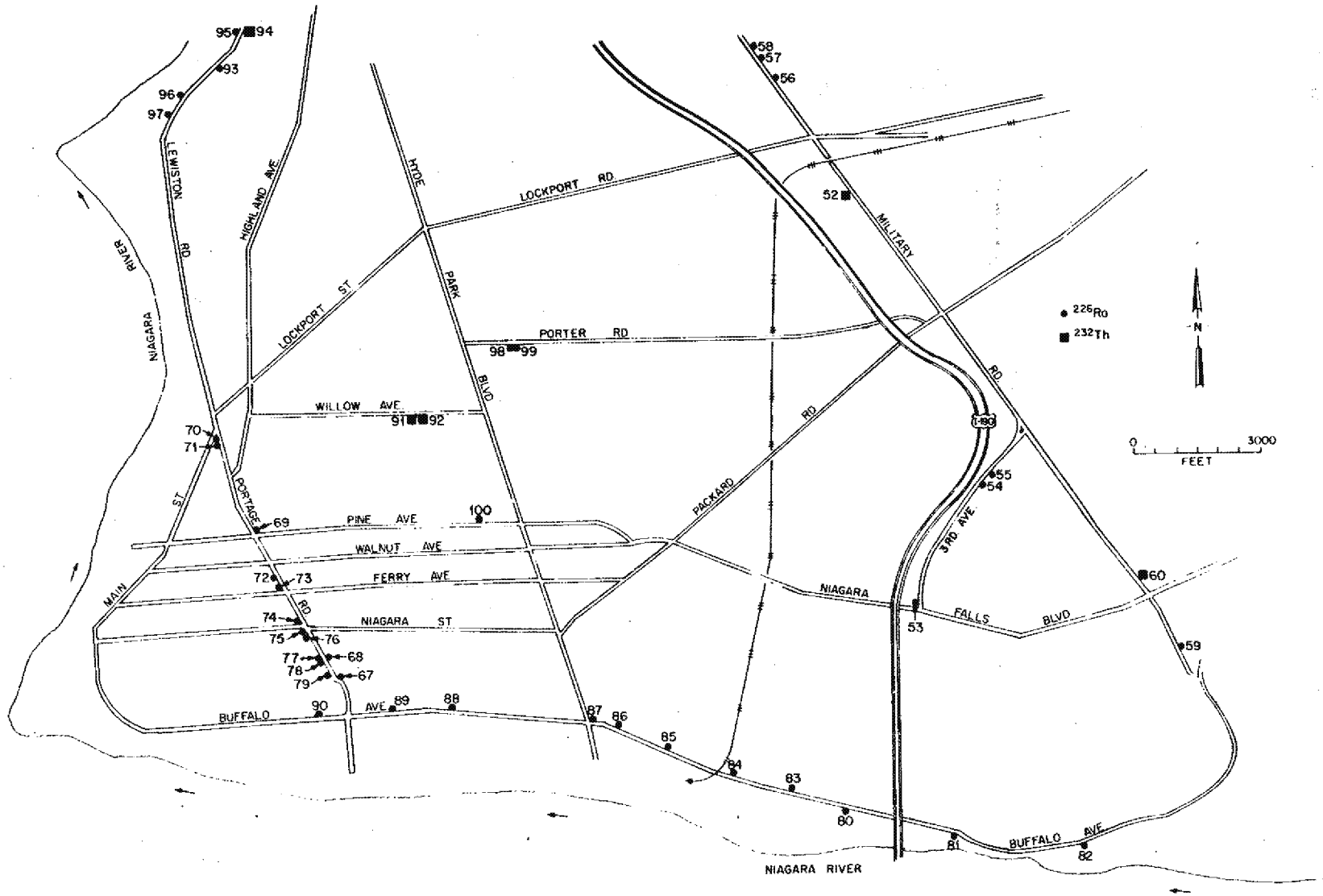

Fig. 3. Anomaly locations in the Niagara Falls area.

ORNL-DWG 86-11616

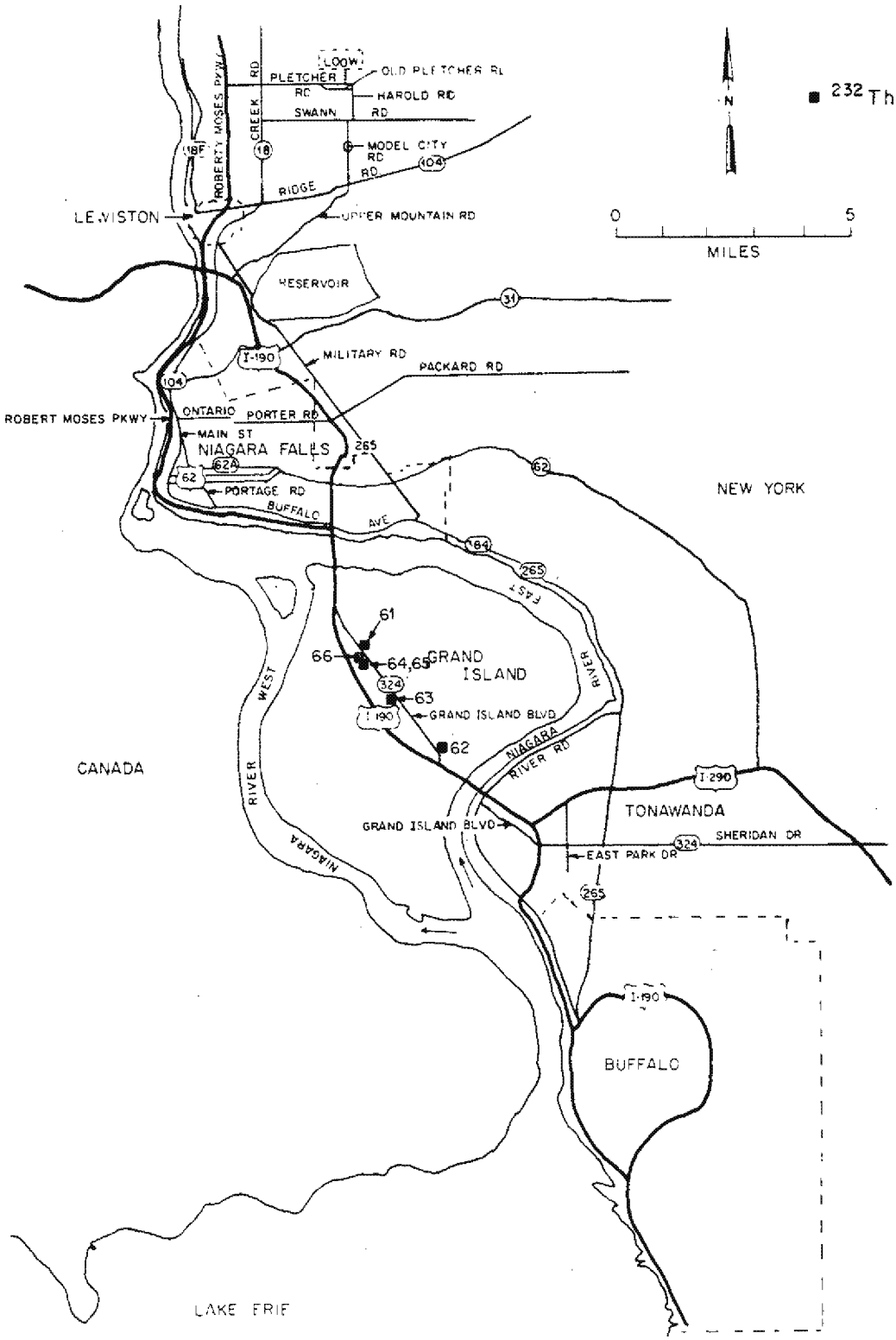

Fig. 4. Anomaly locations in the Grand Island–Tonawanda area.

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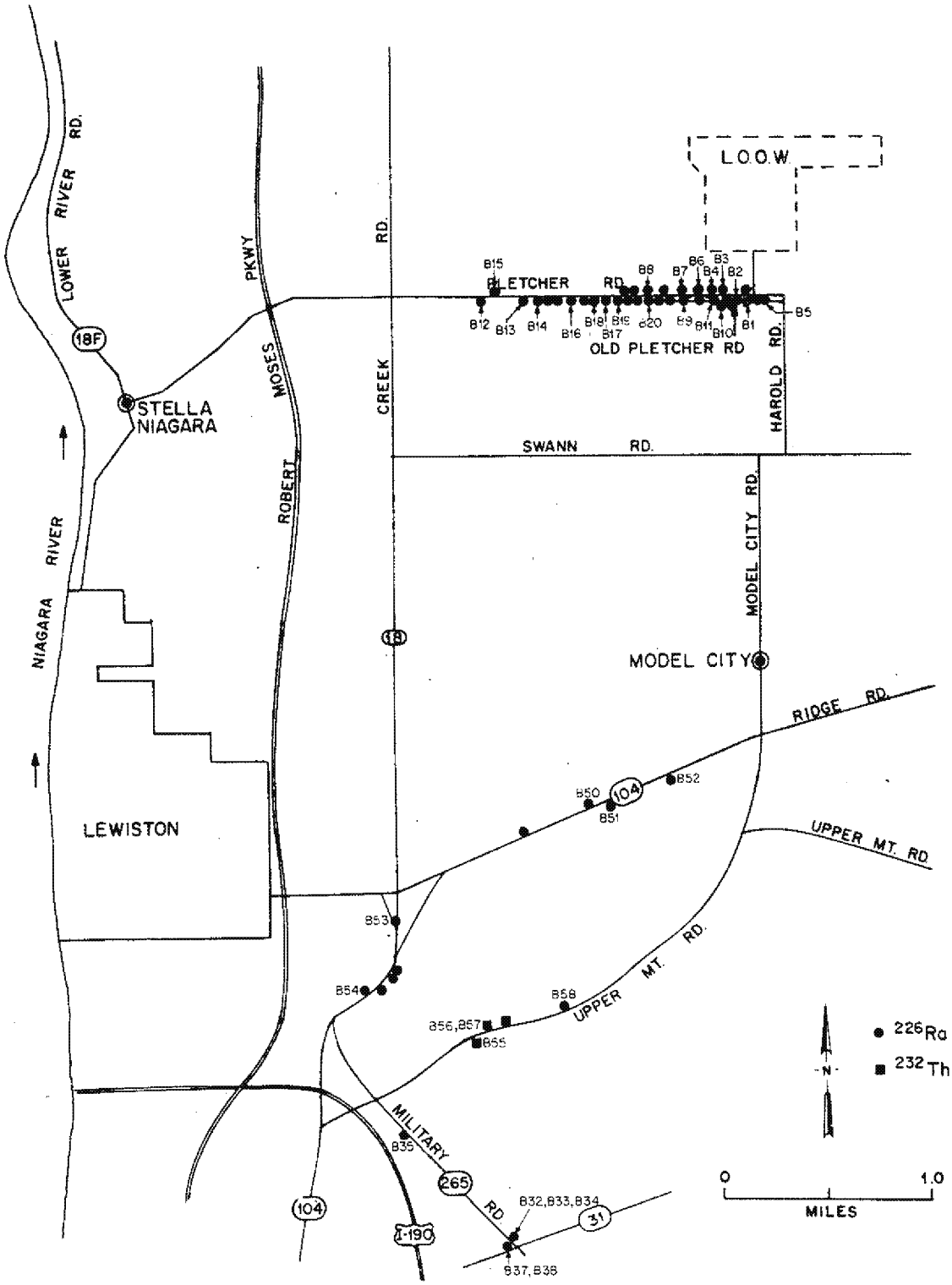

Fig. 5. Locations of soil samples in the Lewiston–Lake Ontario Ordnance Works area.

ORNL-DWG 86-11618

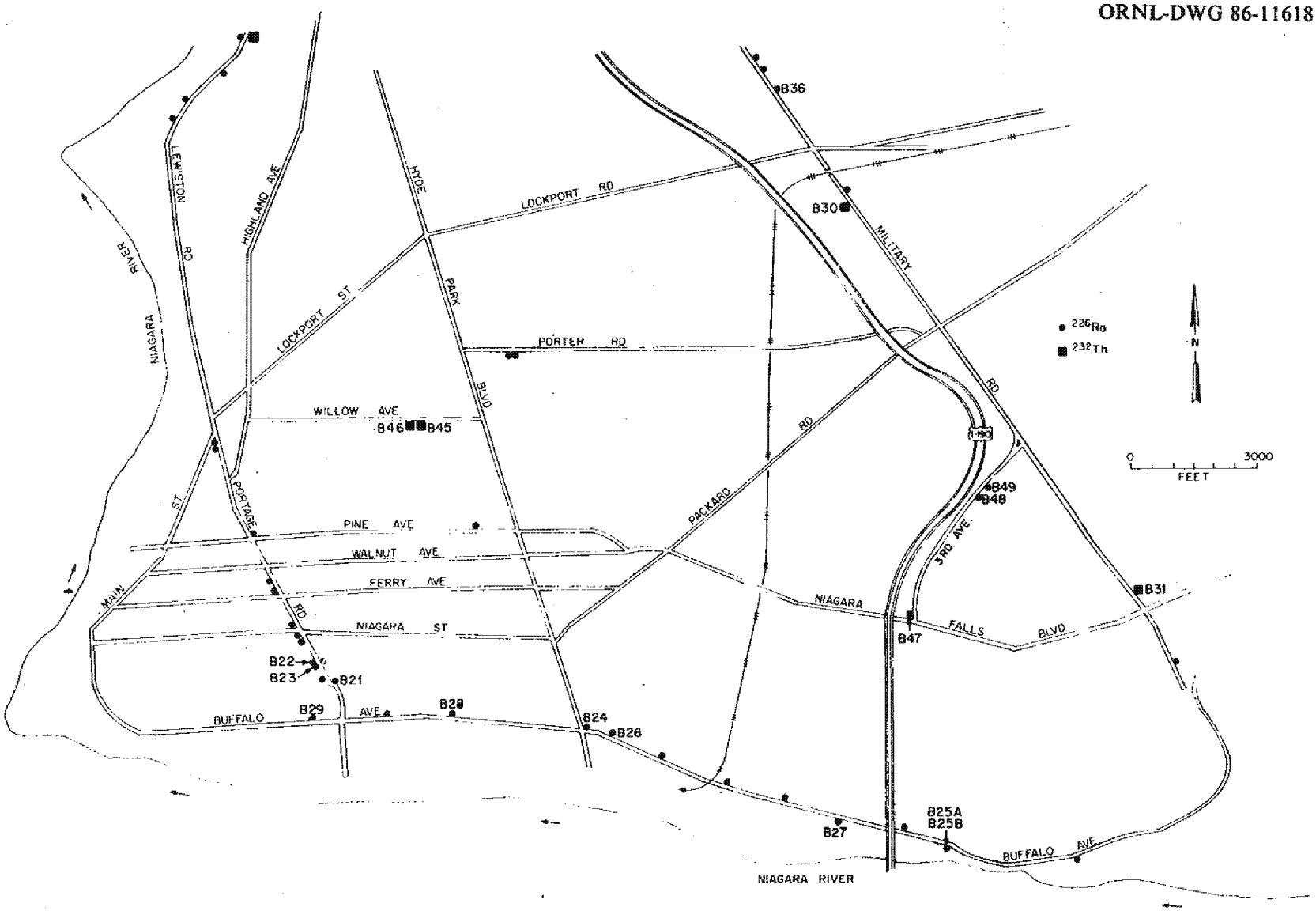

Fig. 6. Locations of soil samples in the Niagara Falls area.

ORNL-DWG 86-11619

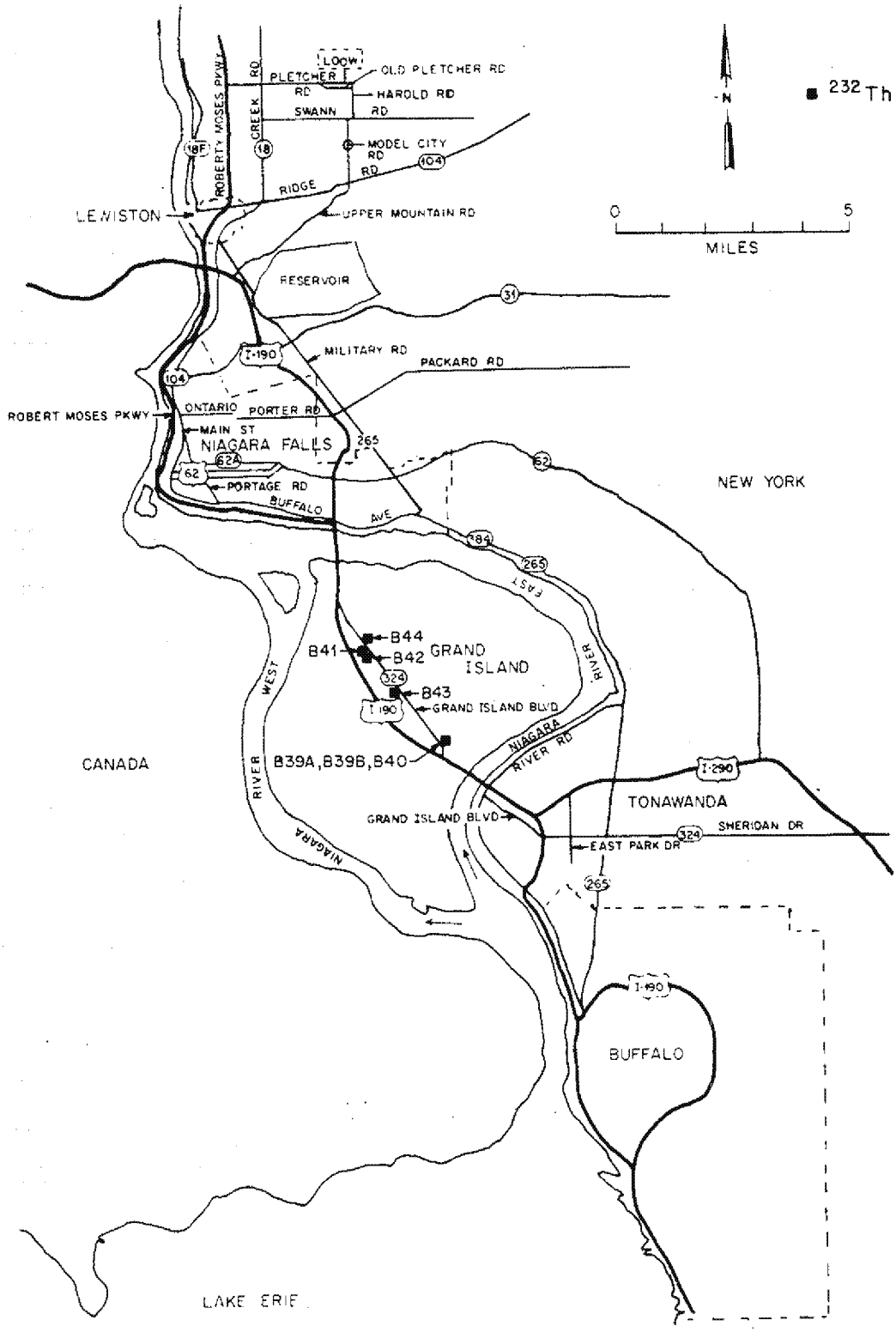

Fig. 7. Locations of soil samples in the Grand Island-Tonawanda area.

Table 1. Background radiation levels in the Niagara Falls area

Type of radiation measurement or sample	Radiation level or radionuclide concentration	
	Range	Average
Gamma exposure rate at 1 m above floor or ground surface (μR/h)[a]	8–10	9
Concentration of radionuclides in soil (pCi/g)[b]		
^{238}U	0.76–1.2	0.96
^{226}Ra	0.48–1.2	0.85

[a]Values obtained from four locations in the New York area.
[b]Soil samples obtained from six locations around the Niagara Falls area.[13]

Table 2. Results of the gamma exposure rate measurements outdoors on the south side of Pletcher Road

(Distance measurements in feet scanning east from Creek Road)

Anomaly number	Distance (ft)	Gamma exposure rates (μR/h)		Range of gamma exposure rate during scan (μR/h)
		Gamma exposure rate at 1 m	Gamma exposure rate at the surface	
1	2200	14	37	11–86
2	2950	23	86	11–86
3	3950	16	57	11–86
4	4080	a	49	11–86
5	4300	a	49	11–86
6	4880	17	63	11–86
7	5775	a	49	11–86
8	6460	16	43	11–86
9	6875	15	34	11–86
10	7025	13	43	11–86
11	7138	a	49	11–86
12	7192	a	49	11–86
13	7312	19	51	11–86
14	7340	a	49	11–86
15	7407	a	49	11–86
16	7452	17	29	11–86
17	7525	a	49	11–86
18	7600	20	57	11–86
19	7915	11	71	11–86
20	7927	a	49	11–86
21	8343	a	49	11–86
22	8628	a	57	11–86
23	8960	a	230	11–230

[a]Reading not taken.

Table 3. Results of the gamma exposure rate measurements outdoors on the north side of Pletcher Road and south side of Old Pletcher Road

(Distance measurements in feet scanning west from Harold Road)

Anomaly number	Distance (ft)	Gamma exposure rates (μR/h)		Range of gamma exposure rate during scan (μR/h)
		Gamma exposure rate at 1 m	Gamma exposure rate at the surface	
24	746	a	33	9–57
25	1169	a	29	9–57
26	1298	20	31	9–57
27	1488	17	46	9–57
28	2333	20	57	9–57
29	2363	a	33	9–57
30	2530 (large area)	19	34	9–57
31	2768	a	33	9–57
32	2844	a	33	9–57
33	6170	17	57	9–57
34	Old Pletcher Road 490 feet east of KOA entrance	a	33	9–57
35	570 feet east of KOA entrance	23	77	9–57

[a]Reading not taken.

Table 4. Results of the gamma exposure rate measurements outdoors in the Lewiston, New York, area

Anomaly number	Location	Gamma exposure rates (μR/h)		Range of gamma exposure rate during scan (μR/h)
		Gamma exposure rate at 1 m	Gamma exposure rate at the surface	
36	961 Ridge Road	17	34	14–34
37	House between 889 and 913 Ridge Road	22	34	14–34
38	1084 Ridge Road	29	49	14–49
39	Circle gravel drive south side Ridge Road at TP45	20	40	17–43
40	1011 Upper Mt. Road	20	57	17–57
41	783 Upper Mt. Road	17	43	17–43
42	789 Upper Mt. Road	43	130	29–130
43	738 Upper Mt. Road	200	710	17–710
44	4977 Creek Road	a	a	a
45	4979 Creek Road	11	29	17–29
46	4945 Creek Road	14	29	14–29
47	Junction of Highways 18 and 104 (NE side of 104 and 18)[b]	16	77	14–77
48	4986 Creek Road and adjoining lot	16	40	17–40

[a]Anomaly not found.

[b]B. A. Berven, *Results of Radiological Measurements Taken at Junction of Highways 18 and 104 in Niagara Falls, New York*, Oak Ridge National Laboratory, ORNL/RASA-85/40 (December 1985).

Table 5. Results of the gamma exposure rate measurements outdoors northeast of Niagara Falls area

Anomaly number	Location	Gamma exposure rates (μR/h)		Range of gamma exposure rate during scan (μR/h)
		Gamma exposure rate at 1 m	Gamma exposure rate at the surface	
49	Across street from 5439 and 5447 Military Road	16	29	13–29
50	Reservoir State Park (NW corner of Military Road and Highway 31)	24	46	14–60
51	Military Road ~400 ft north of Highway 31 (both sides of creek)[a]	20	29	14–29
52	2924 Military Road	34	140	34–140
53	6560 Niagara Falls Blvd.	26	71	17–86
54	Walter S. Kozdranski Co., Inc., 1865 3rd Avenue	49	86	17–86
55	Nuts and Bolts Products, Inc., 2115 3rd Avenue	29	43	17–63
56	Save-Rite Discount Store, 4301 Military Road	23	43	13–51
57	Louie's Place, 4509 Military Road	b	26	17–57
58	4611 and 4613 Military Road	b	43	17–43
59	Prince of Peace Church, Military Road (Rectory, 908 N. Military Road)	43	77	29–77
60	Metropolitan Life and National Fuel, 1329 N. Military Road	20	49	13–49

[a]B. A. Berven, *Results of Radiological Measurements Taken near Junction of Highway 31 and Military Road in Niagara Falls, New York*, Oak Ridge National Laboratory, ORNL/RASA-85/42 (December 1985).

[b]Reading not taken.

Table 6. Results of the gamma exposure rate measurements outdoors in Grand Island–Tonawanda area

Anomaly number	Location	Gamma exposure rates (μR/h)		Range of gamma exposure rate during scan (μR/h)
		Gamma exposure rate at 1 m	Gamma exposure rate at the surface	
61	Kelly's Country Store 3121 Grand Island Blvd.	21	49	a
62	Mobil Service Station 1685 Grand Island Blvd.	9	29	11–29
63	3060 Grand Island Blvd.	29	140	29–160
64	3050 Grand Island Blvd.	34	57	11–57
65	3044 Grand Island Blvd.	31	51	13–51
66	KOA Campground 2570 Grand Island Blvd.	13	17	12–17

[a]Reading not taken.

Table 7. Results of the gamma exposure rate measurements outdoors Niagara Falls, New York

Anomaly number	Location	Gamma exposure rates (μR/h)		Range of gamma exposure rate during scan (μR/h)
		Gamma exposure rate at 1 m	Gamma exposure rate at the surface	
67	SE corner of Cudaback and Portage Road	17	43	17–43
68	Between 245 and 257 Portage Road	a	a	57
69	Niagara Falls High School, Pine Street and Portage Road	9[b]	23[b]	9–23[b]
70	1318–1324 Portage Road	9[c]	17[c]	9–17[c]
71	Harris and Lever Florists, Portage Road	29	57	29–57
72	574 Portage Road	17[d]	34[d]	17–34[d]
73	NW corner Ferry Avenue and Portage Road (probably 504 Portage Road)	a	a	37
74	Property between 434 Portage Road and 1338 Niagara Street	29	49	29–49
75	368 Portage Road	29	51	29–51
76	356 Portage Road	16	37	16–37
77	256 Portage Road	23	51	23–57
78	Between 242 Portage Road and Payne's Floor Covering	29	91	13–91
79	200 Portage Road	e	e	e
80	Opposite 5704 Buffalo Avenue	29	91	29–91
81	6901 Buffalo Avenue			
	Region #1	17	71	17–71
	Region #2	16	57	11–57
	Region #3	16	57	11–57
	Region #4	86	160	18–160
82	7723 Buffalo Avenue	57	86	29–86
83	5512 Buffalo Avenue	a	a	57

Table 7 (continued)

Anomaly number	Location	Gamma exposure rates (μR/h)		Range of gamma exposure rate during scan (μR/h)
		Gamma exposure rate at 1 m	Gamma exposure rate at the surface	
84	Buffalo Avenue (230 ft west of 53rd Street)	19	43	19–43
85	Occidental Chemical Corp., Buffalo Avenue	19	43	17–43
86	Opposite ALOX Corp., Buffalo Avenue	29	86	17–86
87	Buffalo Avenue (east side of Hyde Park intersection)[f]	17	71	14–71
88	Buffalo Avenue opposite SOHIO	10	29	10–29
89	1920 Buffalo Avenue	a	110	110
90	Buffalo Avenue opposite Carborundum Corp.	86	110	29–110
91	2434 Willow Avenue	31	57	14–57
92	2430 Willow Avenue	11	29	14–29
93	3017 Lewiston Road and property on south side	a	57	57
94	4831 Lewiston Road	a	86	86
95	4842 Lewiston Road	a	43	43
96	Intersection Rankine Road and Lewiston Road (west side)	14	43	14–43
97	Intersection McKinley and Lewiston Road (west side)	14	43	14–43
98	2919 Porter Road	a	34	34
99	2923 Porter Road	a	a	a
100	Corner of Pine Street and 29th Street (Wilson Farms Store)	29	51	11–51

[a]Inaccessible — private property.
[b]Gamma exposure rates due to brick on side of school.
[c]Gamma exposure rates due to brick building on side of street.
[d]Reading taken on contact with granite steps in front of building.
[e]Anomaly not found.
[f]B. A. Berven, *Results of Radiological Measurements Taken near Junction of Buffalo Avenue and Hyde Park Blvd. in Niagara Falls, New York*, Oak Ridge National Laboratory, ORNL/RASA-85/41 (December 1985).

Table 8. Results of biased soil sample analysis on the south side of Pletcher Road (NF002)[a]

Anomaly number	Location[b,c] (ft)	Sample	Depth (cm)	Radionuclide concentration (pCi/g)		
				^{226}Ra[d]	^{232}Th[d]	^{238}U[e]
1	2200	NF002B12	0–15	28 ± 1	0.91 ± 0.7	4.0
2	2950	NF002B13	0–15	71 ± 2	0.60 ± 0.5	1.9
3	3950	NF002B14	0–15	64 ± 2	0.71 ± 0.4	1.5
4	4080	f	f	f	f	f
5	4300	f	f	f	f	f
6	4880	NF002B16	0–15	77 ± 2	0.79 ± 0.9	2.0
7	5775	f	f	f	f	f
8	6460	NF002B18	0–15	37 ± 1	0.79 ± 0.3	1.1
9	6875	NF002B17	0–15	37 ± 1	0.96 ± 0.6	1.4
10	7025	NF002B19	0–15	35 ± 1	0.63 ± 0.3	1.6
11	7138	f	f	f	f	f
12	7192	f	f	f	f	f
13	7312	NF002B23	0–15	42 ± 1	1.4 ± 0.1	3.7
14	7340	f	f	f	f	f
15	7407	f	f	f	f	f
16	7452	NF002B9	0–15	12 ± 0.3	0.55 ± 0.1	1.1
17	7525	f	f	f	f	f
18	7600	NF002B11	0–15	29 ± 0.6	0.95 ± 0.5	2.1
19	7915	NF002B10	0–15	88 ± 2	1.0 ± 0.6	2.4
20	7927	f	f	f	f	f
21	8343	f	f	f	f	f
22	8628	NF002B2	0–15	72 ± 1	0.99 ± 1	2.1
23	8960	NF002B1	0–15	430 ± 10	<4.1	5.0

[a]Biased samples are taken from areas shown to have elevated gamma exposure rates.
[b]Locations of soil samples are shown on Fig. 2.
[c]Scanning east from Creek Road.
[d]Indicated counting error is at the 95% confidence level ($\pm 2\sigma$).
[e]Analytical error of measurement results is $< \pm 5\%$ (95% confidence level).
[f]Not sampled.

Table 9. Results of biased soil sample analysis on the north side of Pletcher Road and south side of Old Pletcher Road (NF002)[a]

Anomaly number	Location[b,c] (ft)	Sample	Depth (cm)	Radionuclide concentration (pCi/g)		
				^{226}Ra[d]	^{232}Th[d]	^{238}U[e]
24	746	f	f	f	f	f
25	1169	NF002B3	0–15	23 ± 2	0.90 ± 0.4	1.3
26	1298	NF002B4	0–15	33 ± 1	1.2 ± 0.4	1.4
27	1488	NF002B6	0–15	39 ± 0.5	0.83 ± 0.6	1.8
28	2333	NF002B7	0–15	53 ± 2	0.58 ± 0.4	1.5
29	2363	f	f	f	f	f
30	2530	NF002B8	0–15	33 ± 0.5	1.1 ± 0.5	2.4
31	2768	f	f	f	f	f
32	2844	f	f	f	f	f
33	6170	NF002B15	0–15	25 ± 0.6	0.75 ± 0.3	1.3
34	Old Pletcher Road 490 feet east of KOA entrance	f	f	f	f	f
35	Old Pletcher Road 570 ft east of KOA entrance	NF002B5	0–15	120 ± 4	<0.99	3.0

[a]Biased samples are taken from areas shown to have elevated gamma exposure rates.
[b]Locations of soil samples are shown on Fig. 2.
[c]Scanning west from Harold Road.
[d]Indicated counting error is at the 95% confidence level ($\pm 2\sigma$).
[e]Analytical error of measurement results is $< \pm 5\%$ (95% confidence level).
[f]Not sampled.

Table 10. Results of biased soil sample analysis in the Lewiston, New York, area (NF002)[a]

Anomaly number	Location[b]	Sample	Depth (cm)	Radionuclide concentration (pCi/g)		
				^{226}Ra[c]	^{232}Th[c]	^{238}U[d]
36	961 Ridge Road	NF002B50	0–10	6.0 ± 0.2	0.61 ± 0.1	4.3
37	House between 889 and 913 Ridge Road	e	e	e	e	e
38	1084 Ridge Road	NF002B51	0–10	7.6 ± 0.2	0.32 ± 0.1	7.0
39	Circle gravel drive south side Ridge Road at TP45	NF002B52	0–10	16 ± 0.6	0.71 ± 0.3	13
40	1011 Upper Mt. Road	NF002B58	0–15	24 ± 0.4	0.29 ± 0.1	24
41	783 Upper Mt. Road	e	e	e	e	e
42	789 Upper Mt. Road	NF002B56	0–15	11 ± 0.5	45 ± 10	9.3
-	789 Upper Mt. Road	NF002B57	0–5	14 ± 0.4	16 ± 3.0	13
43	738 Upper Mt. Road	NF002B55	0–15	92 ± 5	560 ± 180	70
44	4977 Creek Road	e	e	e	e	e
45	4979 Creek Road	e	e	e	e	e
46	4945 Creek Road	e	e	e	e	e
47	Junction of Highways 18 and 104 (NE side of 104 and 18)[f]	NF002B53	0–15	180 ± 3	0.60 ± 0.4	0.97
48	4986 Creek Road and adjoining lot	NF002B54	0–10	26 ± 0.6	0.74 ± 0.2	22

[a]Biased samples are taken from areas shown to have elevated gamma exposure rates.
[b]Locations of soil samples are shown on Fig. 2.
[c]Indicated counting error is at the 95% confidence level ($\pm 2\sigma$).
[d]Analytical error of measurement results is $< \pm 5\%$ (95% confidence level).
[e]Not sampled.
[f]B. A. Berven, *Results of Radiological Measurements Taken at Junction of Highways 18 and 104 in Niagara Falls, New York,* Oak Ridge National Laboratory, ORNL/RASA-85/40 (December 1985).

Table 11. Results of biased soil sample analysis northeast of Niagara Falls area (NF002)[a]

Anomaly number	Location[b]	Sample	Depth (cm)	Radionuclide concentration (pCi/g)		
				^{226}Ra[c]	^{232}Th[c]	^{238}U[d]
49	Across street from 5439 and 5447 Military Road	NF002B35	0–15	3.7 ± 0.1	0.92 ± 0.4	3.7
50	Reservoir State Park (NW corner of Military Road and Highway 31)	NF002B37	0–10	2.8 ± 0.09	0.90 ± 0.2	2.4
-	Reservoir State Park (NW corner of Military Road and Highway 31)	NF002B38	0–15	19 ± 0.5	0.83 ± 0.1	18
51	Military Road ~400 ft north of Highway 31 (both sides of creek)[e]	NF002B33	0–10	40 ± 1	0.62 ± 0.3	4.7
-	Military Road ~400 ft north of Highway 31 (both sides of creek)	NF002B32	0–10	7.2 ± 0.1	0.97 ± 0.3	6.0
-	Military Road ~400 ft north of Highway 31 (both sides of creek)	NF002B34	0–10	18 ± 0.9	0.68 ± 0.7	19
52	2924 Military Road	NF002B30	0–10	12 ± 0.4	45 ± 10	10
53	6560 Niagara Falls Blvd.	NF002B47	0–10	3.7 ± 0.1	0.69 ± 0.4	2.8
54	Walter S. Kozdranski Co., Inc., 1865 3rd Avenue	NF002B48	0–10	36 ± 0.6	0.85 ± 0.6	33
55	Nuts and Bolts Products, Inc., 2115 3rd Avenue	NF002B49	0–10	1.2 ± 0.04	0.53 ± 0.2	1.1
56	Save-Rite Discount Store, 4301 Military Road	NF002B36	5–15	9.2 ± 0.3	0.45 ± 0.2	8.7
57	Louie's Place, 4509 Military Road	f	f	f	f	f
58	4611 and 4613 Military Road	f	f	f	f	f
59	Prince of Peace Church, Military Road (Rectory, 908 N. Military Road)	f	f	f	f	f
60	Metropolitan Life and National Fuel, 1329 N. Military Road	NF002B31	0–10	13 ± 0.4	0.81 ± 0.2	11

[a]Biased samples are taken from areas shown to have elevated gamma exposure rates.
[b]Locations of soil samples are shown on Fig. 3.
[c]Indicated counting error is at the 95% confidence level ($\pm 2\sigma$).
[d]Analytical error of measurement results is $< \pm 5\%$ (95% confidence level).
[e]B. A. Berven, *Results of Radiological Measurements Taken near Junction of Highway 31 and Military Road in Niagara Falls, New York*, Oak Ridge National Laboratory, ORNL/RASA-85/42 (December 1985).
[f]Not sampled.

Table 12. Results of biased soil sample analysis in Grand Island–Tonawanda area (NF002)[a]

Anomaly number	Location[b]	Sample	Depth (cm)	Radionuclide concentration (pCi/g)		
				^{226}Ra[c]	^{232}Th[c]	^{238}U[d]
61	Kelly's Country Store, 3121 Grand Island Blvd.	NF002B44	0–10	3.3 ± 0.08	5.9 ± 1	2.9
62	Mobil Service Station, 1685 Grand Island Blvd.	NF002B39A (dirt)	0–10	1.4 ± 0.06	1.3 ± 0.3	1.2
-	Mobil Service Station, 1685 Grand Island Blvd.	NF002B39B (rock)	0–10	6.1 ± 0.2	9.6 ± 2.0	6.0
-	Mobil Service Station, 1685 Grand Island Blvd.	NF002B40	0–15	2.8 ± 0.08	3.2 ± 0.8	2.8
63	3060 Grand Island Blvd.	NF002B43	0–15	25 ± 0.5	39 ± 9	26
64	3050 Grand Island Blvd.	NF002B42	0–10	3.2 ± 0.06	5.9 ± 1	3.7
65	3044 Grand Island Blvd.	e	e	e	e	e
66	KOA Campground, 2570 Grand Island Blvd.	NF002B41	0–15	2.0 ± 0.2	1.9 ± 0.4	1.7

[a]Biased samples are taken from areas shown to have elevated gamma exposure rates.
[b]Locations of soil samples are shown on Fig. 4.
[c]Indicated counting error is at the 95% confidence level ($\pm 2\sigma$).
[d]Analytical error of measurement results is $< \pm 5\%$ (95% confidence level).
[e]Not sampled.

Table 13. Results of biased soil sample analysis in Niagara Falls, New York (NF002)[a]

Anomaly number	Location[b]	Sample	Depth (cm)	Radionuclide concentration (pCi/g)		
				^{226}Ra[c]	^{232}Th[c]	^{238}U[d]
67	SE corner of Cudaback and Portage Road	NF002B21	0–15	6.5 ± 0.2	0.47 ± 0.3	5.3
68	Between 245 and 257 Portage Road	e	e	e	e	e
69	Niagara Falls High School, Pine Street and Portage Road	e	e	e	e	e
70	1318-1324 Portage Road	e	e	e	e	e
71	Harris and Lever Florists, Portage Road	e	e	e	e	e
72	574 Portage Road	e	e	e	e	e
73	NW corner Ferry Avenue and Portage Road (probably 504 Portage Road)	e	e	e	e	e
74	Property between 434 Portage Road and 1338 Niagara Street	e	e	e	e	e
75	368 Portage Road	e	e	e	e	e
76	356 Portage Road	e	e	e	e	e
77	256 Portage Road	NF002B22	0–15	36 ± 1	0.68 ± 0.4	32
78	Between 242 Portage Road and Payne's Floor Covering	NF002B23	0–15	51 ± 2	0.45 ± 0.3	45
79	200 Portage Road	e	e	e	e	e
80	Opposite 5704 Buffalo Avenue	NF002B27	0–15	12 ± 0.3	0.44 ± 0.2	11
81	6901 Buffalo Avenue Region #1	NF002B25A	0–15	57 ± 1	0.68 ± 0.4	52
-	6901 Buffalo Avenue Region #1	NF002B25B	0–15	19 ± 0.7	0.77 ± 0.1	18
-	6901 Buffalo Avenue Regions #2, #3, and #4	e	e	e	e	e
82	7723 Buffalo Avenue	e	e	e	e	e
83	5512 Buffalo Avenue	e	e	e	e	e
84	Buffalo Avenue (230 ft west of 53rd Street)	e	e	e	e	e
85	Occidental Chemical Corp., Buffalo Avenue	e	e	e	e	e
86	Opposite ALOX Corp., Buffalo Avenue	NF002B26	0–15	29 ± 0.5	0.51 ± 0.3	26

Table 13 (continued)

Anomaly number	Location[b]	Sample	Depth (cm)	Radionuclide concentration (pCi/g)		
				^{226}Ra[c]	^{232}Th[c]	^{238}U[d]
87	Buffalo Avenue (east side of Hyde Park intersection)[f]	NF002B24	0–15	150 ± 4	0.92 ± 0.5	2.3
88	Buffalo Avenue opposite SOHIO	NF002B28	0–15	18 ± 0.2	0.74 ± 0.2	16
89	1920 Buffalo Avenue	e	e	e	e	e
90	Buffalo Avenue opposite Carborundum Corp.	NF002B29	0–15	55 ± 1	0.40 ± 0.3	48
91	2434 Willow Avenue	NF002B46	0–15	7.7 ± 0.3	20 ± 5	7.0
92	2430 Willow Avenue	NF002B45	0–15	4.1 ± 0.2	9.8 ± 2	3.7
93	3017 Lewiston Road and property on south side	e	e	e	e	e
94	4831 Lewiston Road	e	e	e	e	e
95	4842 Lewiston Road	e	e	e	e	e
96	Intersection Rankine Road and Lewiston Road (west side)	e	e	e	e	e
97	Intersection McKinley and Lewiston Road (west side)	e	e	e	e	e
98	2919 Porter Road	e	e	e	e	e
99	2923 Porter Road	e	e	e	e	e
100	Corner of Pine Street and 29th Street (Wilson Farms Store)	e	e	e	e	e

[a]Biased samples are taken from areas shown to have elevated gamma exposure rates.
[b]Locations of soil samples are shown on Fig. 3.
[c]Indicated counting error is at the 95% confidence level ($\pm 2\sigma$).
[d]Analytical error of measurement results is $< \pm 5\%$ (95% confidence level).
[e]Not sampled.
[f]B. A. Berven, *Results of Radiological Measurements Taken near Junction of Buffalo Avenue and Hyde Park Blvd. in Niagara Falls, New York*, Oak Ridge National Laboratory, ORNL/RASA-85/41 (December 1985).

Table 14. Summary of anomalies in the Niagara Falls, New York, area

Anomaly number	Location	Type anomaly	NFSS related anomaly	Property description	Figure number	Tables: Gamma exposure rate	Tables: Soil analysis
			South Side of Pletcher Road[a]				
1	2200 ft[b]	Ra-226	Yes[c]	Open field	2	2	8
2	2950 ft[b]	Ra-226	Yes[c]	Open field	2	2	8
3	3950 ft[b]	Ra-226	Yes[c]	Open field	2	2	8
4	4080 ft[b]	Ra-226	Yes	Open field	2	2	8
5	4300 ft[b]	Ra-226	Yes	Open field	2	2	8
6	4880 ft[b]	Ra-226	Yes[c]	Open field	2	2	8
7	5775 ft[b]	Ra-226	Yes	Open field	2	2	8
8	6460 ft[b]	Ra-226	Yes[c]	Open field	2	2	8
9	6875 ft[b]	Ra-226	Yes[c]	Open field	2	2	8
10	7025 ft[b]	Ra-226	Yes[c]	Open field	2	2	8
11	7138 ft[b]	Ra-226	Yes	Open field	2	2	8
12	7192 ft[b]	Ra-226	Yes	Open field	2	2	8
13	7312 ft[b]	Ra-226	Yes[c]	Open field	2	2	8
14	7340 ft[b]	Ra-226	Yes	Open field	2	2	8
15	7407 ft[b]	Ra-226	Yes	Open field	2	2	8
16	7452 ft[b]	Ra-226	Yes[c]	Open field	2	2	8
17	7525 ft[b]	Ra-226	Yes	Open field	2	2	8
18	7600 ft[b]	Ra-226	Yes[c]	Open field	2	2	8

Table 14 (continued)

Anomaly number	Location	Type anomaly	NFSS related anomaly	Property description	Figure number	Tables: Gamma exposure rate	Tables: Soil analysis
19	7915 ft[b]	Ra-226	Yes[c]	Open field	2	2	8
20	7927 ft[b]	Ra-226	Yes	Open field	2	2	8
21	8343 ft[b]	Ra-226	Yes	Open field	2	2	8
22	8628 ft[b]	Ra-226	Yes[c]	Open field	2	2	8
23	8960 ft[b]	Ra-226	Yes[c]	Open field	2	2	8
North Side of Pletcher Road and South Side of Old Pletcher Road[a]							
24	746 ft[d]	Ra-226	Yes	Open field	2	3	9
25	1169 ft[d]	Ra-226	Yes[c]	Open field	2	3	9
26	1298 ft[d]	Ra-226	Yes[c]	Open field	2	3	9
27	1488 ft[d]	Ra-226	Yes[c]	Open field	2	3	9
28	2333 ft[d]	Ra-226	Yes[c]	Open field	2	3	9
29	2363 ft[d]	Ra-226	Yes	Open field	2	3	9
30	2530 ft[d]	Ra-226	Yes[c]	Open field	2	3	9
31	2768 ft[d]	Ra-226	Yes	Open field	2	3	9
32	2844 ft[d]	Ra-226	Yes	Open field	2	3	9
33	6170 ft[d]	Ra-226	Yes[c]	Open field	2	3	9
34	Old Pletcher Road 490 feet east of KOA entrance	Ra-226	Yes	Open field	2	3	9

Table 14 (continued)

Anomaly number	Location	Type anomaly	NFSS related anomaly	Property description	Figure number	Tables: Gamma exposure rate	Tables: Soil analysis
35	570 feet east of KOA entrance	Ra-226	Yes[c]	Open field	2	3	9
	Lewiston, New York, Area						
36	961 Ridge Road	Ra-226	No-asphalt[e]	Driveway	2	4	10
37	House between 889 and 913 Ridge Road	Ra-226	No-asphalt[e]	Driveway	2	4	10
38	1084 Ridge Road	Ra-226	No-asphalt[e]	Driveway	2	4	10
39	Circle gravel drive south side Ridge Road at TP45	Ra-226	No-gravel, culvert[e]	Open field	2	4	10
40	1011 Upper Mt. Road	Ra-226	No-gravel, culvert[e]	Driveway	2	4	10
41	783 Upper Mt. Road	Th-232	No-slag, fill material[e]	Yard and Driveway	2	4	10
42	789 Upper Mt. Road	Th-232	No-slag, fill material[e]	Yard and Driveway	2	4	10
43	738 Upper Mt. Road	Th-232	No-gravel, slag, fill material[e]	Yard and Driveway	2	4	10
44	4977 Creek Road	Ra-226	Not found	Yard and Driveway	2	4	10
45	4979 Creek Road	Ra-226	No-asphalt pad[e]	Yard and Driveway	2	4	10
46	4945 Creek Road	Ra-226	No-asphalt[e]	Yard and Driveway	2	4	10

Table 14 (continued)

Anomaly number	Location	Type anomaly	NFSS related anomaly	Property description	Figure number	Tables: Gamma exposure rate	Tables: Soil analysis
47	Junction of Highways 18 and 104 (NE side of 104 and 18)[f]	Ra-226	Yes[c]	Highway median	2	4	10
48	4986 Creek Road and adjoining lot	Ra-226	No-asphalt[e]	Yard and Driveway	2	4	10
	Northeast of Niagara Falls Area						
49	Across street from 5439 and 5447 Military Road	Ra-226	No-asphalt[e]	Open field, pavement	3	5	11
50	Reservoir State Park (NW corner of Military Road and Highway 31)	Ra-226	No-asphalt[e]	Park	3	5	11
51	Military Road ~400 ft north of Highway 31 (both sides of creek)[g]	Ra-226	Yes[c]	Vacant lots	3	5	11
52	2924 Military Road	Th-232	No-asphalt[e]	Residence	3	5	11
53	6560 Niagara Falls Blvd.	Ra-226	No-asphalt[e]	Business	3	5	11
54	Walter S. Kozdranski Co., Inc., 1865 3rd Avenue	Ra-226	No-asphalt[e]	Business	3	5	11

Table 14 (continued)

Anomaly number	Location	Type anomaly	NFSS related anomaly	Property description	Figure number	Tables: Gamma exposure rate	Tables: Soil analysis
55	Nuts and Bolts Products, Inc., 2115 3rd Avenue	Ra-226	No-asphalt[e]	Business	3	5	11
56	Save-Rite Discount Store, 4301 Military Road	Ra-226	No-asphalt[e]	Business	3	5	11
57	Louie's Place, 4509 Military Road	Ra-226	No-asphalt[e]	Business	3	5	11
58	4611 and 4613 Military Road	Ra-226	No-asphalt[e]	Parking lot	3	5	11
59	Prince of Peace Church, Military Road (Rectory, 908 N. Military Road)	Ra-226	No-asphalt[e]	Church parking lot	3	5	11
60	Metropolitan Life and National Fuel, 1329 N. Military Road	Th-232	No-asphalt, slag, fill material[e]	Business	3	5	11
	Grand Island–Tonawanda Area						
61	Kelly's Country Store, 3121 Grand Island Blvd.	Th-232	No-asphalt, gravel[e]	Business	4	6	12
62	Mobil Service Station, 1685 Grand Island Blvd.	Th-232	No-asphalt, fill material[e]	Business	4	6	12

Table 14 (continued)

Anomaly number	Location	Type anomaly	NFSS related anomaly	Property description	Figure number	Tables: Gamma exposure rate	Tables: Soil analysis
63	3060 Grand Island Blvd.	Th-232	No-asphalt, fill material[e]	Residence	4	6	12
64	3050 Grand Island Blvd.	Th-232	No-asphalt, fill material[e]	Residence	4	6	12
65	3044 Grand Island Blvd.	Th-232	No-asphalt, fill material[e]	Residence/ business	4	6	12
66	KOA Campground, 2570 Grand Island Blvd.	Th-232	No-asphalt[e]	Business	4	6	12
	Niagara Falls, New York						
67	SE corner of Cudaback and Portage Road	Ra-226	No-gravel[e]	Commercial building	3	7	13
68	Between 245 and 257 Portage Road	Ra-226	No-asphalt[e]	Parking lot	3	7	13
69	Niagara Falls High School, Pine Street and Portage Road	Th-232	No-brick building[e]	School	3	7	13
70	1318-1324 Portage Road	Ra-226	No-brick building[e]	Business	3	7	13
71	Harris and Lever Florists, Portage Road	Ra-226	No-asphalt[e]	Business	3	7	13
72	574 Portage Road	Ra-226	No-granite[e]	Business	3	7	13

Table 14 (continued)

Anomaly number	Location	Type anomaly	NFSS related anomaly	Property description	Figure number	Tables: Gamma exposure rate	Tables: Soil analysis
73	NW corner Ferry Avenue and Portage Road (probably 504 Portage Road)	Ra-226	No-concrete[e]	Vacant lot, driveway	3	7	13
74	Property between 434 Portage Road and 1338 Niagara Street	Ra-226	No-asphalt[e]	Residence	3	7	13
75	368 Portage Road	Ra-226	No-asphalt, concrete[e]	Residence	3	7	13
76	356 Portage Road	Ra-226	No-asphalt[e]	Residence	3	7	13
77	256 Portage Road	Ra-226	No-gravel[e]	Residence	3	7	13
78	Between 242 Portage Road and Payne's Floor Covering	Ra-226	No-rocks[e]	Vacant lot	3	7	13
79	200 Portage Road	Ra-226	Not found	Business	3	7	13
80	Opposite 5704 Buffalo Avenue	Ra-226	No-gravel[e]	Vacant lot	3	7	13
81	6901 Buffalo Avenue	Ra-226	No-asphalt, concrete[e]	Vacant lot	3	7	13
82	7723 Buffalo Avenue	Ra-226	No-asphalt[e]	Business	3	7	13
83	5512 Buffalo Avenue	Ra-226	No-asphalt[e]	Business	3	7	13
84	Buffalo Avenue (230 ft west of 53rd Street)	Ra-226	No-concrete[e]	Grass area and sidewalk	3	7	13

Table 14 (continued)

Anomaly number	Location	Type anomaly	NFSS related anomaly	Property description	Figure number	Tables: Gamma exposure rate	Tables: Soil analysis
85	Occidental Chemical Corp., Buffalo Avenue	Ra-226	No-concrete[e]	Business	3	7	13
86	Opposite ALOX Corp. Buffalo Avenue	Ra-226	No-asphalt[e]	Parking lot	3	7	13
87	Buffalo Avenue (east side of Hyde Park intersection)[h]	Ra-226	Yes[c]	Vacant lot	3	7	13
88	Buffalo Avenue opposite SOHIO	Ra-226	No-asphalt[e]	Parking lot	3	7	13
89	1920 Buffalo Avenue	Ra-226	No-asphalt[e]	Business	3	7	13
90	Buffalo Avenue opposite Carborundum Corp.	Ra-226	No-gravel, asphalt[e]	Vacant lot	3	7	13
91	2434 Willow Avenue	Th-232	No-granite, slag, fill material[e]	Residence	3	7	13
92	2430 Willow Avenue	Th-232	No-granite, slag, fill material[e]	Residence	3	7	13
93	3017 Lewiston Road and property on south side	Ra-226	No-asphalt[e]	Residence	3	7	13
94	4831 Lewiston Road	Th-232	No-rocks[e]	Residence	3	7	13
95	4842 Lewiston Road	Ra-226	No-asphalt[e]	Residence	3	7	13

Table 14 (continued)

Anomaly number	Location	Type anomaly	NFSS related anomaly	Property description	Figure number	Tables: Gamma exposure rate	Tables: Soil analysis
85	Occidental Chemical Corp., Buffalo Avenue	Ra-226	No-concrete[e]	Business	3	7	13
86	Opposite ALOX Corp. Buffalo Avenue	Ra-226	No-asphalt[e]	Parking lot	3	7	13
87	Buffalo Avenue (east side of Hyde Park intersection)[h]	Ra-226	Yes[c]	Vacant lot	3	7	13
88	Buffalo Avenue opposite SOHIO	Ra-226	No-asphalt[e]	Parking lot	3	7	13
89	1920 Buffalo Avenue	Ra-226	No-asphalt[e]	Business	3	7	13
90	Buffalo Avenue opposite Carborundum Corp.	Ra-226	No-gravel, asphalt[e]	Vacant lot	3	7	13
91	2434 Willow Avenue	Th-232	No-granite, slag, fill material[e]	Residence	3	7	13
92	2430 Willow Avenue	Th-232	No-granite, slag, fill material[e]	Residence	3	7	13
93	3017 Lewiston Road and property on south side	Ra-226	No-asphalt[e]	Residence	3	7	13
94	4831 Lewiston Road	Th-232	No-rocks[e]	Residence	3	7	13
95	4842 Lewiston Road	Ra-226	No-asphalt[e]	Residence	3	7	13

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