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NIAGARA FALLS STORAGE SITE ENVIRONMENTAL MONITORING REPORT

Calendar Year 1983

July 1984

Bechtel National, Inc.
Advanced Technology Division

DOE/OR/20722-18

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Prepared for

U.S. DEPARTMENT OF ENERGY
OAK RIDGE OPERATIONS OFFICE
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By

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ABSTRACT

During 1983, an environmental monitoring program was continued at the Niagara Falls Storage Site, a United States Department of Energy (DOE) surplus facility located in Niagara County, New York presently used for the storage of radioactive residues, contaminated soils and rubble. The monitoring program at NFSS measures radon concentrations in air, uranium and radium concentrations in surface water, groundwater, and sediments, and external gamma exposure rates. Radiation doses to the public are also calculated. Environmental samples collected are analyzed to determine compliance with applicable standards.

During 1983, annual average radon concentrations at site boundary and exclusion area locations of the site were below the DOE Concentration Guide (CG) for uncontrolled areas. Annual average uranium and radium-226 concentrations in groundwater and surface water were well below the DOE CG for release to uncontrolled areas. External gamma exposure rates were below the DOE Radiation Protection Standards. All radiation doses to the public were within DOE standards.

Results from sediment samples showed uranium concentrations below the DOE proposed standard for cleanup. The highest annual average concentration of radium-226 in sediments exceeded the proposed standard by a factor of 4. However, this annual average incorporates readings taken while site cleanup operations were underway. By year's end, radium-226 concentrations were below the proposed standard.

Comparison of 1983 monitoring results with 1982 results shows a significant decrease in radon levels at almost every monitoring location. External gamma exposure rates also showed a general decrease.

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ABBREVIATIONS

Ci	Curie
cm/s	centimeters per second
ft	foot
g	gram
gal	gallon
ha	hectare
in.	inch
kg	kilogram
km	kilometer
m	meter
m/s	meters per second
m^2	square meter
m^3	cubic meter
mg/l	milligrams per liter
mi	mile
mrem	millirem
uR/h	microroentgens per hour
pCi/g	picocuries per gram
pCi/l	picocuries per liter
t	metric tonne
yd^3	cubic yards

1.0 INTRODUCTION

This report presents the findings of the environmental monitoring conducted at the Niagara Falls Storage Site (NFSS) during calendar year 1983. The NFSS is part of the United States Department of Energy (DOE) Surplus Facilities Management Program (SFMP), one of four remedial action programs under the direction of the DOE Division of Remedial Action Projects (DRAP). In addition to the basic site, radioactively contaminated vicinity properties located adjacent to or near the NFSS are the responsibility of the Formerly Utilized Sites Remedial Action Program (FUSRAP), another DOE program under the direction of DRAP.

1.1 LOCATION AND DESCRIPTION

The NFSS occupies approximately 77 ha (191 acres) located in northwestern New York within the Town of Lewiston (Niagara County). It lies approximately 6.4 km (4 mi) south of Lake Ontario, 16 km (10 mi) north of the city of Niagara Falls. The site is located in a generally rural setting, though there are several nearby populated areas, including Lewiston (population: 16,185), Youngstown (population: 2,196), Ransomville (population: 1,101) and Porter (population: 7,258). The NFSS and its regional setting are shown in Figure 1-1.

The site is generally level, sloping gently to the northwest and lying at elevations between 97 and 98 m (318 and 321 ft). The site is poorly drained because of the flatness of the terrain and soil characteristics. Soils at NFSS are predominantly silt loams underlain by a clayey glacial till. Sand-gravel inclusions are frequent. Bedrock lies 30 to 50 feet beneath the surface and consists of the thick (1,200 feet) Queenston shale.

All surface water from the site currently discharges via the Central Drainage Ditch and its tributary ditches into Fourmile Creek,

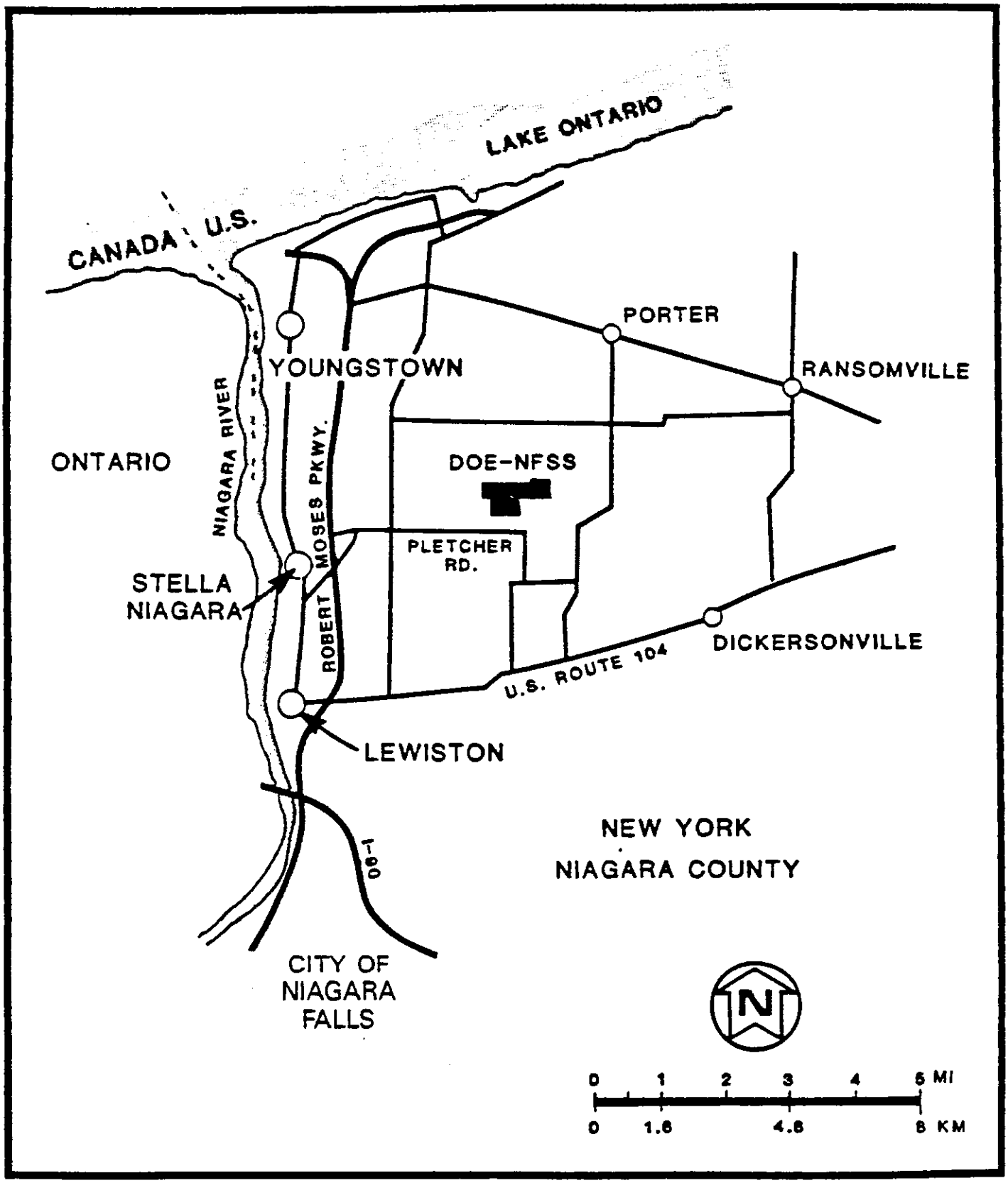


FIGURE 1-1 THE REGIONAL SETTING OF THE NIAGARA FALLS STORAGE SITE

located northwest of the site. Groundwater is present in an aquifer at the bedrock surface, in sand-gravel lenses and in saturated clay zones at depths of 5 to 20 feet. Groundwater level contours indicate a slope of the primary aquifer to the north-northwest of approximately 10 feet per mile. The groundwater discharges into the northern reaches of the Niagara River close to Lake Ontario.

1.2 SITE HISTORY

The NFSS is a remnant of an original 1,511-acre site which was used by the World War II Manhattan Engineer District (MED) project. This 1,511-acre site was a portion of the Department of the Army's Lake Ontario Ordnance Works (LOOW). Except for boron-10 enriching operations during the periods 1954 to 1958 and 1964 to 1971, the site's major use from 1944 to the present has been for storage of radioactive residues produced as by-products of uranium production during the MED project and subsequent Atomic Energy Commission (AEC) projects.

The first materials to arrive at the site were low-grade residues and by-products from the Linde Air Products Division in Tonawanda, New York (the L-30, L-50, and R-10 residues) and from the Middlesex Sampling Plant in Middlesex, New Jersey (the F-32 residues). The L-30 and L-50 residues were stored in Buildings 411, 413, and 414, while the F-32 residues were stored in the Recarbonation Pit directly west of Building 411. The R-10 residues, as well as associated iron cake, were stored in an open area north of Building 411 at NFSS, subject to environmental processes which transported contaminants into the soil and drainageways, resulting in the contamination of other portions of the site and off-site drainageways. The small quantity of Middlesex Sands resulting from decontamination activities at the Middlesex Sampling Plant were stored in Building 410. In 1949, pitchblende residues (the K-65 residues) resulting from uranium extraction conducted at a St. Louis plant were transported to the LOOW in drums. Some of these were stored outdoors along existing roads and rail lines; others were

stored in Building 410. From 1950 to 1952, the K-65 residues were transferred to a renovated concrete water tower (Building 434).

The weight, volume, and storage locations of the residues and sands at NFSS are summarized in Table 1-1. Buildings and other features of the NFSS prior to recent interim remedial actions are illustrated in Figure 1-2.

In 1979, DOE, successor to the AEC, subcontracted with Battelle Columbus Laboratories to perform a comprehensive radiological survey of the NFSS. Battelle published its findings in June 1981 (Ref. 1), and the report served as the basis for initial interim remedial action planning at the site. Bechtel National, Inc. (BNI) was chosen by DOE as the Project Management Contractor (PMC) for the NFSS project in 1981. As part of its duties as PMC, BNI maintains the security of the site, performs maintenance as required, carries out the environmental monitoring program, and helps plan and execute the interim remedial action program for the site. Daily inspections of the site are performed by the BNI Site Operations Supervisor permanently stationed at the facility. Access to the site is controlled by a 2-m- (7-ft-) high fence which encloses the DOE property.

Since 1980, various steps have been taken at the NFSS to minimize potential radiological risks and prevent migration of residues. In the fall of 1980, the vent at the top of Building 434 (the former water tower in which the K-65 residues are stored) was capped to reduce radon flux to the environment. Also during 1980, all pipes penetrating the walls of the residue storage buildings were sealed or resealed as necessary to prevent radionuclide migration. In mid-1981, because radon levels at the site's western boundary were exceeding DOE limits, the site fence was re-located approximately 150 m (500 ft) to the west, creating an exclusion area to protect the public from exposure to the higher radon levels. Radon levels at the site's new boundary were well below applicable guidelines.

TABLE 1-1

SUMMARY OF THE MAJOR PITCHBLENDE RESIDUES AND MIDDLESEX SANDS STORED AT THE NFSS[a]

	Weight		Volume		Storage Location
	kg x 10^6	tons	m^3	yd^3	
Residue					
K-65	3.53	3,891	3,120	4,080	Building 434
L-30	7.46	8,227	6,080	7,960	Building 411
L-50	1.70	1,878	1,640	2,150	Buildings 413 and 414
F-32	0.13	138	340	440	Recarbonation Pit
R-10	7.47	8,235	7,180	9,400	North of Building 411
Middlesex Sands	0.002	2	175	229	Building 410

[a]Battelle, 1981 (Ref. 1).

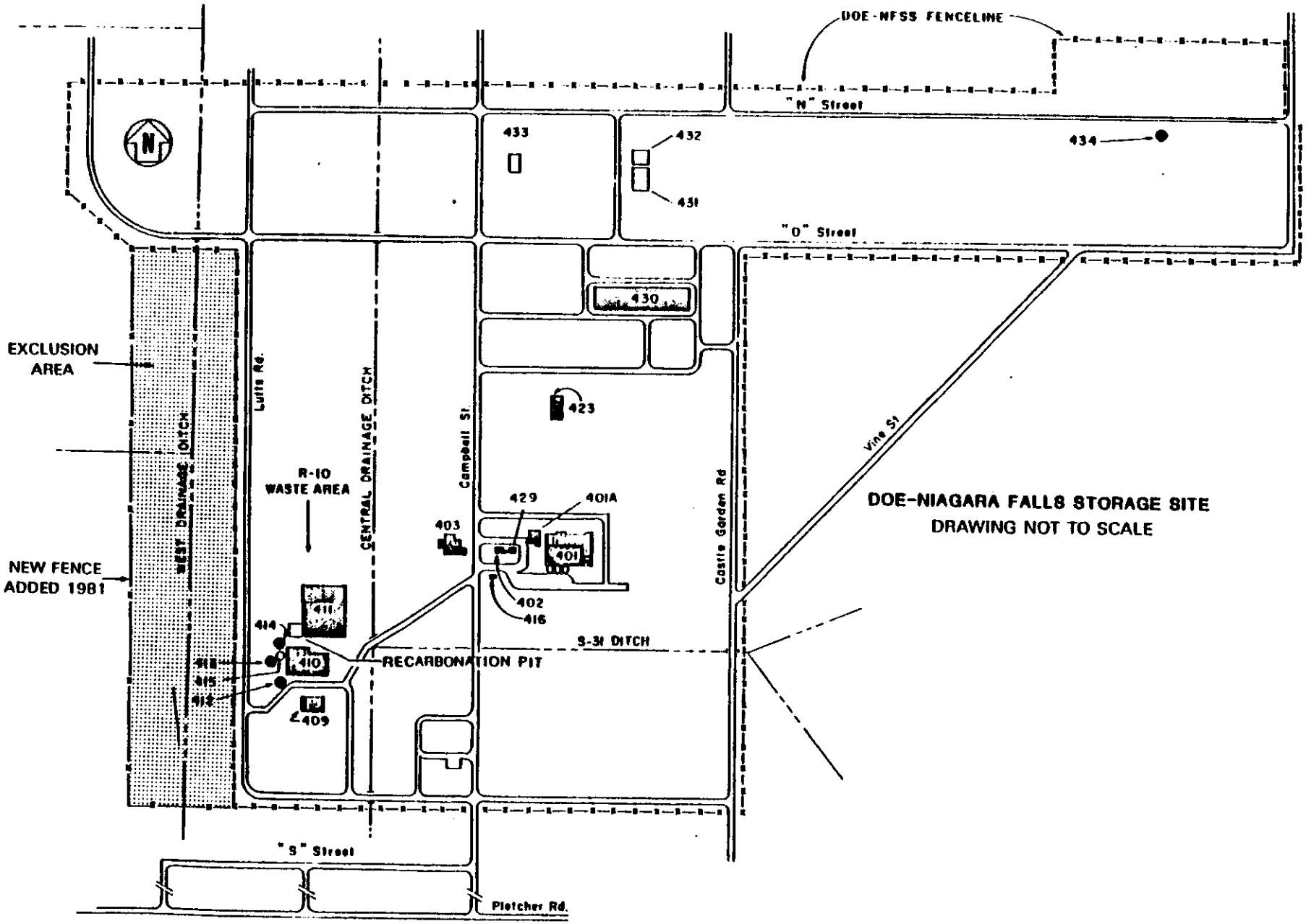


FIGURE 1-2 DIAGRAM OF THE NFSS SHOWING STRUCTURES AND FEATURES OF THE SITE PRIOR TO INTERIM REMEDIAL ACTIONS

Also in 1981, remedial action was performed on a triangular-shaped area located just off the NFSS in an area bounded by Vine and O Streets and Castle Garden Road. Approximately 345 m^3 (450 yd^3) of contaminated material were excavated from this vicinity property and were relocated to the R-10 waste storage area.

To further reduce the levels of radon emanating from the site, in 1982 Buildings 413 and 414 (used for storing the L-50 residues) were upgraded and sealed. Also in 1982, to prevent further migration of residues, contaminated soil near the R-10 pile was moved onto the pile, and a dike and cutoff wall were constructed around the R-10 area. The R-10 pile was then covered with an ethylene propylene diene monomer (EPDM) liner, which resulted in a marked reduction in radon emanations from the R-10 area.

1.3 1983 SITE ACTIVITIES

During 1983, interim remedial actions involved the excavation of approximately 38,000 m^3 (50,000 yd^3) of contaminated materials from on-site contaminated areas and on-site and off-site drainage areas. These materials were relocated to the R-10 waste storage area. Work also continued in 1983 to develop the R-10 area and the area south of Building 411 as an interim waste containment area.

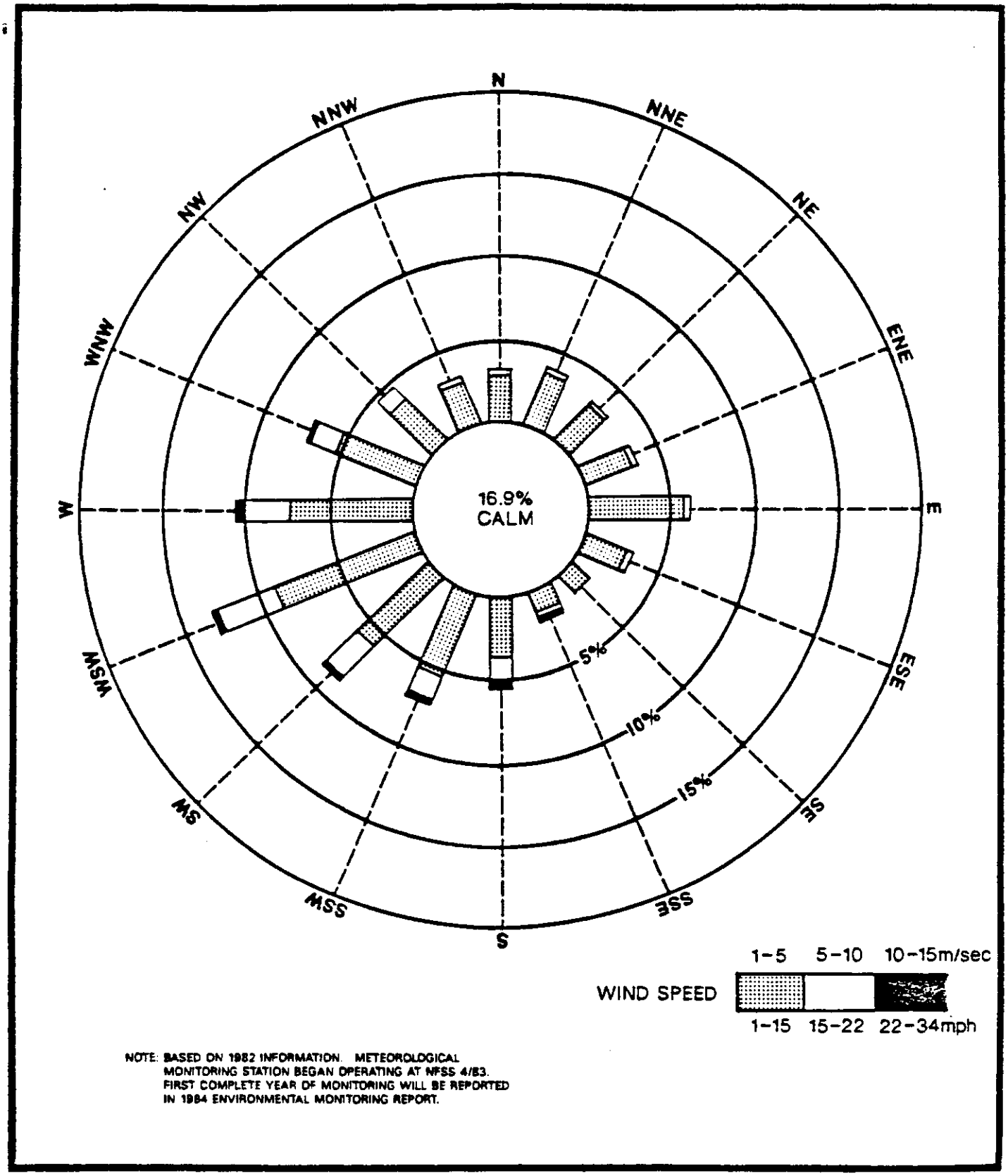
Other 1983 activities included: (1) testing and preparation for the planned relocation and consolidation of pitchblende residues (including the K-65 residues) within the waste containment area; and (2) installation of a meteorological tower which began operating in April 1983. All 1983 activities and planned future activities are described in detail in the Niagara Falls Storage Site Project Management Plan (Ref. 2).

1.4 CLIMATE

The climate of the NFSS is classified as humid continental, with considerable moderating influence from Lake Ontario. The normal

temperature range is -4°C to 24°C (25°F to 76°F) with a mean annual temperature of 9°C (48°F). Mean annual precipitation is 81 cm (32 in.). Snowfall averages 142 cm (56 in.) per year, accounting for about ten percent of the annual total precipitation.

Wind speeds and directions for the site are shown in Figure 1-3. Examination of the data shows that the wind originates predominantly from a 45° sector that includes west, west-southwest and southwest for a total of 31 percent of the time. Of this total time, velocities are 0-5 m/s 69 percent of the time, 5-10 m/s 29 percent of the time, with velocities over 10 m/s (22 mph) reached only about 2 percent of the time.



NOTE: BASED ON 1982 INFORMATION. METEOROLOGICAL MONITORING STATION BEGAN OPERATING AT NFSS 4/83. FIRST COMPLETE YEAR OF MONITORING WILL BE REPORTED IN 1984 ENVIRONMENTAL MONITORING REPORT.

FIGURE 1-3 WIND SPEEDS AND DIRECTIONS FOR NFSS

2.0 SUMMARY OF MONITORING RESULTS

During 1983, the environmental monitoring program at the NFSS continued to sample air, water, and sediments, and external gamma rates were monitored to determine the site's compliance with DOE Concentration Guides (CGs) provided in DOE Order 5480.1A, Chapter XI (Ref. 3). Radiation doses were calculated to determine hypothetical exposure levels, which were compared to the DOE Radiation Protection Standards (RPS).

Radon concentrations at the site boundary and exclusion area monitoring locations were all below the DOE CG limit of 3.0 pCi/l. In general, radon levels were higher at all monitoring locations during summer months. The highest monthly level recorded, 2.43 pCi/l (in September), was below the CG. The highest annual average recorded at the site was equal to 30 percent of the CG. Comparison with 1982 radon concentrations reveals an overall decrease for radon during 1983, as illustrated in Figure 3-2.

Water sampling and analysis during 1983 showed that uranium and radium-226 concentrations were below the DOE CG limit for release to uncontrolled areas. For locations subject to the DOE CG limits for uncontrolled areas, 1.0 mg/l, the highest annual average concentration of uranium was 0.046 mg/l, or 4.6 percent of the CG. For radium-226, the highest annual average concentration was 4.0 pCi/l, or 13.3 percent of the CG for release to uncontrolled areas.

Sediment samples generally showed higher uranium and radium-226 concentrations during the second quarter of 1983, when remedial action in the Central Ditch was underway. Concentrations decreased sharply thereafter. The highest annual average concentration of uranium at a location in an uncontrolled area was 6.12 pCi/g, or 8 percent of the DOE proposed standard for cleanup (Ref. 5).

The highest annual average concentration of radium-226 in sediments was 21.2 pCi/g, or more than four times (424 percent) the proposed standard of 5 pCi/g in the top 15 cm (6 in.) of soil (Ref. 5).

However, this annual average incorporates high readings obtained in the first two quarters of the year, prior to the completion of cleanup. In the third and fourth quarters, radium-226 concentrations at the same sampling location were 0.6 pCi/g and 0.1 pCi/g, respectively. Therefore, by year's end all radium-226 concentrations were below the proposed guideline for cleanup.

The highest annual average external gamma rate recorded at the site boundary was 31.1 uR/h. This equals approximately 55 percent of the DOE RPS of 57 uR/h (Ref. 3).

Radiological exposures to a hypothetical individual were calculated, assuming the person resided continuously at the points of highest exposure potential. Three exposure pathways were quantified: inhalation of radon and radon daughters; ingestion of contaminated surface or groundwater; and exposure to external gamma radiation.

The maximally exposed individual at the NFSS boundary would receive a calculated dose to the lung of 400 mrem/yr from radon inhalation. The DOE RPS restricts lung doses to 1500 mrem/yr.

Ingestion of water exiting the site in the Central Ditch would result in a 50 year dose commitment to the bone of approximately 100 mrem. Ingestion of water containing radium-226 at the DOE CG of 30 pCi/l would produce a 50 year dose commitment to the bone of 2340 mrem.

External gamma radiation from radioactive materials at the NFSS irradiate the whole body at a rate of 160 mrem/yr, compared to the DOE limit of 500 mrem/yr.

Results of the 1983 monitoring show that the NFSS presently is in compliance with all DOE CG and RPS limits. The 1983 results also reflect the effect interim remedial actions are having on reducing radon concentrations and external gamma exposure rates.

3.0 DATA COLLECTION, ANALYSIS, AND EVALUATION

This section provides the results of 1983 environmental monitoring at the NFSS, including the sampling, monitoring, and analytical procedures and the extent of conformance with applicable DOE standards. The average values listed in the individual tables are the arithmetic average of the sum of individual results. Individual sources of error (i.e., analytical error, sampling error, etc.) were not estimated. In computing the averages, where values are less than the limit of sensitivity of the analytical method, values are considered as being equal to the limit of sensitivity and the "average" value is reported without the notation "less than."

During 1983, air, water, and sediment samples were collected by site personnel and external radiation intensity was measured to determine the radioactivity concentrations in the environs of the site. Supplemental radon monitoring was conducted at the NFSS and off-site areas by Mound Laboratory, operated for DOE by Monsanto Research Corporation, Miamisburg, Ohio.

DOE standards for radionuclides are provided in the CGs contained in Reference 3. The CGs for radionuclides of concern at the NFSS are included in Appendix A of this report.

3.1 AIR SAMPLING

Thirty-four radon gas detectors are maintained at on-site and site boundary locations at the NFSS, with three of the detectors (31, 32, and 33) designated as quality control stations. The locations of the radon monitors are shown in Figure 3-1.

The radon gas monitors are Terradex Type-F Track-Etch detectors, with a sensitivity level of 1.0 pCi/l per month. The lower limit of detection at the 1.0 pCi/l per month level is 0.27 pCi/l per month. Detectors are obtained from the Terradex Corporation, placed at the sample locations and collected by site personnel, then returned to Terradex for analytical services.

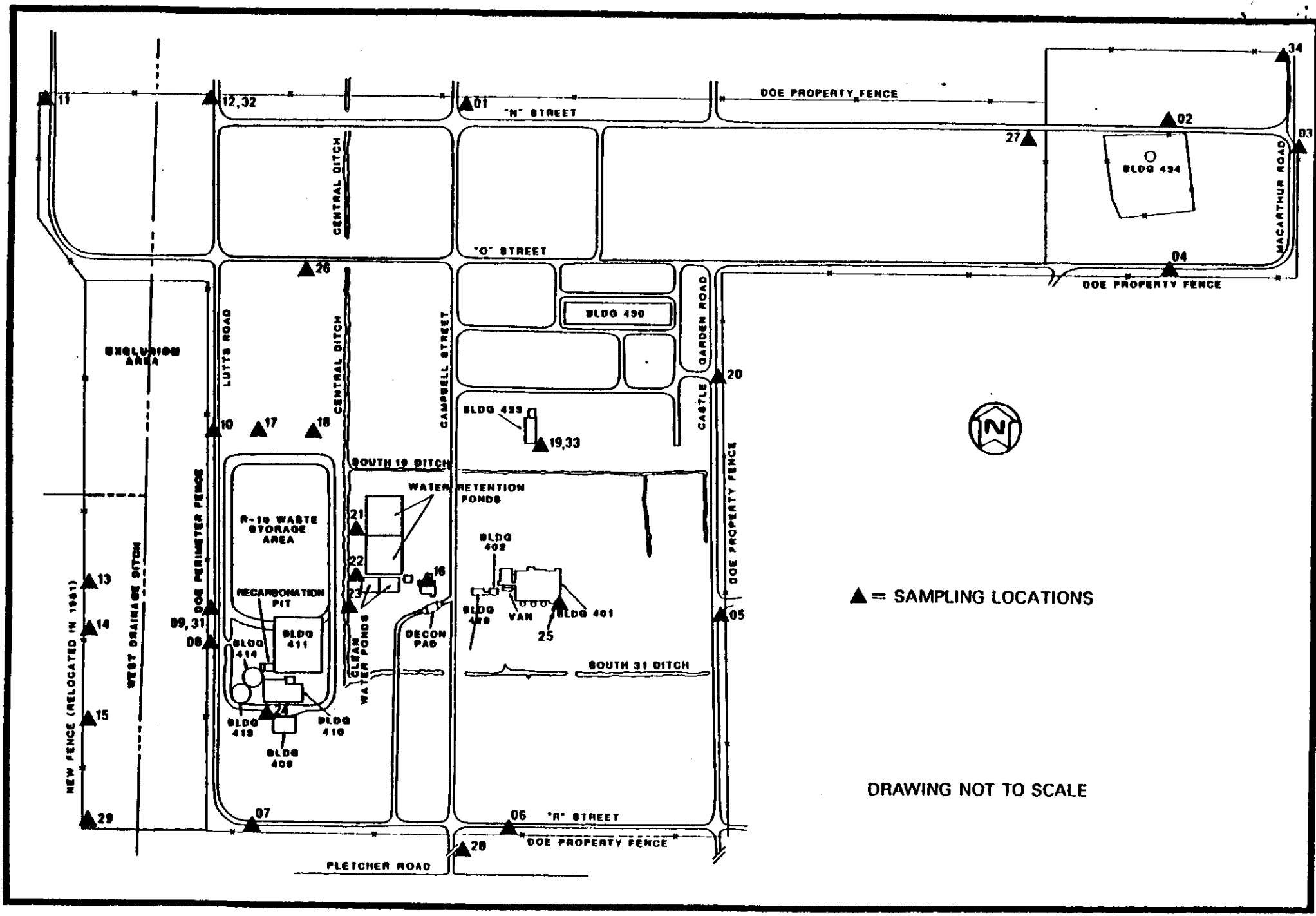


FIGURE 3-1 RADON AND EXTERNAL GAMMA MONITORING LOCATIONS AT NFSS

Table 3-1 reports the average concentrations of radon gas in the air recorded at site boundary monitoring locations and the exclusion area (established in 1981 when a portion of the site's western fence line was relocated further west). As the data show, monthly average concentrations ranged from 0.02 to 2.43 pCi/l. Annual averages ranged from 0.37 to 0.89 pCi/l. All these values are below the DOE CG for release of radon to uncontrolled areas. The highest annual average is equal to 30 percent of the CG.

The maximum monthly radon level recorded in 1983, 2.43 pCi/l, was recorded at Location 1 during September. This location is near an area from which contaminated soil was excavated during 1983, and the effects of the construction activity are reflected in the elevated September reading. In general, the data in Table 3-1 show elevated radon readings during the summer months at most of the monitoring locations. These higher readings reflect both the effect of construction activities and the normal increases expected during summer months.

Radon levels have shown a decrease from 1982 to 1983. Annual averages in 1982 ranged from 0.36 to 2.97 pCi/l; in 1983 averages ranged from 0.37 to 0.89 pCi/l. This decrease is reflected graphically in Figure 3-2. The lower radon levels in 1983 possibly reflect the effect of interim remedial actions at the site.

3.1.1 Supplemental Radon Monitoring

Mound Laboratories also performed radon monitoring at NFSS during 1983 at 12 locations on the site perimeter, 2 locations in the exclusion area, and 30 off-site locations. Mound's program uses passive environmental radon monitors (PERMs), which have a thermoluminescent dosimeter (TLD) as the detection element. The TLDs are changed on a weekly basis.

Figure 3-3 shows the locations of the 14 site boundary/exclusion area PERMs and 22 of the off-site locations. The remaining 8 off-site locations are shown in Figure 3-4. The results from the

TABLE 3-1

MONTHLY AVERAGES FOR RADON-222 MONITORING LOCATIONS AT SITE BOUNDARIES AND EXCLUSION AREA[a]

Units = Picocuries per liter (pCi/l)

Month	Sampling Location[b]																				
	1	3	4	5	6	7	8	9	10	11	12	13	14	15	20	28	29	30	31	32	34
January	0.92	0.41	0.19	0.27	0.56	0.56	0.63	0.27	0.85	0.70	0.48	0.56	0.34	0.70	0.92	0.19	1.14	0.63	0.34	0.56	0.34
February	0.74	0.57	0.40	0.31	0.23	0.66	0.48	1.25	1.00	0.48	0.57	0.14	0.48	0.40	0.57	0.40	0.40	0.83	0.91	0.48	0.23
March	0.05	0.05	0.23	0.28	0.28	0.05	0.82	0.21	0.05	0.05	0.13	0.05	0.05	0.05	0.21	0.21	0.05	0.05	0.51	0.13	0.21
April	0.13	0.28	0.44	0.21	0.28	0.13	0.21	1.05	0.21	0.75	0.13	0.21	0.28	0.28	0.36	0.13	0.21	0.51	0.98	0.21	0.75
May	0.18	0.10	0.50	0.26	0.10	0.50	0.02	0.42	0.10	0.34	0.34	0.26	0.34	0.10	0.18	0.26	0.50.	...h	0.50	0.26	0.18
June	0.75	0.26	0.83	0.34	0.75	1.23	0.99	0.91	1.23	0.58	0.50	0.50	0.42	0.66	0.99	0.42	1.99	0.58[h]	0.91	0.66	0.99
July	1.90	0.62	1.53	0.40	0.92	0.40	1.53[c]	0.70	0.40	0.25	1.00	0.55	0.62	0.77	0.47	0.40	0.62	0.85	1.53	0.25	0.70
August	0.72	0.95	0.33	0.64	0.41	0.26	0.57	0.57	0.57	0.26	0.64	0.33	...d	0.64	0.41	0.41	0.57	0.18	1.96	0.26	0.10
September	2.43	1.57	1.92	1.14	1.14	0.97	0.45	...e	1.14	0.63	1.14	1.14	1.40	1.83	0.80	1.06	1.40	1.14	...e	0.63	1.49
October	0.64	0.57	0.26	0.18	0.41	0.72	0.26	0.10	0.41	0.33	0.57	0.33	0.57	0.49	0.33	0.18	0.41	0.18	0.49	0.18	0.66
November	0.57	0.57	0.18	0.64	0.41	0.72	0.72	1.65	1.26	0.95	0.41	0.26	0.10	0.26	0.26	0.33	0.72	0.10	1.03	0.57	1.03
December	0.53	0.53	0.17	0.17	0.17	0.24	0.31	0.60	0.31	0.31	0.68	0.09	0.24	0.31	0.82	0.39	0.31	0.17	0.60	0.39	0.24
Average[f]	0.80	0.54	0.58	0.40	0.47	0.54	0.50	0.70	0.63	0.47	0.55	0.37	0.44	0.54	0.53	0.37	0.64	h,i	0.89	0.38	0.58
No. of Measurements	12	12	12	12	12	12	11	11	12	12	12	12	11	12	12	12	12	h,i	11	12	12
Percent of Standard[g]	27	19	19	13	16	19	17	23	22	16	18	13	15	19	18	12	22	h,i	30	13	19

a - Measurements are total radon concentrations and background has not been subtracted. Sampling locations 8, 9, 10 and 31 are at the site's original legal boundary and are in a controlled area. Sampling locations 13, 14 and 15 are located at the perimeter of the new exclusion area established October 1, 1981. At the 1.0 sensitivity level, the lower limit of detection is actually 0.27 pCi/l per month.

b - Sampling locations are shown in Figure 3-1.

c - Detector had oil substance on filter and radon value was not used in calculating average or percentage.

d - Detector missing from sampling location.

e - Detector under water due to construction activities.

f - Average is calculated on the number of measurements corresponding to an identical number of months.

g - The DOE CG limit for radon-222 is 3.0 pCi/l for uncontrolled areas, per DOE Order 5480.1A (Ref. 3). Percentage has been rounded to the nearest whole number.

h - Background detector not returned at end of exposure period.

i - Background detector relocated to new location at 144 Jackson St. Youngstown, New York. Detector was exposed inside a building and the radon-222 values recorded can not be used to estimate natural background.

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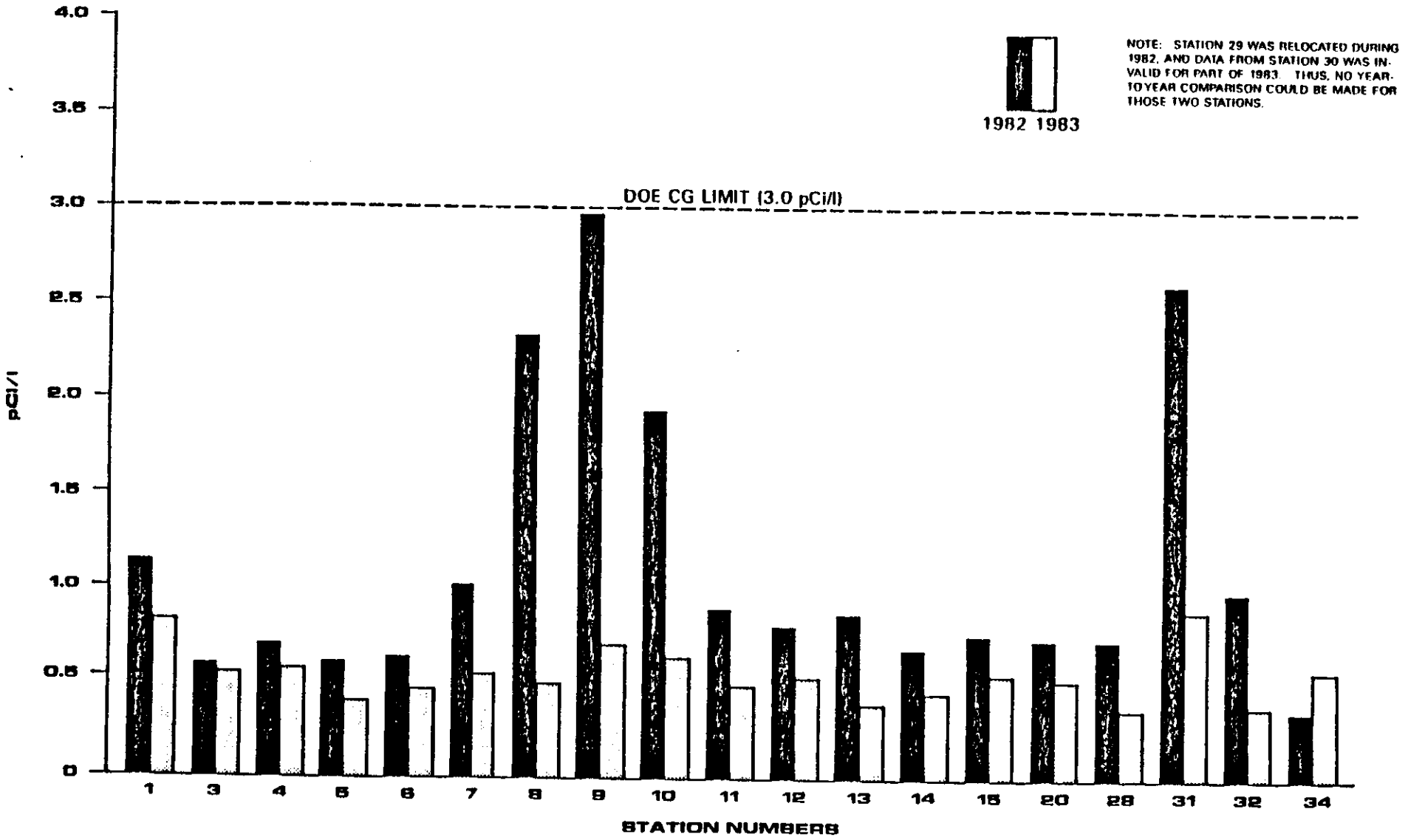

FIGURE 3-2 COMPARISON OF RADON-222 ANNUAL AVERAGES,CALENDAR YEARS 1982 AND 1983

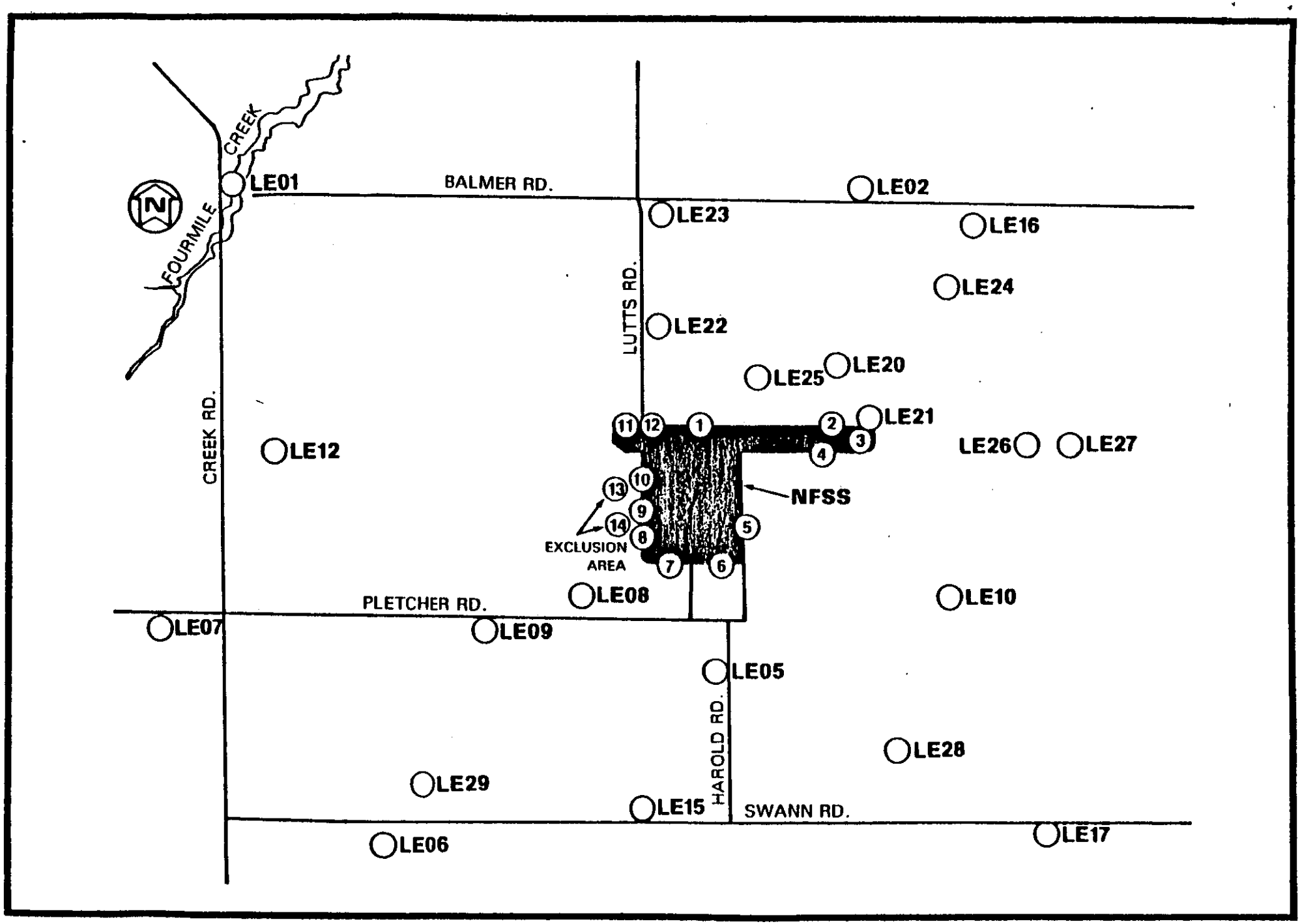

FIGURE 3-3 SITE BOUNDARY, EXCLUSION AREA, AND 22 OFF-SITE PERM LOCATIONS

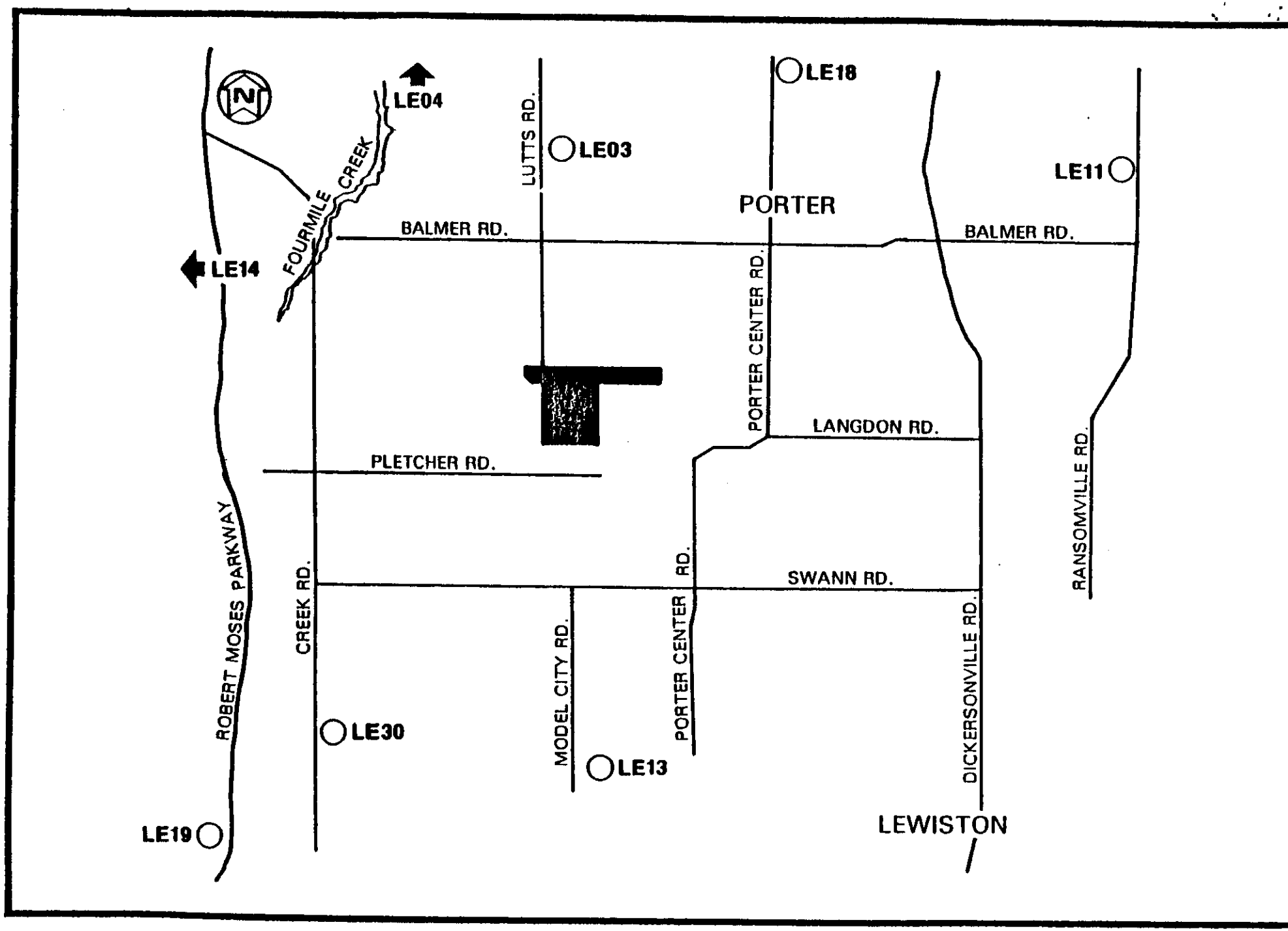

FIGURE 3-4 LOCATION OF EIGHT OFF-SITE PERMS 2000 METERS OR FURTHER FROM NFSS

on-site monitors are presented in Table 3-2. Annual averages ranged from 0.22 to 0.43 pCi/l, with the highest annual average equal to 14.3 percent of the DOE CG for release to uncontrolled areas.

Results from the 30 off-site PERMs are presented in Table 3-3. Annual averages for off-site monitors ranged from 0.17 to 0.28. The highest average is equal to 9.3 percent of the DOE CG for release of radon to uncontrolled areas. The average natural background for the NFSS area recorded by Mound Laboratory was 0.18 pCi/l.

3.2 WATER SAMPLING

During 1983, sampling was performed to determine the concentrations of uranium and radium in surface water and groundwater at both on-site and off-site locations. On-site sampling locations are shown in Figure 3-5; off-site locations are shown in Figure 3-6. Figure 3-7 shows the locations of 16 new on-site groundwater wells added to the monitoring program during 1983. The results of analyses for uranium for all sampling locations are presented in Table 3-4; radium concentrations are presented in Table 3-5.

Surface water samples were collected quarterly from the Central Ditch at locations 10, 11, 12, and 20. Locations 12 and 20 are off-site, 1.6 km (1 mi) and 3.2 km (2 mi), respectively, downstream from the NFSS northern boundary. Samples were collected using the grab sampling technique and were analyzed by Eberline Instrument Corporation (EIC) for total uranium (by fluorometry) and dissolved radium-226 (by radon emanation).

The DOE CG for release of uranium to uncontrolled areas (1.0 mg/l) would apply to locations 11, 12, 20. Concentrations at these locations were well below the CG (Table 3-4). Location 10 had one quarterly average of 3.9 mg/l and an annual average concentration of 0.994 mg/l. However, this is an on-site controlled location for which the CG is 30 mg/l.

TABLE 3-2

SUMMARY OF DATA FOR ON-SITE PASSIVE ENVIRONMENTAL RADON MONITORS, 1983[a]

Sampling Location[b]	Quarterly Averages				Concentration (pCi/l)			Percent of Standard[c] (Annual Average)
	1st	2nd	3rd	4th	Minimum	Maximum	Average	
1	0.29	0.25	0.40	0.26	0.25	0.40	0.30	10.0
2	0.21	0.27	0.42	0.23	0.21	0.42	0.29	9.7
3	0.22	0.30	0.50	0.28	0.22	0.50	0.33	11.0
4	0.25	0.28	0.51	0.30	0.25	0.51	0.34	11.3
5	0.18	0.18	0.37[d]	0.26	0.18	0.37	0.22	7.3
6	0.16	0.21	0.34	0.20	0.16	0.34	0.23	7.7
7	0.31	0.32	0.39	0.22	0.22	0.39	0.31	10.3
8[e]	0.46	0.41	0.34	0.43	0.34	0.46	0.41	13.7
9[e]	0.31	0.45	0.38	0.59	0.31	0.59	0.43	14.3
10[e]	0.33	0.32	0.34	0.25	0.25	0.34	0.31	10.3
11	0.19	0.29	0.30	0.21	0.19	0.30	0.24	8.0
12	0.30	0.28	0.41	0.23	0.23	0.41	0.31	10.3
13	0.17	0.26	0.41	0.21	0.17	0.41	0.27	9.0
14	0.15	0.23	0.38	0.25	0.15	0.38	0.26	8.7

a - Measurements by Mound Laboratory, Monsanto Research Corporation. These measurements are total radon concentrations and background has not been subtracted.
b - Sampling locations are shown in Figure 3-3.
c - The DOE CG for radon-222 is 3.0 pCi/l for uncontrolled areas, per DOE Order 5480.1A (Ref. 3)
d - Location 5 was inaccessible except for the last two weeks of the monitoring period. The value reported is the average of two measurements.
e - Monitoring locations are within a controlled area where members of the public cannot enter.

TABLE 3-3

SUMMARY OF DATA FOR OFF-SITE PASSIVE ENVIRONMENTAL RADON MONITORS, 1983[a]

Sampling Location[b]	Quarterly Averages				Concentration (pCi/l)			Percent of Standard (Annual Average)
	1st	2nd	3rd	4th	Minimum	Maximum	Average	
LE01[c]	0.13	0.19	0.27	0.18	0.13	0.27	0.19	6.3
LE02	0.12	0.18	0.26	0.17	0.12	0.26	0.18	6.0
LE03	0.13	0.16	0.33	0.16	0.13	0.33	0.20	6.7
LE04[c]	0.15	0.14	0.23	0.13	0.13	0.23	0.16	5.3
LE05	0.14	0.14	0.38	0.27	0.14	0.38	0.24	8.0
LE06	0.12	0.15	0.24	0.16	0.12	0.24	0.18	6.0
LE07[c]	0.13	0.18	0.34	0.19	0.13	0.34	0.21	7.0
LE08	0.15	0.30	0.36	0.26	0.15	0.36	0.28	9.3
LE09	0.15	0.21	0.50	0.25	0.15	0.50	0.28	9.3
LE10	0.13	0.17	0.36	0.19	0.13	0.36	0.21	7.0
LE11[c]	0.16	0.19	0.31	0.19	0.16	0.31	0.22	7.3
LE12	0.14	0.17	0.29	0.26	0.14	0.29	0.22	7.3
LE13[c]	0.10	0.13	0.20	0.16	0.10	0.20	0.15	5.9
LE14[c]	0.11	0.16	0.21	0.14	0.11	0.21	0.16	5.3
LE15	0.21	0.17	0.25	0.19	0.17	0.25	0.21	7.0
LE16	0.14	0.17	0.36	0.20	0.14	0.36	0.22	7.3
LE17[c]	0.13	0.16	0.24	0.17	0.13	0.24	0.18	6.0
LE18[c]	0.11	0.13	0.25	0.15	0.11	0.25	0.17	5.7
LE19[c]	0.14	0.14	0.22	0.18	0.14	0.22	0.17	5.7
LE20	0.11	0.17	0.21	0.18	0.11	0.21	0.17	5.7
LE21	0.18	0.24	0.41	0.23	0.18	0.41	0.27	9.0
LE22	0.19	0.25	0.40	0.18	0.18	0.40	0.25	8.3
LE23	0.18	0.23	0.29	0.21	0.18	0.29	0.23	7.7
LE24	0.13	0.18	0.30	0.21	0.13	0.30	0.21	7.0

TABLE 3-3
(continued)

Sampling Location	Quarterly Averages				Concentration (pCi/l)			Percent of Standard (Annual Average)
	1st	2nd	3rd	4th	Minimum	Maximum	Average	
LE25	0.19	0.23	0.28	0.23	0.19	0.28	0.23	7.7
LE26	0.16	0.18	0.43	0.26	0.16	0.43	0.26	8.7
LE27	0.14	0.20	0.42	0.25	0.14	0.42	0.26	8.7
LE28	0.13	0.17	0.32	0.18	0.13	0.32	0.20	6.7
LE29	0.16	0.15	0.26	0.22	0.15	0.26	0.20	6.7
LE30[c]	0.12	0.15	0.23	0.19	0.12	0.23	0.17	5.7
Background	0.13	0.16	0.25	0.17	0.13	0.25	0.18	6.0

a - Measurements by Mound Laboratory, Monsanto Research Corporation.
b - Sampling locations are shown in Figures 3-3 and 3-4.
c - These locations form a control group for measuring background radon levels. Values ranged from 0.10 to 0.50 pCi/l and averaged 0.18 pCi/l for 1983 average natural background. The DOE CG for radon-222 is 3.0 pCi/l for uncontrolled areas, per DOE Order 5480.1A (Ref. 3).

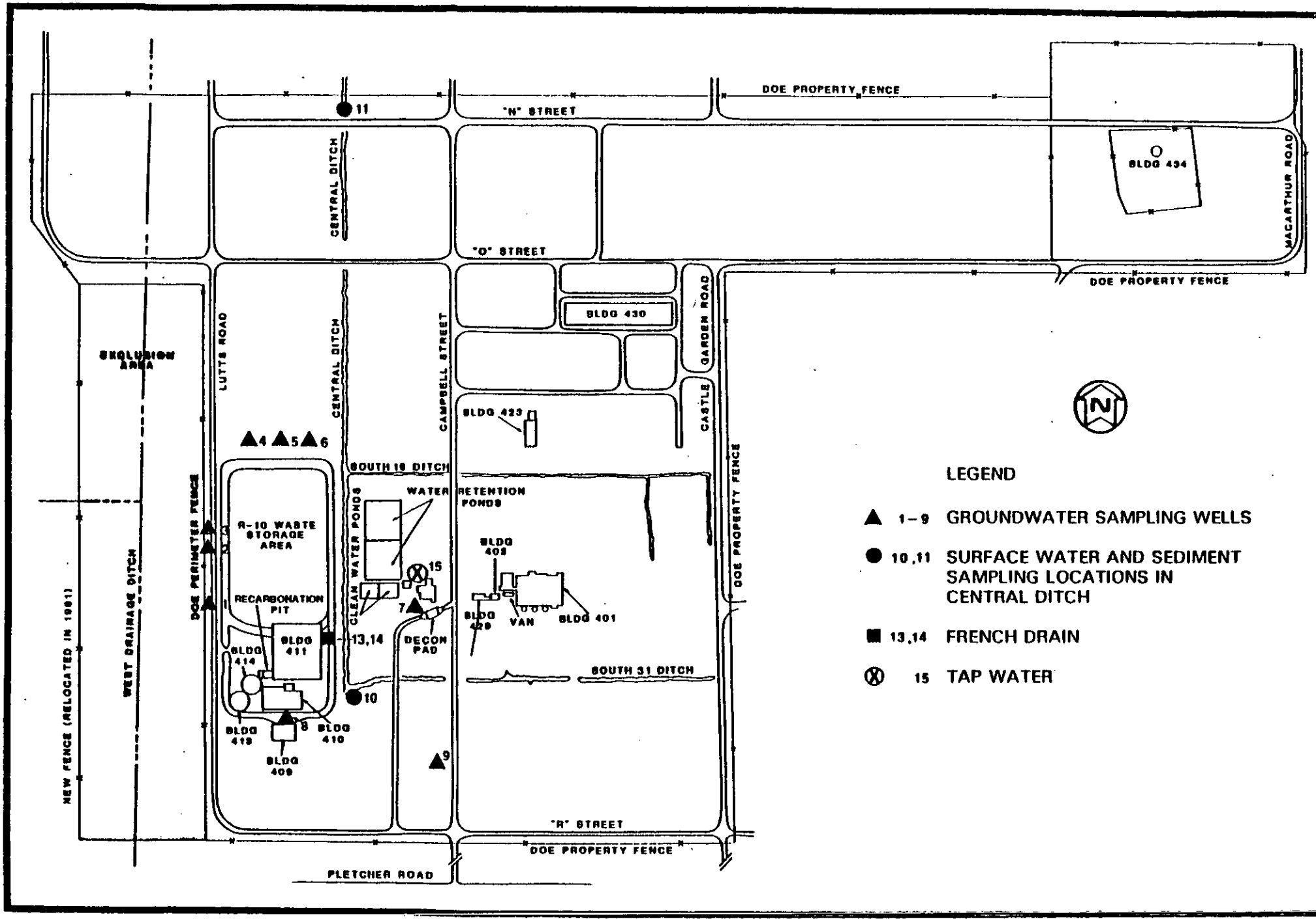

FIGURE 3-5 ON-SITE WATER SAMPLING LOCATIONS

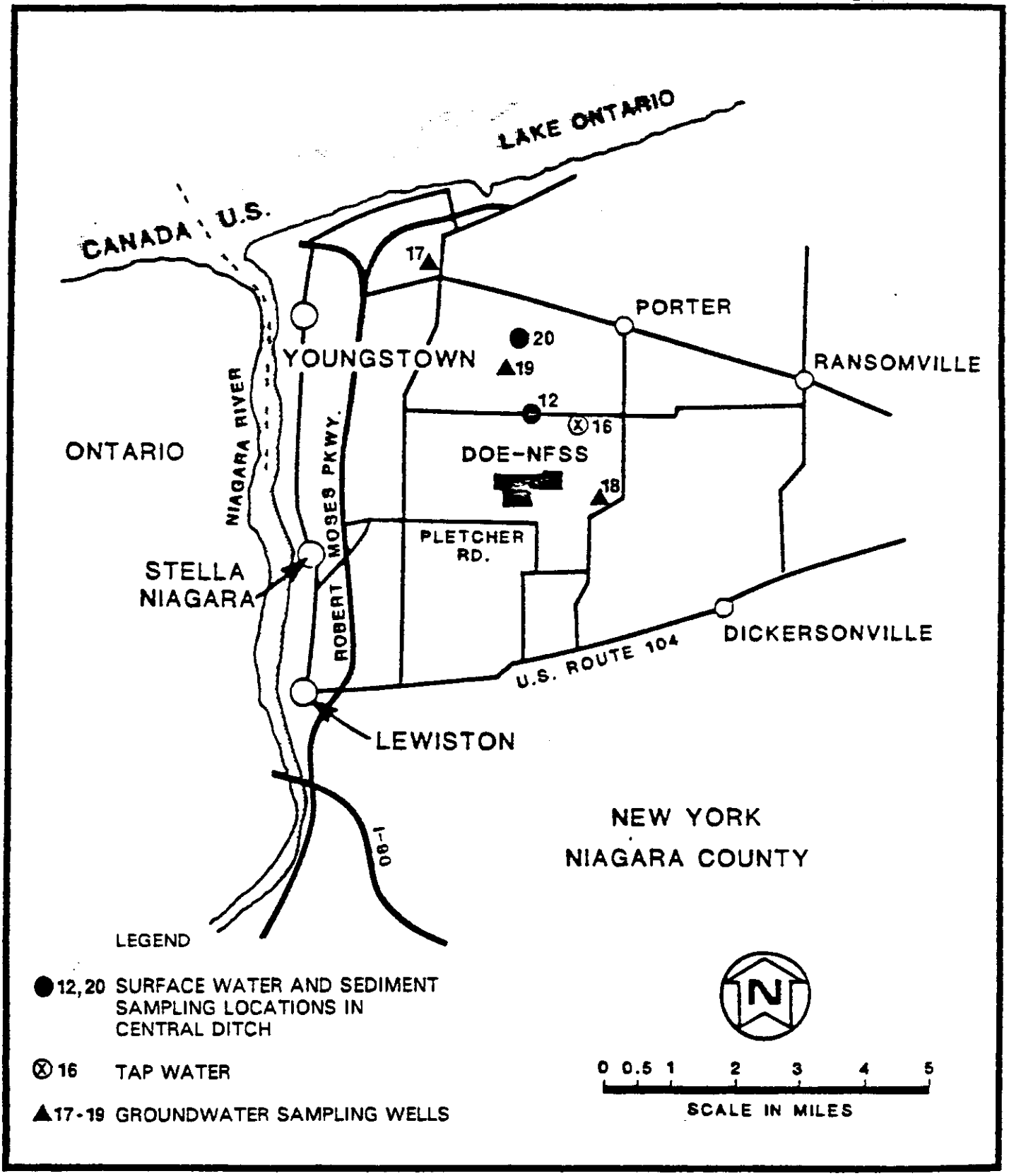

FIGURE 3-6 OFF-SITE WATER SAMPLING LOCATIONS

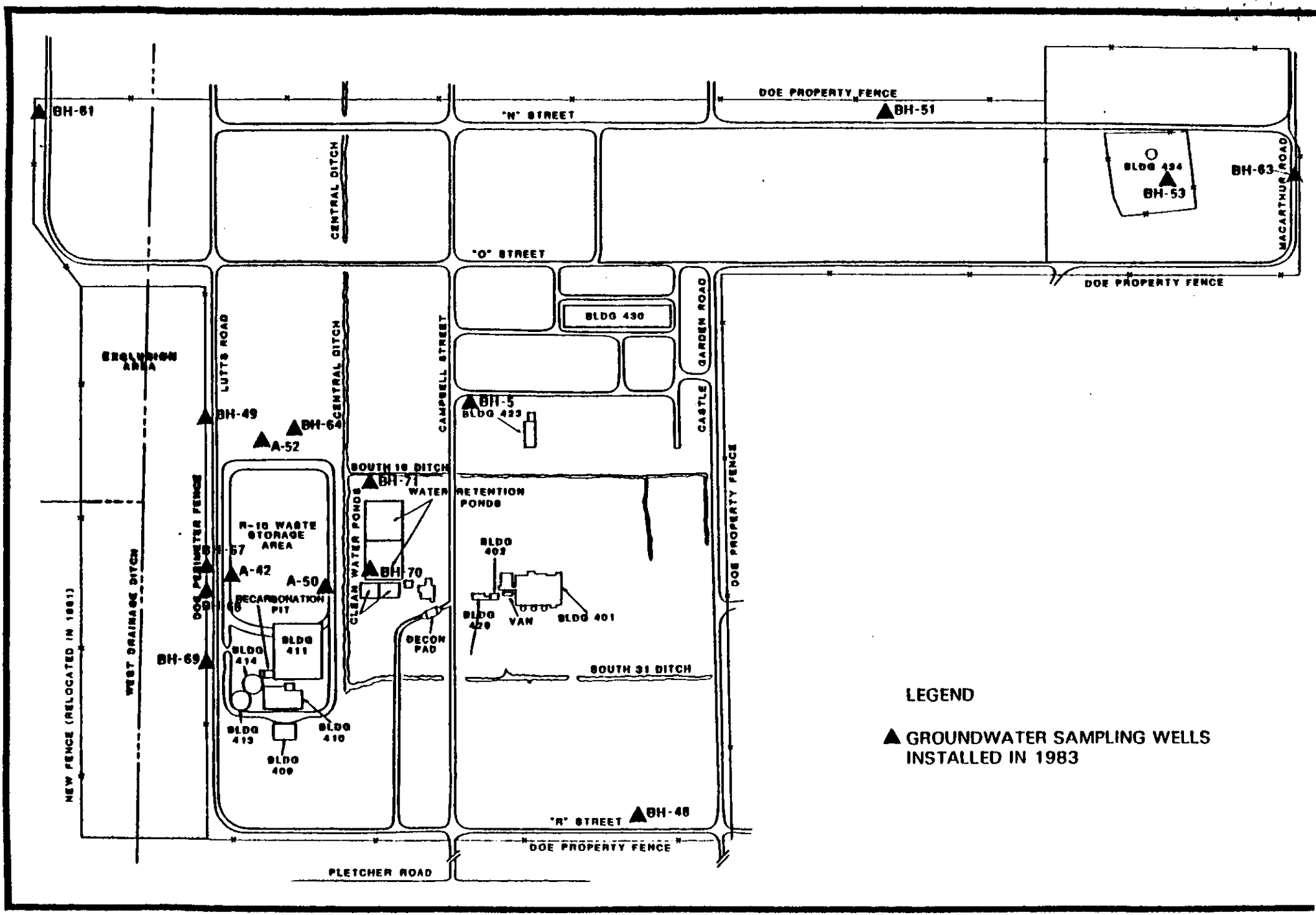

FIGURE 3-7 LOCATION OF ON-SITE GROUNDWATER SAMPLING WELLS INSTALLED DURING 1983

TABLE 3-4

DISSOLVED URANIUM CONCENTRATIONS IN NFSS WATER SAMPLES, 1983

Sampling Location[a]	Quarterly Averages				Concentration (mg/l)			Percent of Standard[b] (Annual Average)
	1st	2nd	3rd	4th	Minimum	Maximum	Average	
On-Site Groundwater								
1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	0.5
2	0.014	<0.005	——[c]	——[c]	<0.005	0.014	0.010	1.0
3	<0.005	<0.005	<0.005	0.005	<0.005	0.005	0.005	0.5
4	0.009	<0.005	<0.005	0.005	<0.005	0.009	0.006	0.6
5	0.005	<0.005	<0.005	<0.005	<0.005	0.005	0.005	0.5
6	<0.011	<0.005	<0.005	<0.005	<0.005	0.011	0.007	0.7
7	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	0.5
8	0.006	<0.005	——[c]	——[c]	<0.005	0.006	0.006	0.6
9	0.011	<0.005	<0.005	<0.005	<0.005	0.011	0.007	0.7
BH-5	——[d]	——[d]	0.009	<0.005	0.005	0.009	0.007	0.7
BH-48	——[d]	——[d]	<0.005	0.008	0.005	0.008	0.007	0.7
BH-49	——[d]	——[d]	0.005	<0.005	<0.005	0.005	0.005	0.5
BH-51	——[d]	——[d]	0.019	0.008	0.008	0.019	0.014	1.4
BH-53	——[d]	——[d]	0.009	0.005	0.005	0.009	0.007	0.7
BH-61	——[d]	——[d]	0.011	<0.005	<0.005	0.011	0.008	0.8
BH-63	——[d]	——[d]	0.015	0.012	0.012	0.015	0.014	1.4
BH-64	——[d]	——[d]	0.029	0.024	0.024	0.029	0.027	2.7
BH-67	——[d]	——[d]	0.013	0.006	0.006	0.013	0.010	1.0
BH-68	——[d]	——[d]	0.025	0.020	0.020	0.025	0.023	2.3
BH-69	——[d]	——[d]	<0.005	<0.005	<0.005	<0.005	0.005	0.5
BH-70	——[d]	——[d]	0.006	0.007	0.006	0.007	0.007	0.7
BH-71	——[d]	——[d]	<0.005	<0.005	<0.005	<0.005	0.005	0.5
A-42	——[d]	——[d]	0.075	0.094	0.075	0.094	0.085	8.5
A-50	——[d]	——[d]	0.012	0.011	0.011	0.012	0.012	1.2
A-52	——[d]	——[d]	——[e]	——[e]	——[e]	——[e]	——[e]	——[e]
Off-Site Groundwater								
17[f]	<0.005	—	—	—	—	—	0.005	0.5
18[f]	0.010	—	—	—	—	—	0.010	1.0
19[f]	<0.005	—	—	—	—	—	0.005	0.5
On-Site Surface Water								
10[g]	0.015	3.9	0.040	0.020	0.015	3.9	0.994	99.4
11	0.022	0.100	0.041	0.020	0.020	0.100	0.046	4.6
Off-Site Surface Water								
12	<0.005	0.050	0.068	0.022	0.005	0.068	0.036	3.6
20	0.005	0.012	0.110	0.009	0.005	0.110	0.034	3.4
French Drain								
13[c,g]	0.005	—	—	—	—	—	0.005	0.5
14[c,g]	0.018	—	—	—	—	—	0.018	1.8
On-Site Tap Water								
15	<0.005	0.005	<0.005	——[h]	<0.005	0.005	0.005	0.5
Off-Site Tap Water								
16[f]	<0.005	—	—	—	—	—	0.005	0.5

a - Sampling locations are shown in Figures 3-5, 3-6, and 3-7.
b - The DOE CG for uranium in water released to uncontrolled areas is 1 mg/l. For controlled areas, the CG is 30 mg/l. The CG for uncontrolled areas was used to calculate percent of standard.
c - These sampling locations were discontinued as a result of 1983 construction activities.
d - These groundwater sampling wells were added to the monitoring program during 1983. Sampling will occur quarterly.
e - No samples could be obtained. Well casing damaged.
f - Sampling performed annually.
g - The DOE CG for release to uncontrolled areas would not apply to this on-site controlled area location.
h - No sample collected during fourth quarter.

TABLE 3-5

DISSOLVED RADIUM-226 CONCENTRATIONS IN NFSS WATER SAMPLES, 1983

Sampling Location[a]	Quarterly Averages				Concentration (pCi/l)			Percent of Standard[b] (Annual Average)
	1st	2nd	3rd	4th	Minimum	Maximum	Average	
On-Site Groundwater								
1	<0.1	0.3 ± 0.1	<0.1	0.2 ± 0.1	<0.1	0.3	0.2	0.7
2	1.3 ± 0.4	0.1 ± 0.1	—[c]	—[c]	0.1	1.3	0.7	2.3
3	0.3 ± 0.1	0.2 ± 0.1	<0.1	0.2	<0.1	0.3	0.2	0.7
4	0.1 ± 0.1	<0.1	<0.1	0.1	<0.1	0.1	0.1	0.3
5	0.2 ± 0.1	0.1 ± 0.1	0.1 ± 0.1	0.1	<0.1	0.2	0.1	0.3
6	0.2 ± 0.1	<0.1	<0.1	0.2 ± 0.1	<0.1	<0.2	0.2	0.7
7	0.1 ± 0.1	<0.1	<0.1	0.2	<0.1	0.2	0.1	0.3
8	<0.1	0.2 ± 0.1	—[c]	—[c]	<0.1	0.2	0.2	0.7
9	0.2 ± 0.1	0.2 ± 0.1	0.9 ± 0.3	0.3 ± 0.1	0.2	0.9	0.4	1.3
BH-5	—[d]	—[d]	0.1 ± 0.1	0.1 ± 0.1	0.1	0.1	0.1	0.3
BH-4B	—[d]	—[d]	0.2 ± 0.1	0.2 ± 0.1	0.2	0.2	0.2	0.7
BH-49	—[d]	—[d]	0.1 ± 0.1	0.3 ± 0.1	0.1	0.3	0.2	0.7
BH-51	—[d]	—[d]	0.3 ± 0.1	0.3 ± 0.1	0.3	0.3	0.3	1.0
BH-53	—[d]	—[d]	0.1 ± 0.1	0.2 ± 0.1	0.1	0.2	0.2	0.7
BH-61	—[d]	—[d]	0.1 ± 0.1	0.1	0.1	0.1	0.1	0.3
BH-63	—[d]	—[d]	0.1 ± 0.1	0.5 ± 0.2	0.1	0.5	0.3	1.0
BH-64	—[d]	—[d]	<0.1	0.2 ± 0.1	0.1	0.2	0.2	0.7
BH-67	—[d]	—[d]	0.3 ± 0.1	0.3 ± 0.1	0.3	0.3	0.3	1.0
BH-68	—[d]	—[d]	7 ± 2	0.5 ± 0.2	0.5	7.0	4.0	13.3
BH-69	—[d]	—[d]	0.4 ± 0.1	0.4 ± 0.1	0.4	0.4	0.4	1.3
BH-70	—[d]	—[d]	0.6 ± 0.2	0.6 ± 0.2	0.6	0.6	0.6	2.0
BH-71	—[d]	—[d]	0.3 ± 0.1	0.4 ± 0.1	0.3	0.4	0.4	1.3
A-42	—[d]	—[d]	0.1 ± 0.1	0.2 ± 0.1	0.1	0.2	0.2	0.7
A-50	—[d]	—[d]	0.2 ± 0.1	0.4 ± 0.1	0.2	0.4	0.3	1.0
A-52	—[d]	—[d]	—[e]	—[e]	—[e]	—[e]	—[e]	—[e]
Off-Site Groundwater								
17[f]	0.1 ± 0.1	—	—	—	—	—	0.1	0.3
18[f]	0.1 ± 0.1	—	—	—	—	—	0.1	0.3
19[f]	0.1	—	—	—	—	—	0.1	0.3
On-Site Surface Water								
10[g]	0.2 ± 0.1	1.1 ± 0.3	<0.1	<0.1	<0.1	1.1	0.4	1.3
11	0.2 ± 0.1	4.0 ± 1.0	0.5 ± 0.2	<0.1	<0.1	4.0	1.2	4.0
Off-Site Surface Water								
12	1.0 ± 0.3	0.8 ± 0.2	1.1 ± 0.3	0.2 ± 0.1	0.2	1.1	0.8	2.7
20	0.3 ± 0.1	0.6 ± 0.2	0.7 ± 0.2	0.6 ± 0.2	0.3	0.7	0.6	2.0
French Drain								
13[c,g]	0.3 ± 0.1	—[c]	—[c]	—[c]	—	—	0.3	1.0
14[c,g]	0.2 ± 0.1	—[c]	—[c]	—[c]	—	—	0.2	0.7
On-Site Tap Water								
15	<0.1	0.1	0.2 ± 0.1	—[h]	0.1	0.2	0.2	0.7
Off-Site Tap Water								
16[f]	<0.1	—	—	—	—	—	0.1	0.3

a - Sampling locations are shown in Figures 3-5, 3-6, and 3-7.
b - The DOE CG for radium-226 in water released to uncontrolled areas is 30 pCi/l. For controlled areas, the CG is 400 pCi/l. The CG for uncontrolled areas was used to calculate percent of standard.
c - These sampling locations were discontinued as a result of 1983 construction activities.
d - These groundwater sampling wells were added to the monitoring program during 1983. Sampling will occur quarterly.
e - No samples could be obtained. Well casing is damaged.
f - Sampling performed annually.
g - The DOE CG for release to uncontrolled areas would not apply to this on-site controlled area location.
h - No sample collected during fourth quarter.

The concentrations of radium in surface water at all sampling locations were well below the DOE CG for radium in water released to uncontrolled areas. The highest annual average, at Location 11, was only 4.0 percent of the CG.

During 1983, groundwater samples were collected quarterly from 9 on-site wells and annually from 3 off-site wells. During the third quarter of 1983, the groundwater monitoring program was upgraded, and 16 on-site wells were added to the monitoring program (see Figure 3-7). The old groundwater sampling locations (1-9) were or will be phased out. New wells BH-5, BH-48, BH-51, BH-53, BH-64, BH-67, BH-69, and BH-70 monitor the lower aquifer. Wells BH-68 and BH-71 monitor the bedrock aquifer. Wells A-42, A-50, and A-52 monitor the upper aquifer around the interim waste storage area. Well BH 48 is a background upgradient monitoring location and well BH-61 is a downgradient monitoring location. The new wells were sampled quarterly, beginning in the third quarter of the year.

Groundwater samples were collected 24 hours after the wells had been pumped "dry" or two casing volumes had been removed. Each well has its own collection equipment to prevent cross-contamination of samples. Samples were analyzed by EIC for total uranium (by fluorometry) and dissolved radium-226 (by radon emanation).

Results of analyses for concentrations of uranium in groundwater are presented in Table 3-4; radium results are presented in Table 3-5. Because of the limited size of the site, the proximity of the wells to the site boundary, and the lack of control over movement of groundwater, the DOE CGs for release of water to uncontrolled areas has been used in computing percent of standard (see Tables). The highest annual average concentrations of uranium in groundwater was 0.085 mg/l, measured at on-site well A-42. This reading is 8.5 percent of the DOE CG for uranium released to uncontrolled areas. The highest concentration at any off-site well was only 1.0 percent of the CG.

The highest annual average concentration of radium in groundwater was 4.0 pCi/l, measured at on-site well BH-68. This concentration is equal to 13.3 percent of the DOE CG for radium in water released to uncontrolled areas. All off-site wells had readings equal to only 0.1 percent of the CG.

In addition to surface water and groundwater, water was also sampled during 1983 at a French Drain near Building 411. Two samples taken during the first quarter (locations 13 and 14) were well below the DOE CG. During the second quarter, water was blocked from entering this drain system and the pipes were removed entirely during the third quarter.

Water was also sampled from taps supplied by a municipal water system. Location 15 samples the water on-site, and Location 16 samples the water off-site after it has passed through the NFSS. As Tables 3-4 and 3-5 show, the readings for uranium and radium at both locations were far below the DOE CG.

3.3 SEDIMENT SAMPLING

During 1983, sediment samples were collected on-site and off-site at surface water sampling Locations 10, 11, 12 and 20 (see Figures 3-5 and 3-6).

The analysis results, based on dry weight, are presented in Tables 3-6 (uranium) and 3-7 (radium). Quarterly analyses results for uranium ranged from less than 0.068 pCi/g to 401.2 pCi/g. The highest concentration was recorded during the second quarter at sampling location 10. The highest annual average for uranium concentrations also was recorded at Location 10 and equalled 136 percent of the proposed guidelines for cleanup of uranium. This location is in the on-site portion of the Central Ditch from which contaminated materials were excavated during 1983.

As the data in Table 3-7 show, the concentrations at all sampling locations peaked during the second quarter and thereafter decreased

TABLE 3-6

URANIUM CONCENTRATIONS IN NFSS SEDIMENT SAMPLES, 1983

Sampling Location[a]	Quarterly Results				Concentration (mg/g)			Percent of Standard[b] (Annual Average)
	1st	2nd	3rd	4th	Minimum	Maximum	Average	
On-Site								
10	4.82	401.20	1.70	0.068	0.068	401.2	102.0	136
11	0.88	21.08	1.49	0.068	0.068	21.08	6.12	8
Off-Site								
12	2.72	14.96	1.76	0.068	0.068	14.96	4.76	6
20	0.34	3.67	4.83	0.068	0.068	4.83	2.04	3

a - Sampling locations are shown in Figures 3-5 and 3-6.
b - The DOE proposed guideline for cleanup of uranium in soil is 75 pCi/g (Ref. 5).

TABLE 3-7

RADIUM-226 CONCENTRATIONS IN NFSS SEDIMENT SAMPLES, 1983

Sampling Location[a]	Quarterly Results				Concentration (p/Ci/g)			Percent of Standard[b] (Annual Average)
	1st	2nd	3rd	4th	Minimum	Maximum	Average	
On-Site								
10	3 ± 1	5 ± 1	1.4 ± 0.4	1.3 ± 0.4	1.3 ± 0.4	5 ± 1	2.7 ± 0.7	54
11	30 ± 10	54 ± 16	0.6 ± 0.2	0.1 ± 0.1	0.1 ± 0.1	54 ± 16	21.2 ± 6.6	424
Off-Site								
12	3 ± 1	14 ± 4	2.3 ± 0.7	3 ± 1	2.3 ± 0.7	14 ± 4	5.6 ± 1.7	112
20	4 ± 1	5 ± 1	2.1 ± 0.6	0.1 ± 0.1	0.1 ± 0.1	5 ± 1	2.8 ± 0.8	56

a - Sampling locations are shown in Figures 3-5 and 3-6.
b - The DOE proposed guideline for cleanup of radium in soil is less than 5 pCi/g above background in the top 15 cm (6 in.) and less than 15 pCi/l averaged over 15-cm-thick layers more than 15 cm below the surface (Ref. 5).

to less than 0.068 pCi/g at each location. These readings probably reflect the results of interim remedial action cleanup at the site during 1983.

The highest quarterly uranium concentration for a sampling location in an uncontrolled area was 21.08 pCi/g. The highest annual average recorded at the same location was 6.12 pCi/g, or 8 percent of the DOE proposed standard for cleanup.

Results of analyses for radium are similar to those obtained for uranium. The highest single reading, 54 pCi/g, and the highest annual average, 21.2 pCi/g, were both obtained from Location 11. The highest readings for all locations were obtained during the second quarter, with concentrations dropping in the third and fourth quarters. Though annual averages for Location 11 and Location 12 exceeded the proposed standard for radium, the fourth quarter results for all locations were well below the proposed standard. This probably reflects the results of interim remedial action cleanup during 1983.

3.4 EXTERNAL GAMMA EXPOSURE RATES

External gamma exposure rates were measured at 34 monitoring locations, 19 of which are located on the site boundary and the perimeter of the exclusion area. Two of the monitoring locations are located off-site, and the remainder are on-site. All locations correspond to radon (Terradex) detector locations, as shown in Figure 3-1.

The external gamma exposure rates are measured using lithium fluoride (LiF) thermoluminescent dosimeters (TLDs), exchanged quarterly.

Each monitor contains five TLD chips, the responses of which are averaged. At the 95 percent confidence level, the error for dosimeter results is approximately $\pm$ 25 percent.

The results for the 19 site perimeter and 2 off-site external gamma monitoring locations are presented in Table 3-8. Annual average exposure rates at all but eight of the monitoring locations were within the normal background range of 10 to 15 uR/h (Ref. 6). Three of these locations (8, 9, and quality control location 31) are located within the exclusion area where members of the public would not be exposed. Of the five locations where members of the public would be exposed, the highest annual average was recorded at Location 4, located near Building 434. This reading, 31.1 uR/h, is more than twice background for the area, but is only approximately 55 percent of the DOE RPS of 57 uR/h (Ref. 3).

3.5 RADIOLOGICAL EXPOSURE

To assess the radiological impact of the radioactive materials stored at the NFSS on members of the general public, a hypothetical individual was assumed to reside on the site boundary. The radiological exposure of this person was evaluated for each of three pathways: inhalation of radon; ingestion of water containing natural uranium and radium-226; and external gamma irradiation. For these calculations, this hypothetical person resided at the point of the highest average radon concentration, consumed water exclusively from the point of the highest measured uranium and radium concentrations, and was exposed to the highest measured annual external gamma dose rate. This approach will conservatively estimate the radiological dose received by the maximally exposed individual from exposure to radioactive materials at the NFSS.

For each of the three pathways considered, the entire body receives some radiological exposure. However, depending on the method of internal deposition and the chemical characteristics of the radionuclides, some organs receive a higher exposure than others. These are called "critical organs" because the effect of the exposure is maximized in them.

Because the radon is an inert gas, inhalation is the critical pathway. When inhaled, the alpha-emitting radon daughters are

TABLE 3-8

EXTERNAL GAMMA EXPOSURE RATES FOR NFSS, 1983[a,b]

Sampling Location[c]	No. of Measurements	Exposure Rate (uR/h)		
		Minimum	Maximum	Average
1	4	10.1	12.8	11.2
3	4	21.6	26.8	23.6
4	4	34.5	42.0	31.1
5	4	17.1	21.4	18.9
6	4	9.8	12.0	10.7
7	4	10.1	12.7	11.0
8	4	16.6	30.5	23.5
9	4	12.5	39.6	26.1
10	4	10.1	16.5	13.4
11	4	8.9	12.7	10.3
12	4	8.3	11.8	10.4
13	4	9.4	11.9	10.6
14	4	9.2	11.1	9.9
15	4	6.4	10.5	8.7
20	4	19.7	25.7	22.9
28[d]	4	8.0	11.3	9.9
29	4	9.8	10.7	10.4
30[d,e]	2	8.2	11.0	9.6
31	4	12.8	48.9	30.2
32	4	9.7	12.0	10.9
34	4	16.7	19.4	18.0

a - Site boundary, exclusion areas, and off-site monitoring locations only. Background has not been subtracted.
b - Reported at the 95 percent confidence level.
c - Sampling locations are shown in Figure 3-1.
d - Off-site monitoring location.
e - Monitor located at 572 Montrose St., Kenmore, New York, for background. Monitor was relocated to new location at 144 Jackson St., Youngstown, New York, but was placed inside a building, thereby invalidating exposure rate data for the final two quarters of 1983.

deposited on the linings of the bronchial air passageways, the bronchial epithelium. This portion of the lung therefore receives the highest exposure from radon inhalation; however, the dosimetry of radon daughters acting on the bronchial epithelium is not well understood and reliable estimates are difficult to obtain. In addition, the DOE radiation protection standards are formulated for the whole lung. For these reasons, only the dose to the entire lung will be calculated, although the dose to the bronchial epithelium has been reported in previous years.

Radium and uranium taken into the body via ingestion tend to migrate and incorporate into the bone, which is the critical organ for the ingestion pathway. Conversion of measured quantities in water to an internal dose to the bone requires several assumptions. An intake rate must be postulated. For these calculations, the water intake rate (730 ml of water per day) of Reference Man was used (Ref. 7). Radionuclide intakes were converted to internal doses to the bone using the methodology described in ERDA 77-24, A Guide for Environmental Radiological Surveillance at ERDA Installations (Ref. 8). All reported doses are the 50 year dose commitments. The 50 year dose commitment is a concept which provides for the fact that an intake of a radionuclide with a long half-life (such as uranium and radium) may result in an internal exposure for many years. Application of the 50 year dose commitment in this report causes calculated doses to be higher than those reported in previous environmental reports even though the radionuclide concentrations in effluents have not increased.

Gamma radiation from external sources is assumed to irradiate the body uniformly. The total body is therefore the critical organ for external gamma exposure. Internal organs are assumed to be exposed to the same level as the entire body. Exposures of organs resulting from internal and external sources are additive.

3.5.1 Radiological Exposure from Radon

At the site boundary, location 1 had the highest annual average radon concentration, 0.82 pCi/l. This measurement includes a contribution from naturally occurring sources, which the National Council on Radiation Protection and Measurements (NCRP) estimates at 0.15 pCi/l on a nationwide basis (Ref. 9).

The NCRP states that the dose to the lung from the inhalation of naturally occurring radon and the subsequent disposition of radon daughter nuclides is on the order of 90 mrem/yr. After subtracting the background contribution from the measured value, radon emanating from the NFSS would result in a lung dose to the hypothetical resident of about 400 mrem/yr. The DOE RPS for the lung is 1,500 mrem/yr.

3.5.2 Radiological Exposure from Ingestion of Water Containing Natural Uranium and Radium-226

The highest internal dose from the ingestion of water would occur if surface water from monitoring Location 11 in the Central Ditch were used as a source of potable water. Assuming that the hypothetical, maximally exposed individual used this location as his exclusive source of drinking water, the fifty year dose commitment to the bone would be 100 mrem. Ingestion of radium-226 contributes 94 percent of this dose. Ingestion of water containing radium-226 at the DOE CG of 30 pCi/l would result in a dose commitment to the bone of 2340 mrem.

3.5.3 Radiological Exposure from External Gamma

The highest measured average external gamma exposure rate along the NFSS site boundary was 31.1 uR/h, including contributions from naturally occurring sources. The typical background exposure rate is estimated to be 12.5 uR/h (Ref. 6). Subtracting the natural background from the measured value indicates that the radioactive

materials stored at the NFSS irradiate the whole body of the hypothetical individual at a rate of 18.6 uR/h, or 160 mrem/yr. The DOE RPS for the whole body is 500 mrem/yr.

3.6 QUALITY ASSURANCE

Established procedures were followed in the collection and analysis of environmental samples during 1983. Bechtel personnel working at the site collected and prepared samples in accordance with specific procedures. Sample analyses conducted by EIC were governed by an internal quality control program which consists of duplicate, spike, and blank samples. EIC's internal quality control results are compared monthly with EPA crosscheck program results. Sample analyses conducted by the Terradex Corporation were also governed by an internal quality control program.

4.0 NEW YORK STATE POLLUTION DISCHARGE ELIMINATION SYSTEM PERMIT

NFSS water discharges are regulated by the New York State Department of Environmental Conservation, under the New York State Pollutant Discharge Elimination System (SPDES), Permit No. NY-0110469. The permit was issued May 1, 1983 and is in effect for a period of five years.

During 1983, a total of 3.75 million liters (4 million gallons) of site wastewater was released in four separate discharge events. Discharges consisted of runoff water from the R-10 interim storage area, wash water from the vehicle decontamination facility, and construction wastewater. Water was discharged to the Central Drainage Ditch, which is a tributary to Four Mile Creek. All water was released in a manner to minimize any negative environmental impacts to surrounding areas.

All water discharged was analyzed before and during release for permit parameters, which are presented in Table 4-1. For radioactivity, the DOE limits of 600 pCi/l for uranium and 30 pCi/l for radium-226 are applicable. All water released was found to be within SPDES permit parameter limits and DOE radioactive release criteria.

TABLE 4-1

1983 SPDES PERMIT PARAMETERS

(PER DISCHARGE EVENT)

	BAT[a]	Water[b] Quality	Units
Flow	288,000		Gallons per day
Suspended Solids	50.0		mg/l
pH (Range)	6.0-9.0		SU
Arsenic, Total	0.33	0.05[a]	mg/l
Barium, Total	0.42		mg/l
Cerium, Total	0.10		mg/l
Chromium, Total	0.15	0.05[a]	mg/l
Cobalt, Total	0.10	0.005[a]	mg/l
Copper, Total	0.10		mg/l
Fluoride, Total	4.20	1.5[a]	mg/l
Iron[c], Total	0.42	0.3[b]	mg/l
Lanthanium, Total	0.10		mg/l
Lead, Total	0.10	0.03[a]	mg/l
Lithium, Total	0.42		mg/l
Manganese, Total	0.10		mg/l
Nickel, Total	0.10	0.03[a]	mg/l
Strontium[c], Total	0.42		mg/l
Vanadium, Total	0.40		mg/l
Zirconium, Total	0.10		mg/l
Settleable Solids	0.30		mg/l
Heptachlor[d]		0.003	ug/l
Benzene Hexachloride (Lindane)[d]		2.0	ug/l
Asbestos[e]			millionfibers/l

Note: All values are based on grab samples.

a - Best Available Technology limits.
b - Water quality discharge limits at the point of discharge based on zero flow in the Central Drainage Ditch. Water meeting BAT limits must be diluted by stream flow to levels less than water quality limits.
c - Permit parameter limit was revised October 1983.
d - Permit Parameter was added October 1983.
e - Measured for presence only. No permit parameter.

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9. National Council on Radiation Protection Measurements. Natural Background Radiation in the United States, NCRP Report 45, NCRP Scientific Committee on Natural Background Radiation, Washington, DC, 1975.

APPENDIX A

ENVIRONMENTAL STANDARDS

DOE Order 5480.1A, Chapter XI, Attachment XI-1 (Ref. 1) contains the applicable Concentration Guides (CGs) which provide limits for maximum permissible radioactivity both on-site (controlled area) and beyond the external perimeter of the site (uncontrolled area). The CGs for the common radionuclides at the NFSS are presented in Table A-1.

TABLE A-1

RADIOACTIVITY CONCENTRATION GUIDES FOR THE NFSS

Radionuclide	Transport Media	Controlled Area	Uncontrolled Area
Uranium-Natural	Water (soluble)	30 mg/l (20,000 pCi/l)	1 mg/l (600 pCi/l)
	Soil		75 pCi/g[a]
Radium-226	Water (soluble)	400 pCi/l	30 pCi/l
	Soil		5 pCi/g[a]
Radon-222	Air	100 pCi/l	3 pCi/l

a - DOE proposed guideline for soil cleanup based on 40 CFR 192.