NUS-4Ø82 A

ANNUAL REPORT FOR 1981

OF THE

PREOPERATIONAL RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM AT THE PERRY NUCLEAR POWER PLANT

Prepared for
The Cleveland Electric Illuminating Company

by
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I. INTRODUCTION

The preoperational radiological environmental monitoring program for Perry Nuclear Power Plant (PNPP) was initiated in March 1981 and will continue until fuel loading, presently scheduled for November, 1983. This program is being conducted by NUS Corporation under contract with The Cleveland Electric Illuminating Company (CEI). This is the first Annual Report for the radiological environmental monitoring program being conducted under contract. This report covers the period March 23, 1981 through December 29, 1981 and summarizes the results of measurements and analyses of data obtained from samples collected during this interval.

A. Site and Station Description

PNPP will consist of two BWR units, each designed to operate at a power level of about 1205 megawatts with the main condenser circulating water cooled by a system of closed-loop natural draft cooling towers. The plant is located on Lake Erie, on approximately 1100 acres about thirty-five (35) miles northeast of Cleveland, Ohio and about seven (7) miles northeast of Painesville, Ohio. PNPP is situated in North Perry Village in northeastern Lake County, Ohio.

B. Objectives and Overview of PNPP Monitoring Program

United States Nuclear Regulatory Commission (USNRC) regulations require that nuclear power plants be designed, constructed, and operated to keep levels of radioactive material in effluents to unrestricted areas as low as reasonably achievable (ALARA)(10 CFR 50.34). To assure that these criteria are met, each license authorizing reactor operation includes technical specifications (10 CFR 50.36a) governing the release of radioactive effluents.

In-plant monitoring will be used to assure that these predetermined release limits are not exceeded. However, as a precaution against unexpected and undefined processes which might allow undue accumulation of radioactivity in any sector of man's environment, a program for monitoring the plant environs is also included.

The regulations governing the quantities of radioactivity in reactor effluents allow nuclear power plants to contribute, at most, only a few percent increase above normal background radioactivity. Background levels at any one location are not constant but vary with time as they are influenced by external events such as cosmic ray bombardment, weapons test fallout, and seasonal variations. These levels also can vary spatially within relatively short distances reflecting variations in geological composition. Because of these spatial and temporal variations, the radiological surveys of the plant environs are divided into preoperational and operational phases. The preoperational phase of the program of sampling and measuring radioactivity in various media permits a general characterization of the radiation levels and concentrations prevailing prior to plant operation along with an indication of the degree of natural variation to be expected. The operational phase of the program obtains data which, when considered along with the data obtained in the preoperational phase, assist in the evaluation of the radiological impact of plant operation.

Implementation of the preoperational monitoring program fulfills the following objectives:

1. Evaluation of procedures, equipment and techniques.

2. Identification of potentially important pathways to be monitored after the plant is in operation.

3. Measurement of background levels and their variations along potentially important pathways in the area surrounding the plant.

4. Provision of baseline data for statistical comparison with future operational analytical results.

Sampling locations were selected on the basis of local ecology, meteorology, physical characteristics of the region, and demographic and land use features of the site vicinity. The preoperational program was designed on the basis of the USNRC Branch Technical Position on radiological environmental monitoring issued by the Radiological Assessment Branch, Revision 1 (November 1979).[1]

In 1981 the radiological monitoring program included the measurement of ambient gamma radiation by thermoluminescent dosimetry and pressurized ion chamber measurements, and the determination of gamma emitters in shoreline sediments and fish.

II. PROGRAM DESCRIPTION

Twenty-eight locations within a radius of about 15 miles from the PNPP site were included in the monitoring program for 1981. The number and location of monitoring points were determined by considering the locations where the highest off-site environmental concentrations have been predicted from plant effluent source terms, site hydrology, and site meteorological conditions. Other factors considered were applicable regulations, population distribution, ease of access to sampling stations, security and future program integrity.

The preoperational environmental radiological program for Perry is summarized in Table 1. Table 2 describes sample locations, associated media, and approximate distance and direction from the site. Figures 1 and 2 designate sampling locations by station number.

The program during 1981 consisted of measurements of gamma dose rate with TLDs and a pressurized ion chamber and semi-annual collections of fish and sediment. The balance of the preoperational program will be instituted in 1982.

TABLE 1

PNPP RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Sample Media	Locations	Sampling Frequency	Analysis Type	Analysis Frequency
Airborne radioiodine[(a)] and particulates[(b)]	1 through 6	Continuous sampler operation with collection weekly or as required by dust loading, whichever is more frequent	Radioiodine I-131	Weekly following canister change
			Particulates[(d)] Gross Beta	Weekly following filter change
			Gamma Isotopic[(e)]	Composite, by location, quarterly
Direct Radiation (4 TLDs/location)	At each airborne monitoring location	Continuous sampling, one TLD exchanged monthly	Gamma Dose	Monthly
	7 through 24	Continuous sampling, one TLD exchanged annually	Gamma Dose	Annually
Waterborne[(b)] surface drinking[(b)]	34, 27, 26, 28	Composite[(f)]	H-3	Composite, by location, quarterly
			Gross Beta	Monthly
			Gamma Isotopic	Monthly
Sediment from shoreline	25, 26, 27, 32	Semiannually--spring and fall as weather permits	Gamma Isotopic	Semiannually

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TABLE 1 (continued)

PNPP RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Sample Media	Locations	Sampling Frequency	Analysis Type	Analysis Frequency
Ingestion Milk(b,c)	29, 30, 31, 33	Monthly when animals are not on pasture	Gamma Isotopic	All samples
		Semimonthly when animals are on pasture	I-131	All samples
Fish	25, 32	Semiannually--spring and fall as weather permits	Gamma Isotopic (edible portion)	Semiannually

(a) Sampling begins at least six months prior to PNPP operation.
(b) Sampling begins at least one year prior to PNPP operation.
(c) I-131 to be performed at least for 6 months of the last full pasture season prior to operation.
(d) Particulate sample filters will be analyzed for gross beta 24 hours or more after sampling to allow for radon and thoron daughter decay. If gross beta activity in air or water is greater than ten times the mean control samples for any medium, gamma isotopic analysis will be performed on the individual samples.
(e) Gamma isotopic analysis means the identification and quantification of gamma-emitting radionuclides that may be attributable to the effluents from the facility.
(f) Composite samples will be collected with equipment that is capable of collecting an aliquot at time intervals that are very short (e.g., hourly) relative to the compositing period (e.g., monthly).
(g) Definitive sampling locations will be determined by a milk-animal census prior to initiation of preoperational monitoring.

TABLE 2

Sample Locations and Media for the Perry Radiological Environmental Monitoring Program

Location No.	Description	Distance (Miles)	Direction	Media(1)
1	Redbird (Haines Road, North of West Chapel Road)	3.4	ENE	APT, AI, TLD
2	Site Boundary; Tree line	0.7	E	APT, AI, TLD
3	Meteorological Tower	1.0	SE	APT, AI, TLD
4	Site Boundary; Parmly Road (side gate)	0.7	S	APT, AI, TLD
5	Site Boundary; Quincy Substation	0.6	SW	APT, AI, TLD
6	Concord Service Center (Control)	12.1	SSW	APT, AI, TLD
7	Site Boundary; Lockwood Road Bus Turnaround	0.6	NE	TLD
8	Site Boundary; Tree Line	0.8	ENE	TLD
9	Site Boundary; Transmission Line Tower	0.7	ESE	TLD
10	Site Boundary; Southsoutheast Corner Security Fence	0.8	SSE	TLD
11	Site Boundary; Transmission Line Tower	0.6	SSW	TLD
12	Site Boundary; Transmission Line Tower	0.6	WSW	TLD
13	Madison-on-the-Lake (Whitewood Drive)	4.7	ENE	TLD
14	Hubbard Road (South of North Ridge Road)	4.9	E	TLD
15	Madison Substation (Eagle Street)	5.1	ESE	TLD
16	Dayton Road (North of Interstate 90)	5.0	SE	TLD
17	Chadwick Road (Cul de Sac South of Interstate 90)	5.2	SSE	TLD
18	Blair Road (West of Grand River Bridge)	5.0	S	TLD
19	Lane Road and South Ridge Road	5.3	SSW	TLD
20	Nursery Road at Route 2 Overpass	5.3	SW	TLD
21	Hardy Road at Painesville Township Park	5.1	WSW	TLD
22	Painesville (Main Street, South of Evergreen Cemetery)	6.9	SW	TLD
23	Fairport Harbor (High Street and New Street)	7.9	WSW	TLD
24	St. Clair Ave. Substation (Control)	15.1	SW	TLD
25	PNPP Discharge	0.6	NNW	SED, FSH
26	Ohio Water Service Co., LEE, Madison (at end of Green Road in Redbird)	4.2	ENE	WTR, SED

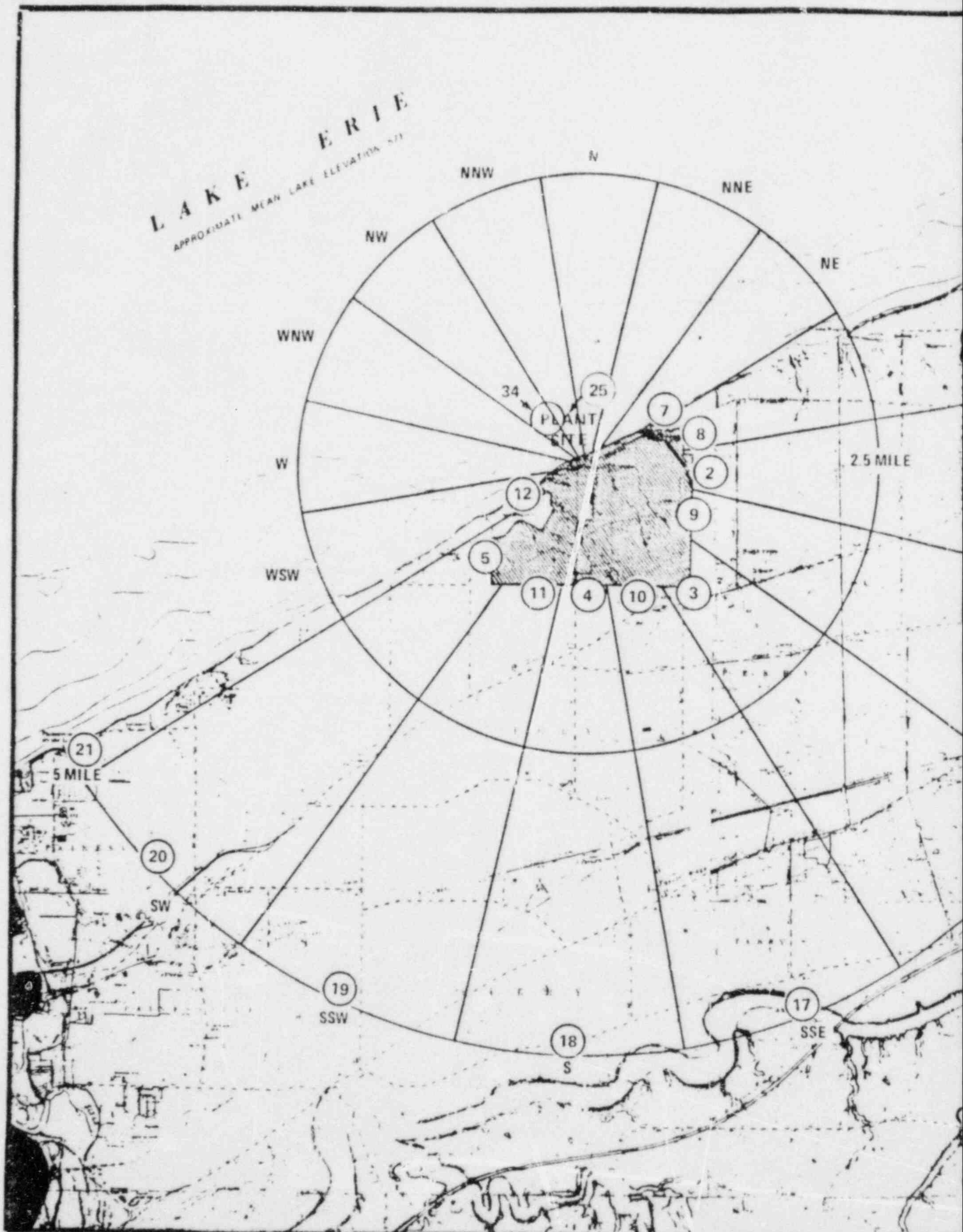
TABLE 2 (continued)

Sample Locations and Media for the Perry
Radiological Environmental Monitoring Program

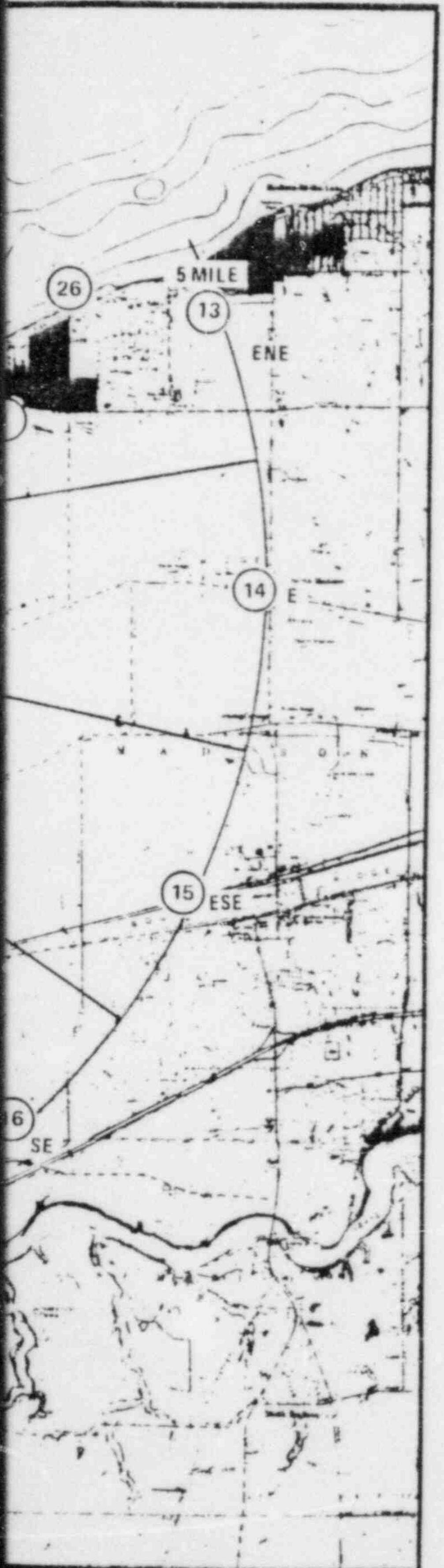
Location No.	Description	Distance (Miles)	Direction	Media(1)
27	Fairport Harbor Water Supply System	7.9	WSW	WTR, SED
28	Ashtabula (Control)	18	ENE	WTR
29	Milk Farm	-	- (2)	MLK
30	Milk Farm	-	- (2)	MLK
31	Milk Farm	-	- (2)	MLK
32	Mentor-on-the-Lake (Control)	15.8	WSW	SED, FSH
33	Milk Farm (Control)	-	- (2)	MLK
34	PNPP Intake	0.7	NW	WTR

(1) APT = Air particulate
AI = Air iodine
TLD = Ambient gamma dose rate
SED = Sediment
WTR = Water
FSH = Fish
MLK = Milk

(2) These locations to be determined in the annual milch animal survey.



LAKE ERIE
APPROXIMATE MEAN LAKE ELEVATION 571
N
NNW
NNE
NW
NE
WNW
W
WSW
SW
SSW
S
SSE
2.5 MILE
5 MILE
PLANT SITE
34
25
7
8
2
12
9
5
11
4
10
3
21
20
19
18
17



1 0 1 2 3 4

MILES

LEGEND

Station No.	Media	Direction
1	Air – TLD	ENE
2	TLD	E
3	Air – TLD	SE
4	Air – TLD	S
5	Air – TLD	SW
7	TLD	NE
8	TLD	ENE
9	Air – TLD	ESE
10	TLD	SSE
11	TLD	SSW
12	TLD	WSW
13	TLD	ENE
14	TLD	E
15	TLD	ESE
16	TLD	SE
17	TLD	SSE
18	TLD	S
19	TLD	SSW
20	TLD	SW
21	TLD	WSW
25	Sediment-Fish	NNW
26	Water – Sediment	ENE
34	Water	NW

PNPP PREOPERATIONAL ENVIRONMENTAL
RADIOLOGICAL MONITORING PROGRAM
SAMPLING LOCATIONS WITHIN 5 MILES OF SITE

PERRY NUCLEAR POWER PLANT 1 & 2

THE CLEVELAND ELECTRIC
ILLUMINATING COMPANY

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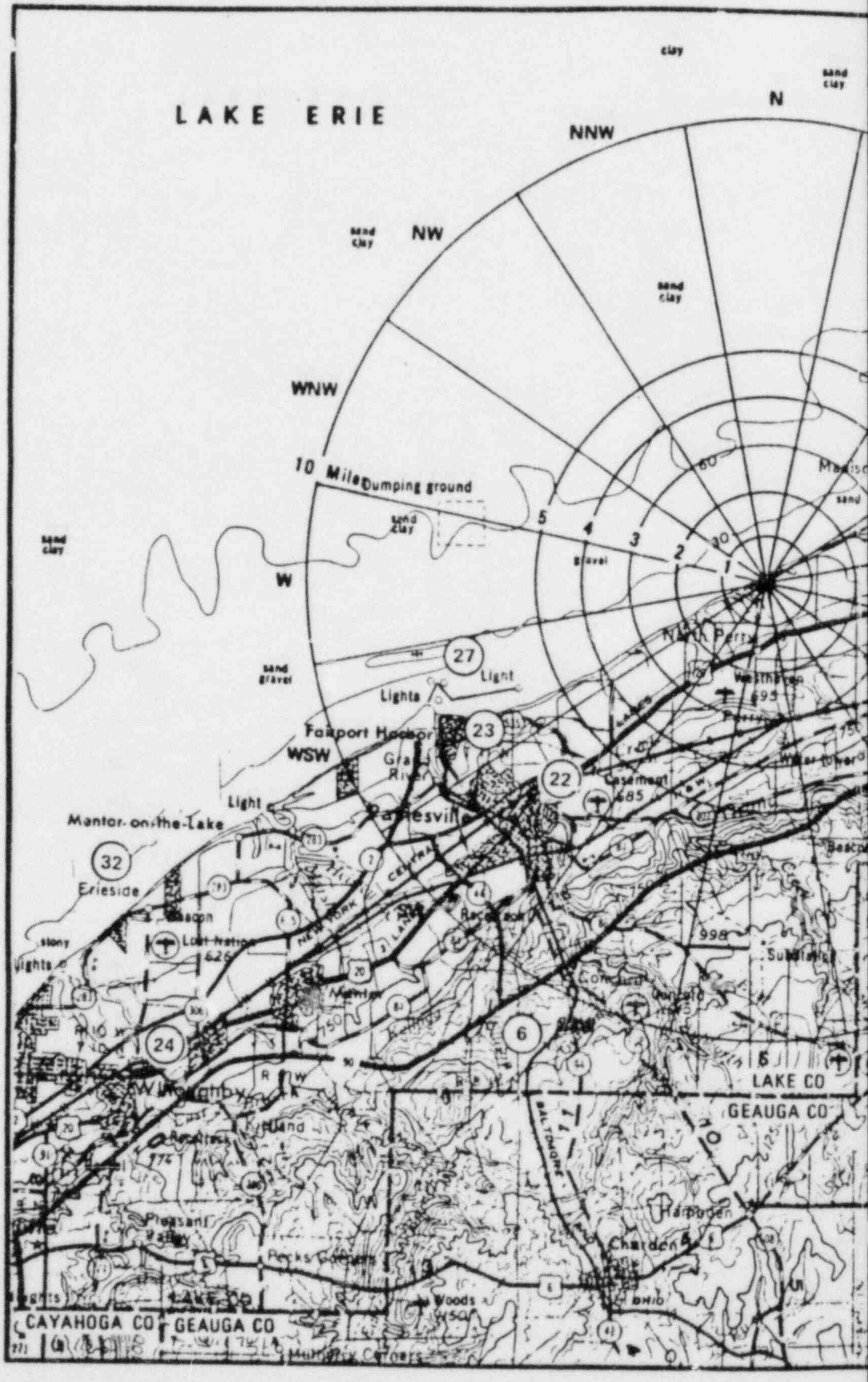
Figure 1


LAKE ERIE
clay
sand clay
N
NNW
NW
WNW
W
WSW
10 Miles
Dumping ground
5
4
3
2
1
gravel
sand gravel
stony
27
23
22
32
24
6
Light
Lights
Fairport Harbor
Grand River
Painesville
Mentor-on-the-Lake
Erieside
Mentor
Willoughby
Concord
Casement
685
626
998
Pleasant Valley
Pecks Corners
Chardon
Hambden
LAKE CO
GEAUGA CO
CAYAHOGA CO
GEAUGA CO
Woods
NEW YORK CENTRAL
BALTIMORE
OHIO

LEGEND

ROAD DATA 1956 PARTIALLY REVISED 1966

POPULATED PLACES
- Over 500,000 — BOSTON
- 100,000 to 500,000 — RICHMOND
- 25,000 to 100,000 — EVANSTON
- 5,000 to 25,000 — Hialeah
- 1,000 to 5,000 — Bar Harbor
- Less than 1,000 — Fishkill

ROADS
- Hard surface, heavy duty
  - More than two lanes wide — 3 LANES / 4 LANES
  - Two lanes wide; Federal route marker
- Hard surface, medium duty
  - More than two lanes wide — 3 LANES / 4 LANES
  - Two lanes wide; State, Interstate route markers
- Improved light duty

RAILROADS — Single track, Double or Multiple
- Standard gauge
- Narrow gauge

BOUNDARIES
- International
- State
- County
- Park or reservation

Landmarks
- Landplane airport
- Landing area

Depth curve in feet

LEGEND

Station No.	Media	Direction
6	Air – TLD – Milk (Control)	SSW
22	TLD	SW
23	TLD	WSW
24	TLD (Control)	SW
27	Water – Sediment	WSW
28	Water (Control)	ENE
32	Fish – Sediment (Control)	WSW

Also Available On Aperture Card

TI APERTURE CARD

PNPP PREOPERATIONAL ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM SAMPLING LOCATIONS > 5 MILES FROM SITE

PERRY NUCLEAR POWER PLANT 1 & 2

THE CLEVELAND ELECTRIC ILLUMINATING COMPANY

Figure 2

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III SAMPLING METHODS AND PROCEDURES

To derive meaningful and useful data from the radiological environmental monitoring program, sampling methods and procedures are required which will provide samples representative of potential pathways of the area. During the preoperational phase of the program, samples are collected and analyzed not only to obtain background radiological levels, but at the same time to acquire experience with the sampling methodology and procedural format dictated by site specific requirements.(2)

A. Direct Radiation

Thermoluminescent dosimeters (TLDs) were used to determine the direct (ambient) radiation levels at twenty-four (24) monitoring points as described in Tables 1 and 2. Sampling locations were chosen according to the criteria given in the USNRC Branch Technical Position on Radiological Monitoring (Revision 1, November 1979).(1) TLDs were located in two rings around the station. An inner ring was located at the site boundary and an outer ring was located at a distance of 4 to 5 miles from the station.

The area around the station was divided into 16 radial sectors of 22 1/2 degrees each. TLDs were placed in all sectors except those which radiated from the site directly out over the lake without intersecting any unrestricted areas. Additional TLDs were located at three nearby communities and two control locations.

Prior to finalization of TLD locations, gamma exposure rates were measured at each proposed dosimetry location with a pressurized ion chamber. This was to avoid inadvertently selecting a location for TLD placement which normally would show an atypical exposure rate. The results of these measurements are included in this report.

For routine TLD measurements, two dosimeters of $CaSO_4:D_y$ in teflon cards were deployed at each selected location. One set of dosimeters were exchanged on a monthly basis and the second set was exchanged on an annual basis. Additional sets of dosimeters were shipped with each exchange cycle to serve as in-transit controls. For routine exchanges TLDs were shipped by overnight Greyhound one evening, picked up and exchanged the following day, and returned by overnight Greyhound on the second evening. This was done to maintain the minimum possible in-transit dose.

Individual dosimeters were calibrated by exposure to an accurately known radiation field from a calibrated Cs-137 source.

B. Fish

Fish sampling was conducted in May and November at two locations for this program. The immediate vicinity of the discharge was selected as an indicator location, and an offshore location at Mentor-on-the-Lake was chosen as a control location.

Using a passive collection technique, an experimental gill net (mesh ranging from approximately 0.5 to 3.5 inches to decrease size selectivity) was set at each sampling location by biologists from NUS Corporation. Nets were set in the evening and removed the following morning. Entrapped surviving fish not required for sampling were released. A Scientific Collecting Permit was obtained from the Ohio Department of Natural Resources to permit this sampling.

Available edible species were filleted at the time of collection. The edible portions were packed in ice and shipped to the laboratory for analysis by gamma spectrometry.

C. Sediment

Sediment samples were collected in May and November at four locations. Two locations were nominally the same as the locations chosen for fish sampling. At Mentor the sediment was collected approximately 400 yards further offshore, and at the Perry discharge the sediment was collected approximately 600 yards further offshore. Some movement was necessary to find a suitable substrate for sampling. Sediment samples were also collected offshore in the vicinities of Fairport Harbor and Redbird. Samples were collected with a petite ponar grab sampler in about 30 feet of water. A sample was composited at each location in a 3 gallon plastic bucket. Approximately 1 kilogram was frozen and shipped to the laboratory for analysis by gamma spectrometry.

IV. SUMMARY AND DISCUSSION OF 1981 ANALYTICAL RESULTS

Data from the radiological analyses of environmental media collected during the report period are tabulated and discussed below. The procedures and specifications followed in the laboratory for these analyses are as required in Section 5.0 of the NUS Environmental Systems Group Qualilty Assurance Manual, Issue B, and are detailed in the NUS Radiological Laboratory Work Instructions.

Radiological analyses of environmental media characteristically approach and frequently fall below the detection limits of state-of-the-art measurement methods.[2] The use of "LT" in the data tables is the equivalent of the less than symbol (<) and is consistent with the NUS Radiological Laboratory practice of data reporting. The number following the "LT" is a result of the lower limit of detection (LLD) calculation as defined in Appendix B. "ND" (Not Detected) is used periodically in the tables presenting gamma analysis results for various media. It primarily appears under the "Others" column, and indicates that no other detectable gamma emitting nuclides were identified. NUS analytical methods meet the LLD requirements addressed in Table 2 of the USNRC Branch Technical Position on Radiological Monitoring (November 1979, Revision 1).[1]

Tables 3 through 6 give the radioanalytical results for individual samples. A statistical summary of the results appears in Table 7. The reported averages are based only on concentrations above the limit of detection. In Table 7, the fraction (f) of the total number of analyses which were detectable follows in parentheses. Also given in parentheses are the minimum and maximum values of detectable activity during the report period.

A. Direct Radiation

Environmental radiation dose rates determined by thermoluminescent dosimeters (TLDs) are given in Table 3. TLD badges of four readout areas each were deployed at each location on monthly and annual cycles. For this, the first year of the program, the "annual" cycle covers the period May through December. The mean values of four readings (corrected individually for response to a known dose and for in-transit exposure) are reported.

A statistical summary of the 1981 data is included in Table 7. Individual measurements of external radiation levels in the environs of the PNPP site ranged from 0.11 to 0.37 mR/day. Table 4 compares the [illegible] from the pressurized ion chamber measurements with the data [illegible]om the annual cycle TLDs and the annual averages of the monthly cycle T.Ds. Agreement between the three types of data is generally quite good. This is especially true considering that the PIC readings were in the nature of a grab sample taken when no TLDs were actually in the field.

TABLE 3

Direct Radiation - Thermoluminescent Dosimetry
Results for Monthly Exchange Cycles
PNPP REMP 1981

(Results in Units of mR/Day±2σ[1])

Location	May	June	July	August	September	October	November	December	Average ±2 [1]
1	.22±.08	.25±06	.15±.05	.16±.04	.18±.06	.24±.01	.22±.02	.17±.03	.20±.08
2	.18±.09	.18±.04	.14±.05	.14±.05	.19±.06	.21±.04	.12±.02	.18±.03	.17±.06
3	.23±.06	.21±.04	.16±.06	.15±.04	.21±.06	.26±.03	.23±.02	.16±.02	.20±.08
4	.23±.08	.22±.12	.18±.08	.17±.04	.21±.06	.26±.02	.22±.02	.16±.04	.21±.07
5	.21±.06	.20±.03	.15±.06	.18±.04	.17±.06	.22±.03	.19±.03	.17±.02	.19±.05
6	.22±.08	.27±.06	.17±.06	*	.19±.06	*	.15±.02	.20±.03	.20±.08
7	*	.25±.06	.16±.08	.17±.04	.18±.06	.22±.02	.17±.02	.29±.04	.21±.10
8	.17±.06	.18±.08	.15±.06	.17±.05	.18±.06	.21±.03	.19±.02	.19±.03	.18±.04
9	.19±.07	.23±.05	.15±.06	.15±.05	.17±.06	.22±.03	.15±.02	.13±.03	.17±.07
10	.19±.06	.20±.07	.14±.05	.15±.04	.18±.06	.22±.03	.15±.03	.18±.02	.18±.06
11	.18±.06	.19±.04	.13±.05	.15±.04	.16±.04	.23±.04	.16±.02	.19±.03	.17±.06
12	.16±.08	.17±.07	.14±.06	.16±.05	.17±.06	.25±.03	.19±.03	.15±.02	.17±.07
13	.21±.07	.20±.06	.14±.06	.15±.04	.17±.06	.22±.03	.24±.03	.14±.02	.18±.08
14	.21±.06	.23±.03	.16±.06	*	.17±.06	.24±.02	.23±.02	.16±.02	.20±.07
15	.19±.07	.23±.07	.17±.05	.16±.04	.18±.06	.22±.02	.26±.03	.16±.02	.20±.07
16	.17±.07	.29±.04	.19±.06	.22±.05	.21±.06	.28±.03	.25±.02	.21±.06	.23±.08
17	.16±.07	.26±.03	.17±.05	.19±.04	.22±.06	.27±.02	.28±.04	.15±.02	.21±.10
18	.19±.08	.37±.12	.22±.05	.25±.04	.27±.06	.28±.03	.25±.03	.27±.02	.26±.11
19	.18±.07	.27±.04	.17±.05	.19±.04	.20±.06	.21±.02	.29±.06	.19±.02	.21±.09
20	.15±.06	.20±.04	.16±.06	.15±.04	.18±.06	.22±.02	.17±.03	.16±.02	.17±.05
21	.15±.07	.23±.04	.18±.05	.17±.05	.20±.06	.25±.02	.20±.03	.16±.02	.19±.07
22	.12±.06	.27±.08	.15±.06	*	.17±.06	.23±.03	.19±.02	*	.19±.11
23	.14±.06	.26±.05	.19±.06	.15±.04	.22±.06	.25±.02	.22±.05	.18±.02	.20±.09
24	.16±.08	*	.17±.06	.11±.04	.18±.06	.22±.05	.20±.04	.14±.03	.17±.07
Average (±2σ)[2]	.18±.06	.23±.09	.16±.04	.17±.06	.19±.05	.24±.04	.20±.09	.18±.08	-

* TLD lost due to vandalism.

(1) Errors for individual measurements are two standard deviations of the average of four readings per dosimeter.

(2) Errors of row and column averages are 2 standard deviations calculated from the same row or column data used to generate the average.

TABLE 4

Comparison of Direct Radiation Measurements
PNPP REMP 1981

(Results in Units of mR/Day ± 2σ [1])

Dates	PIC Readings (3-24-81)	Annual Cycle TLD (5-1-81 to 12-29-81)	Average of Monthly Cycles (5-1-81 to 12-29-81)
1	.20±.02	.18±.01	.20±.08
2	.18±.01	.17±.01	.17±.06
3	.19±.03	.15±.01	.20±.08
4	.21±.02	.18±.02	.21±.07
5	.20±.02	.14±.02	.19±.05
6	.20±.02	.19±.01 [2]	.20±.08
7	.19±.02	.15±.06 [3]	.20±.10
8	.19±.02	.15±.01	.18±.04
9	.19±.04	.15±.02	.17±.07
10	.19±.02	.17±.02	.18±.06
11	.21±.03	.14±.04	.17±.06
12	.19±.02	.18±.01	.17±.07
13	.21±.01	.12±.05	.18±.08
14	.20±.02	.25±.03 [4]	.20±.07
15	.21±.02	.16±.02	.20±.07
16	.25±.03	.20±.02	.23±.08
17	.23±.01	.17±.02	.21±.10
18	.28±.02	.23±.03	.26±.11
19	.21±.02	.15±.02	.21±.08
20	.21±.02	.16±.02	.17±.06
21	.22±.01	.18±.02	.19±.07
22	.20±.02	.20±.04 [2]	.19±.11
23	.23±.02	.19±.02	.20±.09
24	.20±.02	.18±.03	.17±.07

(1) Errors of PIC readings are two standard deviations of the average of 10 field readings; errors of annual TLDs are two standard deviations of the 4 readout areas on each TLD; errors of monthly averages are two standard deviations of the average of the individual monthly results.

(2) 9-30-81 to 12-29-81

(3) 6-2-81 to 12-29-81

(4) 9-1-81 to 12-29-81

TABLE 5

Gamma Spectrometry of Fish Samples
PNPP REMP 1981

(Results in Units of pCi/Kg(wet)±2σ)

Location	Fish Species	Collection Date	Mn-54	Fe-59	Co-58	Co-60	Zn-65	Cs-134	Cs-137	K-40
25	Yellow Perch	5-20-81	LT130 (1)	LT25000 (2)	LT1500 (2)	LT100	LT500	LT80	56±39	9900±900
25	Spottail Shiner	5-20-81	LT40	LT130	LT30	LT30	LT80	LT20	LT30	2100±100
32	Yellow Perch	5-20-81	LT14	LT50	LT20	LT13	LT30	LT10	19±4	3000±100
32	Carp	5-20-81	LT14	LT50	LT20	LT12	LT40	LT11	11±5	3000±200
32	Brown Trout	5-20-81	LT40	LT100	LT50	LT20	LT60	LT17	30±9	4600±300
32	Spottail Shiner	5-20-81	LT50	LT140	LT70	LT30	LT80	LT20	LT60	1600±300
25	Walleye	11-12-81	LT10	LT200	LT30	LT12	LT30	LT10	51±6	3400±200
25	Freshwater Drum	11-12-81	LT60	LT2000	LT200	LT50	LT180	LT40	LT40	4900±500
32	White Sucker	11-13-81	LT20	LT800	LT90	LT20	LT70	LT15	14±8	4200±300
32	Freshwater Drum	11-13-81	LT50	LT1600	LT180	LT40	LT140	LT40	LT30	2900±300
32	Yellow Perch	11-13-81	LT30	LT600	LT80	LT30	LT90	LT19	LT17	4300±300

(1) LT = less than

(2) Sensitivities exceed Branch Technical Position guides due to equipment failures and delay in counting.

TABLE 6

Gamma Spectrometry of Sediment Samples
PNPP REMP 1981

(Results in pCi/Kg(dry) ± 2σ)

Location	Collection Date	Bi-214	Pb-214	Ra-226	Bi-212	Pb-212	Tl-208	Ac-228	K-40	Cs-134	Cs-137	Co-60	Others
25	5-20-81	1200±100	1300±100	1100±200	ND	980±50	440±30	1100±100	17000±1000	LT90[2]	190±30	ND	ND
26	5-20-81	1300±200	1500±300	1300±300	ND	1200±200	ND	1100±300	24000±4000	LT70	450±80	190±30	Ce-144@950±130
27	5-20-81	ND[1]	460±30	490±100	ND	310±20	150±20	410±70	9700±400	LT30	24±12	ND	ND
32	5-20-81	800±50	810±40	720±110	550±200	470±30	250±20	680±70	12000±1000	LT60	38±14	ND	ND
25	11-12-81	1300±200	1300±300	1400±500	ND	910±150	ND	1100±400	24000±2000	LT130	390±70	ND	ND
26	11-12-81	1500±130	1600±300	1600±300	1200±500	1300±200	ND	1100±200	17000±1000	LT60	390±50	150±40	Ra-224@3400±1000
27	11-12-81	800±80	820±160	980±200	710±350	720±110	ND	600±160	15000±1000	LT80	150±30	120±50	Ra-224@1800±600
32	11-12-81	830±80	950±170	970±180	660±350	760±110	ND	680±140	16000±1000	LT80	160±30	87±30	Ra-224@1900±500

[1] ND = Not Detected

[2] LT = Less Than

TABLE 7

SUMMARY OF DATA FOR THE PERRY NPP RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM - 1981
(Sheet 1 of 2)

Name of Facility: Perry NPP Units 1 and 2, Docket Nos. 50-440 and 50-441
Location of Facility: 35 Miles Northeast of Cleveland, Ohio (Lake County)
Reporting Period: March 23, 1981, through December 29, 1981

Medium or Pathway Sampled (Units of Measurement)	Type and Total Number of Analyses Performed	Lower Limit of Detection(1)	All Indicator Locations Mean (f) (Range)	Location with Highest Annual Mean: Name, Distance and Direction	Location with Highest Annual Mean: Mean (f)(2) (Range)	Control Location Mean (f)(2) (Range)
TLDs (mR/day)	Gamma Dose 185		0.19(172/172) (0.12-0.37)	Station 18 4.9 miles S	0.26(8/8) (0.19-0.37)	0.18(13/13) (0.11-0.27)
Fish (pCi/Kg (wet))	Gamma Spec 11					
	K-40	-	5100(4/4) (2100-9900)	Only one indicator location sampled for this medium		3400(7/7) (1600-4600)
	Mn-54	130	LLD			LLD
	Fe-59	260	LLD			LLD
	Co-58,60	130	LLD			LLD
	Zn-65	260	LLD			LLD
	Cs-134	130	LLD			LLD
	Cs-137	150	54(2/4) (51-56)			19(4/7) (11-30)
Shoreline Sediments (pCi/Kg (dry))	Gamma Spec 8					
	Bi-214		1200(5/6) (800-1500)	Station 26 4.2 miles ENE	1400(2/2) (1300-1500)	820(2/2) (800-830)
	Pb-214		1200(6/6) (460-1600)	Station 26 4.2 miles ENE	1600(2/2) (1500-1600)	880(2/2) (810-950)

Note: See footnotes at end of table.

TABLE 7

SUMMARY OF DATA FOR THE PERRY NPP RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM - 1981
(Sheet 2 of 2)

Name of Facility: Perry NPP Units 1 and 2, Docket Nos. 50-440 and 50-441
Location of Facility: 35 Miles Northeast of Cleveland, Ohio (Lake County)
Reporting Period: March 23, 1981, through December 29, 1981

Medium or Pathway Sampled (Units of Measurement)	Type and Total Number of Analyses Performed	Lower Limit of Detection(1)	All Indicator Locations Mean (f) (Range)	Location with Highest Annual Mean: Name, Distance and Direction	Location with Highest Annual Mean: Mean (f)(2) (Range)	Control Location Mean (f)(2) (Range)
Shoreline Sediments (Con't)	Ra-226		1100(6/6) (490-1600)	Station 26 4.2 miles ENE	1500(2/2) (1300-1600)	850(2/2) (720-970)
	Bi-212		960(2/6) (710-1200)	Station 26 4.2 miles ENE	1200(1/2) (1200-1200)	600(2/2) (550-660)
	Pb-212		900(6/6) (310-1300)	Station 26 4.2 miles ENE	1300(2/2) (1200-1300)	620(2/2) (470-760)
	Tl-208		300(2/6) (150-440)	Station 25 0.6 miles NNW	440(1/2) (440-440)	250(1/2) (250-250)
	Ac-228		900(6/6) (410-1100)	Stations 25 & 26 0.6 miles NNW & 4.2 miles ENE	1100(2/2)(3) (1100-1100)	680(2/2) (680-680)
	K-40		18000(6/6) (9700-24000)	Stations 25 & 26 0.6 miles NNW & 4.2 miles ENE	21000(2/2)(3) (17000-24000)	14000(2/2) (12000-16000)
	Cs-134	150	LLD	-	-	-
	Cs-137	180	270(6/6) (24-450)	Station 26 4.2 miles ENE	420(2/2) (390-450)	100(2/2) (38-160)
	Co-60		150(3/6) (120-190)	Station 26 4.2 miles ENE	170(2/2) (150-190)	87(1/2) (87-87)

(1)LLD is lower limit of detection as defined and required in USNRC Branch Technical Position on An Acceptable Radiological Environmental Monitoring Program, Revision 1, November 1979.

(2)(f) is the ratio of positive results to the number of samples analyzed for the parameter of interest.

(3)Means, "f" values and ranges are identical for the two locations.

Annual averages (from the monthly cycles) ranged from Ø.17 to Ø.26 mR/day or 62 to 95 mR/year.

Oakley[3] calculates an ionizing radiation dose equivalent of 82.2 mR/year for Ohio including a terrestrial component of 45.6 mR/year and an ionizing cosmic ray component of 36.6 mR/year (excludes neutron component). Since Oakley's values represent averages covering wide geographical areas, the measured ambient radiation average of 71 mR/year for the immediate locale of Perry is not inconsistent with Oakley's observations. Significant variations occur between geographical areas as a result of geological composition and altitude differences. Temporal variations result from changes in cosmic ray intensity, local human activities, and factors such as ground cover and soil moisture.

B. Fish

The results of gamma spectrometric analysis of fish samples collected during 1981 are presented in Table 5. A total of 11 samples were analyzed, four from the indicator location and seven from the control location. A few additional species were collected but in insufficient size to perform the analysis at the required sensitivity. Future sampling efforts will concentrate on the larger edible species of commercial and/or recreational importance. Since most (9Ø%) of the fish of filleting size were caught in the 1-inch mesh size of the gill nets, application will be made for the 1982 sampling to limit the size of the gill net mesh and eliminate the unproductive panels from the experimental gill nets. This should permit more efficient and useful sampling.

As expected, naturally occurring K-4Ø was the major detectable activity in the edible portions of the fish. Cs-137 was also detected in 6 of 11 samples ranging from 11 to 56 picoCuries per kilogram (wet). This isotope has often been reported in fish flesh in other environmental monitoring programs. Since it is present in global fallout, the occasional detection of Cs-137 in environmental media is not unusual.

C . Shoreline Sediments

The processes by which radionuclides and stable elements are concentrated in bottom sediments are complex, involving physicochemical interaction in the environment between the various organic and inorganic materials from the watershed. These interactions can proceed by a myriad of steps in which the elements are adsorbed on or displaced from the surfaces of colloidal particles enriched with chelating organic materials. Biological action of bacteria and other benthic organisms also contribute to the concentration of certain elements and in the acceleration of the sedimentation process.

Results of the gamma isotopic analyses of the sediments sampled from the PNPP environment are given in Table 6. The average, fraction of detectables, and range of radionuclide concentrations are summarized in Table 7.

Most of the observed gamma emitters were naturally occurring members of the uranium and thorium decay chains. These were detected in their expected concentrations. Similarly, K-40 was observed in all samples at its expected range of activities. The predominant man-made radionuclide observed in the sediment samples was Cs-137. Because of its presence in global fallout, the detection of this isotope is neither unexpected nor unusual. The activity levels reported (24 to 450 picoCuries per kilogram (dry)) are within the range of observed values for other environmental monitoring programs. Due to the inhomogeneity typical of sediment samples, wide variations between samples are expected even when the samples are taken relatively near each other.

Detectable activities of Co-60 were observed in 4 of 8 sediment samples. The detection of Co-60 in sediment samples is less common than is the detection of Cs-137. Collaboration of this data is being sought in other programs. This will also be watched closely in future sampling efforts.

A single sample contained detectable activity of Ce-144. This nuclide is occasionally detected due to its presence in fallout from nuclear weapons testing.

V. REFERENCES

1. U.S. Nuclear Regulatory Commission, "An Acceptable Radiological Environmental Monitoring Program," Radiological Assessment Branch Technical Position, November 1979, Revision 1.

2. National Council on Radiation Protection and Measurements, "Environmental Radiation Measurements," NCRP Report No. 50, Washington, D.C., December 27, 1976.

3. Oakley, D.C., "Natural Radiation Exposure in the United States," ORP/SID 72-1 Office of Radiation Programs, U.S. Environmental Protection Agency, Washington, D.C., June 1972.

APPENDIX A

LABORATORY QUALITY ASSURANCE

1. Introduction

The quality assurance program of the Radiological Laboratory of NUS is briefly described in this appendix.

Information on each incoming sample is entered in a permanent log book. A sample number is assigned to each sample at the time of receipt. This sample number uniquely identifies each sample.

Laboratory counting instruments are calibrated, using radionuclide standards obtained from the National Bureau of Standards, the EPA, and reliable commercial suppliers, such as Amersham-Searle. Calibration of counting instruments is maintained by regular counting of radioactive reference sources. Background counting rates are measured regularly on all counting instruments. Additional performance checks for the gamma-ray scintillation spectrometer include regular checks and adjustment, when necessary, of energy calibration.

Blank samples are processed, with each group of samples analyzed for specific radionuclides, using radiochemical separation procedures. Blank, spiked (known quantities of radioactivity added), and replicate samples are processed periodically to determine analytical precision and accuracy.

2. Laboratory Analyses for Quality Assurance

The quality assurance procedures employed in the conduct of radiological monitoring programs by the Environmental Services Division Radiological Laboratory are as required in Section 5.0 of the NUS Environmental Systems Group Quality Assurance Manual and detailed in the NUS Radiological Laboratory Manual. These procedures include the requirement for (1) laboratory analysis of samples distributed by appropriate government or other standards-maintaining agencies in a laboratory intercomparison program, (2) analysis of some of the client's environmental samples split with other independent laboratories, and (3) analysis in duplicate of a specific fraction of the client's environmental samples.

The NUS Radiological Laboratory participates in the U.S. Environmental Protection Agency Radioactivity Intercomparison Studies (Cross-check) Program. The NUS results of analyses performed on samples pertinent to the Perry program and the known values are listed in Tables A-1 through A-5.

TABLE A-1. USEPA Intercomparison Program

Analytical Results - Gross Beta

Collection Date	EPA Results (pCi/filter ± 1σ)	NUS Results (pCi/filter ± 1σ)
Air Filter		
1-5-79	18 ± 5	22 ± 2
10-5-79	31 ± 5	37 ± 1
12-28-79	29 ± 5	33 ± 1
3-28-80	41 ± 5	45 ± 1
6-27-80	28 ± 5	49 ± 2 (32 ± 2)(1)
9-26-80	10 ± 5	11 ± 1
12-19-80	19 ± 5	18 ± 2
3-27-81	50 ± 5	54 ± 1
6-26-81	54 ± 5	62 ± 3
9-25-81	51 ± 5	59 ± 1
Water		
9-22-78	10 ± 5	11 ± 1
11-17-78	26 ± 5	24 ± 2
1-19-78	16 ± 5	15 ± 1
3-23-79	16 ± 5	16 ± 0
5-25-79	22 ± 5	22 ± 1
9-21-79	40 ± 5	9 ± 1 (42 ± 4)(2)
11-30-79	27 ± 5	NR(3)
1-18-80	45 ± 5	50 ± 6
3-21-80	22 ± 5	25 ± 1
5-16-80	14 ± 5	22 ± 0
7-18-80	38 ± 5	92 ± 9 (49 ± 5)(1)
9-19-80	21 ± 5	24 ± 8
11-21-80	13 ± 3	16 ± 1
3-20-81	25 ± 5	25 ± 1
5-22-81	14 ± 5	16 ± 2
7-17-81	15 ± 5	18 ± 1
9-18-81	28 ± 5	26 ± 0
11-20-81	23 ± 5	22 ± 3

(1) These samples were inadvertently counted with alpha discriminator at "off" on the proportional counter. This caused the beta channel to accumulate alpha plus beta. Values in parentheses are the corrected values.

(2) Actual value reported to EPA was 9 ± 1. This was due to the use of 1 liter as the sample volume when only 200 mls were evaporated. Corrected value is in parentheses.

(3) Sample destroyed in shipment.

TABLE A-2. USEPA Intercomparison Program

Analytical Results - Tritium in Water

Collection Date	EPA Known Value (pCi/l ± 1σ)	NUS Result (pCi/l ± 1σ)
2-17-78	1680 ± 340	1613 ± 29
4-14-78	2220 ± 349	2173 ± 116
6-9-78	2270 ± 349	2260 ± 70
8-11-78	1230 ± 330	1227 ± 127
12-15-78	2030 ± 346	2203 ± 217
2-9-79	1280 ± 331	1395 ± 168
4-13-79	2270 ± 349	1933 ± 35
6-15-79	1538 ± 337	1407 ± 91
8-10-79	1480 ± 335	NR*
10-05-79	1560 ± 337	1370 ± 66
12-14-79	2040 ± 346	1670 ± 170
2-8-80	1750 ± 341	1660 ± 0
4-11-80	3400 ± 360	3003 ± 42
6-13-80	2000 ± 345	1947 ± 247
8-15-80	1210 ± 329	1200 ± 100
10-10-80	3200 ± 360	3067 ± 153
12-26-80	2240 ± 350	2167 ± 58
2-13-81	1760 ± 341	1667 ± 58
4-10-81	2710 ± 355	2467 ± 153
6-12-81	1950 ± 344	1933 ± 58
8-07-81	2630 ± 354	2967 ± 115
10-09-81	2210 ± 348	1900 ± 100
12-11-81	2700 ± 355	2633 ± 153

*Analysis not performed.

TABLE A-3. USEPA Intercomparison Program

Analytical Results - Cs-137 on Air Filters

Collection Date	EPA Results (pCi/filter ± 1σ)	NUS Results (pCi/filter ± 1σ)
1-5-79	6 ± 5	9 ± 1
10-5-79	12 ± 5	17 ± 3
12-28-79	10 ± 5	16 ± 2
3-28-80	20 ± 5	27 ± 1
6-27-80	12 ± 5	16 ± 1
9-26-80	10 ± 5	12 ± 3
12-19-80	19 ± 5	27 ± 4
9-25-81	19 ± 5	29 ± 3

TABLE A-4. USEPA Intercomparison Program
(Sheet 1 of 2)

Gamma Spectrometry of Water Samples

Collection Date	Nuclide	EPA Result (pCi/l ± 1σ)	NUS Result (pCi/l ± 1σ)
2-10-78	Co-60	34 ± 5	32 ± 2
	Zn-65	29 ± 5	26 ± 2
	Ru-106	36 ± 5	43 ± 7
	Cs-134	52 ± 5	46 ± 3
4-7-78	Co-60	34 ± 5	32 ± 2
	Zn-65	59 ± 5	57 ± 3
	Ru-106	113 ± 6	114 ± 13
	Cs-134	74 ± 5	63 ± 2
6-2-78	Cr-51	102 ± 5	96 ± 16
	Co-60	22 ± 5	21 ± 2
	Zn-65	54 ± 5	48 ± 7
	Ru-106	58 ± 5	73 ± 10
	Cs-134	22 ± 5	18 ± 1
	Cs-137	30 ± 5	30 ± 2
8-4-78	Cr-51	105 ± 5	96 ± 14
	Co-60	27 ± 5	25 ± 2
	Zn-65	62 ± 5	52 ± 5
	Ru-106	41 ± 5	55 ± 15
	Cs-134	9 ± 5	8 ± 1
	Cs-137	15 ± 5	16 ± 2
10-20-78	Cr-51	117 ± 6	LT 373*
	Co-60	23 ± 5	21 ± 3
	Zn-65	82 ± 5	84 ± 10
	Ru-106	46 ± 5	LT 128
	Cs-134	25 ± 5	18 ± 1
	Cs-137	125 ± 6	113 ± 4
2-2-79	Co-60	9 ± 5	LT 15**
	Zn-65	21 ± 5	LT 13
	Cs-134	6 ± 5	LT 10
	Cs-137	12 ± 5	LT 12

Note: See footnotes at end of table.

TABLE A-4. USEPA Intercomparison Program
(Sheet 2 of 2)

Gamma Spectrometry of Water Sample

Collection Date	Nuclide	EPA Result (pCi/l ± 1σ)	NUS Result (pCi/l ± 1σ)
6-8-79	Co-60	47 ± 5	49 ± 3
	Cs-134	71 ± 5	69 ± 4
10-5-79	Cr-51	113 ± 6	LT 226
	Co-60	6 ± 5	LT 9
	Cs-134	7 ± 5	LT 15
	Cs-137	11 ± 5	LT 13
2-1-80	Cr-51	101 ± 5	106 ± 25
	Co-60	11 ± 5	12 ± 1
	Zn-65	25 ± 5	24 ± 1
	Ru-106	51 ± 5	54 ± 5
	Cs-134	10 ± 5	10 ± 0
	Cs-137	30 ± 5	33 ± 1
6-6-80	Cr-51	13 ± 5	LT 160
	Co-60	5 ± 5	8 ± 4
	Zn-65	23 ± 5	24 ± 5
	Ru-106	37 ± 5	LT 100
	Cs-134	11 ± 5	10 ± 1
	Cs-137	17 ± 5	12 ± 1
10-3-80	Cr-51	86 ± 5	LT 193
	Co-60	16 ± 5	18 ± 5
	Zn-65	25 ± 5	28 ± 10
	Ru-106	46 ± 5	LT 103
	Cs-134	20 ± 5	17 ± 2
	Cs-137	12 ± 5	14 ± 1
2-6-81	Cr-51	0	LT 130
	Co-60	25 ± 5	24 ± 2
	Zn-65	85 ± 5	83 ± 13
	Ru-106	0	LT 50
	Cs-134	36 ± 5	33 ± 1
	Cs-137	4 ± 5	LT 6

*LT = Less Than
**Single determination only

TABLE A-5. USEPA Intercomparison Program

Analytical Results - Gamma Spectrometry of Milk Samples

Collection Date	Nuclide	EPA Result (pCi/l ± 1σ)	NUS Result (pCi/l ± 1σ)
4-28-78	I-131	82 ± 5	80 ± 5
	Cs-137	23 ± 5	25 ± 3
	K-40[(1)]	1500 ± 75	1567 ± 40
7-21-78	Cs-137	53 ± 5	54 ± 4
	K-40	1560 ± 78	1443 ± 47
1-26-79	I-131	105 ± 5	94 ± 5
	Cs-137	49 ± 5	48 ± 4
	K-40	1560 ± 78	1351 ± 59
11-2-79	I-131	637 ± 32	673 ± 9
	Cs-137	49 ± 5	50 ± 7
	K-40	1470 ± 73	1684 ± 144
1-25-80	Cs-137	40 ± 5	43 ± 3
	K-40	1600 ± 80	1767 ± 100
4-25-80	I-131	33 ± 5	LT 250[(2)]
	Cs-137	28 ± 5	28 ± 2
	K-40	1190 ± 60	1350 ± 71
7-25-80	Cs-137	35 ± 5	34 ± 2
	K-40	1550 ± 78	1667 ± 58
10-31-80	I-131	18 ± 5	16 ± 1
	Co-137	21 ± 5	22 ± 3
	K-40	1700 ± 85	1600 ± 0

(1) Results for K-40 are in mg/liter.

(2) LT = Less Than

APPENDIX B

REPORTING OF ANALYTICAL RESULTS

In the tables presenting analytical measurements, the calculated value is reported with the two sigma counting error (2σ) derived from a statistical analysis of both the sample and background count rates. The precision of the results is influenced by the size of the sample, the background count rate, and the method used to round off the value obtained to reflect the degree of significance of the results. For analytical results obtained from gamma spectral analysis, the precision is also influenced by the composition and concentrations of the radionuclides in the sample, the size of the sample, and the assumptions used in selecting the radionuclides to be quantitatively determined. The two sigma error for the net counting rate is:

$$2\sigma = 2\sqrt{\frac{R_s}{t_s} + \frac{R_b}{t_b}}$$

where

R_s = sample counting rate
R_b = background counting rate
t_s = sample counting time
t_b = background counting time.

If the measurements on the samples are not statistically significant (i.e., the two sigma count error is equal to or greater than the net measured value), then the radioactivity concentrations in the sample are considered not detected.

Results reported as less than ("LT") are below the lower limit of detection (LLD). The LLD is defined as the smallest concentration of radioactive material in a sample that will yield a net count (above system background) that will be detected with 95 percent probability with only 5 percent probability of falsely concluding that blank observation repesents a "real" signal.

For a particular measurement system (that may include radiochemical separation):

$$LLD = \frac{4.66 s_b}{E \times V \times 2.22 \times Y \times \exp(-\lambda \Delta t)}$$

where:

LLD is the lower limit of detection as defined above (as pCi per unit mass or volume)

s_b is the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (as counts per minute)

E is the counting efficiency (as counts per disintegration)

V is the sample size (in units of mass or volume)

2.22 is the number of disintegrations per minute per picocurie

Y is the fractional radiochemical yield (when applicable)

λ is the radioactive decay constant for the particular radionuclide

Δt is the elapsed time between sample collection and counting.

The following are definitions or descriptions of statistical terms used in the reporting and analysis of environmental monitoring results.

Precision relates to the reproducibility of measurements within a set, that is, to the scatter or dispersion of a set about its central value.

Measures of the Central Value of a Set. Mean (or Average or Arithmetic Mean) is the sum $\sum_{i=1}^{n} {}_i$ of the values of individual results divided by the number of results in the set. The mean is given by

$$\overline{X} = (X_1 + X_2 + \ldots X_n)/n = \sum_{i=1}^{n} X_i/n$$

Measures of Precision with a Set. Standard Deviation is the square root of the quantity (sum of squares of deviations of individual results from the mean, divided by one less than the number of results in the set). The standard deviation, s, is given by:

$$s = \sum_{i=1}^{n} (X_1 - \overline{X})^2/(n-1)$$

Standard deviation has the same units as the measurement. It becomes a more reliable expression of precision as n becomes larger. When the measurements are independent and normally distributed, the most useful statistics are the mean for the central value and the standard deviation for the dispersion.

Relative Standard Deviation is the standard deviation expressed as a fraction of the mean, $s/\overline{X}$. It is sometimes multiplied by 100 and expressed as a percentage.

Range is the difference in magnitude between the largest and the smallest results in a set. Instead of a single value, the actual limits are sometimes expressed (minimum value/maximum value).