NUS-3346

PREOPERATIONAL ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM

at

FERMI-2

Annual Report
1978

Prepared for

The Detroit Edison Company

by

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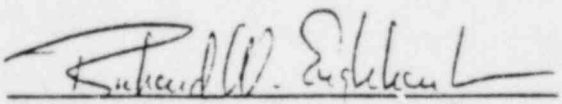

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

I. INTRODUCTION

The preoperational radiological environmental monitoring program for Fermi-2 was initiated on March 15, 1978 and will continue until fuel loading, presently scheduled for June 1980. This program is being conducted by NUS Corporation under contract with The Detroit Edison Company. This is the first Annual Report for the radiological environmental monitoring program being conducted under the contract. This report covers the period March 15, 1978 through December 31, 1978 and summarizes the results of measurements and analyses of data obtained from samples collected during this interval.

A. Site and Station Description

Fermi-2 is a BWR designed to operate at a powe. level of about 1150 megawatts of electrical output with the main condenser circulating water cooled by two natural draft, wet type, hyperbolic cooling towers. The plant is located on approximately 1120 acres about eight miles east-northeast of Monroe, Michigan; thirty miles southwest of downtown Detroit, Michigan; and, twenty-five miles northeast of downtown Toledo, Ohio. Fermi-2, bounded on the east by Lake Erie, is situated in Frenchtown Township in Monroe County, Michigan.

B. Objectives and Overview of Fermi-2 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 is utilized 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 variation in the 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. Provides 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 frequency of sampling and duration of the preoperational program follow the guidance outlined in the USNRC Branch Technical Position on radiological environmental monitoring as issued by the Radiological Assessment Branch (March, 1978).[1]

During 1978, the period covered by this report, the scope of the program was limited to the measurement of ambient gamma radiation by thermoluminescent dosimetry and to the determination of gamma emitters in shoreline sediments and fish (Perca flavescens).

In 1979, the radiological monitoring program will be expanded. Additional analyses included in the regime will consist of the determination of gross beta and gamma emitters in air particulates; the collection and measurement of gaseous I-131 on charcoal cartridges; the measurement of gross beta in drinking water as well as the determination of gamma emitters and tritium in drinking and surface water; and, the determination of I-131 and other gamma emitters in milk.

II. PROGRAM DESCRIPTION

Twelve (12) locations within a radius of about 15 miles from the Fermi-2 site were monitored. At seven (7) TLD locations, two thermoluminescent dosimeters were deployed quarterly to obtain ambient background radiation levels. Additionally, six (6) shoreline sediment samples from three (3) locations and four (4) fish samples from two (2) locations were collected. The number and location of monitoring points were determined by considering the locations where the highest offsite environmental concentrations have been predicted from plant effluent source terms, site hydrology, and site meteorological conditions. Other factors considered were population distribution, ease of access to sampling stations, security and future program integrity.

The Preoperational Environmental Radiological Monitoring Program for Fermi-2 is summarized in Table 1 for the first year (1978) and in Table 2 for the second year (1979). Table 3 describes sample locations, associated media, and approximate distance and direction from the site Figures 1 and 2 designate sampling locations by station number.

TABLE 1

Environmental Radiological Monitoring Program, First Year (1978)

Sample Media	Station Number & Location		Sampling Frequency	Analysis Type	Analysis Frequency
Direct Radiation	1	Telephone pole # DE6935 H-6	Continuous sampling TLD s changed quarterly(2 TLD s/ station	Gamma dose	Quarterly
	2	Tree at the termination of Brancho Street			
	3	Tree adjacent to Swan Boat Club			
	4	Site Boundary and Toll Road, Telephone Pole #DE 762 356 C			
	5	Site Boundary and Toll Road, Telephone Pole #DE56R 776 35 G5			
	6	Site Boundary and Toll Road, Telephone Pole			
	7	Doty Farm,N.Custer Rd.(Control)			
Fish Yellow Perch (Perca flavescens)	16	Fermi-2 discharge	Semi-annually	Gamma isotopic (edible portion)	Semi-annually(1)
	11	Control in vicinity of Celeron Island			
Shoreline Sediments(2)	8	Pt.Aux Peaux, 110' offshore siting directly to land-based water tower			
	9	Fermi-2 discharge	Semi-annually	Gamma isotopic	Semi-annually(1)
	10	Estral Beach, 300' offshore siting directly to land-based windmill			

(1) Samples analyzed in duplicate.

(2) Current patterns vary with seasons approximately 50% upstream and 50 % downstream, consequently no "control" is established.

TABLE 2

Environmental Radiological Monitoring Program, Second Year (1979)

Sample Media	Station Number & Location	Sampling Frequency	Analysis Type	Analysis Frequency
Fish Direct Radiation Shoreline Sediments	Same as first year	Same as first year	Same as first year	
I. Airborne a) Particulates[2]	1 Telephone Pole #DE6935 H-6 4 Site Boundary and Toll Road, Telephone Pole #DE 762 35 GC 5 Site Boundary and Toll Road, Telephone Pole #DE 56R 776 3565 7 Doty Farm, Route #50 (Control)	Continuous sampling, change filters weekly	Gross beta[2]	Weekly[1] - following each filter change
b) Radioiodine	(Same as Particulates)	Continuous sampling, change canisters weekly	Gamma isotopic Iodine-131	Weekly-[1] following each canister change
Surface Water	12 Unit 1 Raw Lake Water Intake Structure 14 Trenton Power Plant Intake Structure (Screenhouse #2) (Control)	Monthly	Gamma isotopic Tritium	Monthly[1] Quarterly[1] - composite by location
Drinking Water[2]	13 Monroe Water Station 15 Detroit Water Station[3] (Fighting Island) (Control)	Monthly	Gross beta[2] Gamma isotopic Tritium	Monthly[1] Monthly[1] Quarterly[1] - composite by location

TABLE 2 (continued)

Sample Media	Station Number & Location	Sampling Frequency	Analysis	
			Type	Frequency
Milk	Indicator locations[3]	1. Monthly 2. Semi-monthly when animals on pasture	Gamma isotopic Iodine -131	1. Monthly 2. (Semi-monthly when animals on pasture)
	7 Doty Farm (Control)			

(1) Samples analyzed in duplicate

(2) If gross beta in air or water is greater than 10 times the mean of control samples for any medium, gamma isotopic analysis performed on individual samples.

(3) To be finalized after milch animal census is conducted in Spring 1979.

TABLE 3

Preoperational Environmental Radiological Monitoring Program, Fermi-2
Sample Locations and Associated Media

Station Number[1]	Direction	Distance from Reactor (Approx.)	Description	Media
1	NE	1.3 mi.	Telephone Pole #DE 6935 H-6	Direct Radiation Radioiodine Particulates
2	NNE	1.1 mi.	Tree at the termination of Brancho Street (private residence)	Direct Radiation
3	N	1.1 mi.	Tree adjacent to Swan Boat Club	Direct Radiation
4	NNW	0.6 mi.	Site Boundary and Toll Road, Telephone Pole #DE 762 35 GC	Direct Radiation Radioiodine Particulates
5	NW	0.6 mi.	Site Boundary and Toll Road, Telephone Pole #DE 56R 776 356 G	Direct Radiation Radioiodine Particulates
6	WNW	0.6 mi.	Site Boundary and Toll Road, Telephone Pole	Direct Radiation
7	W	15 mi.	Doty Farm, N. Custer Rd. (Control)	Direct Radiation Radioiodine Particulates Milk
8	S	0.9 mi.	Pt. Aux Peaux, 110 ft. off-shore sighting directly to land based water tower	Sediment
9	E	0.2 mi.	Fermi-2 discharge	Sediment
10	NE	1.1 mi.	Estral Beach, 300' off-shore sighting directly to land based windmill	Sediment

TABLE 3 (continued)

Preoperational Environmental Radiological Monitoring Program, Fermi-2
Sample Locations and Associated Media

Station Number	Direction	Distance from Reactor (Approx.)	Direction	Media
11	NNE	9.5 mi.	Control in vicinity of Celeron Island	Perca flavescens
12	SSE	0.4 mi.	Unit 1 Raw Lake Water Intake Structure	Surface Water
13	S	1.2 mi.	Monroe Water Station	Drinking Water
14	NE	13 mi.	Trenton Power Plant Intake Structure (Screenhouse #2)	Surface Water
15	NNE	20 mi.	Detroit Water Station[2] (Fighting Island)	Drinking Water
16	E	0.4 mi.	Fermi-2 discharge (1200 ft. offshore)	Perca flavescens

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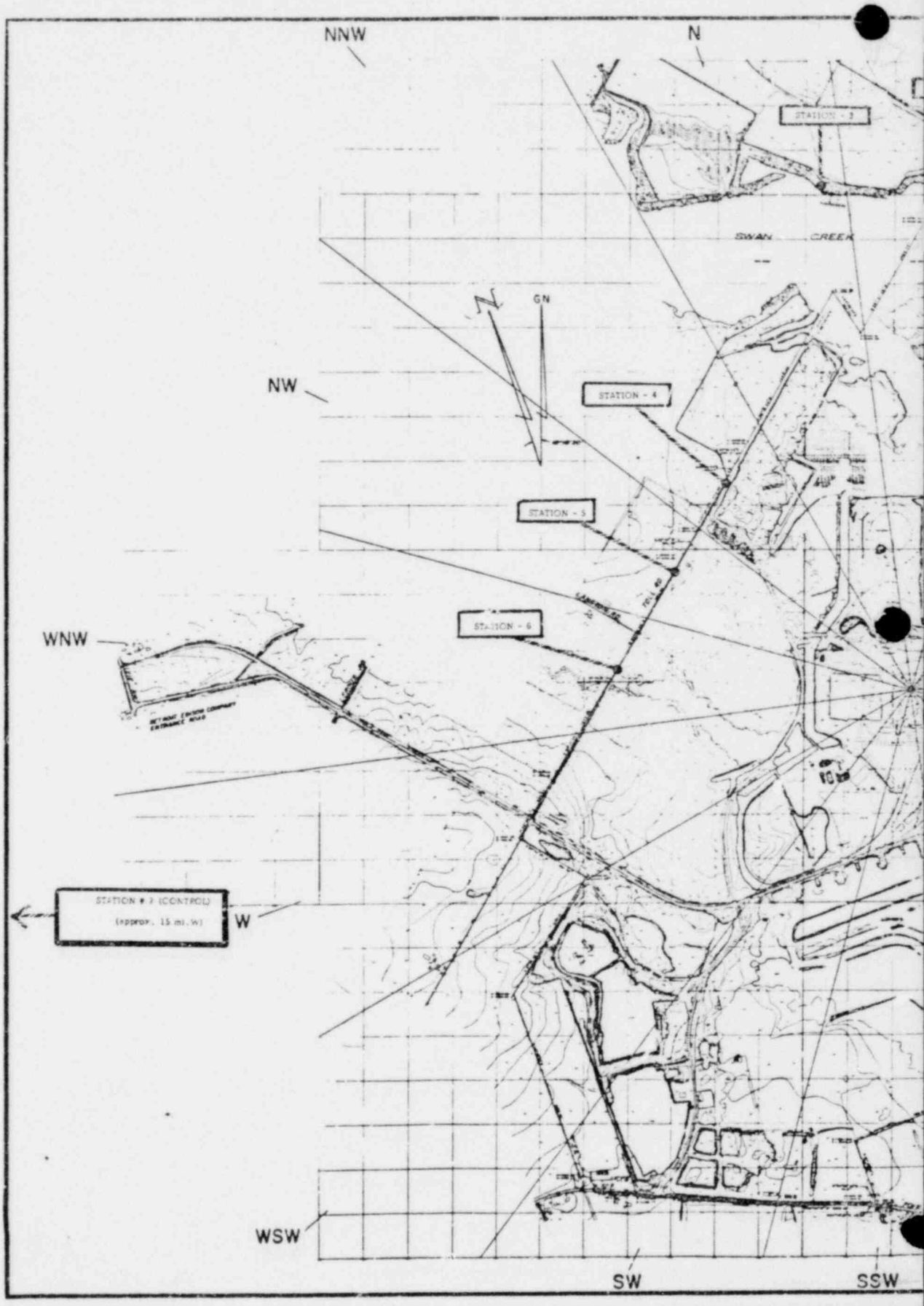
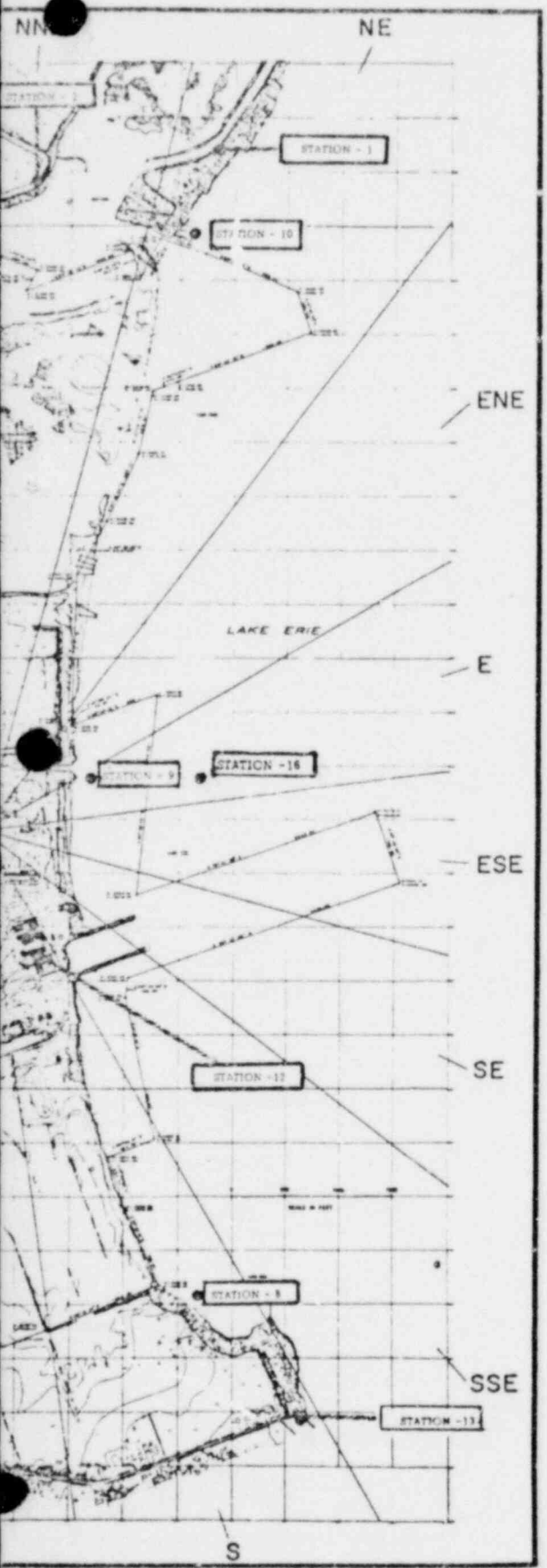
(1) Indicator milk sampling locations will be finalized after milch animal census is conducted in Spring, 1979.

(2) Access to this location not finalized.

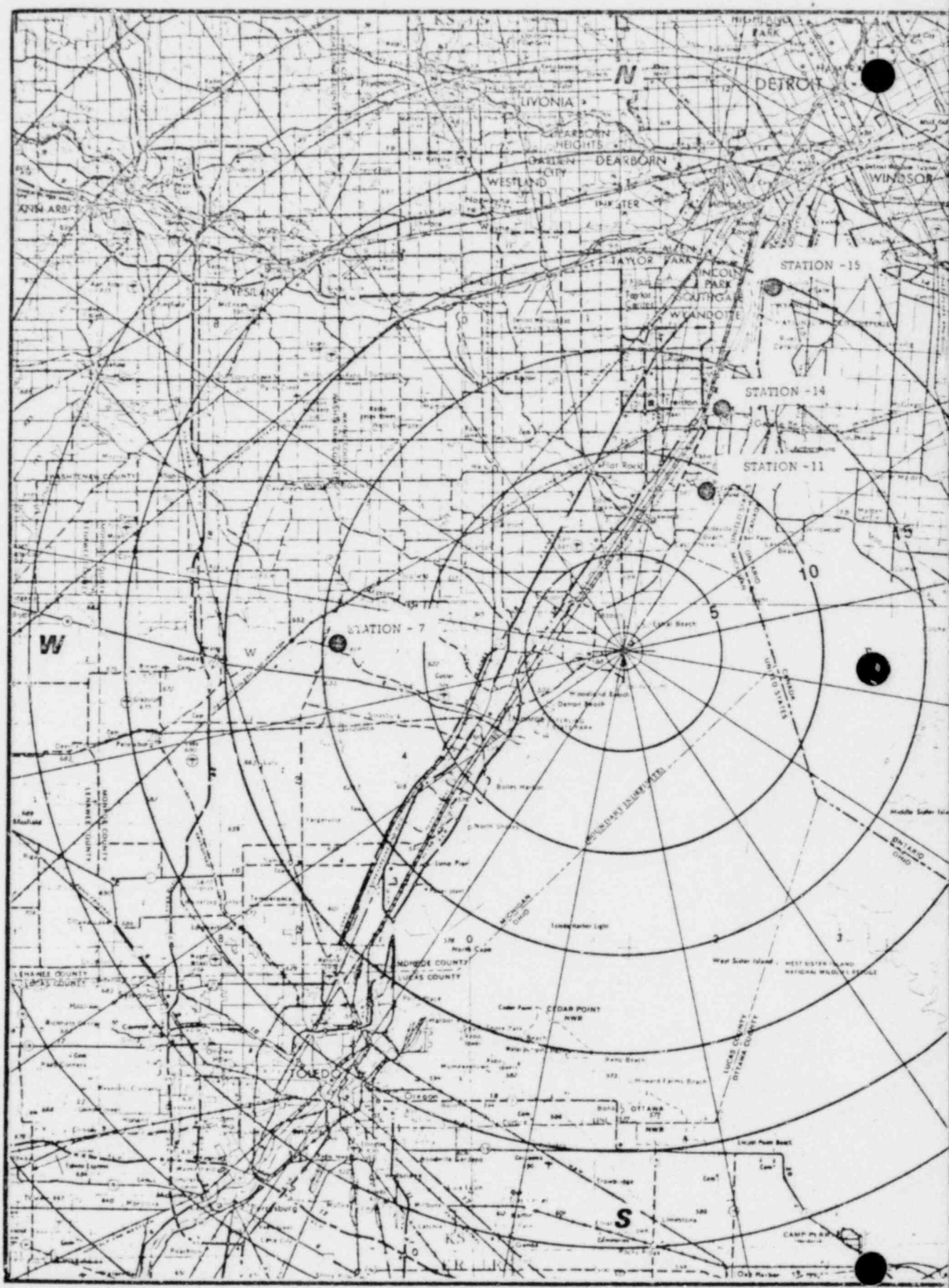

NNW
N
STATION - 3
SWAN CREEK
GN
NW
STATION - 4
STATION - 5
STATION - 6
WNW
STATION # 7 (CONTROL)
(approx. 15 mi. W)
W
WSW
SW
SSW

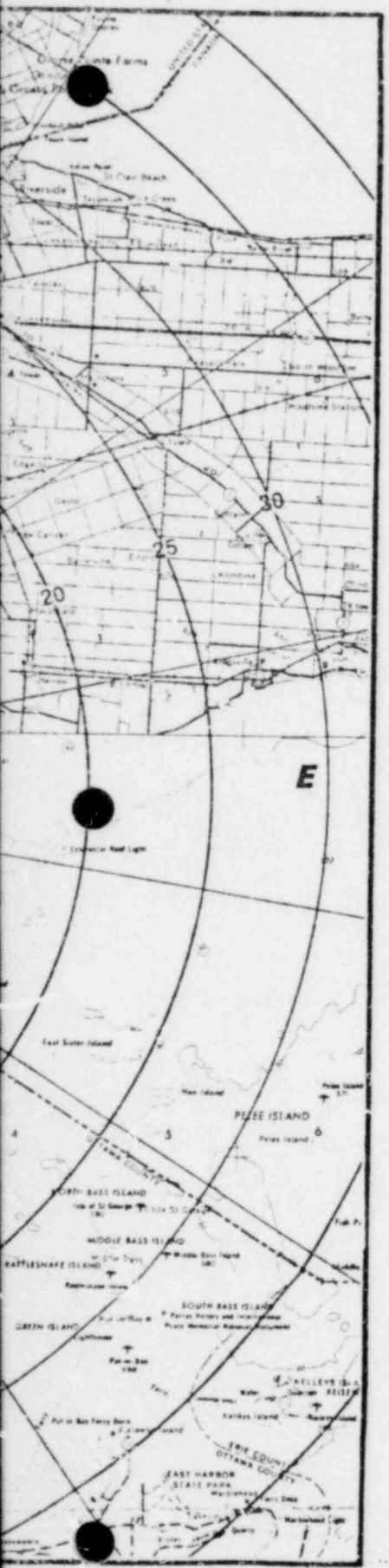


ENRICO FERMI ATOMIC POWER PLANT
UNIT 2

Figure 1

Sampling Locations-By Station Number
(Immediate Vicinity of Fermi-2)


N
DETROIT
LIVONIA
DEARBORN
WESTLAND
WINDSOR
STATION - 15
STATION - 14
STATION - 11
STATION - 7
W
S
5
10
TOLEDO
CEDAR POINT
NWR



ENRICO FERMI ATOMIC POWER PLANT
UNIT 2

Figure 2
Sampling Locations-By Station Number
(Greater Than 5 Miles)

III. SAMPLING METHODS AND PROCEDURES

To derive meaningful and useful data from the Environmental Radiological 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.

A. Direct Radiation

Thermoluminescent dosimeters (TLDs) were used to determine the direct (ambient) radiation levels at seven (7) monitoring points. The locations were selected by ranking the mixed-mode χ/Q values. Stations 1 through 6 are situated in the six highest sectors around the plant site. Station 7, the control, is located approximately 15 miles west of Fermi-2 in the least prevalent wind direction. The selection of the TLD locations follows the guidelines outlined in the USNRC Branch Technical Position on Radiological Environmental Monitoring (March, 1978).[1] Duplicate dosimeters of $CaSO_4$:Dy in teflon, obtained from Teledyne Isotopes, were deployed at each location and exchanged on a quarterly basis by an NUS environmental scientist.

To minimize the in-transit dose contribution, the dosimeters were annealed close to the site within 24 hours prior to field placement. Freshly annealed control dosimeters were sent along with the exposed field dosimeters to determine the exposure received by the dosimeters in transit from the site to readout in Rockville, Maryland. Calibrations of the dosimeters were

performed in April of 1977 and August of 1978 by obtaining accurately known Cs-137 radiation exposures at the National Bureau of Standards. An exposure history of each dosimeter was maintained to determine any significant change in sensitivity as a result of repeated use and annealing.

B. Fish

Because of its importance to both commercial and recreational fishermen, and the predominance of the species in local waters, yellow perch (Perca flavescens) were collected semiannually for the monitoring program. As described in Table 1, perch were collected from Lake Erie in the vicinity of the Fermi-2 discharge (Station 16) and a control location in the vicinity of Celeron Island (Station 11) approximately nine (9) miles NNE of the plant.

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 The Detroit Edison Company. The net was retrieved after approximately 24 hours. Entrapped, surviving species other than yellow perch were released.

C. Shoreline Sediments

Sediments were collected semiannually from three (3) locations by biologists from The Detroit Edison Company. Samples were taken with a Ponar dredge from the vicinities of Point Au Peaux (Station 8), Fermi-2 discharge (Station 9), and Estral Beach (Station 10). The locations are shown in Figure 1.

IV. SUMMARY AND DISCUSSION OF 1978 ANALYTICAL RESULTS

Summary data of radiological analyses of environmental media from Fermi-2 collected during 1978 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 Environmental Systems Group Quality Assurance Manual of NUS Corporation and are detailed in the NUS Radiological Laboratory Manual - "Environmental Monitoring and Radiological Services Procedures/Work Instructions."

Radiological analyses of environmental media characteristically approach and frequently fall below the detection limits of state-of-the-art measurement methods.[3] 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 D. NUS analytical methods meet the LLD requirements addressed in Table 2 of the USNRC Branch Technical Position.[1]

Tables 4 through 6 specify the radioanalytical results for individual samples. A statistical summary of the 1978 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 4. Duplicate TLD badges of four read-out areas each were deployed at each location quarterly. The mean values of four readings (corrected individually for response to a known dose and for in-transit exposure) are reported as "a" and "b". The mean of the two dosimeters is estimated to be correct to $\pm$ two times the standard deviation of eight readings (95% confidence level).

A statistical summary of the data is included in Table 7. External radiation levels in the environs of the Fermi-2 site ranged from 0.12 to 0.23 mR/day, which extrapolates to 44 to 84 mR/year. Oakley[2] calculates an ionizing radiation dose equivalent of 88.8 mR/year for Michigan, including a terrestrial component of 45.6 mR/year and an ionizing cosmic ray component of 43.2 mR/year. Since Oakley's values represent averages covering wide geographical areas, the measured ambient radiation average of 62 mR/year for the immediate locale of Fermi-2 may not be inconsistent with Oakley's observations. Significant variations occur between geographical areas as a result of geologic 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. Additional data need to be accumulated to insure that the observed values are indeed typical of the local environment.

TABLE 4

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM, FERMI-2
PREOPERATIONAL, 1978

DIRECT RADIATION-ANALYTICAL RESULTS

Quarter	Sampling Period	Sampling Location	External Gamma Dose Rate, mR/day			
			a	b	mean	2 x Relative Standard Deviation(%) (1)
1	No Data (2)					
2	3/15/78 to 6/19/78	1	0.14	0.14	0.14	9%
		2	0.15	0.14	0.14	7%
		3	0.19	0.17	0.18	6%
		4 (3)	-	-	-	-
		5	0.21	0.21	0.21	4%
		6	0.15	0.16	0.16	9%
		7	0.18	0.17	0.18	4%
3	6/19/78 to 9/26/78	1	0.13	0.12	0.12	7%
		2	0.16	0.15	0.16	5%
		3	0.16	0.15	0.16	6%
		4	0.17	0.18	0.18	6%
		5	0.19	0.19	0.19	4%
		6	0.15	0.16	0.16	8%
		7	0.17	0.18	0.18	4%
4	9/26/77 to 12/29/78	1	0.13	0.16	0.14	9%
		2	0.17	0.18	0.18	9%
		3	0.18	0.18	0.18	11%
		4	0.20	0.18	0.19	7%
		5	0.23	0.19	0.21	8%
		6	0.18	0.18	0.18	10%
		7	0.20	0.19	0.20	10%

(1) Calculated from 8 readings

(2) Program started 3/15/78.

(3) TLD's vandalized.

B. Fish

The results of gamma analysis performed on yellow perch (Perca flavescens) collected during 1978 are presented in Table 5. A statistical evaluation is given in Table 7. Naturally occurring K-40 constituted the only detectable nuclide activity in the flesh portion of the fish. No fission-produced radionuclides were identified.

TABLE 5

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM, FERMI-2
PREOPERATIONAL, 1978

FISH - YELLOW PERCH (Perca flavescens), EDIBLE PORTION
ANALYTICAL RESULTS

Quarter	Collection Date	Sampling Location	NUS Sample Number	Gamma-Emitting Nuclides, pCi/kg, wet, ± 2σ							
				K-40	Mn-54	Fe-59	Co-58	Co-60	Zn-65	Cs-134	Cs-137
2	6/21/78	16	9760a	2800±400	LT 60 (1)	LT100	LT 60	LT 40	LT 80	LT 70	LT 90
			9760b	3400±500	LT 60	LT 90	LT 60	LT 40	LT 90	LT 30	LT 80
			mean	3100±500	LT 60	LT 90	LT 60	LT 40	LT 90	LT 50	LT 90
3	7/19/78	11 (2)	9791a	3500±900	LT 90	LT150	LT 90	LT 60	LT160	LT 50	LT 70
			9791b	3600±800	LT 80	LT120	LT 90	LT 50	LT140	LT 90	LT110
			mean	3600±900	LT 90	LT140	LT 90	LT 60	LT150	LT 70	LT 90
4	10/16/78	16	9860a	2000±1200	LT 80	LT220	LT 90	LT 80	LT210	LT 60	LT 80
			9860b	3600±1500	LT100	LT210	LT 90	LT 90	LT190	LT100	LT100
			mean	2800±1300	LT 90	LT220	LT 90	LT 80	LT200	LT 80	LT 90
	10/16/78	11	9861a	3900±1000	LT120	LT220	LT 80	LT 80	LT200	LT 90	LT 80
			9861b (3)	3700±1000	LT110	LT230	LT 70	LT 80	LT180	LT 60	LT 60
			mean	3800±1000	LT110	LT230	LT 80	LT 80	LT190	LT 80	LT 70

(1) LT = less than

(2) No fish obtained on first sampling attempt - See Appendix A

(3) Replicate count

B. 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 analysis of the sediments sampled from the Fermi-2 environment in 1978 are given in Table 6. The average, fraction of detectables, and range of radionuclide concentrations are summarized in Table 7. Naturally occurring K-40 is the predominant radionuclide detected in the samples.

Another radionuclide of natural origin, Ra-226, was identified in NUS Sample Number 9858 collected from Station 9 in October. Due to the non-homogeneity typical of sediment samples, the occasional detection of this isotope is not unusual.

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM, FERMI-2
PREOPERATIONAL, 1978

SHORELINE SEDIMENTS-ANALYTICAL RESULTS

Quarter	Collection Date	Sampling Location	NUS Sample Number	Gamma-Emitting Nuclides, pCi/kg, dry, ± 2σ					
				U daughters	Th daughters	K-40	Cs-134	Cs-137	Others
2	6/20/78	8	9757a	150± 20	110± 20	11000±500	LT 20 (1)	40±10	N.D. (2)
			9757b	170± 40	100± 50	10000±1100	LT 40	60±30	N.D.
			mean	160± 30	100± 40	11000±800	LT 30	50±20	N.D.
	6/20/78	9	9758a	620± 90	580±100	12000±1600	LT 80	LT 90	N.D.
			9758b	590±100	580± 90	10000±1500	LT 90	LT110	N.D.
			mean	600±100	580±100	11000±1600	LT 80	LT100	N.D.
	6/20/78	10	9759a	210± 40	170± 30	12000±800	LT 30	LT 50	N.D.
			9759b	240± 40	170± 50	12000±1100	LT 40	LT 80	N.D.
			mean	220± 40	170± 40	12000±900	LT 40	LT 60	N.D.
4	10/10/78	8	9857a	280± 70	220± 70	9800±1200	LT 60	LT100	N.D.
			9857b	290± 70	280± 60	12000±1400	LT 70	LT120	N.D.
			mean	280± 70	250± 60	11000±1300	LT 60	LT110	N.D.
	10/10/78	9	9858a	1100±140	840±220	14000±1900	LT110	LT150	2000±600 (3)
			9858b	1090±140	890±140	17000±2200	LT110	LT130	2100±700 (3)
			mean	1100±160	860±180	16000±2000	LT110	LT140	2000±600

(1) LT = less than
(2) N.D. = Not detected
(3) Ra-226

TABLE 6 (Continued)

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM, FERMI-2
PREOPERATIONAL, 1978

SHORELINE SEDIMENTS-ANALYTICAL RESULTS

Quarter	Collection Date	Sampling Location	NUS Sample Number	Gamma-Emitting Nuclides, pCi/kg, dry $\pm 2\sigma$					
				U daughters	Th daughters	K-40	Cs-134	Cs-137	Others
4	10/10/78	10	9859a	240 ± 70	330 ± 90	13000 ± 1400	LT 60	LT 90	N.D.
			9859b	320 ± 70	170 ± 60	13000 ± 1400	LT 60	LT140	N.D.
			mean	280 ± 70	250 ± 80	13000 ± 1400	LT 60	LT110	N.D.

(1) LT = less than
(2) N.D. = Not detected
(3) Ra-226

TABLE 7

Indicator Location Statistical Evaluation

Environmental Radiological Monitoring Program Annual Report

Name of Facility: Enrico Fermi Unit 2 Docket No. 50-341
Location of Facility: 30 miles Southwest of Detroit, Michigan (Frenchtown Township)

Reporting Period: March 15, 1978 through December 31, 1978

Medium or Pathway Sampled (Unit of Measurement)	Type and Total Number of Analyses Performed		Lower Limit of Detection (1) (LLD)	All Indicator Locations Mean (f)[2] Range	Location with Highest Annual Mean Name / Distance & Direction	Mean (f)[2] Range	Control Locations Mean (f)[2] Range	Number of Nonroutine Reported Measurements
TLD's - Direct Radiation (mR/day)	Gamma Dose	40		0.17 (34/34) (0.12-0.23)	Tel.Pole #DE56R 776 35G5 0.6 mi. NW (Station 5)	0.20(6/6) (0.19-0.23)	0.18 (6/6) (0.17-0.20)	0
Shoreline Sediments pCi/kg (dry weight)	Gamma Spec	12						
	U daughters			440 (12/12) (150-1100)	Fermi-2 Discharge 0.2 mi. E (Station 9)	850 (4/4) (590-1100)	See note 3	0
	Th daughters			370(12/12) (100-890)	Fermi-2 Discharge 0.2 mi. E (Station 9)	720 (4/4) (580-890)		0
	40K			12000(12/12) (9800-17000)	Fermi-2 Discharge 0.2 mi. E (Station 9)	13000(4/4) (10000-17000)		0
	134Cs		150	<LLD		<LLD		
	137Cs		150	50(2/12) (40-60)	Pt. Aux Peau 0.9 mi. S (Station 8)	50(2/4) (40-60)		0
	226Ra			2000(2/12) (2000-2100)	Fermi-2 Discharge 0.2 mi. E (Station 9)	2000 (2/4) (2000-2100)		0
Fish pCi/kg (wet weight)	Gamma Spec	8						
	40K			3000(4/4) (2000-3600)	Fermi-2 Discharge 0.4 mi. E (Station 16)	3000(4/4) (2000-3600)	3700(4/4) (3500-3900)	0
	54Mn		130	<LLD		<LLD	<LLD	0
	59Fe		260	<LLD		<LLD	<LLD	0
	58Co		130	<LLD		<LLD	<LLD	0
	60Co		130	<LLD		<LLD	<LLD	0
	65Zn		260	<LLD		<LLD	<LLD	0
	134Cs		130	<LLD		<LLD	<LLD	0
	137Cs		130	<LLD		<LLD	<LLD	0

(1) LLD = Lower Limit of Detection as defined in the USNRC Branch Technical Position on radiological environmental monitoring, Table 2, (March 1978).

(2) Mean and range bases upon detectable measurements only. Fraction of detectable measurements at specified locations is indicated in parentheses (f).

(3) Current patterns vary with seasons approximately 50% upstream and 50% downstream, consequently no "control" is established.

V. REFERENCES

1. U.S. Nuclear Regulatory Commission, "An Acceptable Radiological Environmental Monitoring Program", Radiological Assessment Branch Technical Position, March 1978

2. 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.

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

APPENDIX A

Deviations in the Sampling and Analytical Regime

The following deviations in the Fermi-2 monitoring program have been documented by NUS Corporation and transmitted to The Detroit Edison Company during 1978.

A. Direct Radiation

The second quarter TLDs, deployed at Station 4 along Toll Road at the site boundary were missing at the end of the exposure period. There was evidence of target shooting in the area and, in all probability, the TLDs were destroyed in this manner. The third quarter TLDs were deployed as usual at this location and, to date, no further vandalism has occurred.

B. Fish

Fish (Perca flavescens) were not collected by Detroit Edison biologists on the first sampling attempt in June at Station 11 (control), originally located in the vicinity of Edison's Trenton Channel Plant. Due to the swift currents and abundance of detritus suspended in the ambient waters, the net became "loaded" and was avoided by fish. As a result, the control location was changed to the vicinity of Celeron Island, approximately 9 miles NNE of the Fermi-2 plant site. Perch were successfully collected from this location on July 19, 1978. The results of the gamma isotopic analysis for fish collected from this location are included in Table 5 under NUS Sample Number 9791.

Contractual agreements between Detroit Edison and NUS Corporation require that duplicate gamma analyses be performed on fish samples.

"Duplicate" is defined as separate aliquots of the sample media. Insufficient sample (Perca flavescens) was collected at Station 11 (Celeron Island) by Detroit Edison biologists to yield two (2) individual sample aliquots. Consequently, replicate gamma isotopic analyses were performed on the entire available sample media. This sample is designated as NUS Sample Number 9861; the analytical results appear in Table 5.

APPENDIX B

Laboratory Quality Assurance

I. 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.

Separate laboratory notebooks are used for each major environmental monitoring program.

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.

II. Laboratory Analyses for Quality Assurance

The quality assurance procedures employed in the conduct of radiological monitoring programs by the Northern Environmental Services Division Radiological Laboratory are as required in Section 5.0 of the 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 specified portion of the client's environmental samples.

The results of the QA analyses performed by the NESD Radiological Laboratory of NUS Corporation in 1978 are given below.

A. Samples Split with Independent Laboratory

Aliquots of shoreline sediments collected in October from Stations 8 and 10 were sent to an independent laboratory for gamma analyses. The results of the intercomparison are listed in Table B-1. Considering the low levels of radionuclides present in the samples and the difficulty included in processing sediment so that replicate, homogeneous portions may be obtained, the agreement between the results is considered good.

B. In-House Duplicate Analyses

All analytical work for the Fermi-2 program during 1978 was performed in duplicate and has been addressed in Tables 4 through 6.

C. Environmental Dosimeters

NUS Corporation has participated in the second and third International Intercomparison of Environmental Dosimeters, sponsored by DOE-EML, ORNL, and the University of Texas School of Public Health. Results for both field and laboratory tests deviated less than an average of five percent from the known exposure (laboratory) or average of doses reported (field) for over one hundred sets of submitted dosimeters.

NUS is participating in the Fourth Intercomparison scheduled during the late winter and early spring of 1979.

TABLE B-1

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM, FERMI-2

PREOPERATIONAL, 1978

SHORELINE SEDIMENTS

INDEPENDENT LABORATORY GAMMA RESULTS

Quarter	Collection Date	Sampling Location	NUS Sample Number (1)	Gamma-Emitting Nuclides, pCi/kg, dry, ± 2σ					
				U daughters	Th daughters	K-40	Cs-134	Cs-137	Others (4)
4	10/10/78	8	9863(9857)	N.R. (3)	155±18	9360± 940	LT 20 (2)	LT 2[illegible]	N.D.
	10/10/78	10	9864(9859)	N.R. (3)	267±27	11800±1200	LT 20	LT 20	N.D.

NUS GAMMA RESULTS

Quarter	Collection Date	Sampling Location	NUS Sample (1) Number	Gamma-Emitting Nuclides, pCi/kg, dry, ± 2σ					
				U daughters	Th daughters	K-40	Cs-134	Cs-137	Others
4	10/10/78	8	9857a	280± 70	220± 70	9800±1200	LT 60	LT100	N.D.
			9857b	290± 70	280± 60	12000±1400	LT 70	LT120	N.D.
			mean	280± 70	250± 60	11000±1300	LT 60	LT110	N.D.
4	10/10/78	10	9859a	240± 70	330± 90	13000±1400	LT 6[illegible]	LT 90	N.D.
			9859b	320± 70	170± 60	13000±1400	LT 60	LT140	N.D.
			mean	280± 70	250± 80	13000±1400	LT 60	LT110	N.D.

(1) Number in parenthesis is corresponding NUS sample (duplicate)

(2) LT = less than

(3) N.R. = Not Reported

(4) N.D. = Not Detected

APPENDIX C

Analytical Procedures

Environmental samples for the Fermi-2 Environmental Radiological Monitoring Program were collected and analyzed in accordance with procedures described in detail in the NUS Laboratory Manual - "Environmental Monitoring and Radiological Services Procedures/Work Instructions". These analytical procedures have been adapted from the published analytical methods of the Environmental Measurements Laboratory (EML - formerly HASL), the laboratories of the Environmental Protection Agency, and pertinent ASTM procedures.

APPENDIX D

I. 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 counting 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% probability with only 5% probability of falsely concluding that a blank observation represents a "real" signal.

For a particular measurement system (which 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 picucurie

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 $\sum_{i=1}^{n} X_i$ of the values of individual results divided by the number, n, 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 or σ, is given by

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

Standard deviation has the same units as the measurement. It becomes a more reliable expression of precision as n becomes large. 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 smallest results in a set. Instead of a single value, the actual limits are sometimes expressed (minimum value - maximum value).