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FEED MATERIALS PRODUCTION CENTER ENVIRONMENTAL MONITORING ANNUAL REPORT FOR 1985

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FEED MATERIALS PRODUCTION CENTER ENVIRONMENTAL MONITORING ANNUAL REPORT FOR 1985

By
C. A. Aas, D. L. Jones, and R. W. Keys

May 30, 1986

FEED MATERIALS PRODUCTION CENTER

Westinghouse Materials Company of Ohio
P. O. BOX 398704
CINCINNATI, OHIO 45239

PREPARED FOR THE
U.S. DEPARTMENT OF ENERGY
WEAPONS DIVISION OF OAK RIDGE OPERATIONS
UNDER CONTRACT DE-AC05-860R21600

Attachment I

ERRATA FOR THE FEED MATERIALS PRODUCTION CENTER ENVIRONMENTAL MONITORING ANNUAL REPORT FOR 1985

EXECUTIVE SUMMARY

Page 1, pp 2. "Radon (^{222}Rn)" should read:

"Radon (^{222}Rn and ^{220}Rn)."

Page 2, pp 3. "...the overall was average..." should read:

"...the overall average was..."

ENVIRONMENTAL STANDARDS

Page 9, pp 1. "...areas was generally used as the standard of..." should read:

"...areas were generally used as the standards of..."

DATA ANALYSIS

Page 11, pp 1. "While samples vary, most samples..." should read:

"Most samples..."

SAMPLE COLLECTION AND ANALYSIS

Air

Radiological Parameters

Page 14, pp 2. The existing paragraph should be replaced with:

"Radon is a naturally occurring isotope which is produced from the decay of radium (^{226}Ra) and thorium (^{224}Th), both of which are also natural isotopes found in soils and rock. As in 1984, concentrations of radon were monitored at 7 on-site and 2 off-site monitoring stations using commercially available instruments. The overall average for radon measured at boundary stations in 1985 was slightly less than the overall average radon measured in 1984 (Table 3). Typical background levels of radon are measured annually at OS1 and OS2, which are located 5 and 3 kms from the FMPC, respectively. In 1985, the average concentration of radon measured at these background stations ranged from 0.4 to 0.6 pCi per liter of air."

ERRATA FOR THE FEED MATERIALS PRODUCTION CENTER ENVIRONMENTAL MONITORING ANNUAL REPORT FOR 1985

Fish

Page 39, pp 1.	"A total of 252 fish representing 25 species were taken: 52 from sampling location 1, 41 from location 2, and 159 from location 3." should read:
	"A total of 251 fish representing 25 species were taken: 52 from sampling location 1, 42 from location 2, and 157 from location 3."
Page 39, pp 3.	"...and were lowest upstream (Table 22);..." should read:
	"...and were lowest downstream (Table 22);..."
Page 40	FIGURE 13 FISH SAMPLING LOCATIONS should be replaced with the attached corrected FIGURE 13. Fish sampling locations 1 and 3 were incorrectly labeled on the figure.

APPENDIX I TABLES

Page 52	Table 2 Radionuclides in Air should be replaced with the attached corrected Table 2. The combined isotopes Pu-239,240 were analyzed, and not Pu-239 alone as indicated on the table.
Page 53	Table 3 ^{222}Radon in Ambient Air should be replaced with the attached corrected Table 3. The combined isotopes of radon were analyzed, and not ^{222}Radon alone as indicated on the table.
Page 70	Table 20 Uranium Concentration in Garden Produce: Potatoes should be replaced with the attached corrected Table 20. All results reported were μg/g not pCi/g as indicated on the table, and the conversion to Bq/g was meaningless.
Page 72	Table 24 Summary of Radiation Exposure Due to 1985 Emissions should be replaced with the attached corrected Table 24. The Sievert conversion for Maximum Individual Dose, All Pathways From All Airborne Releases, Bone Surface was 3.1 and not 9.5, and the Sievert conversion for 80 Km Population Total, Effective was 550 and not 526, as indicated on the table.

ERRATA FOR THE FEED MATERIALS PRODUCTION CENTER ENVIRONMENTAL MONITORING ANNUAL REPORT FOR 1985

APPENDIX II
PARAMETERS TO BE ANALYZED FOR RCRA GROUNDWATER SAMPLING

Page 76, D.	"28. Carbontetrachloride" should be:
	"28. Carbon tetrachloride."
Page 76, E.	"9. Cesuium 137" should be:
	"9. Cesium 137."

APPENDIX III
RESULTS OF RCRA GROUNDWATER SAMPLING

Page 88, NOTES	"(3) Conductivity results in umhos<cm" should be:
	"(3) Conductivity results in umhos/cm."

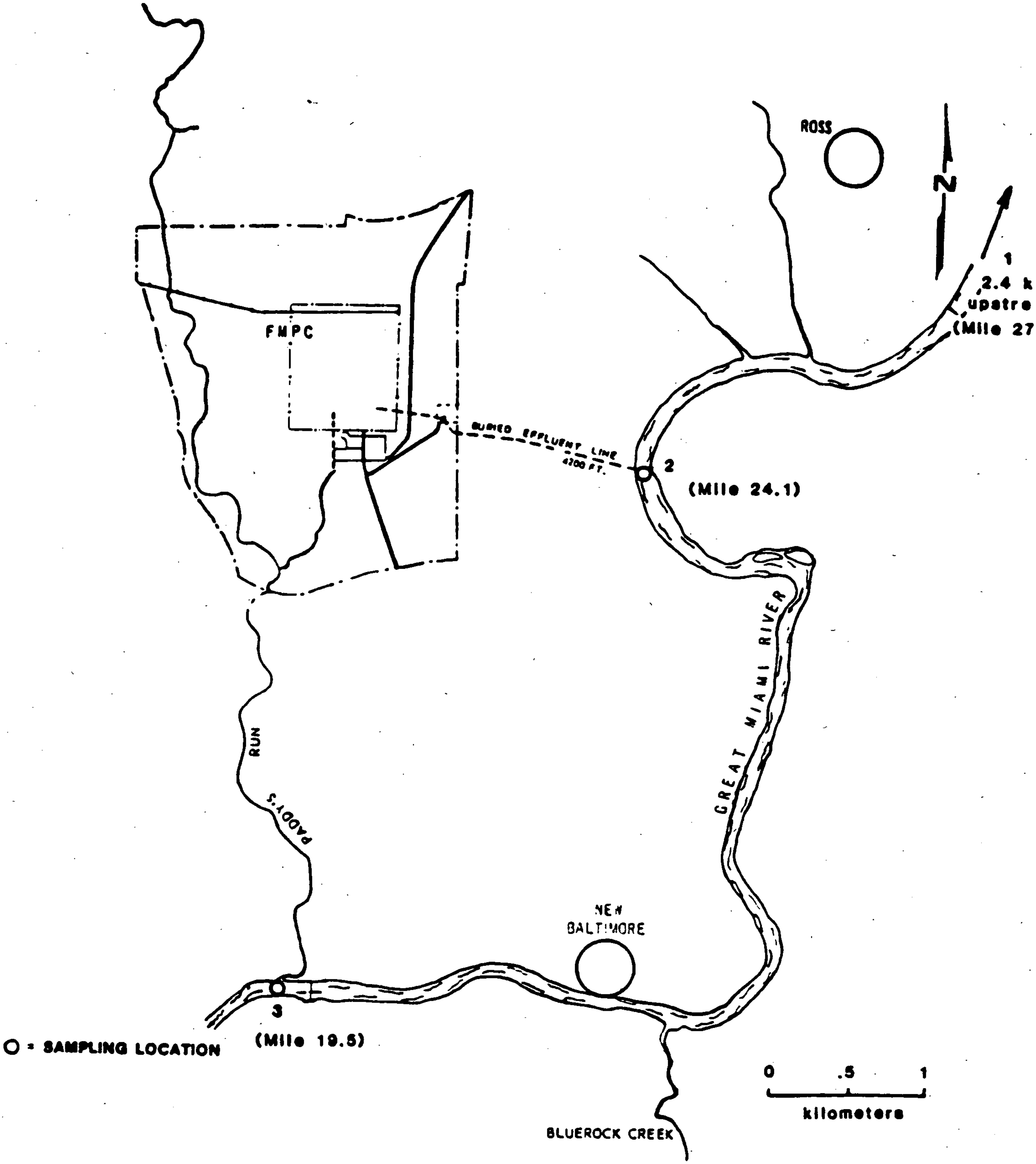

FIGURE 13 FISH SAMPLING LOCATIONS

TABLE 2 Radionuclides in Air

Radionuclide	Guideline pCi/l (4)	Concentration of Radionuclides at Boundary Stations (1) in $pCi/l \times 10^{-9} \pm 2\sigma$ (2,3)						
		BS1	BS2	BS3	BS4	BS5	BS6	BS7
Cs-137	2.0000	<21.8	<22.4	<26.1	<22.4	<11.4	<24.3 15.5	<22.6
Np-237	0.0040	<2.2	<1.1	<1.3	<3.4	<3.4	<1.1	<1.1
Pu-238	0.0010	1.3 ± 0.7	1.5 ± 0.7	2.0 ± 0.8	1.3 ± 0.6	1.0 ± 0.4	1.3 ± 0.6	0.9 ± 0.6
Pu-239,240	0.0010	8.6 ± 1.9	8.7 ± 1.7	12.5 ± 2.0	4.9 ± 1.1	7.6 ± 1.3	6.8 ± 1.2	3.2 ± 1.2
Pu-241	1.0000	42.8 ± 0.9	41.2 ± 0.9	60.6 ± 1.6	26.3 ± 0.5	32.6 ± 0.5	31.4 ± 0.9	11.8 ± 0.5
Ra-226	0.0020	<76.2	<55.9	<52.2	<56.1	<45.8	110.4 ± 44.1	45.3 ± 39.6
Ra-228	0.0010	<3.3	<11.2	39.1 ± 39.1	<11.2	<11.4	<11.0	<11.3
Ru-106	0.2000	304.9 ± 32.7	2069.7 ± 295.7	3304.4 341.8	2531.9 ± 316.5	2362.1 ± 296.3	2474.3 ± 296.9	2408.9 ± 278.0
Sr-90	0.0300	28.3 ± 18.5	246.2 ± 55.9	261.0 ± 65.2	224.3 ± 56.1	13.7 ± 25.2	66.2 ± 30.9	17.0 ± 23.8
Tc-99	2.0000	707.7 ± 76.2	3942.3 ± 591.3	6380.9 ± 797.6	3270.4 ± 633.0	4036.3 ± 492.1	118.3 ± 29.7	1576.1 ± 370.6
Th-228	0.0002	14.2 ± 2.2	10.6 ± 3.6	26.1 ± 5.2	21.3 ± 5.6	32.1 ± 5.7	17.7 ± 4.4	22.6 ± 5.7
Th-230	0.0003	152.4 ± 21.8	77.2 ± 28.9	261.0 ± 52.2	134.6 ± 33.6	194.6 ± 34.3	121.4 ± 33.1	82.6 ± 22.6
Th-232	0.0010	9.7 ± 1.6	8.7 ± 2.9	14.4 ± 2.6	12.3 ± 3.4	13.7 ± 2.3	13.2 ± 3.3	11.3 ± 3.4

Footnotes:

(1) See Figure 2.

(2) Reported in units of pCi/l of air, uncertainties are counting uncertainties only at the 95% C.L. To obtain Bq/l, multiply the value by 3.7×10^{-11}.

(3) A composite of 52 weekly samples for BS3, 53 samples for all other boundary stations.

(4) As stated in 10 CFR Part 20, Appendix B, Concentrations in Air and Water Above Natural Background.

TABLE 3 Radon in Ambient Air

Location (1)	Radon Activity in pCi/l (2)			
	Minimum	Maximum	Average (3)	95% (4) C.L.
Onsite				
BS1	0.49	1.12	0.81 (0.03)	0.64
BS2	0.41	1.39	0.82 (0.03)	1.03
BS3	0.33	0.50	0.28 (0.01)	0.76
BS4	0.43	0.72	0.56 (0.02)	0.30
BS5	0.52	0.96	0.80 (0.03)	0.49
BS6A	0.72	1.42	1.06 (0.04)	0.71
BS6B	0.30	0.50	0.27 (0.01)	0.90
BS7	0.72	1.31	1.01 (0.04)	0.60
Offsite (5)				
OS1	0.49	0.75	0.59 (0.02)	0.28
OS2	0.30	0.50	0.37 (0.01)	0.23

Footnotes:

(1) See Figure 2.

(2) 10 CFR Part 20, Appendix B, established a guideline level of 3 pCi/l above background.

(3) Bq/l in parentheses.

(4) C.L. = Average Concentration +/- the value shown.

(5) Located at nearby residences and used for background comparisons.

TABLE 20 Uranium Concentration in Garden Produce

Sampling Point (1)	Number of Samples	Concentration in Peels (pCi/g dry wt.)				Concentration in Flesh (pCi/g dry wt.)			
		Minimum	Maximum	Average(2)	95% C.L. (3)	Minimum	Maximum	Average(2)	95% C.L. (3)
1	6	0.61	0.82	0.69 (0.0255)	1.0	0.0013	0.0045	0.0020 (0.00008)	1.1
2	6	0.15	0.44	0.20 (0.0073)	1.1	0.0022	0.0088	0.0043 (0.00016)	1.1
3	6	0.22	0.51	0.29 (0.0108)	1.0	0.0037	0.0074	0.0060 (0.00022)	1.0
4	6	0.13	0.25	0.17 (0.0063)	1.0	0.0022	0.0074	0.0042 (0.00016)	1.1
Control(4)	12	0.09	0.23	0.18 (0.0065)	1.0	0.0003	0.0074	0.0037 (0.00014)	1.3

Footnotes:
(1) See Figure 12.
(2) Bq/g in parentheses.
(3) C.L. = Average Concentration x÷ value shown.
Derived from log transformed data; = $t_{\alpha,6}S\bar{X}$.
(4) Control Samples were collected from two remote sites in Indiana.

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TABLE 24 Summary of Radiation Exposure Due to 1985 Emissions

Exposures	Organ	Dose Equivalent 50-Year Commitment mrem	(SV)	Guideline (1)	% of Guideline
I. Maximum Individual Dose					
A. All pathways from all Airborne Releases (2)	Effective	1.9	(18.7)	100	1.9
	Bone Surface	0.3	(3.1)	75	0.4
	Pulmonary	8.9	(88.7)	75	11.9
	Whole Body (3)	<0.0002	(<0.002)	25	<0.0008
B. Ingestion (4)					
Great Miami River Water	Effective	0.002	(0.02)	100	0.002
	Bone Surface	0.04	(0.4)	5000	0.0008
Off-Site Well 15 (5)	Effective	22.1	(221)	100	22.1
	Bone Surface	328.1	(3281)	5000	6.6
C. Direct External Exposure	Whole Body (6)	17.5	(175)	100	17.5
II. Individual in Ross, Ohio Inhalation Pathway (4)	Effective	0.5	(5)	100	0.5
	Bone Surface	1.4	(14)	75	1.9
	Pulmonary	3.3	(33)	75	4.4
III. 80 km Population Total (2)	Effective	55	(550)	2.6×10^{8}	2.1×10^{-7}
	Whole Body	0.007	(0.07)	6.44×10^{7}	7.8×10^{-9}

Footnotes:

(1) Guidelines: Radiation Standards for Protection of the Public in the Vicinity of DOE Facilities, published November 14, 1985, adopts the standards of 40 CFR 61, Subpart H (NESHAP) for Air Pathway Exposures (25 mrem whole body, 75 mrem to any organ), and adopts the recommendations of ICRP 26 for prolonged periods of exposure for all pathways. (100 mrem effective dose, 100 mrem whole body dose, 5 rem to any organ).

(2) Dose calculations provided by ORNL using AIRDOS/DARTAB. 80 km population dose is expressed as person-rem.

(3) Whole body dose equivalent provided by ORNL. It results from radionuclides not deposited throughout the body, therefore the whole body dose equivalent from all radionuclides released at FMPC results from external exposure only.

(4) Dose equivalent calculation based on environmental measurements according to ICRP 26/30 Methodology. ICRP 26/30 based 50-year commitment dose conversion factors from Dunning (1986)[18].

(5) Off-site Well 15 contained the highest concentration of uranium measured in offsite wells in 1985. Dose calculations show maximum hypothetical dose from off-site well water ingestion.

(6) Calculated from measured exposure at the nearest residence west of the K-65 storage silos.

Department of Energy
Oak Ridge Operations
P. O. Box E
Oak Ridge, Tennessee 37831

June 20, 1986

Distribution

ENVIRONMENTAL MONITORING REPORT - FEED MATERIALS PRODUCTION CENTER

Enclosed for your information and retention is a copy of the 1985 Environmental Monitoring Report for the U.S. Department of Energy's Feed Materials Production Center located in your region. This report is prepared and published annually for distribution to interested local, State, and Federal agencies, members of the public, and to the press.

If you have any questions on the content of this report or desire additional information, please contact James A. Reafsnyder, DOE Site Manager, at (513) 738-6357.

Enclosure:
FMPC EMR

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May 30, 1986

WESTINGHOUSE MATERIALS COMPANY OF OHIO

P. O. Box 398704

Cincinnati, Ohio 45239

Prepared for:

U. S. Department of Energy
Weapons Division of Oak Ridge Operations
Contract DE-AC05-86OR21600

Approved:

L. C. Bogar, Vice President & Mgr.
Environment, Safety and Health

CONTENTS

FIGURES

EXECUTIVE SUMMARY

During the year 1985, the Feed Materials Production Center (FMPC) continued to conduct a comprehensive environmental monitoring program in order to assess any possible effects of FMPC operations on the quality of local surroundings.

The total emission of uranium to the atmosphere in 1985 (0.051 Curies) was reduced 80% from 1984. Reductions of the overall average uranium concentrations and beta activities measured in air at the site boundaries in 1985 ranged from 31% to 71% of the average values for 1984. Concentrations of Radon (^{222}Rn) at the site boundaries were at least 65% below the levels established by the Code of Federal Regulations (10 CFR Part 20, Appendix B)(1), and down slightly from 1984 values.

The total amount of uranium discharged in the liquid effluent to the Great Miami River in 1985 (0.41 Curies) was reduced 40% from 1984. The total amount of uranium discharged in stormwater runoff from the site to Paddy's Run via the Storm Sewer Outfall Ditch (0.026 Curies) was 32% less in 1985 than 1984. Concentrations of each radionuclide measured in the liquid effluent prior to discharge to the Great Miami River was decreased in 1985 except for thorium (^{232}Th) which was less than 0.89% of the Federal guideline. As in 1984, non-radiological constituents in liquid effluent exceeded the National Pollutant Discharge Elimination System (NPDES) permit limits less than 2% in 1985. Decreases in radiological and non-radiological constituents in liquid effluent were possibly due to reduced operations and enhanced administrative controls during 1985.

Results for the 1985 quarterly on-site groundwater sampling showed no differences from the 1984 overall average values for uranium content and radioactivity due to alpha and beta particles. As in past years, the 1985 average uranium concentrations measured in monthly samples collected from all but three off-site wells were within the range of natural background. A groundwater study identifying the sources of the above background concentrations in the three off-site wells was completed in 1985. A comprehensive quarterly monitoring program was initiated in 1985 and consists of the sampling and analysis of 35 on-site and six off-site wells for 95 pollutant parameters.

Reductions in the average uranium concentrations in soils for 1985 ranged from 14% to 95% of the average values at the same locations in 1984. Uranium concentrations in sediments of the Great Miami River in 1985 were equivalent to background levels found in the area and were relatively unchanged from 1984 concentrations. Uranium concentrations in Paddy's Run sediments at most locations were also equal to background, with the highest concentrations nearest the confluence of the Storm Sewer Outfall Ditch with Paddy's Run.

Vegetation, farm produce, milk and fish were sampled in 1985. Uranium and fluoride concentrations in vegetation samples measured in 1985 were lower than concentrations measured in 1984. Uranium concentrations in vegetation appeared to be closely linked to the concentrations of uranium found in the soil at the same locations in 1985. The average uranium concentrations in potato flesh were no different from 1984 to 1985 and also between each different sampling location. Although the overall was average on the same order of magnitude as vegetation samples, uranium concentration in potato peels was greater than the overall average for 1984 due to higher concentrations at one location. No detectable concentrations of uranium were measured in any of the samples of milk collected in 1985. The overall average uranium concentration in fish was 51% lower than for fish collected in 1984.

Radiological concentrations in air and water above natural background are outlined in Appendix B of 10 CFR Part 20. Adherence to these guidelines is designed to protect the public from emissions from facilities like the FMPC. Guidelines used by FMPC for uranium isotopes and total uranium are more stringent than levels set by 10 CFR Part 20, Appendix B. There are also National Emission Standards for Hazardous Air Pollutants (NESHAP)[2] which add an additional measure of safety. In 1985, radiation exposures to the public from direct exposure, inhalation and ingestion pathways, were below the Federal guidelines set by 10 CFR Part 20 and NESHAP.

The estimate of how much radiation dose the whole individual receives over a 50 year period to the pulmonary tissue was 0.0089 rem (88.1% less than the Federal guidelines), the weighted average estimate of how much radiation the individual received over 50 years was 0.0019 rem (98.1% less than the guideline) and the external whole body dose received over 50 years was 2×10^{-7} rem (99.99% less than the guideline). A conservative estimate of annual exposure to the individual who lives closest to an additional source of radiation (K-65 Silos) was calculated. If the individual remained on the public road in front of his house 100 percent of the time throughout the year, his annual dose would be 0.018 rem (30% less than the guideline).

The radiation dose the whole individual receives over 50 years if he were to drink Great Miami River water at the FMPC effluent discharge was 0.00004 rem to the bone surface, and the weighted average dose estimate for all body organs was 2×10^{-6} rem (0.0008% and 0.002% of the guidelines, respectively). The radiation dose the whole individual would receive over 50 years from drinking from the well with the highest above background levels of uranium is 0.022 rem for a weighted average dose for all body organs (77.9% less than the guideline) and 0.33 rem (93.4% less than the guideline) to the bone surface.

The dose to the individual who remains in the town of Ross, Ohio (4 km from the FMPC) 100 percent of the time is 0.0014 rem to the bone surface (98.1% less than the guideline), 0.0033 rem to the pulmonary system (95.6% less than the guideline) and 0.0005 rem for a weighted average dose for all body organs (99.5% less than the standard). The estimated weighted average of how much radiation dose the human population within 80 km of the FMPC receives over 50 years is 55 person-rem (0.00002% of the guideline), and the external whole body dose received over 50 years for that same population was 0.0017 person-rem (7.8×10^{-9}% of the guideline).

INTRODUCTION

The Feed Materials Production Center (FMPC) is an industrial facility owned by the United States Department of Energy (DOE), and was managed by NLO, Inc. in 1985. Management of the facility is under the direction of Westinghouse Materials Company of Ohio (WMCO) since January 1, 1986. Located approximately 32 km (20 mi) northwest of downtown Cincinnati, Ohio, production operations cover approximately 55 hectares (136 acres) in the center of a 425 hectare (1050 acres) site. Several rural communities lie within a 1-5 km radius of the plant (Figure 1).

The primary function of the FMPC is the production of metallic uranium fuel elements and target cores and other uranium compounds for use at other DOE facilities. The isotopic content of the final product may be depleted, normal, or slightly enriched in ^{235}U. However, the average ^{235}U content is close to that of uranium found in nature (0.71 percent).

The production of fuel elements and target cores may begin with ore concentrates, recycled uranium, or with other uranium compounds. Some of the material is first dissolved in nitric acid to extract uranium from most of the impurities. A solution of uranyl nitrate is then produced.

Evaporation and heating convert the nitrate solution to uranium trioxide powder. This trioxide is reduced to uranium dioxide and subsequently reacted with anhydrous hydrogen fluoride to produce uranium tetrafluoride. Uranium tetrafluoride is then reacted with magnesium metal to produce metallic uranium. This metallic uranium is then combined with scrap uranium metal and remelted to yield a purified uranium ingot. Ingots are then extruded to form rods or tubes and machined to the dimensions specified by other DOE sites.

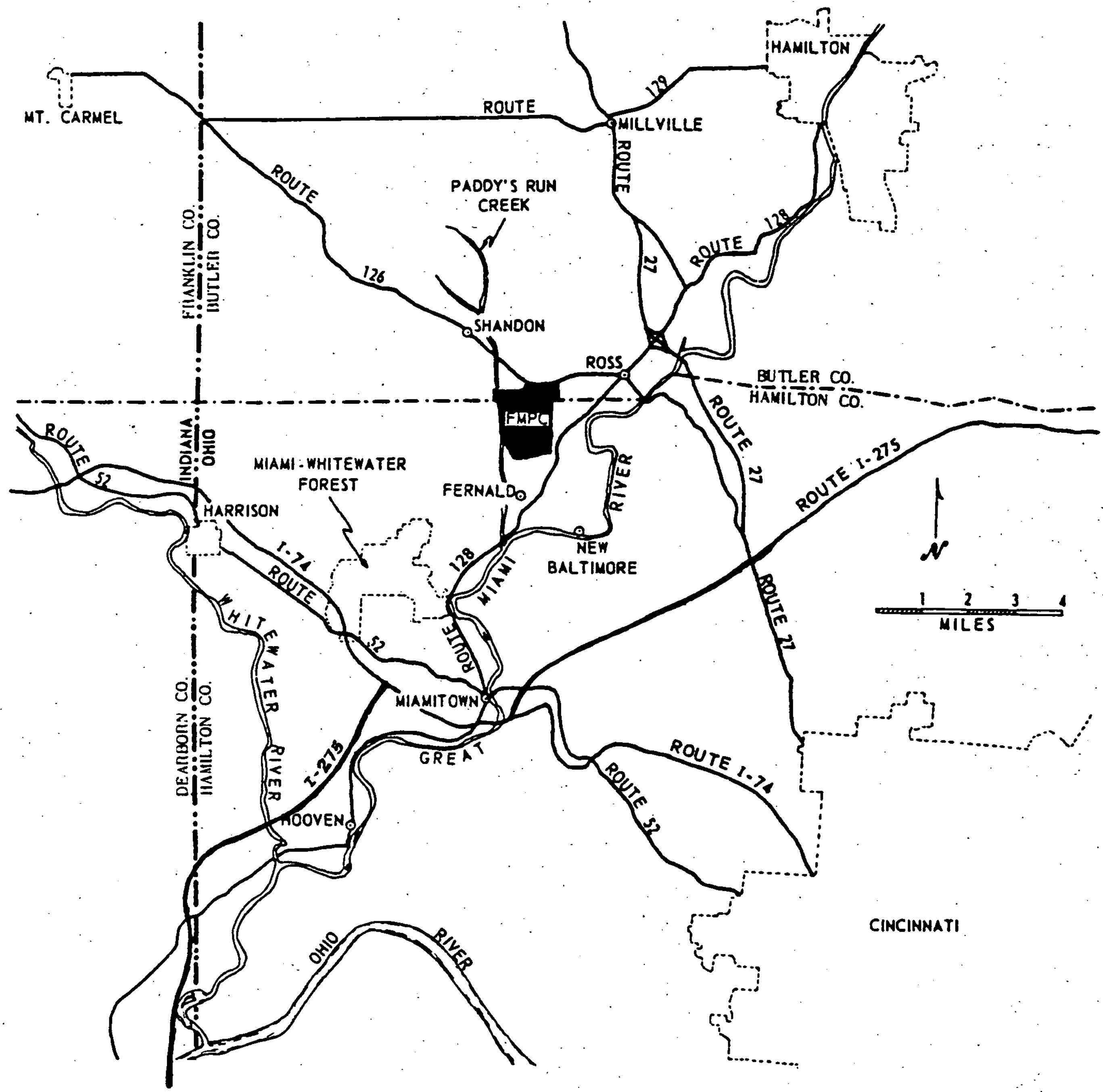

FIGURE 1 AREA MAP

In the past, small amounts of thorium have been processed but none was produced in 1985. Thorium production is similar to uranium production; however, the final product may be in the form of thorium nitrate solution, solid thorium compounds, or metallic thorium.

AREA GEOLOGICAL FEATURES

Glacial action during the time of the Illinoian and Wisconsin ice sheets left the area in much the same geological form as it is today. In the immediate area, outwash from retreating glaciers filled the remains of an ancient river valley. The Great Miami River, which runs in a southerly direction about 1 km east of the FMPC, cut its present course through this fill. The present river bed lies approximately 18 m below the original surface level of the glacial deposit. Nearly 15 m of clay-rich till underlies the FMPC and is probably the remnant of a large glacial moraine. Beneath this till is a wide (approximately 5 km) and deep (about 46 m) bed of sand and gravel.

The FMPC site topography is a relatively level elevated plain, some 177 m (580 ft) above sea level. The land rises slightly to the north (213 m elevation at the northern boundary) and, on the west, slopes downward to Paddy's Run (168 m elevation). Soils at the FMPC are generally characterized as Fincastle-Xenia silt loams grading into Fox-Gennessee and Russell-Xenia silt loams at the western edge and northeast corner of the site, respectively.

On-site vegetation is typical of that occurring elsewhere in the region under similar land use practices. The on-site areas north and west of the production area are moderately wooded with a variety of deciduous hardwoods. Along the west side of the site and to some extent on the south, these wooded portions are found mainly along the natural watersheds. Several acres immediately north of the production area were planted with white pine (*Pinus strobus*) and Austrian Pine (*Pinus nigra*). The major planting was done in 1973 as part of an environmental improvement project. The remainder of the site is covered with a variety of pasture grasses typical of the area and most of this is leased to local dairy producers for grazing purposes.

Although there are several small industries nearby, the major economic activities in the area are farming, dairying, and the raising of beef cattle. Major farm crops include sweet corn, field corn, soybeans, and wheat. Several nearby farms are also involved in the production of garden produce which is sold either at local roadside stands or trucked to nearby urban markets.

Due to the nature of the geology underlying the area, groundwater and gravel are important area products which are sold commercially. A nearby water company (approximately 2 km upstream of the FMPC outfall) began operations just prior to construction of the FMPC and pumps nearly 20 million gallons of water per day. This is sold chiefly to industries in and near Cincinnati. This aquifer, from which the FMPC also obtains its water supply, is recharged in part by the Great Miami River. Many gravel pit operations exist in the Great Miami Valley. These are found both along the river and in the flood plain some distance inland.

Substantial amounts of industrial and municipal wastes from the upstream communities of Dayton, Middletown, Hamilton, and Fairfield are discharged into the Great Miami River; therefore, little recreational use is made of the river.

Downstream areas of the river are sparsely settled and industries are small and scattered. The confluence of the Great Miami with the Ohio River is located approximately 29 km (18 mi) to the south of the FMPC.

Precipitation for the area averages 958 mm (37.7 inches) annually. 1985 was slightly above average with 992 mm (39.1 inches) total precipitation (measured as water) recorded. Monthly maximum and minimum values were 225 mm (8.8 inches) during the month of November and 14 mm (0.5 inches) during September, respectively.

ENVIRONMENTAL STANDARDS

Effluent discharges of air and water from the FMPC are required to meet Federal guidelines for radiation protection. Concentrations for radiological constituents outlined in 10 CFR Part 20, Appendix B for air and water above natural background in uncontrolled (off-site) areas was generally used as the standard of comparison for the environmental data presented in this report; however, the guidelines used by FMPC for uranium isotopes and total uranium are more stringent than levels set by 10 CFR Part 20, Appendix B. The National Emission Standards for Hazardous Air Pollutants (NESHAP) which became effective in February, 1985, were also used for evaluating air emissions from the FMPC in 1985.

The criteria used for non-radiological air and waterborne contaminants were taken from standards adopted by Ohio EPA[3,4]. Results of groundwater sampling were compared to National Primary and Secondary Drinking Water Regulations as well as the Federal guidelines for radiation protection. Non-radiological liquid effluent discharged from the FMPC is regulated by Ohio EPA as part of the National Pollutant Discharge Elimination System (NPDES).

QUALITY ASSURANCE

An essential part of the verification of environmental data is the implementation of a comprehensive quality assurance program. The analytical laboratories at the FMPC maintain such a program. The FMPC laboratories calibrate their instruments daily, analyze standards with each set of samples, and frequently analyze blanks and spiked samples. With each set of samples sent to independent laboratories for analysis, certified quality assurance and control blanks are also included. Depending on the constituent to be analyzed, the results must occur within a specified performance limit or within the routine limit set by each laboratory for a standard level comparable to the specified true value.

A very important program in which the FMPC participates is the Quality Assurance Program administered by the DOE Environmental Measurements Laboratory (EML) in New York. EML provides radiological samples to be analyzed by FMPC laboratories and the results of these analyses are compared to the respective standards. If the analytical results from the two laboratories were to compare exactly, the ratio between results would be one. The average value of the ratio recorded in 1985 for the FMPC was 1.18 and indicates less than 20% variance which shows excellent agreement between the two analytical laboratories.

In cooperation with U. S. EPA, the FMPC laboratories participate in the NPDES laboratory performance evaluation program. Samples containing constituents regulated under the NPDES permit for the FMPC are submitted for analysis and checked with the standard results. The overall 1985 values determined by the FMPC laboratories were closely related to the U.S. EPA standards.

DATA ANALYSIS

The results of the extensive FMPC environmental monitoring program are presented in this document. Sampling the air, water, vegetation, soil and other media requires careful planning and design. When a sample is taken from a population within the environment, it exhibits a natural variation from all other samples collected. While samples vary, most samples will have only slight differences in one another and they cluster around the "most probable" value. This is considered to be a normal distribution.

Samples may not be distributed normally. This is no cause for concern because adjustments in the mathematical analysis can allow for the use of the techniques designed for normal populations. If, for example, something were to continually double its size during its period of growth, one could account for this excessive growth and apply the assumptions of normal growth. Some sampling programs are recognized to produce non-normally distributed samples (fish sampling and radiological air monitoring, for instance). This was accounted for in the data analysis.

The actual evaluation of data involves taking the variation of the results from one sample and indirectly comparing this variation to standard population distributions. The comparison is adjusted by the number of samples that were collected and how demanding a test is required. The tests can compare averages to see if they are different from one another, and establish limits around the most probable calculated value. All information gathered for this report was treated in this manner, and all tests were designed to be 95% certain of the results obtained in each respective test.

SAMPLE COLLECTION AND ANALYSIS

Air

Radiological Parameters

The conversion of impure uranium compounds to reactor-grade feed materials can generate radioactive particulates in the air. Ventilation and air cleaning systems are used to reduce the exposure of the employees to these particles and to reduce the emission of the particles to the atmosphere. As part of the reclamation program at the FMPC, the more valuable of these materials are returned to the production process.

Before release to the atmosphere, the air is filtered or scrubbed. A total of 75 kg (0.051 Ci) of uranium was emitted into the atmosphere during 1985. This is an 80% decrease from the 376 kg of uranium emitted in 1984.

Seven high volume air samplers (Figure 2) are located along the FMPC boundary to collect continuous samples of airborne particules. Samples are collected and analyzed at weekly intervals. At each sampler, air was drawn through a 20 cm by 25 cm filter at a rate of approximately 1 m^3/min. Filters used during the week were accurately weighed before installation and after collection to obtain the weight of the particulate matter collected. The filter was then dissolved in acid and the solutions were analyzed for uranium content and beta activity. Analysis for uranium and beta activity were done nine days after collection. A portion of each of these solutions was retained to provide a long-term composite, which was used to detect the presence of trace radionuclides (e.g., ^{237}Np, ^{239}Pu, and ^{232}Th). More frequent analyses for these other radionuclides were not considered necessary since analysis of the sample solution showed there were extremely small amounts of these elements present on-site.

Average particulate and uranium concentrations, and beta activity from the various radionuclides present in the air samples are shown in Table 1. Comparisons were made between 1984 and 1985 data. Concentrations of uranium measured at the boundary air stations in 1985 were 45% to 71% lower than concentrations measured in 1984. Beta activity was 31% to 61% lower at all

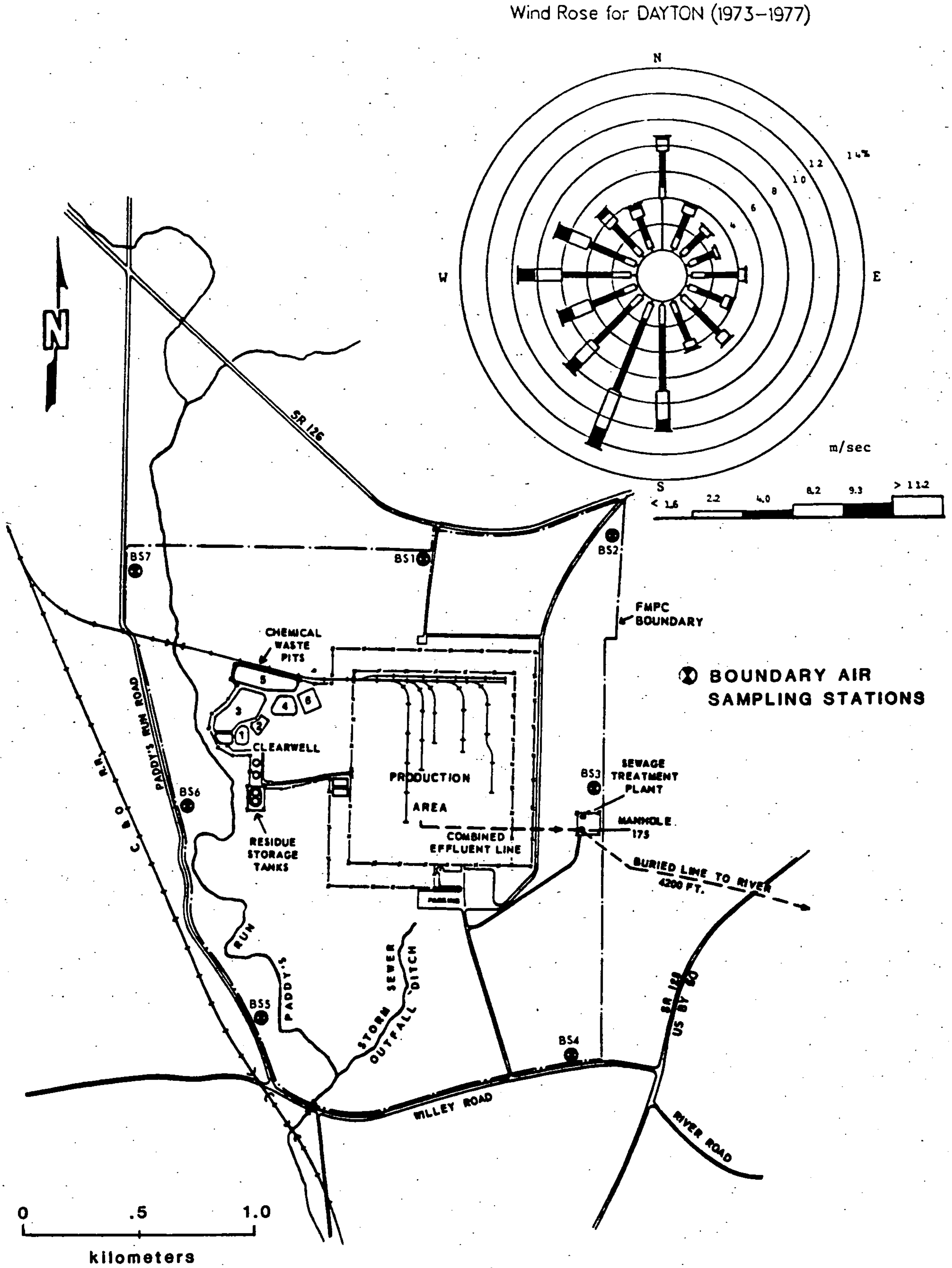

FIGURE 2 FMPC SITE MAP AND BOUNDARY AIR STATION LOCATIONS

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boundary air stations in 1985 than in 1984. Data regarding the airborne trace radionuclides encountered on site are presented in Table 2. The radionuclides ^{137}Cs, ^{226}Ra, ^{228}Ra, ^{106}Ru, ^{90}Sr and ^{99}Tc were analyzed in 1985 for the first time. Levels of trace radionuclides were generally lower than those measured in 1984 (see Figure 3).

Radon (^{222}Rn) is a naturally occurring isotope which is produced from the decay of radium (^{226}Ra), also a natural isotope found in soils and rock. As in 1984, concentrations of ^{222}Rn were monitored at 7 on-site and 2 off-site monitoring stations using commercially available instruments. The overall average for ^{222}Rn measured at boundary stations in 1985 was slightly less than the overall average ^{222}Rn measured in 1984 (Table 3). Typical background levels of ^{222}Rn are measured annually at OS1 and OS2, which are located 5 and 3 kms from the FMPC, respectively. In 1985, the average concentration of ^{222}Rn measured at these background stations ranged from 0.4 to 0.6 pCi per liter of air.

Nonradiological Parameters

Analysis of particle concentrations from boundary air station filters (Table 1) showed a reduction from 1984 values for boundary stations 1, 2, 3, 4, and 7. The highest concentration of particles was found at BS4. Overall reductions in particle concentrations may account for decreases in uranium and beta particles, since these may be borne on the surfaces of larger particles.

The steam generation plant at the FMPC utilizes two boilers with a total design capacity of 150,000 pounds of steam per hour. Electrostatic devices keep particulate discharges below the Ohio EPA particulate limit of 0.19 pounds per million British thermal units (BTU) input. Stack testing, as required by the Ohio Administrative Code (OAC), was performed during 1985 at the Boiler Plant in

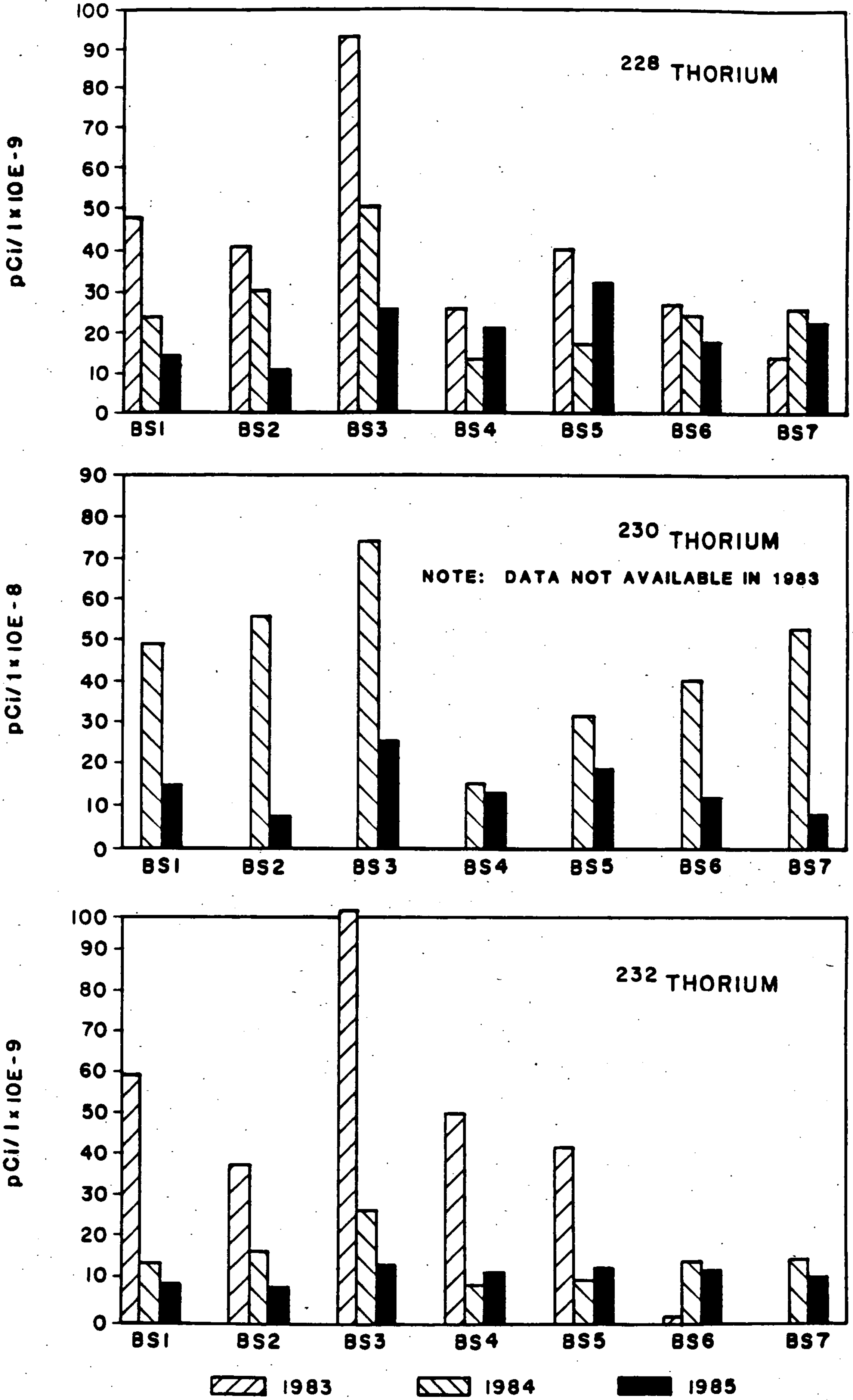


FIGURE 3 A COMPARISON OF NON-URANIC RADIONUCLIDE CONCENTRATIONS IN AIR 1983-1985

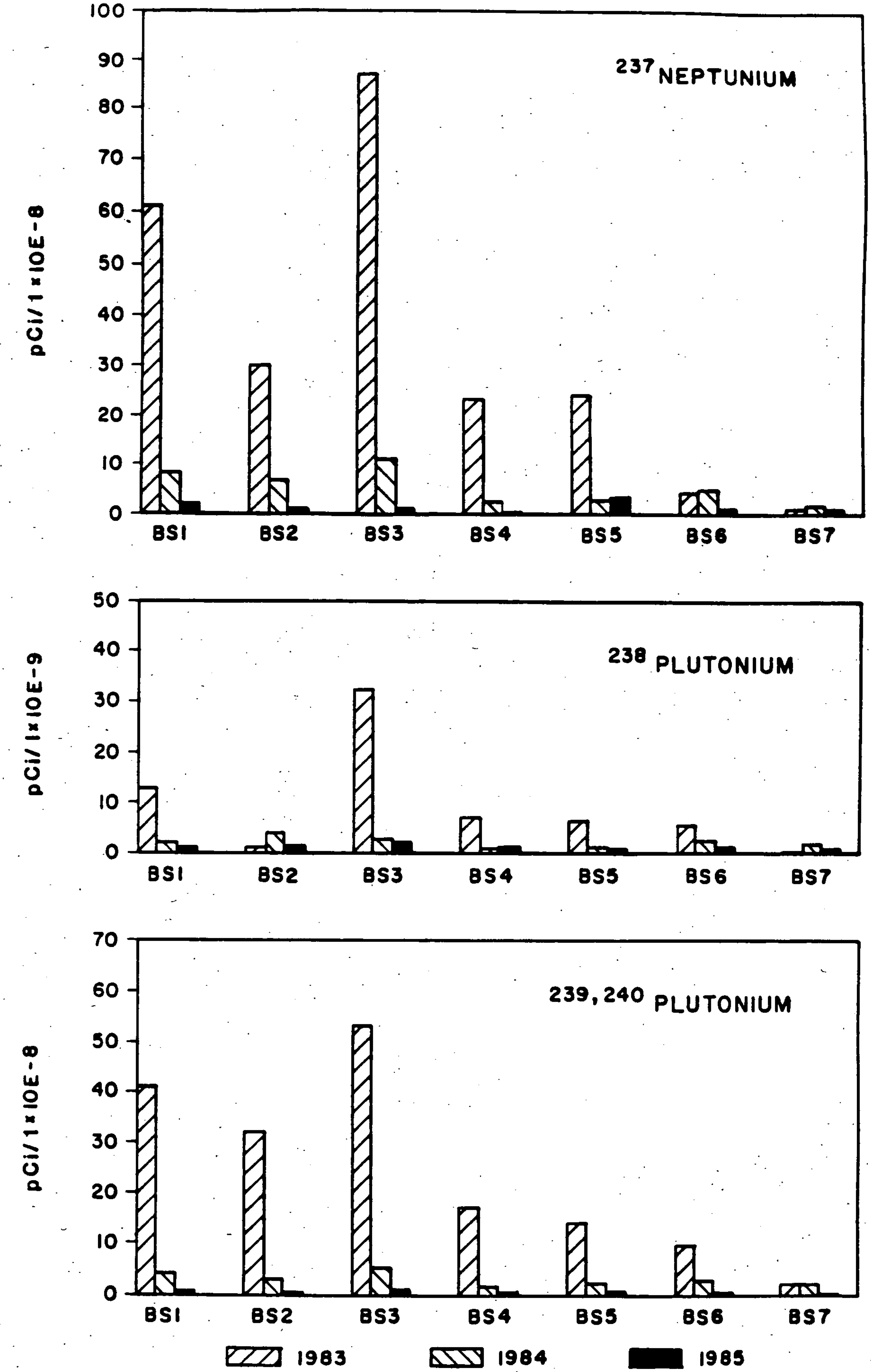


FIGURE 3 A COMPARISON OF NON-URANIC RADIONUCLIDE CONCENTRATIONS IN AIR 1983-1985

cooperation with the Southwestern Ohio Air Pollution Control Agency (SWOAPCA). The results of the stack testing indicated the average emission of the steam plant to be 0.040 pounds per million BTU, based on three runs using EPA Reference Methods 1-5. As a result of this testing, air emission source permits to operate were renewed for Boilers No. 1 and 3 on June 7, 1985. Expiration date for these permits is June of 1988.

Sulfur dioxide (SO_2) emission limits for stationary facilities have been adopted by the OEPA. Under these rules, the limit for the FMPC steam plant is less than 1 kg (2.2 pounds) of SO_2 per million BTU input from each boiler. This limit is equivalent to the use of coal containing 1.3 percent sulfur. Coal containing only one percent or less sulfur is purchased and utilized at the boiler plant in order to meet the SO_2 emission requirement.

The State of Ohio currently has no emission limit for NO_x for sources in existance prior to January 1, 1974. The FMPC, in keeping within its commitment to worker protection and environmental improvement, maintains NO_x emissions at levels as low as practicably achievable. The major sources of potential NO_x emission at the FMPC are ventilated to a bubble cap tower for scrubbing prior to release to the atmosphere. Emissions from this tower are limited to 100 parts per million NO_x as indicated in an FMPC standard operating procedure. Other smaller sources of potential NO_x emissions do exist at the FMPC which are not ventilated through scrubber systems. Emissions from these facilities are kept as low as achievable through administrative controls. Engineering efforts are underway to examine the application of control systems to reduce emissions from these facilities.

Maximum permissible levels of particulate emissions from industrial processes are established under Section 3745-17-11 of the OAC. These limitations are based upon each individual process and its emission sources at maximum operating conditions. Emission stack testing conducted in 1985 by Northern Kentucky Environmental Services indicated removal efficiencies above 99 percent for 14 out of the 15 collectors tested. Through the use of highly efficient environmental control systems and tight administrative controls, particulate emissions from industrial process sources are minimized. All industrial sources of particulate emissions are well within the established guidelines.

The FMPC solid waste incinerator is used for the destruction of combustible material such as wood, and discarded paper. This material is surveyed for radioactivity in order to eliminate potentially contaminated items from the waste stream prior to burning. The incinerator was specified to meet state emission standards of one gram particulate matter per kilogram of solid refuse charged. Compliance testing, as required by OAC, was completed during 1985 by Northern Kentucky Environmental Services and a permit to operate the solid waste incinerator was issued on August 18, 1985 with expiration three years later. The compliance testing determined the average emissions for the incinerator to be 0.0985 pounds per 100 pound charge, based on three runs using EPA Reference Methods 1-5. A liquid waste incinerator has been constructed for the disposal of non-hazardous waste oils. Stack emissions from this incinerator are minimized by a baghouse collector.

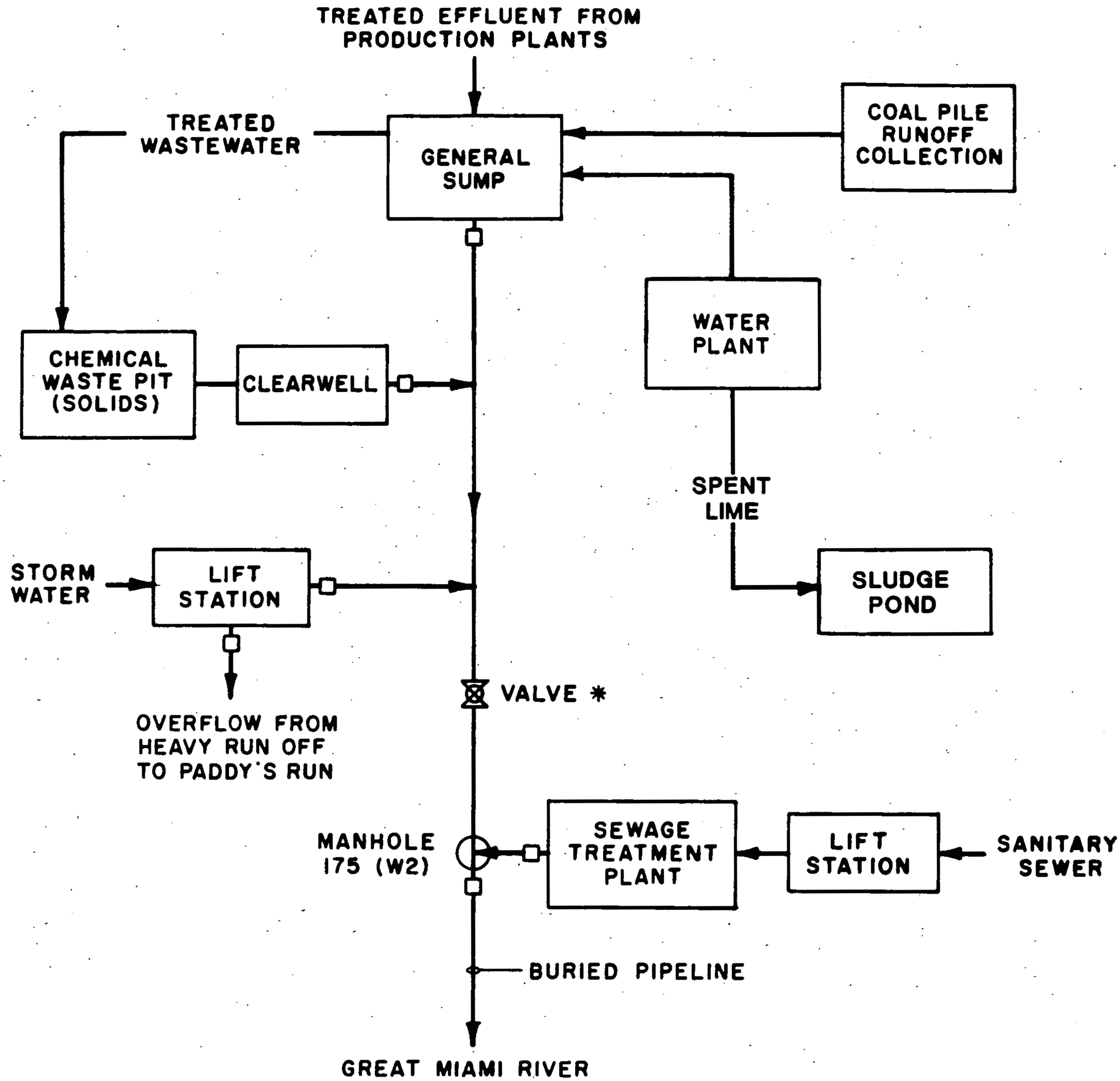
Surface Water

Radiological Parameters

Each of the major production plants at the FMPC has the capability to collect and pretreat process wastewater. Uranium is collected for recycling as part of these pretreatment systems. Effluent from each plant sump system is collected at a centralized facility, the General Sump, for additional treatment. Treated wastewater is allowed to settle and clear prior to being routed to a lagoon and clearwell system for further solids removal. Effluent from the Clearwell and non-contaminated supernatant from the General Sump are combined with sewage treatment effluent and a portion of stormwater runoff prior to discharge to the Great Miami River. Excessive stormwater runoff from the site overflows at the Storm Sewer Lift Station to an outfall ditch which drains to Paddy's Run (see Figures 2 and 4). Paddy's Run is a small intermittent stream lying along the west site boundary and joins the Great Miami River approximately 3 km south of the FMPC.

Surface water sampling locations are shown in Figures 4 and 5. At the final access point (W2) prior to discharge to the Great Miami River, samples are continuously collected in proportion to the total flow. Samples (24-hour composites) were collected daily and analyzed for uranium content and radioactivity due to alpha and beta particles. One-month composites of the daily samples were analyzed for ^{226}Ra, ^{228}Ra, ^{106}Ru, and ^{232}Th. Two semi-annual composites were analyzed for other radionuclides.

At sampling location W2, the total amount of radioactivity for the isotopes listed in Table 4 was less in 1985 than in 1984 except for ^{232}Th. This value is expressed as a "less than" total for 1985; therefore, a comparison of ^{232}Th between the two years is difficult. Reductions of at least one order of magnitude in ^{137}Cs, ^{238}Pu, ^{90}Sr, ^{235}U, and ^{236}U were evident in the 1985 total values. Additionally, a two-fold reduction of ^{99}Tc was measured at the W2 sampling location and may be due, in part, to decreased refinery operations in 1985. The average concentrations for 1985 were compared to Federal guidelines for uncontrolled areas. Table 4 indicates the highest "percent of guideline" for any of the radionuclides in 1985 to be that of total uranium (55.1%). Daily



* STORM SEWER WATER CAN BE DIVERTED TO THE CHEMICAL WASTE PIT OR THE GENERAL SUMP.

□ NPDES SAMPLING LOCATIONS

FIGURE 4 LIQUID WASTE STREAM FLOW DIAGRAM

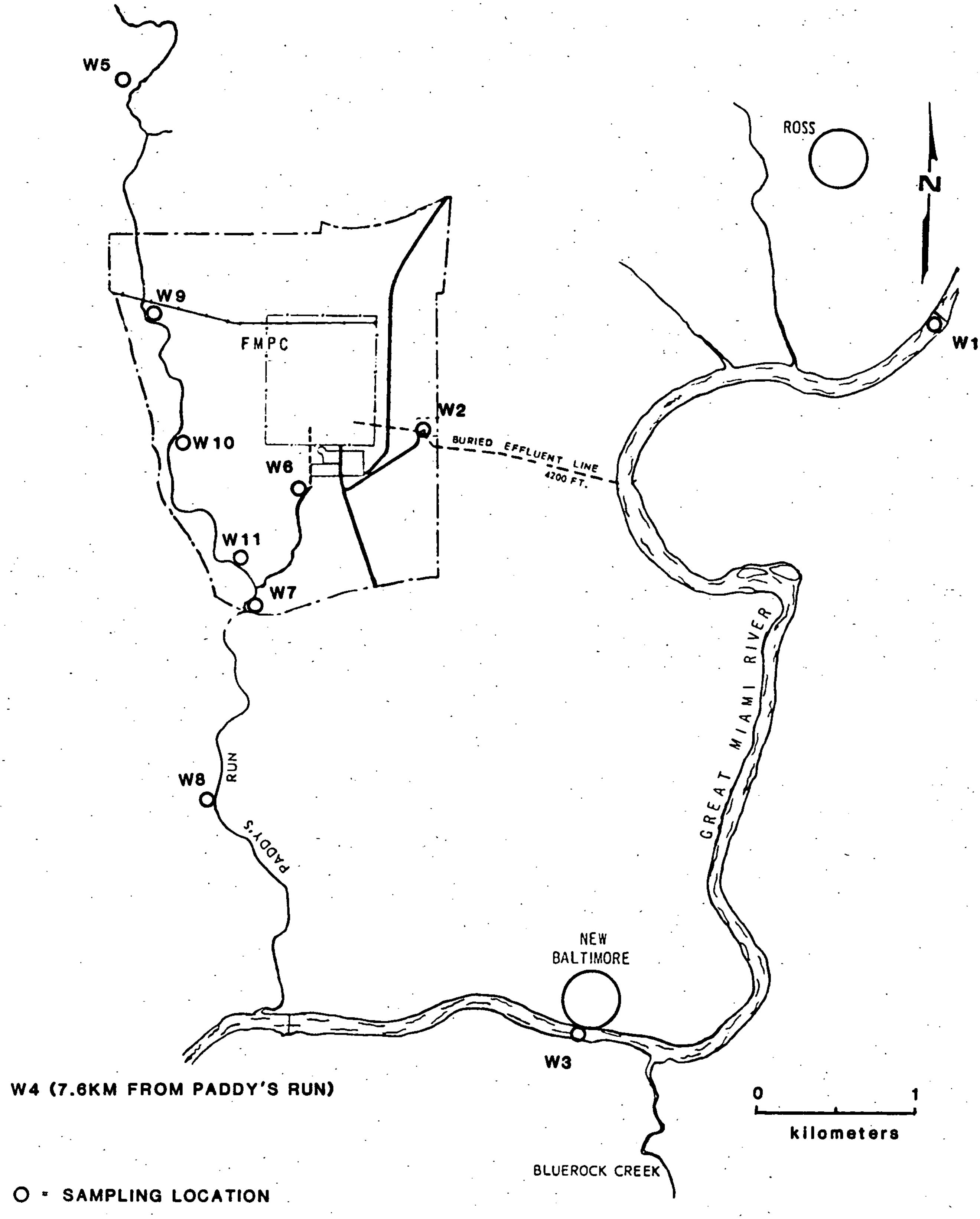


FIGURE 5 SURFACE WATER SAMPLING LOCATIONS

grab samples were collected at river sampling points W1 (upstream) and W3 (downstream) as shown in Figure 5. These samples were composited for monthly determinations of ^{226}Ra and ^{228}Ra content. A weekly grab sample was collected at point W4 which is approximately 7.5 km downstream of the confluence of Paddy's Run with the Great Miami River. At least one sample per week from each of the three river locations was analyzed for uranium concentration and radioactivity due to alpha and beta particles. Grab samples were collected weekly from sampling points W5 and W7 (or W8) on Paddy's Run for the entire year. Due to the intermittent nature of Paddy's Run, samples were collected at either points W7 or W8, depending on the the amount of water present at these locations. Sampling points W9, W10, and W11 were incorporated into the surface water sampling program for Paddy's Run in late 1985. These points are located between W5 and W7 (Figure 5). Weekly samples were analyzed for uranium content and radioactivity from alpha and beta particles. ^{226}Ra and ^{228}Ra analyses were performed on bimonthly composites of water collected at W5 and, when available, on monthly composites from W7. Table 5 summarizes these results.

The majority of the radionuclide results for the surface water samples collected from the various sampling locations on the Great Miami River and Paddy's Run were relatively unchanged from 1984 to 1985. Two differences in the 1985 data were noted involving the ^{99}Tc concentrations at river locations W1, W3, and W4 and the uranium content and activities due to alpha and beta particles at W7 on Paddy's Run. Concentrations of ^{99}Tc decreased as much as 79% at the river locations downstream of the FMPC outfall which, as previously mentioned, is probably due to reduced refinery operations. Gross alpha activity and uranium content at sampling point W7 on Paddy's Run for 1985 showed at least a two-fold increase over the 1984 values, and gross beta activity was increased approximately 35%. Since the total amount of uranium (2.6×10^{-2} Curies) discharged via the Storm Sewer Outfall Ditch to Paddy's Run in 1985 was less than in 1984, additional source(s) contributing to the higher uranium concentrations measured at sampling point W7 are implied.

A portion of stormwater runoff emanating from the Waste Storage Area is discharged directly to Paddy's Run at points approximately 0.9 to 1.5 km above the confluence of the Storm Sewer Outfall Ditch with Paddy's Run. This runoff water has been identified to contain above background concentrations of uranium[5], and therefore, may possibly be contributing to the higher W7 value for 1985 regardless of the uranium discharged via the storm sewer system. Points W9, W10, and W11 were added to the surface water sampling program for Paddy's Run in 1985, showing averages for total uranium concentration of 23.33, 235.51, and 9.82 pCi/l, respectively. Water collected from the W7 sampling location had an average uranium of content 43.37 pCi/l for 1985. In addition, sediments sampled at locations 16 (in the Storm Sewer Outfall Ditch) and 17 (in Paddy's Run), as shown in Figure 10, measured the highest total uranium concentration in sediment samples collected in 1985, 33.5 and 46.2 pCi/g, respectively. During periods of increased erosion from heavy runoff, re-suspension of sediments such as these may have also contributed to the higher uranium content in surface water sampled at the W7 location in 1985.

Non-Radiological Parameters

In 1985, the FMPC discharged an average of 0.45 million gallons of water per day to the Great Miami River (as measured at sampling point W2). An additional 0.18 million gallons of runoff water during each storm event was discharged to Paddy's Run via the Storm Sewer Outfall Ditch in 1985. Both of these discharge points, as well as four other on-site locations, are defined and regulated by a National Pollutant Discharge Elimination System (NPDES) permit. This permit, issued by Region V of the U.S. EPA, is administered by the Ohio EPA and requires the FMPC to characterize effluent streams by analyzing samples collected at the locations shown in Figure 4. Schedules for sampling are specified in the permit and results were reported to the U.S. EPA on a quarterly basis and to the Ohio EPA on a monthly basis in 1985. A renewal NPDES Permit Application for the FMPC was filed with Ohio EPA in 1984.

Through an extensive NPDES surveillance and monitoring program of liquid effluents at the FMPC, it was determined that the facility exceeded the NPDES daily maximum or monthly average permit limits less than 2 percent of the time in 1985. This program entailed the collection of over 1700 samples. Results of the NPDES analyses on these samples are shown in Table 6.

Approximately a third of the noncompliances involved hexavalent chromium in samples collected from the Combined General Sump and Clearwell location. Another third of the values which exceeded the NPDES limits for iron, copper, and total suspended solids (TSS) also occurred at the Sump/Clearwell location. All of these noncompliances occurred at times of increased precipitation and Clearwell pumping. Effluent from the Sewage Treatment Plant exceeded the loading limits for either BOD_5 or TSS only five times in 1985, even though concentrations were below the required limits. The remaining four noncompliances involved TSS and oil & grease at the two discharge locations. These measurements occurred during periods of heavy stormwater runoff or snowmelt and may be associated with increased sitewide construction activities. The completion of the Stormwater Retention Basin and Biodenitrification Facility scheduled for 1986 should significantly reduce the number of NPDES noncompliances.

Weekly samples collected from points W1, W3, and W4 on the Great Miami River were analyzed for fluorides, chlorides, nitrates, and pH (Table 7). No statistical differences for these parameters were found between the 1984 and 1985 overall average values. Samples collected at Paddy's Run locations W5, W7, and W8 were analyzed monthly for the fluorides, chlorides, nitrates, and pH and also showed no statistical differences in the 1984 and 1985 overall averages. Samples analyzed from points W9, W10, and W11 which were added to the program in late 1985 indicated general consistency with results from the other Paddy's Run locations.

The current Water Pollution Control Project at the FMPC is designed to improve the quality of liquid effluent and consists of four subprojects: Biodenitrification System, Stormwater Retention Basin, Coal Pile Runoff Collection System, and Ultraviolet Disinfection of Sewage Effluent. The Biodenitrification project is designed to lower nitrate loadings discharge to the Great Miami River and is scheduled for completion in 1986. In order to substantially decrease stormwater discharges to Paddy's Run, the Stormwater Retention project will be completed in 1986. The Coal Pile Runoff and Ultraviolet Disinfection projects are currently operational. The Coal Pile project provides for the collection and transport of runoff from the coal storage area for treatment and the Ultraviolet Disinfection project involves the replacement of chlorine as the disinfectant at the Sewage Treatment Plant.

Groundwater

<u>Radiological Parameters</u>

Water samples were collected quarterly from each of the 13 on-site wells and monthly from the 25 off-site wells during 1985. The location of these wells are shown in Figures 6 and 7. Quarterly samples from the on-site wells were analyzed for the concentration of uranium and the radioactivity due to alpha

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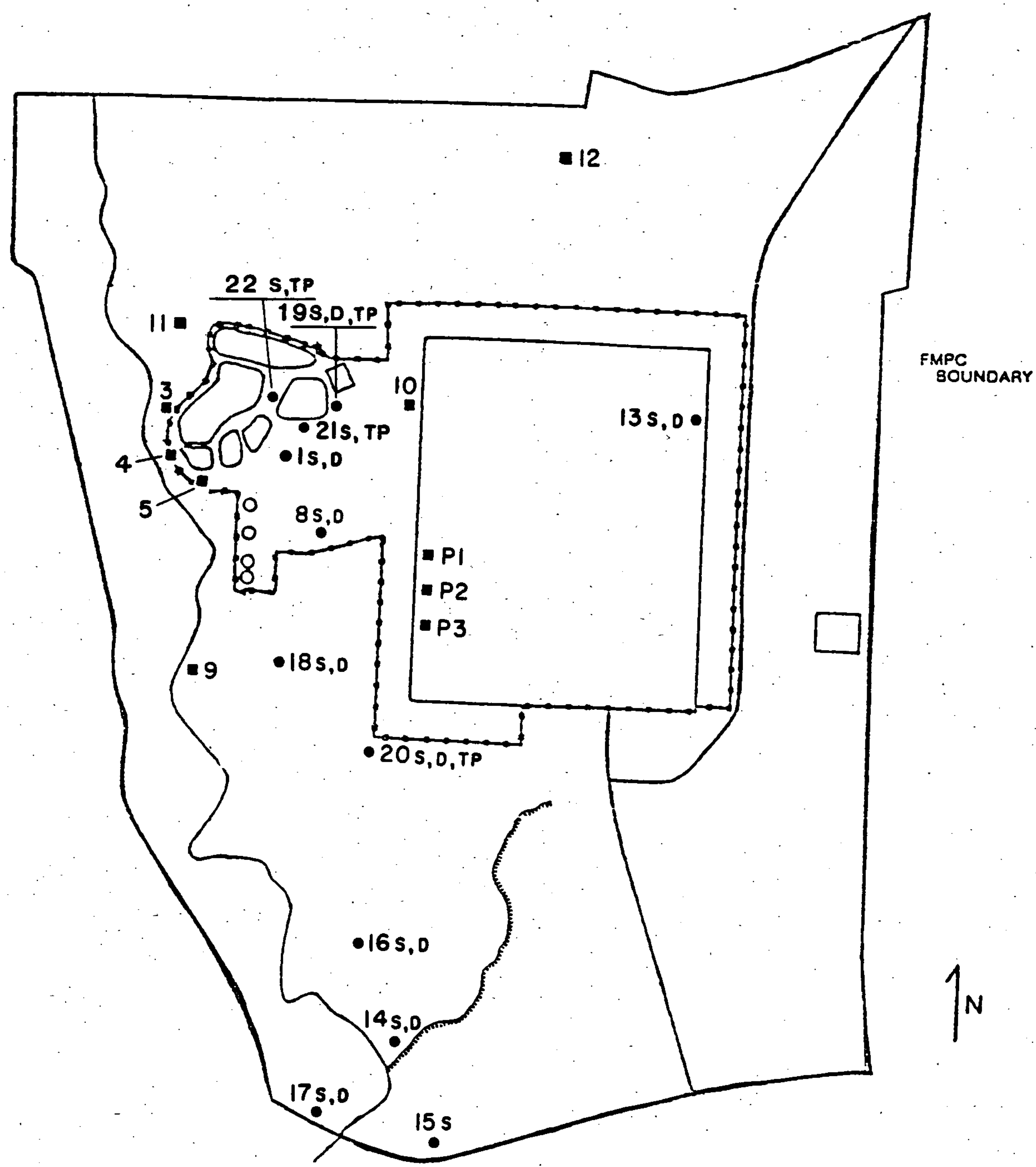

■ - SINGLE WELL LOCATIONS

● - CLUSTER WELL LOCATIONS
(S-shallow)
(D-deep)
(TP-test pit)

FIGURE 6 FMPC ON-SITE PRODUCTION AND TEST WELL LOCATIONS

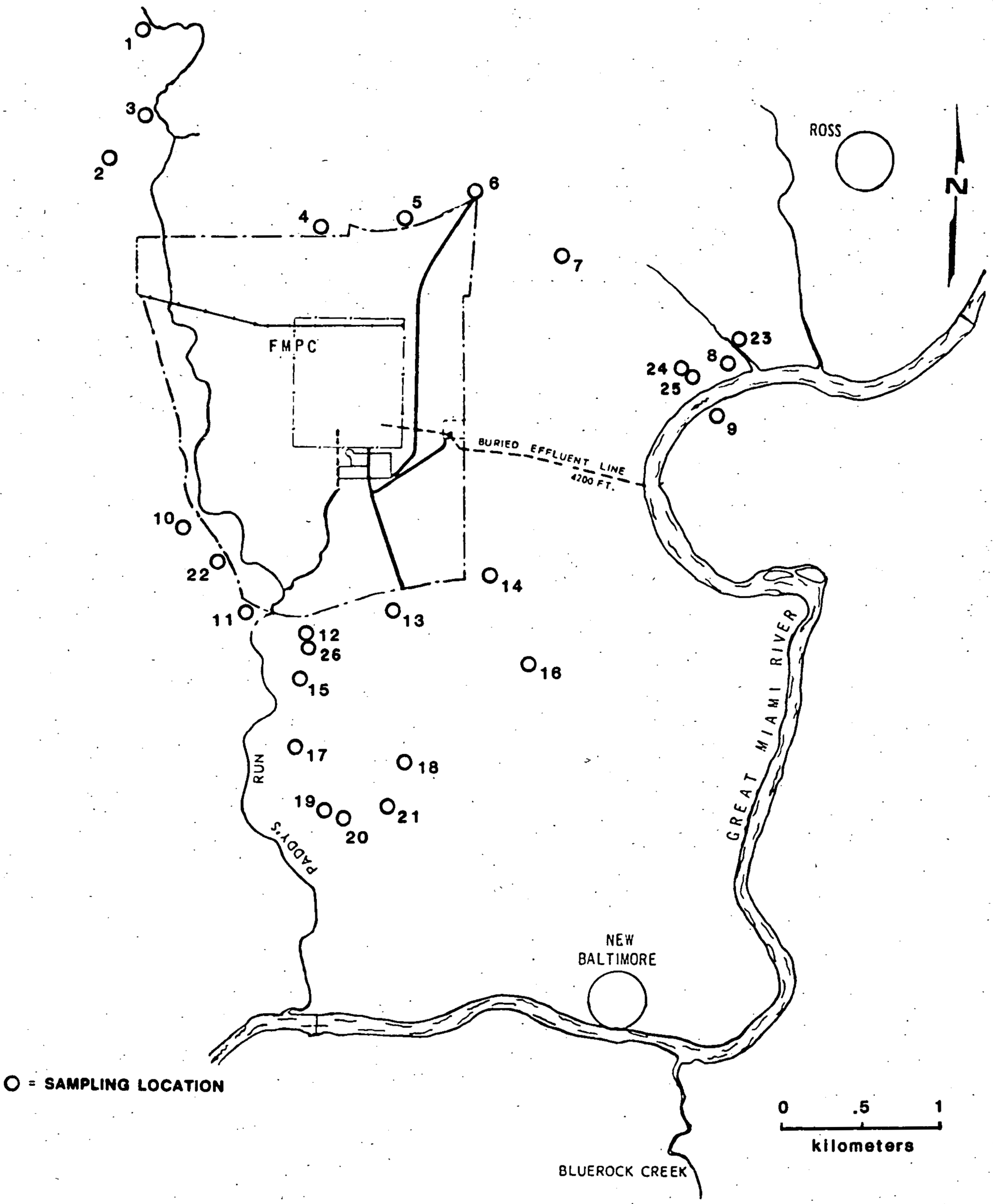

FIGURE 7 OFF-SITE MONITORING WELL LOCATIONS

and beta particles, (Tables 8, 9 and 10). Monthly samples from the off-site wells were analyzed for uranium content (Table 11).

In general, results of the quarterly on-site groundwater sampling for 1985 showed no statistical differences from the 1984 overall average values for uranium content and alpha and beta radioactivity. The 1985 monthly off-site results for uranium content were very similiar to the 1984 values. As in past years, the average uranium concentrations in samples collected from all but three of the off-site wells were within the range of natural background for uranium content in groundwater. Estimates for background concentrations of uranium in local groundwater range from 0.068 to 1.83 pCi/l[5] and in most natural waters in the U.S. from 0.068 to 6.8 pCi/l[6]. Sources of the above background concentrations of uranium in the three off-site wells were identified by a Dames & Moore Groundwater Study for the FMPC[5] in 1985.

As part of the Dames & Moore Study, 22 on-site groundwater monitoring wells and one off-site groundwater monitoring/supply well were installed. In late 1985, these wells (along with the existing 13 on-site and five off-site wells) were sampled and analyzed for the 95 parameters (15 of which were radionuclides) indicated in Appendix II. This sampling was performed in accordance with guidelines and protocol set forth by U.S. EPA in the Resource Conservation and Recovery Act (RCRA). Results of "Round 1" for the quarterly RCRA groundwater sampling are provided in Appendix III. A summary report is prepared upon the evaluation of analytical data for each sampling round[7]; however, an accurate assessment of the overall groundwater quality cannot be determined until the conclusion of four RCRA sampling rounds.

Non-radiological Parameters

The quarterly on-site and monthly off-site groundwater samples were analyzed for nitrate content in 1985 (Table 12 and 14). The 1985 overall averages for nitrate concentrations in all of the on-site wells were less than 3 mg/l except for Well 10 which showed a three-fold increase above 1984 levels. Surface water runoff from a nearby waste storage area has been identified as a potential source for the elevated nitrate levels in Well 10[7]. Concentrations of nitrates in the monthly samples from off-site wells for 1985 were similar to the 1984 concentrations. The highest average nitrate concentration in off-site wells for 1985 was 9.54 mg/l in Well 5 which is located upgradient of the FMPC. Common nitrate concentrations in water range from 0.1 to 0.3 mg/l in rainwater to as much as 600 mg/l in groundwater from areas influenced by excessive applications of nitrate fertilizer or runoff from barnyards [8].

The quarterly on-site well samples were also analyzed for chlorides, sulfates, and pH in 1985 (Tables 12 and 13). Values for pH remained relatively unchanged over the past two years. The 1985 chloride and sulfate results correlated closely to those of 1984 with Well 10 exhibiting the highest average concentrations for both of these parameters.

Samples were collected from 22 of the off-site wells in January, 1985 and analyzed for barium content in order to determine any possible effects of the barium chloride processing/storage facilities at the FMPC on the local groundwater. Results of this sampling is provided in Appendix III. All of the measured values were within background concentrations for barium in U.S. drinking waters[9]. Results of the barium analyses for the RCRA Round 1 sampling of 41 on-site and off-site wells are also provided in Appendix III.

The quarterly RCRA groundwater sampling program incorporates the analysis of 85 parameters (Appendix II) which pertain to non-radiological compounds. These parameters were selected to more accurately assess the general water quality, drinking water suitability, and the potential presence of metals, organics, or other pollutants in the groundwater underlying the FMPC and vicinity. The results shown in Appendix III for the RCRA Round 1 sampling will be compared to additional results of quarterly sampling rounds which are scheduled for completion in 1986.

Soil

As part of the routine soil monitoring program, samples were collected from each of the 15 annual on-site and off-site locations (Figure 8). Other samples were collected at 21 locations which correspond to grass sampling sites (Figure 11). Each soil sample was made up of a composite of nine cores 2 cm in diameter and 5 cm deep, but exclusive of vegetation insofar as this was possible. The cores were taken from the top layer of the soil profile with one core being obtained from each coordinate of a 4 m^2 grid. Results for routinely monitored soils are shown in Table 15, and grass/soil samples results are shown in Table 19. Discussion of correlation between the activity of uranium in grass and soil follows the section on vegetation.

Soils were analyzed for uranium concentration only, since analyses for other radionuclides in 1984 revealed small or undetectable concentrations of those radionuclides. Samples collected at all but two locations showed uranium concentrations typical for southwestern Ohio soils. Uranium concentrations up to 7 pCi/g are typical in southwestern Ohio soils. Uranium concentrations in soil sampled in 1985 were lower than the average values for 1984; however, a strong correlation existed between the two years for samples collected at the same locations. The highest uranium concentrations in the soil were measured near the eastern boundary of the FMPC are probably artifacts of the former operation of an incinerator adjacent to the sewage treatment plant.

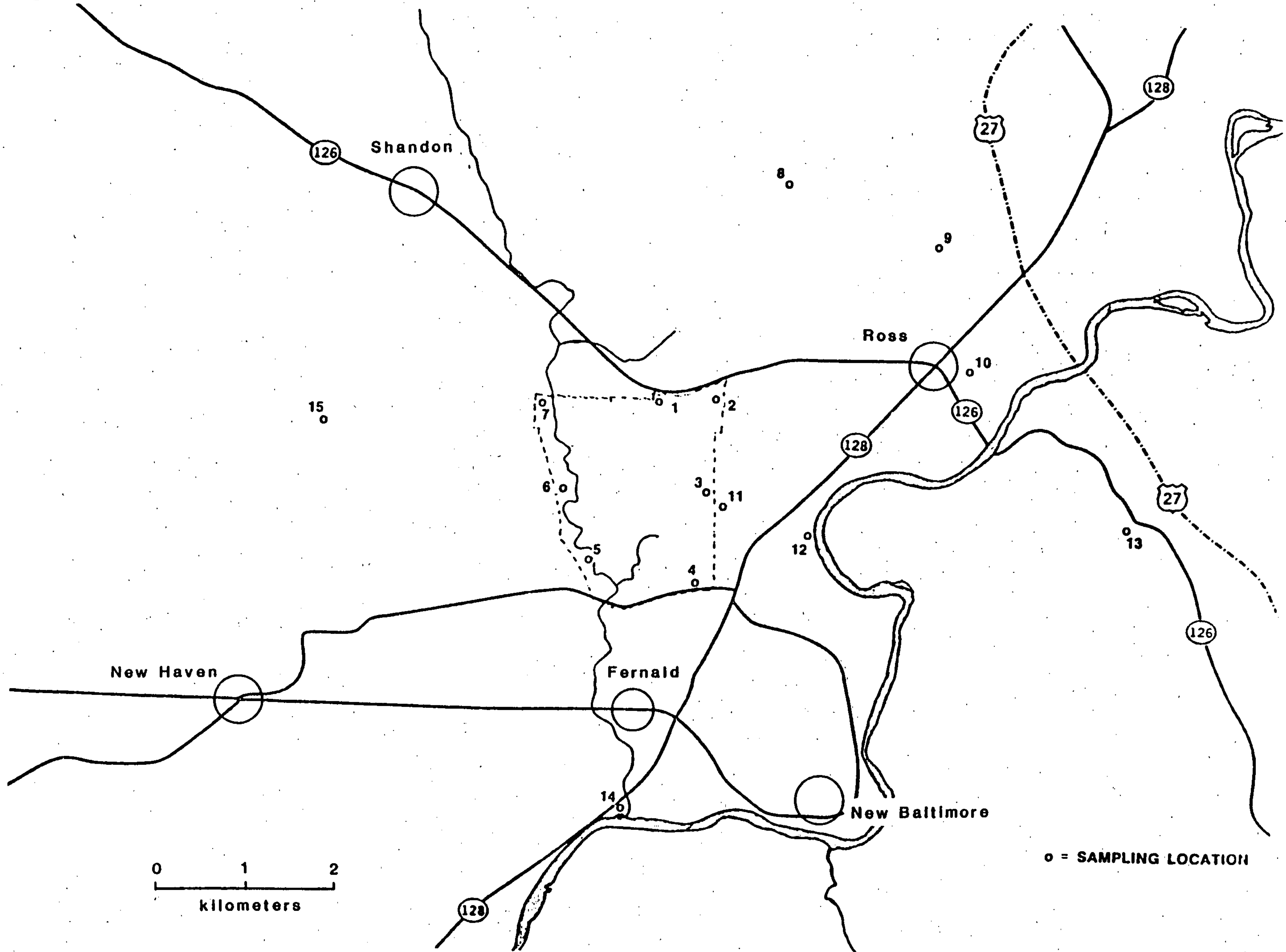

FIGURE 8 ROUTINE SOIL SAMPLING LOCATIONS

No standards have been established for radionuclide levels in soils other than guidelines relative to burial of radioactive contaminants. The FMPC presently uses 35 pCi/g (52 ppm) of uranium content in soil as a reference point, this being the level generally used in the DOE's remedial action programs for acceptance of decontaminated areas. All but two samples showed soil uranium concentrations that were below this guideline. Soil pathway analysis to determine site specific guidelines has been initiated for 1986.

Sediments

Sediment samples were collected from six locations off-site along the Great Miami River, and from twenty locations along Paddy's Run and the Storm Sewer Outfall Ditch (Figure 9). All sediments were analyzed for uranium, and selected samples were analyzed for ^{99}Tc.

Uranium concentrations in sediment samples collected along the Great Miami River (Table 16) are within the range of background commonly found in the area. There was no statistical difference between the average concentration of samples from upstream and downstream locations for riverbank and midstream sediments, nor was there any statistical difference between concentrations in sediments collected in 1984 and 1985. Riverbank sediments had slightly elevated uranium concentrations up to 3.3 km from the FMPC outfall. The highest ^{99}Tc concentration collected along the Great Miami River was found near the FMPC effluent outfall.

Uranium concentrations in sediment samples collected from on-site locations varied greatly from location to location and did not consistently decrease or increase in upstream or downstream directions (Table 17). Uranium concentrations in Paddy's Run sediments did not appear to follow concentration

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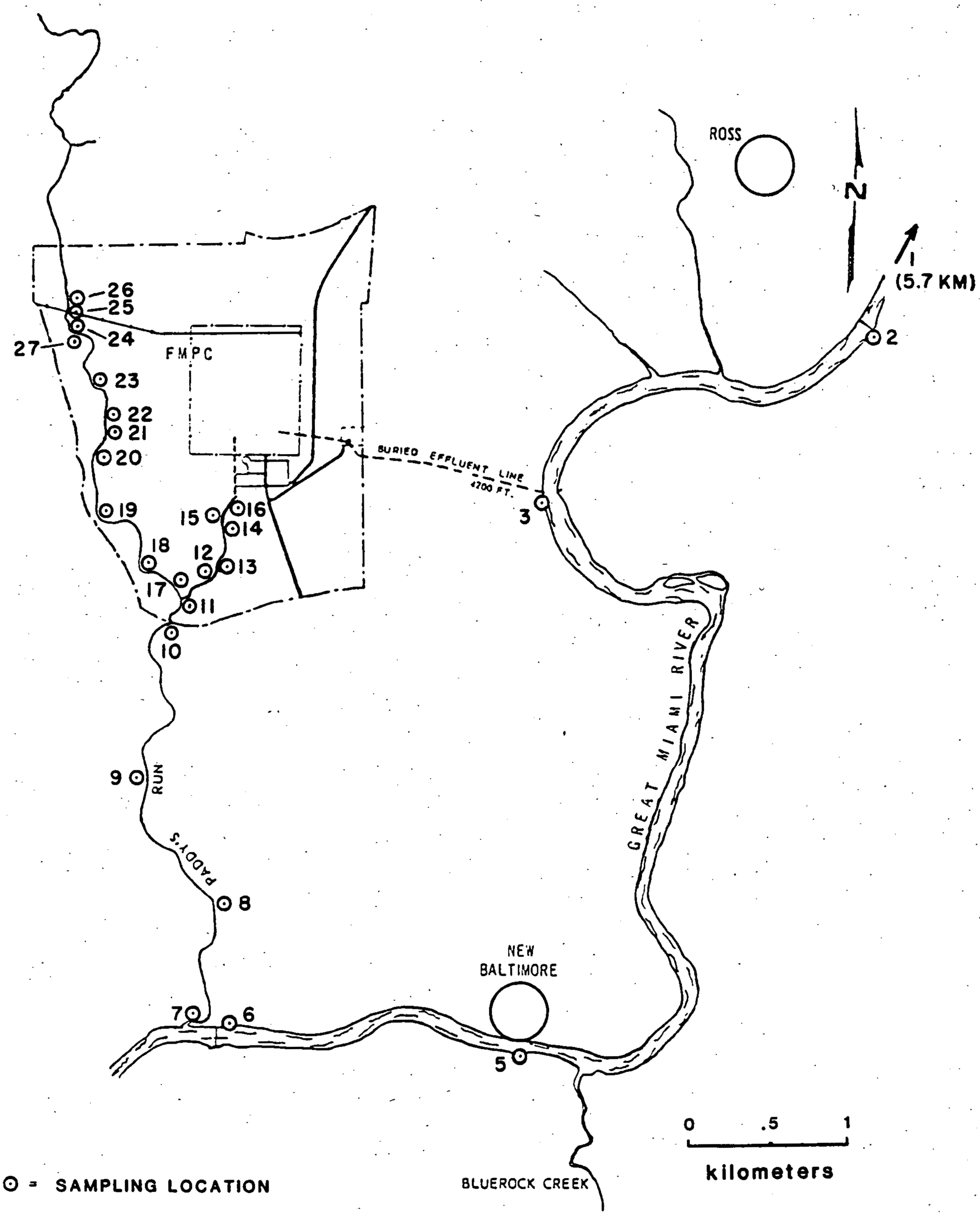

FIGURE 9 SEDIMENT SAMPLING LOCATIONS

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trends for uranium in surface water from Paddy's Run. The highest uranium and ^{99}Tc concentrations were found at the Storm Sewer Outfall, and in Paddy's Run near the confluence with the Storm Sewer Outfall Ditch. Variations from location to location are apparent and may be caused by flushing during heavy storm events.

BIOLOGICAL MONITORING

Vegetation

During 1985, samples of grass and other available forage were collected, along with parallel soil samples, from sites selected in 1984 (Figures 10 and 11). The majority of samples were collected to the northwest of the site which is in the direction of prevailing winds. Each vegetation sample was a composite of a number of subsamples in order to provide approximately 500g (wet weight) total. Each subsample consisted of all above ground plant material (material was clipped near gound level using battery powered grass shears) from a 0.5 m diameter circular quadrant (5 such subsamples = 1 m^2 of ground cover). Soil samples were collected in the same manner as they were for routine monitoring purposes. After collection, the vegetation samples were air dried before analysis for uranium and floride. Soils were analyzed for uranium content only.

The overall average uranium concentration of 0.52 pCi/g, detected in vegetation in 1985 was statistically lower than the average uranium concentration found in vegetation in 1984 (Table 18). There appeared to be a weak relationship between the uranium concentration in the vegetation at each sampling point and the distance from the FMPC. A strong relationship existed between uranium concentrations in soil samples and uranium concentrations in grass samples (Table 19). The overall average fluoride concentration of 5.5 ug/g detected in

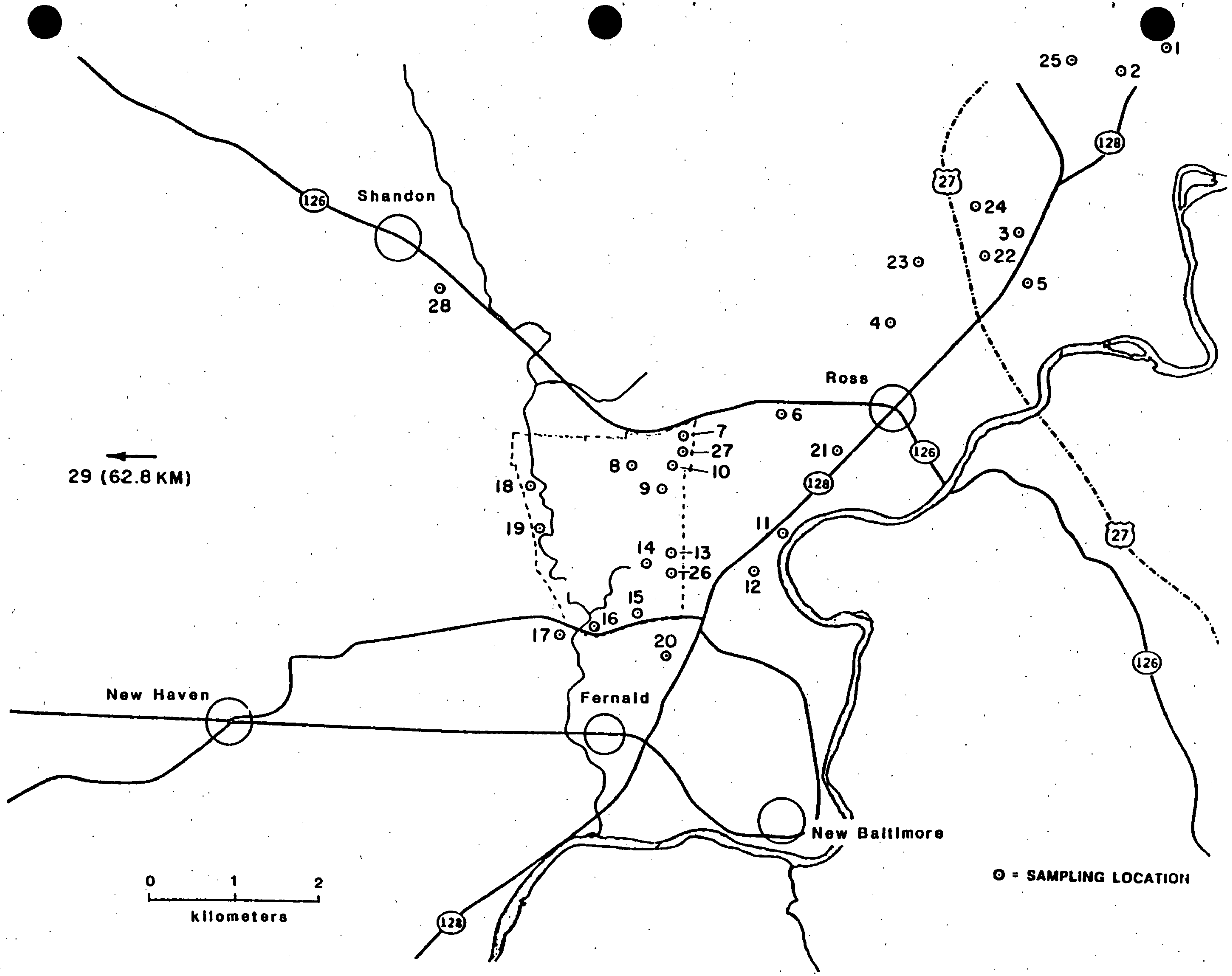

FIGURE 10 GRASS AND FORAGE SAMPLING LOCATIONS

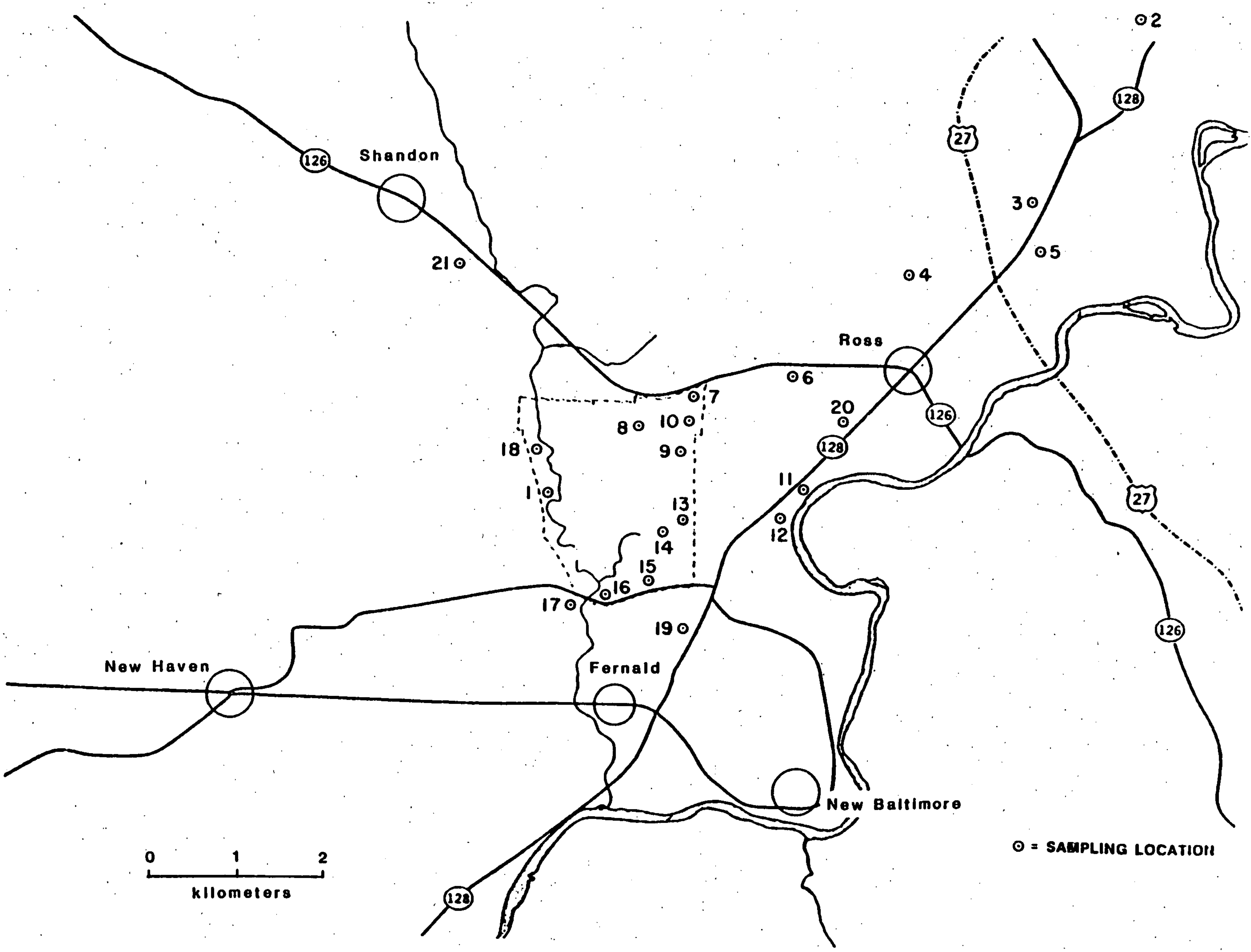

FIGURE 11 LOCATIONS OF PARALLEL SOIL AND GRASS SAMPLING

vegetation in 1985 was statistically lower than the average fluoride concentration found in vegetation in 1984 and fluoride measured at all location was only about 7% of the Kentucky standard of 80 ppm. There was no relationship between the observed fluoride concentration at each sampling point and the distance from the FMPC.

Garden Produce

Potatoes are the best locally available source for measuring the possible introduction of uranium into humans from the ingestion of food.[14] Six replicate samples of potatoes were collected from four farms and gardens in the vicinity of the FMPC (Figure 12). Twelve replicates samples were collected from locations in Indiana and were used as a comparison for background.

Peels from the potatoes sampled from location number 1 had statistically greater uranium concentrations than potatoes obtained from Indiana (Table 20). The overall average uranium concentration in peels collected in 1984 was statistically lower than for peels collected in 1985, probably inflated from the results from location number 1. Peels collected from all the other locations and flesh from potatoes sampled at all locations showed uranium concentrations to not be statistically different than the background concentrations. In addition, there was no statistical difference in the flesh of all the potatoes sampled in the past two years.

Milk

Milk produced by cows grazing on FMPC and adjacent pasture land was monitored three times in 1985. A similar sample was collected concurrently from a remote site 29-30 km southeast of the FMPC for comparison purposes. No detectable

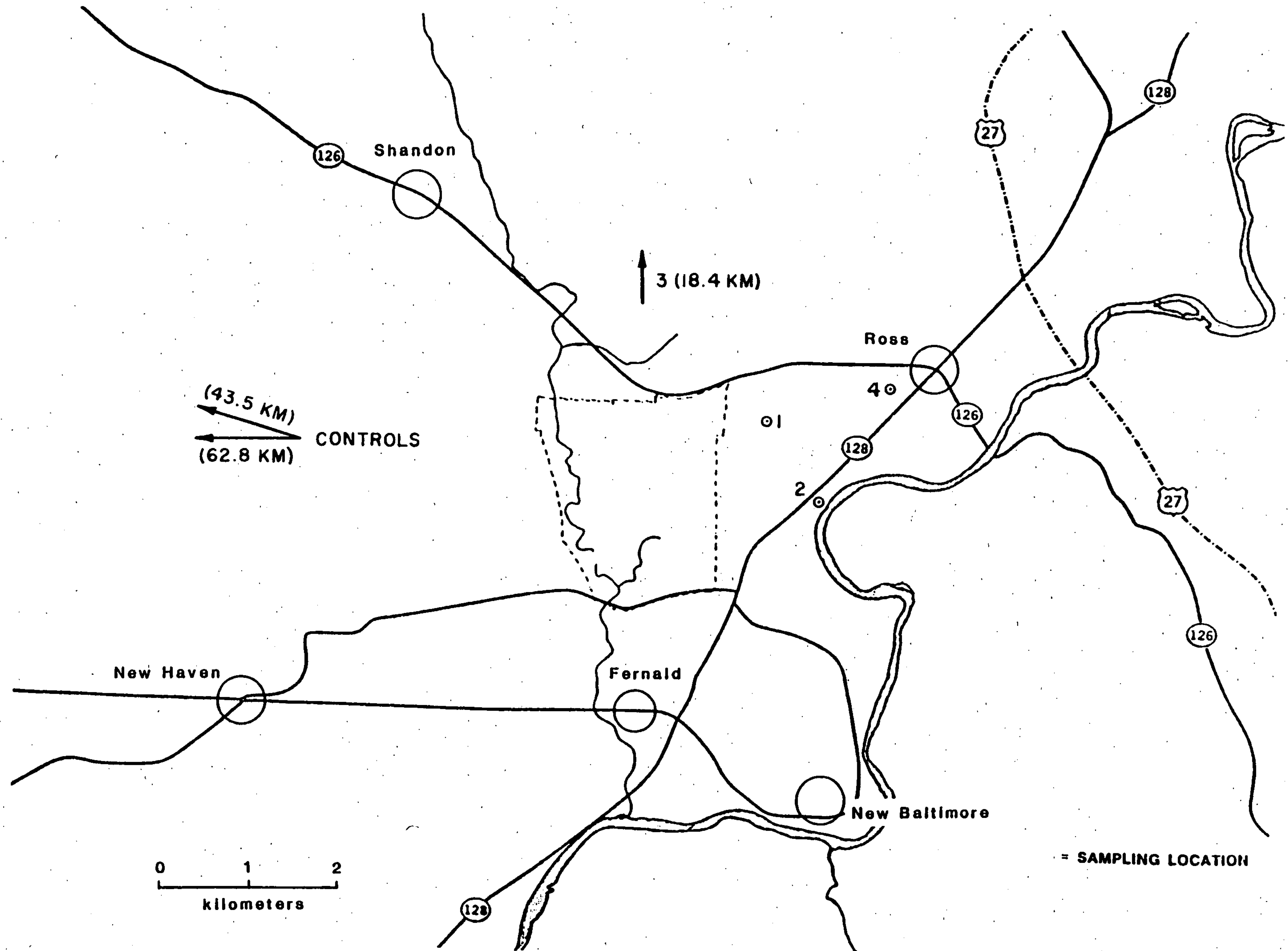

FIGURE 12 SAMPLING LOCATIONS FOR GARDEN PRODUCE

quantity of uranium was present in the samples from either of the two locations during 1985 (Table 21).

Fish

Fish were collected from three stretches of the Great Miami River (Figure 13) in September, 1985, with the aid of a fisheries research team and electroshocking equipment from the University of Cincinnati. A total of 252 fish representing 25 species were taken: 52 from sampling location 1, 41 from location 2, and 159 from location 3. The fish from each location were placed in plastic bags, packed in ice, and then scaled and prepared as for human consumption (heads and entrailes removed, and filleted if total weight was above 800-900 grams). The fillets were then frozen, packed in dry ice, and shipped to an independent testing lab for analysis.

The University of Cincinnati determined that species diversity was highest at the FMPC effluent outfall location. The length to weight ratios were similar at each location. These suggest that populations throughout the river were healthy.

The overall average uranium concentration in fish collected in 1985 was statistically lower than the overall average for fish collected in 1984. Average uranium concentrations in fish were slightly higher at the FMPC Outfall to the Great Miami River and were the lowest upstream (Table 22); however, the differences in uranium concentration between any of the locations or between species were not significantly different.

ESTIMATION OF RADIATION EXPOSURE

The Federal guideline for prolonged radiation exposure to the maximally exposed

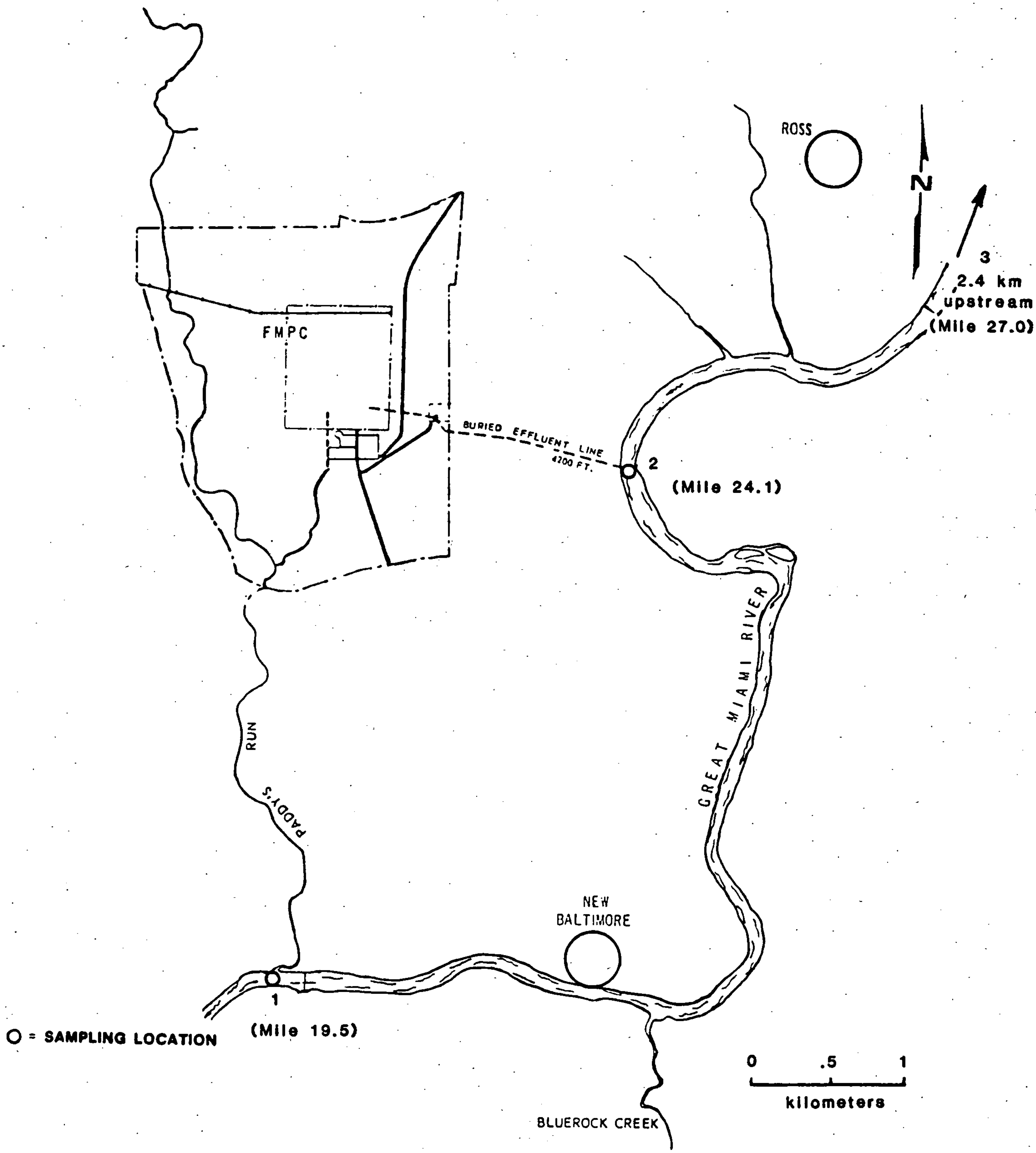

FIGURE 13 FISH SAMPLING LOCATIONS

individual is 0.1 rem but individual organs can receive up to 5 rem. For air pathway exposures, National Emission Standards for Hazardous Air Pollutants (NESHAP) sets standards at 0.025 rem for the individual, and 0.075 rem to any organ. It should be noted that the dose contribution of radon and its daughter products is not included in the NESHAP.

Some general concepts can be developed. The "whole body radiation exposure" from all radionuclide emissions at the FMPC is assumed to be from external exposure only (as opposed to ingestion and inhalation) and there would be no significant contributions from radionuclides that deposit throughout all the body. The "radiation exposure averaged over the whole body" is another concept that represents a weighted average of exposure to specific organs. This weighted average should actually represent the same risk of health effects as a whole body radiation exposure. These become the concepts on which to compute exposure with the AIRDOS/DARTAB program.

The AIRDOS-EPA and DARTAB computer programs were used by the Oak Ridge National Laboratory (ORNL) to estimate the radiation exposure an individual receives due to FMPC operations. These programs were used to compute the dispersion of airborne radionuclides, and then calculate the maximum potential radiation exposure to an individual and the total exposure to the human population within 80 km of the FMPC. The following data were used for the computer calculations:

- 0.051 Ci of airborne uranium emitted,
- a particle size of one micron,
- an average stack height of 16.15 m,
- meteorological data for 1985 from James Cox Airport in Dayton, Ohio,
- EPA approved radiation dose conversion factors based on recommendations by the International Commission on Radiation Protection (10),

- Uranium particle solubility of 60% W (moderately soluble) and 40% Y (chemically insoluble).

With this information, an estimate of how much radiation exposure an individual receives due to airborne emission of uranium, and subsequent inhalation, ingestion, and/or direct radiation exposures is computed. The EPA computer program also uses dose conversion factors that "weights" the organs of the human body, based upon the sensitivities of the organs to radiation. Instead of using just lung tissue, the computer program considers the pulmonary tissue (consisting of lung tissue and pulmonary lymph tissue) as the most critical organ.

Maximum Exposure to the Individual

Using the AIRDOS and DARTAB computer models for airborne emissions, the estimate of how much radiation dose the whole individual receives over a 50 year period to pulmonary tissue is estimated to be 0.0089 rem, and to the bone surface, 0.0003 rem. The weighted average estimate of how much radiation the individual received over 50 years was 0.0019 rem, and the external whole body dose received over 50 years was 2×10^{-7} rem. This is based on the uranium concentration at the point of maximum exposure to the nearest resident (1128 meters north of the FMPC). These calculated values are well within the 1985 guidelines. New administrative controls and new equipment to control stack emissions have helped insure full compliance with NESHAP during 1985.

External exposure from other radiation sources was measured at seven air monitoring stations on the FMPC boundary (Table 23). The maximum annual exposure was measured at BS6, which is the closest station to the waste materials stored in the K-65 silos on the western side of the FMPC. The resulting conservatively calculated annual dose to the nearest resident (if that resident stayed at home 100 percent of the time) was 0.018 rem last year. It should be noted that the background dose from natural sources measured at a residence located 3.7 km southwest of the FMPC was 0.078 rem per year.

The Great Miami River is not designated as a public water supply source by Ohio EPA. Calculations were made, however, to estimate how much radiation dose the whole individual receives over 50 years if a person drank water from the river at the FMPC effluent discharge. A daily intake of 1.2 liters [11] would result in a dose of 0.00004 rem to the bone surface and a weighted average dose estimate of 2×10^{-6} rem. The maximum dose from drinking river water would be less than 0.001 percent of the guidelines for radiation protection of the public in the vicinity of the FMPC.

Twenty-five off-site wells were sampled monthly to determine the average concentration of uranium in well water. Above background concentrations were measured in well numbers 12, 15, and 17 (Table 11). For the highest concentration, the potential radiation dose an individual could receive over 50 years due to ingestion of water from well number 15 was calculated. The potential dose due to drinking this water (Table 24) is then 0.022 rem for a weighted average (77.9% less than the guideline) and 0.33 rem to the bone surface (93.4% less than the guideline).

Locally grown produce and fish from the Great Miami River were analyzed for uranium content. As previously discussed, there was no statistical difference between average uranium concentrations in the fish collected upstream and those collected downstream of the FMPC. One locally collected potato sample had an average uranium concentration in the peels that was statistically greater than in potatoes obtained from Indiana and used as a background comparison. This increased uranium content was not statistically significant in the flesh of those potatoes. The weighted average estimate of how much radiation dose the individual receives over 50 years was calculated (based on an annual consumption of 62 pounds of potatoes per year) to be 6.6×10^{-9} rem, which is considered to be insignificant. Therefore, it is apparent that the consumption of these potatoes does not contribute any significant radiation dose due to FMPC operations.

Maximum Potential Exposure to a Population Group

The community of Ross, Ohio (population 3000) is located 4 km from the center of the FMPC. Because of the prevailing wind direction, airborne contaminants moving toward Ross would also be measured at boundary air monitoring station BS3. Therefore, BS3 data was used to calculate the maximum potential dose to a population group. The object was to calculate the hypothetical worst case with emission levels measured in 1985. The methodology of the calculations is described in DOE/TIC-11468[12]. The annual averages for radionuclides at BS3 were used to calculate the average emission rates from the FMPC, and subsequently the average concentration of radionuclides at the center of Ross. Based on these assumptions, the average concentration of uranium at Ross was estimated to be 7.9×10^{-7} pCi per liter of air.

Assuming an individual remained in Ross 100 percent of the time, the estimate of how much radiation dose the whole individual receives over 50 years was 0.0014 rem to the bone surface, 0.0033 rem pulmonary and 0.0005 rem weighted average dose.

80 km Population Exposure

The weighted average estimate of how much radiation dose the human population within 80 km of the FMPC (Table 25) receives over 50 years was calculated using AIRDOS/DARTAB. This dose due to 1985 airborne emissions is estimated to be 55 person-rem (Table 24). The external whole body dose received over 50 years for the population is 0.0017 person-rem due to 1985 airborne emissions. As a comparison, the annual external whole body dose due to natural radiation for the same population group was 275,000 person-rem, substantially higher than the FMPC airborne emission exposure.

SIGNIFICANT EVENTS

Several events relating to environmental issues at the FMPC occurred during 1985 in which the public was notified. A cooperative agreement was signed between U.S. Department of Energy (DOE) and the Ohio Department of Health (ODH) whereby ODH will assist in monitoring the environment surrounding the FMPC. The ODH monitoring will primarily consist of sampling and analyzing local water supplies within a 2-1/2 mile radius of the FMPC. An aerial radiation survey over a 25 square mile area surrounding the FMPC was also conducted in 1985 by EG&G, Inc., in order to determine the kinds and levels of radioactivity present, including naturally occurring background radiation.

A hydrogeological study for the FMPC and vicinity was completed in 1985 by Dames & Moore. This study identified the sources of uranium detected in three off-site wells and outlined appropriate remedial actions which are presently underway. A draft report was prepared by Camargo Associates, Ltd., in late 1985 which addressed the structural integrity of the K-65 storage silos at the FMPC.

Interim protective measures have been implemented to provide structural stability to the silos. Also in 1985, the FMPC became aware of the fact that a local industry, which uses groundwater previously identified as having elevated levels of uranium, produces a sludge as a by-product from its water treatment system. This system was then sampled by FMPC in order to determine the impact, if any, of using this water. Elevated levels of uranium were found in the sludge (100 to 500 parts per million, or ppm) from the filtering system used to treat the water before process use. The filtered water uranium content was within normal background levels (0.001 ppm).

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REFERENCES

(1) Code of Federal Regulations, Title 10, Part 20, Appendix B, "Concentrations in Air and Water Above Natural Background," Revised as of January 1, 1985.

(2) Code of Federal Regulations, Title 40, Parts 61.93 and 61.94, "National Emission Standards for Hazardous Air Pollutants," Vol. 50, No. 25, February, 1985.

(3) Ohio Environmental Protection Agency, "General Provisions on Air Pollution Control," Regulation No. 3745-15 (EP-10), Laws and Regulations, January, 1980.

(4) Ohio Environmental Protection Agency, "Water Quality Standards," Regulation No. 3745-1, Laws and Regulations, February, 1978.

(5) DOE/FMPC Groundwater Study Task C Report, Dames & Moore, White Plains, NY, July, 1985.

(6) Hem, John D., Study and Interpretation of the Chemical Characteristics of Natural Water, Geological Survey Water Supply Paper 1473, 1970.

(7) Results of Round 1 Groundwater Sampling - FMPC, Dames & Moore, Pearl River, NY, May 6, 1986.

(8) Davis, S. N. and R. J. M. DeWeist, Hydrogeology, John Wiley & Sons, New York, NY, 1966.

(9) American Public Health Association, Standard Methods For The Examination of Water and Wastewater, 16th Edition, 1985.

(10) International Commission on Radiological Protection, Annals of the ICRP, Recommendations of the International Commission on Radiological Protection, ICRP Publication Nos. 26/30, Pergamon Press, Oxford, NY, 1977.

(11) International Commission on Radiological Protection, Recommendations of the International Commission on Radiological Protection, ICRP Publication No. 2, Pergamon Press, Oxford, NY, 1959.

(12) Miller, Charles W. (ed.), Models and Parameters for Environmental Radiological Assessments, Oak Ridge National Laboratory, Report DOE/TIC-11468, 1984.

(13) Dunning, Donald E., "Estimates of Internal Dose Equivalent From Inhalation and Ingestion of Selected Radionuclides," Westinghouse Electric Corporation, Report WIPP-DOE-176, 1986.

(14) Tracy, B. L., F. A. Prantl, and J. M. Quinn, "Transfer of ^{226}Ra, ^{210}Pb and Uranium from Soil to Garden Produce: Assessment of Risk," Health Physics, Vol. 44 (1983), pp. 469-477.

APPENDIX I

TABLES

TABLE 1 Particulates, Uranium, and Gross β Activity in Air

Sampling Location (1)	Number of Samples	Particulates (ug/m³) (2)				Uranium (pCi/l × 10^{-5}) (2)				Beta Activity (pCi/l × 10^{-5}) (2)			
		Minimum	Maximum	Average	95% C.L. (3)	Minimum	Maximum	Average (3)	95% C.L. (3)	Minimum	Maximum	Average (3)	95% C.L. (3)
BS1	53	17	56	31.0	1.09	0.013	3.117	0.296 (1.09)	1.31	0.81	4.14	1.89 (6.99)	1.11
BS2	53	13	57	31.5	1.10	0.058	2.629	0.311 (1.15)	1.24	1.05	6.07	2.08 (7.69)	1.11
BS3	52	16	59	34.9	1.10	0.057	2.709	0.557 (2.06)	1.25	0.95	6.14	2.64 (9.76)	1.13
BS4	53	19	69	40.2	1.09	0.044	1.042	0.213 (0.79)	1.22	0.96	5.46	1.79 (6.61)	1.10
BS5	53	18	82	36.9	1.09	0.027	1.892	0.221 (0.82)	1.28	0.90	11.94	1.86 (6.87)	1.12
BS6	53	12	67	37.3	1.10	0.035	1.264	0.247 (0.91)	1.27	0.82	9.82	1.94 (7.16)	1.12
BS7	53	16	63	35.7	1.09	0.011	0.506	0.111 (0.41)	1.22	0.79	9.91	1.66 (6.14)	1.12

Footnotes:

(1) See Figure 2.

(2) The following guidelines were used for comparison:

a. Uranium = 2.0×10^{-3} pCi/l as stated in Guidelines more stringent than levels set by 10 CFR Part 20, Appendix B.

b. Gross β = 1.0×10^{-1} pCi/l as stated in 10 CFR Part 20, Appendix B.

c. Particulates = 60 ug/m³ (annual geometric mean) as stated in 10 CFR Part 50, National Ambient Air Quality Standards.

(3) Bq/l × 10^{-7} in parentheses.

(4) C. L. = Average Concentration ×÷ the value shown; Derived from log-transformed data; = $t_{(0.05, df)} S_{\bar{x}}$.

TABLE 2 Radionuclides in Air

Radionuclide	Guideline pCi/l (4)	Concentration of Radionuclides at Boundary Stations (1) in pCi/l $\times 10^{-9} \pm 2\sigma$ (2,3)						
		BS1	BS2	BS3	BS4	BS5	BS6	BS7
Cs-137	2.0000	<21.8	<22.4	<26.1	<22.4	<11.4	<24.3 15.5	<22.6
Np-237	0.0040	<2.2	<1.1	<1.3	<3.4	<3.4	<1.1	<1.1
Pu-238	0.0010	1.3 ± 0.7	1.5 ± 0.7	2.0 ± 0.8	1.3 ± 0.6	1.0 ± 0.4	1.3 ± 0.6	0.9 ± 0.6
Pu-239	0.0010	8.6 ± 1.9	8.7 ± 1.7	12.5 ± 2.0	4.9 ± 1.1	7.6 ± 1.3	6.8 ± 1.2	3.2 ± 1.2
Pu-241	1.0000	42.8 ± 0.9	41.2 ± 0.9	60.6 ± 1.6	25.3 ± 0.5	32.6 ± 0.5	31.4 ± 0.9	11.8 ± 0.5
Ra-226	0.0020	<76.2	<55.9	<52.2	<56.1	<45.8	110.4 ± 44.1	45.3 ± 39.6
Ra-228	0.0010	<3.3	<11.2	39.1 ± 39.1	<11.2	<11.4	<11.0	<11.3
Ru-106	0.2000	304.9 ± 32.7	2069.7 ± 295.7	3304.4 341.8	2531.9 ± 316.5	2362.1 ± 295.3	2474.3 ± 296.9	2408.9 ± 278.0
Sr-90	0.0300	28.3 ± 18.5	246.2 ± 55.9	261.0 ± 65.2	224.3 ± 56.1	13.7 ± 25.2	66.2 ± 30.9	17.0 ± 23.8
Tc-99	2.0000	707.7 ± 76.2	3942.3 ± 591.3	6380.9 ± 797.6	3270.4 ± 633.0	4035.3 ± 492.1	118.8 ± 29.7	1575.1 ± 370.6
Th-228	0.0002	14.2 ± 2.2	10.6 ± 3.6	26.1 ± 5.2	21.3 ± 5.6	32.1 ± 5.7	17.7 ± 4.4	22.6 ± 5.7
Th-230	0.0003	152.4 ± 21.8	77.2 ± 26.9	261.0 ± 52.2	134.6 ± 33.6	194.6 ± 34.3	121.4 ± 33.1	82.6 ± 22.6
Th-232	0.0010	9.7 ± 1.6	8.7 ± 2.9	14.4 ± 2.6	12.3 ± 3.4	13.7 ± 2.3	13.2 ± 3.3	11.3 ± 3.4

Footnotes:

(1) See Figure 2.

(2) Reported in units of pCi/l of air, uncertainties are counting uncertainties only at the 95% C.L. To obtain Bq/l, multiply the value by 3.7×10^{-11}.

(3) A composite of 52 weekly samples for BS3, 53 samples for all other boundary stations.

(4) As stated in 10 CFR Part 20, Appendix B, Concentrations in Air and Water Above Natural Background.

TABLE 3 ^{222}Radon in Ambient Air

Location (1)	Radon Activity in pCi/l (2)			
	Minimum	Maximum	Average (3)	95% (4) C.L.
Onsite				
BS1	0.49	1.12	0.81 (0.03)	0.64
BS2	0.41	1.39	0.82 (0.03)	1.03
BS3	0.33	0.50	0.28 (0.01)	0.76
BS4	0.43	0.72	0.56 (0.02)	0.30
BS5	0.52	0.96	0.80 (0.03)	0.49
BS6A	0.72	1.42	1.06 (0.04)	0.71
BS6B	0.30	0.50	0.27 (0.01)	0.90
BS7	0.72	1.31	1.01 (0.04)	0.60
Offsite (5)				
OS1	0.49	0.75	0.59 (0.02)	0.28
OS2	0.30	0.50	0.37 (0.01)	0.23

Footnotes:
(1) See Figure 2.
(2) 10 CFR Part 20, Appendix B, established a guideline level of 3 pCi/l above background.
(3) Bq/l in parentheses.
(4) C.L. = Average Concentration +/- the value shown.
(5) Located at nearby residences and used for background comparisons.

TABLE 4 Radionuclides Discharged at Sampling Point W2

Radionuclide (1)	Total Curies 1984	Total Curies 1985 (2)	Average Concentration 1985 pCi/l (3)	Guideline pCi/l (4)	% of Guideline
^{137} Cesium	0.017	0.0097 (3.6×10^{8})	15.68 (0.58)	20,000	0.08
^{237} Neptunium	0.0002	<0.00017 (<6.3×10^{6})	<0.27 (<0.010)	3,000	<0.009
^{238} Plutonium	0.00003	7.5×10^{-6} (2.8×10^{5})	0.0082 (0.00031)	5,000	0.0002
^{239,240} Plutonium	0.00005	1.5×10^{-5} (5.6×10^{5})	.023 (0.00085)	5,000	0.0005
^{226} Radium	<0.017	<0.0038 (<1.4×10^{8})	<8.11 (<0.30)	30	<27.0
^{228} Radium	<0.014	<0.0036 (<1.3×10^{8})	<12.86 (<0.48)	30	<42.9
^{106} Ruthenium	0.0005	<0.00044 (<1.6×10^{7})	<1.58 (<0.058)	10,000	<0.002
^{90} Strontium	0.012	0.0052 (1.9×10^{8})	8.39 (0.31)	300	2.8
^{99} Technetium	18.96	8.3 (3.1×10^{11})	13378.38 (495.00)	300,000	4.5
^{232} Thorium	0.0005	<0.011 (<4.1×10^{8})	<17.73 (<0.66)	2,000	<0.89
^{234} Uranium	0.34	0.15 (5.5×10^{9})	243.30 (9.00)	4,000 (5)	6.1
^{235} Uranium	0.018	0.0074 (2.7×10^{8})	11.92 (0.44)	4,000 (5)	0.30
^{236} Uranium	0.021	0.0049 (1.8×10^{8})	7.89 (0.29)	5,000 (5)	0.16
^{238} Uranium	0.39	0.20 (7.4×10^{9})	326.71 (12.09)	600 (5)	54.5
Uranium (6)	0.68	0.41 (1.5×10^{10})	660.84 (24.45)	1,200 (5)	55.1

Footnotes:

(1) Radionuclide concentrations in the plant effluent discharged to the Great Miami River through a buried pipeline, (with the exception of the three radium isotopes, thorium, ruthenium, and uranium) are determined from two 6-month composites. An additional 2.6×10^{-2} Curies of uranium was contained in storm sewer overflow discharged into Paddy's Run above sampling point W7.

(2) Bq in parentheses.

(3) Bq/l in parentheses.

(4) As stated in 10 CFR Part 20, Appendix B, Concentrations in Air and Water Above Natural Background.

(5) Guidelines used by FMPC for uranium isotopes and total uranium are more stringent than levels set by 10 CFR Part 20, Appendix B.

(6) From twelve monthly averages assuming total uranium as natural uranium (^{235}U = 0.71% by weight).

TABLE 5 Radionuclides in Surface Water

Radionuclide	Sampling Point (1)	Number of Samples (2)	Concentration (pCi/l) (3) Minimum	Maximum	Average	95% (4) C. L.	% of Guideline	Guideline pCi/l (5)
Gross α (6)	W1	52	0.81	7.21	2.24 (0.08)	0.27	7.5	30
	W3	52	1.04	4.96	2.58 (0.10)	0.22	8.6	
	W4	52	1.35	5.95	2.77 (0.10)	0.26	9.2	
	W5	50	0.45	12.61	2.77 (0.10)	0.49	5.7	
	W7	30	0.77	428.38	32.71 (1.21)	35.28	109.0	
	W8	18	4.05	10.81	7.96 (0.29)	0.93	26.5	
	W9	13	2.03	41.89	9.44 (0.35)	8.41	31.5	
	W10	8	1.22	12.61	5.75 (0.21)	3.27	19.2	
	W11	8	4.51	11.71	6.87 (0.25)	1.73	22.9	
Gross β (6)	W1	52	0.81	9.82	4.91 (0.18)	0.47	16.4	30
	W3	52	4.05	17.12	7.49 (0.28)	0.85	25.0	
	W4	52	3.60	15.77	7.17 (0.27)	0.82	23.9	
	W5	50	0.90	45.05	5.85 (0.22)	2.22	19.5	
	W7	30	4.37	140.09	16.71 (0.62)	10.14	55.7	
	W8	18	5.41	19.82	12.61 (0.47)	2.23	42.0	
	W9	13	2.61	17.12	9.53 (0.35)	2.77	31.8	
	W10	8	2.25	13.51	7.61 (0.28)	3.56	25.4	
	W11	8	5.36	130.63	23.81 (0.88)	30.18	79.4	
^{137}Cesium	W1	2	<2.70	< 5.41	<4.05 (0.15)	17.22	<0.01	20,000
	W3	2	<2.70	< 5.41	<4.05 (0.15)	17.22	<0.01	
	W4	2	<2.43	< 2.70	<2.70 (0.10)	1.72	<0.01	
^{226}Radium	W1	12	<0.45	0.45	<0.45 (0.017)	NA (7)	<1.5	30
	W3	12	<0.45	0.45	<0.45 (0.017)	NA	<1.5	
	W4	12	<0.45	0.45	<0.45 (0.017)	NA	<1.5	
	W5	6	<0.45	0.45	<0.45 (0.017)	NA	<1.5	
	W7	11	<0.45	0.45	<0.45 (0.017)	NA	<1.5	
^{228}Radium	W1	12	<0.45	0.45	<0.45 (0.017)	NA	<1.5	30
	W3	12	<0.45	0.45	<0.45 (0.017)	NA	<1.5	
	W4	12	<0.45	0.45	<0.45 (0.017)	NA	<1.5	
	W5	6	<0.45	0.45	<0.45 (0.017)	NA	<1.5	
	W7	11	<0.45	0.45	<0.45 (0.017)	NA	<1.5	
^{90}Strontium	W1	2	0.27	< 1.35	<0.81 (0.03)	6.86	<0.27	300
	W3	2	0.81	< 1.62	<1.35 (0.05)	5.15	0.45	
	W4	2	0.81	1.89	1.35 (0.05)	6.88	<0.45	
^{99}Technetium	W1	2	1.08	1.35	1.08 (0.04)	1.72	<0.01	300,000
	W3	2	2.70	3.24	2.97 (0.11)	3.44	<0.01	
	W4	2	4.32	4.86	4.59 (0.17)	3.44	<0.01	
^{234}Uranium	W1	2	3.40	4.04	3.72 (0.14)	2.84	0.09	4,000 (8)
	W3	2	3.71	4.58	4.14 (0.15)	3.88	0.10	
	W4	2	3.86	4.00	3.93 (0.15)	0.63	0.10	
^{235}Uranium	W1	2	0.15	0.17	0.16 (0.006)	0.12	0.004	4,000 (8)
	W3	2	0.16	0.20	0.18 (0.002)	0.18	0.005	
	W4	2	0.17	0.17	0.17 (0.006)	0.024	0.004	
^{236}Uranium	W1	2	0.04	0.05	0.04 (0.001)	0.037	0.001	5,000 (8)
	W3	2	0.05	0.07	0.06 (0.007)	0.096	0.001	
	W4	2	0.04	0.06	0.05 (0.002)	0.092	0.001	
^{238}Uranium	W1	2	3.41	4.02	3.72 (0.14)	2.70	0.62	600 (8)
	W3	2	3.66	4.65	4.16 (0.15)	4.43	0.69	
	W4	2	3.91	4.00	3.96 (0.15)	0.39	0.66	
Uranium	W1	52	0.95	8.81	1.57 (0.06)	0.29	0.1	1,200 (8)
	W3	52	0.95	2.57	1.61 (0.06)	0.09	0.1	
	W4	52	0.88	15.57	1.89 (0.07)	0.55	0.2	
	W5	50	0.47	11.51	1.60 (0.06)	0.57	0.1	
	W7	31	1.21	580.87	43.37 (1.60)	45.77	3.6	
	W8	18	3.39	10.83	7.18 (0.27)	1.11	0.6	
	W9	13	1.35	176.02	23.33 (0.86)	29.81	1.9	
	W10	8	1.35	1827.90	235.51 (8.71)	434.53	19.6	
	W11	8	4.06	16.25	9.82 (0.36)	3.08	0.8	

Footnotes:
(1) See Figure 5.
(2) Samples are composited for radium analyses as follows: one-month composites of daily samples from W1 and W3; one-month composites of weekly samples from W4, two-month composites of weekly samples from W5, and one-month composites of all available weekly samples from W7. Semi-annual composites were used for those isotopes where two samples are noted.
(3) Bq/l in parentheses.
(4) C. L. = Average +/- the value shown; = $t_{(0.05,\ df)} S_{\bar{x}}$.
(5) As stated in 10 CFR Part 20, Appendix B, Concentrations in Air and Water Above Natural Background.
(6) Gross α and Gross β activity values contain activity of uranium and radium in the samples, thus are highly conservative.
(7) NA = Not Applicable.
(8) Guidelines used by FMPC for uranium isotopes and total uranium are more stringent than levels set by 10 CFR Part 20, Appendix B.

TABLE 6 NPDES Data for 1985

Parameter	Units	Number Of Samples	Daily Minimum	Daily Maximum	Annual Average	NPDES Permit Limits: Daily Maximum	NPDES Permit Limits: Monthly Average	Percent Compliance
Discharge 001 (MH175)								
Flow rate	MGD	Continuous	0.106	1.131	0.451	NA	NA	NA
pH	pH Units	Daily Grab	7.4	9.1	NA	Range = 6.5 to 10.0		100
Suspended Solids	mg/L*	52	<2	26	5	60	20	100
Ammonia (as N)	kg/day	52	<1	3	<1	43	28	100
Oil & Grease (mg/L)	mg/L	52	<5	19	<5	15	NA	98
Residual Chlorine	mg/L	25[a]	<0.02	0.06	0.03	0.10	NA	100
Nitrate (as N)	kg/day	52	40	1275	370	3180	1590	100
Discharge 002 (Storm Sewer Outfall)								
Flow rate	MG/Event	Continuous	0.007	0.844	0.179	NA	NA	NA
pH	pH Units	Grab/Event	7.5	8.3	NA	Range = 6.5 to 9.0		100
Suspended Solids	mg/L*	68	<2	175	15	100	30	96
Oil & Grease	mg/L	68	<5	<5	<5	15	NA	100
Sampling Location 001A (Sewage Treament Plant)								
Flow rate	MGD	Continuous	0.035	0.253	0.124	NA	NA	NA
pH	pH Units	Daily Grab	7.2	7.9	NA	Range = 6.5 to 9.0		100
BOD_5	mg/L* (kg/day)	52	1(0.6)	27(20.3)	9(4.4)	40(10.0)	20(5.0)	94
Suspended Solids	mg/L* (kg/day)	52	1(0.4)	27(14.8)	5(2.5)	40(10.0)	20(5.0)	96
Fecal Coliform	MPN/100ml*	27[a]	0	1000	76[b]	2000	1000	100
Sampling Locations 001B & C (Combined General Sump & Clearwell)								
Flow rate	MGD	Continuous	0.000	0.992	0.196	NA	NA	NA
Suspended Solids	kg/day	52	0.9	112.4	6.9	12.8	6.2	90
Chromium (+6)	kg/day	52	0.001	0.051	0.005	0.008	0.004	79
Chromium (total)	kg/day	52	0.002	0.058	0.012	0.102	0.050	100
Iron	kg/day	52	0.01	1.16	0.21	0.85	0.41	92
Nickel	kg/day	52	0.006	0.119	0.033	0.256	0.124	100
Copper	kg/day	52	0.005	0.088	0.017	0.051	0.025	96
Sampling Location 001D (Lift Station)								
Flow rate	MGD	Continuous	0.079	0.694	0.248	NA	NA	NA
Suspended Solids	mg/L	52	<2	35	<5	100	30	100
Oil & Grease	mg/L	52	<5	5	<5	15	NA	100

Footnotes:

NA = Not applicable.

* = Flow-weighted averages.

[a] Monitoring not required during winter months.

[b] Geometric mean.

TABLE 7 Ion and pH Levels in Surface Water

Parameter	Sampling Point (1)	Number Of Samples	Concentration (mg/l)					Guideline (3)
			Minimum	Maximum	Average	95% C. L. (2)	% of Guideline	
Fluoride	W1	52	0.2	0.9	0.49	0.05	27	1.8 mg/l
	W3	52	0.2	0.9	0.50	0.05	28	
	W4	52	0.2	1.0	0.50	0.05	28	
	W5	13	0.2	0.5	0.25	0.05	14	
	W7	12	0.1	1.2	0.35	0.17	19	
	W8	12	0.1	0.2	0.15	0.03	8	
	W9	3	0.1	0.2	0.17	0.12	9	
	W10	2	0.2	0.3	0.25	0.64	14	
	W11	2	0.2	0.5	0.35	0.91	19	
Nitrate (as N)	W1	52	2.1	6.3	3.57	0.26	36	10 mg/l
	W3	52	2.1	6.6	3.64	0.26	36	
	W4	52	1.8	6.8	3.62	0.31	36	
	W5	12	0.7	2.9	1.68	0.40	17	
	W7	12	0.1	7.1	2.01	1.07	20	
	W8	11	0.1	4.4	0.82	0.81	8	
	W9	3	0.1	2.5	1.47	25.0	15	
	W10	2	0.2	1.9	1.03	10.83	10	
	W11	2	2.1	2.6	2.35	3.19	24	
Chloride	W1	52	20.0	114.0	60.1	6.71	24	250 mg/l
	W3	52	20.0	112.0	60.0	6.62	24	
	W4	52	21.0	114.0	60.6	6.87	24	
	W5	12	5.0	111.0	34.2	16.52	14	
	W7	13	7.0	35.0	21.2	4.41	8	
	W8	11	19.0	111.0	46.2	15.98	18	
	W9	3	13.0	40.0	24.0	28.76	10	
	W10	2	10.0	19.0	14.5	57.35	6	
	W11	2	10.0	19.0	14.5	57.35	6	
pH (4)	W1	52	7.6	8.9	NA (5)	NA (5)	NA (5)	6.5 - 9.0
	W3	52	7.6	9.0				
	W4	52	7.7	9.0				
	W5	50	7.5	8.3				
	W7	31	7.6	8.5				
	W8	18	7.5	8.1				
	W9	13	7.6	8.5				
	W10	8	7.6	8.6				
	W11	8	7.6	8.7				

Footnotes:

(1) See Figure 5.

(2) C. L. = Average Concentration +/− value shown; = $t_{(0.05, df)} S_{\bar{x}}$.

(3) Ohio EPA Water Quality Standards, Administrative Code Chapter 3745-1 (Public Water Supply Use Designation).

(4) pH is reported in standard units.

(5) NA = Not Applicable.

TABLE 8 Uranium in On-Site Well Water

Sampling Point (1)	Number of Samples	Concentration (pCi/l)				
		Minimum	Maximum	Average (2)	95% (3) C. L.	% of (4) Standard
P1	3	0.07	0.41	0.25 (0.01)	0.35	0.02
P2	4	0.07	0.68	0.30 (0.01)	0.49	0.03
P3	4	0.07	0.20	0.15 (0.01)	0.12	0.01
T1S	4	5.82	8.12	6.89 (0.25)	1.77	0.57
T1D	4	0.07	0.27	0.19 (0.01)	0.16	0.02
T3	4	1.56	2.03	1.76 (0.17)	0.40	0.15
T4	4	4.13	6.16	5.52 (0.20)	1.77	0.46
T5	4	1.83	3.05	2.49 (0.09)	1.04	0.21
T8S	4	0.47	0.68	0.59 (0.02)	0.16	0.05
T8D	4	0.20	0.27	0.24 (0.01)	0.07	0.02
T9	4	0.74	1.02	0.90 (0.03)	0.22	0.07
T10	4	12.80	16.18	13.88 (0.51)	2.92	1.16
T11	4	0.07	0.27	0.15 (0.01)	0.16	0.01

Footnotes:
(1) See Figure 6.
(2) Bq/l in parentheses.
(3) C. L. = Average Concentration +/- the value shown; = $t_{(0.05,\ df)} S_{\bar{x}}$.
(4) Guidelines used by FMPC for uranium are more stringent than levels set by 10 CFR Part 20, Appendix B, Concentrations in Air and Water Above Natural Background.

TABLE 9 Gross α Activity in On-Site Well Water

Sampling Point (1)	Number of Samples	Concentration (pCi/l) (2)				
		Minimum	Maximum	Average(3)	95% (4) C. L.	% of (5) Standard
P1	3	<1.35	3.60	<2.70 (0.10)	2.42	<9.0
P2	4	0.45	4.05	1.57 (0.06)	2.35	5.2
P3	4	0.45	2.43	0.97 (0.04)	1.35	3.2
T1S	4	5.09	9.01	7.55 (0.28)	2.58	25.2
T1D	4	<0.45	1.13	<0.75 (0.03)	0.49	<2.5
T3	4	2.66	4.51	3.27 (0.12)	1.19	10.9
T4	4	3.60	4.96	4.39 (0.16)	0.78	14.6
T5	4	0.77	4.51	3.22 (0.12)	2.32	10.7
T8S	4	1.35	2.34	1.94 (0.07)	0.63	6.5
T8D	4	0.45	1.35	0.80 (0.03)	0.54	2.7
T9	4	1.22	2.25	1.84 (0.07)	0.62	6.1
T10	4	10.81	20.72	15.77 (0.58)	5.60	52.6
T11	4	0.14	1.49	1.08 (0.04)	0.87	3.6

Footnotes:
(1) See Figure 6.
(2) Includes activity due to Uranium (see Table 8), thus results are conservative.
(3) Bq/l in parentheses.
(4) C. L. = Average Concentration +/- the value shown; = $t_{(0.05,\ df)} S_{\bar{x}}$.
(5) As stated in 10 CFR Part 20, Appendix B, Concentrations in Air and Water Above Natural Background.

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TABLE 10 Gross β Activity in On-Site Well Water

Sampling Point (1)	Number of Samples	Concentration (pCi/l) (2)				
		Minimum	Maximum	Average (3)	95% (4) C. L.	% of (5) Standard
P1	3	3.60	4.51	3.98 (0.15)	0.95	13.3
P2	4	0.95	2.21	1.58 (0.06)	1.02	5.3
P3	4	0.90	2.61	1.71 (0.06)	1.39	5.7
T1S	4	7.75	11.26	9.33 (0.35)	2.71	31.1
T1D	4	0.90	1.58	1.33 (0.05)	0.56	4.4
T3	4	4.05	6.53	5.16 (0.19)	1.99	17.2
T4	4	5.41	10.23	7.22 (0.27)	4.06	24.1
T5	4	0.63	5.86	4.16 (0.15)	4.44	13.9
T8S	4	2.57	3.56	3.11 (0.12)	0.76	10.4
T8D	4	1.26	1.80	1.48 (0.05)	0.44	4.9
T9	4	3.60	5.00	4.21 (0.16)	1.08	14.0
T10	4	30.18	33.79	31.83 (1.18)	2.90	106.1
T11	4	<0.90	2.61	<1.89 (0.07)	1.38	6.3

Footnotes:

(1) See Figure 6.

(2) Includes activity due to Uranium (see Table 8), thus results are conservative.

(3) Bq/l in parentheses.

(4) C. L. = Average Concentration +/- the value shown; = $t_{(0.05, dn)} S_{\bar{x}}$.

(5) As stated in 10 CFR Part 20, Appendix B, Concentrations in Air and Water Above Natural Background.

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TABLE 11 Uranium in Off-Site Well Water

Sampling Point (1)	Number of Samples	Concentration (pCi/l)				
		Minimum	Maximum	Average (2)	95% (3) C. L.	% of (4) Standard
1	11	0.04	0.81	0.30(0.01)	0.15	0.02
2	NS (5)	NS	NS	NS	NS	NS
3	11	0.03	0.41	0.23(0.01)	0.10	0.02
4	11	0.81	1.56	1.08(0.04)	0.14	0.09
5	11	0.68	1.56	1.31(0.05)	0.15	0.11
6	11	0.95	1.69	1.37(0.05)	0.14	0.11
7	11	0.74	1.15	0.95(0.04)	0.08	0.08
8	11	0.47	0.61	0.53(0.02)	0.03	0.04
9	11	0.68	2.78	0.99(0.04)	0.38	0.08
10	11	0.34	0.47	0.38(0.01)	0.03	0.03
11	11	0.61	1.22	0.81(0.03)	0.13	0.07
12	11	114.41	164.51	140.00(5.18)	10.34	11.67
13	11	0.34	0.61	0.44(0.02)	0.06	0.04
14	11	0.68	0.88	0.73(0.03)	0.04	0.06
15	11	151.65	234.72	204.27(7.56)	21.88	17.02
16	11	0.27	1.92	0.67(0.02)	0.30	0.06
17	11	21.80	37.24	31.15(1.15)	3.10	2.60
18	11	0.03	0.47	0.29(0.01)	0.09	0.02
19	11	0.03	0.47	0.20(0.01)	0.11	0.02
20	11	0.03	0.34	0.16(0.01)	0.07	0.01
21	11	0.20	0.41	0.29(0.01)	0.04	0.02
22	10	0.54	1.52	0.76(0.03)	0.18	0.06
23	11	0.47	0.68	0.55(.02)	0.05	0.05
24	9	0.20	0.41	0.32(0.01)	0.04	0.03
25	4 (6)	0.27	0.28	0.27(0.01)	0.01	0.02
26	9	0.14	0.41	0.24(0.01)	0.07	0.02

Footnotes:
(1) See Figure 7.
(2) Average Bq/l in parentheses.
(3) C. L. = Average Concentration +/- value shown; = $t_{(0.05,\ df)} S_{\bar{x}}$.
(4) Guidelines used by FMPC for uranium are more stringent than levels set by 10 CFR Part 20, Appendix B, Concentrations in Air and Water Above Natural Background.
(5) NS = Not Sampled at homeowner's request.
(6) Quarterly determination at homeowner's request.

TABLE 12 Nitrate Nitrogen and Sulfate in On-Site Well Water

Sampling Point (1)	Number of Samples	Nitrate Nitrogen (mg/l)					Sulfate (mg/l)				
		Minimum	Maximum	Average	95% (2) C. L.	% of (3) Standard	Minimum	Maximum	Average	95% (2) C. L.	% of (4) Standard
P1	3	<0.5	1.3	<0.53	1.65	<5.3	96	107	101.0	13.83	40.4
P2	4	<0.10	0.20	<0.13	<0.08	<1.3	8	10	8.8	1.52	3.5
P3	4	<0.10	<0.10	<0.10	NA (5)	<1.0	40	54	44.8	10.01	17.9
T1S	4	<0.10	0.30	<0.15	0.16	<1.5	75	84	78.3	6.41	31.3
T1D	4	<0.10	0.10	<0.10	NA	<1.0	10	37	24.5	17.74	9.8
T3	4	<0.10	0.10	<0.10	NA	<1.0	89	96	93.3	4.93	37.3
T4	4	0.9	2.40	1.7	1.00	17.0	55	71	63.3	10.90	25.3
T5	4	<0.10	0.20	<0.13	0.08	<1.3	79	92	84.5	9.76	33.8
T8S	4	<0.10	<0.10	<0.10	NA	<1.0	70	78	75.3	5.72	30.1
T8D	4	<0.10	<0.20	<0.13	0.08	<1.3	8	14	10.0	4.50	4.0
T9	4	1.10	3.40	2.13	1.65	21.3	71	80	76.5	6.43	30.6
T10	4	156.0	285.0	229.5	94.2	2295.0	693	787	724.0	68.07	289.6
T11	4	<0.10	0.40	0.18	0.24	<2.4	80	90	84.5	0.70	33.8

Footnotes:
(1) See Figure 6.
(2) C. L. = Average +/− the value shown; = $t_{(0.05,\ df)} S_{\bar{x}}$.
(3) 10 mg/l per 40CFR Part 141, National Interim Primary Drinking Water Regulations.
(4) 250 mg/l per 40CFR Part 143, National Secondary Drinking Water Regulations.
Standards apply only to drinking water, and thus only to well P3. Used for reference purposes only on others.
(5) NA = Not Applicable.

TABLE 13 pH and Chloride in On-Site Well Water

Sampling Point (1)	Number of Samples	pH		Chloride (mg/l)				
		Minimum	Maximum	Minimum	Maximum	Average	95% (3) C. L.	% of (4) Standard
P1	3	7.1	7.6	38	40	39.0	2.48	15.6
P2	4	7.2	7.6	18	20	19.3	1.52	7.7
P3	4	7.2	8.4	11	13	12.3	1.52	4.9
T1S	4	7.2	7.4	17	20	18.3	2.00	7.3
T1D	4	7.2	7.4	21	23	22.3	1.52	8.9
T3	4	7.3	7.5	19	24	21.8	3.53	8.7
T4	4	7.3	7.4	17	28	21.8	7.28	8.7
T5	4	7.3	7.4	17	25	21.0	5.20	8.4
T8S	4	7.3	7.4	20	20	20.0	NA (5)	8.0
T8D	4	7.3	7.5	11	12	11.5	3.67	4.6
T9	4	7.3	7.5	21	23	22.0	1.30	8.8
T10	4	6.8	7.1	21	96	65.3	50.42	26.1
T11	4	7.3	7.4	20	68	32.0	38.18	12.8

Footnotes:

(1) See Figure 6.

(2) C. L. = $\pm 2\sigma$.

(3) C. L. = Average +/− the value shown; $= t_{(0.05,\ df)} S_{\bar{x}}$.

(4) 250 mg/l per 40CFR Part 143, National Secondary Drinking Water Regulations.

(5) NA = Not Applicable.

TABLE 14 Nitrate Nitrogen in Off-Site Well Water

Sampling Location (1)	Number of Samples	Concentration (mg/l)				
		Minimum	Maximum	Average	95% (2) C. L.	% of (3) Standard
1	11	<0.10	<0.10	<0.10	NA (4)	<1.0
2	NS (5)	NS	NS	NS	NS	NS
3	11	<0.10	<0.10	<0.10	NA	<1.0
4	11	0.30	1.90	0.93	0.29	9.4
5	11	1.30	14.00	9.54	2.92	95.4
6	11	1.10	5.60	2.85	1.03	28.6
7	11	<0.10	<0.10	<0.10	NA	<1.0
8	11	1.60	3.60	2.59	0.43	25.9
9	11	1.10	3.30	2.05	0.43	20.5
10	11	<0.10	<0.10	<0.10	NA	<1.0
11	11	2.00	4.50	3.25	0.48	32.6
12	10	1.80	4.20	2.77	0.62	27.7
13	11	1.20	4.60	2.44	0.68	24.4
14	11	1.30	4.70	2.98	0.70	29.8
15	11	1.60	4.70	2.73	0.66	27.3
16	11	<0.10	0.35	<0.17	0.05	<1.7
17	11	<0.10	0.50	<0.17	0.08	<1.7
18	11	<0.10	<0.10	<0.10	NA	<1.0
19	11	<0.10	<0.10	<0.10	NA	<1.0
20	11	<0.10	0.70	<0.35	0.15	<3.5
21	11	<0.10	0.20	<0.11	0.02	<1.1
22	10	<0.10	1.50	<0.79	0.38	<7.9
23	11	<0.10	<0.10	<0.10	NA	<1.0
24	9	2.00	6.50	3.61	1.15	36.1
25	4 (6)	3.00	6.50	4.55	1.71	45.5
26	7	<0.10	<0.10	<0.10	NA	<1.0

Footnotes:
(1) See Figure 7.
(2) C. L. = Average Concentration +/− value shown; = $t_{(0.05,\ df)} S_{\bar{x}}$.
(3) 10 mg/l per Ohio EPA Rule 3745-81-11, Maximum Contaminant Levels for Inorganic Chemicals.
(4) NA = Not Applicable.
(5) NS = Not Sampled at homeowner's request.
(6) Sampled quarterly at homeowner's request.

TABLE 15 Comparison of Uranium in Routine Soil Samples for 1984 and 1985

Sampling Point (1)	Concentration (2) (pCi/g dry wt.)			
	1984 (3)	1985	±2σ (4)	% of (5) Guideline
1	6.35 (0.24)	4.35 (0.16)	1.74	12.4
2	8.98 (0.33)	1.95 (0.07)	0.82	5.6
3 (6)	54.22 (2.01)	35.88 (1.33)	14.5	102.5
4	7.45 (0.28)	3.05 (0.11)	1.26	8.7
5	9.09 (0.34)	2.88 (0.11)	1.20	8.5
6	4.46 (0.17)	1.25 (0.05)	0.55	3.6
7	3.41 (0.13)	0.42 (0.02)	0.21	1.2
8	2.48 (0.09)	0.43 (0.02)	0.30	1.2
9	3.94 (0.15)	1.71 (0.06)	0.28	4.9
10	2.94 (0.11)	0.42 (0.02)	0.21	1.2
11	16.54 (0.61)	14.15 (0.52)	0.73	40.4
12	2.12 (0.08)	0.67 (0.02)	0.21	1.9
13	3.81 (0.14)	0.44 (0.02)	6.04	1.3
14	2.19 (0.08)	0.61 (0.02)	0.21	1.7
15	7.73 (0.29)	0.35 (0.01)	0.17	1.0

Footnotes:

(1) See Figure 8.
(2) Bq/g in Parentheses.
(3) See 1984 Environmental Monitoring Report.
(4) Applies to analytical uncertainty for 1985 value.
(5) Value of 35 pCi/g used as guideline for these calculations.
(6) This location is on site near an out of service incinerator.

TABLE 16 Uranium and Technetium in Great Miami River Sediments

Sampling Location (1)	Distance (km) From FMPC Effluent Outfall	Uranium Concentration		Technetium Concentration	
		pCi/g Dry Wt. (2)	95% C.L. (3)	pCi/g Dry Wt. (2)	95% C.L. (3)
	Upstream -				
1	5.9	0.9 (0.03)	0.3		
1 (4)	5.9	1.5 (0.06)	0.2		
2	2.4	0.8 (0.03)	0.1	0.0 (0.0)	0.3
2 (4)	2.4	1.1 (0.04)	0.3		
	Downstream -				
3	0.015	2.4 (0.09)	0.3	4.9 (3.3)	0.8
5	3.3	2.6 (0.10)	0.3	1.4 (0.9)	0.6
5 (4)	3.3	0.6 (0.03)	0.1		
6	4.5	0.9 (0.03)	0.1	0.0 (0.0)	0.3
7	4.7	0.7 (0.03)	0.2		

Footnotes:
(1) See Figure 9.
(2) Bq/g in parentheses.
(3) C.L. = $\pm 2\sigma$.
(4) Midstream sample.

TABLE 17 Uranium and Technetium in On-Site Sediments

Sampling Location (1)	Uranium Concentration		Technetium Concentration	
	pCi/g Dry Wt. (2)	95% C.L. (3)	pCi/g Dry Wt. (2)	95% C.L. (3)
8	1.8 (0.07)	0.1		
9	1.1 (0.04)	0.1		
10	10.2 (0.38)	0.1	2.3 (1.6)	0.3
11	6.1 (0.23)	0.3		
12	21.7 (0.80)	1.4	2.5 (1.7)	0.3
13	9.0 (0.33)	0.5		
14	21.0 (0.78)	1.4		
15	4.2 (0.16)	0.2		
16	33.5 (1.24)	2.5	6.9 (4.7)	0.4
17	46.2 (1.71)	2.2	5.1 (3.5)	0.4
18	1.3 (0.05)	0.1		
19	6.0 (0.22)	0.3		
20	3.7 (0.14)	0.2		
21	11.6 (0.43)	0.5		
22	2.2 (0.08)	0.1	0.5 (0.3)	0.3
23	4.0 (0.15)	0.2	0.0 (0.0)	0.3
24	1.9 (0.07)	0.1		
25	1.0 (0.04)	0.1		
26	0.5 (0.02)	0.1	0.0 (0.0)	0.3
27	0.6 (0.02)	0.1		

Footnotes:

(1) See Figure 9. Locations 8 and 9 are approximately 2.5 and 3.5 km south of FMPC.

(2) Bq/g in parentheses.

(3) C.L. = $\pm 2\sigma$.

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TABLE 18 Uranium and Fluoride in Grass and Other Forage (1)

Sampling Point (2)	Distance (km) From FMPC (3)	Uranium Concentration		Fluoride Concentration	
		pCi/g Dry Wt. (4)	95% C.L. (5)	ppm	% of Standard (6)
1	10.5	0.09 (0.003)	NA (7)	3.0	3.8
2	8.7	0.10 (0.004)	±0.10	5.1	6.4
3	6.2	0.12 (0.005)	NA	14.0	17.5
4	4.1	0.25 (0.009)	±0.05	5.8	7.3
5	5.3	0.15 (0.006)	NA	3.3	4.1
6	2.3	0.54 (0.020)	±0.08	6.0	7.5
7	1.4	1.40 (0.052)	±0.01	6.5	8.1
8	0.7	0.88 (0.033)	±0.01	5.6	7.0
9	0.9	1.57 (0.058)	±0.53	8.4	10.5
10	0.8	2.34 (0.086)	±0.38	11.5	14.4
11	1.9	0.65 (0.024)	±0.07	11.1	13.9
12	1.9	0.31 (0.012)	±0.44	4.1	5.1
13	1.0	1.63 (0.060)	±0.64	6.9	8.6
14	0.7	1.50 (0.055)	±0.32	5.7	7.1
15	1.3	0.37 (0.014)	±0.53	5.9	7.4
16	1.5	0.31 (0.012)	±0.34	3.5	4.4
17	1.6	0.26 (0.010)	±0.02	4.0	5.0
18	1.2	0.67 (0.025)	±0.10	6.2	7.8
19	1.0	0.02 (0.001)	±0.007	<2.4	<3.0
20	0.9	0.18 (0.007)	±0.03	6.2	7.8
21	2.7	0.40 (0.015)	±0.04	6.8	8.5
22	7.0	0.05 (0.002)	±0.01	4.7	5.9
23	8.0	0.03 (0.001)	±0.01	<2.4	<3.0
24	8.1	0.08 (0.003)	±0.01	<2.4	<3.0
25	8.5	0.04 (0.002)	±0.01	5.9	7.4
26	0.8	0.38 (0.014)	±0.02	<2.4	<3.0
27	1.0	0.20 (0.008)	±0.01	<2.4	<3.0
28	4.0	0.26 (0.010)	±0.14	6.5	8.1
29 (8)	62.8	0.25 (0.010)	±0.81	2.5	2.0

Footnotes:

(1) The plant material analyzed was primarily brome grass (*Bromus* spp), but some samples contained species from the following genera: *Allium, Daucus, Hordeum, Medicago, Melilotus, Poa, Secale, and Triticum.*

(2) See Figure 10.

(3) For the purpose of this table, the center of the production area (Figure 2) was used for distance measurements.

(4) Bq/g in parentheses.

(5) C.L. = $\pm 2\sigma$.

(6) No Ohio standard established; Kentucky standard of 80 ppm was used.

(7) Not Applicable.

(8) Control samples collected from a farm in Indiana.

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TABLE 19 Comparison of Uranium Concentrations in Grass and Soils at Parallel Sampling Locations

Sampling Location (1)	Distance (km) From FMPC (2)	Grass		Soil	
		pCi/g Dry Wt. (3)	95% C.L. (4)	pCi/g Dry Wt. (3)	95% C.L. (4)
1	0.5	0.02 (0.0008)	0.007	1.25 (0.05)	0.55
2	8.7	0.10 (0.004)	0.10	1.22 (0.05)	0.14
3	6.2	0.12 (0.005)	NA (5)	1.90 (0.07)	0.14
4	4.1	0.25 (0.009)	0.05	1.96 (0.07)	0.14
5	5.3	0.15 (0.006)	NA	1.29 (0.05)	0.14
6	2.3	0.54 (0.020)	0.08	5.69 (0.21)	0.27
7	1.4	1.40 (0.052)	0.01	14.22 (0.53)	0.68
8	0.7	0.88 (0.033)	0.01	18.96 (0.70)	0.68
9	0.9	1.57 (0.058)	0.53	16.93 (0.63)	0.68
10	0.8	2.34 (0.086)	0.38	64.32 (2.38)	3.39
11	1.9	0.65 (0.024)	0.07	2.84 (0.11)	0.14
12	1.9	0.31 (0.012)	0.44	1.08 (0.04)	0.14
13	1.0	1.63 (0.060)	0.64	31.14 (1.15)	1.35
14	0.7	1.50 (0.055)	0.32	17.60 (0.65)	1.35
15	1.0	0.37 (0.014)	0.53	5.75 (0.21)	0.27
16	1.5	0.31 (0.012)	0.34	3.25 (0.12)	0.14
17	1.6	0.26 (0.010)	0.02	4.27 (0.16)	0.20
18	1.2	0.67 (0.025)	0.10	5.08 (0.19)	0.27
19	0.9	0.18 (0.007)	0.03	3.11 (0.12)	0.14
20	2.7	0.40 (0.015)	0.04	2.23 (0.08)	0.14
21	4.0	0.26 (0.010)	0.14	2.57 (0.10)	0.14

Footnotes:
(1) See Figure 11.
(2) For the purpose of this table, the center of the production area (Figure 2) was used for distance measurements.
(3) Bq/g in parentheses.
(4) C.L. = $\pm 2\sigma$.
(5) NA = Not Applicable.

TABLE 20 Uranium Concentration in Garden Produce: Potatoes

Sampling Point (1)	Number of Samples	Concentration in Peels (pCi/g dry wt.)				Concentration in Flesh (pCi/g dry wt.)			
		Minimum	Maximum	Average (2)	95% (3) C. L.	Minimum	Maximum	Average (2)	95% (3) C. L.
1	6	0.90	1.22	1.02 (0.038)	1.0	0.0019	0.0066	0.0030 (0.00011)	1.1
2	6	0.22	0.65	0.29 (0.011)	1.1	0.0033	0.013	0.0063 (0.00023)	1.1
3	6	0.32	0.75	0.43 (0.016)	1.0	0.0055	0.011	0.0089 (0.00033)	1.0
4	6	0.19	0.37	0.25 (0.0093)	1.0	0.0033	0.011	0.0062 (0.00023)	1.1
Control (4)	12	0.14	0.34	0.26 (0.0096)	1.0	0.00048	0.011	0.0054 (0.00020)	1.3

Footnotes:

(1) See Figure 12.

(2) Bq/g in parentheses.

(3) C. L. = Average Concentration ×÷ value shown. Derived from log-transformed data; $= t_{(0.05,\ df)} S_{\bar{x}}$.

(4) Control samples were collected from two remote sites in Indiana.

TABLE 21 Uranium In Milk

Sampling Location (1)	Number of Samples	Average Concentration (2)		Standard
		μg/l	pCi/l (3)	
1	3	<1.0	<0.68 (0.025)	(4)
2	3	<1.0	<0.68 (0.025)	(4)

Footnotes:

(1) Sampling locations: 1 = dairy farm adjacent to the FMPC.
2 = dairy farm in Kentucky approximately 29 km southeast of the FMPC.

(2) All analyses for both sites yielded the same results; i.e., <1 μg/l.

(3) Bq/l in parentheses.

(4) No standards have been established.

TABLE 22 Uranium Concentration in Fish

Sampling Point (1)	Family (2)	Number of Samples	Concentration (pCi/g) (3) Minimum	Maximum	Average (4)	95% (5) C. L.
1	1	9	0.067	0.286	0.095 (0.0035)	0.749
	2	2	0.106	0.153	0.107 (0.0046)	6.121
	3	4	0.089	0.128	0.100 (0.0037)	1.246
	4	2	0.213	0.280	0.244 (0.0090)	0.712
	Total	17	0.067	0.280	0.109 (0.0040)	0.523
2	1	6	0.064	0.286	0.156 (0.0056)	1.125
	2	6	0.086	0.153	0.118 (0.0044)	0.871
	3	1	0.083	0.083	0.083 (0.0031)	ND (6)
	4	2	0.234	0.344	0.284 (0.0105)	7.370
	5	6	0.141	0.254	0.187 (0.0069)	0.900
	Total	21	0.064	0.344	0.156 (0.0058)	0.477
3	1	1	0.057	0.057	0.057 (0.0021)	ND(6)
	2	2	0.073	0.081	0.077 (0.0028)	6.412
	3	4	0.039	0.118	0.066 (0.0024)	1.678
	4	9	0.060	0.173	0.104 (0.0038)	0.712
	Total	16	0.039	0.173	0.086 (0.0032)	0.535

Footnotes:

(1) See Figure 13.

(2) Family: 1 = Cyprinidae (carp)
2 = Catastomidae (carpsucker, redhorse)
3 = Centrarchidae, Sciaenidae (bass, sunfish, drum)
4 = Clupeidae (gizzard shad)
5 = Ictaluridae (catfish)

(3) All concentrations in pCi(U)/g ash; wet weight: ash weight ratio ≅31:1.

(4) Bq/g in parentheses.

(5) C. L. = Average Concentration ×÷ the value shown. Derived from log-transformed data; $= 2t_{(0.05,\, df)} S_{\bar{x}}$.

(6) ND = Not Determined.

TABLE 23 External Radiation Exposure

Sampling Location (1)	Exposure Rate in uR/hr (also = Gy/hr × 10^{-8}) Minimum	Maximum	Average (2)
BS1	8.24	12.33	10.78
BS2	9.16	12.88	11.51
BS3	9.10	12.52	11.06
BS4	9.36	12.19	11.10
BS5	8.92	12.73	11.10
BS6	14.50	19.10	16.95
BS7	10.30	13.77	12.44
Off Site 1A	10.08	12.71	11.75
Off Site 1B	9.64	12.43	11.38
Off Site 2A	9.90	12.76	11.50
Off Site 2B	9.51	12.00	11.08

Footnotes:

(1) See Figure 2..

(2) Continuous monitoring with environmental TLD's processed quarterly.

TABLE 24 Summary of Radiation Exposure Due to 1985 Emissions

Exposures	Organ	Dose Equivalent 50-Year Commitment mrem	(SV)	Guideline (1)	% of Guideline
I. Maximum Individual Dose					
A. All pathways from all Airborne Releases (2)	Effective	1.9	(18.7)	100	1.9
	Bone Surface	0.3	(9.5)	75	0.4
	Pulmonary	8.9	(88.7)	75	11.9
	Whole Body (3)	<0.0002	(<0.002)	25	<0.0008
B. Ingestion (4)					
Great Miami River Water	Effective	0.002	(0.02)	100	0.002
	Bone Surface	0.04	(0.4)	5000	0.0008
Off-Site Well 15 (5)	Effective	22.1	(221)	100	22.1
	Bone Surface	328.1	(3281)	5000	6.6
C. Direct External Exposure	Whole Body (6)	17.5	(175)	100	17.5
II. Individual in Ross, Ohio Inhalation Pathway (4)	Effective	0.5	(5)	100	0.5
	Bone Surface	1.4	(14)	75	1.9
	Pulmonary	3.3	(33)	75	4.4
III. 80 km Population Total (2)	Effective	55	(526)	2.6×10^{8}	2.1×10^{-7}
	Whole Body	0.005	(0.05)	6.44×10^{7}	7.8×10^{-9}

Footnotes:

(1) Guidelines: Radiation Standards for Protection of the Public in the Vicinity of DOE Facilities, published November 14, 1985, adopts the standards of 40 CFR 61, Subpart H (NESHAP) for Air Pathway Exposures (25 mrem whole body, 75 mrem to any organ), and adopts the recommendations of ICRP 26 for prolonged periods of exposure for all pathways. (100 mrem effective dose, 100 mrem whole body dose, 5 rem to any organ).

(2) Dose calculations provided by ORNL using AIRDOS/DARTAB. 80 km population dose is expressed as person-rem.

(3) Whole body dose equivalent provided by ORNL. It results from radionuclides not deposited throughout the body, therefore the whole body dose equivalent from all radionuclides released at FMPC results from external exposure only.

(4) Dose equivalent calculation based on environmental measurements according to ICRP 26/30 Methodology. ICRP 26/30 based 50-year commitment dose conversion factors from Dunning (1986)[13].

(5) Off-site Well 15 contained the highest concentration of uranium measured in offsite wells in 1985. Dose calculations show maximum hypothetical dose from off-site well water ingestion.

(6) Calculated from measured exposure at the nearest residence west of the K-65 storage silos.

TABLE 25 Population Distribution Within 80 km (50 mi) of the FMPC

Compass Sector	Estimated Population (1)			
	0 - 8 km (0 - 5 mi)	8 - 16 km (5 - 10 mi)	16 - 32 km (10 - 20 mi)	32 - 80 km (20 - 50 mi)
N	445	3,395	6,743	29,597
NNE	221	18,959	12,805	148,079
NE	489	32,001	36,705	557,783
ENE	2,489	25,760	29,830	55,078
E	512	40,770	70,762	85,240
ESE	713	54,533	150,630	107,365
SE	1,606	36,467	247,846	118,490
SSE	985	28,932	207,202	51,946
S	669	19,214	53,673	39,116
SSW	390	4,217	10,614	21,987
SW	185	2,957	13,066	16,574
WSW	440	4,961	3,930	19,199
W	519	1,765	3,292	31,629
WNW	157	1,361	5,211	21,605
NW	511	1,433	1,802	37,945
NNW	519	1,134	21,042	71,493
Totals	10,850	277,859	875,153	1,413,126
Total in all sectors: 2,576,988				

Footnote:

(1) Based on "Report of Findings, Population Studies for DOE Feed Materials Production Center, Near Fernald, Ohio, for NLO, Inc.", May 18, 1981.

APPENDIX II

PARAMETERS TO BE ANALYZED FOR RCRA GROUNDWATER SAMPLING

A. For General Water Quality

1. Chloride
2. Iron
3. Manganese
4. Phenols (total)
5. Sodium
6. Sulfate

B. For Indicators of Contamination (Quadruplicate Analysis)

1. pH
2. Specific Conductance
3. Total Organic Carbon (TOC)
4. Total Organic Halogen (TOX)

C. For Drinking Water Suitability

1. Arsenic
2. Barium
3. Cadmium
4. Chromium - Hexavalent
   - Total
5. Fluoride
6. Lead
7. Mercury
8. Nitrate (as N)
9. Selenium
10. Silver
11. Gross alpha
12. Gross beta
13. Radium
14. Endrin
15. Lindane
16. Methoxychlor
17. Toxaphene
18. 2, 4-D
19. 2, 4, 5-TP Silvex
20. Coliform Bacteria

D. Other Metals, Organics, and Site Specific Parameters

1. Nickel
2. Cyanide
3. Copper
4. Zinc
5. Magnesium
6. Calcium
7. Phosphorus
8. Chlorobenzene
9. Chlorodibromomethane
10. Chloroethane
11. 2-chloroethylvinyl Ether
12. Chloroform
13. Dichlorobromomethane
14. Dichlorodifluoromethane
15. Total Dissolved Solids (TDS)
16. Total Potassium
17. Chemical Oxygen Demand (COD)
18. per Chloroethylene
19. cis 1, 2 Dichloroethylene
20. Tributylphosphate

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21. Acrolein
22. Acrylonitrile
23. Benzene
24. bis(chloromethyl) Ether
25. Bromoform
26. Bromodichloromethane
27. Bromomethane
28. Carbontetrachloride
29. Chloromethane
30. 1.2 Dichlorobenzene
31. 1,3 Dichlorobenzene
32. 1,4 Dichlorobenzene
33. 1,1 Dichloroethane
34. 1,2 Dichloroethane
35. 1,1 Dichloroethylene
36. 1,2 Dichloropropane
37. 1,2 Dichloropropylene
38. Ethylbenzene
39. Methylbromide
40. Methylchloride
41. trans-1,2 Dichloroethylene
42. 1,3 Dichloropropene
43. 1,1,2,2 Tetrachloroethane
44. Tetrachloroethylene
45. Toulene
46. 1,1,1 Trichloroethane
47. 1,1,2 Trichloroethane
48. Trichloroethylene
49. Trichlorofluoromethane
50. Vinyl Chloride

E. Radionuclides

1. Potassium 40
2. Total Uranium
3. Radium 226
4. Radium 228
5. Technetium 99
6. Thorium 228
7. Thorium 230
8. Thorium 232
9. Cesuium 137
10. Strontium 90
11. Ruthenium 106
12. Neptunium 237
13. Plutonium 238
14. Plutonium 239
15. Plutonium 240

F. Schedule - Quarterly for one (1) years, semiannual thereafter (or as necessary according to regulations).

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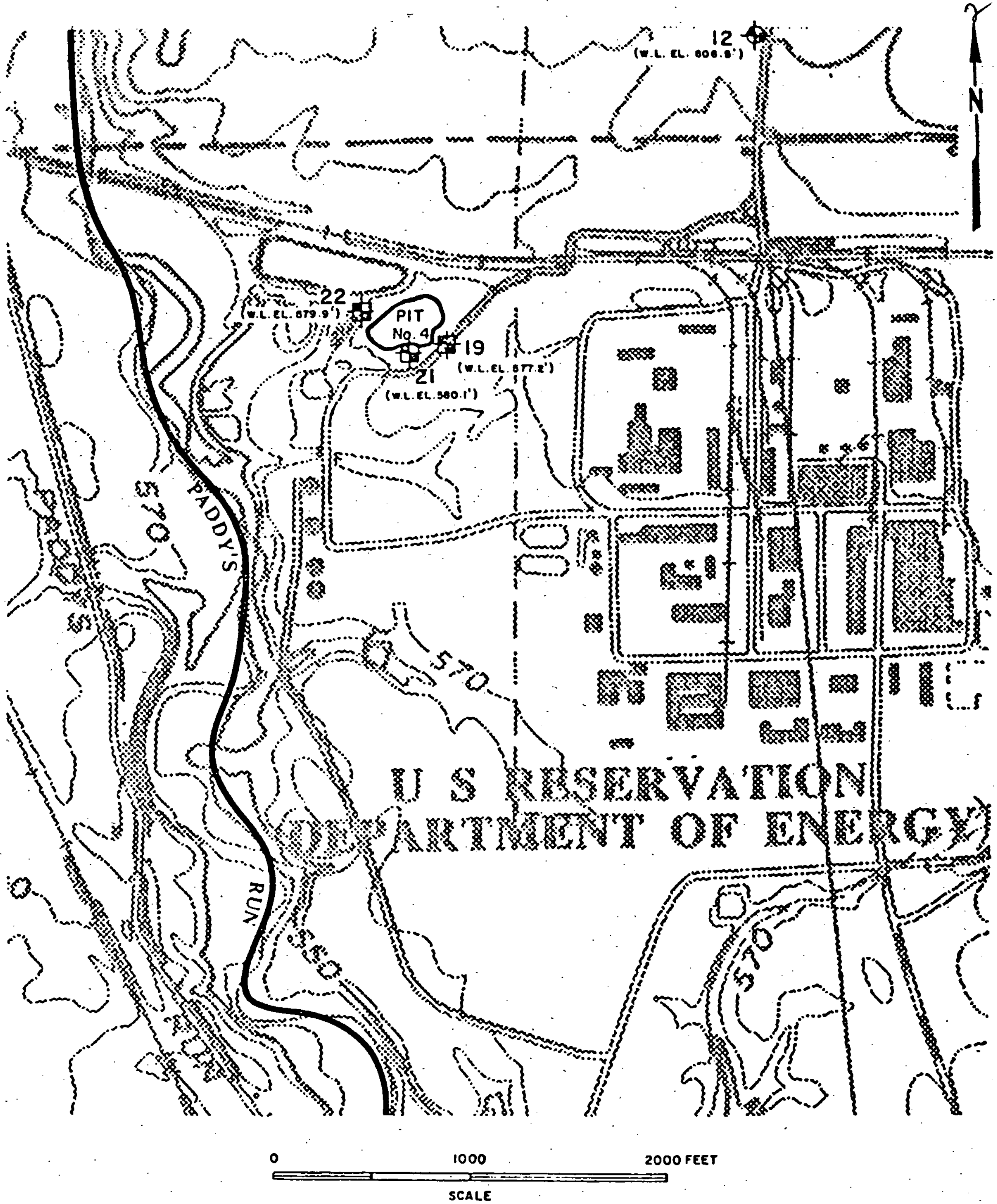
APPENDIX III

RESULTS OF RCRA GROUNDWATER SAMPLING



EXPLANATION:

- SINGLE WELL LOCATION
- CLUSTER WELL LOCATION

RCRA
WELL LOCATIONS

REFERENCE: BASE MAP TAKEN FROM U.S.G.S. 7.5' TOPOGRAPHIC MAP, SHANDON, OHIO (1981) QUADRANGLE

GROUND-WATER SAMPLING RESULTS - FMPC - Pit #4
(All results in ppm except as noted)

	MW-12	MW-TP19	MW-TP21	MW-TP22	Standards		
					Primary(6)	Secondary (7)	Recommended (12)
Chloride	109	459	58	118	--	250	--
Iron	18.1	4.57	58.4	2.26	--	0.3	--
Manganese	0.216	2.75	3.77	2.01	--	0.05	--
Phenols	0.019	0.049	<0.005	<0.005	--	--	0.001
Sodium	268.0	34.6	40.5	19.3	--	--	--
Sulfate	72	575	30	850	--	250	--
Silver	<0.030	<0.030	<0.030	<0.030	0.05	--	--
Arsenic	<0.0025	0.008	0.03	0.006	0.05	--	--
Barium	<0.200	0.308	0.863	0.363	1.0	--	--
Calcium	53	372	415	154	--	--	--
Cadmium	<0.002	<0.002	<0.002	<0.002	0.010	--	--
Cyanide	<0.005	<0.005	<0.005	<0.005	--	--	0.05
Chromium							
- Total	0.055	0.049	0.08	<0.005	0.05	--	--
- Hexavalent	<0.01	<0.01	<0.01	<0.01	--	--	--
Copper	<0.025	<0.025	0.074	<0.025	--	1.0	--
Fluoride	2.00	0.33	0.52	1.80	1.4-2.4	--	--
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	0.002	--	--
Potassium	NA	NA	NA	NA	--	--	--
Magnesium	12.3	12.8	18.3	7.8	--	--	--
Nickel	0.06	0.026	0.137	0.015	--	--	--
Nitrates	<0.02	<0.02	<0.02	0.06	10.0	--	--
Lead	0.320	<0.005	0.012	<0.005	0.05	--	--
Phosphorus, total	0.26	0.14	0.21	1.15	--	--	--
Selenium	<0.0025	<0.0025	<0.0025	<0.0025	0.01	--	--
Zinc	0.081	0.029	0.240	<0.025	--	5.0	--
T.D.S.	660	2540	936	2240	--	500	--
C.O.D.	17.0	12.0	14.	44.	--	--	--
pH-lab (1)(2)	7.48	6.63	6.99	6.75	--	6.5-8.5	--
Conductivity-lab (1)(3)	880	2350	1000	1950	--	--	--
T.O.C.(1)	<1.00	4.00	4.00	6.5	--	--	--
T.O.X.(1)(4)	<10.00	80.25	<10.00	<10.00	--	--	--

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	MW-12	MW-TP19	MW-TP21	MW-TP22	Standards		
					Primary (6)	Restricted (9)	Unrestricted (9)
Gross Beta (5)	30	94	250 (8)	1340 (8)	30	--	--
Gross Alpha (5)	<10	43	230 (8)	1370 (8)	15	--	--
Potassium 40 (5)	<10	<10	15	75	--	90,000	3000
Uranium Natural(5)	<10	<10	<10	<50	--	20,000	600
Radium-226 (5)	<10	<10	<10	<50	5 (10)	400	30
Radium-228 (5)	<5	<5	12	75	5 (10)	800	30
Technicium-99 (5)	<5	<5	<5	<5	--	10,000,000	300,000
Thorium-228 (5)	<5	<5	<5	<5	--	200,000	7000
Thorium-230 (5)	<5	<5	<5	<5	--	50,000	2000
Thorium-232 (5)	<5	<5	<5	88	--	50,000	2000
Cesium-137 (5)	<5	22	48	115	--	400,000	20000
Strontium-90 (5)	<5	<5	14	28	8	10,000	300
Ruthenium-106 (5)	<10	<10	15	80	--	400,000	10000
Neptunium-237 (5)	<10	<10	14	50	--	90,000	3000
Plutonium-238 (5)	<10	<10	<40	<100	--	100,000	5000
Plutonium-239 (5)	<10	<10	<40	<100	--	100,000	5000
Plutonium-240 (5)	<10	<10	<40	<100	--	100,000	5000
Coliform, Total (11)	<20	<20	<20	<20	1	--	--
Lindane (4)	<0.2	<0.2	<0.2	<0.2	4	--	--
Endrin (4)	<0.2	<0.2	<0.2	<0.2	0.2	--	--
Methoxychlor(4)	<0.2	<0.2	<0.2	<0.2	100	--	--
Toxaphene (4)	<0.5	<0.5	<0.5	<0.5	5	--	--
2,4-D (4)	<0.4	<0.4	<0.4	<0.4	10	--	--
2,4,5-TP, Silvex (4)	<0.2	<0.2	<0.2	<0.2	10	--	--
Benzene (4)	14.8	ND	ND	ND	--	--	--
Xylenes (4)	11.8	ND	ND	ND	--	--	--
1,1 Dichloro-ethane (4)	ND	3.4	ND	ND	--	--	--
Methylene chloride (4)	ND	Trace	ND	ND	--	--	--

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NOTES

ND Not detected

NA Not Analyzed due to laboratory error

(1) Average of four tests

(2) pH results in standard units

(3) Conductivity results in umhos/cm

(4) Concentrations reported in ppb

(5) Results in pCi/l

(6) Taken from 40 CFR Part 141 National Interim Primary Drinking Water Regulations -Subpart B - Maximum Contaminant Levels, July 1, 1984.

(7) Taken from 40 CFR Part 143 National Secondary Drinking Water Regulations -Section 143.3 - Secondary Maximum Contaminant Levels.

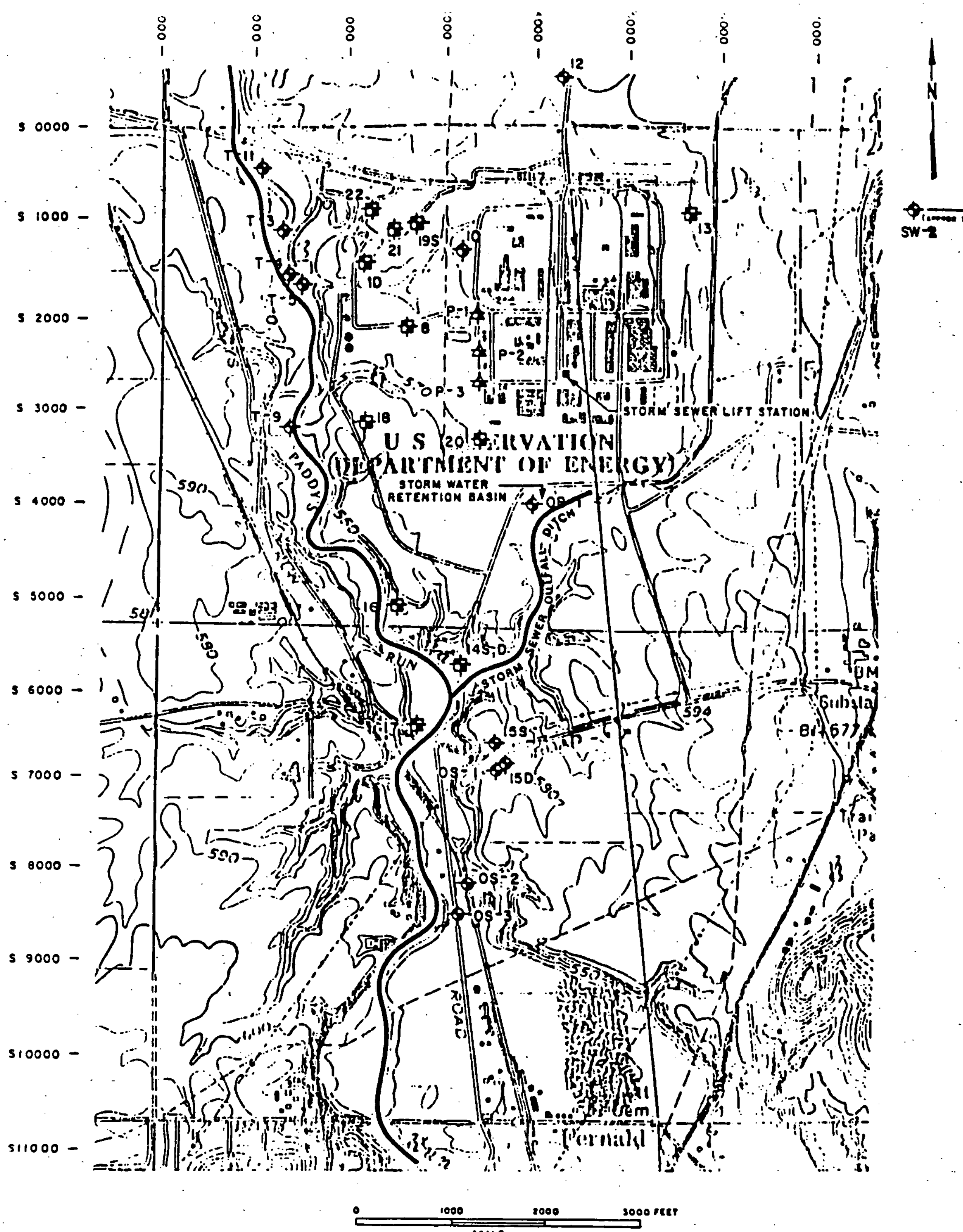
(8) High counts did not yield any individual elements using a 4096 channel analyzer. These levels are due to solids only in the samples

(9) Taken from DOE Order 5480.1A: Limit for Release to Restricted and Unrestricted Areas.

(10) Standard is for Radium -226 Plus Radium -228.

(11) Reported in per 100 ml.

(12) Taken from World Health Organization, European Standards, 1970.



EXPLANATION:

- SINGLE WELL LOCATION
- CLUSTER WELL LOCATION
- PRODUCTION WELL LOCATION
- S2000 - PLANT COORDINATE SYSTEM

REFERENCE: BASE MAP TAKEN FROM U.S.G.S. 7.5' TOPOGRAPHIC MAP, SHANDON, OHIO (1981) QUADRANGLE

WELL LOCATIONS

GROUND-WATER SAMPLING RESULTS - FMPC - Sand and Gravel Aquifer
(All results in ppm except as noted)

	SW-1	MW-1d	MW-10	Standards Primary (6)	Standards Secondary (7)	Standards Recommended (8)
Chloride	30	25	76	---	250	---
Iron	<0.05	61.8	18.9	---	0.3	---
Manganese	0.125	0.649	5.5	---	0.05	---
Phenols	<0.005	0.015	<0.005	---	---	0.001
Sodium	15	29.7	162	---	---	---
Sulfate	60	40	470	---	250	---
Silver	<0.03	<0.03	<0.03	0.05	---	---
Arsenic	<0.005	<0.005	<0.005	0.05	---	---
Barium	<0.2	<0.2	<0.2	1.0	---	---
Calcium	94.4	80.7	1,232	---	---	---
Cadmium	<0.002	<0.002	0.003	0.010	---	---
Cyanide	<0.005	<0.005	0.005	---	---	0.05
Chromium						
- Total	<0.005	0.019	0.014	0.05	---	---
- Hexavalent	<0.005	0.01	0.01	---	---	---
Copper	<0.025	0.146	<0.025	---	1.0	---
Fluoride	0.15	0.12	0.05	1.4-2.4	---	---
Mercury	<0.0002	<0.0002	<0.0002	0.002	---	---
Potassium	2.4	1.5	20.2	---	---	---
Magnesium	27.2	24.2	90	---	---	---
Nickel	<0.005	0.012	0.039	---	---	---
Nitrates	2.06	<0.02	155.6	10.0	---	---
Lead	<0.005	0.028	<0.005	0.05	---	---
Phosphorus. total	<0.02	0.45	0.05	---	---	---

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	SW-2	MW-1d	MW-10	Standards Primary (6)	Restricted (9)	Unrestricted (9)
Gross Reta (5)	<5	<10	<10	30 (12)	---	---
Gross Alpha (5)	<10	12	10	15	---	---
Potassium 40 (5)	<10	<10	<10	---	90,000	3000
Uranium Natural (5)	<10	<10	<10	---	20,000	600
Radium-226 (5)	<10	<10	<10	5 (10)	400	30
Radium-228 (5)	<5	<5	<5	5 (10)	800	30
Technicium-99 (5)	<5	<5	<5	---	10,000,000	300,000
Thorium-228 (5)	<5	<5	<5	---	200,000	7000
Thorium-230 (5)	<5	<5	<5	---	50,000	2000
Thorium-232 (5)	<5	<5	<5	---	50,000	2000
Cesium-137 (5)	<5	<5	12	---	400,000	20,000
Strontium-90 (5)	<5	<5	<5	8	10,000	300
Ruthenium-106 (5)	<10	<10	<10	---	400,000	10,000
Neptunium-237 (5)	<10	<10	<10	---	90,000	3000
Plutonium-238 (5)	<10	<10	<10	---	100,000	5000
Plutonium-239 (5)	<10	<10	<10	---	100,000	5000
Plutonium-240 (5)	<10	<10	<10	---	100,000	5000
Coliform, Total (10)	18	190,000	140,000	1	---	---
Lindane (4)	NA	NA	NA	4	---	---
Endrin (4)	NA	NA	NA	0.2	---	---
Methoxychlor (4)	NA	NA	NA	100	---	---
Toxaphene (4	NA	NA	NA	5	---	---
2,4-D (4)	NA	NA	NA	10	---	---
2,4,5-TP, Silvex (4)	NA	NA	NA	10	---	---

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	MW-14d	MW-14s	MW-18s	MW-19s	Standards Primary (6)	Secondary (7)	Recommended (8)
Chloride	15	19	7	49	---	250	---
Iron	0.123	37.2	18.3	5.33	---	0.3	---
Manganese	<0.02	0.451	0.818	0.318	---	0.05	---
Phenols	<0.005	0.015	<0.005	0.006	---	---	0.001
Sodium	12.7	10.4	8.6	180	---	---	---
Sulfate	70	70	50	130	---	250	---
Silver	<0.03	<0.03	<0.03	<0.03	0.05	---	---
Arsenic	<0.005	<0.025	<0.01	<0.005	0.05	---	---
Barium	<0.2	<0.2	<0.2	<0.2	1.0	---	---
Calcium	89	241	165	361	---	---	---
Cadmium	<0.002	0.005	0.003	0.002	0.010	---	---
Cyanide	<0.005	<0.005	<0.005	0.013	---	---	0.05
Chromium							
- Total	<0.005	0.159	0.147	0.133	0.05	---	---
- Hexavalent	<0.005	0.03	0.01	<0.01	---	---	---
Copper	<0.025	0.289	0.179	0.109	---	1.0	---
Fluoride	0.13	1.1	0.7	1.06	1.4-2.4	---	---
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	0.002	---	---
Potassium	1.9	5	5.22	5.7	---	---	---
Magnesium	19	44.3	50	93	---	---	---
Nickel	0.01	0.027	0.022	0.008	---	---	---
Nitrates	1.2	0.89	0.72	25.04	10.0	---	---
Lead	0.011	0.1	0.047	0.072	0.05	---	---
Phosphorus, total	0.06	1.04	0.44	0.13	---	---	---
Selenium	<0.0025	<0.0025	<0.0025	<0.0025	0.01	---	---
Zinc	<0.025	0.166	0.109	0.281	---	5.0	---
T.D.S.	352	436	396	888	---	500	---
C.O.D.	10	32	52	18	---	---	---

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	MW-14d	MW-14s	MW-18s	MW-19s	Standards Primary (6)	Standards Secondary (7)	Standards Recommended (8)
pH-lab (1)(2)	6.97	8.1	7.1	7.06	---	6.5-8.5	---
Conductivity-lab (1)(3)	400	420	480	1,000	---	---	---
T.O.C. (1)	4.5	4	3.25	3	---	---	---
T.O.X. (1)(4)	NA	NA	NA	NA	---	---	---

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	MW-14d	MW-14s	MW-18s	MW-19s	Standards Primary (6)	Standards Restricted (9)	Standards Unrestricted (9)
Gross Reta (5)	<5	46	44	1,250	30 (12)	---	---
Gross Alpha (5)	<10	47	21	36	15	---	---
Potassium 40 (5)	<10	<10	<10	40	---	90,000	3000
Uranium Natural (5)	<10	<10	<10	<10	---	20,000	600
Radium-226 (5)	<10	<10	<10	<10	5 (10)	400	30
Radium-228 (5)	<5	<5	<5	70	5 (10)	800	30
Technicium-99 (5)	<5	<5	<5	<5	---	10,000,000	300,000
Thorium-228 (5)	<5	<5	<5	<5	---	200,000	7000
Thorium-230 (5)	<5	<5	<5	<5	---	50,000	2000
Thorium-232 (5)	<5	<5	<5	80	---	50,000	2000
Cesium-137 (5)	<5	12	12	110	---	400,000	20,000
Strontium-90 (5)	<5	<5	<5	24	8	10,000	300
Ruthenium-106 (5)	<10	<10	<10	75	---	400,000	10,000
Neptunium-237 (5)	<10	<10	<10	<10	---	90,000	3000
Plutonium-238 (5)	<10	<10	<10	<100	---	100,000	5000
Plutonium-239 (5)	<10	<10	<10	<100	---	100,000	5000
Plutonium-240 (5)	<10	<10	<10	<100	---	100,000	5000
Coliform, Total (10)	110	2,200	3,500	197	1	---	---
Lindane (4)	NA	NA	NA	NA	4	---	---
Endrin (4)	NA	NA	NA	NA	0.2	---	---
Methoxychlor (4)	NA	NA	NA	NA	100	---	---
Toxaphene (4)	NA	NA	NA	NA	5	---	---
2,4-D (4)	NA	NA	NA	NA	10	---	---
2,4,5-TP, Silvex (4)	NA	NA	NA	NA	10	---	---
1,1,1 Trichloro-ethane	ND	ND	ND	8.6	---	---	---

NOTES

ND Not Detected
NA Not Analyzed (See page 3-4 for explanation)
(1) Average of four tests
(2) pH results in standard units
(3) Conductivity results in umhos<cm
(4) Concentrations reported in ppb
(5) Results in pCi/l
(6) Taken from 40 CFR Part 141 National Interim Primary Drinking Water Regulations - Support B - Maximum Contaminant Levels, July 1, 1984.
(7) Taken from 40 CFR Part 143 National Secondary Drinking Water Regulations - Section 143.3 - Secondary Maximum Contaminant Levels.
(8) High counts did not yield any individual elements using a 4096 channel analyzer. These levels are due to solids only in the samples.
(9) Taken from DOE Order 5480.1A: Limit for Release to Restricted and Unrestricted Areas
(10) Standard is for Radium -226 Plus Radium -228.
(11) Reported in per 100 ml
(12) Maximum Permissible Activity taken from World Health Organization, 1970 European Standards. National Primary Drinking Water Regulation for gross beta is 4 mR/year.

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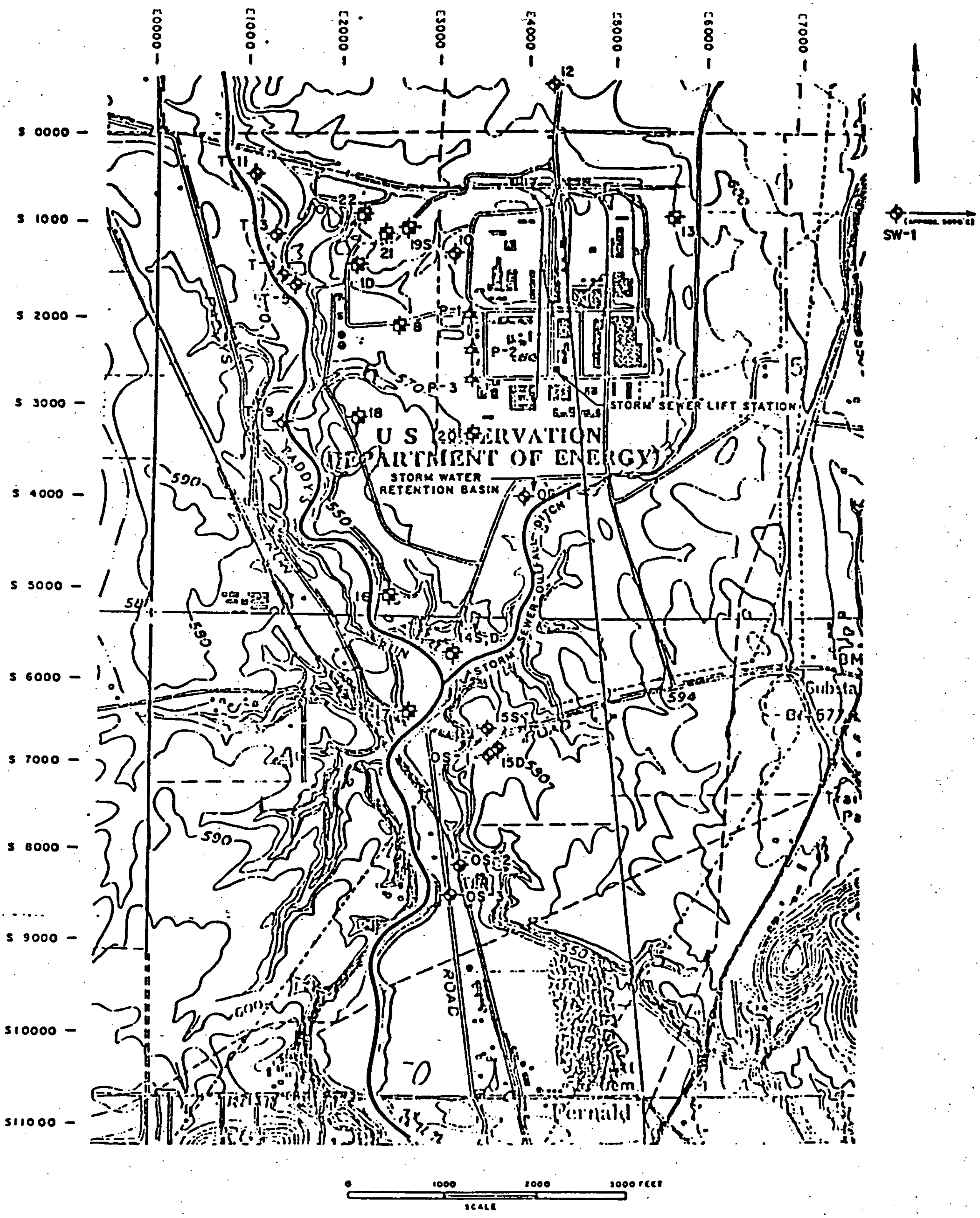

EXPLANATION:

- SINGLE WELL LOCATION
- CLUSTER WELL LOCATION
- PRODUCTION WELL LOCATION
- PLANT COORDINATE SYSTEM

REFERENCE: BASE MAP TAKEN FROM U.S.G.S. 7.5' TOPOGRAPHIC MAP, SHANDON, OHIO (1961) QUADRANGLE

WELL LOCATIONS

GROUND-WATER SAMPLING RESULTS - FMPC
(All results in ppm except as noted)

	1S	1D	3	4	5	8S	Standards Primary (6)	Secondary (7)	Recommended (8)
Chloride	18	25	22	32	17	19	---	250	---
Iron	0.628	61.8	0.638	0.218	1.82	1.6	---	0.3	---
Manganese	0.511	0.649	0.426	<0.02	0.532	0.257	---	0.05	---
Phenols	<0.005	0.015	<0.005	<0.005	<0.005	<0.005	---	---	0.001
Sodium	10	29.7	9.5	12.6	12.8	9.5	---	---	---
Sulfate	74	40	88	54.0	82	78	---	250	---
Silver	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.05	---	---
Arsenic	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.05	---	---
Barium	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	1.0	---	---
Calcium	108	80.7	102	101	115	104	---	---	---
Cadmium	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.010	---	---
Cyanide	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	---	---	0.05
Chromium									
- Total	<0.005	0.019	<0.005	<0.005	<0.005	<0.005	0.05	---	---
- Hexavalent	<0.005	0.01	<0.005	<0.005	<0.005	<0.005	---	---	---
Copper	<0.025	0.146	<0.025	<0.025	<0.025	<0.025	---	1.0	---
Fluoride	0.41	0.12	0.25	0.29	0.24	0.14	1.4-2.4	---	---
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.002	---	---
Potassium	2.26	1.5	2.40	2.79	2.21	2.34	---	---	---
Magnesium	23.9	24.2	23.3	22.2	25.5	22.5	---	---	---
Nickel	<0.005	0.012	<0.005	<0.005	<0.005	<0.005	---	---	---
Nitrates	0.04	<0.02	<0.02	1.43	0.09	<0.02	10.0	---	---
Lead	<0.005	0.028	<0.005	<0.005	<0.005	<0.005	0.05	---	---
Phosphorus, total	<0.04	0.45	<0.04	<0.04	<0.04	<0.04	---	---	---

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GROUND-WATER SAMPLING RESULTS - FMPC
(All results in ppm except as noted)

	1S	1D	3	4	5	8S	Standards Primary (6)	Standards Secondary (7)	Standards Recommended (8)
Selenium	<0.005	<0.0025	<0.005	<0.005	<0.005	<0.005	0.01	---	---
Zinc	<0.025	0.141	<0.025	<0.025	<0.025	<0.025	---	5.0	---
T.D.S.	415	444	369	369	396	381	---	500	---
C.O.D.	<10	84	<10	<10	<10	<10	---	---	---
pH-lab (1) (2)	7.20	7.26	7.32	7.36	7.36	7.34	---	6.5-8.5	---
Conductivity-lab (1) (3)	600	400	590	580	620	588	---	---	---
T.O.C. (1)	1	5	1	1	<1	<1	---	---	---
T.O.X. (1) (4)	28.5	NA	11.8	<10	<10	<10	---	---	---
Coliform (4) (5)	<2	190,000	<2	380	17	36	1	---	---
Lindane (4)	<0.1	NA	<0.1	<0.1	<0.1	<0.1	4	---	---
Endrin (4)	<0.1	NA	<0.1	<0.1	<0.1	<0.1	0.2	---	---
Methoxychlor (4)	<0.1	NA	<0.1	<0.1	<0.1	<0.1	100	---	---
Toxaphene (4)	<0.5	NA	<0.5	<0.5	<0.5	<0.5	5	---	---
2,4-D (4)	<0.4	NA	<0.4	<0.4	<0.4	<0.4	10	---	---
2,4,5-TP, Silvex (4)	<0.2	NA	<0.2	<0.2	<0.2	<0.2	10	---	---
VOC's (4)	NA	ND	NA	ND	NA	ND	---	---	---
Gross Alpha(9)	<15.0	(11)	<15.0	<15.0	<15.0	<15.0	See previous table, p.		
Gross Beta(9)	15	(11)	17	17	12	7	The result of <5.0 pCi/l is applied to all		
Rad Scan(9)(10)	<5.0	(11)	<5.0	<5.0	<5.0	<5.0	radionuclides listed in Appendix II.		
Radium (9)	<5.0	(11)	<5.0	<5.0	<5.0	<5.0			

GROUND-WATER SAMPLING RESULTS - FMPC
(All results in ppm except as noted)

	8D	9	10	11	12 (8/1/85)	12 (1/8/86)	13S	13D	14D	14S	15S	16S	16D
Chloride	13	22	76	21	109	105	25	61	15	19	23	19	20
Iron	2.62	0.072	18.9	2.93	18.1	30.8	2.71	6.93	0.123	37.2	0.078	<0.05	0.123
Manganese	0.365	0.071	5.5	0.193	0.216	0.592	0.205	0.349	<0.02	0.451	<0.020	0.025	<0.02
Phenols	<0.005	0.007	<0.005	<0.007	0.019	0.021	<0.005	0.012	<0.005	0.015	0.007	0.009	0.009
Sodium	11.9	11.0	162	12.9	268.0	224	14.7	49	12.7	10.4	11.9	15.6	11.1
Sulfate	10	76	470	88	72	64	92	300	70	70	49	50	60
Silver	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Arsenic	<0.005	<0.005	<0.005	<0.005	<0.0025	0.006	<0.005	<0.005	<0.005	<0.025	<0.005	<0.005	<0.005
Barium	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Calcium	94.7	96.6	1,232	123	53	72.1	137	163	89	241	71.9	88.5	81.8
Cadmium	<0.002	<0.002	0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.005	<0.002	<0.002	<0.002
Cyanide	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Chromium													
- Total	<0.005	<0.005	0.014	<0.005	0.055	0.058	<0.005	<0.005	<0.005	0.159	<0.005	<0.005	<0.005
- Hexavalent	<0.005	<0.005	0.01	<0.005	<0.01	<0.01	<0.005	<0.005	<0.005	0.03	<0.005	<0.005	<0.005
Copper	<0.025	<0.025	<0.025	<0.025	<0.025	0.055	<0.025	<0.025	<0.025	0.289	<0.025	<0.025	<0.025
Fluoride	0.24	0.21	0.05	0.21	2.00	1.21	0.23	0.31	0.13	1.1	0.43	0.22	0.16
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Potassium	1.04	2.02	20.2	0.984	NA	12.8	2.05	5.11	1.9	5	2.37	2.17	1.85
Magnesium	21.1	22.1	90	28.3	12.3	18.3	28.6	44	19	44.3	19.5	23.4	20.7
Nickel	<0.005	<0.005	0.039	<0.005	0.06	0.048	<0.005	<0.0005	0.01	0.027	<0.0005	<0.0005	<0.0005
Nitrates	<0.02	3.52	155.6	<0.01	<0.02	<0.02	<0.02	<0.02	1.2	0.89	3.3	2.52	2.36
Lead	<0.005	<0.005	<0.005	<0.005	0.320	0.04	<0.005	<0.005	0.011	0.1	<0.005	<0.005	<0.005
Phosphorus, total	<0.04	<0.04	0.05	<0.04	0.26	0.14	<0.04	<0.04	0.06	1.04	0.12	<0.04	<0.04

GROUND-WATER SAMPLING RESULTS - FMPC
(All results in ppm except as noted)

	8D	9	10	11	12 (8/1/85)	12 (1/8/86)	13S	13D	14D	14S	15S	16S	16D
Selenium	<0.005	<0.005	<0.0025	<0.005	<0.0025	<0.005	<0.005	<0.005	<0.0025	<0.0025	<0.005	<0.005	<0.005
Zinc	<0.025	<0.025	0.056	<0.025	0.081	0.135	<0.025	<0.025	<0.025	0.166	<0.025	<0.025	<0.025
T.D.S.	288	377	2,540	423	660	580	300	956	352	436	376	364	356
C.O.D.	<10	<10	20	<10	17.0	<10	<10	13	10	32	17	11	21
pH-lab (1) (2)	7.40	7.46	7.1	7.42	7.48	7.79	7.15	6.97	6.97	8.1	7.54	7.50	7.54
Conductivity-lab (1) (3)	530	540	2,400	650	880	998	695	1,250	400	420	498	560	520
T.O.C. (1)	<1	<1	4	1	<1.00	<1	<1	1	4.5	4	<1	1	<1
T.O.X. (1) (4)	<10	<10	NA	<10	<10.00	64	44.7	79	NA	NA	21.8	16.9	28.5
Coliform (5)	<4	24	140,000	<4	<20	<4	<4	<2	110	2,200	<2	<2	<2
Lindane (4)	<0.1	<0.1	NA	<0.1	<0.2	<0.1	<0.1	<0.1	NA	NA	<0.1	<0.1	<0.1
Endrin (4)	<0.1	<0.1	NA	<0.1	<0.2	<0.1	<0.1	<0.1	NA	NA	<0.1	<0.1	<0.1
Methoxychlor (4)	<0.1	<0.1	NA	<0.1	<0.2	<0.1	<0.1	<0.1	NA	NA	<0.1	<0.1	<0.1
Toxaphene (4)	<0.5	<0.5	NA	<0.5	<0.5	<0.5	<0.5	<0.5	NA	NA	<0.5	<0.5	<0.5
2,4-D (4)	<0.4	<0.4	NA	<0.4	<0.4	<0.4	<0.4	<0.4	NA	NA	<0.4	<0.4	<0.4
2,4,5-TP, Silvex (4)	<0.2	<0.2	NA	<0.2	<0.2	<0.2	<0.2	<0.2	NA	NA	<0.2	<0.2	<0.2
VOC's (4)	ND	ND	ND	ND		ND	ND	ND	ND	ND	ND	ND	ND
Benzene (4)					14.8								
Xylene (4)					11.8								
Gross Alpha(9)	<15.0	<15.0	(11)	<15.0	(11)	18	<15.0	<15.0	(11)	(11)	<15.0	<15.0	<15.0
Gross Beta(9)	12	11	(11)	9	(11)	78	15	< 5.0	(11)	(11)	< 5.0	< 5.0	< 5.0
Rad Scan(9)(10)	< 5.0	< 5.0	(11)	< 5.0	(11)	<5.0	< 5.0	< 5.0	(11)	(11)	< 5.0	< 5.0	< 5.0
Radium (9)	< 5.0	< 5.0	(11)	< 5.0	(11)	<5.0	< 5.0	< 5.0	(11)	(11)	< 5.0	< 5.0	< 5.0

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GROUND-WATER SAMPLING RESULTS - FMPC
(All results in ppm except as noted)

	17S	17D	18S	18D	19D	19S	20S	20D	TP-20	21S	22S	OS-1A
Chloride	24	19	7	4	57	49	21	20	3	37	62	34
Iron	0.101	1.29	18.3	8.94	<0.05	5.33	0.102	1.12	5.43	0.262	0.379	0.338
Manganese	0.234	0.36	0.818	0.104	3.73	0.318	0.043	0.235	1.04	0.052	0.061	0.054
Phenols	0.006	0.011	<0.005	0.006	0.011	0.006	0.006	<0.005	0.007	0.015	0.006	0.012
Sodium	8.75	10.2	8.6	4.59	86.8	180	11.6	14.1	4.1	28.3	31.8	33.1
Sulfate	150	72	50	62	440	130	78	80	48	84	98	102
Silver	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Arsenic	<0.005	<0.005	<0.01	<0.005	<0.005	<0.005	<0.005	<0.005	0.011	<0.005	<0.005	<0.005
Barium	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Calcium	148	106	165	102	240	361	96.6	99	108	148	137	143
Cadmium	<0.002	<0.002	0.003	<0.002	<0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Cyanide	<0.005	<0.005	<0.005	<0.005	<0.005	0.013	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Chromium												
- Total	<0.005	<0.005	0.147	<0.005	<0.005	0.133	0.017	<0.005	<0.005	<0.005	<0.005	<0.005
- Hexavalent	<0.005	<0.005	0.01	<0.005	<0.005	<0.01	<0.01	<0.005	<0.005	<0.005	<0.005	<0.005
Copper	<0.025	<0.025	0.179	<0.025	<0.025	0.109	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Fluoride	0.3	0.12	0.7	0.44	0.08	1.06	0.15	0.11	0.47	0.21	0.71	0.24
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Potassium	1.94	1.9	5.22	0.556	8.73	5.7	2.46	1.69	1.22	9.35	3.95	32.4
Magnesium	32.1	19.5	50	35.3	35.5	93	21.1	23.1	31.7	18	40.3	47
Nickel	<0.005	<0.005	0.022	<0.005	<0.009	0.008	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Nitrates	0.15	<0.02	0.72	<0.02	0.46	25.04	5.67	<0.02	<0.02	39.3	42	7.99
Lead	<0.005	<0.005	0.047	<0.005	<0.005	0.072	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Phosphorus, total	<0.04	<0.04	0.44	0.11	<0.04	0.13	<0.04	<0.04	0.44	<0.04	<0.04	0.38

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GROUND-WATER SAMPLING RESULTS - FMPC
(All results in ppm except as noted)

	17S	17D	18S	18D	19D	19S	20S	20D	TP-20	21S	22S	OS-1A
Selenium	<0.005	<0.005	<0.0025	<0.005	<0.005	<0.0025	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Zinc	<0.025	<0.025	0.109	<0.025	<0.025	0.281	<0.025	<0.025	<0.025	<0.025	<0.025	<0.07
T.D.S.	612	612	396	388	424	888	436	420	324	712	712	600
C.O.D.	<10	<10	52	<10	<10	18	<10	<10	<10	<10	<10	<10
pH-lab (1) (2)	7.13	7.31	7.1	7.30	6.83	7.06	7.50	7.41	7.05	7.33	7.30	7.15
Conductivity-lab (1) (3)	810	553	480	575	1,600	1,000	545	560	570	908	980	1,010
T.O.C. (1)	<1	<1	3.25	<1	1	3	<1	<1	3	1	2	2.5
T.O.X. (1) (4)	<10	<10	NA	<10	<10	NA	36.5	18.9	25.5	<10	29	23.3
Coliform (5)	<2	<2	3,500	<4	<4	197	<2	<2	10	<2	<2	2
Lindane (4)	<0.1	<0.1	NA	<0.1	<0.1	NA	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Endrin (4)	<0.1	<0.1	NA	<0.1	<0.1	NA	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Methoxychlor (4)	<0.1	<0.1	NA	<0.1	<0.1	NA	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Toxaphene (4)	<0.5	<0.5	NA	<0.5	<0.5	NA	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
2,4-D (4)	<0.4	<0.4	NA	<0.4	<0.4	NA	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
2,4,5-TP, Silvex (4)	<0.2	<0.2	NA	<0.2	<0.2	NA	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
VOC's (4)	NA	NA	ND	NA	NA		ND	ND	ND	ND	ND	ND
1,1,1 Trichloroethane (4)						8.6						
Gross Alpha (9)	<15.0	<15.0	(11)	<15.0	<15.0	(11)	<15.0	<15.0	<15.0	<15.0	<15.0	<15.0
Gross Beta (9)	< 5.0	< 5.0	(11)	< 5.0	< 5.0	(11)	< 9	< 5.0	77	400	78	< 5.0
Rad Scan (9)(10)	< 5.0	< 5.0	(11)	< 5.0	< 5.0	(11)	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0
Radium (9)	< 5.0	< 5.0	(11)	< 5.0	< 5.0	(11)	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0	< 5.0

GROUND-WATER SAMPLING RESULTS - FMPC
(All results in ppm except as noted)

	OS-1	15-D	OS-3	OS-2	SW-2 (8/27/85)	SW-2 (1/8/86)	P-1	P-2	P-3	TP19	TP21	TP22
Chloride	19	28	26	29	30	35	36	20	12	459	58	118
Iron	0.05	2.61	1.25	<0.05	<0.05	<0.05	5.31	2.78	2.51	4.57	58.4	2.26
Manganese	<0.02	0.349	0.373	<0.02	0.125	0.154	0.425	0.358	0.418	2.75	3.77	2.01
Phenols	0.008	0.014	0.02	0.011	<0.005	0.009	0.008	0.012	0.018	0.049	<0.005	<0.005
Sodium	11.2	6.8	10.5	11	15	17.4	26.6	11.5	11.0	34.6	40.5	19.3
Sulfate	54	86	58	18	60	96	16	50	42	575	30	850
Silver	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Arsenic	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.008	0.03	0.006
Barium	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.308	0.863	0.363
Calcium	67.8	106	85.7	90.6	94.4	93.2	116	84.5	85.3	372	415	154
Cadmium	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Cyanide	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Chromium												
- Total	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.049	0.08	<0.005
- Hexavalent	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.01	<0.01
Copper	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	0.074	<0.025
Fluoride	0.46	0.13	0.24	0.22	0.15	0.2	0.18	0.19	0.14	0.33	0.52	1.80
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Potassium	2.36	1.75	2.2	2.88	2.4	2.35	3.4	1.22	1.62	NA	NA	NA
Magnesium	18.9	27.2	22	24.3	27.2	28.9	33.9	23.6	22.2	12.8	18.3	7.8
Nickel	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.026	0.137	0.015
Nitrates	2.55	<0.02	<0.02	3.64	2.06	2.89	<0.02	<0.02	<0.02	<0.02	<0.02	0.06
Lead	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.012	<0.005
Phosphorus, total	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	0.12	0.12	0.06	0.14	0.21	1.15

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GROUND-WATER SAMPLING RESULTS - FMPC
(All results in ppm except as noted)

	OS-1	15-D	OS-3	OS-2	SW-2 (8/27/85)	SW-2 (1/8/86)	P-1	P-2	P-3	TP19	TP-21	TP-22
Selenium	<0.005	<0.005	<0.005	<0.005	<0.0025	<0.005	<0.005	<0.005	<0.005	<0.0025	<0.0025	<0.0025
Zinc	0.109	<0.071	<0.025	0.037	0.025	<0.025	<0.025	<0.025	<0.025	0.029	0.240	<0.025
T.D.S.	304	408	308	376	504	468	420	240	240	2540	936	2240
C.O.D.	<10	<10	<10	<10	<10	<10	<10	<10	10	12.0	14	44
pH-lab (1) (2)	7.48	7.35	7.62	7.39	7.78	7.36	7.45	7.50	7.36	6.63	6.99	6.75
Conductivity-lab (1) (3)	491	638	575	610	520	660	835	555	533	2350	1000	1950
T.O.C. (1)	<1	<1	<1	<1	2	<1	<1	<1	<1	4.00	4.00	6.5
T.O.X. (1) (4)	32	40.8	43.3	49.3	NA	61.5	12.8	10	12.4	80.25	<10.00	<10.00
Coliform	<2	<2	<2	40	18	<2	<2	<2	<2	<20	<20	<20
Lindane (4)	<0.1	<0.1	<0.1	<0.1	NA	<0.1	<0.1	<0.1	<0.1	<0.2	<0.2	<0.2
Endrin (4)	<0.1	<0.1	<0.1	<0.1	NA	<0.1	<0.1	<0.1	<0.1	<0.2	<0.2	<0.2
Methoxychlor	<0.1	<0.1	<0.1	<0.1	NA	<0.1	<0.1	<0.1	<0.1	<0.2	<0.2	<0.2
Toxaphene (4)	<0.5	<0.5	<0.5	<0.5	NA	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
2,4-D (4)	<0.4	<0.4	<0.4	<0.4	NA	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
2,4,5-TP, Silvex (4)	<0.2	<0.2	<0.2	<0.2	NA	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
VOC's	NA	NA	NA	--	ND	ND	NA	NA	NA	--	ND	ND
1,1 Dichlorethane										3.4		
Methylene Chloride										Trace		
Gross Alpha (9)	<15.0	<15.0	20	<15.0	(11)	<15.0	<15.0	<15.0	<15.0	(11)	(11)	(11)
Gross Beta (9)	28	< 5.0	42	< 5.0	(11)	< 5.0	< 5.0	< 5.0	< 5.0	(11)	(11)	(11)
Rad Scan (9)(10)	< 5.0	< 5.0	5.0	< 5.0	(11)	< 5.0	< 5.0	< 5.0	< 5.0	(11)	(11)	(11)
Radium (9)	< 5.0	< 5.0	5.0	< 5.0	(11)	< 5.0	< 5.0	< 5.0	< 5.0	(11)	(11)	(11)

NOTES

ND Not Detected.

NA Not Analyzed.

(1) Average of four tests.

(2) pH results in standard units.

(3) Conductivity results in umhos/cm.

(4) Concentrations reported in ppb.

(5) Results in colony/100 ml.

(6) Taken from 40 CFR Part 141 National Interim Primary Drinking Water Regulations - Subpart B - Maximum Contaminant Levels, July 1, 1984.

(7) Taken from 40 CFR Part 143 National Secondary Drinking Water Regulations - Section 143.3 - Secondary Maximum Contaminant Levels.

(8) Taken from Groundwater, Freeze and Cherry.

(9) Results in pCi/l.

(10) Rad scan represents analysis of 15 radionuclides as listed in Appendix II

(11) Previously sampled. Results shown in other Tables of Appendix III.

(General)

Radiological analyses were conducted utilizing a Canberra 2404F low-level alpha/beta/gamma counter with multiple counting port and sample exchanger. System connected to IBM computer utilizing software from Canberra and NBS libraries for sample identification when utilizing the 4096 channel analyzer. Standards utilized for quantitation and standardization of instrument were all traceable to NBS. Amerscham nuclides are utilized to determine window and plateaus for maximum counting efficiencies. These nuclides are also traceable to NBS.

Counts for alpha which are less than the Drinking Water Standards are listed as <15 pCi/l. Counts for beta are listed as <5.0 pCi/l, yet should actually be listed in mrem/year. Since there is no method of determining body exposure of the water to an individual, the value of <4 mrem/year is not suitable. The EPA recognized value of 50 pCi/l ANNUAL AVERAGE should be utilized, or a value of <50 pCi/l per year for reporting purposes to EPA.

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APPENDIX III

OFF-SITE RESULTS FOR BARIUM CONTENT - JANUARY, 1985

Location[1]	Barium (mg/l)[2]
1	0.451
2	NS[3]
3	0.472
4	0.056
5	0.059
6	0.048
7	0.141
8	0.047
9	0.063
10	0.121
11	0.001
12	0.049
13	0.039
14	0.198
15	0.076
16	0.048
17	0.023
18	0.058
19	0.013
20	0.113
21	0.085
22	0.054
23	0.049
24	NS
25	NS
26	NS

(1) See Figure 7 in text.

(2) Barium concentrations of U.S. drinking waters ranges between 0.0007 to 0.900 mg/l with a geometric mean of 0.049 mg/l.[18]

(3) Not sampled.

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Appendix IV

DEFINITIONS, UNITS, PREFIXES, ABBREVIATIONS, AND ACRONYMS

Definitions

Activity - The number of spontaneous nuclear transformations, in a given quantity of material per unit time. Varies with each type of radioactive decay and with each radionuclide.

AIRDOS/DARTAB - A computerized methodology for estimating environmental concentration and dose to man from airborne releases of radionuclides.

Confidence limit (CL) - A confidence limit is a statement that the population parameter (usually the mean) has a value lying between two specified limits. It has the feature that, in repeated sampling, a known proportion (for instance, 95%) of the intervals computed by this method will include the population parameter. The 95% confidence limit for a sample can be estimated by the following: $t_{(\alpha=.05,df)} S_{\bar{x}}$ where "t" is the tabular "t" statistic, and $S_{\bar{x}}$ is the standard deviation of the mean.

Critical organ - A particular organ or tissue that is likely to be of greatest importance when more than one organ is exposed because of the dose it received, its sensitivity to radiation, or the importance to health of any damage that results.

Dose - Quantity of radiation absorbed by the body.

Geometric mean and standard deviation - When the variance of a population is related to the mean, a logarithmic transformation of the original data will sometimes help to stabilize the variance. A mean that is calculated on the logarithmic data and then transformed back (using the antilogarithm) to the original units is the geometric (or derived) mean.

To estimate the standard deviation about the geometric mean, the standard deviation of the logarithms is transformed back to the original data and the geometric mean is then multiplied and divided by the antilog of the standard deviation.

Weighting factor - The ratio of the stochastic risk arising from exposure of a tissue to the total risk when the whole body is irradiated uniformly.

W Solubility Class - That class of materials deposited in the lung that has a clearance half-time on the order of weeks. This material is considered to be moderately soluble.

Y Solubility Class - That class of materials deposited in the lung that has a clearance half-time on the order of years. This material is considered to be chemically insoluble.

Radiation units

Unit	Definition
Curie (Ci) and Becquerel (Bq)	Units of radioactivity which are a measure of those spontaneous, energy-emitting, atomic transformations that involve changes in the state of the nuclei of radioactive atoms. 1 Ci = 3.7 E+10 Bq
Roentgen (R) and coulombs per kilogram (C/kg)	Units of exposure to radioactivity. 1 R = 2.58 E-4 C/kg
Rad and Gray (Gy)	Units of absorbed dose in any medium. 1 rad = 1 E-2 Gy
Roentgen equivalent man (rem) and Sievert (Sv)	Units of dose equivalent which account for the relative biological effectiveness of a given absorbed dose. 1 rem = 1 E-2 Sv

Unit prefixes

Factor	Prefix	Symbol
10^{15}	peta	P
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10^{1}	deka	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	u
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f

Elements and Compounds

Ag	silver	Na	sodium
Al	aluminum	Nb	niobium
As	arsenic	NH_3	ammonia
B	boron	Np	neptunium
Ba	barium	$NH_3(N)$	ammonia nitrogen
Be	beryllium	$NO_3(N)$	nitrate nitrogen
Br	bromine	NO_3^-	nitrate
Ca	calcium	Ni	nickel
Cd	cadmium	P	phosphorus
Ce	cerium	Pb	lead
Cl	chlorine	PO_4^{3-}	phosphate
Cl^-	chloride	Pu	plutonium
CN^-	cyanide	Ra	radium
Co	cobalt	Rn	radon
Cr	chromium	Ru	ruthenium
Cs	cesium	Sb	antimony
Cu	copper	Sc	scandium
F^-	fluoride	Se	selenium
Fe	iron	Si	silicon
Ga	gallium	SO_4^{2-}	sulfate
^3H	tritium	Sr	strontium
Hf	hafnium	Tc	technetium
Hg	mercury	Th	thorium
I	iodine	Ti	titanium
K	potassium	U	uranium
Kr	krypton	V	vanadium
La	lanthanum	Xe	xenon
Li	lithium	Y	yttrium
Mg	magnesium	Zn	zinc
Mn	manganese	Zr	zirconium
Mo	molybdenum		

Acronyms

ALARA	as low as reasonably achievable
BOD_5	five day biochemical oxygen demand
BTU	British thermal units
CFR	Code of Federal Regulations
DOE	Department of Energy
EML	Environmental Measurements Laboratory
EPA	Environmental Protection Agency
ICRP	International Commission on Radiological Protection
NESHAP	National Emission Standards for Hazardous Air Pollutants
NLO	National Lead Company of Ohio
NPDES	National Pollutant Discharge Elimination System
OAC	Ohio Administrative Code
ODH	Ohio Department of Health
RCRA	Resource Concervation and Recovery Act
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
TOX	Total Organic Halogen
TSS	Total Suspendid Solids
WMCO	Westinghouse Materials Company of Ohio

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