521

G-000-105.4

SITE CHARACTERIZATION OF THE WASTE STORAGE AREAS
PART 1: EVALUATION OF CURRENT SITUATION
AUGUST 1986

08/01/86

ROY F. WESTON, INC/WMCO
100
REPORT

G-000-105.4

521

Department of Energy
Feed Materials
Production
Center
Fernald, Ohio

Site Characterization Of The Waste Storage Areas

Part 1: Evaluation of Current Situation

For: Westinghouse
Materials Company
Of Ohio

Prepared By:
Roy F. Weston, Inc.

August 1986

SITE CHARACTERIZATION OF THE WASTE STORAGE AREAS

PART 1: EVALUATION OF CURRENT SITUATION

DEPARTMENT OF ENERGY
FEED MATERIALS PRODUCTION CENTER
FERNALD, OHIO

FOR: WESTINGHOUSE MATERIALS COMPANY OF OHIO

Prepared by:

ROY F. WESTON, INC.

August 1986

TABLE OF CONTENTS

SECTION		PAGE
1.0	INTRODUCTION	1-1
2.0	SITE BACKGROUND	2-1
3.0	NATURE AND EXTENT OF THE PROBLEM	3-1
4.0	HISTORY OF RESPONSE ACTIONS	4-1
5.0	DEFINITION OF BOUNDARY CONDITIONS	5-1
6.0	SITE TOPOGRAPHIC MAPPING AND SAMPLING GRID	6-1
7.0	PREINVESTIGATION EVALUATION	7-1

REFERENCES

LIST OF TABLES

TABLE NO.		
2-1	Radioactive Air Emissions Sampled at the FMPC Since 1973	2-7
2-2	Average Annual TSP Concentrations at the FMPC	2-9
2-3	Maximum and Minimum Uranium Concentrations at the FMPC	2-12
2-4	Average Uranium Concentrations Measured at the FMPC	2-13
2-5	Average Annual Gross Alpha and Gross Beta	2-15

TABLE OF CONTENTS (continued)

TABLE NO.		PAGE
2-6	Thorium Concentrations at the FMPC	2-16
2-7	Thorium Isotope Levels Measured at the FMPC	2-17
2-8	Maximum and Minimum Radon Gas Levels Measured On-Site and Off-Site of the FMPC	2-20
2-9	Average Annual Radon Gas of Levels Measured at On-Site and Off-Site at the FMPC	2-21
2-10	Water Quality In The Great Miami River Near Miamisburg, Ohio, 1979	2-31
2-11	Water Quality In The Great Miami River At New Balitmore, Ohio, 1979	2-32
2-12	NPDES Effluent Concentration For 1984 and 1985	2-34
2-13	Population By Sector Within A Five Mile Radius of the FMPC	2-44
2-14	Population Centers Within a Five Mile Radius of the FMPC	2-45
2-15	Average Daily Traffic (ADT)	2-47
3-1	Waste Storage Area Characteristics	3-17
3-2	Approximate Waste Storage Inventory	3-19
3-3	Constituents of Waste Pits 3 and 5	3-21
3-4	Elemental Constituents of FMPC Silos	3-26
3-5	Dose Conversion Factors for Target Organs (rem/microCi)	3-32

TABLE OF CONTENTS (continued)

LIST OF TABLES (continued)

TABLE NO.		PAGE
3-6	Fifty-Year Dose Commitment Per Year of Consumption of Radionuclides in Drinking Water (MREM/Year)	3-32
3-7	Summary of Drinking Water Health Effects Analysis	3-33
7-1	General Response Actions for the Fernald Site	7-3
7-2	Potential Remedial Technologies for Source Control at the Fernald Site	7-4
7-3	Potential Remedial Technologies for Migration Pathway Control at the Fernald Site Remedial Technology	7-5
7-4	Site Characteristics Data Requirements	7-8
7-5	Waste Characteristics Data Requirements	7-10

LIST OF FIGURES

FIGURE NO.		PAGE
2-1	Preliminary Map of the Site Feed Materials Production Center, Fernald, Ohio	2-2
2-2	Percent Frequence of Wind Direction for the Period 1948 through 1978 at the Greater Cincinnati Metropolitan Airport	2-4

TABLE OF CONTENTS (continued)

LIST OF FIGURES (continued)

FIGURE NO.		PAGE
2-3	Location of Perimeter Air Sample Stations at the FMPC	2-6
2-4	Generalized Geologic Cross Section of the New Haven Trough	2-23
2-5	Soil Sampling Locations	2-27
2-6	Uranium Levels in Soils Adjacent to FMPC	2-28
3-1	Schematic Diagram of the FMPC Process	3-2
3-2	Production Area	3-3
3-3	Waste Treatment and Storage Locations	3-8
3-4	General Sump Historical Flow Diagram	3-11
3-5	Waste Storage Area	3-15
3-6	Map of Site	3-29
6-1	Mapping Areas	6-2

Section 1

SECTION 1.0

INTRODUCTION

Westinghouse Materials Company of Ohio (WMCO) operating under its prime contract with the United States Department of Energy (DOE), coordinates activities, including waste management, at the Feed Materials Production Center (FMPC), Fernald, Ohio. WMCO is administratively responsible to the Oak Ridge Operations Office of the DOE. Waste management activities are funded and directed by the DOE Office of Defense Waste and By-Product Management.

As part of the comprehensive waste management and environmental program for the FMPC, specific alternatives are being developed and evaluated for the final disposition of low-level radioactive waste inventory currently stored at the site. The Waste Storage Areas under evaluation in this program consist of six storage pits, the clear well, the burn pit, three concrete silos, two fly-ash piles, and adjoining areas.

This program is being implemented in two phases. Phase I will include site characterization, consisting of assessment of existing data and reports, development of a detailed work plan, performance of field investigations, data interpretation and analysis and final reporting. Phase II will include the development of remedial alternatives, initial screening of alternatives, detailed analysis of options, ranking of alternatives, and final reporting.

The documents presented here constitute what is commonly referred to as the Work Plan. It is divided into two parts. The first presents an evaluation of the current situation; the second, Support Documentation, consists of the environmental monitoring plan and other programmatic plans.

Part 1, Evaluation of Current Situation, is made up of seven sections, which in their entirety describe the present situation as it is known from obtainable records, previous studies and monitoring data, and conversations with plant personnel. Section 2.0, Site Background, presents a general description of the regional and site environment organized into traditional categories such as geology, soils, groundwater, water quality, flora and fauna, land use, population, etc., and indicates the limitations of present knowledge. Section 3.0, Nature and Extent of Problem, describes the production process, waste management operations and facilities, waste composition and distribution,

and an evaluation of environmental and public health risk associated with the existing situation. Section 4.0, History of Response Actions, includes descriptions of past remedial measures performed in the Waste Storage Areas. Section 5.0, Definition of Boundary Conditions, sets the outer geographic limits of the characterizations, based on present knowledge. Section 6.0, Site Topographic Mapping, describes the types of maps which will be available for the project, as well as the grid system to be used for position location. Section 7.0, Preinvestigation Evaluation, identifies potential disposal categories which are likely to be considered and is used to ensure that the data collected in the characterization is sufficient for the engineering evaluations in Phase II.

Section 2

SECTION 2.0

BACKGROUND

2.1 LOCATION

The Feed Materials Production Center (FMPC) is located near the unincorporated village of Fernald in the valley of the Great Miami River approximately 20 miles northwest of Cincinnati in southwestern Ohio. The unincorporated villages of New Baltimore, Venice (i.e., Ross), and Shandon are within a few miles. Hamilton, Ohio is approximately 10 miles northeast. Specifically, the FMPC occupies parts of Sections 30 and 31, Township 3 North, Range 2 East, and parts of Sections 5, 6, 7, and 8, Township 2 North, Range 2 East.

The FMPC comprises 1050 acres of which approximately 850 acres are in northern Hamilton County and about 200 acres are in southern Butler County. The production area encompasses approximately 136 acres in the center of the FMPC.

The FMPC is bounded roughly by state highway 126 to the north, a transmission line to the east, Willey Road to the south, and Paddy's Run Road and the Ohio and Chesapeake Railroad to the west (Figure 2.1).

2.2 CLIMATE AND AIR QUALITY

2.2.1 Climate

Data from the Greater Cincinnati Metropolitan Airport are used in this section as site specific weather data are not yet available in a consistent, reliable form. A meteorological tower has been installed on the FMPC and calibration and testing are scheduled for completion during calendar year 1986 (ORAU, 1985).

Of significance are rainfall and prevailing wind direction. Heavy precipitation and subsequent runoff can, and have, caused loss of containment of wastes with concomitant contamination of soils, sediments, and waters (See Section 2.5.2 and 3.0) off the waste storage area. Wind direction frequency is important as it relates to contamination of these media through the transmission of contaminants. These data were available for various periods of record from NOAA (1984).

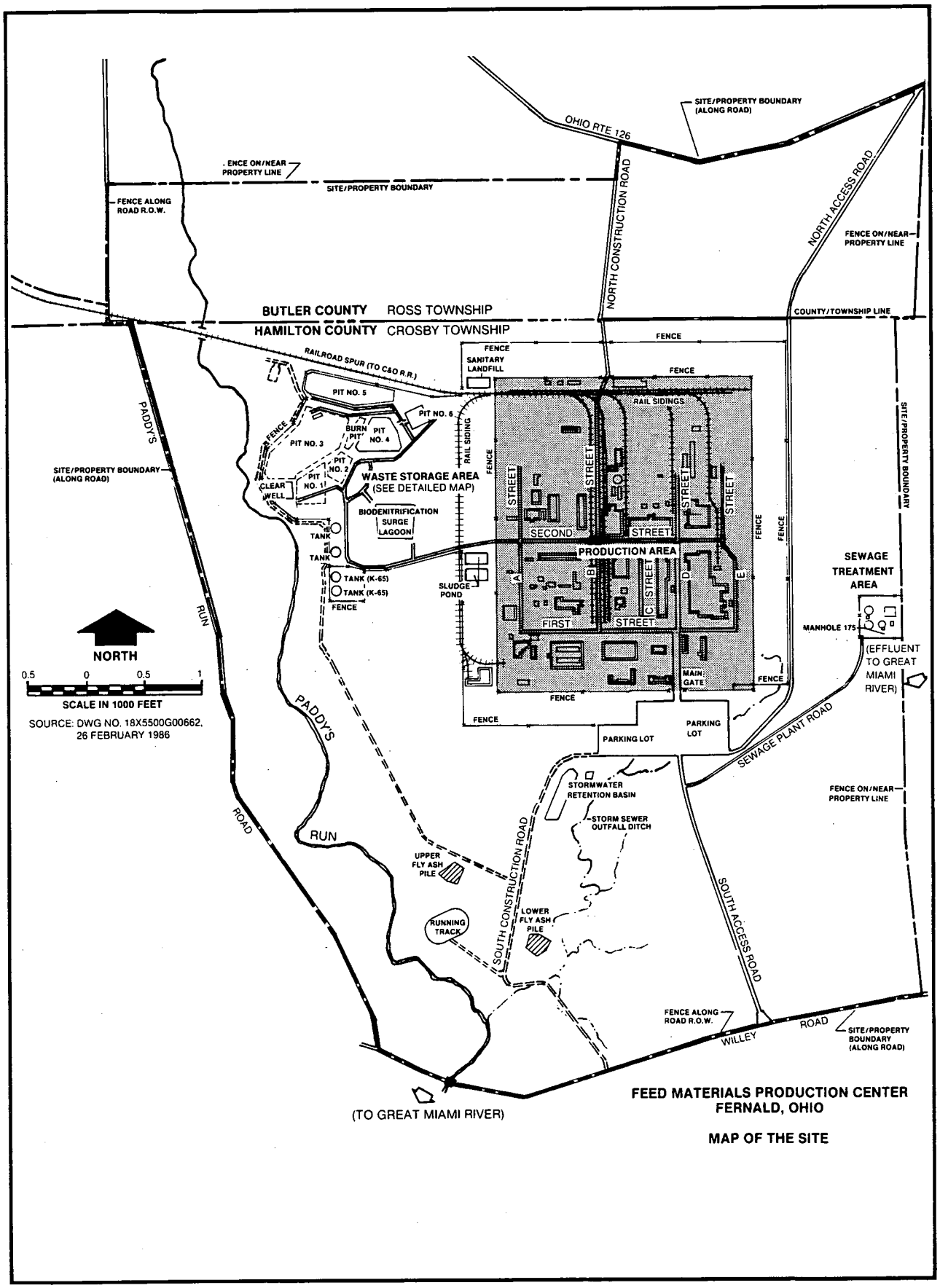


FIGURE 2-1 MAP OF THE SITE FEED MATERIALS PRODUCTION CENTER, FERNALD, OHIO

The climate in the region of the FMPC is continental with temperatures ranging from an average of 29.0°F in January to 75.5°F in July (NOAA, 1984). The highest temperature recorded from 1950 through 1984 was 102°F in August, 1962, and the lowest was -25°F in January, 1977. There was an average of 110 days per year with a minimum temperature of 32°F or less while there was an average of 20 days with a maximum temperature of 90°F or above. Frost depth ranges from 30 to 36 inches (Cummings, 1986).

The average annual precipitation for the period 1955 through 1984 was 40.64 inches and ranged from 27.94 to 52.76 inches per year (NOAA, 1984). The highest precipitation occurred during the spring and early summer; precipitation was lowest in late summer and fall. The average annual snowfall for the same period was 24.0 inches with heaviest snowfall in January.

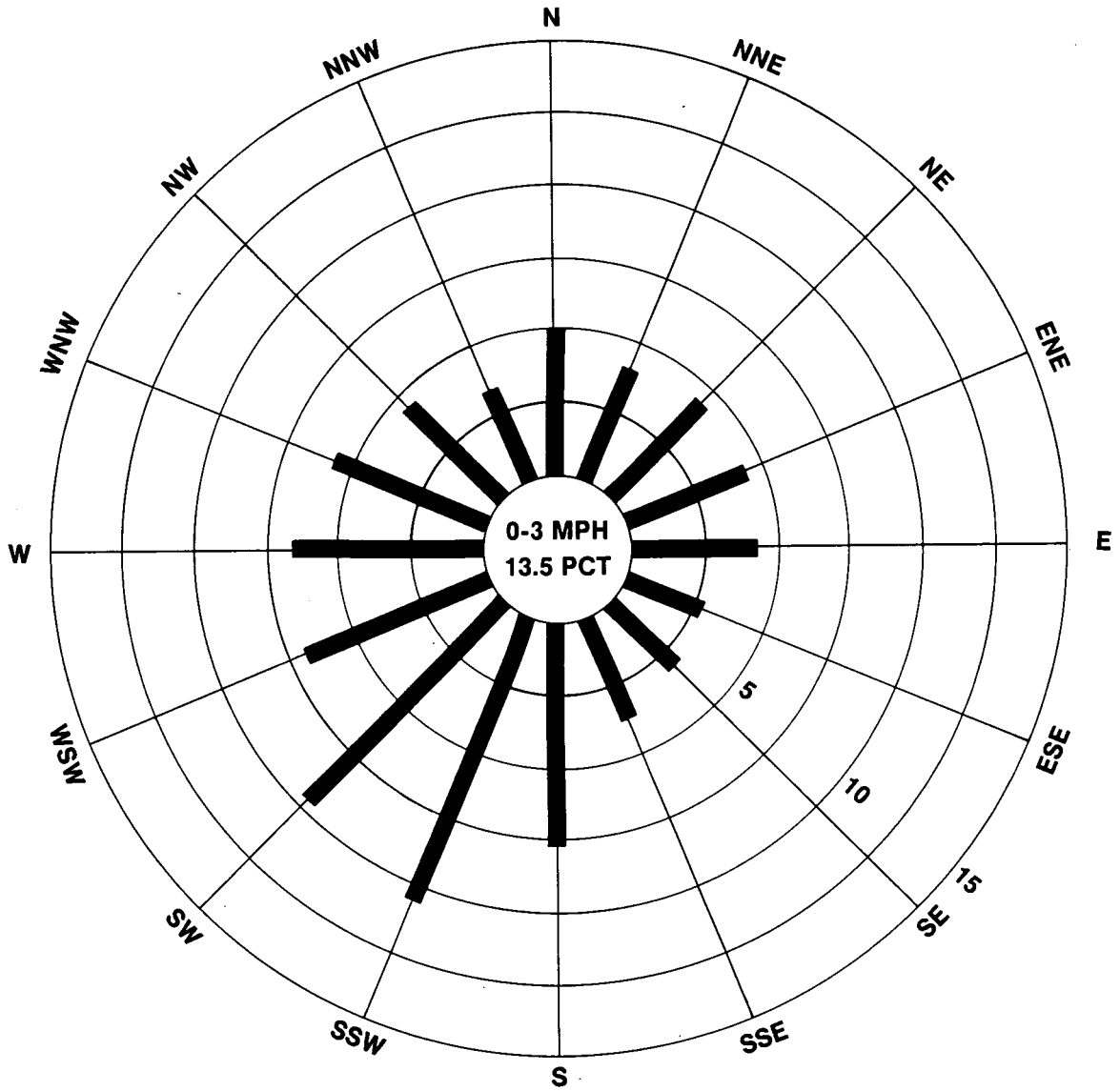
Heavy precipitation events, defined as 1.5 inches per 24 hours, have occurred several times since 1955 (NOAA, 1984). The maximum recorded 24-hour precipitation event occurred in March, 1964 when 5.21 inches fell.

Windflow data for the period 1948 through 1978 indicate that the winds blow 86.5 percent of the time (NOAA, 1984). The prevailing winds were from the south-southwest (11.2%) and southwest (9.9%) (Figure 2.2).

Average monthly wind speed ranged from 6.7 mph in August to 11.1 mph in March (NOAA, 1984). Highest wind speeds occurred in winter and spring, while the summer and early fall had the lowest wind speeds. Maximum sustained wind speeds (one minute or more) ranged from 32 mph in September, 1975, to 46 mph in January, 1946, and again in April, 1985. The strongest winds tend to come from the five wind directions in the west-northwest to south-southwest quadrant.

2.2.2 Air Quality

Approximately 430 radioactive and non-radioactive controlled air emission sources occur at the FMPC (ORAU, 1985). Ventilation and air cleaning systems such as bag collectors, electrostatic precipitators, and scrubbing towers are used to control these emissions (Battelle, 1981). In addition to the controlled sources, uncontrolled emissions arise from the waste storage area, access roads, construction activities, and the like.



Reference: NOAA, 1984.

FIGURE 2-2 PERCENT FREQUENCY OF WIND DIRECTION FOR THE PERIOD 1948 THROUGH 1978 AT THE GREATER CINCINNATI METROPOLITAN AIRPORT

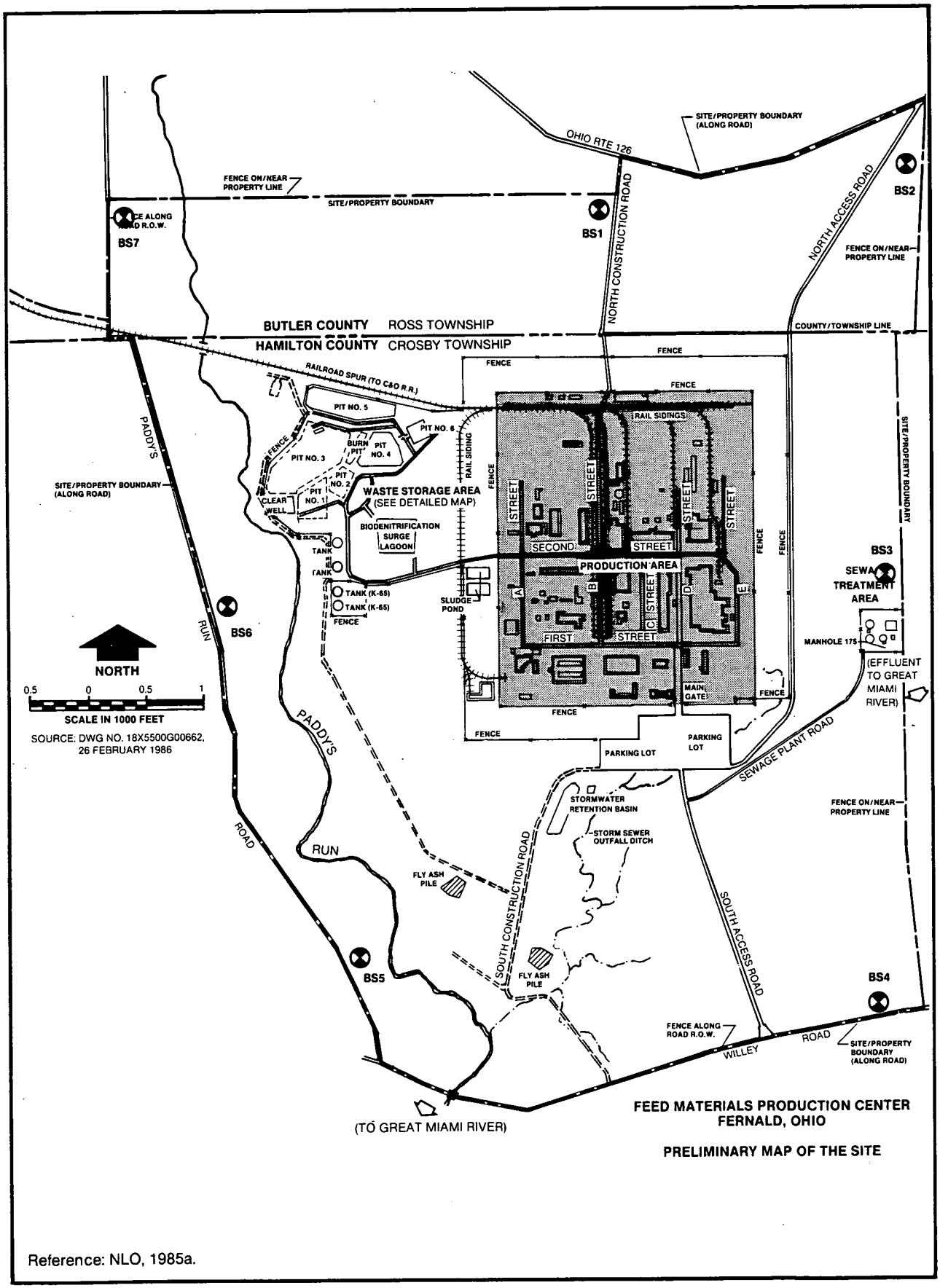
Non-radioactive air emissions that have been measured include total suspended particulates (TSP), nitrogen dioxide, sulfur dioxide, total oxidants and aldehydes. Since 1973, TSP has been sampled weekly at monitoring stations (BS1-BS7) around the perimeter of the FMPC (Figure 2.3). In 1973 and 1974 sulfur dioxide was sampled at one monitoring station (BS2). Nitrogen dioxide was sampled from 1974 through 1977 at one monitoring station (BS2); in 1977 station BS1 was also sampled. Total oxidants and aldehydes were sampled at station BS2 in 1973 and 1974.

Radioactive air emissions have been measured for many years. Table 2.1 provides a list of monitored radionuclides, years of sampling, sampling frequency and sampling locations.

Non-radioactive Air Emissions

Although 24-hour TSP measurements were not recorded, weekly measurements from 1973 through 1985 indicated that the highest average annual TSP concentrations ranged from 31 to 60 microg/m^3 (NLO 1986; 1984; 1983; 1981; 1980; 1979; 1978; 1977; 1976; 1975; 1974) (Table 2.2). These averages were less than the Federal annual standard except in 1975 when it equaled the pre-1982 standard of 60 microg/m^3 (EPA, 1984). None of the average annual concentrations exceeded or equaled the present Federal and state primary standard of 75 microg/m^3 (EPA, 1984; OEPA, 1980).

Although TSP have been less than standards, the annual averages all are undoubtedly an overestimate as most of the monitoring stations (except BS3) are located near roads where vehicular traffic generates dust Station BS4 had the highest maximum weekly concentrations in 5 of the 11 years and the highest average annual concentration in 7 of the 11 years monitoring period. This site is located on the edge of Willey Road which has relatively high vehicle traffic when compared to other roads around the FMPC. The significance of dust generated by traffic is confirmed by the consistently low TSP concentrations measured at BS1 and BS2 which are located downward of the prevailing southwesterlies, but slightly off state route 126 and the north access road, respectively.



Reference: NLO, 1985a.

FIGURE 2-3 LOCATIONS OF PERIMETER AIR SAMPLING STATIONS AT THE FMPC

TABLE 2.1
RADIOACTIVE AIR EMISSIONS SAMPLED AT THE FMPC SINCE 1973

Radionuclide	Sampling Period	Sampling Frequency	Sampling Locations[a]
Uranium	1973 through 1985	weekly	BSI through BS7[b]
Total Thorium	1973 through 1980	weekly	BSI through BS6
Thorium-228	1982 through 1985	annually	BSI through BS7
Thorium-230	1985	annually	BSI through BS7
Thorium-232	1982 through 1985	annually	BSI through BS7
Neptunium-237	1982 through 1985	annually	BSI through BS7
Plutonium-238	1982 through 1985	annually	BSI through BS7
Plutonium-239	1982 through 1985	annually	BSI through BS7
Plutonium-240	1985	annually	BSI through BS7
Plutonium-241	1985	annually	BSI through BS7
Cesium-237	1985	annually	BSI through BS7
Radium-226	1985	annually	BSI through BS7
Radium-228	1985	annually	BSI through BS7
Strontium-90	1985	annually	BSI through BS7
Ruthenium-106	1985	annually	BSI through BS7
Technetium-99	1985	annually	BSI through BS7
Gross Alpha	1973 through 1982	weekly	BSI through BS6

TABLE 2.1 (continued)

RADIOACTIVE AIR EMISSIONS SAMPLED AT THE FMPC SINCE 1973

Radionuclide	Sampling Period	Sampling Frequency	Sampling Locations[a]
Gross Beta	1973 through 1985	weekly	BSI through BS7
Radon-222	1982 through 1985	quarterly	BSI through BS7 2 off-site locations
Radon-222 (Mound, 1985)	Sept., 1984 to Feb., 1985	weekly biweekly	17 stations primarily in the waste storage area
Radon Flux (Mound, 1985)	24 October, 1984	One to two	48 sites on two K-65 tanks hours

[a] Sampling locations BSI through BS7 are shown on Figure 2.4

[b] Six sampling locations (BSI through BS6) used from 1973 through 1980; a seventh station (BS7) was added after 1980

Ref: - Mound, 1985; NLO, 1986; 1985a; 1984; 1983; 1981; 1979; 1978; 1977; 1976; 1975; 1974

TABLE 2.2

AVERAGE ANNUAL TSP CONCENTRATIONS AT THE FMPC (micrograms per cubic meter)

Year/ Concentration	Sampling Station[a,b]						
	BS1	BS2	BS3	BS4	BS5	BS6	BS7
1973							
Concentration	48	52	52	58	54	52	--
% of standard[c]	80	87	87	97	90	87	--
1974							
Concentration	52	53	46	58	54	52	--
% of standard	87	88	77	97	90	87	--
1975							
Concentration	48	55	52	53	60	51	--
% of standard	80	91	86	88	100	85	--
1976							
Concentration	48	49	48	59	51	53	--
% of standard	80	82	80	98	85	88	--
1977							
Concentration	46	45	47	53	49	48	--
% of standard	77	75	78	88	82	80	--
1978							
Concentration	47	52	47	52	48	53	--
% of standard	72	80	72	80	74	82	--
1979							
Concentration	48	42	34	47	42	43	--
% of standard	80	70	57	78	70	72	--
1980							
Concentration	33	42	31	48	37	38	--
% of standard	63	70	52	80	62	63	--

TABLE 2.2 (continued)

AVERAGE ANNUAL TSP CONCENTRATIONS AT THE FMPC (micrograms per cubic meter)

Year/ Concentration	Sampling Station[a,b]						
	BS1	BS2	BS3	BS4	BS5	BS6	BS7
1982							
Concentration	42	38	44	45	46	43	40
% of standard	56	51	59	60	61	57	53
1983							
Concentration	36	37	38	42	37	41	39
% of standard	48	49	51	56	49	55	52
1985							
Concentration	31	32	35	40	37	37	36
% of standard	41	43	47	53	49	49	48

Ref: NLO, 1986; 1984; 1983; 1981; 1980; 1979; 1978; 1977; 1976; 1975; 1974; EPA, 1984; OEPA, 1980

[a] Location of sampling stations shown on Figure 2.4

[b] Six air sampling stations were in operation from 1973-1980; seven were used from 1982-1985.

[c] Annual primary standard was 60 micrograms per cubic meter through 1980 and 75 micrograms per cubic meter since 1982

Nitrogen dioxide and sulfur dioxide were sampled from 1973 through 1977, and in 1973 and 1974, respectively. Sampling frequency varied. The average annual concentrations of nitrogen dioxide ranged from 22 to 80 microg/m^3 which is below the Federal and state standard of 100 microg/m^3 (EPA, 1984; OEPA, 1980; NLO, 1978; 1977; 1976; 1975; 1974). The average annual concentrations of sulfur dioxide were 20 microg/m^3 in 1973 and 23 microg/m^3 in 1974. These concentrations were approximately one-third the Federal and state standard of 80 microg/m^3 (EPA, 1984; OEPA, 1980).

Radioactive Air Emissions

Maximum annual concentrations of airborne uranium were highest at perimeter monitoring stations BS1 and BS3 (Table 2.3). These sites are located north and east of the FMPC and are downwind of the prevailing southwesterlies. The highest average annual uranium concentrations were recorded 10 of 12 years at station BS3 and two of 12 years at station BS1 (Table 2.4). The lowest concentrations were consistently recorded at stations BS4, BS5, and BS6 which are upwind of the prevailing wind direction. Average annual concentrations have been well below applicable standards.

Gross alpha radioactivity was measured from 1973 through 1982 and gross beta was measured from 1973 through 1985. As with airborne uranium, average annual gross alpha and gross beta measurements were usually highest at BS3 and BS1 (8 of 9 years), and BS3 (9 of 12 years), respectively (Table 2.5). All averages were within applicable standards.

Thorium concentrations were determined from 1973 through 1980; thorium isotopes were not analyzed separately until 1982. Total thorium levels were very low at all air monitoring stations (Table 2.6). In all cases, the percent of standard was less than 0.001 percent.

In 1982, thorium-228, and -232 were measured; thorium -230 was included in 1984. As with total thorium, the measured levels of thorium isotopes were very low and never reached more than 0.2 percent of the applicable standard (Table 2.7).

TABLE 2.3

MAXIMUM AND MINIMUM URANIUM CONCENTRATIONS AT THE FMPC (pCi/l x 10^{-5})

Year	Sampling Station	Maximum Concentration	Minimum Concentration
1973	BS6	4.58	--[a]
1974	BS1	3.42	0.04
1975	BS3	5.77	0.09
1976	BS1	7.08	0.08
1977	BS1	3.40	0.0003
1978	BS3	8.80	0.0006
1979	BS3	23.00	0.0003
1980	BS3	2.30	0.0003
1982	BS1	3.80	0.0004
1983	BS3	25.00	0.0003
1984	BS3	18.79	0.0023
1985	BS1	3.12	0.0001

Ref: NLO 1986; 1985a; 1984; 1983; 1981; 1980; 1979; 1978; 1977; 1976; 1975; 1974.

[a] Below detection limits

TABLE 2.4
AVERAGE ANNUAL URANIUM CONCENTRATIONS
MEASURED AT THE FMPC (pCi/l x 10^{-5})

Year/ Concentration	Sampling Station BS1	BS2	BS3	BS4	BS5	BS6	BS7
1973							
Concentration	1.07	0.85	1.19	0.32	0.34	0.87	--
% of guideline[a]	0.5	0.4	0.6	0.2	0.2	0.4	--
1974							
Concentration	1.09	0.85	0.84	0.24	0.35	0.58	--
% of guideline	0.5	0.4	0.4	0.1	0.2	0.3	--
1975							
Concentration	1.24	1.09	1.34	0.37	0.43	0.87	--
% of guideline	0.6	0.5	0.7	0.2	0.2	0.4	--
1976							
Concentration	0.93	0.62	0.97	0.30	0.30	0.49	--
% of guideline	0.5	0.3	0.5	0.2	0.2	0.2	--
1977							
Concentration	0.56	0.41	0.64	0.20	0.25	0.25	--
% of guideline	0.3	0.2	0.3	0.1	0.1	0.1	--
1978							
Concentration	0.39	0.42	1.40	0.44	0.50	0.34	--
% of guideline	0.2	0.2	0.7	0.2	0.3	0.2	--
1979							
Concentration	0.67	0.55	0.96	0.41	0.54	0.47	--
% of guideline	0.3	0.3	0.5	0.2	0.3	0.2	--
1980							
Concentration	0.21	0.18	0.23	0.17	0.15	0.20	--
% of guideline	0.1	0.1	0.1	0.1	0.1	0.1	--

TABLE 2.4 (continued)

AVERAGE ANNUAL URANIUM CONCENTRATIONS
MEASURED AT THE FMPC (pCi/l x 10^{-5})

Year/ Concentration	Sampling Station BS1	BS2	BS3	BS4	BS5	BS6	BS7
1982							
Concentration	0.77	0.42	0.70	0.21	0.35	0.39	0.22
% of guideline	0.3	0.2	0.3	0.1	0.2	0.2	0.1
1983							
Concentration	2.10	1.40	2.50	0.89	0.98	1.10	0.48
% of guideline	0.5	0.3	0.6	0.2	0.2	0.3	0.1
1984							
Concentration	1.03	0.92	1.36	0.35	0.40	0.63	0.30
% of guideline	0.5	0.5	0.7	0.2	0.2	0.3	0.2
1985							
Concentration	0.30	0.31	0.56	0.21	0.22	0.25	0.11
% of guideline	0.2	0.2	0.3	0.1	0.1	0.1	0.1

Ref: NLO, 1986; 1985a; 1984; 1983; 1981; 1980; 1979; 1978; 1977; 1976; 1975; 1974

[a] Guideline was $2x10^{-3}$ pCi/l for 1973-1980, $4x10^{-3}$ pCi/l for 1982 and 1983, and $2.0x10^{-3}$ pCi/l in 1984 and 1985. 1973-1980 guidelines from DOE manual, Chapter 0524, Annex A, Table II: 1982-1985 guidelines from DOE Order 5480.1A, Attachment XI-1, Table II.

TABLE 2-5

Average Annual Gross Alpha and Gross Beta

Year/ Concentration	Sampling Station													
	BS1		BS2		BS3		BS4		BS5		BS6		BS7	
	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta
1973														
Concentration[1]	1.13	2.70	0.94	2.65	2.37	3.54	0.35	2.35	0.38	2.32	0.94	3.35	-	-
% of Guidelines	0.06	0.003	0.5	0.003	1.2	0.004	0.2	0.002	0.2	0.002	0.5	0.003	-	-
1974														
Concentration	1.22	5.87	0.93	5.16	0.92	5.45	0.28	5.91	0.36	6.29	0.65	6.56	-	-
% of Guidelines	0.6	0.06	0.5	0.05	0.5	0.05	0.1	0.06	0.2	0.06	0.3	0.06	-	-
1975														
Concentration	1.28	4.10	1.21	4.14	1.41	4.84	0.40	3.74	0.48	4.60	0.30	4.58	-	-
% of Guidelines	0.6	0.04	0.6	0.04	0.7	0.05	0.2	0.04	0.2	0.05	0.5	0.04	-	-
1976														
Concentration	0.99	3.10	0.69	2.94	0.96	3.70	0.37	3.07	0.38	3.45	0.52	4.00	-	-
% of Guidelines	0.5	0.03	0.3	0.03	0.5	0.04	0.2	0.03	0.2	0.05	0.5	0.04	-	-
1977														
Concentration	0.81	6.80	0.45	5.80	0.72	6.90	0.25	6.20	0.28	6.70	0.30	6.90	-	-
% of Standard	0.4	0.07	0.2	0.06	0.4	0.07	0.1	0.06	0.1	0.07	0.2	0.07	-	-
1978														
Concentration	0.36	4.80	0.39	5.20	0.80	6.90	0.26	4.60	0.89	5.50	0.43	5.40	-	-
% of Standard	0.2	0.05	0.2	0.05	0.4	0.07	0.1	0.05	0.4	0.06	0.2	0.05	-	-
1979														
Concentration	0.63	2.50	0.39	1.90	0.97	2.50	0.47	2.00	0.52	2.20	0.47	2.40	-	-
% of Standard	0.3	0.02	0.2	0.02	0.5	0.03	0.2	0.02	0.3	0.02	0.2	0.02	-	-
1980														
Concentration	0.20	2.20	0.16	1.80	0.21	1.90	0.16	1.90	0.14	1.90	0.19	2.00	-	-
% of Standard	0.1	0.02	0.1	0.02	0.1	0.02	0.1	0.02	0.1	0.02	0.1	0.02	-	-
1982														
Concentration	0.79	8.70	0.44	6.00	0.83	9.80	0.26	3.60	0.48	6.70	0.40	5.60	0.20	3.60
% of Standard	0.4	0.09	0.2	0.06	0.4	0.10	0.1	0.04	0.2	0.07	0.2	0.07	0.1	0.04
1983[2]														
Concentration		5.60		4.10		5.70		2.80		3.10		3.70		3.20
% of Standard		0.06		0.04		0.06		0.03		0.03		0.04		0.03
1984														
Concentration		4.91		4.56		6.38		2.60		2.88		3.39		2.46
% of Standard		0.05		0.05		0.06		0.03		0.03		0.03		0.02
1985														
Concentration		1.89		2.08		2.64		1.79		1.86		1.94		1.66
% of Standard		0.02		0.02		0.03		0.02		0.02		0.02		0.02

Ref. NLO, 1986; 1985; 1984; 1983; 1981; 1980; 1979; 1978; 1977; 1976; 1974

[1] Gross alpha measurements discontinued beginning in 1983. 1973 through 198 guidelines from DOE manual, chapter 0524, Annex A, Table II; 1982 through 1985 guidelines from DOE order 5480.1A, Attachment XI-1, Table II.

[2] Gross alpha measurements discontinued beginning in 1983.

TABLE 2.6

THORIUM CONCENTRATIONS AT THE FMPC (pCi/l x 10^{-5})[a]

Year/ Concentration	Sampling Station BS1	BS2	BS3	BS4	BS5	BS6
1973 Concentration[b]	0.002	0.002	0.002	0.002	0.002	0.002
1974 Concentration	0.002	0.002	0.002	0.001	0.002	0.002
1975 Concentration	0.002	0.004	0.002	0.002	0.003	0.002
1976 Concentration	0.003	0.004	0.003	0.003	0.002	0.003
1977 Concentration	0.003	0.003	0.004	0.003	0.002	0.003
1978 Concentration	0.003	0.003	0.003	0.002	0.001	0.002
1979 Concentration	0.003	0.03	0.004	0.003	0.003	0.004
1980 Concentration	0.0002	0.0006	0.0005	0.0005	0.0003	0.0005

Ref: NLO 1981; 1980; 1979; 1978; 1977; 1976; 1975; 1974

[a] One composite sample of the weekly samples was analyzed for thorium each year.

[b] Percent of standard less than 0.001%; Standard was $1x10^{-3}$ pCi/l. Standard from DOE Manual, Chapter 0524, Annex A, Table II.

TABLE 2.7

THORIUM ISOTOPE LEVELS MEASURED
AT THE FMPC (pCi/l x 10^{-5})

Year/ Isotope	Sampling Station						
	BS1	BS2	BS3	BS4	BS5	BS6	BS7
1982							
Thorium-228							
Concentration	0.0064	0.0037	0.0079	0.0032	0.0034	0.0039	0.0019
% of Guideline	0.03	0.02	0.04	0.02	0.02	0.02	0.01
Thorium-232							
Concentration	0.0024	0.0021	0.0048	0.0020	0.0019	0.0021	0.0012
% of Guideline	--	--	--	--	--	--	--
1983							
Thorium-228							
Concentration	0.0048	0.0041	0.0093	0.0026	0.0040	0.0027	0.0014
% of Standard	0.02	0.02	0.05	0.01	0.02	0.01	0.01
Thorium-232							
Concentration	0.0061	0.0039	0.0014	0.0051	0.0043	0.0019	
% of Standard	--	--	--	--	--	--	--
1984							
Thorium-228							
Concentration	0.0024	0.0031	0.0051	0.0013	0.0017	0.0024	0.0026
% of Standard	0.01	0.01	0.03	0.01	0.01	0.01	0.01
Thorium-230							
Concentration	0.0495	0.0559	0.0746	0.0155	0.0321	0.0406	0.0532
% of Standard	0.20	0.02	0.02	0.05	0.10	0.10	0.20
Thorium-232							
Concentration	0.0015	0.0018	0.0028	0.0009	0.0011	0.0015	0.0016
of Standard	--[c]	--	--	--	--	--	--
1985							
Thorium-228							
Concentration	0.0014	0.0011	0.0026	0.0021	0.0032	0.0018	0.0023
of Standard	0.01	0.01	0.01	0.01	0.02	0.01	0.01

TABLE 2.7 (continued)

THORIUM ISOTOPE LEVELS MEASURED
AT THE FMPC (pCi/l x 10^{-5})

Year/ Isotope	Sampling Station						
	BS1	BS2	BS3	BS4	BS5	BS6	BS7
Thorium-230							
Concentration	0.0152	0.0077	0.0261	0.0135	0.0195	0.0121	0.0083
% of Standard	0.05	0.03	0.09	0.05	0.07	0.04	0.03
Thorium-232							
Concentration	0.0010	0.0009	0.0014	0.0012	0.0014	0.0013	0.0011
% of Standard	--	--	--	--	--	--	--

REF. NLO, 1986; 1985a; 1984; 1983

[a] One complete sample of the weekly samples was analyzed for thorium isotopes each year

[b] Guidelines from DOF Order 5480.1A, Attachment XI-1, Table II

[c] Percent of standard less than 0.01%

Airborne neptunium-237, and plutonium-238 and -239 concentrations were determined annually from 1982 through 1985. As with thorium, these radionuclides occurred in very small quantities never reaching more than 0.09 percent, 0.02 percent, and 0.02 percent of the applicable standards, respectively (DOE Order 5480.1A, Attachment XI-I, Table II) (NLO, 1986; 1985a; 1984; 1983).

The remaining airborne radionuclides, plutonium-241, cesium-137, radium-226, radium-228, ruthenium-106, strontium-90, and technetium-99 were measured only in 1985 (NLO, 1986). Levels of these radionuclides were very low accounting for only a small fraction of a percent of the applicable standards.

From a potential airborne health effects perspective, radon may be the most important radionuclide present at the FMPC. However, radon levels have been measured in a routine fashion only from 1982 through 1985 at the seven on-site perimeter locations and at two off-site locations. The maximum level that occurred on site was 1.99 pCi/l at station BS7 in 1983 (Table 2.8). Maximum off-site levels were similar to those measured on site.

Analysis of the average annual radon concentrations indicated that on-site sampling sites BS5, BS6, and BS7 generally had the highest levels (Table 2.9). These are locations that are closest to the K65 sites and waste pits. All annual levels reported were below the standard with the highest average annual level reported from station BS7 in 1982.

In addition to the routine sampling at the perimeter locations, an intensive survey of radon concentrations was conducted from September, 1984 to February, 1985 (Mound, 1985). This study was designed to assess the radon releases near the two K-65 tanks, and thus, 17 radon monitors were established with most located inside the waste storage area. Radon flux from the two K-65 tanks also was measured at 24 locations on K-65 silos 1 and 2.

The average radon concentrations at the 17 monitors ranged from 5.1 to 0.24 pCi/l (Mound, 1985). The maximum concentrations were found near the tanks while the minimum levels were along the eastern perimeter of the FMPC. Contours of equal radon concentrations indicate that the 3.0 pCi/l levels are generally confined to the waste storage area while the 1.0 pCi/l levels extend into the production area.

TABLE 2.8

MAXIMUM AND MINIMUM RADON GAS LEVELS
MEASURED ON-SITE AND OFF-SITE OF THE FMPC (pCi/l)

Year	On-Site			Off-Site		
	Sampling Station	Maximum	Minimum	Sampling Station	Maximum	Minimum
1982	BS1	1.50	0.33	ENE[a]	1.34	0.16
1983	BS7	1.99	0.48	ENE	1.25	0.36
1984	BS6	1.55	0.28	ENE	2.19	0.29
1985	BS6	1.42	0.72	OSI	0.75	0.49

Ref. NLO, 1986; 1985a; 1984; 1983

[a] ENE is off-site sampling station located 8 miles east/ northeast of the FMPC.

TABLE 2.9

AVERAGE ANNUAL RADON GAS OF LEVELS MEASURED
AT ON-SITE AND OFF-SITE AT THE FMPC
(Concentrations in pCi/l)

Year/	Sampling Station								
	On-Site							Off-site	
Concentration	BS1	BS2	BS3	BS4	BS5	BS6	BS7	ENE	WSW
1982									
Concentration	0.79	0.91	0.66	0.90	0.94	1.01	1.07	0.56	0.66
% of Standard	26	30	22	30	31	34	36	19	22
1983									
Concentration	0.65	0.77	0.76	0.65	1.05	0.82	0.91	0.77	0.61
% of Standard	22	26	25	22	35	27	30	26	20
1984									
Concentration	0.92	0.80	0.84	0.59	0.97	0.58	0.71	0.84	0.36
% of Standard	28	25	26	18	30	18	22	26	11
1985									
Concentration	0.81	0.82	0.28	0.56	0.80	1.06	1.01	0.59	0.37
% of Standard	25	25	9	17	25	33	31	18	11

NLO, 1986; 1985a; 1984; 1983

[a] Average annual concentration based on four samples

[b] Standard is 3 pCi/l above background; from DOE Order 5480.1A Attachment XI-1, Table II

Radon flux values ranged from 13 $pCi/m^2/sec$ to $3x10^7$ $pCi/m^2/sec$ on silo 2 and from 30 $pCi/m^2/sec$ to $1.4x10^7$ $pCi/m^2/sec$ on silo 1 (Mound, 1985). The highest levels occur near cracks in the tank domes.

2.3 PHYSIOGRAPHY AND TOPOGRAPHY

The FMPC and surrounding region are located in the Till Plains section of the Central Lowlands physiographic province. This province is characterized by sedimentary and structural basins, domes, and arches of the Paleozoic Period (SCS, 1982). One of these features, the Cincinnati Arch (a geoanticline), is structurally significant in southwestern Ohio; Hamilton and Butler Counties lie almost atop its crest (SCS, 1982).

The topography and geology of the region have been influenced by Pleistocene glaciation. The FMPC is located in a two mile wide ancestral river valley, known as the New Haven Trough, which was filled with 200 feet of glacial deposits. Today the region is influenced by action (i.e. flooding, meander) of the Great Miami River.

The FMPC is located on a relatively level terrace approximately 580 feet above sea level. Along the southern and western boundaries of the FMPC, elevations decrease to about 550 feet.

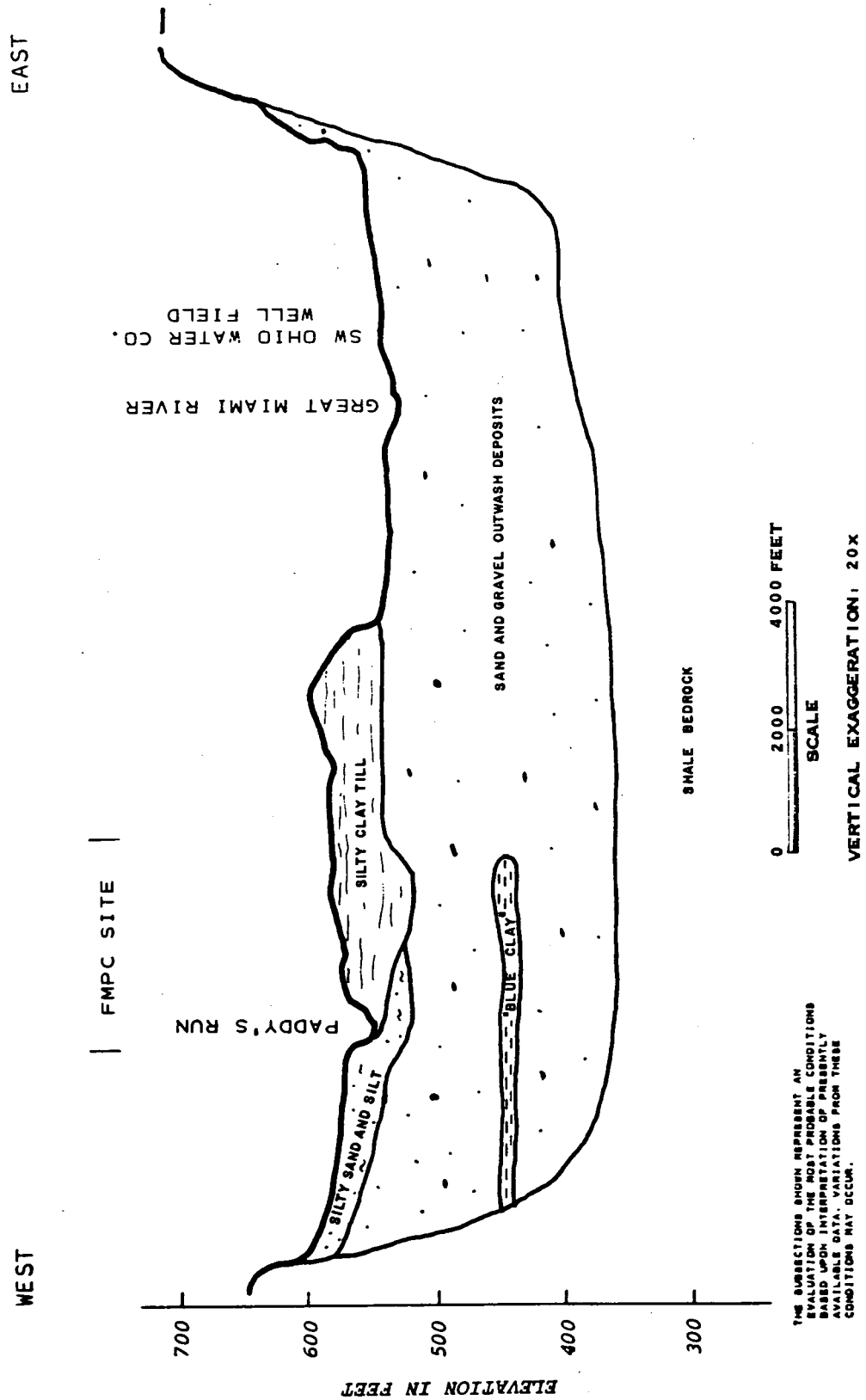
2.4 SURFACE AND SUBSURFACE FEATURES

2.4.1 Geology

Regional Geology

The bedrock underlying the FMPC is an olive gray shale of the Cincinnatian Series of the Late Ordovician Age. The depositional environment for the shale was a shallow epicontinental sea which accounts for the fine grained texture of the bedrock. The shale is relatively level and impermeable with thin limestone interbeds.

Following deposition of the shale and prior to, or during, Pleistocene glaciation, a two mile wide trough (New Haven Trough) was cut northeast to southwest through the bedrock shale. The trough slopes between 1.3 and 2.0 feet per mile. Prior to Illinoian time, a deep stage drainage cut into the bedrock to an elevation of approximately 350 feet, which is 200 feet below the present elevation of the Great Miami River (Figure 2.4). During



Reference: Dames and Moore, 1985

FIGURE 2-4 GENERALIZED GEOLOGIC CROSS SECTION OF NEW HAVEN TROUGH

early Wisconsin time, it is postulated that ice blocked the drainage in the south and west sections of the main valley and created a smaller valley cut to an elevation of 450 feet (Spieker, 1969). This bifurcation of the valley occurs about 1.5 miles southeast of the FMPC and it is through this valley that the Great Miami River presently flows to the Ohio River. As a result of these glacial processes, numerous bedrock highs occur. Two of particular significance in that they affect ground water flow (See Section 2.6) are located just east of Fernald, Ohio, and just north of the FMPC (Dames & Moore, 1985; Geotrans, 1985; Spieker, 1968).

Glacial processes resulted in the deposition of several hundred feet of fill in the trough. Uncomformably overlying the Ordovician shale bedrock are Pleistocene glacial deposits. Glaciation during Illinoian and Wisconsin time, the last ice advances in the region, deposited over 200 feet of glacial outwash in the area. These glacial materials consist of well-sorted, well-rounded unconsolidated sand and gravel that form the major and highly permeable aquifer in the area (See Section 2.6) (Dames & Moore, 1985, Geotrans, 1985; Spieker, 1968).

Overlying the outwash deposits in some areas of the region is a glacial till that varies in composition from clay rich to sand rich. These till deposits also vary in thickness depending on location. For example, near the bedrock highs the outwash materials are absent and the till directly overlies the bedrock shale (Dames & Moore, 1985; Geotrans, 1985).

Subsequent erosion by the present day Great Miami River and its tributaries has removed some of the glacial fill materials leaving terrace remnants throughout the area such as the one the FMPC is located on (Spieker, 1968).

Geology at the FMPC

The elevation of the bedrock surface varies from 327 feet (MSL) south of the production area to 400 feet just north of the FMPC (Geotrans, 1985).

The highly permeable sand and gravel outwash materials beneath the FMPC are separated by a 10 to 20 foot thick greenish black, silty clay that lies at a depth of 100 to 125 feet below the surface. This clay layer, located in the vicinity of the waste storage area and production wells, is discontinuous and has been termed "blue clay" by previous investigators (Figure 2.4) (Geotrans, 1985; Spieker, 1968). Dames and Moore (1985) interpreted this clay layer to extend from west of Paddy's Run to east

of the production wells. There are insufficient data to determine the northern extent of the clay although it pinches out in the area beneath the storm sewer outfall ditch (Dames & Moore, 1985; Geotrans, 1985; Spieker, 1968).

Near the surface of the FMPC overlying the outwash materials, is a dense silty clay glacial till that varies in composition vertically and laterally. The till contains lenses of poorly sorted fine to medium-grained sand and gravel to silty sand and silt with layers of silty clay to the west and south of the site. The silty clay remains continuous to the north and east of the FMPC. The till varies in thickness from 20 to 50 feet and its base is at an elevation of 540 feet (MSL) (Dames & Moore, 1985; Geotrans, 1985; Spieker, 1968).

In summary, given the regional prehistoric depositional environment and subsequent erosional and depositional events during glaciation and stream course meander, considerable uncertainty exists of the subsurface conditions beneath the FMPC. This is readily evident by the discontinuous nature of the glacial till and glacial outwash, as well as the variability in their composition. A properly designed and implemented drilling and sampling program would provide the necessary data to determine the spatial changes of the glacial materials. These data should include information such as clay and silt content, thickness, and other physical and engineering properties of these materials.

2.4.2 Soils

The soil associations in the area around the FMPC consist primarily of Russell - Urban land - Xenia and Markland - Urban land - Patton associations (SCS, 1982; 1980). The Russell - Urban land - Xenia association is characterized by deep, nearly level or gently sloping, well drained to moderately well drained, medium textured soils. These soils are suitable for building site development and also for cropland, pasture, and gardens. The Markland - Urban land - Patton association is characterized as deep, nearly level to steep, moderately well drained to poorly drained, moderately fine textured soils. The nearly level and gently sloping soils of this association are suitable for cropland, although such use can be limited by poor natural drainage and high erosion potential (SCS, 1982).

The predominant soils at the FMPC are classified as Fincastle silt loams and Henshaw silt loams. Fincastle soils have low permeability, moderate productivity, seasonal wetness, and low soil strength. Henshaw silt loam soil is found south of the production area. This soil is deep, nearly level, is somewhat

poorly drained, and occurs on flats and slight rises on low stream terraces. It has moderately low permeability, low runoff and seasonal wetness. Surrounding the FMPC are other silt loams such as Xenia, Markland, and Miamian (SCS, 1982; 1980). Additional information on the physical, chemical, and engineering properties of these soils can be found in the soil surveys for Hamilton and Butler Counties (SCS, 1982; 1980).

Since 1971, annual soil samples have been collected for uranium analysis on and off of the FMPC (Figure 2.5). Each sample was a composite of six cores (2cm in diameter) taken 2 and 10 cm deep (the 1984 and 1985 sampling used 9 cores). On the FMPC, the highest concentration has occurred near the sewage treatment plant (up to 54.22 pCi/g). These concentrations have been attributed to contamination from a nearby incinerator (NLO, 1985a). Off-site soil uranium concentrations, except for a location east of the Sewage Treatment Plant (16.54 pCi/g), have ranged from 0.42 pCi/g to 7.33 pCi/g, and are usually less than on-site concentrations for a given year.

Figure 2.6 shows the results of a study of 105 soil samples taken in 1984 off-site to determine uranium concentrations in the top 5 cm of soil. The high concentrations east of the FMPC are attributed to the former incinerator. The elevated concentration (14.3 ppm) east of Ross is attributed to the sample containing residue from burning coal, which typically has higher uranium concentrations (NLO, 1985a).

In 1984, an additional 25 locations on and off the FMPC were sampled to determine possible contamination of soils by uranium and several other radionuclides (NLO, 1985a). These analyses were unable to detect neptunium-237, and plutonium- 238, -239, and -240. Concentrations of technetium-99 ranged from 0.0 to 4.0 pCi/g. The highest concentrations were found on-site and off-site south of the production area. Thorium-228, -230, and -232 were detected in all samples in concentrations up to 2 pCi/g; concentrations were highest west of Paddy's Run and south of the production area. Total uranium concentrations ranged from 1.4 to 11.8 pCi/g. The highest concentrations were north of the FMPC in Butler County and in one site east of the production area (NLO, 1985a). As noted above, the concentrations east of the FMPC have been attributed to a former nearby incinerator (NLO, 1985a).

Sediment sampling of the Great Miami River upstream (2 locations) and downstream (4 locations) of the effluent line and at the confluence of Paddy's Run (1 location) was begun in 1975. In addition, since 1983, sediment samples were collected for analysis of uranium and technetium at several locations on and off the

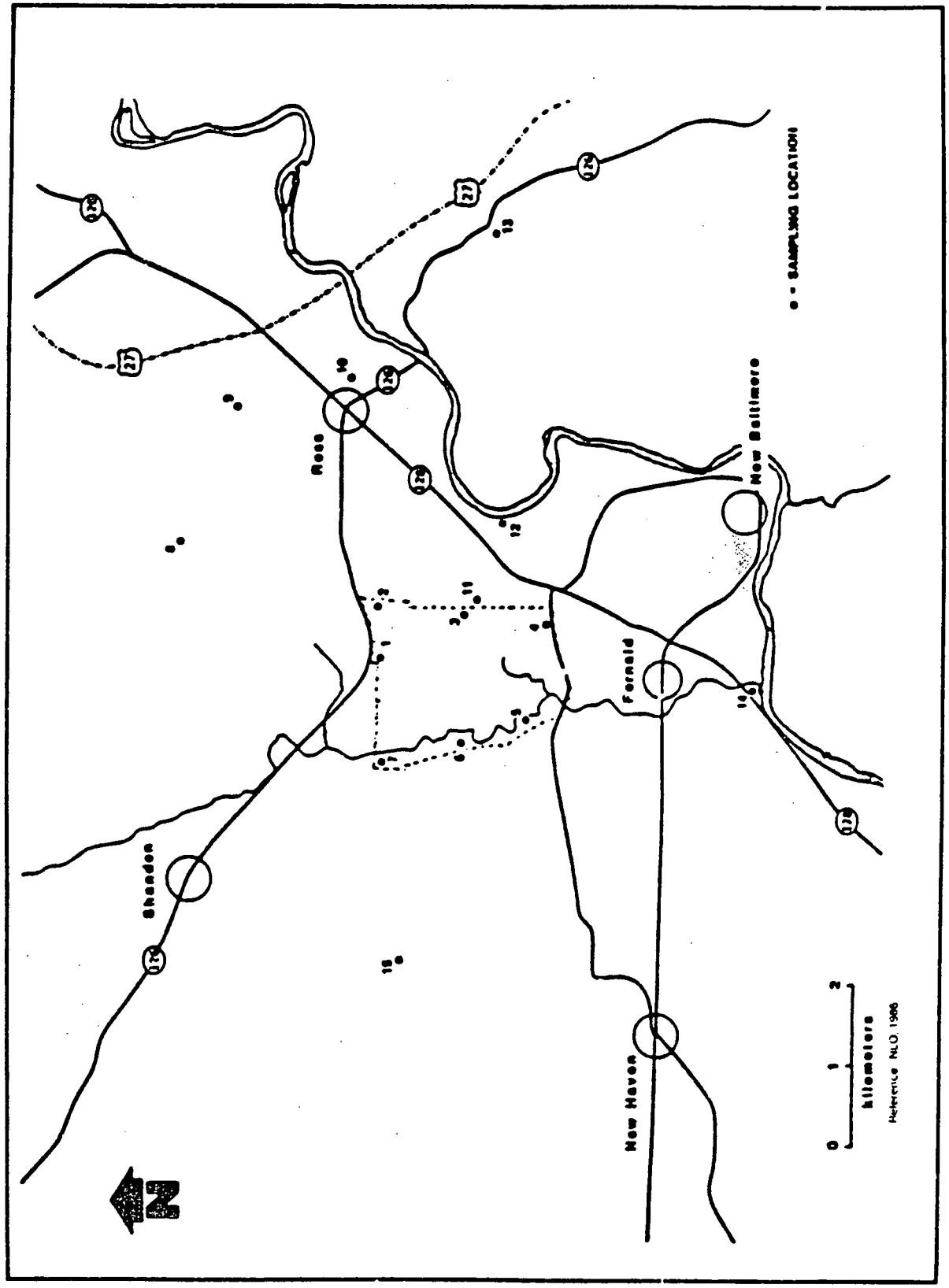


FIGURE 2-5 SOIL SAMPLING LOCATIONS

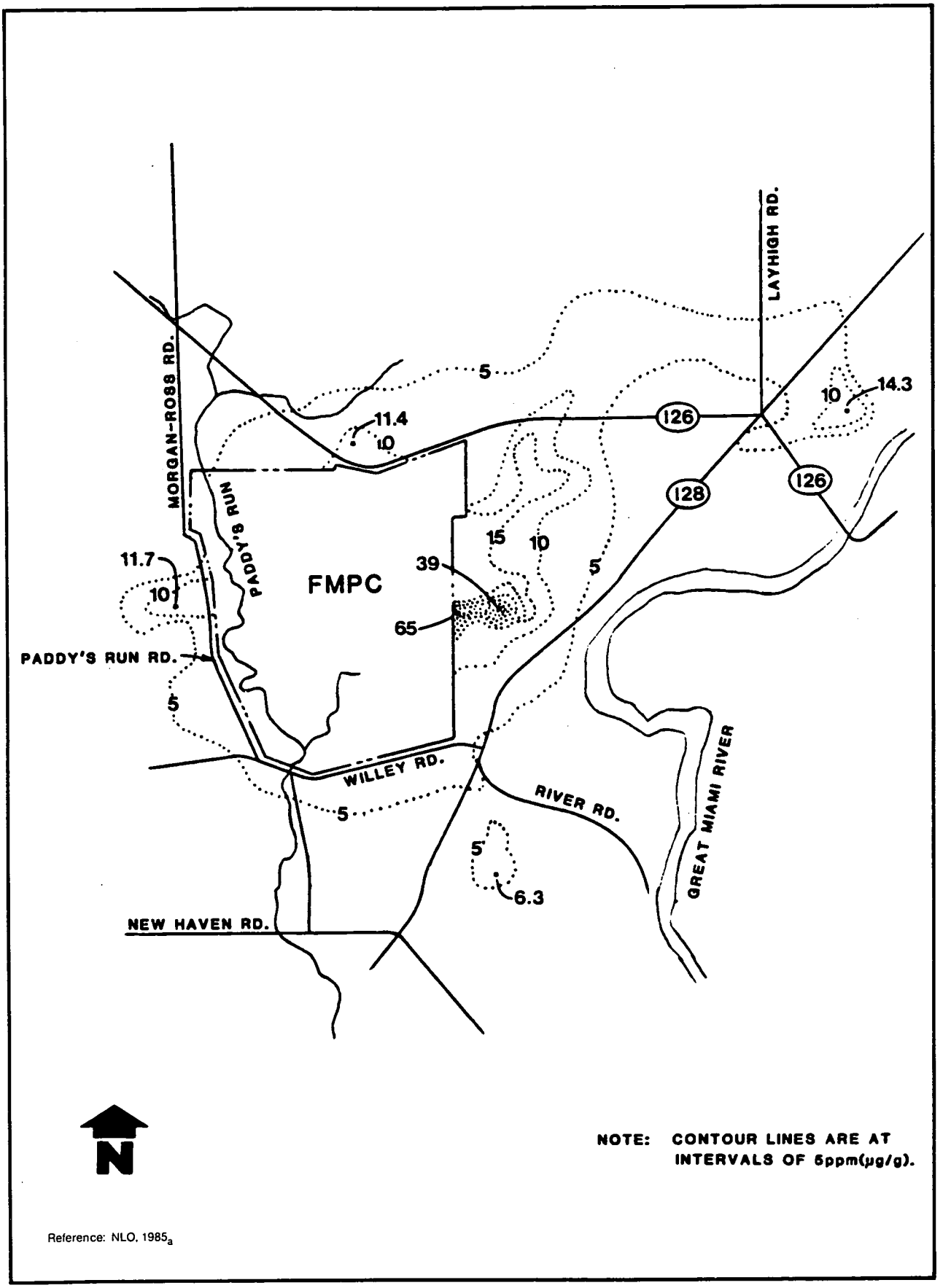


FIGURE 2-6 URANIUM LEVELS IN SOILS ADJACENT TO THE FMPC

Sediment sampling of the Great Miami River upstream (2 locations) and downstream (4 locations) of the effluent line and at the confluence of Paddy's Run (1 location) was begun in 1975. In addition, since 1983, sediment samples were collected for analysis of uranium and technetium at several locations on and off the FMPC in Paddy's Run, the storm sewer outfall ditch, and other drainages.

Uranium concentrations in sediments from the Great Miami River ranged from below detection limits to 3.3 pCi/g; technetium concentrations ranged from 0.0 to 4.9 pCi/g. No trends were apparent for uranium levels, however, technetium concentrations were highest at the effluent outfall than at locations up or downstream.

Uranium concentrations in Paddy's Run sediments ranged up to 180.0 pCi/g. The highest technetium concentration was 30.0 pCi/g. Concentrations generally increased downstream.

The highest uranium concentration detected in on-site (various drainages) sediments was 190 pCi/g, with the highest technetium concentration being 17.0 pCi/g.

Data pertaining to background concentrations of radionuclides and other contaminants (i.e., metals, organics) in the soils and sediments near the FMPC, and the presence of other radionuclides and contaminants are not available. In addition, the vertical and horizontal extent of contamination has not been fully characterized.

2.4.3 Seismic

The FMPC is located in seismic risk zone 2 which indicates the area could experience moderate earthquake damage. However, to date, no earthquake damage has occurred (Battelle, 1981). Two relatively significant (intensities of VII and VIII on the Modified Mercalli scale) earthquakes occurred in 1937 in the Anna, Ohio area, approximately 70 miles north. These quakes resulted in cracked walls and fallen chimneys and was felt over an area of approximately 50 miles.

In 1980, a quake (5.1 on the Richter scale) in Maysville, Kentucky, along the Ohio River, 60 miles southeast of the Fernald site, toppled chimneys in the Cincinnati area (Battelle, 1981).

Prior to 1980, 80 earthquakes have occurred in Ohio since 1776. Six of these quakes (all intensity of II on the Modified Mercalli scale) occurred in the Cincinnati area, last of which occurred in 1937 (Battelle, 1981).

2.5 SURFACE WATER

2.5.1 Regional

The major surface water drainage in the vicinity of the FMPC is the Great Miami River, which originates approximately 80 miles north, and has a drainage area of approximately 3,636 square miles above Hamilton. The Great Miami River joins the Ohio River approximately 15 miles southwest.

Upstream, the river has five ungated flood control structures which assist in regulating the flow of the river (Plummer, 1986). The average discharge for 53 years of record at Hamilton is 3,290 cubic feet per second (cfs). The maximum regulated discharge at Hamilton was 108,000 cfs in January, 1959 and the minimum regulated discharge was 155 cfs in September, 1941. An estimated 1000-year flood event occurred in March, 1913 and resulted in an unregulated discharge of 352,000 cfs at Hamilton (Plummer, 1986).

Water Quality

Water quality is poor to moderate as characterized by low dissolved oxygen and high ammonia (Tables 2-10 and 2-11) (Battelle, 1981). The mean total dissolved solids (TDS) and conductivity recorded at Hamilton in 1984 were 406 mg/liter and 640 microhmos/cm, respectively (Plummer, 1986). Since 1960, NLO (Annual Environmental Monitoring Reports 1961-1986) has sampled the Great Miami River upstream and downstream of the FMPC effluent outflow for uranium, gross alpha, gross beta, chloride, fluoride, nitrate, and pH. In the last few years, radium-226, -228, strontium-90, technetium-99, uranium-234, -235, -236, -228, and -238 also have been sampled. Average annual concentrations of the various constituents were lower than those established by DOE guidelines; upstream concentrations were similar to downstream concentrations.

2.5.2 FMPC

Within the FMPC, the principal drainage is Paddy's Run, an ungaged intermittent tributary which flows into the Great Miami River approximately 1.5 miles south of the FMPC. The run flows only from January through May at an estimated 0.2 to 4.0 cfs (Dames and Moore, 1985). By May, 1986, flow had ceased at the crossing at Willey Road (Lechel, 1986).

A second drainage, the storm Sewer Outfall Ditch, flows south of the Production Area joining with Paddy's Run near the southwest corner of the FMPC. In addition, surface runoff from the Waste Storage Area and fly-ash piles flows to Paddy's Run or its numerous tributaries.

TABLE 2.10 WATER QUALITY IN THE GREAT MIAMI RIVER NEAR MIAMISBURG, OHIO, 1979

	Maximum	Minimum
Specific Conductance (umho/cm^2)	1270	270
pH (SU)	9.1	7.0
Water Temperature (^oC)	31.0	0.0
Dissolved Oxygen (mg/L)	16.1	2.9

Ref. Battelle, 1981

TABLE 2.11 WATER QUALITY IN THE GREAT MIAMI RIVER AT NEW BALTIMORE, OHIO, 1979

Parameter[a]	Maximum	Minimum
Specific Conductance (mho/cm^2)	1030	261
pH(SU)	9.1	2.3
Water Temperature (^oC)	30.0	0.0
Dissolved Oxygen	18.9	3.6
Hardness, as $CaCo_3$	420	220
Alkalinity	260	160
Chloride	90	22
Fluoride	0.8	0.2
Dissolved Solids	544	252
Ammonia	2.4	0.75
Nitrogen, Total	9.1	3.6
Nitrogen, Nitrate	40	16
Phosphorus, Total	0.70	0.18
Arsenic	0.003	0.001
Barium	0.1	0.1
Cadmium	0.004	0.000
Chromium	0.03	0.002
Copper	0.02	0.002
Iron	0.5	0.000
Lead	0.039	0.003
Mercury	<0.0005	<0.0005
Selenium	0.001	0.000
Silver	0.002	0.000
Zinc	0.05	0.01

Ref. Battelle, 1981

[a]All values in mg/L except as noted.

Water Quality

From 1979 through 1985, water quality samples taken along Paddy's Run, upstream and downstream of the FMPC, were analyzed for uranium, gross alpha, gross beta, pH (weekly), chloride, flouride, nitrate (monthly), and radium (bimonthly composites). All average annual levels of the various constituents were lower than established DOE guidelines. However, the average levels of total uranium in samples taken at the confluence of Paddy's Run and the storm sewer outflow ditch in 1984 and 1985 were 15.44 pCi/l and 43.37 pCi/l, respectively, which exceeded the proposed EPA health effects guidance limit of 10 pCi/l (Cothern, et al., 1983). In 1985, total uranium concentrations at two locations upstream also exceed the guidance limit.

As required by the National Pollutant Discharge Elimination System (NPDES) permit, a variety of constituents are sampled at multiple locations on the FMPC. Except for hexavalent chromium and occasionally copper, all other constituents were usually within permit limitations (Table 2.12).

Surface water quality data on heavy metals, organics, and other radioactive constituents are required for upstream of the FMPC and below the confluence of Paddy's Run and the Great Miami River. In addition, the same data are required for on-site surface waters. These data are important in determining the possible contaminant contribution to the groundwater aquifer from surface water recharge and possible contamination of soils and sediments in the area.

2.6 GROUND WATER

2.6.1 Regional

The major aquifer in the region is the very permeable glacial fill (i.e., outwash) aquifer which occupies the New Haven Trough. (The relatively impermeable bedrock shale beneath the glacial materials is not an aquifer). This aquifer yields large quantities of water for domestic, municipal, and industrial uses throughout the region, however, it is extremely variable due to the spatial variations of the composition of the glacial fill that comprises the aquifer (Geotrans, 1985; Spieker, 1968). Therefore, aquifer properties are very locally dependent, although aquifer testing has shown that the system behaves as a single hydrostatic unit. Transmissivity of this aquifer ranges from 150,000 to 500,000 gallons per day per foot (gpd/ft); a storage coefficient of 0.20 has been calculated. Well yields range up to 3,000 gpm (Dames and Moore, 1985; Geotrans, 1985; Walton, 1970; Spieker, 1968).

TABLE 2.12
NPDES EFFLUENT CONCENTRATION FOR 1984 AND 1985

	Daily Minimum		Daily Maximum		NYPDES Permit Limits Daily Maximum	Monthly Average	Compliance		Number of Samples	
	1984	1985	1984	1985			1984	1985	1984	1985
Manhole 175										
pH (Standard Units)	7.3	7.4	9.3	9.1	6.5 to	10.0	100	100	Daily Grab	
Suspended Solids mg/l	<2	<2	33	26	60	20	100	100	53	52
Ammonia (as N) kg/day	<1	<1	46	3	43	28	98	100	53	52
Oil & Grease mg/l	<5	<5	9	19	15	NS	100	98	53	52
Residual Chlorine mg/l	0.01	<0.02	0.08	0.06	0.10	NS	100	100	25[a]	25[a]
Nitrate (as N) kg/day	86	40	2318	1275	3180	1590	98	100	53	52
Flow MGD	0.072	0.106	1.102	1.131	NS[b]	NS	NS	NS	Continuous	
Storm Sewer Outflow										
pH	7.4	7.5	8.5	8.3	6.5 to	10.0	100	100	Grab/Event	
Suspended Solids mg/l	<2	<2	64	175	100	30	100	96	98	68
Oil & Grease mg/l	<5	<5	17	<5	15	NS	100	100	98	68
Flow mg/event	0.006	0.007	1.00	0.844	NS	NS	NS	NS	Continuous	
Sewage Treatment Plant										
pH	7.1	7.2	8.3	7.9	6.5 to	10.0	100	100	Daily Grab	
BOD mg/l	<1	1	18	27	40	20	100	94	53	52
Suspended Solids mg/l	1	1	12	27	40	20	100	96	53	52
Fecal Coliform mpn/100ml	1	0	2000	1000	2000	1000	100	100	29[a]	27[b]
Flow Rate MGD	0.020	0.035	0.246	0.253	NS	NS	NS	NS	Continuous	

TABLE 2.12 (continued)
NPDES EFFLUENT CONCENTRATION FOR 1984 AND 1985

	Daily Minimum		Daily Maximum		NYPDES Permit Limits Daily Maximum	Monthly Average	Compliance		Number of Samples	
	1984	1985	1984	1985			1984	1985	1984	1985
Combined Clear Well & General Sump										
Suspended Solids kg/day	0.6	0.9	17.8	112.4	12.8	6.2	94	90	53	52
Chromium (+6) kg/day	0.0003	0.001	0.013	0.051	0.008	0.004	75	79	53	52
Chromium (Total) kg/day	0.003	0.002	0.047	0.058	0.102	0.050	100	100	53	52
Iron kg/day	0.06	0.01	0.66	1.16	0.85	0.41	98	92	53	52
Nickel kg/day	0.003	0.006	0.161	0.119	0.256	0.124	100	100	53	52
Copper kg/day	0.005	0.005	0.104	0.088	0.051	0.025	86	96	53	52
Flow MGD	0.0	0.000	0.312	0.992	NS	NS	NS	NS	Continuous	
Lift Station										
Suspended Solids mg/l	<2	<2	73	35	100	30	100	100	53	52
Oil & Grease mg/l	<5	<5	7	5	15	NS	100	100	53	52
Flow MGD	0.0	0.079	0.632	0.694	NS	NS	NS	NS	Continuous	

Ref:
[a] monitoring not required during winter
[b] NS = not sampled

Glacial till overlies the outwash materials in some areas. Glacial till, primarily the clay rich types, does not have storage for significant volumes of ground water, although more water can be obtained from sandy tills or those that have developed joints. Well yields of over 15 gpm are not common in till deposits (Driscoll, 1986).

Recharge of the regional aquifer is largely from induced infiltration from the Great Miami River and from precipitation. Induced infiltration which is seasonally dependent, is controlled by temperature, the hydraulic conditions of the stream bed, and the gradient between the aquifer and the river, and is a major factor in the aquifer's ability to sustain large volumes of ground water production (Geotrans, 1985; Walton, 1970).

Studies conducted by Walton (1970) in the Big Bend area of the river, just east of the FMPC, estimated that the average infiltration rate of the river in the area was 168,000 gpd/acre, which constituted approximately 62 percent of the pumped volume. The deep channel of the river has sufficient flow to prevent sedimentation and therefore, has a higher infiltration rate than the shallow parts of the river where the flow rates are lower and sedimentation greater (Geotrans, 1985; Walton, 1970).

Recharge estimates of the aquifer from precipitation for the Big Bend area range from 6 to 21 inches per year. Walton (1970) estimated recharge in the Big Bend area to be 8.5 inches per year, which was approximately 22 percent of the precipitation for that year.

Although the data are not conclusive, the regional potentiometric surface is generally perpendicular to the steep bedrock valley walls. The ground water gradient is down the regional slope of the bedrock, although variations from this occur near high volume pumping centers, and areas of bedrock highs. The bedrock high east of Fernald diverts the regional ground water flow (Geotrans, 1985; Spieker, 1968).

Water Quality

Regional ground water quality is excellent. TDS concentrations range from 340 to 770 mg/l. Concentrations of sulfates and nitrates are low as well as other cations and anions (Geotrans, 1985).

2.6.2 Site

The glacial materials that comprise the aquifer at the FMPC consist of two types; sorted, unconsolidated sand and gravel outwash materials, and a poorly sorted glacial till of clay, silt, sand, and gravel (Figure 2.4) (Dames and Moore, 1985).

The transmissivity of the glacial outwash at the FMPC ranges from 35,000 to 300,000 gpd/ft and has a hydraulic conductivity that ranges from 270 to 370 feet/day. The silty clay layer, 100 to 125 feet beneath the waste storage pits, is discontinuous and as a result permits the transmission of water between the sand layers above and below. Wells that penetrate the clay layer do not have significant head differences from those completed above the layer. Dames and Moore (1985) have estimated the hydraulic conductivity of the clay to be 0.4 ft/day.

The water table elevation within the outwash is 50 to 90 feet below the land surface of the FMPC (Dames and Moore, 1985; Geotrans, 1985). The saturated thickness of the aquifer is 110 to 160 feet. Recharge of the aquifer at the FMPC is primarily from precipitation, with some recharge entering from upgradient. Surface water flow recharges the outwash aquifer at the lower elevations of the FMPC where the clay cap has eroded.

A 20 to 50 foot cap of glacial till, which has eroded in the lower elevations of the FMPC, overlays the glacial outwash along Paddy's Run and the storm sewer outflow ditch. This till has a small localized saturated zone, 4 to 9 feet below the surface. Recharge is from local precipitation. This saturated zone has transmissivities that range from 3.5 gpd/ft to 150 gpd/ft, and hydraulic conductivities of 0.2 ft/day to 2.5 ft/day (Dames and Moore, 1985). The ground water within the till enters the sewer pipes and discharges almost continuously (less than 2 gpm) into the storm sewer outflow ditch (Dames and Moore, 1985; Geotrans, 1985).

Ground water flow at the FMPC is not clearly understood. Suggestions of the possibility of a ground water divide east of the FMPC have not been substantiated. A divide to the east of the site would impede the migration of water borne materials east to the Great Miami River. Ground water flow within the aquifer beneath the waste area has been studied extensively by Dames and Moore. The flow of the aquifer in this area is to the east to the production wells and then south towards Fernald (Dames and Moore, 1985; Spieker, 1968).

Water Quality

Since ground water samples were first collected, concentrations of uranium have been detected in the ground water on-site and off-site (NLO, 1986; 1985a; 1984). This concentration coincides with the channel of Paddy's Run which indicates uranium-bearing surface water is recharging the sand and gravel aquifer (Dames and Moore, 1985). On-site wells have been analyzed quarterly for gross alpha, gross beta, total uranium, nitrate, sulfate, chloride, and pH since 1984. In 1983, only uranium was analyzed in on-site wells. Off-site wells have been sampled for uranium since 1984. On-site concentrations of uranium have ranged from 0.25 to 18.0 pCi/l and off-site concentrations have ranged from 0.14 to 290.0 pCi/l. The measured levels of uranium and other materials analyzed were below applicable DOE limits (NLO, 1986; 1985a, 1984; Dames and Moore, 1985). However, average levels of uranium detected in three off-site wells in 1983, 1984, and 1985, exceed the EPA health effects guidance limit of 10 pCi/l (Cothern, et. al., 1983). These three wells are south of the facilities (NLO, 1985a). Additional water quality data for on-site and off-site wells for constituents such as heavy metals, cations, and anions can be found in Dames and Moore (1986). There is no information on background concentrations of the radioactive constituents, organics, and heavy metals.

To confirm the presence of a ground water divide east of the FMPC, additional data are required. The presence of such a divide is important in determining a more accurate and representative ground water flow regime and thus, the possible route of materials into the regional ground water system. Additional data are also required to determine the presence of a ground water divide west of the FMPC toward the Whitewater River because of its influence on system recharge. To evaluate possible connections between the site specific and regional aquifers, additional data would be required on the hydrologic properties of the glacial till at and near the FMPC. In addition, because of the apparent hydraulic connection between surface water and ground water along the southern reaches of Paddy's Run, further investigations are necessary to assess the hydraulic connection including estimations of recharge rates, because of the high potential for ground water contamination. Further, additional ground water quality data are required to evaluate the horizontal and vertical extent of transport to the site specific aquifer and possibly the regional aquifer. These data should include additional radionuclides, heavy metals, and organics, and a determination of their background concentrations.

2.6.3 Water Use

The primary source of water for Hamilton County and Cincinnati is the Ohio River. Over 100 million gallons per day are withdrawn from a submerged intake crib near the Kentucky shore more than twenty miles upstream from the confluence of the Great Miami and Ohio Rivers. The Cincinnati water works serves 23 municipalities and villages, and most of the unincorporated area of Hamilton County, and parts of Butler and Warren Counties (SCS, 1982).

The Great Miami River in the area of the FMPC is classified by the Ohio EPA for use as primary contact, recreational (seasonal), agricultural, and industrial (OEPA, 1985). The principal use is for cooling of two fossil fuel power plants located upstream near Franklin and Miamisburg, and for process water at two paper mills and one steel mill. Future water use is expected to remain similar to current uses (Plummer, 1986).

There are several major users of the ground water in the region. The Southwestern Ohio Water Company has two production wells east of the FMPC that withdraw an average of 17 million gallons per day (mgpd). The Cincinnati Bolton Plant at Fairfield has 10 wells which collectively withdraw 15 mgpd, a local water association's three wells withdraw 1.5 mgpd, and the three production wells at the FMPC withdraw an average of 0.4 mgpd (Geotrans, 1985). These major users constitute approximately 68 percent of the ground water use in the area.

The surrounding communities of Hamilton and Fairfield also use ground water (SCS, 1980).

2.7 FLORA AND FAUNA

The flora and fauna of the FMPC have been described by Battelle (1977) and thus, much is known regarding species composition. Cursory field surveys conducted by Burt (1986) and Lechel (1986) were confirmatory. However, little is known regarding the presence and extent of wetlands, ponds, and other depressions that naturally act as collector sinks for contaminants caused by surface runoff from the Waste Storage Area.

2.7.1 Flora

The FMPC is in the transition zone between the climax beech forests to the north and the mixed mesophytic deciduous forests of the southern Appalachians. Vegetation outside the fenced, "controlled" area includes mowed pastures, brushy fields, and transition zones to second growth deciduous forests. Within the

waste storage area, vegetation primarily is grass on the covered waste pits and scattered shrubs along small drainages.

Much of the pasture lands are grass and herb dominated habitat with few widely scattered trees. Two areas of mowed fields were planted with conifers in 1972 (NLO, 1986) and trees now are typically 15 to 25 feet tall (Burt, 1986). Deciduous woods occur principally along Paddy's Run with other woodlots north of the Production Area. These woodlots vary from pole sized woods (3 to 10 inch diameter at breast height (dbh)) to woods dominated by trees with two to three foot dbh. Common tree species observed were white ash (Fraxinus americana), sugar maple (Acer saccharium), and elm (Ulmus americana) with sycamore (Platanus occidentalis), and cottonwood (Populus deltoides) becoming more common near Paddy's Run (Burt, 1986). Common understory trees observed were elm and boxelder (Acer negundo). The ground cover was dense being dominated by herbs with scattered clumps of grass. Much of the woods is undisturbed; grazed woods and a large old field habitat occur north of the production area. The old field is typically open with clumps of shrubs and small plots of wood interspersed throughout.

Wetland areas occur principally along drainage ditches near the railroad tracks, and at the western edge of waste pit 3 (Burt, 1986). Common wetland species include sedges (Carex sp.), rushes (Juncus), and cattail (typha sp.). Two small ponds and scattered wet meadows were also observed during brief field surveys in April, 1986 (Burt, 1986). The location, extent, and species composition of all wetlands and ponds on the FMPC is not known.

Fauna

Few reptile and amphibian species have been recorded on the site. The eastern box turtle (Terrapene carolina) and eastern garter snake (Thamnoplus sirtalis) were observed with signs of the snapping turtle (Chelydra serpentina) noted along Paddy's Run (Burt, 1986). Frogs of undetermined species were recorded from two small ponds. Additional species of reptiles and amphibians are very likely to occur on the FMPC.

Fifty-seven species of birds have been observed (Battelle, 1977; Burt, 1986). Common nesting species in the open pasture were the meadowlark (Sturnella magna), red-winged blackbird (Agelaius phoeniceus), and mourning dove (Zenaida macroura). Common species recorded from the woods were the blue jay (Cyanocitta cristata), cardinal (Cardinalis cardinalis), robin (Turdus migratorius), and tufted titmouse (Parus bicolor). Common

species in the shrubby fields were the song sparrow (Melospiza melodia), common yellow throat (Geothlypis trichas) and red-winged blackbird.

A total of 41 species of mammals have ranges in the area of Ohio which includes the FMPC (Gottschang, 1981). The common species observed include the white-tailed deer (Odocoileus virginianus), eastern cottontail (Sylvilagus floridanus), fox squirrel (Sciurus niger), eastern chipmunk (Tamlas striatus), woodchuck (Marmota monax), and raccoon (Procyon lotor). An additional six species have been observed on the FMPC (Battelle, 1977).

Hunting is not allowed on the FMPC. Commonly recorded game species observed include the white-tailed deer and bobwhite quail (Dolinus virginianus). Scattered waterfowl and woodcock (Philohela minor) were also observed. Deer have fairly extensive home ranges that would be expected to extend into the off-site adjacent lands. These animals would be subject to hunting pressure while outside the FMPC. The bobwhite has a much smaller home range and most of the FMPC nesting population probably remain on-site. This species is more mobile during the fall and may be subject to hunting outside the FMPC.

Paddy' Run, the only waterbody of significance on the FMPC, harbors at least 23 species of fish (Bauer, et al., 1978; Battelle, 1977). Minnows and darters were the dominant species. Representative species included the emerald shiner (Notropis atherinoides), spotfin shiner (N. spilopterus), rosefin shiner (N. ardens), and the orangethroat darter (Etheostoma spectabile).

2.8 LAND USE AND POPULATION

2.8.1 Land Use

The FMPC is located in Hamilton and Butler Counties. Both counties are highly urbanized as characterized by residential, commercial, and light industrial development along the Great Miami River and highway corridors. The growing community of Venice (Ross) lies at the junction of state routes 126 and 128 about 2 miles northeast of the FMPC. However, areas immediately surrounding the FMPC are primarily rural in nature as characterized by the predominance of agriculture; light industry, and scattered residences also occur.

Nearby agriculture consists primarily of dairy and beef cattle, and corn and soy bean production. Three dairy operations occur within two miles of the FMPC. Dairy cattle and beef cattle have

grazed for a number of years on land within the confines of the FMPC. Truck crops also are grown for sale at local produce stands and in nearby communities (Battelle, 1981).

The average farm size for these counties varies from 107 to 147 acres. Since 1975, the average farm size has increased although the total land in farm use has decreased (Priest, 1986). The rural nature of the area has attracted many people who work in metropolitan Cincinnati, but prefer a rural residence on 1 to 2 acres as well as those who maintain "hobby" farms of 5-10 acres (Bartels, 1986).

Other local land uses of lesser significance than agriculture include gravel operations along the Great Miami River, industrial facilities (e.g., Delta Steel), parks, and primary and secondary transportation corridors. Two commercial gravel extraction operations are located 1 mile east and 2 miles southeast of the FMPC, respectively.

Three parks that are used primarily during the summer are in the vicinity of the FMPC. Camp Ross Trails (1.5 miles northeast) and Camp Fort Scott (2.0 miles southeast) are youth camps operated by the Girl Scouts of America, and the Roman Catholic Archdiocese of Cincinnati, respectively.

The Miami Whitewater Forest, located 5.0 miles southwest of the FMPC, is one of the largest parks in Hamilton County. Approximately 20 percent of the 2,261-acre park is available or may be developed for public use (e.g., golfing, paddle boats). The remainder is dedicated as a wildlife sanctuary (Welsh, 1986).

Land use in Butler County is guided by the County Land Use Plan which was adopted in 1983-1984. Morgan Township adjacent to the FMPC within Butler County has zoning ordinances and relies on the County plan to control land uses. Ross Township (containing approximately 200 acres of the 1050 acre FMPC) zones by class, i.e., residential, agricultural (Kosobut, 1986). The area north of the FMPC and south of state route 126 is zoned for agricultural use (Thiem, 1986).

Adjacent Hamilton County does not have a county plan; individual townships or municipalities may have their own zoning ordinances (Brienza, 1986). The majority of the FMPC is within Crosby Township which controls land uses by zoning. Land immediately south of the FMPC is zoned industrial, to the east it is zoned agricultural. The FMPC existed prior to township zoning and is thus preempted from zoning ordinances (Strunk, 1986).

Although not a land use per se, schools, hospitals, retirement homes, and the like are of concern because of the higher number of uses and thus, the potential for long term exposure to contaminants. There are no hospitals or retirement homes within five miles of the FMPC; the closest facilities are located in the cities of Hamilton and Cincinnati. The nearest schools are located in Venice (Ross) and the Crosby Township School on New Haven Road, both approximately 2.0 miles from the FMPC.

2.8.2 Population

Within 50 miles of the FMPC there is a population of approximately 2,577,000. Hamilton County supports a population of about 864,000 and Butler County a population of about 275,000 (NLO, 1985a).

Between 1960 and 1970, Hamilton and Butler Counties grew at rates of 6.8 percent and 13.6 percent, respectively. However, between 1970 and 1984, the population of Hamilton County decreased 6.5 percent, from 924,018 to 863,989 whereas the population of Butler County increased 21.5 percent from 226,207 (1970) to a projected 1985 population of 274,800 (Brienza, 1986; Kosobut, 1986).

Within Crosby, Morgan, and Ross townships, population increases have occurred. These increases are thought to be correlated with the larger family size associated with rural areas (e.g., 2.95 for Crosby Township versus 2.65 for Hamilton County) and also to the desirability of living in rural areas and commuting to urban centers (Brienza, 1986).

Most populated areas in the vicinity of the FMPC are unincorporated small towns varying from an estimated population of 30 at Fernald to 3,000 at Venice (Ross). Table 2.13 identifies population by sector within a five-mile radius of the FMPC. Table 2.14 shows the population for the towns within this radius.

The FMPC supports a weekday workforce population of 1,128 during the 8:00 am to 4:30 pm shift, 170 from 4:00 pm to 12:30 am, and 130 until 8:00 am (Carr, 1986). On weekends, this workforce population is reduced, but no lower than 130 workers.

TABLE 2-1

(Population Estimates by Sector Within a Five Mile Radius of the FMPC)

Miles From FMPC	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Distance Totals
0-1	13	3	6	3	0	6	6	0	10	16	6	3	0	3	0	13	88
1-2	13	10	323	134	19	3	493	13	38	42	48	6	10	10	22	29	1,213
2-3	102	90	58	2,224	26	118	176	358	58	134	54	38	16	19	294	86	3,851
3-4	45	54	61	112	243	218	214	262	192	118	58	669	192	61	102	141	2,742
4-5	272	64	41	16	224	368	717	352	371	80	19	224	301	64	93	250	3,456
Total	445	221	489	2,489	512	713	1,606	985	669	390	185	940	519	157	511	519	11,350

REF. Dames and Moore, n.d.

TABLE 2.14
POPULATION CENTERS WITHIN A FIVE-MILE RADIUS
OF THE FMPC

Population Center	Approximate Distance	Estimated Population
Fernald	1.75	30
Shandon	2.0	200
Venice (Ross)	2.5	3,000
New Baltimore	2.75	200
New Haven	3.0	200
Dunlap	4.0	100
Harrison	5.0	4,408
Total		8,138

Ref. - NLO, 1977

2.9 TRANSPORTATION

The regional transportation network is highly developed and is characterized by high-speed, high-capacity interstates (e.g., I-74), and heavy-duty state and county roads. The roads nearby the FMPC include light-duty secondary roads (e.g., Paddy's Run Road) and medium and heavy-duty state routes 126 and 128, respectively. Willey Road is classified as medium-duty. Table 2.15 provides the most recent average daily traffic (ADT) counts for roads near the FMPC (Smith, 1986).

TABLE 2.15

AVERAGE DAILY TRAFFIC (ADT)

Location	Passenger	Commercial
Intersection routes 126 and 128	6,560	210
Route 128 between Venice and Hamilton County line	4,470	560
Intersection route 128 and Willey Road	4,470	560
Route 128 between Willey Road and New Haven Road	3,570	560
Route 748 at Shandon to Morgan Ross Road	3,260	130

Ref. Smith, 1986

[a] Butler County, 1985; Hamilton County, 1984.

References

Bartels, S., 1986. Butler County Cooperative Extension Service, Hamilton, Ohio. Personal Communication with Sandra Beranich, Roy F. Weston, Inc., Albuquerque, NM, April 24, 1986.

Battelle, 1981. "Final Report, Environmental Report of the Feed Materials Production Center," prepared for National Lead of Ohio, Inc, Cincinnati, Ohio.

Battelle, 1977. "Final Report on Ecological Assessment at the Feed Materials Production Center, Cincinnati, Ohio," prepared for National Lead of Ohio, Inc., Cincinnati, Ohio.

Bauer et al., Bauer, B.H., B.A. Branson, and S.T. Colwell, 1978. Fishes of Paddy's Run Creek and the Dry Fork of the Whitewater River, Southwestern Ohio. Ohio J. Sci. 78(3):144-148.

Brienza, A., 1986. Hamilton County Regional Planning Commission, Cincinnati, Ohio. Personal Communications with Sandra Beranich, Roy F. Weston, Inc., Albuquerque, NM, April 24 and May 1, 1986.

Burt, C.J., 1986. "Unpublished Field Notes FMPC Site, 29 and 30 April, 1986." Roy F. Weston, Inc., Albuquerque, NM.

Carr, D., 1986. Westinghouse Materials Company of Ohio. Communications with Sandra Beranich, Roy F. Weston, Inc., Albuquerque, NM, June 2, 1986.

Cummings, G., 1986. U.S. Soil Conservation Service, Cincinnati, Ohio. Personal communication with Chuck Burt, Roy F. Weston, Inc., Albuquerque, NM, June 3, 1986.

Cothern et al. (Cothern, C.R., W.L. Lappenenbusch, and J.A. Cotruvo), 1983. "Health Effects Guidance for Uranium in Drinking Water," Health Physics, Volume 44, Supplement No. 1, pp. 377-384.

Dames and Moore, 1986. "Results of Round 1 Groundwater Sampling, Feed Materials Production Center, Fernald, Ohio," Prepared for Westinhouse Materials Company of Ohio, Cincinnati, Ohio.

Dames and Moore, 1985. Department of Energy Feed Materials Production Center, Ground Water Task C Report, prepared for National Lead of Ohio, Inc., Cincinnati, Ohio.

Dames and Moore, no date. Final Safety Analysis Report FMPC Waste Storage Area. Prepared for National Lead of Ohio, Inc., Cincinnati, Ohio.

EPA (U.S. Environmental Protection Agency), 1984. 40CFR Part 50 - National Primary and Secondary Ambient Air Quality Standards.

Geotrans, 1985. "Preliminary Characterization of the Groundwater Flow System Near the Feed Materials Production Center, Great Miami River Valley Fill Aquifer, Fernald Ohio." Prepared by Geotrans, Inc., Dayton, Ohio for Ohio Environmental Protection Agency, Dayton, Ohio, September, 1985.

Gottschang, J.L., 1981. A Guide to the Mammals of Ohio. The Ohio State University Press, Columbus, Ohio.

Kosobut, F., 1986. Butler County Planning Director, Hamilton, Ohio. Personal Communication with Sandra Beranich, Roy F. Weston, Inc., Albuquerque, NM, May 6, 1986.

Lechel, D.J., 1986. "Unpublished Field Notes FMPC Site, 29 and 30 April, 1986." Roy F. Weston, Inc., Albuquerque, NM.

Mound, 1985. Radon and Radon Flux Measurements at the Feed Materials Production Center, Fernald, Ohio. Prepared for the U.S. Department of Energy by Mound Laboratories, Miamisburg, Ohio.

NLO (National Lead of Ohio, Inc.), 1986. "Feed Materials Production Center Environmental Monitoring Annual Report for 1985," National Lead of Ohio, Inc., Cincinnati, Ohio.

NLO (National Lead of Ohio, Inc.), 1985a. "Feed Materials Production Center Environmental Monitoring Annual Report for 1984," National Lead of Ohio, Inc., Cincinnati, Ohio.

NLO (National Lead of Ohio, Inc.), 1984. "Feed Materials Production Center Environmental Monitoring Annual Report for 1983," National Lead of Ohio, Inc., Cincinnati, Ohio.

NLO (National Lead of Ohio, Inc.), 1983. "Feed Materials Production Center Environmental Monitoring Annual Report for 1982," National Lead of Ohio, Inc., Cincinnati, Ohio.

NLO (National Lead of Ohio, Inc.), 1981. "Feed Materials Production Center Environmental Monitoring Annual Report for 1980," National Lead of Ohio, Inc., Cincinnati, Ohio.

NLO (National Lead of Ohio, Inc.), 1980. "Feed Materials Production Center Environmental Monitoring Annual Report for 1979," National Lead of Ohio, Inc., Cincinnati, Ohio.

NLO (National Lead of Ohio, Inc.), 1979. "Feed Materials Production Center Environmental Monitoring Annual Report for 1978," National Lead of Ohio, Inc., Cincinnati, Ohio.

NLO (National Lead of Ohio, Inc.), 1978. "Feed Materials Production Center Environmental Monitoring Annual Report for 1977," National Lead of Ohio, Inc., Cincinnati, Ohio.

NLO (National Lead of Ohio, Inc.), 1976. "Feed Materials Production Center Environmental Monitoring Annual Report for 1975," National Lead of Ohio, Inc., Cincinnati, Ohio.

NLO (National Lead of Ohio, Inc.), 1975. "Feed Materials Production Center Environmental Monitoring Annual Report for 1974," National Lead of Ohio, Inc., Cincinnati, Ohio.

NLO (National Lead of Ohio, Inc.), 1974. "Feed Materials Production Center Environmental Monitoring Annual Report for 1973," National Lead of Ohio, Inc., Cincinnati, Ohio.

NLO (National Lead of Ohio, Inc.), 1973. "Feed Materials Production Center Environmental Monitoring Annual Report for 1971," National Lead of Ohio, Inc., Cincinnati, Ohio.

NLO (National Lead of Ohio, Inc.), 1977. Study of Radioactive Waste Storage Areas at the Feed Mill Production Center, National Lead of Ohio, Inc., Cincinnati, Ohio.

NOAA (National Oceanic and Atmospheric Administration), 1984. "Local Climatological Data Annual Summary With Comparative Data, Cincinnati (Greater Cincinnati Airport), Ohio," National Climatic Data Center, Asheville, North Carolina.

Ohio EPA (Ohio Environmental Protection Agency), 1980. "General Provisions on Air Pollution Control," OAC-3745-15 (Former Rule AP-Z). Southwest District Office, Dayton, Ohio.

OEPA (Ohio Environmental Protection Agency), 1985. State of Ohio Worker Quality Standards, Chapter 3745-1 of the Administration Code.

ORAU (Oak Ridge Associated Universities), 1985. "Environmental Program Review of the Feed Materials Production Center, Fernald, Ohio." Prepared for U.S. Department of Energy, Oak Ridge Operations Office, Oak Ridge, TN.

Plummer, Paul, 1986. Miami Conservancy District, Dayton, Ohio, Personal Communication with Denise Bierley of Roy F. Weston, Inc., Albuquerque, NM, May 2, 1986.

Poff, T., 1986. Westinghouse Materials Company of Ohio, Personal Communication with David Lechel, Roy F. Weston, Inc., Albuquerque, NM, May 8, 1986.

Priest, J., 1986. Hamilton county Cooperative Extension Service, Cincinnati, Ohio. Personal Communication with Sandra Beranich, Roy F. Weston, Inc., Albuquerque, NM, May 6, 1986.

Riley, V., 1986. Ohio Public Utilities Commission, Columbus, Ohio. Personal Communication with Sandra Beranich, Roy F. Weston, Inc., Albuquerque, NM, May 20, 1986.

SCS (Soil Conservation Service), 1982. Soil Survey of Hamilton County, Ohio. U.S. Department of Agriculture.

SCS (Soil Conservation Service), 1980. Soil Survey of Butler County, Ohio. U.S. Department of Agriculture.

Smith, D., 1986. Ohio Department of Transportation, Columbus, Ohio. Personal communication with Sandra Beranich, Roy F. Weston, Inc., Albuquerque, NM, June 6, 1986.

Spieker, A.M., 1968. Groundwater Hydrology and Geology of the Lower Greater Miami River Valley, Ohio. U.S. Geological Survey Professional Paper 605-A, Reston, VA.

Strunk, W., 1986. Crosby Township Trustee. Personal communication with Sandra Beranich, Roy F. Weston, Inc., Albuquerque, NM, May 20, 1986.

Thiem, D., 1986. Ross Township Trustee, Millville, Ohio. Personal communication with Sandra Beranich, Roy F. Weston, Inc., Albuquerque, NM, May 28, 1986.

Walton, William 1970. Groundwater Resource Evaluation. McGraw-Hill Company, New York, New York.

Welsh, S., 1986. Miami-Whitewater Forest, Cincinnati, Ohio. Personal communication with Sandra Beranich, Roy F. Weston, Inc., Albuquerque, NM, May 28, 1986.

Section 3

CHAPTER 3

NATURE AND EXTENT OF THE PROBLEM

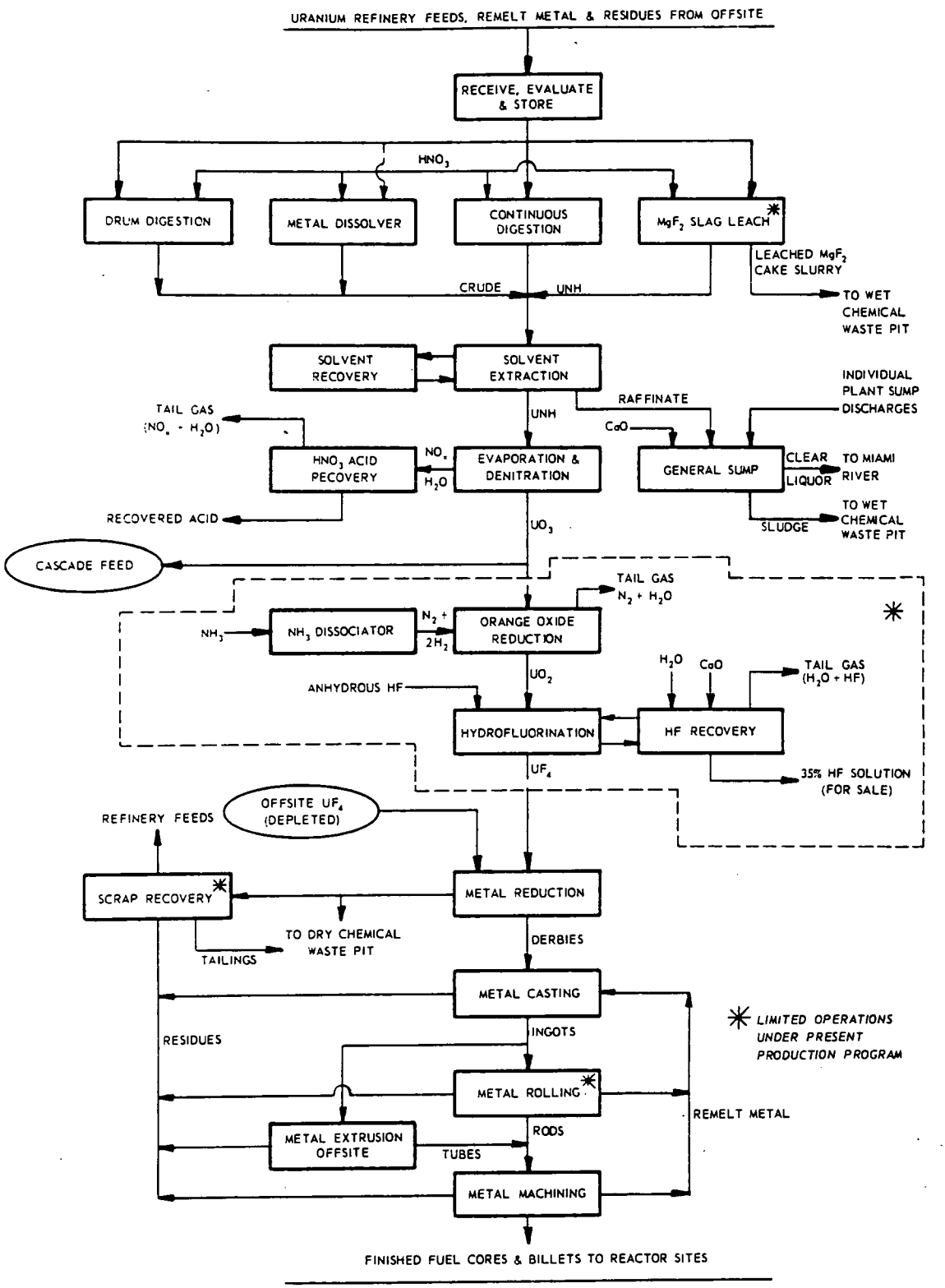
3.1 FMPC PRODUCTION ACTIVITIES

The FMPC was constructed in 1951 to produce high purity uranium metal in several physical forms for use at various DOE facilities. A wide variety of chemical and metallurgical processes are utilized; Figure 3.1 is a schematic of these processes (ORAU, 1985).

Several radionuclides are known to be present in feed materials processed, stored, or disposed on the FMPC. U-235 enrichments in raw materials range up to approximately 20%. However, the maximum product enrichment is 1.25% and the average product is slightly depleted. A small amount of thorium processing also has been performed in the past, but presently thorium is only stored. Small quantities of fission products (e.g. Sr-90, Cs-137, and Tc-99) and transuranics are also possible in some plant effluents and wastes as a consequence of processing some recycled fuel (ORAU, 1985). In addition, other non-uranic radionuclides (e.g., neptunium, plutonium) have been found in plant effluents. Raw feed materials containing very low concentrations of plutonium were used as late as May 1986 (Employee Bulletin, 1986).

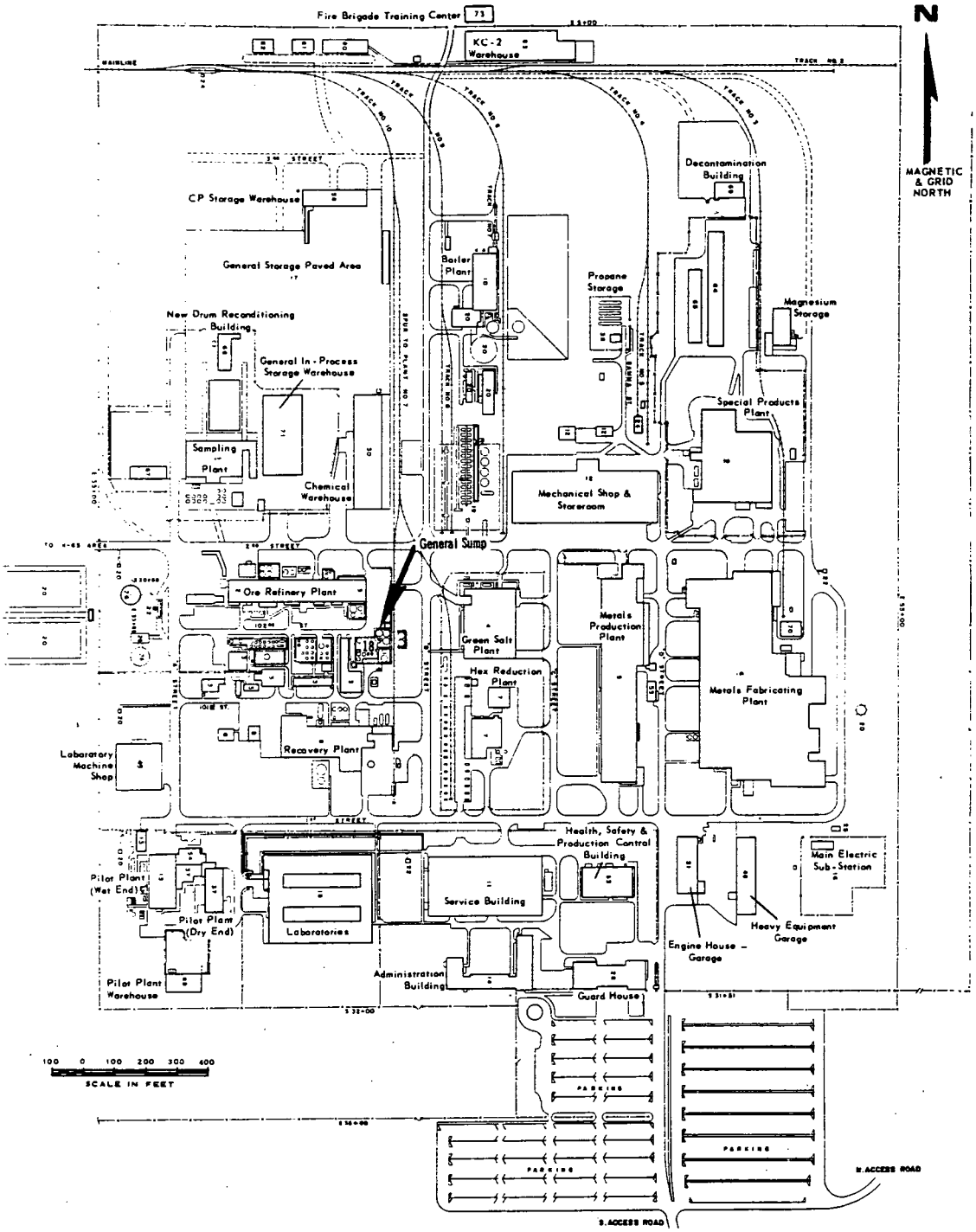
In general, production facilities at the FMPC consist of eight separate operations plants. The FMPC also maintains support buildings and facilities, and waste storage and treatment facilities (Figure 3.2).

Uranium production begins at the Sampling Plant with ore concentrates, recycled uranium from spent reactor fuel, or with various uranium compounds. At the Refinery, these materials are dissolved in nitric acid, the uranium extracted into an organic liquid and then back-extracted into dilute nitric acid to yield a solution of uranyl nitrate (NLO, 1985a). The uranyl nitrate is evaporated and heated to convert the solution to uranium trioxide (UO_3) powder. In the Green Salt Plant, the UO_3 is reduced to uranium dioxide (UO_2) with hydrogen and then converted to uranium tetrafluoride (UF_4) by reaction with anhydrous hydrogen fluoride. In the Metals Production Plant, UF_4 and magnesium are combined in a refractory lined reduction



Reference ORAU, 1985.

FIGURE 3-1 SCHEMATIC DIAGRAM OF THE FMPC PROCESS



Reference NLO 1985b.

FIGURE 3-2 PRODUCTION AREA

vessel to produce uranium. This primary uranium metal is then re-melted with scrap uranium metal to yield purified uranium ingots which are extruded to form rods or tubes in the Metals Fabrication Plant. Sections are then cut and machined to final dimensions. Primary metal and metal castings of other shapes are also final products (NLO, 1985a).

In addition to uranium production, the FMPC maintains facilities to recycle materials, and to produce special products and thorium.

3.1.1 Sampling Plant

The Sampling Plant's primary function is to weigh and sample incoming feed materials to establish the nuclear materials accountability base (Battelle, 1981). The Sampling Plant also: opens fuel rods containing enriched UO_2 pellets and powders; reclaims uranium from cleaning solvents by distillation; recovers solvents; reconditions steel drums for reuse; and stores waste materials, recycled materials, and uranium bearing concentrates.

3.1.2 Refinery

The Refinery produces UO_3 through a multi-stage process involving digestion, extraction, and denitration (Battelle, 1981).

Feed materials are fed into tanks for digestion in nitric acid. The resulting slurry consists of acid insolubles, a solution of impure uranyl nitrate, and excess nitric acid. The slurry is then pumped to the extraction system for filtration and evaporation prior to extraction.

In the primary extraction column, the aqueous feed slurry is mixed with tributyl phosphate and kerosene to selectively extract uranium. Thus, most of the nitric acid and impurities remain in the aqueous raffinate. A raffinate mixer-settler is sometimes used in series with the primary extraction column to further reduce the uranium content of the aqueous waste stream leaving the primary extraction column.

The uranium contained in the extract stream is further purified by scrubbing with a counterflow of water in the compound primary extraction column. The aqueous stream from the scrubbing operation combines with the aqueous feed in the primary

extraction column. The purified uranyl nitrate is recovered from the organic solvent stream by back-extraction with deionized water in stripping columns. After treatment with a sodium carbonate solution to remove degradation products, the stripped solvent stream is recycled to the primary extraction column.

In the denitration process, aqueous uranyl nitrate is concentrated by evaporation and boildown and is then calcined in denitration pots to yield the end product (UO_3) of the Refinery operations. The UO_3 product is packaged and is retained for further processing or shipped to other DOE facilities.

Concurrent with Refinery operations, nitric acid is recovered from the exhaust gas streams in the digestion and denitration areas and from several other minor sources. This acid is returned to the digestion area of the Refinery for reuse.

What little uranium is contained in the aqueous waste streams from the solvent treatment and cleanout operations is precipitated with magnesia, sodium hydroxide, or calcium oxide. Extraction raffinate and other low-level uranium wastes are precipitated and neutralized with lime before disposal.

3.1.3 Green Salt Plant

UO_3 is converted to UO_2 in the Green Salt Plant by reduction with hydrogen (Battelle, 1981). The UO_2 is then coverted to uranium tetrafluoride, UF_4 (i.e., green salt), in a reaction with anhydrous hydrogen fluoride.

UO_3 is fed to heated stainless steel, fluidized bed reactors. Dissociated ammonia enters at the bottom of the reactors through a gas diffuser; hydrogen and nitrogen hold the UO_3 powder in suspension. Partially converted UO_3 overflows from the first fluidized bed reactor into the second where the reaction with hydrogen completes the production of UO_2.

Production of green salt takes place in groups of three heated horizontal, ribbon-screw reactors arranged in vertical stacks. UO_2 enters at one end of the top reactor and is conveyed slowly to the other end by a power-driven ribbon screw. The operating temperature is progressively higher for each reactor, starting at about 300°F and ranging up to 1200°F. Anhydrous hydrogen fluoride gas enters at the discharge end of the bottom reactor and flows countercurrent to the UO_2 up through the three reactors and produces UF_4.

3.1.4 Metals Production Plant

Uranium metal is produced from UF_4 by reduction in a closed steel reduction pot lined with packed magnesium fluoride slag (Battelle, 1981). UF_4 and magnesium granules are blended and charged into the slag-lined pot. The pot is capped with slag, sealed, and heated in a resistance furnace until the contents react spontaneously. After this reaction, the pot is removed, cooled, and the uranium mass (called a derby) is separated, cleaned, weighed and transferred to the casting area. The slag from the pot liner is milled for reuse as liner material.

In the casting process, cleaned derbies and scrap uranium metal are put into a graphite crucible. The loaded crucible is placed in a vacuum induction furnace and heated; the molten metal flows into a heated graphite mold. After cooling, the mold is removed from the ingot, cleaned, and readied for reuse.

Ingots destined for extrusion are sampled and cropped (i.e., a piece is sawed from the top section of the ingot to remove shrinkage cavities and impurities).

3.1.5 Metals Fabrication Plant

Ingots made for extrusion are heat-treated in a molten salt bath in the Metals Fabrication Plant before shipment to an off-site extrusion facility (Battelle, 1981). The metal is returned as extruded tubes approximately 10 feet in length. These tubes are cut into 8-inch lengths. Further processing consists of heat-treating in molten salt, quenching in oil, and reaming; reduction of the outside diameter; and machining of each end-face on a multi-station transfer machine. The finished tubular cores are cleaned and inspected for surface defects, dimensional accuracy, and grain size before packaging for shipment to other DOE facilities.

Uranium ingots also can be converted to solid fuel element cores in the Metals Fabrication Plant. The ingots are first heated in a molten salt bath and then reduced to round rods by a series of rolling operations. The rods are air-cooled, conveyed through a rod straightener, weighed, and inspected.

The rods are then cut into blanks, heat-treated and machined to final size. The machined cores are stamped for identification, degreased, pickled in nitric acid, rinsed, and inspected for surface defects, dimensional accuracy, and grain size.

3.1.6 Recovery Plant

Uranium recycle materials for process operations at the FMPC and elsewhere are sorted, calcined, screened, milled, and blended as necessary. Recycled materials containing metallics, oil, and graphite must be calcined to oxidize these components. Several furnaces are used for this purpose: a rotary kiln, three multiple-hearth vertical furnaces, and two small single-hearth furnaces.

3.1.7 Pilot Plant

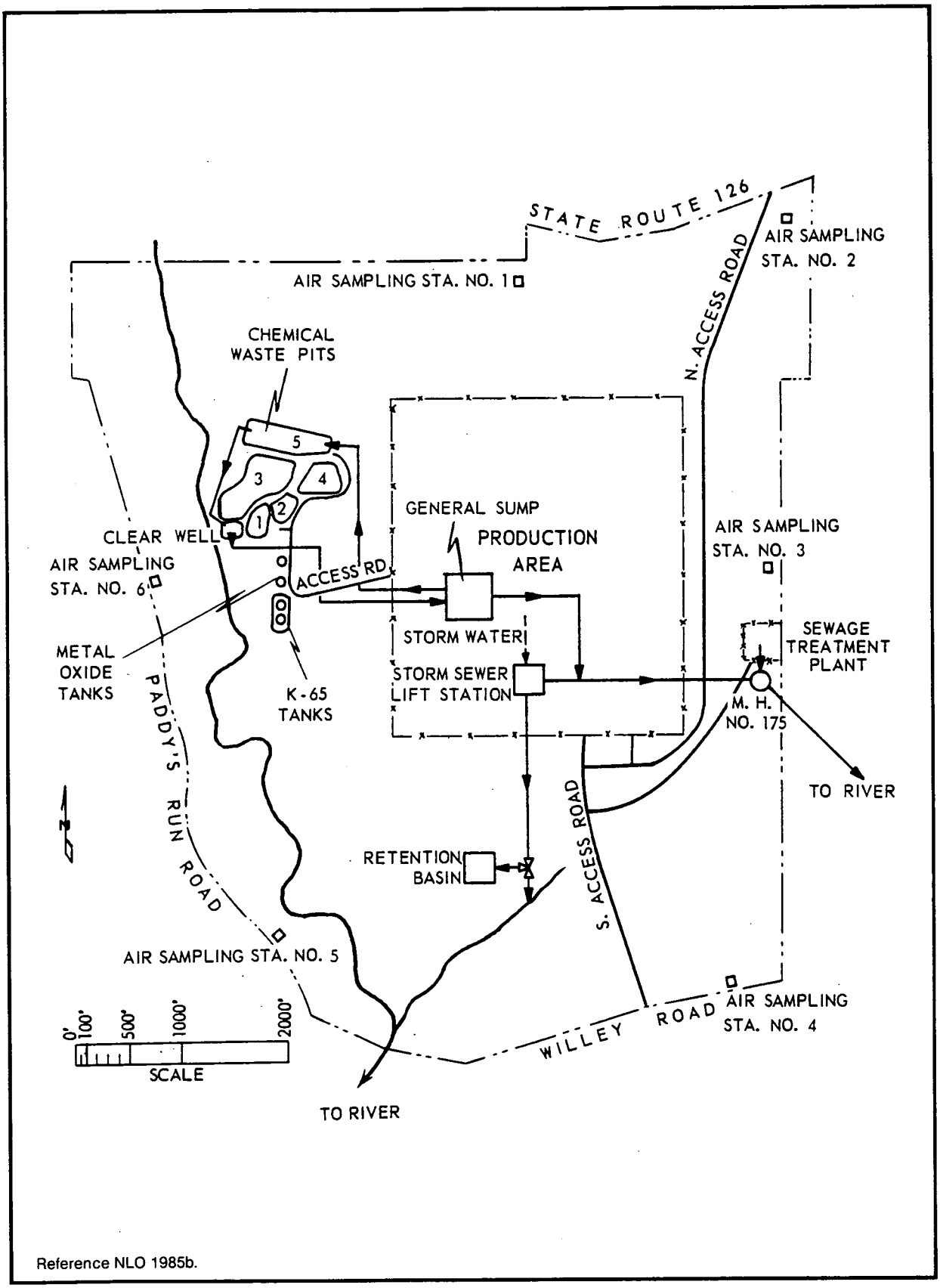
The Pilot Plant has a wide range of chemical and metallurgical process equipment principally used for handling enriched uranium feed materials containing up to 10 percent U-235 (Battelle, 1981). The Pilot Plant is also utilized for the infrequent processing of thorium. The plant can produce purified thorium nitrate, thorium oxalate, thorium metal, and thoria gel. Thorium processing includes a complete solvent-extraction refining system, a multi-tank system for precipitation, several filters, an oven-drying system, atmospheric furnaces for dehydration and metal reduction, vacuum furnaces for dezincing, and all auxiliary systems, including milling, sawing, and dust collection.

3.1.8 Special Products Plant

This plant processes uranium metal pieces larger in size than those processed in the Metals Production and Metals Fabrication Plants (Battelle, 1981). A decladding operation (Zirnlo process) is also performed in this plant. Reject fuel elements from the cladding operation of reactor sites are processed to remove the jacket materials that encase the uranium metal fuel elements. The clad elements are immersed in a solution of hydrofluoric acid to dissolve the jacket and the unaffected uranium metal cores are recovered for reuse.

3.2 WASTE TREATMENT FACILITIES

Contaminated and uncontaminated solid and liquid wastes are produced at the FMPC. Figure 3.3 depicts the locations of waste treatment and storage facilities. Much of the succeeding discussion is based upon NLO (1985b).



Reference NLO 1985b.

FIGURE 3-3 WASTE TREATMENT, STORAGE LOCATIONS, AND PERIMETER AIR SAMPLING LOCATIONS

3.2.1 Solid Wastes

Production processes at the various plants produce, in general, three types of solid wastes: noncombustible wastes; combustible residues, sludges, and other waste products; and filter cakes.

These solid wastes are boxed or drummed for off-site shipment and disposal at the Nevada Test Site (NTS). The uranium content of these wastes is low and uranium recovery is not feasible (Poff, 1986).

Uranium is recovered from the generated ash in the Recovery Plant or the Refinery. Currently, contaminated wood is stored on the FMPC. In the future this wood may be disposed by: shipping to Oak Ridge, Tennessee for incineration; on-site incineration; or reduction in size with disposal at the NTS (Poff, 1986).

Dry filter cakes from the Recovery Plant, resulting from the filtration of raffinates and sludges that have accumulated in the general sump, currently are stored in drums for disposal at the NTS. Wet filter cakes are drummed and stored on the FMPC. Future disposal plans call for further drying in a rotary hearth furnace with disposal at the NTS (Poff, 1986).

3.2.2 Liquid Wastes

Liquid wastes are generated in every operation of the FMPC. The three branches of the liquid waste stream are: process waste, (including facility washdown water), sanitary sewage, and storm water.

Process Waste

- Plant Treatment Facilities

Each of the major process areas have individual treatment facilities designed to pretreat liquid wastes that are unique to that particular process step. In these plant treatment units, virtually all of the radioactive materials in the wastes are removed as filter cakes and processed for recovery of uranium (NLO, 1985b).

Generally, the plant treatment facilities are simple installations which provide equipment and tankage to collect waste liquors, adjust the pH to precipitate uranium, and filter the resultant slurry. Where oils are present, preliminary steps are taken to separate the oils by acidification and decantation

before neutralization and precipitation. After sampling and analysis is performed to ascertain that uranium content is within pre-set allowable discard limits, the filtrate is pumped to the general sump and filter cakes are sent to the Refinery or the Recovery Plant as a process residue (Battelle, 1981).

When thorium is processed in the Pilot Plant, the waste liquors are neutralized with barium carbonate and aluminum sulfate to reduce Ra-228 activity. Because of its higher Ra-228 content, raffinate from the thorium extraction process is segregated from other thorium liquid wastes and subjected to a second $BaCO_3$-$Al_2(SO_4)_3$ treatment and filtration before the resultant filtrate is pumped to the general sump (Battelle, 1981).

- General Sump

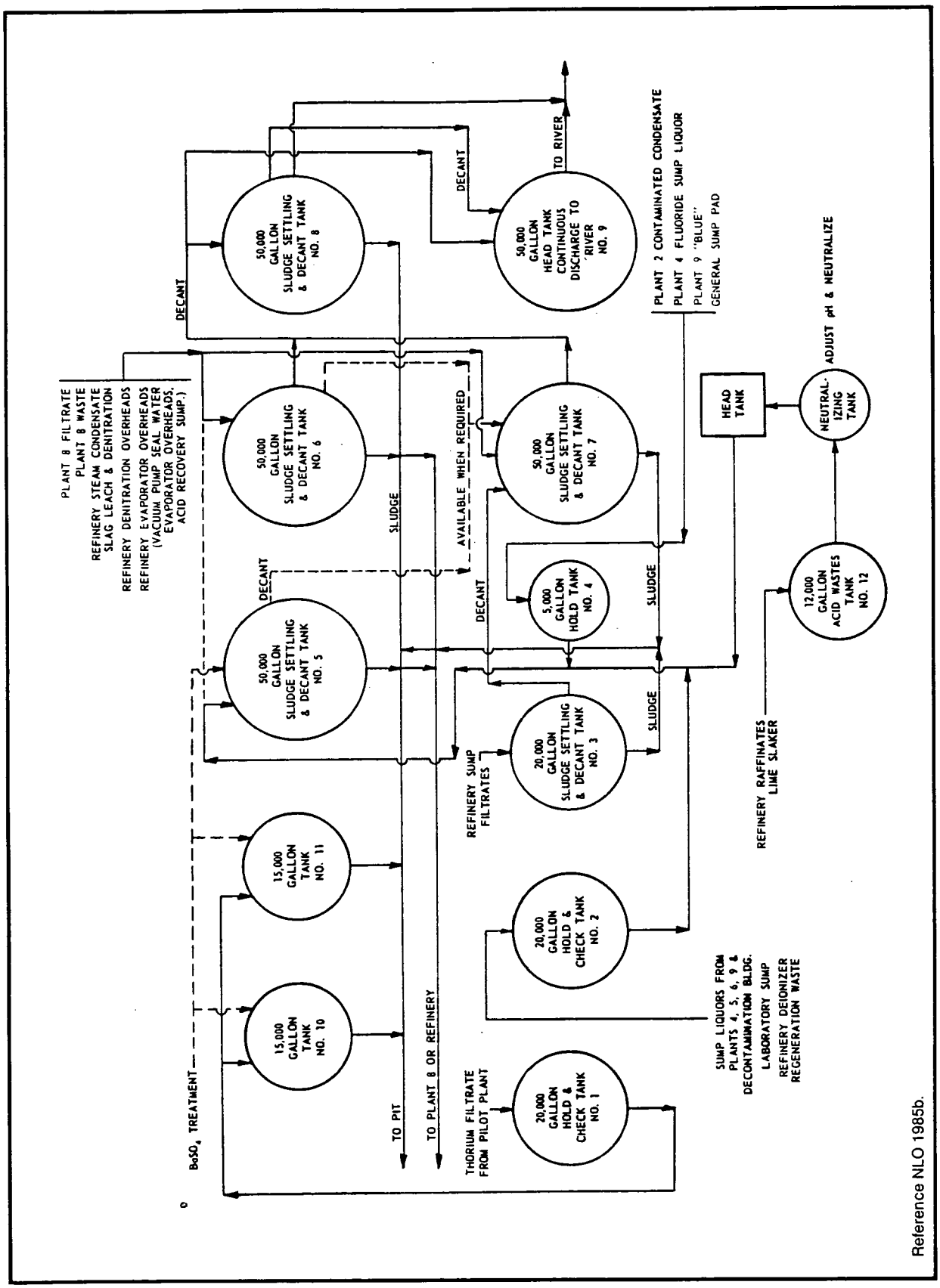
A simplified historical flow diagram of the general sump is shown in Figure 3.4.

The general sump consists of vertical tanks, pumps, piping, and valves on a pad. The general sumps facilitate the transfer, storage, and discharge of liquid wastes within the complex, and the addition of various reagents and coagulating agents. The general sump has provisions for grab and continuous sampling. The controlled pad is equipped with its own sump and drainage trenches to handle any leaks or accidental spills (NLO, 1985b).

The process wastes from the various plants and service facilities are received at the general sump, checked for uranium (or thorium) content, and segregated or selectively combined as required. If wastes exceed discard specifications, they are neutralized, precipitated, and filtered, and the filter cakes are held for recovery of uranium or thorium prior to disposal. Thorium wastes, if present, are segregated, co-precipitated with barium carbonate and aluminum sulfate to further reduce Ra-228 activity (Battelle, 1981).

Acidic raffinates from the refinery extraction process are segregated, neutralized with calcium oxide, and then pumped to the Recovery Plant for solids removal by filtration on rotary vacuum filters (NLO, 1985b).

Most other uranium-bearing wastes are pH adjusted with calcium oxide to maximize precipitation of remaining radionuclides, settled, and decanted prior to discharge of the effluent to the Great Miami River. The settled sludges are also transferred to the Recovery Plant for filtration.



Reference NLO 1985b.

FIGURE 3-4 GENERAL SUMP HISTORICAL FLOW DIAGRAM

Before discharge from the general sump to the Great Miami River, all liquid wastes are sampled and analyzed. Discharges to the Great Miami River are treated to effluent concentrations in accordance with the National Pollutant Discharge Elimination System (NPDES) permit.

- Recovery Plant

Waste slurries, including neutralized Refinery raffinate, general sump slurry, and slag leach slurry, are filtered on rotary vacuum filters in the Recovery Plant. The filter cakes currently are stored in drums on storage pads: dry filter cakes drums are disposed at the NTS; wet filter cakes drums are in temporary storage (See Section 3.2.1) (Poff, 1986). The filtrate is pumped to the clear well for subsequent discharge to the Great Miami River in accordance with the NPDES permit.

- Waste Pit 5

Waste Pit 5, like Waste Pit 3, was used as a final settling basin located northwest of the production area. It is roughly rectangular in shape, with a surface area of approximately 3.6 acres and a capacity of approximately 21,000,000 gallons, lined with 60 mil thick Royal-Seal EPDM Elastomeric Membrane (Uniroyal). It no longer serves as a settling basin, but unconfined filter effluent flows across the pit prior to discharge to the clear well (NLO, 1985b).

The filtrate liquid from the Recovery Plant rotary vacuum filters is pumped to Pit 5 which overflows through an effluent control tower near the western end of the pit into the clear well from which it is pumped to the Great Miami River.

Sanitary Sewage

The sanitary waste collection and treatment system is distinct from the process waste system. Uranium enters the system through the plant laundry and showers; however, most of the uranium is removed in the sanitary sewage treatment system and captured in the sludge. The sludge is dried and roasted in the Recovery Plant for recovery of uranium. Liquid wastes are transported to the Sewage Treatment Plant for treatment to meet effluent concentrations in accordance with the FMPC's NPDES permit.

Storm Water

It is possible for uranium to enter the storm water system through accidental spills, pickup of settled particulates from stack emissions, and from corrosion and transport of uranium metal and uranium contaminated equipment. Currently during severe precipitation, storm sewer outfall flow exceeds pumping capacity, and contaminated runoff travels via the storm sewer outfall ditch to Paddy's Run. A retention basin is under construction to collect and pump excessive storm flows to the discharge line to the Great Miami River.

Storm water run-off also discharges to Paddy's Run from the Waste Storage Area. Although much of the water is collected by the Clearwell, an unknown quantity flows directly to the stream.

3.2.3 Liquid Waste Control

Liquid effluent streams from the FMPC are discharged pursuant to the NPDES permit at two locations; combined sewers, and the storm sewer.

The combined sewer outfall discharges into the Great Miami River at a point almost directly east of the plant site. This point is 3.5 river miles upstream (river mile 24.1) from the village of New Baltimore.

The storm sewer overflow currently discharges into a branch of Paddy's Run on-site (see Section 3.2.2). Paddy's Run joins the Great Miami River approximately two miles south of the FMPC (river mile 19.5) and 1.5 miles downstream from New Baltimore (NLO, 1985b).

3.2.4 Airborne Waste Control

All radioactive dusts, fumes, mists, and the like emanating from production processes at the FMPC are emitted to the atmosphere only after passing through collection devices such as bag collectors, electrostatic precipitators, and scrubbing towers. Each installation is designed for the operation it serves. For some discharge stacks continuous stack samplers and visual inspection are used to monitor the performance of dry air cleaning systems and grab sampling is used to evaluate efficiencies of wet scrubbers(NLO, 1985b).

3.3 HISTORIC DISPOSAL PRACTICES

3.3.1 General Description of FMPC Wastes

Wastes stored at the FMPC include general uncontaminated scrap and refuse, contaminated and uncontaminated metal scrap, waste oils, low level radioactive waste, hazardous wastes, mixed wastes, sewage treatment plant sludge, and fly ash from the steam plant (ORAU, 1985).

Wastes currently stored at the Waste Storage Area and elsewhere on the FMPC are estimated to total more than 3.5×10^5 m^3 (ORAU, 1985).

The radionuclides encountered at the FMPC are basically uranium, thorium, and the radioactive daughters of each. The processing of recycled compounds has introduced transuranic radionuclides such as plutonium and neptunium, as well as fission fragments like ruthenium and technetium (present in the FMPC effluent). Other radionuclides are present in trace quantities (NLO, 1985b). In addition, the FMPC has been designated as the DOE thorium storage center and about 1050 metric tons of thorium feed material and products are stored on the site (ORAU, 1985).

Other stored wastes include uncontaminated and contaminated metal scrap, 1,1,1-trichloroethane, spent barium chloride salt, methylene chloride/perchloroethylene degreaser, various caustic bases and acids (e.g. anhydrous ammonia, hydrofluoric acid), contaminated waste oil, PCB mixed wastes, and construction rubble and debris (NLO, 1985b; ORAU 1985; Dames & Moore, n.d.)

The historic waste storage facilities at the FMPC consist of six waste pits (numbered 1-6), two concrete silos (K-65 silos 1 and 2), two additional concrete silos (metal oxide tanks 3 and 4), a burn pit, the clear well, fly ash disposal areas 1 and 2, sanitary landfill, and two lime sludge ponds. Although not waste storage facilities per se, Paddy's Run and the storm sewer outfall ditch are contaminated because of past practices. The six waste pits, four concrete silos, burn pit, and Clearwell are located west of the production facility within the fenced, "controlled" area (Figure 3.5). The fly ash areas are located southwest of the production area.

3.3.2 Waste Pits

The waste pits consist of waste pits 1 through 6, the Burn Pit, and the Clear Well. The waste pits are numbered chronologically in their order of construction. The pits also are typically

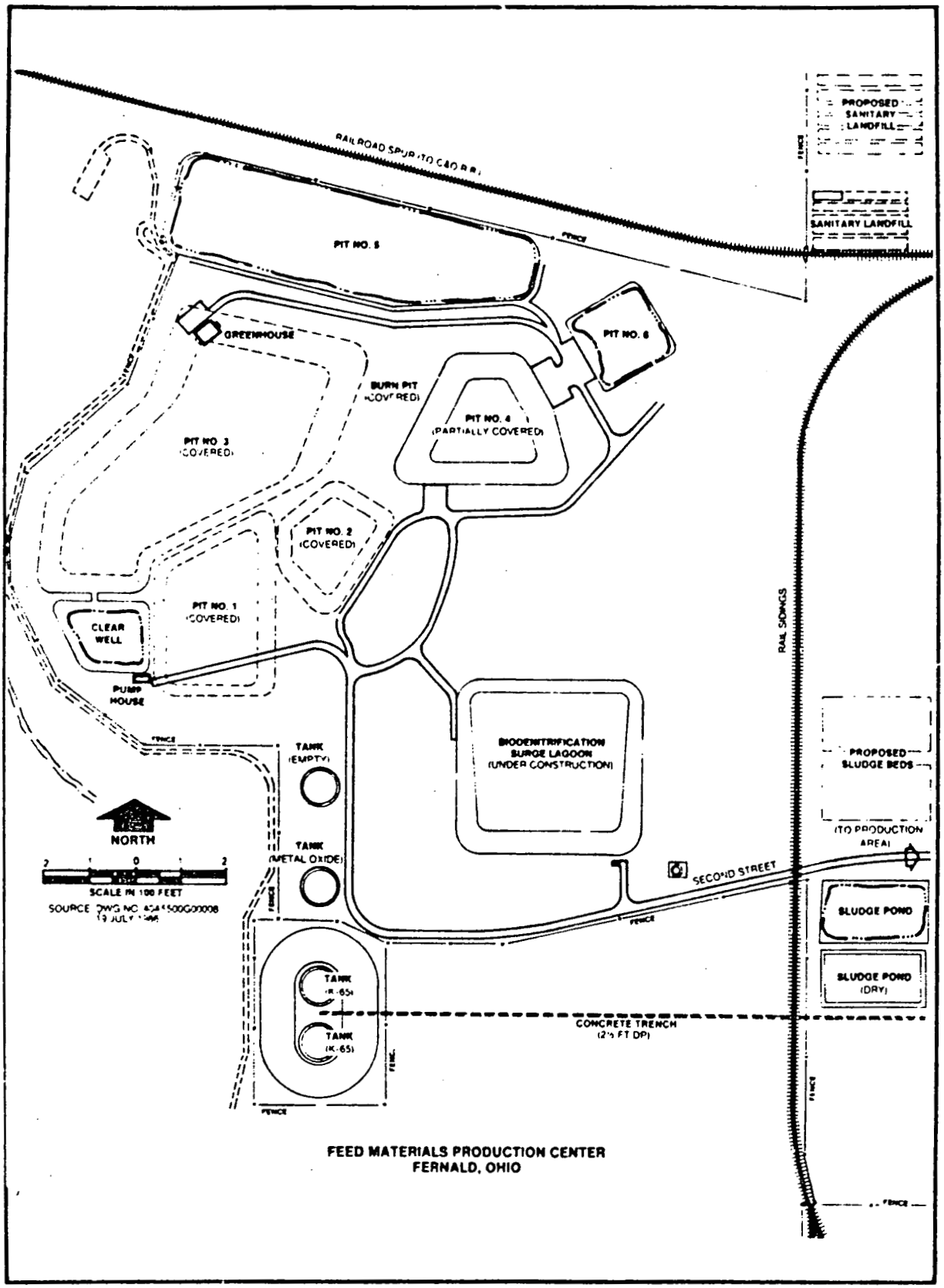


FIGURE 3-5 MAP OF THE STORAGE AREA WEST SIDE MIDDLE OF SITE

referred to as "wet" if they received waste in slurry form (3 and 5) or "dry" if they received solid waste from trucks (1,2,4, and 6). Tables 3.1 and 3.2 describe the characteristics of the Waste Storage Area, and an approximate inventory of stored wastes, respectively, based on a very limited amount of historical information. No characterization studies of the Pits have been performed to date.

Transport of solid wastes to the pits was dependent upon the types of wastes generated, and the types of storage containers. In general, drummed wastes were transported on semi-flatbed trailers, metal dumpsters were carried by dumpster vehicles, bulk wastes were transported by dump trucks and dump trailers, and drummed pyrophoric metal was conveyed on four-wheeled flatbed trailers pulled by tow tractors (NLO, 1977).

At the waste storage area, dump trucks, dump trailers, dumpster units and drummed wastes were emptied directly onto the pit's edge. The materials were then pushed into the pits by either a bulldozer or a drag line scraper (NLO, 1977). Loose contamination was washed from bulldozers, drag line scraper, vehicles, dumpster, and fork trucks with water at the pit. Empty drums were washed in the drum washing facility.

Liquid wastes were transported between the general sump and the waste storage area via two 6 inch diameter pipes (Dames and Moore, n.d.). These pipes exited the production area on the west side enclosed in a concrete trench that was covered with slabs of concrete. The trench extended to the fence of the K-65 tanks at which point the pipes turned north and were buried underground. The two pipes then branched with one running north between pits 2,3 and 4 to pit 5 while the other ran west to the clear well.

On the southern dike of pit 5, the pipe from the general sump connected to three berm valves. With these valves, the liquid wastes could be directed from the general sump to pit 4 or 5, from either of the two pits to the other, and from either pit back to the general sump (Dames and Moore, n.d.)

An additional pipe originated in the tower at the west end of pit 5 and extended, buried in the dike of pit 3, to the clear well. This pipe transported pit 5 supernatant to the clear well. The other 6 inch pipe, which connected the clear well and the general sump, was used to transport clear well effluent back to the general sump (Dames and Moore, n.d.).

TABLE 3.1

WASTE STORAGE AREA CHARACTERISTICS

Facility	Estimated Bottom Elevation Feet (asl)	Lining/Walls	Period of Use[b]
Pit 1	560	1.5-2.0 ft compacted clay[a] or 4 ft. clay[b]	1952-1959
Pit 2	570	1.5-2.0 ft compacted clay,[a] unknown[b]	1957-1964
Pit 3	548	1.0 ft compacted clay[a,b]	1959-1968 1975-1977
Pit 4	560	1.0 ft compacted clay[a,b]	1960-1986
Pit 5	558	1/16 inch rubberized elastomeric membrane[a,b]	1968-1983
Pit 6	560	elastomeric membrane[a,b]	1979-1985
K-65 Silos (1, 2)	--	8 inch concrete post stressed with high tensile steel wire, earth embankment[a,b]	1952-1959
Metal Oxide Tank (3)	--	8 inch concrete post stressed with high tensile steel wire[a,b]	1952-1959

TABLE 3.1 (Continued)

WASTE STORAGE AREA CHARACTERISTICS

Facility	Estimated Bottom Elevation Feet (asl)	Lining/Walls	Period of Use[b]
Metal Oxide Tank (4)	--	8 inch concrete post stressed with high tensile steel wire[a,b]	Never Used
Burn Pit	?	none	1957-1986
Clear well	?	clay	1959-Present
Fly Ash Area 1	--	none	?
Fly Ash Area 2	--	none	?-Present

[a] from Dames and Moore, n.d.

[b] NLO, 1985c
251 - above sea level

TABLE 3.2

APPROXIMATE WASTE STORAGE INVENTORY

Facility	Contents [a, b, c]	Estimated Volume (cy)	Uranium (kg)	Uranium-235 (kg)	Thorium (kg)	Total curies[b] (Ci)
Pit 1	neutralized waste filter cakes, graphite, brick scrap, sump liquor & cakes, depleted slag	40,000[a]	52,000[a,c]	370[a,c]	unk	108
Pit 2	neutralized waste filter cakes, graphite, brick scrap, sump liquor & cakes, depleted slag	13,000[a]	1,206,000[a,c]	2,550[a,c]	400[a,c]	35
Pit 3	lime neutralized raffinate concentrate, slag leach residues, filter cakes, fly ash, lime sludge	227,000[b]	129,000[a,c,]	1,771[a] 1,010[c]	400[a,c]	553
Pit 4	process residues, trailer cakes, slurries, raffinates, depleted graphite, non-burnable trash, asbestos.	50,000[a,b]	3,000,371[a] 3,048,087[c]	5,400[a] 5,529[c]	61,700[a] 61,800[c]	233
Pit 5	solids from neutralized raffinate, slag leach slurry, sump slurry, lime sludge	102,500[a,b]	50,261[a] 50,309[c]	420[a,c]	17,000[a,c]	327
Pit 6	depleted slag, scrap green salt, process residues, filter cake	9,000[a,b]	427,857[a] 843,142[c]	813[a] 1,740[c]	unk	178
K-65 Silos (1, 2)	Australian radium cake, pitchblende processing residues	7,200[a,b]	11,200[a,b]	80[a,c]	unk	17,600
Metal Oxide tanks (3)	metallic oxides	5,100[a,b]	18,000[a,b]	130[a,c]	unk	23
Burn Pit	pyrophoric and reactive chemicals, oils, combustible wastes	unk[a,b,c]	unk	unk	unk	unk
Clear well	clear process effluents, surface runoff	unk	unk	unk	unk	unk
Fly Ash Area 1	fly ash, oils	50,000[c]	1,000[c]	unk	unk	unk
Fly Ash Area 2	fly ash	33,000[c]	unk	unk	unk	unk

[a] NLO, 1985c
[b] Dames and Moore, n.d.
[c] H&R, 1986
unk= unknown

Waste Pit 1, constructed in 1952, was excavated into an existing clay lens and was lined with clay excavated from the burn pit (Table 3.1)(H&R, 1986). The capacity of the waste pit was expanded by the addition of a berm on the west end in 1957 to provide a total capacity of 40,000 cubic yards (cy) (Table 3.2). The waste material that was placed in the waste pit consisted primarily of neutralized waste filter cakes, production plant sump cakes, depleted slag, scrap graphite, contaminated brick, and sump liquor. Although the majority of the wastes were dry solids, decant pipes were constructed through the west berm; these were used rarely (NLO, 1985c). The quantity of uranium placed in the pit is estimated to be 52,000 kg. Waste pit 1 was closed in 1959, backfilled, and covered with clean fill dirt (NLO, 1985c). Surface water runoff is diverted to the clear well prior to its discharge to the Great Miami River.

Waste Pit 2 was constructed in 1957 and was operated from 1957 to 1964 (H&R, 1986). This pit was constructed near a small pond east of Waste Pit 1 and was lined with a compacted on-site native clay layer (Dames and Moore, n.d.) (Table 3.1). Waste Pit 2 received primarily dry, low-level radioactive wastes consisting of neutralized waste filter cakes, sump cakes, depleted slag, contaminated brick, sump liquor and concentrated raffinate residues (Table 3.2). Like pit 1, decant pipes were located through the west berm. The pit holds approximately 13,000 cy of wastes that contain about 1,206,000 kg of uranium and approximately 400 kg of thorium. The Waste Pit has been covered with clean, uncontaminated fill and graded to provide surface drainage to the clear well for subsequent discharge to the Great Miami River.

Waste Pit 3 was constructed in 1959 by excavating into the underlying clay lens and placing a layer of clay along the pit walls (Dames and Moore, n.d.). Waste Pit 3 was operated as a settling basin from 1959 to 1968 receiving wet waste streams consisting of lime-neutralized radioactive raffinate concentrate from the Recovery Plant and the general sump (Table 3.1) (H&R, 1986; NLO, 1985c). From 1975 to 1977, the Waste Pit was used to dispose slag leach residue, filter cakes, fly-ash, and lime sludges. The pit contains an estimated 227,000 cy of wastes including 129,000 kg of uranium, and 400 kg of thorium (Table 3.2). The limited amount of data on other constituents are shown in Table 3.3. The pit was retired in 1977 and clean fill was placed over the waste. Surface water runoff is diverted to the clear well prior to discharge to the Great Miami River.

TABLE 3.3
SOME CONSTITUENTS OF WASTE PITS 3 AND 5

CONSTITUENT	Pit 3 MT[a,b]	Pit 5 MT
Ag	<2.55	<0.88
Al	1,530	529
As	65	34
Au	--	--
B	10.2	3.5
Ba	191	66
Be	<2.55	<0.88
Bi	<2.55	<0.88
Ca	46,155	15,967
Cd	<38.25	<13.2
Cl	155	80
Co	<20.4	<7.1
Cr	35.7	12.3
Cu	446.25	154.4
F	12.59	6.49
Fe	5,674	1,963
Hg	--	--

TABLE 3.3 (Continued)
SOME CONSTITUENTS OF WASTE PITS 3 AND 5

CONSTITUENT	Pit 3 MT[a,b]	Pit 5 MT
La	<20.4	<7.1
Mg	23,378	8,087
Mn	2,805	970
Mo	2.55	0.88
Na	1,304	672
Ni	76.5	26.5
Pb	153	53
PO_4	171	88
Sb	--	--
Se	--	--
SiO_2	5,100	1,764
Sn	86.7	30
SO_4	788	406
Ti	33.15	11.47
V	15.3	5.3
Zn	<306	<105.9
Zr	102	35.3
Rare Earths:		
Dy	<15.3	<5.29
Er	<0.09	<0.05

TABLE 3.3 (Continued)
SOME CONSTITUENTS OF WASTE PITS 3 AND 5

CONSTITUENT	Pit 3 MT[a,b]	Pit 5 MT
Eu	<5.1	<1.76
Gd	<7.65	<2.65
Ho	<0.06	<0.02
Lu	<0.02	<0.008
Sm	<15.3	<5.29
Tb	<0.06	<0.02
Tm	<0.03	<0.01
Y	7.65	2.65
Yb	<0.60	<0.20

Ref. NLO, 1985c

---

[a] 1% on dried solids ba

[b] MT = Metric Tons

[c] Calculations for Pit
Pit 3.

Waste Pit 4 was constructed in 1960 and was used until May 1986 (Table 3.1). This pit was constructed similar to Pit 3. Waste Pit 4 received process residues, trailer cakes, slurries, raffinates, graphite, non-combustible trash, and asbestos (H&R, 1986; NLO, 1985c). The pit contains an estimated 53,000 cy, including more than 3 million kg of uranium and 61,800 kg of thorium (Table 3.2). Pit 4 remains partially covered.

Waste Pit 5 was constructed in 1968 and was operated from 1968 to 1983 (Table 3.1)(H&R, 1986; NLO, 1985c). The pit is lined with a 60 mil thick Royal-Seal EPDM Elastomeric Membrane. This liner has been particularly durable although occasional joint failures and tears have occurred (NLO, 1985c). These have occured at the surface and noticed during routine inspection at various times and ascribed to weathering effects. The corrective action has been to re-glue the seam. Like wet pit 3, this waste pit received liquid waste slurries from the Refinery and the Recovery Plant including neutralized raffinate settled solids, slag leach slurry, sump slurries, and lime sludge (Table 3.2). The waste volume consists of approximately 102,500 cy, containing 50,309 kg of uranium and 17,000 kg of thorium (H&R, 1986). Other constituents are shown in Table 3.3.

Waste Pit 6 was constructed in 1979 and operated until 1985 (Table 3.1) (H&R, 1986). It was constructed in the same manner as Waste Pit 5 and lined with a similar synthetic liner, although no joint failures or tears have been observed (NLO, 1985c). Non-coarse, non-pyrophoric solid wastes, including green salt, filter cakes, and process residues, containing elevated levels of uranium have been stored. Rainfall that is collected in the pit is pumped to Waste Pit 5 for settling discharge via the clear well. The current waste volume is approximately 9,000 cy, which consists of 843,142 kg uranium (Table 3.1) (H&R, 1986). The capacity of Waste Pit 6 has not been reached; however, the pit is currently inactive.

The burn pit was constructed in 1957 as a site to excavate clay to line Waste Pits 1 and 2 (Table 3.1). The burn pit was subsequently used to dispose laboratory chemicals and to burn combustible materials, including pyrophoric and reactive chemicals, oils and other low-level contaminated combustible materials (H&R, 1986). The actual inventory of materials or chemicals that was disposed in the burn pit is unknown. Although reported as having been backfilled (H&R, 1986), the boundaries of the burn pit are no longer discernible from partially covered pit 4 (Lechel, 1986).

The clear well receives surface runoff from the waste pits as well as some flow-through liquids. It is used as a final settling basin prior to discharge to the Great Miami River via the FMPC NPDES discharge point. It is anticipated that a significant amount of uranium-bearing settled solids is contained in the basin; however, no volume or mass estimates are available (H&R, 1986).

3.3.3 Waste Storage Silos

The waste storage silos are located south of the waste pits area as shown on Figure 3.5.

The four 80-foot silos were constructed with floors of 4-inch concrete over an 8-inch layer of gravel containing an underdrain system of 2-inch slotted pipe draining to a collection tank (NLO, 1985c). Below the gravel is a 2-inch layer of asphaltic concrete underlain by 18 inches of compacted clay. The walls are 18 inches thick pre- and post-stressed concrete with a 0.75-inch gunite coating on the exterior. The domed roofs are 4-inch thick reinforced concrete (Table 3.1).

Waste raffinate slurries were pumped into the K-65 silos where the solids would settle. The clarified liquid was then decanted through valves placed along the 26-foot height of the silo wall and sent to the refinery sump. As the depth of solids reached the level of a valve, it was sealed and the next higher valve was used to decant liquids. Settling and decanting were continued in this way until the silos were filled to approximately 4 feet below the top of the vertical wall (NLO, 1985c).

Metal oxide tank 3 contains waste raffinate slurries that had been dewatered in an evaporator and spray calciner to produce a dry, powder-like waste. This calcined waste was pneumatically conveyed to the tank. Excess conveying air was filtered through a bag house dust collector (NLO, 1985c). Metal oxide tank 4 remains empty.

From 1952 through 1959 more than 7,200 cy of residues resulting from the processing of pitchblende ores were disposed in the K-65 silos (Tables 3.1 and 3.2) (H&R, 1986). This residue contains 11,200 kg of uranium, as well as radium and trace amounts of precious and heavy metals (Table 3.4).

In 1964, the walls of the silos were covered with an earthen embankment to provide protection and support, and to minimize gamma emissions. In 1979, all obviously visible tank openings were sealed. The earthen embankment was further enlarged in 1983 to alleviate observed soil erosion on the slopes. Following identification of cracks in the center portion of the domes of

TABLE 3.4
ELEMENTAL CONSTITUENTS
OF FMPC SILOS

CONSTITUENT	Silos 1 & 2 MT[b]	Silo 3 MT
Ag	0.176	<0.07
Al	77	98.67
As	<2.64	
Au	0.44	<0.14
B	1.32	0.70
Ba	6.16	0.70
Be		d
Bi		d
Ca	342	144.48
Cd	<0.008	
Cl	0.19	
Co	15.4	8.81
Cr	1.06	1.76
Cu	4.4	8.81
F	0.33	
Fe	105.6	225.52

TABLE 3.4 (Continued)
ELEMENTAL CONSTITUENTS
OF FMPC SILOS

CONSTITUENT	Silos 1 & 2 MT	Silo 3 MT
Hg		
La	7.83	d
Mg	110	229.52
Mn	1.76	17.27
Mo	1.76	2.11
Na	61.6	133.90
Ni	19.8	22.90
Pb	448.8	8.81
PO_4		683.62
Sb		<0.53
Se		d
SiO_2	3,587	461.62
Sn	0.7	1.41
SO_4	d	692.08
Ti	6.16	2.11
V	1.85	3.52
Zn	<0.060	
Zr	1.76	1.06
Rare Earths:		
Dy	0.26	<0.11
Er	<0.006	
Eu	<0.001	
Gd	0.35	<0.21
Ho	0.13	<0.11
Lu	<0.002	
Sm	0.42	<0.21
Tb		d
Tm	0.07	<0.07
Y	0.35	0.28
Yb	0.05	0.14

Ref. NLO, 1985c

---

[a] NLO analyses of K-65 samples, September 1970.

[b] MT = Metric Tons

[c] NLO analyses of Silo 3 Metal Oxides

[d] No Data

the silos, protective covers consisting of prefabricated wood and metal structures, were placed over the domes of Silos 1 and 2 (H&R, 1986).

Metal Oxide Tank 3 was designed in a similar fashion to Silos 1 and 2. From 1952 through 1959 more than 5,100 cy of calcined residues were stored in the silo. These residues stored in the silo contain approximately 18,000 kg uranium, some metal oxides, heavy metals, and trace amounts of radium (Table 3.4).

3.3.4 Paddy's Run

Paddy's Run is a small, intermittent stream that borders the west boundary of the FMPC and discharges to the Great Miami River approximately 1.5 miles south of the FMPC (Figure 3.6). Paddy's Run, which receives runoff from the waste storage area, and other potentially contaminated surface areas, has above background concentrations of radionuclides (NLO, 1986; 1985a) (1984) (See Section 2.4). Paddy's Run has been identified as a potential source of water quality degradation in several off-site wells used for local drinking water supplies (H&R, 1986). Uranium contained in its waters is transported to an area where the less permeable glacial till underlying the stream grades into a more permeable sand and gravel. The surface water percolates into the ground water aquifer near the confluence of Paddy's Run and the storm sewer outfall ditch.

3.3.5 Storm Sewer Outfall Ditch

The storm sewer outfall ditch is a narrow and shallow ravine which receives overflow surface water runoff from portions of the production area and surrounding terrain (Figure 3.6). Radionuclides and other materials originating from the production area have entered the storm sewer system through accidental spills and through surface runoff (H&R, 1986). Under normal conditions, the storm sewer water is combined with the general sump effluent and other plant liquid effluents and is discharged to the Great Miami River. During periods of heavy runoff, excess storm sewer water is discharged directly into the storm sewer outfall ditch which discharges into Paddy's Run. Since Paddy's Run is intermittent during periods of prolonged dryness and it serves as a surface runoff collection source for the area, it may also serve as a recharge zone for ground water (See Section 2.5). (Dames & Moore, 1985). The stream and the outfall ditch may be acting as a source and transportation mechanism for above background concentrations of radionuclides in the offsite ground water (H&R, 1986).

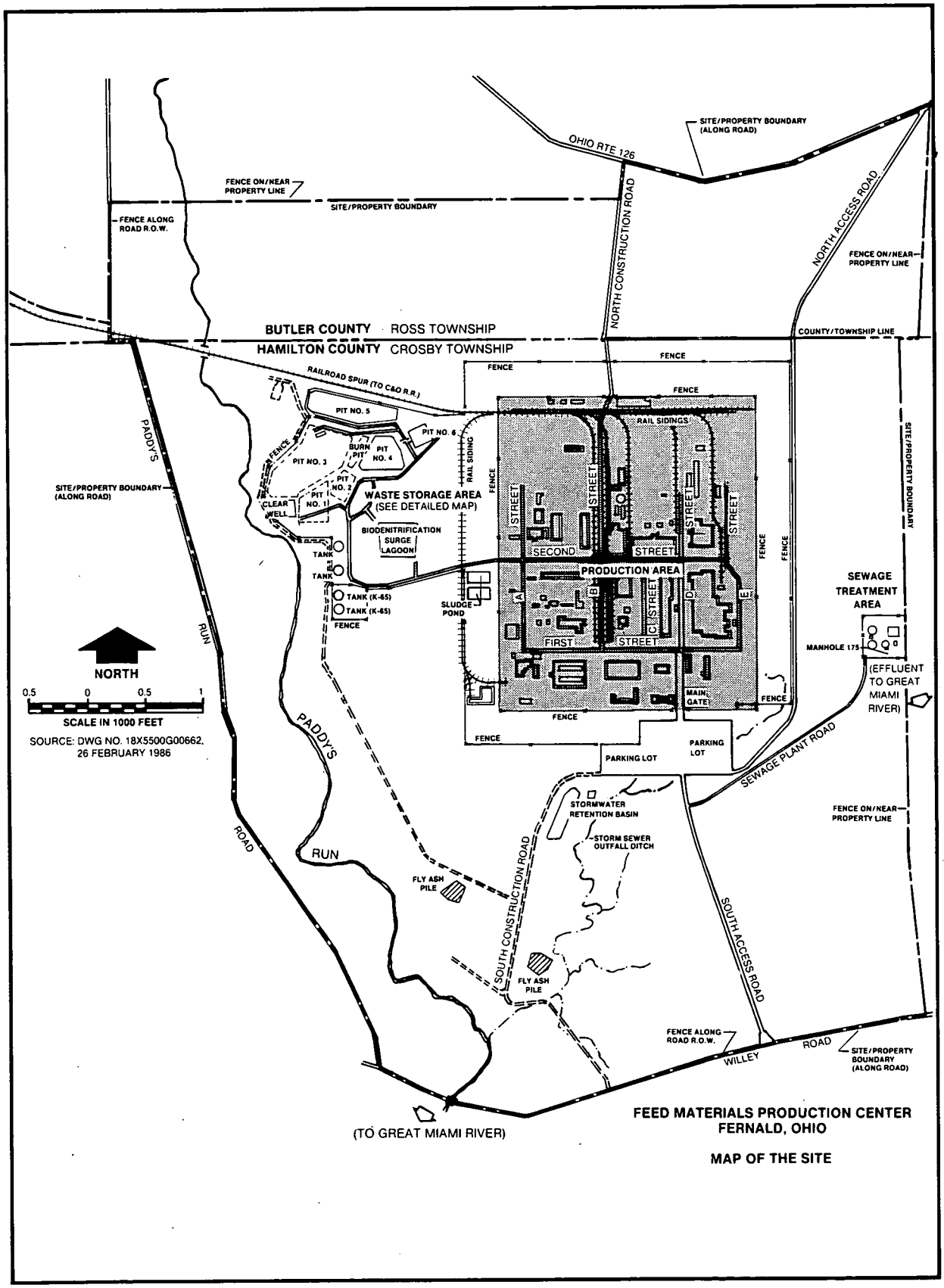


FIGURE 3-6 MAP OF THE SITE

3.3.6 Fly Ash Disposal Areas

The fly ash disposal areas are located southwest of the production area (Figure 3.6). Fly-ash resulting from the coal-fired boiler plant is loaded into dump trucks and transported to the disposal area (H&R, 1986). The inactive, retired upper pile contains approximately 50,000 cy of fly ash and is sparsely covered with soil and vegetation. About 1,000 kg of uranium are present from the spreading of contaminated oils over the fly ash to control dust. The active lower pile located southeast of the inactive site currently contains approximately 33,000 cy of fly ash.

Due to the close proximity of their respective locations, the area known as the Southfield is assumed to be encompassed by the areas including the fly ash piles. The Southfields area is believed to be directly north of the inactive fly ash pile (H&R, 1986). This area was reported to be the repository for below ground disposal of construction rubble containing low levels of radioactivity. Radiological surveys indicate that the soil in this area contains elevated levels of radionuclides (H&R, 1986).

3.4 POTENTIAL HEALTH EFFECTS IMPACT EVALUATION

The purpose of this section is to identify contaminated releases such as leachate and run-off, pathways of exposure, any human or environmental exposure, with a description of the threat or potential threat to public health and environment.

Little definitive information exists on the chemical composition of the materials stored in the Waste Storage Area, or on releases to the environment through potential pathways such as air, surface water, and groundwater. Consequently, health impact evaluations will have to await completion of the site investigation and subsequent analysis. A complete exposure (risk) assessment will be made for hazardous constituents identified which will include environmental fate and transport and toxicological properties.

At present, the only material which has been clearly identified as migrating into an environmental pathway is the uranium which has been found in above background concentration in wells south of the FMPC. This information was obtained from the Draft 1985 FMPC Annual Environmental Report. Since the text does not indicate whether the uranium is U-total or U-natural, it will be assumed that the material is U-natural. For U-natural, the U-238

and U-234 isotopes are in equilibrium, each having a concentration of 117.5 pCi/L. U-total would have the U-235 component included.

The following is an assessment of the radiological risk to individuals using this groundwater well as their source for drinking water. This health effects calculation is based upon a radiological assessment prepared by Millard and Baggett (1984).

In the calculation, a 50-year dose commitment (DC-50) will be determined per year of exposure for all pertinent organs. These are the bone, endosteum (bone surface), liver, kidney, and the lung. An F1 uptake to the blood factor (fraction of ingested radioactivity that is absorbed into the blood) for U-natural (U-238 and U-234) is 0.05 (Dunning, 1981; ICRP, 1981). The average daily water intake for an individual is assumed to be 1.0 liter/day. Dose conversion factors (DCF) in units of rem/microCi were taken from the report by Dunning (1981) and are summarized in Table 3.5 for each target organ.

Table 3.7 presents the lifetime risk coefficients used for each target organ (NAS, 1980; Millard, 1984) and also the resulting risk estimates from ingestion of ground water in terms of individual organ risk per year of consumption. The individual organ risk was determined from multiplying the 50-year dose commitment per year of consumption times the lifetime risk coefficient.

Based on these calculations, the total organ risk for an exposed individual would be 0.0255×10^{-4} excess health effects per year of consumption.

The Battelle Report (1981), states that the Great Miami River is not used as a source of drinking water. This report calculated the 50-year dose commitment to the bone and 0.03 mrem to the whole body from drinking water at a point downstream from the FMPC discharge point. This was based on a daily intake of 2.2 liters (2 quarts).

During the FMPC characterization, extensive surface water sampling will be conducted at all drainages discharging into land including Paddy's Run. These data will be used to provide additional input into health effects evaluations and to delineate offsite migration of radioactive material.

TABLE 3.5

DOSE CONVERSION FACTORS FOR TARGET ORGANS
(rem/microCi)

Target Organ	U-238	U-234
Total bone	7.0	7.8
Endosteum	2.8	3.6
Liver	0.013	0.016
Kidney	1.5	1.7
Lung	0.015	0.017

Using a quality factor of 20 for alpha emitters, the dose commitments per year can be calculated as follows:

$$\text{DC-50} = (\text{concentration pCi/L}) \times \frac{(1\ \text{liter})}{\text{day}} \times \frac{(365\ \text{days})}{\text{year}} \times \frac{1\ \text{MicroCi})}{10\text{E}6\ \text{pCi}} \times (\text{DCF}) \times \frac{(1000\ \text{mrem})}{\text{rem}} = \frac{\text{mrem}}{\text{year}}$$

Table 3.6 presents the 50-year dose commitments per year of consumption for each target organ as calculated using this formula.

TABLE 3.6

FIFTY-YEAR DOSE COMMITMENT PER YEAR OF CONSUMPTION
OF RADIONUCLIDES IN DRINKING WATER (MREM/YEAR)

Target Organ	U-238	U-234	Total
Total Bone	300.2	334.5	634.7
Endosteum	120.1	154.4	274.5
Liver	0.56	0.69	1.25
Kidney	64.3	72.91	137.2
Lung	0.64	0.73	1.4

TABLE 3.7

SUMMARY OF DRINKING WATER HEALTH EFFECTS ANALYSIS

Target Organ	Lifetime risk Coefficient (risk/1056 Person-rem)	Individual Organ Risk Per Year of Consumption (excess health effects x 10E4 per year
Total Bone (a)	1.9	0.0121
Endosteum	1.9	0.0052
Liver	30	0.0004
Kidney	5.5 (b)	0.0075
Lung	20 (c)	0.003
TOTAL		0.0255

[a]Total bone and endosteum risk coefficients were taken from the BEIR-III report (NAS, 1980) for a 7000 g bone, and modified to give average skeletal doses for a 5000 g bone by multiplying BEIR coefficients by 5000/7000.

[b]The risk coefficient for kidneys was obtained by taking a ratio of low LET risk rate coefficients reported in the BEIR-III report and multiplying by the higher LET risk coefficient for liver.

[c]This risk coefficient was taken from Evans (1981) and is equivalent to the lifetime risk coefficient of 100 x $10E^{-6}$ deaths per person - WLM, where one WLM is approximately equal to a 5-rem dose equivalent commitment to the lung.

REFERENCES

Battelle, 1981. "Final Report, Environmental Report of the Feed Materials Production Center," prepared for National Lead of Ohio, Inc, Cincinnati, Ohio.

Camargo Associates, Limited, 1986. K-65 Silos Study and Evaluation for the Feed Materials Production Center, Volume I, prepared for Westinghouse Materials Company of Ohio, Cincinnati, Ohio.

Dames and Moore, 1985. Department of Energy, Feed Materials Production Center, Groundwater Study Task C Report, prepared for National Lead of Ohio, Inc., Cincinnati, Ohio.

Dames and Moore, no date. "Final Safety Analysis Report, FMPC Waste Storage Area." Prepared for National Lead of Ohio, Inc., Cincinnati, Ohio.

DOE (U.S. Department of Energy), 1983. Final Environmental Impact Statement on Remedial Actions at the Former Vitro Rare Metals Plant Site, Canonsburg, Washington County, Pennsylvania, DOE/EIS-0096-F, Washington, D.C.

DOE (U.S. Department of Energy), 1984. Final Environmental Impact Statement on Remedial Actions at the Former Vitro Chemical Company Site, South Salt Lake, Salt Lake County, Utah, DOE/EIS - 0099F, Washington, D.C.

Dunning, D.E., Jr., 1981. "Estimates of Internal Dose Equivalents to 22 Target Organs for Radionuclides Occurring in Routine Releases from Nuclear Fuel-Cycle Facilities," Volume III, NUREG/CR-0150, Oak Ridge National laboratory, Oak Ridge, Tennessee.

Employee Bulletin, April, 1986. Prepared by Westinghouse Materials Company of Ohio.

Environmental Report of the Feed Materials Production Center, Battelle Columbus Laboratories, 1981.

Evans et al. (R.D. Evans, J.H. Harley, W. Jacobi, A.S. McLean, W.A. Mills, and C.G. Stewart), 1981. "Estimate of Risk from Environmental Exposure to Radon-222 and It's Decay Products," Nature, Vol. 290, No. 5802, pp. 90-100.

Feed Materials Production Center Environmental Monitoring Annual Report for 1985 (Draft), Westinghouse Materials Company of Ohio.

H&R (H&R Technical Associates, Inc.), 1986. "Draft Feed Materials Production Center Installation Assessment," FMPC-2049, prepared for U.S. Department of Energy, Weapons Division of Oak Ridge Operations, Oak Ridge, Tennessee.

Lechel, D.J., 1986. "Unpublished Field Notes FMPC Site, 29 and 30 April, 1986." Roy F. Weston, Inc., Albuquerque, NM.

NLO (National Lead of Ohio, Inc.), 1986. "Feed Materials Production Center Environmental Monitoring Annual Report for 1985," National Lead of Ohio, Inc., Cincinnati, Ohio.

NLO (National Lead of Ohio, Inc.), 1985a. "Feed Materials Production Center Environmental Monitoring Annual Report for 1984," National Lead of Ohio, Inc., Cincinnati, Ohio.

NLO (National Lead of Ohio, Inc.) 1985b. "Feed Materials Production Center Radioactive Waste Management Plan," NLCO-1100, Revision 6, National Lead of Ohio, Inc., Cincinnati, Ohio.

NLO (National Lead of Ohio, Inc.) 1985c. Unpublished Description of Waste Storage Facilities, contract with Roy F. Weston, Inc., West Chester, Pennsylvania.

NLO (National Lead of Ohio, Inc.) 1977. "Study of Radioactive Waste Storage Areas at the Feed Mill Production Center", National Lead of Ohio, Inc., Cincinnati, Ohio.

ORAU (Oak Ridge Associated Universities), 1985. "Environmental Program Review of Feed Materials Production Center, Fernald, Ohio," prepared for U.S. Department of Energy, Oak Ridge Operations Office, Oak Ridge, Tennessee

Poff, T., 1986. Westinghouse Materials Company of Ohio, Personal Communication with David Lechel, Roy F. Weston, Inc., Albuquerque, NM, May 8, 1986.

ICRP (International Commission on Radiological Protection), 1977. Recommendations of the International Commission on Radiological Protection (adopted January 17, 1977), ICRP Publication 26, Pergamon Press, Elmsford, New York.

Millard, J.B., and D.J. Baggett, 1984. "Radiological Assessment of the Populated Areas Southwest of the Homestake Mining Company Uranium MIll," New Mexico Environmental Improvement Division, Santa Fe, New Mexico.

NAS (National Academy of Sciences), 1980. BEIR-III report. The Effects on Population Exposure to Low Levels of Ionizing Radiation, Advisory Committee on Biological Effects of Ionizing Radiation, National Research Council, Washington, D.C.

Section 4

SECTION 4

HISTORY OF RESPONSE ACTIONS

The only information located which can be considered as response actions, is in connection with structural repairs of the two K-65 silos.

The following historical account is reproduced directly from a recent structural analysis.

The two K-65 silos, located on the west side of the Fernald site, were constructed in 1955. The silos are used for storage of radium bearing residues, a byproduct of uranium ore processing. The silos are of cylindrical concrete construction, 80 feet in diameter and approximately 27 feet high. The silo domes were originally designated to be 4 inches thick at the center tapering to 8 inches at the dome-wall edge.

The walls were post-tensioned reinforced with 0.162 inch diameter wire stressed to 140,000 pounds per square inch (PSI) (with assumed 30% loss, for a design stress of 100,000 PSI). These post-tensioning wires were covered by a 3/4 inch thick gunite coating. The minimum 28-day compressive strength used was 4500 PSI for the dome and walls and 3000 PSI for the floor and footing. The maximum allowable soil pressure was 4000 pounds per square foot (PSF). The silo design information was supplied to CAL in the original silo design drawings dated 1951.

The silos were designed to be loaded with the metal oxides in slurry form at a maximum rate of 8000 gallons per day. The radioactive residues were allowed to settle and the water was decanted, leaving sludge with a density of 100 pounds per cubic foot (PCF) and angle of repose of 0 degrees. The maximum allowable height of solid material was 23 feet and the water level was limited to a maximum height of 25 feet.

In 1963, the silos were showing signs of exterior surface deterioration. Large areas of spalling occurred in the exterior surface gunite coating, particularly on the north silo, leaving post-tensioning wires exposed to weather. Subsequently, patches of the wires became severely corroded and broken. Various options were investigated as remedial actions for the silos. Repairs began in 1964 by first chipping away all loose gunite material and then patching the surface with a 3/4 inch coat of cement mortar. After the gunite was repaired and a waterproofing

sealant was applied to the external silo walls, an earth embankment was built to the top of the wall on a one and one-half to one (1-1/2:1) slope (horizontal:vertical). The earthen embankment was to provide relief from tensile stress within the walls by counterbalancing the load from the internal contents, since the broken wires were not replaced. A soil was chosen with roughly the same density (125 PCF) as the contents of the silos (100 PCF). Two additional purposes of the embankment were to provide weather protection and to reduce the radon emission from the silos.

In subsequent years, problems with soil erosion on the silo embankment were frequent. The eroded areas were repaired, but with heavy rains the problem reoccurred. In 1983, the embankment was enlarged to achieve a 3:1 slope. No further evidence of large scale erosion has occurred. (Camargo Associates, Limited, 1986)

Protective covers of prefabricated wood and metal were placed over the center portions of the domes of Silos 1 and 2 in early 1986, after cracks were found. Attempts have been made to apply sealant to some of the dome areas but this has not been completed to date.

Section 5

SECTION 5

DEFINITION OF BOUNDARY CONDITIONS

The purpose of these investigations is to conduct a comprehensive characterization of the Waste Storage Area and to examine the various disposal action alternatives available for the eventual disposition of the stored waste inventories. The FMPC Waste Storage Area includes six low-level radioactive waste storage pits, two earthern-bermed concrete silos containing K-65 residues (high specific activity, low-level radium-bearing residues), one concrete silo containing metal oxides and all affected adjoining areas. This scope has been expanded to include two of fly ash piles located approximately 3000 feet SSW of the waste storage area, as well as the burn pit situated between Pits 3 and 4.

In addition to the characterization of the waste material itself, a second part of the objective is to characterize its actual or potential impact on public health and the environment, and to provide data for evaluating remedial alternatives. In order to comply with this requirement it is necessary to evaluate the possibility that waste material, in either liquid or solid form, has migrated beyond the borders of the Waste Storage Area. The migration mechanism determines the potential geographic extent of transport and establishes the probable boundaries of contaminant excursion. For example, surface water is a potential migration mechanism which will follow drainage pathways to the nearest stream or river and will follow its course to a discharge point.

Another boundary area determinant is the need to study areas estimated to be free of potential contaminant migration, usually referred to as background conditions. For example, the area upstream from a potential discharge area is usually presumed to be characteristic of natural conditions in the general area and data collected at this point can be compared with below discharge areas to establish a differential due to the discharge.

The boundary conditions of this characterization study are listed by area and transport mechanism:

- Waste storage materials: Samples will be taken of the soils, groundwater, and standing water in and adjacent to Pits 1,2,3,4,5,and 6; Silos 1,2,and 3; the Clear Well, the Burn Pit; and the two Fly-ash Piles. This will include the length of the old slurry line to the silos.

- Groundwater: Water sampling and aquifer testing will take place in background wells north of the Waste Storage Area and to the west and south within the FMPC boundary. Additional test wells will be placed to the east of the Production Area, also within the boundary.

- Surface water and sediments: Samples will be taken of Paddy's Run from above the Waste Storage Area to Willey Road. The storm sewer outfall will be sampled from the Production Facility to its confluence with Paddy's Run. Samples of soil, surface water, and sediments will also be taken from numerous surface drainage swales west and northwest of the Waste Storage Area leading to Paddy's Run.

The present extent of the study area will be contained within the site boundaries of the FMPC and outside of the Production Area. A complete description of sampling locations is contained in the various sampling plans compiled in Part 2: Support Documentation.

Section 6

SECTION 6

SITE TOPOGRAPHIC MAPPING AND SAMPLING GRID

6.1 INTRODUCTION

Digital photogrammetric mapping of the waste storage area and environs will be developed to satisfy the requirements for accurate base maps of the facility and the input requirements of the Technical Information Management System. The Technical Information Management System (TIMS) is a spatial geographically referenced data management and analysis system. TIMS integrates data collected in the field with map representations in two and three dimensions. A description of TIMS is found in Volume 2, Section 9.0, Data Management Plan.

The digital photogrammetric mapping will consist of two distinct parts. Part one involves the acquisition of the primary data necessary for photogrammetric mapping, and consists of aerial photography, field survey control, aerotriangulation, photogrammetric compilation, and associated photo lab work. Part two consists of the design, formatting and digitization of the primary data, and the production of interim and final base map products.

6.2 AERIAL PHOTOGRAPHY DATA ACQUISITION

6.2.1 Aerial Photography

The availability of existing contemporary aerial photography that is suitable for project use will be researched. This imagery, if available, will be supplemented with newly flown aerial photography. Three scales of photography will be developed for specific project requirements:

a. 1"-300' photography for use in developing 1"-100' planimetric mapping and one foot contours within the plant area C (Figure 6.1).

b. 1"-500' photography for use in developing 1"-200' planimetric mapping and two foot contours within the study area B.

c. 1"=1000' photography for use as general reconnaissance within the environs area A.

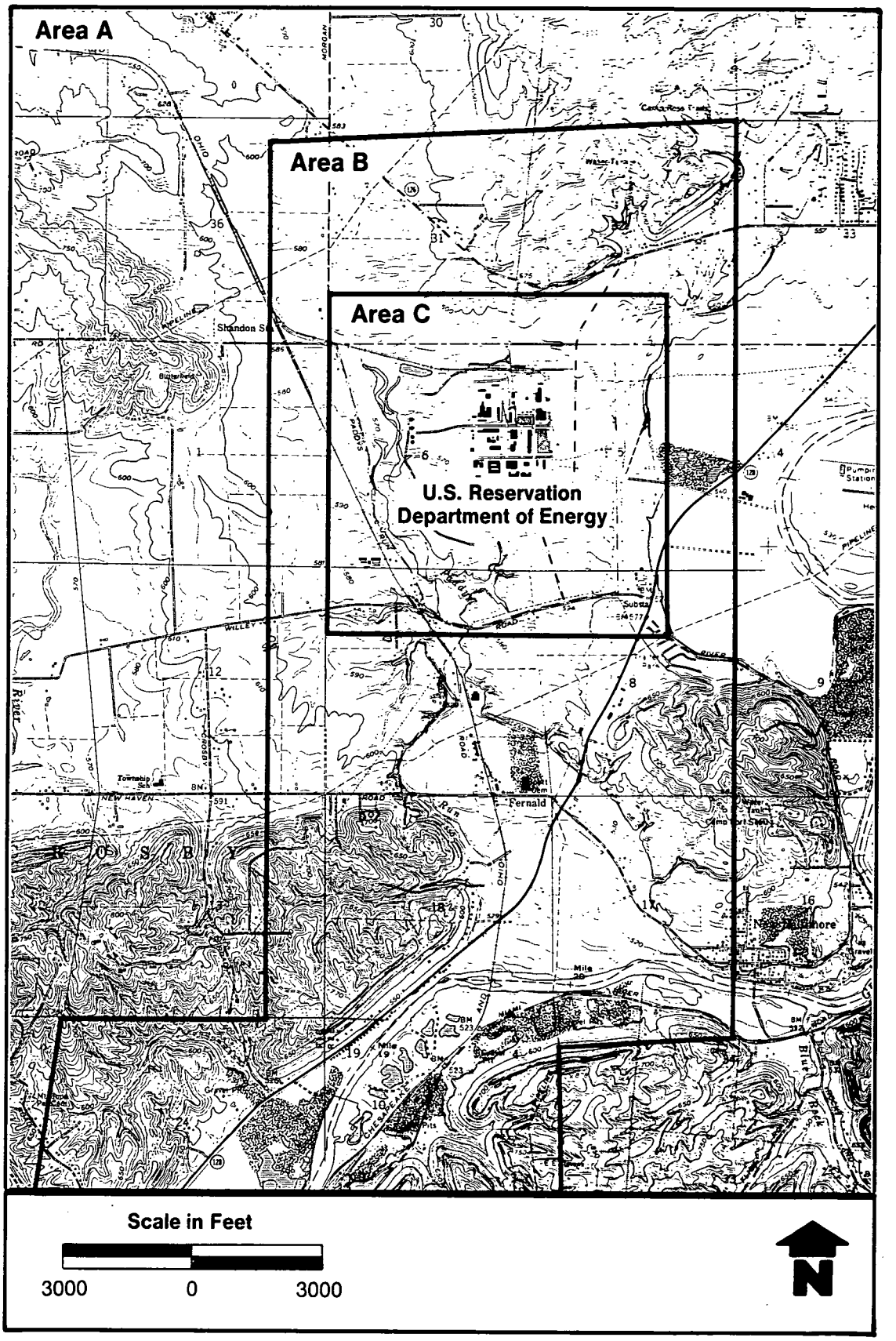


FIGURE 6-1 MAPPING AREAS

All photography will be flown with a 6" lens certifiable by the U.S. Geological Survey. Contact prints and aerial negatives of all photography developed for the project will be provided.

6.2.2 Surveying

In order to establish precise horizontal and vertical control necessary for stereo compilation and analytical bridging, and to serve as a precision reference grid for TIMS, the plant and study area will be surveyed. Utilizing established U.S.G.S. and N.G.S benchmarks as origins, approximately 30 points for horizontal and vertical positions, and an additional 30 points for vertical positions will be surveyed. All surveyed points will be reported in state plane coordinates, third order accuracy in conformance with National Mapping Accuracy standards.

6.2.3 Aerotriangulation

Approximately 130 aerial photo frames (diapositives) will be used to set up the stereo models needed for photogrammetric compilation. Each diapositive requires three precise control points to allow the stereo model to be established. The field survey control will not provide a sufficient number of points to set up all models, hence many additional points will need to be derived. This process allows for the precise identification, marking and calculation of supplementary control points within the analytic stereo models that are set up using the primary surveyed field control.

6.2.4 Photogrammetric Compilation

Utilizing the surveyed field control supplemented by the aerotriangulated supplemental control, numerous stereo models will be established within a precision photogrammetric mapping system. Using the 1"-300' photography, compilations will be produced of four data themes for area C at a scale of 1"-100':

a. Contours at one foot intervals
b. Hydrographic features
c. Buildings
d. Planimetric features (i.e., roads, power lines, etc.)

Utilizing the 1"-500' photography, compilations will be produced of the same four data themes for area B at a scale of 1"-200'; however, the contours will be at two foot intervals.

6.3 TOPOGRAPHIC MAPPING

6.3.1 Digital Contour Mapping and Elevation Model

Utilizing the photogrammetric compilations generated in Part One of the project, the contour lines for the 1"-100' and the 1"-200' contour maps will be digitized. The digitization will be to National Mapping Accuracy standards, and each contour will be tagged with its proper elevation.

A digital elevation model is a grid cell format representation of the contours. A regulation grid of 50' cells (or any cell size best suited for field investigation requirements) is produced by special software within the Geographic Information System (GIS). Each regular cell represents a unit of space on the earth's surface in two dimensions, x and y. Based upon the actual mean contour interval present at that cell location, an elevation or z value is assigned to the cell. These cells with elevation values can then be processed as a terrain surface model, and will be the graphic input to TIMS.

6.3.2 Digital Mapping of Planimetric Features

Utilizing the photogrammetric compilations produced in Part One of this project, feature layers for each of the three remaining information layers at the 1"-100' and 1"-200' scales will be digitized. Although 1"-100' and 1"-200' mapping scales do not permit a high level of differentiation of facilities' detail, care will be taken to address the primary project which is based upon field analysis and remedial action. These mapping scales will, however, allow for a highly precise and relatively detailed layout of all principal plant facilities. These maps are intended to support both the field investigations and to support general plant facilities management activities.

6.3.3 Base Mapping

This task involves the preparation of an interim base map in color at 1"-800' to be used for initial field work planning. The source for this map will be the U.S. Geological Survey 1:24,000 Shandon quadrangle.

A photo map at an approximate scale of 1"-200' will be produced to serve as a further tool in locating actual field investigation locations.

Also to be produced is a high quality one piece reproducible map of study area B, which measures approximately 24" x 36" in size

at a scale of 1" - 800', and displays the four layers of information digitized in Tasks 1 and 2 above.

The last map product to be produced will be a high quality set of reproducible maps of the site area C, which measure approximately 24" x 36" in size at a scale of 1" - 200', and display the four layers of information digitized.

6.4 LOCATIONAL GRID SYSTEM

A grid system will be established which will allow all field sampling, analysis and projections to be located geographically. The system will be referenced to the State Plane Coordinate System. The position of each field measurement and sample will be recorded on the standardized field forms in accordance with a north and east designation measured from an origin located at 137E, 475N. The locations will be measured from survey stakes placed throughout the Waste and Storage Area, in reference to FMPC Monument Designation D, 1960S, 3100E.

Section 7

SECTION 7

PREINVESTIGATION EVALUATION

7.1 PURPOSE AND SCOPE

The Preinvestigation Evaluation is the first step in the disposal alternatives evaluation. The purpose of this step is to identify the general response actions and associated technologies which may be potentially applicable to the Fernald site. This evaluation is performed prior to the initiation of the site characterization investigation so that the data necessary for developing and evaluating alternative disposal actions in Phase II can be identified and incorporated into the scope of the site characterization.

Existing site information is utilized to identify general response actions and to address potential contaminant sources and pathways associated with the Fernald site. This step eliminates inappropriate actions and focuses the data collection efforts towards supporting the evaluation of disposal action alternatives.

7.2 SITE EVALUATION

7.2.1 Potential Sources

A number of potential radioactive and chemical contaminant sources exist at the Fernald site. These include the wastes, contaminated soils, and materials associated with the:

- Six waste storage pits
- Clearwell
- Three waste storage silos
- Burnpit area
- Two flyash piles

A fourth silo is located on the site but it has never been used for waste storage and remains empty.

The locations of these potential sources were identified in Figure 2.1. Detailed descriptions of the source areas and wastes associated with each were provided in Section 3.0.

7.2.2 Potential Pathways and Receptors

The major pathways of contaminant migration from the Fernald site include:

- Air
- Ground water
- Surface water
- Direct exposure
- Food chain

Direct contact with wastes or contaminated soils is an additional pathway for site personnel entering the Waste Storage Area. Flora and fauna species within the Waste Storage Area may also come into direct contact with contaminated materials (plants growing within the closed pit areas and birds entering the ponded waters in Pits 5 and 6).

Contaminant migration via the air pathway may include airborne concentrations of radon, volatile chemicals, radioactive particulates, and chemically contaminated particulates. Additionally, the potential exists for the airborne transportation of asbestos fibers from Pit 4.

The ground water pathway may include the transport of radioactive and/or chemical contaminants which have entered the ground water system through leakage from waste storage areas (pits or silos) and/or leaching of wastes and contaminated materials.

The surface water pathway includes two potential mechanisms for contaminant transport into the environment. The first involves the direct discharge of soluble and suspended contaminants from liquids contained in the storage pits and Clearwell. The second mechanism consists of contaminant transport along drainage ditches and Paddy's Run via surface water run-off. This includes both dissolved chemical and radioactive species leached from contaminated materials (wastes, flyash, soils, sediments) as well as particulates from these sources.

The potential receptors of contaminants transported by the three pathways include on-site workers, neighboring human populations, and surrounding flora and fauna species. On-site workers are most likely to be exposed to contamination via the air pathway while neighboring populations may be exposed by airborne as well as groundwater and surface water contamination. The predominant pathways for contaminant exposure to surrounding flora and fauna species are air and surface water. The potential for direct contact also exists.

7.3 REMEDIAL ACTION

7.3.1 General Response Actions

Based on the information available at this time, general response actions can be identified to address the significant site problems and pathways of contamination at the Fernald site. General response actions represent broad categories of remedial technologies which are potentially applicable to the site. Due to the variety of different wastes and existing control systems, several categories of remedial technology are necessary for the Fernald site.

The classes of general response action identified for the Fernald site are listed in Table 7-1. The "no action" alternative is included as a baseline against which other measures can be evaluated. Some of the categories can be grouped further into surface and subsurface management. It should be recognized that the categories listed are not necessarily final solutions by themselves.

Table 7-1

General Response Actions
for the
Fernald Site

- No Action
- Containment
- Pumping
- Diversion
- Removal
  - Complete
  - Partial
- Treatment
  - On-site
  - Off-site
  - In-situ
- Storage
- Disposal
  - On-site
  - Off-site

TABLE 7-2

POTENTIAL REMEDIAL TECHNOLOGIES FOR SOURCE CONTROL AT THE FERNALD SITE

Class of Response Action	REMEDIAL TECHNOLOGY				
	Wet Pits and Clearwell	Closed Pits and Burnpit Area	Silos	Flyash Piles	Contaminated Soils and Sediments
No action	Surveillance, monitoring, and risk assessment	Surveillance, monitoring, and risk assessment	Surveillance, monitoring, and risk assessment	Surveillance, monitoring, and risk assessment	Surveillance, monitoring, and risk assessment
Surface management	Grading, berms	Capping, grading, berms, revegetation	Cover, dike modification	Capping, grading, berms	Capping, grading, berms, revegetation
Subsurface management	Containment barriers	Containment barriers	Containment barriers	Containment barriers	Containment barriers
Treatment	Incineration; solidification; biological, physical, and chemical treatment	Incineration; solidification; biological, physical, and chemical treatment; insitu treatment	Solidification; physical and chemical treatment; reprocessing	Solidification; biological, physical and chemical treatment	Incineration; solidification, biological, physical, and chemical treatment; insitu treatment
Removal	Complete or partial removal and on-site or off-site landfill disposal	Complete or partial removal and on-site or off-site landfill disposal	Complete or partial removal and on-site or off-site containment/ disposal	Complete or partial removal and on-site or off-site landfill disposal	Complete or partial removal and on-site or off-site landfill disposal

Table 7-3

Potential Remedial Technologies
for Migration Pathway Control
at the Fernald Site

Class of Response Action	Remedial Technology			
	Air	Ground Water	Surface Water	Direct Contact
No Action	Monitoring and Risk Assessment	Monitoring and Risk Assessment	Monitoring and Risk Assessment	Monitoring and Risk Assessment
Surface Management	Capping, cover	Capping, grading, berms, revegetation	Capping, grading, berms, ditches, revegetation, collection, sediment controls	Capping, cover
Subsurface Management	Not applicable	Containment barriers, pumping, collection drains	Not applicable	Not applicable
Treatment	Physical and chemical treatment	Biological, physical, and chemical treatment; in-situ treatment	Biological, physical, and chemical treatment	Not applicable
Removal	Complete or partial removal of sources and on-site or off-site treatment/disposal	Pumping (with or without treatment)	Pumping (with or without treatment)	Complete or partial removal of sources and on-site or off-site treatment/disposal

The Fernald site has several different types of potential contaminant sources that could affect the migration pathways of air, ground water, surface water, and direct contact. The sources and the pathways may interact and affect each other. For example, removing a contaminant source may be a final solution for that location, but does not solve the complete solution of how to dispose of the removed waste. Likewise, remedial action to a migration pathway is only an interim solution without also dealing with the contaminant source. Several response actions may be necessary to completely deal with each source at the Fernald site. It is important to note that the evaluation of each waste source at the Fernald site should be performed as part of a coherent system rather than as independent pieces.

7.3.2 Source and Migration Pathway Controls

The evaluation of remedial action alternatives for a coherent system can be easily categorized by responding to waste sources and migration pathways. Therefore, the general response actions and the corresponding technologies will be evaluated in terms of source controls and migration pathway controls.

The potential remedial technologies for source and migration pathway control appropriate to the Fernald site are listed in Tables 7-2 and 7-3. Some of the general response actions that are listed in Table 7-1 have been grouped into surface or subsurface management. The technologies listed are much more specific in terms of what action will be performed as compared to the general response categories.

The complexity of the system becomes more pronounced as several technologies within a general response category as well as several categories may be applicable and necessary to a particular source or migration pathway. Each technology may require varying degrees of similar or different data requirements. Integrating the different aspects into a coherent system becomes a necessity in order to provide cost effective and technology feasible recommendations for data collection as well as remedial action.

During the course of the remedial investigation, the list of general response actions and associated technologies will be reviewed as new data and information on the site are generated. As a result, additional technologies may be added to the list while some technologies may be modified or eliminated. At the completion of the site characterization, a finalized list of potential technologies will be identified for evaluation. This list will be screened to identify those technologies which can achieve the disposal objectives for the Fernald site. The initial screening process will utilize engineering judgment within the criteria of technical feasibility, environmental impacts, public health considerations, institutional factors, and costs. The screened technologies will then be assembled into remedial alternatives which will be evaluated in detail.

7.4.1 Site Characteristics

Site characteristics data include information on past site practices, physiography, demography, land use, climate, air quality soils, geology hydrogeology, surface water, and surrounding biota. This information is critical to defining the extent of contamination and identifying potential migration pathways and receptors. Table 7-4 summarizes specific site characteristics data requirements.

7.4.2 Waste Characteristics

Waste characteristics data include information on the biological, chemical, and physical characteristics of the wastes. This information defines the nature of the contaminants, their potential health effects, and treatability. Specific waste characteristics data are identified in Table 7-5.

7.4.3 Data Requirements Evaluation

The data requirements contained in Tables 7-4 and 7-5 are sufficient to identify and screen disposal technologies for the Fernald site. However, it is important to note that it may not be necessary to obtain every data requirement listed. The primary purpose of the pre-investigation evaluation is to focus the needs of the data collection so as to direct the site characterization and provide and effective evaluation of disposal action alternatives. Specifically, the criteria of costs, benefits, technical feasibility, environmental impacts and public health considerations have to be applied to the evaluation of data requirements for site characterization as well as the remedial alternatives. That is not to say that additional data needs will not be identified during the site characterization investigation. Specifically, data necessary to evaluate the applicability of technologies for detailed alternative analysis may require laboratory and bench scale treatability studies. If such were the case, a work plan detailing proposed treatability studies would be submitted to Westinghouse for approval prior to the initiation of testing.

Table 7-4

Site Characteristics Data Requirements

- Past Site Practices
- Physiography
  - Topography
  - Slope
  - Site configuration
  - Site area
- Demography
- Land Use
- Climate
  - Precipitation
  - Temperature
  - Wind Speed and direction
  - Evaporation
  - Storms
- Air Quality
  - Radon flux
  - Radon and radioactive particulate concentrations in air
- Soils
  - Type
  - Holding capacity
  - Engineering properties
  - Permeability
  - Variability
  - Porosity
  - Moisture content
  - Chemical characteristics
- Geology
  - Structural features (folds, faults, joints, fractures, interconnected voids)
  - Stratigraphic characteristics (thickness, areal extent, correlation of units, horizontal and vertical extent of aquifers and confining units)
  - Physical characteristics (mineral composition, permeability and porosity, grain-size distribution, in-situ density, moisture content)

Table 7-4
(continued)

- Hydrogeology
  - Groundwater Occurrence (aquifer boundaries and locations, aquifer ability to transmit water)
  - Groundwater movement (direction of flow, rate of flow)
  - Groundwater recharge/discharge (location of recharge/discharge areas, rate)
  - Groundwater quality

- Surface Water
  - Drainage patterns
  - Surface water bodies
  - Flooding potential
  - Surface water quality

- Environmental
  - Fauna and flora
  - Critical habitats
  - Land use characteristics
  - Water use characteristics
  - Biocontamination

Table 7-5

Waste Characteristics Data Requirements

- Quantity
- Type and form
- Integrity of containment structures
- Chemical composition
- Carcinogenicity
- Toxicity - Chronic and Acute
- Persistance
- Biodegradability
- Radioactivity
- Ignitability
- Reactivity
- Corrosivity
- Treatability
- Solubility
- Volatility
- Density
- Partition coeffluent
- Safe levels in the environment
- Compatibility with other chemicals