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Department of Energy

Ohio Field Office
Fernald Closure Project
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Springdale, Ohio 45246
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JUN 6 2005

DOE-0258-05

Dear Fernald Stakeholder:

2004 SITE ENVIRONMENTAL REPORT

Enclosed for your information and reference is the Fernald Closure Project's 2004 Site Environmental Report. This report presents results from the environmental monitoring conducted during calendar year 2004, as well as a summary of progress toward final remediation and regulatory compliance activities at the Fernald site during the year.

Both the U.S. Department of Energy and its contractor, Fluor Fernald, Inc., have reviewed the report to ensure that valid and accurate environmental monitoring data are reported. This report is distributed to local, state, and federal agencies and politicians; the public; and the media. It includes a summary report and a single volume of supporting appendices.

This summary report is intended to serve the same wide audience as past annual reports. Detailed appendices are also available, and are intended to serve a more technical audience such as the regulatory agencies, and will receive limited distribution. The summary report and appendices are available to interested stakeholders through the Public Environmental Information Center located at 690 Crescentville Rd., Cincinnati, OH, 45246, (513) 648-5051; it is open Monday through Thursday, 7:00 a.m. to 4:00 p.m., or by appointment. The summary report will also be made available later in June on the Fernald website (www.fernald.gov) under the "Cleanup" heading and the link to "Environmental Monitoring."

If you have any questions regarding this report, please contact Johnny Reising at (513) 648-3139 or Gary Stegner at (513) 246-0074.

Sincerely,

W G Taylor

William Taylor, Director
Fernald Closure Project

FN:Reising

Enclosure: As Stated

Site Environmental Report 2004

Fernald Closure Project
U.S. Department of Energy
Contract DE-AC24-01OH20115

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Fluor Fernald

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List of Acronyms

ALARA	as low as reasonably achievable
ARARs	applicable or relevant and appropriate requirements
AWWT	advanced wastewater treatment facility
BCG	Biota Concentration Guides
BTV	benchmark toxicity value
CAWWT	converted advanced wastewater treatment facility
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLM/ICP	Comprehensive Legacy Management and Institutional Controls Plan
cm	centimeter
DCG	derived concentration guide
DOE	U.S. Department of Energy
EMS	Environmental Management Systems
EPA	U.S. Environmental Protection Agency
ESD	Explanation of Significant Differences
FCP	Fernald Closure Project
FEMP	Fernald Environmental Management Project
FFA	Federal Facility Agreement
FFCA	Federal Facility Compliance Agreement
FRL	final remediation level
ft^3	cubic feet
ft^3/sec	cubic feet per second
gpm	gallons per minute
HEPA	high-efficiency particulate air
ICRP	International Commission on Radiological Protection
IEMP	Integrated Environmental Monitoring Plan
kg	kilogram
km	kilometer
lbs	pounds
lbs/kg	pounds per kilogram
lbs/yr	pounds per year
Lpm	liters per minute
µCi	microCuries
µCi/hr	microCuries per hour
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
$\mu g/m^3$	micrograms per cubic meter

List of Acronyms (continued)

m^3	cubic meters
M gal	million gallons
M liters	million liters
mCi/yr	milliCuries per year
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mGy/day	milliGray per day
mrem	millirem
m^3/sec	cubic meters per second
mSv	milliSievert
NCRP	National Council on Radiation Protection
NEPA	National Environmental Policy Act
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
NRCP	National Council on Radiation Protection
OAC	Ohio Administrative Code
OEPA	Ohio Environmental Protection Agency
PCB	polychlorinated biphenyl
pCi/g	picoCuries per gram
pCi/L	picoCuries per liter
pCi/m^3	picoCuries per cubic meter
pCi/m^2/sec	picoCuries per square meter per second
person-Sv	person-Sievert
PVS	pugmill ventilation system
RCRA	Resource Conservation and Recovery Act
RCS	Radon Control System
SARA	Superfund Amendment and Reauthorization Act
TLD	thermoluminescent dosimeter
TSCA	Toxic Substance Control Act
USGS	United States Geologic Survey
WPP	Waste Pits Project
yd^3	cubic yards

Units (Abbreviations) and Conversion Table

Multiply	By	To Obtain	Multiply	By	To Obtain
inches (in)	2.54	centimeters (cm)	cm	0.3937	in
feet (ft)	0.3048	meters (m)	m	3.281	ft
miles (mi)	1.609	kilometers (km)	km	0.6214	mi
pounds (lb)	0.454	kilograms (kg)	kg	2.205	lb
tons	0.9072	metric tons	metric tons	1.102	tons
gallons	3.785	liters (L)	L	0.2642	gallons
square feet (ft^2)	0.0929	square meters (m^2)	m^2	10.76	ft^2
acres	0.4047	hectares	hectares	2.471	acre
cubic yards (yd^3)	0.7646	cubic meters (m^3)	m^3	1.308	yd^3
cubic feet (ft^3)	0.02832	cubic meters (m^3)	m^3	35.31	ft^3
picocuries (pCi)	10^{-12}	curies (Ci)	Ci	1012	pCi
pCi/L	10^{-6}	microcuries per liter (μCi/L)	μCi/L	106	pCi/L
Ci	3.7×10^{10}	becquerels (Bq)	Bq	2.7×10^{-11}	Ci
pCi	0.037	Bq	Bq	27.03	pCi
millirem (mrem)	0.001	rem	rem	1000	mrem
mrem	0.01	milliSievert (mSv)	mSv	100	mrem
rem	0.01	Sievert (Sv)	Sv	100	rem
mSv	0.001	Sv	Sv	1000	mSv
person-rem	0.01	person-Sv	person-Sv	100	person-rem
rad	0.01	Gray (Gy)	Gy	100	rad
milliGray (mGy)	0.001	Gy	Gy	1000	mGy
milligrams per liter (mg/L)	1000	micrograms per liter (μg/L)	μg/L	0.001	mg/L
Fahrenheit (˚F)	(˚F - 32) x 5/9	Celsius (˚C)	˚C	(˚C x 9/5) + 32	˚F
For Natural Uranium in Water					
pCi/L	0.0015	mg/L	mg/L	675.7	pCi/L
pCi/L	1.48	μg/L	μg/L	0.6757	pCi/L
μg/L	0.6757	pCi/L	pCi/L	1.48	μg/L
For Natural Uranium in Soil					
pCi/g	1.48	μg/g	μg/g	0.6757	pCi/g
mg/kg	1	μg/g	μg/g	1	mg/kg

ES 1.0 Executive Summary

The 2004 Site Environmental Report provides stakeholders with the results from the Fernald site's environmental monitoring programs for 2004, along with a summary of the U.S. Department of Energy's (DOE's) progress toward final remediation of the site. In addition, this report provides a summary of the Fernald site's compliance with the various environmental regulations, compliance agreements, and DOE policies that govern site activities. All information presented in this executive summary is discussed more fully within the body of this report and the supporting appendices. This report has been prepared in accordance with DOE Order 5400.1, General Environmental Protection Program (DOE 1990), and the Integrated Environmental Monitoring Plan (IEMP), Revision 3 (DOE 2003c). Note that in January 2003, DOE Order 450.1 went into effect, superseding DOE Order 5400.1; however, it has been determined that the intent of this order is met through existing DOE Fernald contractual requirements.

During 2004, DOE and Fluor Fernald, Inc., the prime contractor for the Fernald site, made considerable progress toward final cleanup goals established for the site. A wide range of environmental remediation activities continued during the year, including:

- Excavation and shipment of contaminated waste pit material to an off-site disposal facility (Operable Unit 1)
- Large-scale excavation of contaminated soil and materials from the waste pit area (i.e., 90 percent complete at the end of 2004) and former production area (Operable Unit 5)
- Placement of contaminated soil and debris in the on-site disposal facility (Operable Unit 2)
- Decontamination and dismantlement of former production buildings and support facilities (Operable Unit 3)
- Completion of construction and most of the necessary testing of equipment and facilities for implementation for Silos 1 and 2 remedy, as well as transfer of much of the material from the Silos 1 and 2 to the Transfer Tank Area (Operable Unit 4)
- Extraction and treatment of contaminated groundwater from the Great Miami Aquifer (Operable Unit 5).

Several important milestones toward remediation of the Fernald site were reached in 2004. The last of Fernald’s 10 uranium production complexes were demolished. Thirty-five building structures were demolished, bringing the total to 185 of 316 structures. Two new on-site disposal facility cells (Cells 7 and 8) were opened for waste placement. Plans to reduce the size of the site's wastewater treatment infrastructure were approved and implemented.

The following sections highlight the results of environmental monitoring activities conducted during 2004.

ES 1.1 Liquid Pathway Highlights

ES 1.1.1 Groundwater Pathway

The groundwater pathway at the Fernald site is routinely monitored to:

- Determine capture and restoration of the total uranium plume, as well as non-uranium constituents, and evaluate water quality conditions in the aquifer that indicate a need to modify the design and/or operation of restoration modules

- Meet compliance-based groundwater monitoring obligations.

In May, EPA and OEPA approved the decision to reduce the size of the advanced wastewater treatment facility.

During 2004, active restoration of the Great Miami Aquifer continued or was initiated within each of the following groundwater restoration modules:

- South Field Module – continued pumping from 13 existing extraction wells.

- South Plume/South Plume Optimization Module – continued pumping from six existing extraction wells.

- Waste Storage Area (Phase I) Module – continued pumping from three existing extraction wells into July. In July, one extraction well was shut down for plugging and abandonment, and the other two extraction wells were shut down for preventative maintenance and to facilitate the construction of the converted advanced wastewater treatment facility (CAWWT). Extraction will resume in 2005 and include a replacement for the well that was plugged and abandoned.

- Re-injection Module – continued injecting water into the aquifer for most of the year via four existing re-injection wells. In September, well-based groundwater re-injection was shut down while the CAWWT was under construction. Based on updated groundwater modeling and the results of cost/benefit analysis, the decision was made in 2004 to permanently discontinue well-based re-injection. Note that in June, EPA and OEPA approved the decision to discontinue the use of well-based re-injection.

In addition, approximately 150 monitoring wells were sampled at various frequencies to determine water quality. Water elevations were measured quarterly in approximately 170 monitoring wells. The following highlights describe the key findings from the 2004 groundwater data:

- 2,446 million gallons (9,258 million liters) of groundwater were pumped from the Great Miami Aquifer and 330 million gallons (1,249 million liters) of water were re-injected into the aquifer. As a result of these restoration activities, 922 pounds (419 kilograms [kg]) of uranium were removed from the aquifer.

- The results of 2004 groundwater capture analysis and monitoring for total uranium and non-uranium constituents indicate that the design of the groundwater remedy for the aquifer restoration system is appropriate for capture of the plume. Installation of additional extraction wells was necessary to support the accelerated aquifer remediation schedule. Ongoing refinement of the wellfield configuration will continue based on new monitoring data.

- Pumping of the South Plume/South Plume Optimization Module continued to meet the objective of preventing further southward migration of the southern total uranium plume beyond the extraction wells.

- Leak detection monitoring at Cells 1 through 6 of the on-site disposal facility indicates that all the individual cell liner systems are performing within the specifications outlined in the approved cell design.

ES 1.1.2 Surface Water and Treated Effluent Pathway

Surface water and treated effluent are monitored to determine the effects of Fernald remediation activities on Paddys Run, the Great Miami River, and the underlying Great Miami Aquifer; and to meet compliance-based surface water and treated effluent monitoring obligations. In addition, the results from sediment sampling are discussed as a component of this primary exposure pathway.

In 2004, 16 surface water and treated effluent locations were sampled at various frequencies and six sediment locations were monitored. The following highlights describe the key findings from the 2004 surface water, treated effluent, and sediment monitoring programs:

- The uranium released to the Great Miami River through the treated effluent pathway was an estimated 509 pounds (231 kg), which was below the limit of 600 pounds (272 kg) per year. Uranium released through the uncontrolled runoff pathway was estimated at 104 pounds (47 kg). Therefore, the total amount of uranium released through the treated effluent and uncontrolled surface water pathways during 2004 was estimated to be 613 pounds (278 kg).

- No surface water or treated effluent analytical results from samples collected in 2004 exceeded the final remediation level (FRL) for total uranium, the site's primary contaminant. In addition, there were no FRL exceedances for any other constituent.

- Compliance sampling, consisting of sampling for non-radiological pollutants from uncontrolled runoff and treated effluent discharges from the Fernald site, is regulated under the state-administrated National Pollutant Discharge Elimination System (NPDES) program. The current permit became effective on July 1, 2003, and expires on June 30, 2008.

- Discharges were in compliance with effluent limits identified in the NPDES Permit well over 99 percent of the time during 2004.

- There were no FRL exceedances for any sediment result in 2004.

ES 1.2 Air Pathway Highlights

The air pathway is routinely monitored to assess the impact of Fernald site emissions of radiological air particulates, radon, and direct radiation on the surrounding public and environment. In addition, the data are used to demonstrate compliance with various regulations and DOE Orders.

ES 1.2.1 Radiological Air Particulate Monitoring

Data collected from the network of 17 fenceline and one background air monitoring stations showed the annual average radionuclide concentrations were all less than 1 percent of DOE-derived concentration guidelines contained in DOE Order 5400.5, Radiation Protection of the Public and the Environment.

The maximum effective dose equivalent at the fenceline from 2004 airborne emissions (excluding radon) was estimated to be 0.65 millirem (mrem) per year and occurred at AMS-23 along the north-northeastern boundary of the site. This represents 6.5 percent of the limit of 10 mrem per year established in National Emission Standards for Hazardous Air Pollutants, Subpart H. For comparison, the maximum effective dose was 0.8 mrem in 2002 and 0.82 mrem in 2003.

ES 1.2.2 Radon Monitoring

A network of 32 continuous environmental radon monitors was used for determining compliance with the applicable limits during 2004. The annual average radon concentration recorded at the site's property boundary ranged from 0.3 picoCuries per liter (pCi/L) to 0.6 pCi/L (inclusive of background concentrations). The annual average background concentration measured in 2004 was 0.3 pCi/L. Property boundary results were well below the DOE radon standard of 3.0 pCi/L above background concentrations. In addition, the site's property boundary radon concentrations were below the proposed 10 CFR 834 limit of 0.5 pCi/L.

The annual average radon concentrations in the vicinity of Silos 1 and 2 (Operable Unit 4) during 2004 were comparable to those measured in April 2003 (at which time the Radon Control System [RCS] began operating continually) through the end of 2003. Because of RCS operations, radon concentrations in the vicinity of the silos have decreased sharply. Additionally, there were no exceedances of the DOE limit of 100 pCi/L during 2004.

ES 1.2.3 Direct Radiation Monitoring

Direct radiation measurements were continually collected at 37 locations at the Fernald site and at background locations. The direct radiation levels observed in 2004 indicate that the highest measurements were obtained north-northeast of the site. The direct radiation measurements near Silos 1 and 2 were significantly lower in 2004 than in 2003, primarily due to operation of the RCS.

ES 1.3 Estimated Dose for 2004

In 2004, the maximally exposed individual near the north-northeastern boundary of the Fernald site could have hypothetically received a maximum dose of approximately 11.1 mrem. For comparison purposes, in 2003 it was calculated that the maximally exposed individual living nearest the Fernald site in a west direction could have hypothetically received a maximum dose of approximately 7.33 mrem. This estimate represents the maximum incremental dose above background attributable to the site and is exclusive of the dose received from radon. The contributions to this all-pathway dose for 2004 were 0.65 mrem from air inhalation dose and 10.4 mrem from direct radiation. This dose can be compared to the limit of 100 mrem above background for all pathways (exclusive of radon) that was established by the International Commission on Radiological Protection and adopted by DOE.

ES 1.4 Natural Resources

Natural resources include the diversity of plant and animal life and their supporting habitats found in and around the Fernald site. During 2004, the following primary activities associated with natural resource monitoring and restoration occurred.

- The Wetland Mitigation Project continued with grading of the basins and spillways, and installation of water control structures. Approximately 1,700 trees and shrubs were planted in addition to installation of approximately 1,600 herbaceous plants.

- The Paddys Run West Restoration Project, which encompasses Area 8 (Phase III) South and North, involved planting over 1,100 trees and shrubs east of Paddys Run Road, and roughly nine acres of tallgrass prairie were seeded within Area 8 (Phase III) South.

- The borrow area restoration continued with the initiation of tree and shrub installation.

- The Paddys Run East Restoration Project, which encompasses all of Area 2 (Phases II and III), focused on plant installation in Area 2 (Phase III). Approximately 1,300 trees and shrubs were installed across the project area.

- The Northern Pine Plantation Restoration Project implemented monitoring that focused on mortality counts and herbaceous cover estimates.

Ecological restoration monitoring continued in 2004, and Sloan's crayfish turbidity monitoring in Paddys Run continued until June 2004. Also, several unexpected discoveries of cultural resources occurred during 2004 remediation activities although none were significant and no impacts to cultural resources occurred.

1.0 Site Background

Abbreviated Timeline

1951 Construction of the Feed Materials Production Center began.

1952 Uranium production started.

1986 EPA and DOE signed the Federal Facilities Compliance Agreement, which initiated the remedial investigation/feasibility study process.

1989 Uranium production was suspended. The Fernald site was placed on the National Priorities List, which is the list of CERCLA sites most in need of cleanup.

1990 As part of the Amended Consent Agreement, the site was divided into operable units for characterization and remedy determination.

1991 Uranium production formally ended. The site mission changed from uranium production to environmental remediation and site restoration.

1996 The last operable unit's record of decision was signed, signifying the end of the 10-year remedial investigation/feasibility study process. (The Operable Unit 4 Record of Decision was later re-opened.)

1997 Environmental monitoring and reporting were consolidated under the Integrated Environmental Monitoring Plan (IEMP) to align with remediation efforts.

1999 Excavation of the waste pits was initiated and the first rail shipment of waste material was transported to Envirocare of Utah, Inc.

2000 The Record of Decision Amendment for Operable Unit 4 Silos 1 and 2 Remedial Actions was signed by EPA.

2001 On-site disposal facility Cell 1 was capped. Remediation of the southern waste units was completed.

2002 The Silos 1 and 2 Radon Control System (RCS) began operations and successfully reduced radon levels within the silos. The off-site transfer of nuclear product material was completed. Waste were place into Cells 2, 3, 4, and 5 of the on-site disposal facility.

2003 All major Operable Unit 2 remedial actions were completed in 2003. In addition, approximately 412,000 cubic yards (yd^3) (315,015 cubic meters [m^3]) of waste were placed in Cells 3, 4, 5, and 6 of the on-site disposal facility.

2004 Plans to reduce the size of the site's wastewater treatment infrastructure were approved and implemented. The last of Fernald's 10 uranium production complexes, plus an additional 35 structures and 73 trailers, were demolished. Also, all eight cells of the on-site disposal facility have been capped or are receiving waste, and approximately 513,000 yd^3 (392,240 m^3) were placed in Cells 4, 5, 6, 7, and 8.

In 1951, the Atomic Energy Commission (predecessor of the U.S. Department of Energy [DOE]) began building the Feed Materials Production Center on a 1,050-acre (425-hectare) tract of land outside the small farming community of Fernald, Ohio. The facility's mission was to produce "feed materials" in the form of purified uranium compounds and metal for use by other government facilities involved in the production of nuclear weapons for the nation's defense.

Uranium metal was produced at the Feed Materials Production Center from 1952 through 1989. During that time, over 500 million pounds (227 million kilograms [kg]) of uranium metal products were delivered to other sites. Due to these production operations, releases to the surrounding environment occurred resulting in contamination of soil, surface water, sediment, and groundwater on and around the site.

CERCLA Remedial Process

In broad terms, the process of cleaning up sites under CERCLA consists of the following general phases:

Site Characterization – During this phase, contaminants are identified and quantified, and the potential impacts of those contaminants on human health are determined. This phase includes the remedial investigation and the baseline risk assessment.

Remedy Selection – During this phase, cleanup alternatives are developed and evaluated, and with the input of stakeholders, a remedy is selected. Activities include the feasibility study and proposed plan. After public comments are received, a remedial alternative is selected and documented in a record of decision.

Remedial Design and Remedial Action – This phase of the CERCLA process includes the detailed design and implementation of the remedy. The CERCLA process ends with certification and site closure.

A five-year review process is triggered by the onset of construction for the first operable unit remedial action that will result in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure. Of all the operable units, the site preparation construction to support the Waste Pits Project under the Operable Unit 1 Record of Decision (DOE 1995b) was the first such action. This construction began on April 1, 1996. The First Five-Year Review Report for the site was submitted to and approved by the EPA in 2001. These reviews ensure that the remedy remains effective and continues to be protective of human health and the environment.

Long-term Stewardship will take place at the Fernald site following site closure. Site closure is defined in the current contract between Fluor Fernald and DOE as the physical completion of the scope of work required by the five Records of Decision with the exception of groundwater remedy. DOE's Office of Legacy Management will assume the long-term surveillance monitoring and maintenance of the Fernald site after site closure in order to ensure continued protection of human health and the environment, and continued operation of the groundwater remedy. The Comprehensive Legacy Management and Institutional Controls Plan (DOE 2005a) will define the activities to be conducted with respect to long-term stewardship at the Fernald site. Additionally, the previously mentioned five-year review process will continue in order to provide stakeholders with information on the remedy performance as well as long-term stewardship information.

In 1991, the mission of the site officially changed from uranium production to environmental cleanup under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended. The site was renamed the Fernald Environmental Management Project (FEMP). Today the site is called the Fernald Closure Project (FCP) to reflect the current mission. Fluor Fernald, Inc. manages the remediation and restoration of the site under the terms of a prime contract with DOE. Regulatory oversight is provided by Region V of the U.S. Environmental Protection Agency (EPA) and the Southwest District Office of the Ohio Environmental Protection Agency (OEPA).

In the 1980s, environmental monitoring activities began at the site. The goal was to assess the impact of production operations and monitor the environmental pathways through which residents of the local community might be exposed to contaminants from the site (exposure pathways). The environmental monitoring program provided comprehensive on- and off-property surveillance of contaminant levels in surface water, groundwater, air, and biota. The goal was to continuously measure the levels of contaminants associated with uranium production operations, and report this information to the regulatory agencies and stakeholders.

Exposure Pathways

An **exposure pathway** is a route by which materials could travel between the point of release (a source) and the point of delivering a radiation or chemical dose (a receptor). At the Fernald site, two **primary exposure pathways (liquid and air)** have been identified. A primary pathway is one that may allow pollutants to directly reach the public and/or the environment. Therefore, the liquid and air pathways provide a basis for environmental sampling and information useful for evaluating potential dose to the public and/or the environment.

Secondary exposure pathways have been thoroughly evaluated under previous environmental monitoring programs. Secondary exposure pathways represent indirect routes by which pollutants may reach receptors. An example of a secondary pathway is produce. Through the food chain, one organism may accumulate a contaminant and then be consumed by humans or other animals. The contaminant travels through the air to the soil, where it is absorbed into produce through the roots and is consumed by humans or animals. An evaluation of past monitoring data has shown that secondary exposure pathways at the Fernald site are insignificant routes of exposure to off-site receptors. Therefore, the IEMP's main focus is on the primary exposure pathways.

Refer to Chapter 6 of this report for information pertaining to 2004 dose calculations from all pathways.

Since the conclusion of the site's uranium production mission and completion of the CERCLA remedy selection process, the focus is on the safe and efficient implementation of environmental remediation activities and facility decontamination and dismantling operations. In recognition of this shift in emphasis toward remedy implementation, the environmental monitoring program was revised in 1997 to align with the remediation activities planned for the Fernald site. The site's environmental monitoring program for 2004 is described in the Integrated Environmental Monitoring Plan (IEMP), Revision 3 (DOE 2003c). The IEMP is updated at a minimum of every two years to keep pace with the site's monitoring needs as remediation progresses. The monitoring under the IEMP will also continue after site closure and revision 4 of the plan will be part of the Comprehensive Legacy Management and Institutional Controls Plan (CLM/ICP).

This 2004 Site Environmental Report summarizes the findings from the IEMP monitoring program and provides a status on the progress toward final site restoration. This report consists of the following:

Summary Report The summary report (Chapters 1 through 7) documents the results of environmental monitoring activities at the Fernald site in 2004. It includes a discussion of remediation activities and summaries of environmental data from groundwater, surface water and treated effluent, sediment, air, and natural resources monitoring programs. It also summarizes the information contained in the appendices.

Appendices The detailed appendices provide the 2004 environmental monitoring data for the various media, primarily in the form of graphs and tables. The National Emission Standards for Hazardous Air Pollutants (NESHAP) (40 CFR 61 Subpart H) compliance report (EPA 1985) is also included. The appendices are generally distributed only to the regulatory agencies. However, a complete copy of the appendices is available at the Public Environmental Information Center, which is located at the Fernald Records Center in Springdale, Ohio, and is open Monday through Thursday, 7:00 a.m. to 4:00 p.m.

The remainder of this introductory chapter provides:

- An overview of the current environmental remediation operations and a description of its current cleanup mission, organization, and major remediation activities
- A description of environmental monitoring activities at the Fernald site
- A description of the physical, ecological, and human characteristics of the area.

1.1 The Path to Site Closure

In 1986, the Fernald site began working through the CERCLA process to characterize the nature and extent of contamination at the site, establish risk-based cleanup standards, and select the appropriate remediation technologies to achieve those standards. To facilitate this process, the site was organized into five operable units in 1991. The purpose of the operable unit concept under CERCLA is to organize site components based on their location and/or the potential for similar technologies to be used for environmental remediation. The remedy selection process culminated in 1996 with the approval of the final Records of Decision for each of the five operable units. However, several of the Records of Decision (including those for Operable Units 1, 4, and 5) have subsequently been modified through issuance of Explanation of Significant Differences and/or Record of Decision Amendment documents. These documents were prepared, submitted for EPA and public review, and issued in accordance with CERCLA regulations.

Following approval of the initial records of decision, work began on the design and implementation of the operable unit remedies. In order to align site-wide responsibilities and regulatory obligations of each operable unit and to most efficiently execute remedial design and remedial action, the site established integrated project organizations in 1996. Realignment into project organizations reflected the actual work processes and operations necessary to complete remediation while meeting the requirements of the records of decision. Table 1-1 describes each operable unit and its associated remedy, and provides a crosswalk between each operable unit and the projects responsible for implementing each remedy. When a project is mentioned in this document, references to the applicable operable unit are included, as identified in the Table 1-1 description. It should be noted that several reorganizations have occurred during the past several years; Table 1-1 and text reflect a simplified project organization.

1.2 Environmental Monitoring Program

In the 1980s, an environmental monitoring program was initiated to assess the impact of past operations on the environment and monitor potential exposure pathways to the local community. Additionally, characterization activities were conducted at the Fernald site for nearly 10 years through the remedial investigation phase of the CERCLA process. The initial environmental evaluations performed during the remedial investigation/feasibility study process were used to select the final remedy for Operable Unit 5, which addressed contamination in soil, groundwater, surface water, sediment, air, and biota (produce) – in short, all environmental media and contaminant exposure pathways affected by past uranium production operations at the site. The selected remedy for Operable Unit 5 defined the site's final contaminant cleanup levels and established the extent of on- and off-property remedial actions necessary to provide permanent solutions to environmental concerns posed by the site.

The Operable Unit 5 remedy included plans for both removing the contamination that might be released through these exposure pathways, and monitoring these pathways to measure the site's continuing impact on the environment as remediation progresses. The characterization data used to develop the final remedy were also used to focus on and develop the environmental monitoring program documented in the IEMP.

TABLE 1-1
OPERABLE UNIT REMEDIES AND ASSOCIATED PROJECT RESPONSIBILITIES

Operable Unit	Description	Remedy Overview	Project Organization Responsibilities
1	- Waste Pits 1—6 - Clearwell - Burn pit - Berms, liners, caps, and soil within the boundary	Record of Decision Approved: March 1995 Explanation of Significant Differences Approved: September 2002 Record of Decision Amendment Approved: November 2003 Excavation of materials with constituents of concern above final remediation levels (FRLs), waste processing and treatment by thermal drying (as necessary), off-site disposal at a permitted facility, and FCP remediation.	Waste Pits Project is responsible for rail upgrades; excavation of Operable Unit 1 waste units; pre-treatment of wastewater as necessary to meet Aquifer Restoration Project wastewater acceptance criteria; waste processing, drying, and loading; rail transport; and off-site disposal of all waste pit waste as well as any contaminated soil and debris that exceed the waste acceptance criteria for the on-site disposal facility. (Note: Some of the activities with this project are being performed by Shaw Environmental.) Demolition, Soil, and Disposal Project is responsible for the excavation and certification of contaminated soil beneath the waste pits, and at- and below-grade remediation facilities, and is responsible for decontamination and dismantling of Operable Unit 1 remediation facilities. Aquifer Restoration/Wastewater Project is responsible for final treatment of contaminated runoff, perched water collected during waste pit excavation, and processing wastewater discharges. Each project is responsible for transporting remediation wastewater to the head works of the advanced wastewater treatment facility for treatment.
2	- Solid waste landfill - Inactive flyash pile - Active flyash pile (now inactive) - North and south Lime Sludge Ponds - Other South Field disposal areas - Berms, liners, and soil within the operable unit boundary	Record of Decision Approved: May 1995 Post-Record of Decision Fact Sheet Approved: April 1999 Excavation of all materials with constituents of concern above FRLs, treatment for size reduction and moisture control as required, on-site disposal in the on-site disposal facility, and off-site disposal of excavated material that exceeds the waste acceptance criteria for the on-site disposal facility.	Demolition, Soil, and Disposal Project is responsible for excavating and disposing of waste from all Operable Unit 2 subunits and certifying the footprints. This project is also responsible for the ongoing design, construction, maintenance, and closure of the on-site disposal facility that will contain Operable Unit 2 subunit wastes, Operable Unit 5 soil and debris, and Operable Unit 3 debris. Waste Acceptance Organization is responsible for field oversight of soil excavations, for reviewing and signing manifests for impacted material delivered to the on-site disposal facility for placement, and for rejecting any unacceptable shipments. Aquifer Restoration/Wastewater Project is responsible for treating contaminated runoff and perched water collected during excavation of Operable Unit 2 subunit wastes. This project is responsible for leachate and leak detection monitoring at the on-site disposal facility and for treating leachate from the on-site disposal facility. Each project is responsible for transporting remediation wastewater to the head works of the advanced wastewater treatment facility for treatment.
3	Former production area, associated facilities, and equipment (includes all above- and below-grade improvements) including but not limited to: - All structures, equipment, utilities, effluent lines, and K-65 transfer line - Wastewater treatment facilities - Fire training facilities - Scrap metals piles - Drums, tanks, solid waste, waste product, feedstocks, and thorium	Record of Decision Approved: September 1996 Adoption of Operable Unit 3 Interim Record of Decision; alternatives to disposal through the unrestricted or restricted release of materials as economically feasible for recycling, reuse, or disposal; treatment of material for on- or off-site disposal; required off-site disposal for process residues, product materials, process-related metals, acid brick, concrete from specific locations, and any other material exceeding the on-site disposal facility waste acceptance criteria; and on-site disposal for material that meets the on-site disposal facility waste acceptance criteria.	Demolition, Soil, and Disposal Project is responsible for decontamination and dismantling of all above-grade portions of buildings and facilities at the Fernald site. This project is responsible for excavation and certification of soil beneath facilities and for removal of at- and below-grade structures. This project is also responsible for design, construction, and closure of the on-site disposal facility that will contain Operable Unit 2 subunit wastes, Operable Unit 5 soil, and Operable Unit 3 debris. Waste Acceptance Organization is responsible for reviewing facility decontamination and dismantling planning documents. This organization is also responsible for field oversight of debris sizing, segregation of on-site disposal facility material categories and prohibited items; completing field tracking logs; completing manifests for material bound for the on-site disposal facility; and compiling final records of decontamination and dismantling debris placed in the on-site disposal facility. Aquifer Restoration/Wastewater Project is responsible for treating decontamination and other wastewater during decontamination and dismantling activities, and processing wastewater discharges. Each decontamination and dismantling project is responsible for transporting remediation wastewater to the head works of the advanced wastewater treatment facility for treatment.

TABLE 1-1
(Continued)

Operable Unit	Description	Remedy Overview	Project Organization Responsibilities
4	- Silos 1 and 2 (containing K-65 residues) - Silo 3 (containing cold metal oxides) - Silo 4 (empty and never used; demolished in 2003) - Decant tank system - Berms and soil within the operable unit boundary	Record of Decision Approved: December 1994 Explanation of Significant Differences for Silo 3 Approved: March 1998 Record of Decision Amendment for Silos 1 and 2 Approved: July 2000 Explanation of Significant Differences for Silos 1 and 2 Approved: November 2003 Record of Decision Amendment for Silo 3 Approved: September 2003 Removal of Silo 3 materials for treatment (to the extent implementable) and off-site disposal (amendment to the Record of Decision). Removal of Silos 1 and 2 residues and decant sump tank sludges with on-site stabilization of materials, residues, and sludges followed by off-site disposal; and decontamination and demolition, to the extent possible, of silos and remediation facilities. Excavation of silos area contaminated above the FRLs with on-site disposal for contaminated soils and debris that meet the on-site disposal facility waste acceptance criteria; and site restoration. Concrete from Silos 1 and 2, and contaminated soil and debris that exceed the on-site disposal facility waste acceptance criteria will be disposed of off site.	Silos 1 and 2 Project is responsible for transfer of Silos 1 and 2 residues to temporary transfer tanks, treatment, and transport off site. Waste treatment systems will be completed to support the final remediation of the silos. If wastewater is generated, it will be pre-treated as necessary by the Silos Project. Silo 3 Project is responsible for Silo 3 content removal, treatment, and transport off site. Demolition, Soil, and Disposal Project is responsible for certification, excavation, and disposition of contaminated soil beneath the silos and for removal of subsurface structures (i.e., sub-grade silo decant system). The project is responsible for design, construction, and closure of the on-site disposal facility that will contain Operable Unit 2 subunit wastes, Operable Unit 5 soil, and Operable Unit 3 debris. This project is also responsible for decontamination and dismantling of all Operable Unit 4 remediation facilities and associated above-ground piping. Aquifer Restoration/Wastewater Project is responsible for the ultimate treatment and discharge of wastewater generated from Advanced Waste Retrieval activities and Silo 1, 2, and 3 remediation activities. Once silos projects are complete, this project will provide, as necessary, treatment of decontamination wastewater from demolition activities. Each project is responsible for capturing, pre-treating as necessary, and transporting remediation wastewater to the headworks of the advanced wastewater treatment facility for treatment.
5	- Groundwater - Surface water and sediments - Soil not included in the definitions of Operable Units 1 through 4 - Flora and fauna	Record of Decision Approved: January 1996 Explanation of Significant Differences was approved in November 2001, formally adopting EPA's Safe Drinking Water Act Maximum Contaminant Level for uranium of 30 micrograms per liter (μg/L) as both the FRL for groundwater remediation and the monthly average uranium effluent discharge limit to the Great Miami River. Extraction of contaminated groundwater from the Great Miami Aquifer to meet FRLs at all affected areas of the aquifer. Treatment of contaminated groundwater, storm water, and wastewater to attain concentration and mass-based discharge limits and FRLs in the Great Miami River. Excavation of contaminated soil and sediment to meet FRLs. Excavation of contaminated soil containing perched water that presents an unacceptable threat, through contaminant migration, to the underlying aquifer. On-site disposal of contaminated soil and sediment that meet the on-site disposal facility waste acceptance criteria. Soil and sediment that exceed the waste acceptance criteria for the on-site disposal facility will be treated, when possible, to meet the on-site disposal facility waste acceptance criteria or will be disposed of at an off-site facility. Also includes site restoration, institutional controls, and post-remediation maintenance.	Aquifer Restoration/Wastewater Project is responsible for designing, installing, and operating the systems needed to restore groundwater in the Great Miami Aquifer. This project is responsible for groundwater monitoring in the Great Miami Aquifer; reporting on the progress of aquifer restoration; designing, constructing, and operating all treated effluent discharge systems; and treating and discharging contaminated groundwater, storm water, and remediation wastewater at the Fernald site. This project is also responsible for operation, maintenance, and monitoring of the on-site disposal facility leachate collection system and leak detection system. Demolition, Soil, and Disposal Project is responsible for certification of site-wide soil; excavation and disposition of contaminated soil, sediment, perched groundwater and at- and below-grade structures; and final site restoration. The project is responsible for design, construction, maintenance, and closure of the on-site disposal facility that will contain Operable Unit 2 subunit wastes, Operable Unit 5 soil, and Operable Unit 3 debris. This project is also responsible for decontamination and dismantling of all Operable Unit 5 remediation facilities necessary through the site completion phase following the completion of the aquifer remediation. Waste Acceptance Organization is responsible for reviewing Demolition, Soil, and Disposal Project planning documents. This project is also responsible for oversight of field excavations; segregating on-site disposal facility material categories and segregating prohibited items; completing field tracking logs; completing manifests for material bound for the on-site disposal facility; and compiling final records of soil and at- and below-grade debris placed in the on-site disposal facility.

Following are descriptions of the IEMP's key elements:

- The IEMP defines monitoring activities for environmental media, such as groundwater, surface water and treated effluent, sediment, air (including air particulate, radon, and direct radiation), and natural resources. In general, the primary exposure pathways (liquid and air) are monitored and the program focuses on assessing the collective effect of site-wide emissions on the surrounding environment.

- The IEMP establishes a data evaluation and decision-making process for each environmental medium. Through this process, environmental conditions at the site as a whole are continuously evaluated. These evaluations sometimes affect decisions made about the implementation of remediation activities. For example, environmental data are routinely evaluated to identify any significant trends that may indicate the potential for an unacceptable future impact to the environment if action is not taken. This information is communicated to the appropriate remediation project organizations so that corrective actions can be taken before conditions become unacceptable.

- Recognizing that the type and pace of remediation activities will change over the life of the cleanup effort, the IEMP was developed as a "living document," allowing for adjustment of the program as site remediation progresses. The IEMP is reviewed annually and revised every two years to ensure that the monitoring program adequately addresses changing remediation activities.

- The IEMP consolidates routine reporting of environmental data into mid-year data summary reports and a comprehensive annual report.

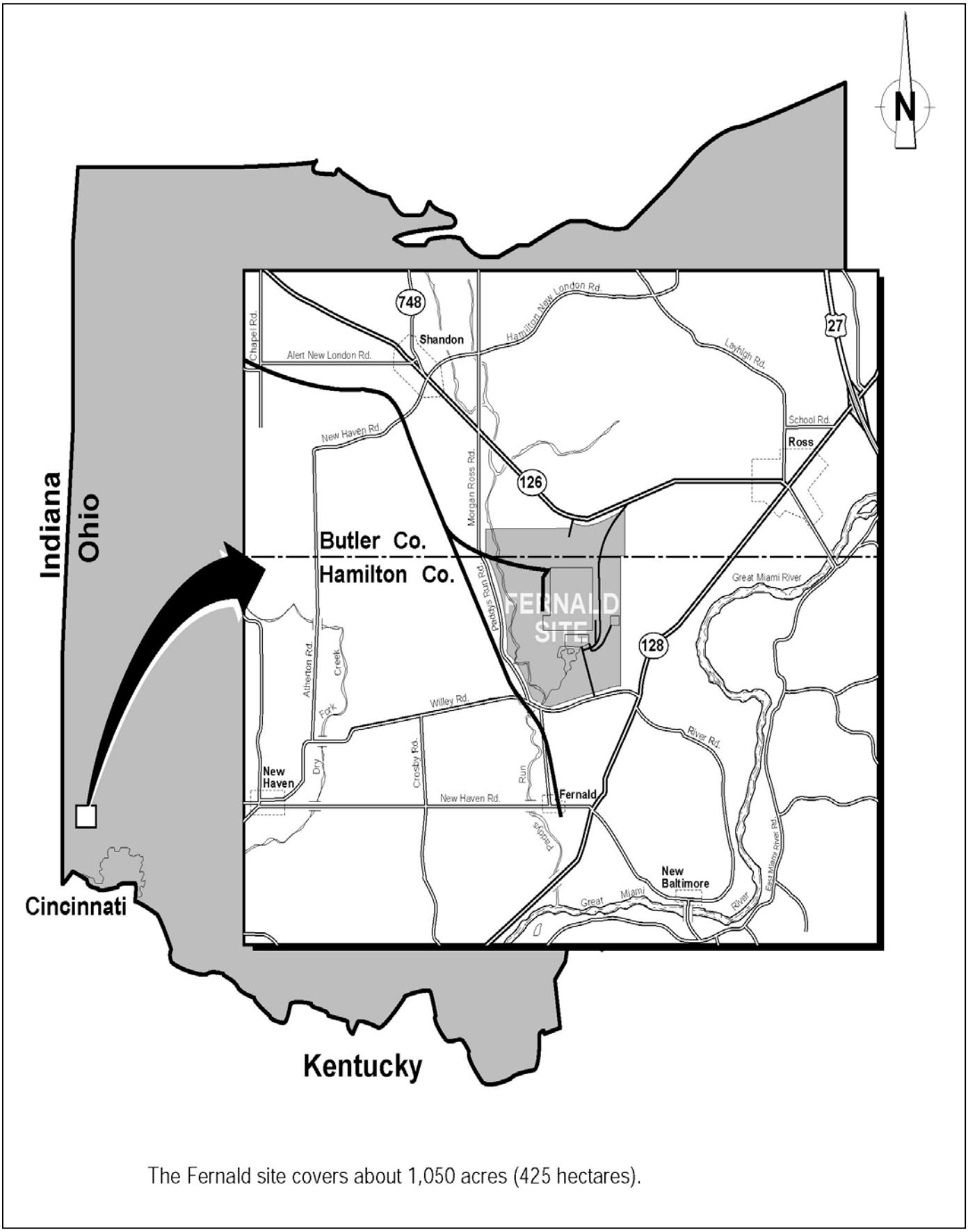
1.3 Characteristics of the Site and Surrounding Area

The natural setting of the Fernald site and nearby human communities were important factors in selecting the final remedy, and remain important in the continuous evaluation of the environmental monitoring program. Land use and demography, local geography, geology, surface hydrology, meteorological conditions, and natural resources all impact monitoring activities and the implementation of the site remedy.

1.3.1 Land Use and Demography

Economic activities in the area rely heavily on the physical environment. Land in the area is used primarily for livestock and crop farming, and gravel pit excavation operations. There is also a private water utility pumping groundwater, primarily for industrial use, approximately 2 miles (3.2 kilometers [km]) east of the Fernald site.

Downtown Cincinnati is approximately 18 miles (29 km) southeast of the Fernald site, as shown in Figure 1-1. The cities of Fairfield and Hamilton are 6 and 8 miles (10 and 13 km) to the east and northeast, respectively, as shown in Figure 1-2. Scattered residences and several villages including Fernald, New Baltimore, New Haven, Ross, and Shandon are located near the site. Based on the 2000 U.S. Census, there is an estimated population of 20,000 within 5 miles (8 km) of the Fernald site and an estimated 2.8 million within 50 miles (80 km).



The Fernald site covers about 1,050 acres (425 hectares).

Figure 1-1. Fernald Site and Vicinity

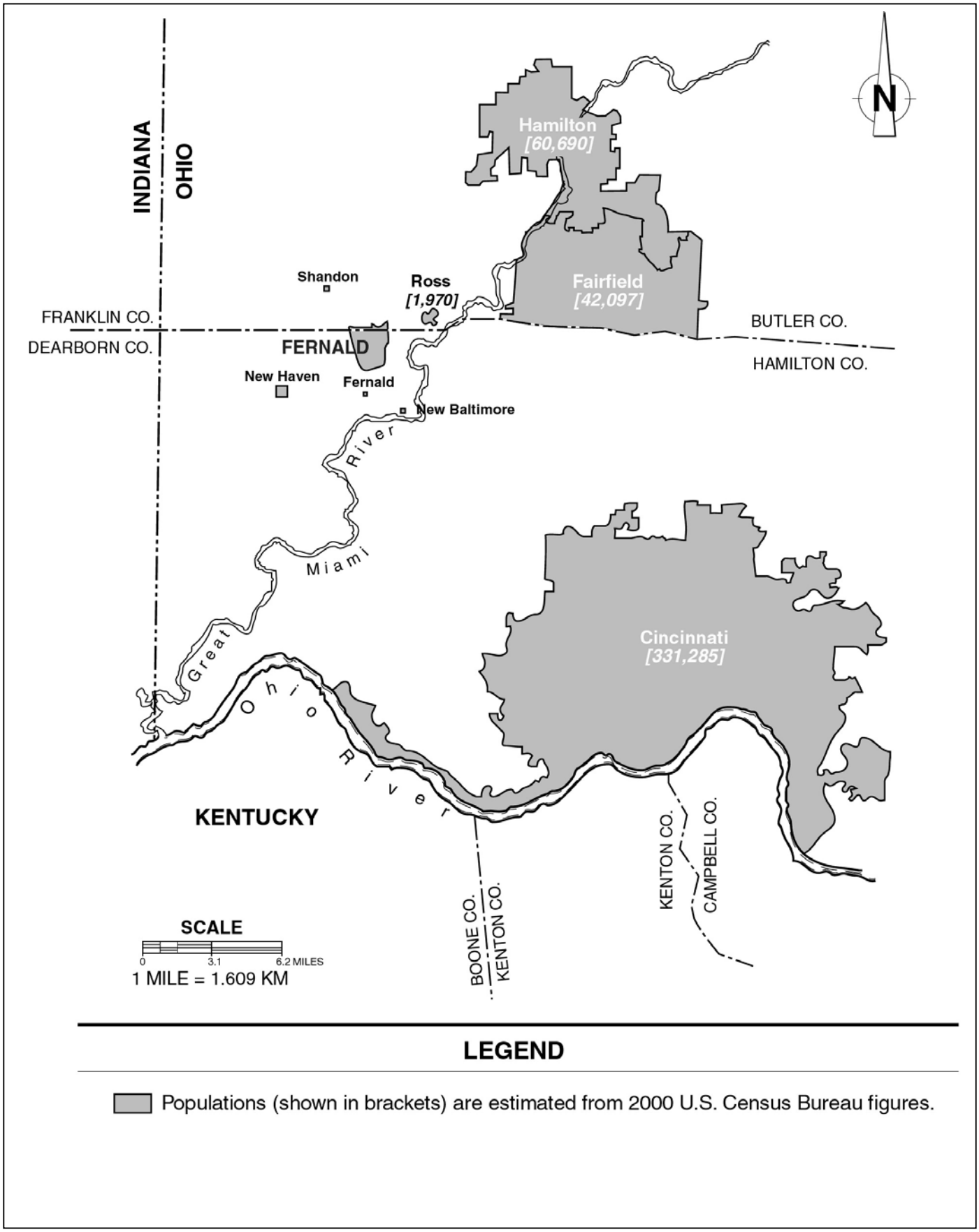


Figure 1-2. Major Communities in Southwestern Ohio

1.3.2 Geography

Figure 1-3 depicts the location of the major physical features of the site, such as the buildings and supporting infrastructure. The former production area and various administrative buildings dominate this view. The former production area occupies approximately 136 acres (55 hectares) in the center of the site. The waste pit area and K-65 Silos are located adjacent to the western edge of the former production area. The Great Miami River cuts a terraced valley to the east of the site while Paddys Run (an intermittent stream) flows from north to south along the site's western boundary. In general, the site lies on a terrace that slopes gently between vegetated bedrock outcroppings to the north, southeast, and southwest.

1.3.3 Geology

Bedrock in the area indicates that approximately 450 million years ago a shallow sea covered the Cincinnati area. Sediments that later became flat-lying shale with interbedded limestone were deposited in the shallow sea as evidenced by the abundance of marine fossils in the bedrock. In the more recent geologic past, the advance and retreat of three separate glaciers shaped the southwestern Ohio landscape. A large river drainage system south of the glaciers created river valleys up to 200 feet (61 meters) deep, which were then filled with sand and gravel when the glaciers melted. These filled river valleys are called buried valleys.

The last glacier to reach the area left an impermeable mixture of clay and silt with minor amounts of sand and gravel deposited across the land surface, called glacial overburden. The site is situated on a layer of glacial overburden that overlies portions of a 2- to 3-mile-wide (3- to 5-km) buried valley. This valley, known as the New Haven Trough, makes up part of the Great Miami Aquifer. The impermeable shale and limestone bedrock that define the edges and bottom of the New Haven Trough confine the groundwater to the sand and gravel within the buried valley. Where present, the glacial overburden limits the downward movement of precipitation and surface water runoff into the underlying sand and gravel of the Great Miami Aquifer.

The Great Miami River and its tributaries have eroded significant portions of the glacial overburden and exposed the underlying sand and gravel of the Great Miami Aquifer. Thus, in some areas, precipitation and surface water runoff can easily migrate into the underlying Great Miami Aquifer, permitting contaminants to be transported to the aquifer as well. Natural and man-made breaches of the glacial overburden were key pathways where contaminated water entered the aquifer, causing the groundwater plumes that are being addressed by aquifer restoration activities. Figure 1-4 provides a glimpse into the structure of subsurface deposits in the region along an east-west cross section through the site, while Figure 1-5 presents the regional groundwater flow patterns in the Great Miami Aquifer.

1.3.4 Surface Hydrology

The site is located in the Great Miami River drainage basin (refer to Figure 1-6). Natural drainage from the site to the Great Miami River occurs primarily via Paddys Run. This intermittent stream begins losing flow to the underlying sand and gravel aquifer south of the waste pit area. Paddys Run empties into the Great Miami River 1.5 miles (2.4 km) south of the site.

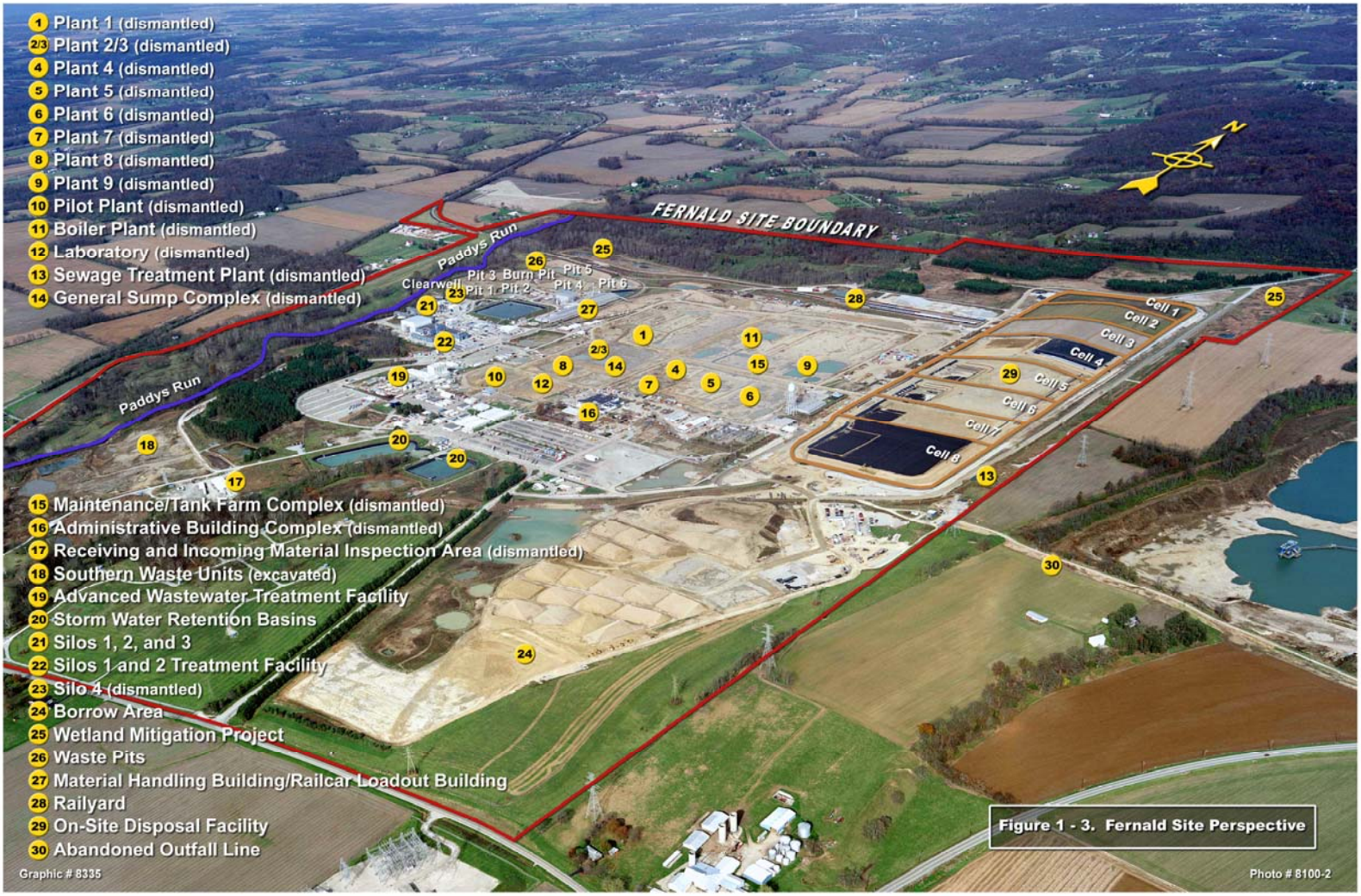


Figure 1 - 3. Fernald Site Perspective

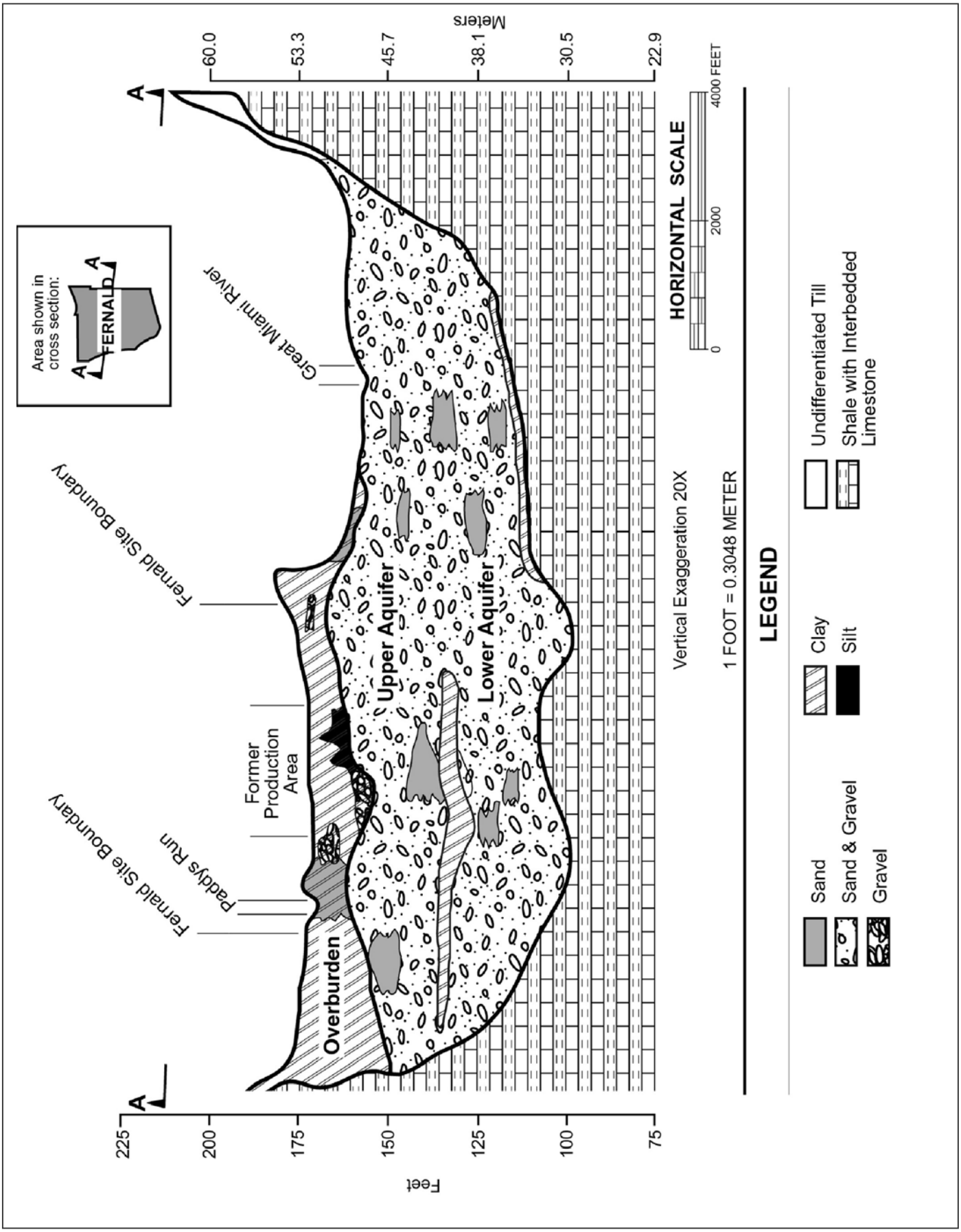


Figure 1-4. Cross Section of the New Haven Trough, Looking North

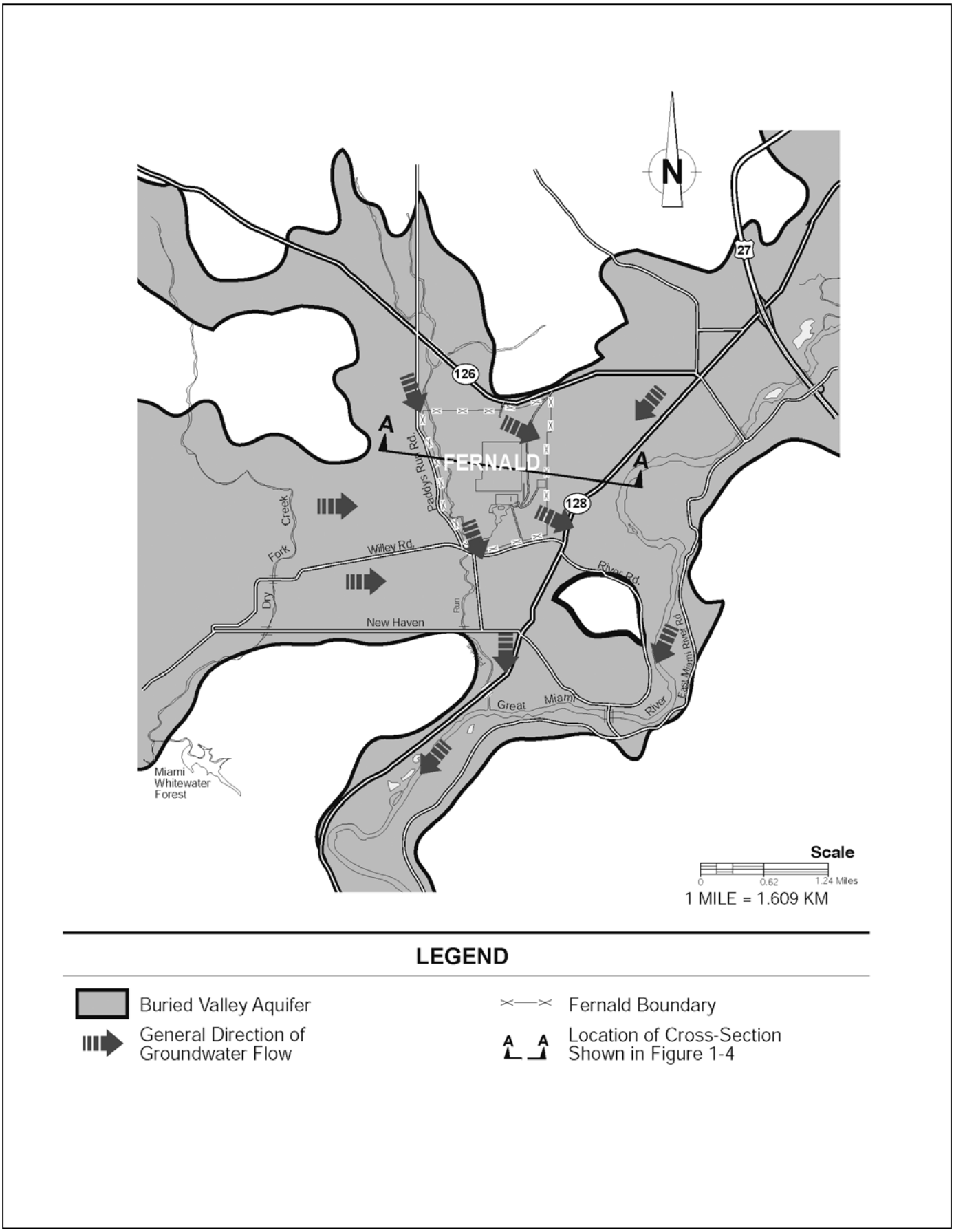


Figure 1-5. Regional Groundwater Flow in the Great Miami Aquifer

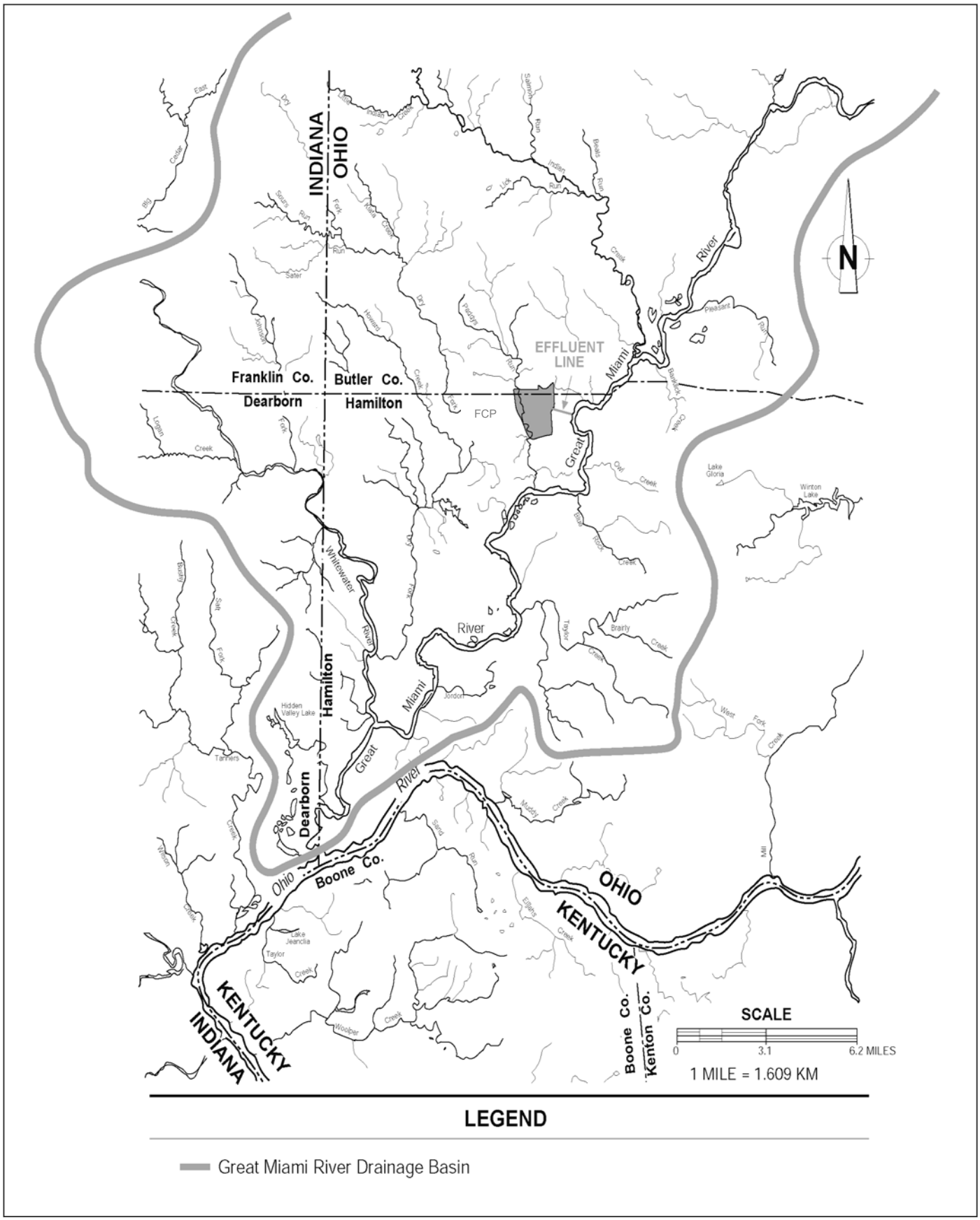


Figure 1-6. Great Miami River Drainage Basin

In addition to natural drainage through Paddys Run, surface water runoff from the former production area, the waste pit area, and other selected areas is collected, treated, and discharged to the Great Miami River. Since January 1995, the majority of this runoff has been treated for uranium removal in the advanced wastewater treatment facility before being discharged. The Great Miami River, 0.6 mile (1 km) east of the Fernald site, runs in a southerly direction and flows into the Ohio River about 24 miles (39 km) downstream of the site. The segment of the river between the Fernald site and the Ohio River is not used as a source of public drinking water.

The average flow volume for the Great Miami River in 2004 was 4,072 cubic feet per second (ft^3/sec) (115.3 cubic meters per second [m^3/sec]). This is based on daily measurements collected at the United States Geologic Survey (USGS) Hamilton stream gauge (USGS 3274000) approximately 10 river miles (16 river km) upstream of the site's effluent discharge.

1.3.5 Meteorological Conditions

Meteorological data are gathered at the Fernald site and used to evaluate site-specific climatic conditions. The environmental monitoring program uses atmospheric models to determine how airborne effluents are mixed and dispersed. These models are then used to assess the impact of operations on the surrounding environment, in accordance with DOE requirements. Airborne pollutants are subject to weather conditions. Wind speed and direction, precipitation, and atmospheric stability play a key role in predicting how pollutants are distributed in the environment and in interpreting environmental data.

Figures 1-7 and 1-8 illustrate the average wind speed and general direction for 2004 measured at the 33-foot (10-meter) and 197-foot (60-meter) levels, respectively, in wind rose format. The prevailing winds were from the southwest 49 percent of the time at the 10-meter height, and 43 percent of the time from the 60-meter height. Tables in Appendix C, Attachment C.4, of this report present meteorological data for 2004, including wind direction and average speed.

In 2004, 40.06 inches (101.75 centimeters [cm]) of precipitation were measured at the Fernald site. This is lower than the average annual precipitation of 41.15 inches (104.5 cm) for 1951 through 2003. Figure 1-9 shows the average precipitation recorded at the Fernald site for each year from 1994 through 2004 and the annual average precipitation for the Cincinnati area from 1951 through 2003. Figure 1-10 shows 2004 precipitation by month at the site compared to the Cincinnati area average precipitation by month from 1951 through 2003.

1.3.6 Natural Resources

Natural resources have important aesthetic, ecological, economic, educational, historical, recreational, and scientific value to the United States. Their protection will be an ongoing process at the Fernald site. Studies such as wildlife surveys (Facemire 1990) and the Operable Unit 5 Ecological Risk Assessment (provided as Appendix B of the Remedial Investigation Report for Operable Unit 5 [DOE 1995d]) show that terrestrial and aquatic flora and fauna at the site are diverse, healthy, and similar in abundance and species composition to those populations of surrounding ecological communities. Chapter 7 provides a discussion of the site's diverse ecological habitats and cultural resources.

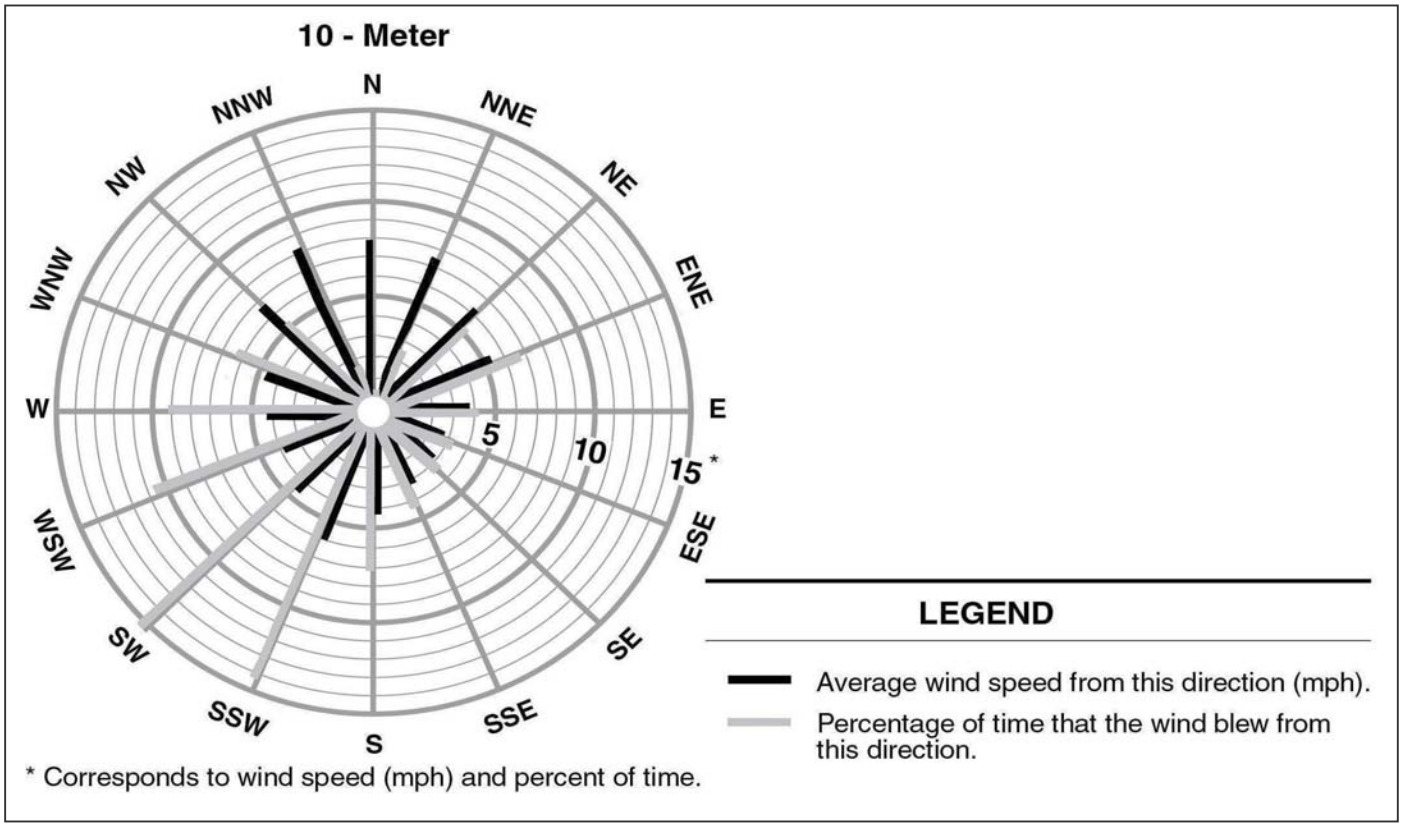


Figure 1-7. 2004 Wind Rose, 33-Foot (10-Meter) Height

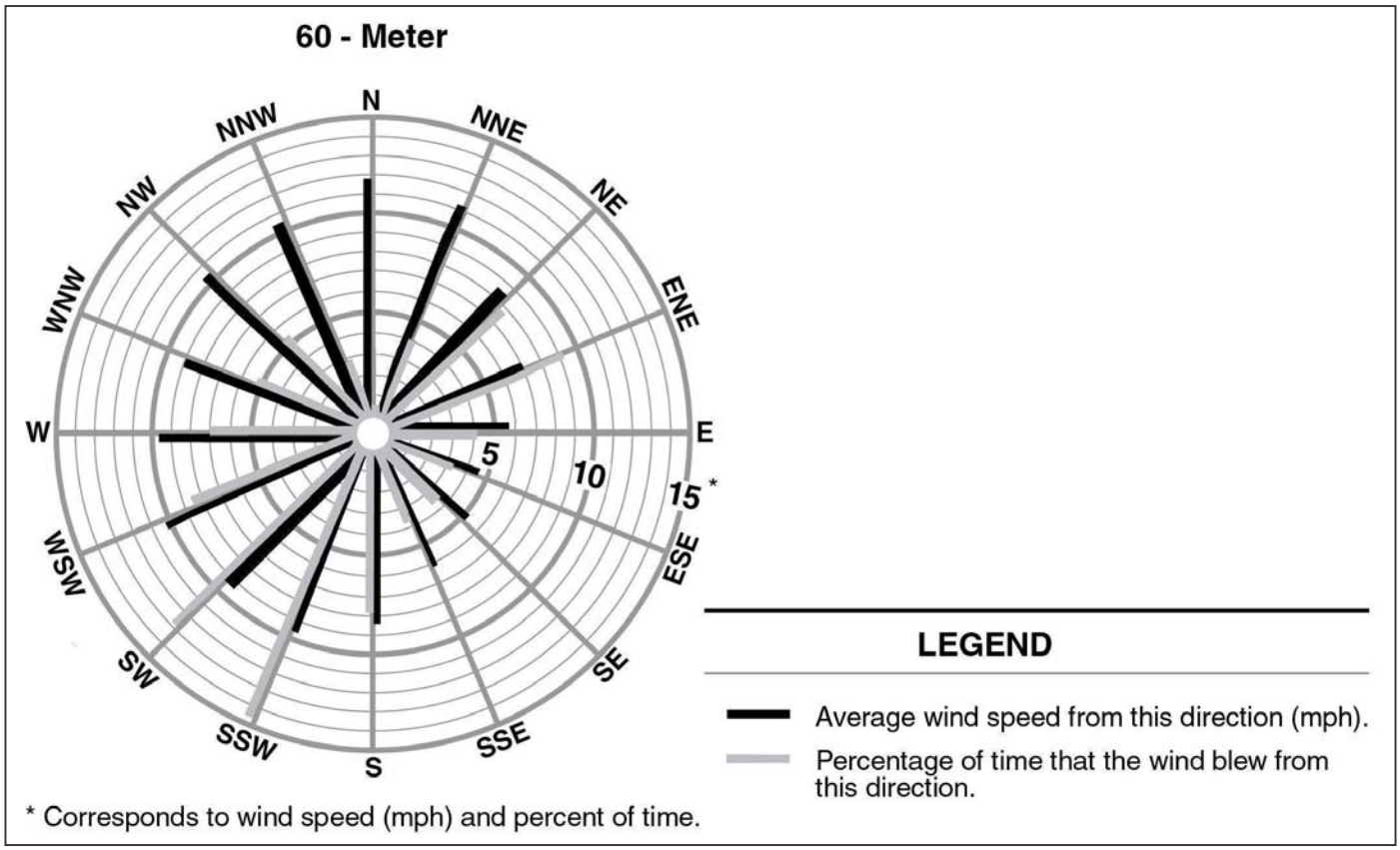


Figure 1-8. 2004 Wind Rose, 197-Foot (60-Meter) Height

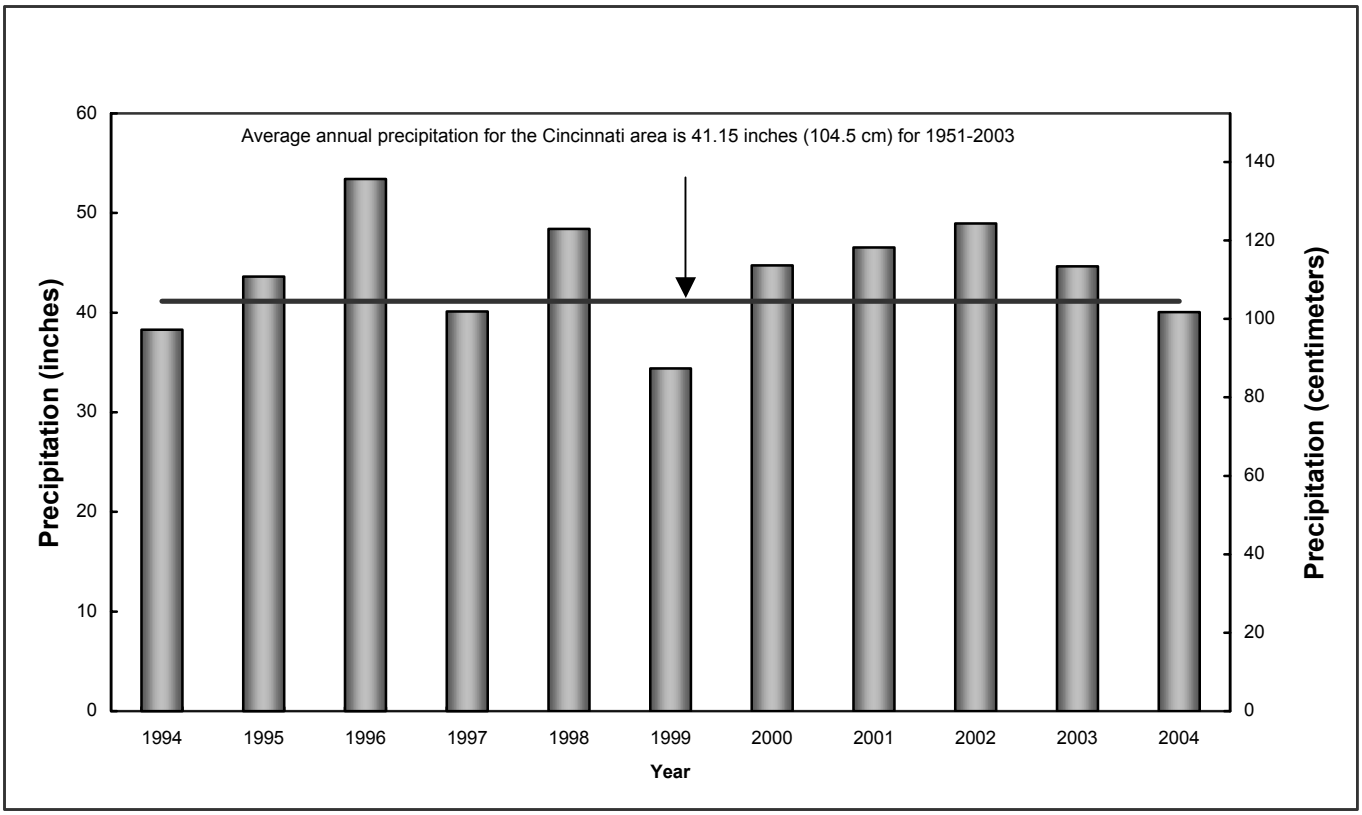


Figure 1-9. Average Annual Precipitation, 1991-2004

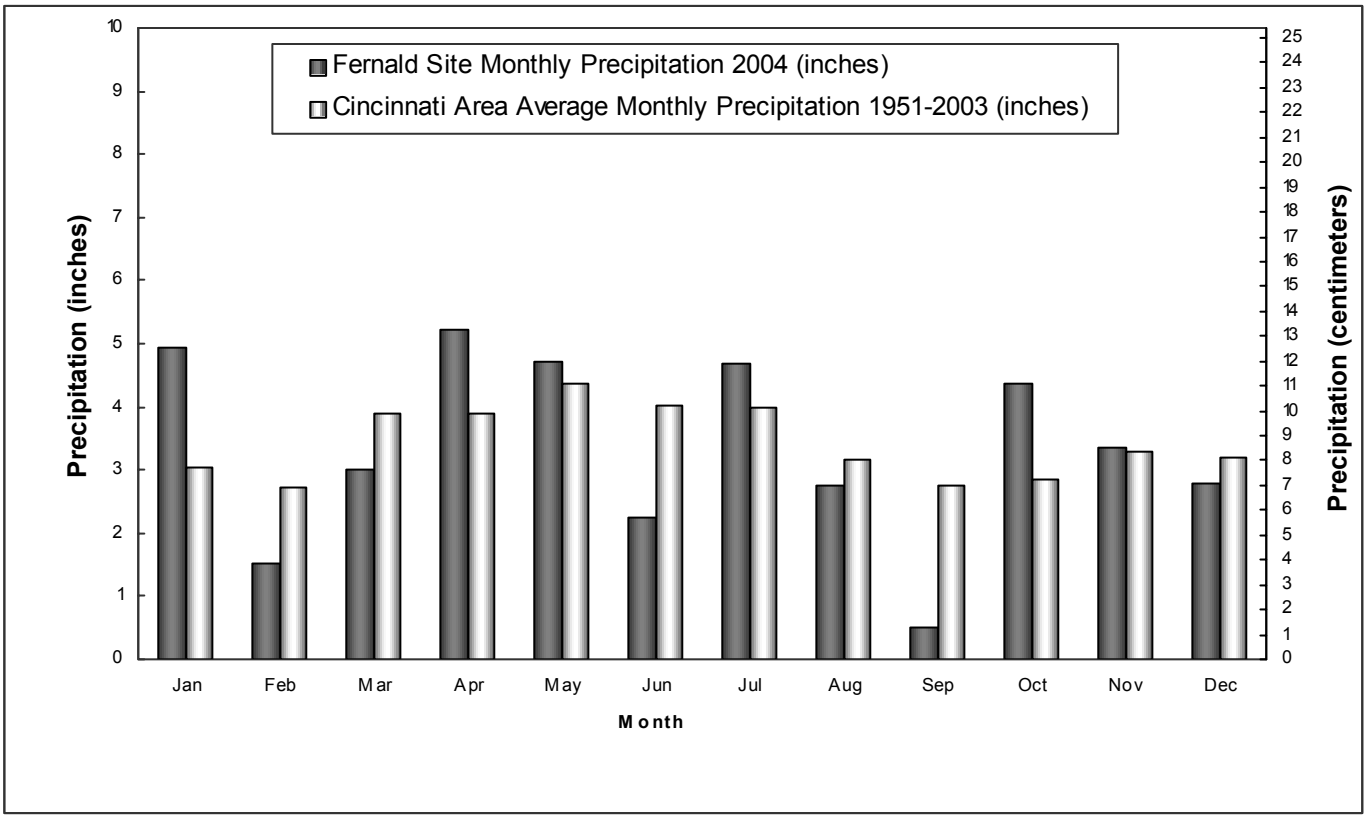


Figure 1-10. Monthly Precipitation for 2004 and Annual Average Precipitation for 1951-2003

2.0 Remediation Status and Compliance Summary

This chapter provides a summary of CERCLA remediation activities in 2004 for each project, and summarizes compliance activities with other applicable environmental laws, regulations, and legal agreements. CERCLA, the "Superfund Act," is the primary driver for environmental remediation of the Fernald site.

The EPA and OEPA enforce the environmental laws, regulations, and legal agreements governing work at the Fernald site. The EPA develops, promulgates, and enforces environmental protection regulations and technology-based standards. EPA regional offices and state agencies enforce these regulations and standards by review of data collected at the Fernald site. Region V of the EPA has regulatory oversight of the CERCLA process at the Fernald site, with active participation from OEPA.

For some programs, such as those under the Resource Conservation and Recovery Act (RCRA) as amended, the Clean Air Act as amended (excluding NESHAP compliance), and the Clean Water Act as amended, EPA has authorized the State of Ohio to act as the primary enforcement authority. For these programs, Ohio promulgates state regulations that must be at least as stringent as federal requirements. Several legal agreements between DOE, EPA Region V, and OEPA identify site-specific requirements for compliance with the regulations. As part of complying with these regulations, DOE Headquarters issues directives to its field and area offices, and conducts audits to ensure compliance with all regulations.

2.1 CERCLA Remediation Status

The process for remediating sites under CERCLA consists of three phases: site characterization, remedy selection, and implementation. The FCP has completed the first two phases, as the regulatory agencies have approved remedy selection documents (i.e., records of decision) for all operable units, as well as several amendments to these documents.

The FCP is currently involved in the implementation phase of CERCLA remediation, which includes remedial design, remedial action (construction and implementation of the remedy), certification of soil and groundwater to verify that the remedy was effective, and ultimately site closure. Remediation activities, documents, and schedules are identified in each operable unit's remedial design and remedial action work plan. It should be noted that significant progress was made during 2004 with respect to remediation efforts. This chapter describes that progress.

Each phase of the CERCLA remediation process requires documentation. The documents produced reflect the input of stakeholders who have helped form the remediation strategy at the Fernald site. Many documents that describe specific remediation activities were issued or approved in 2004, as mentioned throughout this report. All cleanup-related CERCLA documentation, including a copy of the Administrative Record, is available to the public at the Public Environmental Information Center located at the Fernald site. A copy of the Administrative Record is also located at EPA's Region V office in Chicago, Illinois. The progress made by each remedial project toward CERCLA cleanup is summarized later in this chapter.

CERCLA also requires a five-year review process of remedial actions implemented under the signed Record of Decision for each operable unit. The purpose of a five-year review is to determine, through evaluation of performance of the selected remedy, whether the remedy at a site remains protective of human health and the environment. The first five-year review report for the Fernald site (DOE 2001b) was approved by the EPA in September 2001.

Cleanup levels at the Fernald site for surface water, sediment, and groundwater were established in the Record of Decision for Remedial Actions at Operable Unit 5 (DOE 1996). These final remediation levels (FRLs) were established for constituents of concern or those constituents at the Fernald site determined, through risk assessment, to present potential risk to human health or the environment. Table 2-1 lists FRLs identified for constituents in groundwater, surface water, and sediment; these constituents are all monitored under the IEMP. FRLs represent the maximum allowable residual levels (the maximum concentrations which may remain in the environment following remediation), and these levels drive excavation and cleanup.

On November 30, 2001, the EPA approved an Explanation of Significant Differences to the Operable Unit 5 Record of Decision. This document formally adopts the EPA's Safe Drinking Water Act Maximum Contaminant Level for uranium of 30 µg/L as both the FRL for groundwater remediation and the monthly average uranium effluent discharge limit to the Great Miami River.

Benchmark Toxicity Values originated from the Operable Unit 5 Sitewide Ecological Risk Assessment. These concentrations for sediment and surface water are used to determine if a constituent may have a detrimental effect on a particular ecological receptor. For surface water and sediment, ecological receptors include fish and animals that inhabit the surface water body or use surface water as a source of drinking water.

Acceptable levels for constituents of ecological concern were established in the Operable Unit 5 Sitewide Ecological Risk Assessment (Appendix B of the Operable Unit 5 Remedial Investigation Report). The Sitewide Ecological Risk Assessment established benchmark toxicity values (BTVs) for protection of ecological receptors. Through the BTV screening process presented in Appendix C of the final Sitewide Excavation Plan (DOE 1998b), three constituents of ecological concern (barium, cadmium, and silver) were selected for evaluation in the surface water pathway to be protective of aquatic receptors. During 2004, EPA and OEPA agreed with the discontinuation of BTV evaluations; however, it is important to note that barium, cadmium, and silver are still monitored in association with surface water for either National Pollutant Discharge Elimination System (NPDES) or FRL evaluations (refer to Chapter 4).

TABLE 2-1
FINAL REMEDIATION LEVELS FOR GROUNDWATER, SURFACE WATER, AND SEDIMENT

	FRL[a]		
Constituent	**Groundwater**	**Surface Water**	**Sediment**
General Chemistry	**(mg/L)**	**(mg/L)**	**(mg/kg)**
Cyanide	NA[b]	0.012	NA
Fluoride	4[c]	2.0	NA
Nitrate[d]	11	2,400	NA
Inorganics	**(mg/L)**	**(mg/L)**	**(mg/kg)**
Antimony	0.0060	0.19	NA
Arsenic	0.050	0.049	94
Barium	2	100	NA
Beryllium	0.0040	0.0012	33
Boron	0.33	NA	NA
Cadmium	0.014	0.0098	71
Chromium VI[d]	0.022	0.010	3,000
Cobalt	0.17	NA	36,000
Copper	1.3	0.012	NA
Lead	0.015[c]	0.010	NA
Manganese	0.900	1.5	410
Mercury	0.0020	0.00020	NA
Molybdenum	0.10	1.5	NA
Nickel	0.10	0.17	NA
Selenium	0.050	0.0050	NA
Silver	0.050	0.0050	NA
Thallium	NA	NA	88
Vanadium	0.038	3.1	NA
Zinc	0.021	0.11	NA
Radionuclides	**(pCi/L)**	**(pCi/L)**	**(pCi/g)**
Cesium-137	NA	10	7.0
Neptunium-237	1.0	210	32
Lead-210	NA	11	390
Plutonium-238	NA	210	1,200
Plutonium-239/240	NA	200	1,100
Radium-226	20	38	2.9
Radium-228	20	47	4.8
Strontium-90	8.0	41	7,100
Technetium-99	94	150	200,000
Thorium-228	4.0	830	3.2
Thorium-230	15	3500	18,000
Thorium-232	1.2	270	1.6
	(µg/L)	**(µg/L)**	**(mg/kg)**
Total Uranium[e]	30[f]	530	210

TABLE 2-1
(Continued)

Constituent	FRL[a] Groundwater	FRL[a] Surface Water	FRL[a] Sediment
Organics	**(µg/L)**	**(µg/L)**	**(µg/kg)**
Alpha-chlordane	2.0	0.31	NA
Aroclor-1254	0.20	0.20	670
Aroclor-1260	NA	0.20	670
Benzene	5.0	280	NA
Benzo(a)anthracene	NA	1.0	190,000
Benzo(a)pyrene	NA	1.0	19,000
Benzo(b)fluoranthene	NA	NA	190,000
Benzo(k)fluoranthene	NA	NA	1,900,000
Bis(2-chloroisopropyl)ether	5.0	280	NA
Bis(2-ethylhexyl)phthalate	6.0	8.4	5,000,000
Bromodichloromethane	100	240	NA
Bromoform	NA	NA	160,000
Bromomethane	2.1	1300	NA
Carbazole	11	NA	63,000
Carbon disulfide	5.5	NA	NA
Chloroethane	1.0	NA	NA
Chloroform	100	79	NA
Chrysene	NA	NA	19,000,000
Dibenzo(a,h)anthracene	NA	1.0	NA
3,3'-Dichlorobenzidene	NA	7.7	NA
1,1-Dichloroethane	280	NA	NA
1,1-Dichloroethene	7.0	15	NA
1,2-Dichloroethane	5.0	NA	NA
Dieldrin	NA	0.020	NA
Di-n-butylphthalate	NA	6,000	NA
Di-n-octylphthalate	NA	5.0	NA
Methylene chloride	5.0	430	NA
4-Methylphenol	29	2,200	NA
4-Methyl-2-pentanone	NA	NA	2,100,000
4-Nitrophenol	320	7,400,000	NA
N-nitrosodiphenylamine	NA	NA	260,000
Octachlorodibenzo-p-dioxin	0.0001	NA	NA
Phenanthrene	NA	NA	3
2,3,7,8-Tetrachlorodibenzo-p-dioxin	0.010	NA	NA
Tetrachloroethene	NA	45	NA
1,1,1-Trichloroethane	NA	1.0	NA
1,1,2-Trichloroethane	NA	230	NA
Trichloroethene	5.0	NA	NA
Vinyl Chloride	2.0	NA	NA

[a]From Record of Decision for Remedial Actions at Operable Unit 5, Tables 9-4 through 9-6, January 1996.
[b]NA = not applicable. No FRL was required for this constituent in this particular environmental media.
[c]The groundwater FRLs for fluoride and lead were changed from 0.89 milligrams per liter (mg/L) and 0.002 mg/L, respectively, to be consistent with the FRL selection process outlined in the Operable Unit 5 Feasibility Study. The changes were documented in the Operable Unit 5 Record of Decision by change pages.
[d]Because of holding time considerations, nitrate/nitrite is analyzed for nitrate and total chromium is analyzed for hexavalent chromium. Total chromium and nitrate/nitrite provide a more conservative result.
[e]Uranium consists of several isotopes (uranium-234, 235, 236 and 238). This report interchangeably uses the terms uranium and total uranium, both defined as the sum of the various isotopic components.
[f]The total uranium groundwater FRL was changed to 30 µg/L in 2001 to reflect the EPA's adopted Safe Drinking Water Act Final Maximum Contamination Level for uranium.

2.1.1 Waste Pits Project

The Waste Pits Project (Operable Unit 1) is responsible for the excavation, drying (as required), loading, and rail transport of the contents of Waste Pits 1 through 6, the burn pit, and the clearwell to an off-site disposal facility. Sampling and analysis of the waste pit material and the off-site disposal of contaminated soil and debris from other remedial projects that exceed the waste acceptance criteria (physical, chemical, and radiological standards) for the on-site disposal facility are part of this scope of work. The project is also responsible for collecting wastewater and storm water associated with the Waste Pits Project activities and, as needed, pre-treating and discharging this remediation water to the advanced wastewater treatment facility. In addition, the project is responsible for implementing dust control measures, and for implementing point source emission controls for dryer operations.

The Waste Pits Project involves the pre-treatment (e.g., crushing, sorting, and shredding) of waste pit materials, drying (as required), and the loadout of railcars with pit material for shipment to Envirocare of Utah, Inc. During 2004, 28 unit trains left the Fernald site carrying approximately 178,800 tons (162,207 metric tons) of material. From April 1999, when the first rail shipment left the Fernald site, through December 2004, the Waste Pits Project shipped 133 unit trains carrying approximately 849,250 tons (770,440 metric tons) of material to Envirocare of Utah, Inc. for disposal. By the end of 2004, all waste and contaminated liners had been removed from Waste Pits 4, 5, and 6, and the clearwell. In addition, all waste had essentially been removed from Waste Pits 1 and 2, and the burn pit. With the remaining contaminated liner and with Waste Pit 3 being over 90 percent complete, the project as a whole was over 90 percent complete at the end of 2004.

Waste Pit 6 after the waste and 6 inches of the liner were removed. Final remediation activities at Waste Pit 6 initiated.

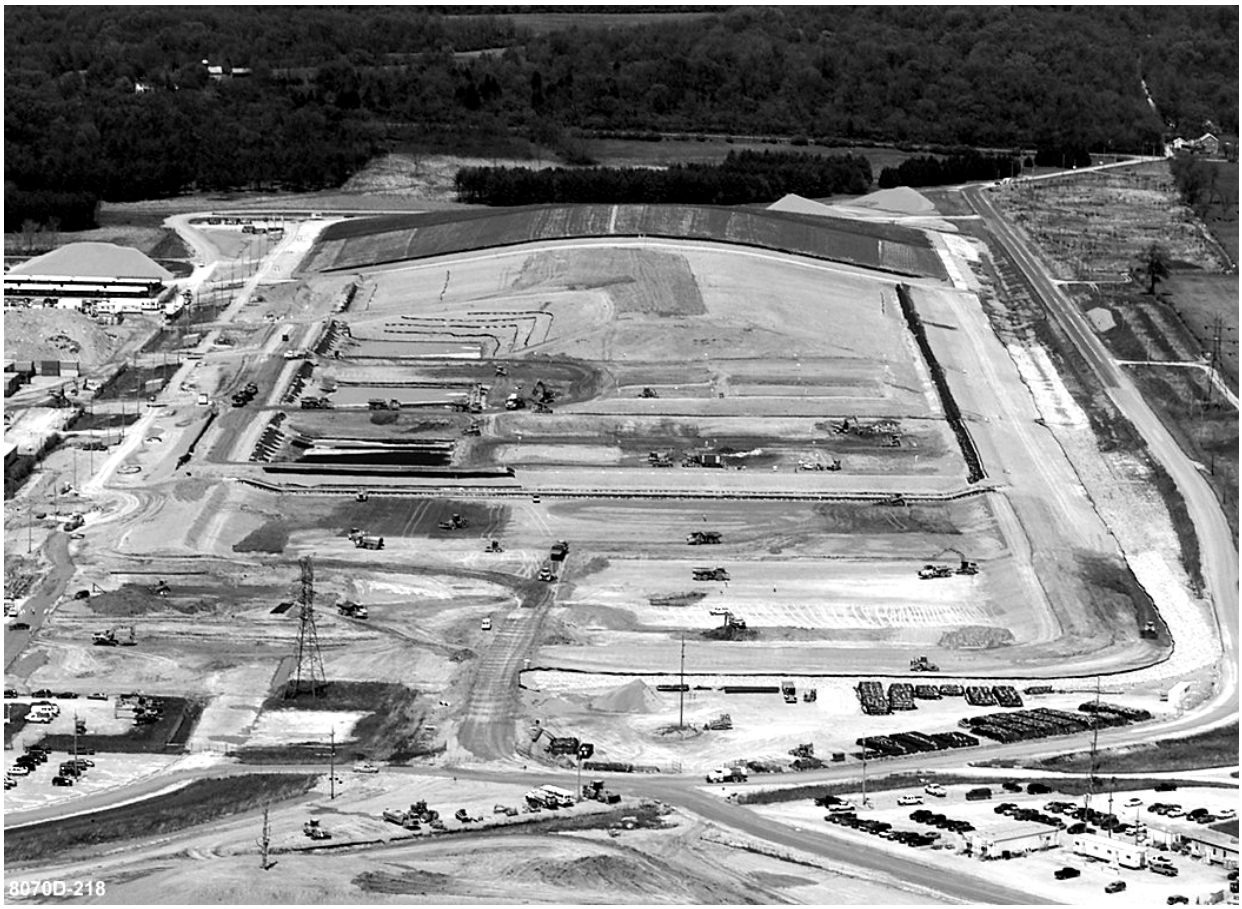
2.1.2 Demolition, Soil, and Disposal Project

The activities associated with this project will be discussed in the following two subsections: Section 2.1.2.1, Soil and Disposal Facility Project, and Section 2.1.2.2, Decontamination and Demolition Project.

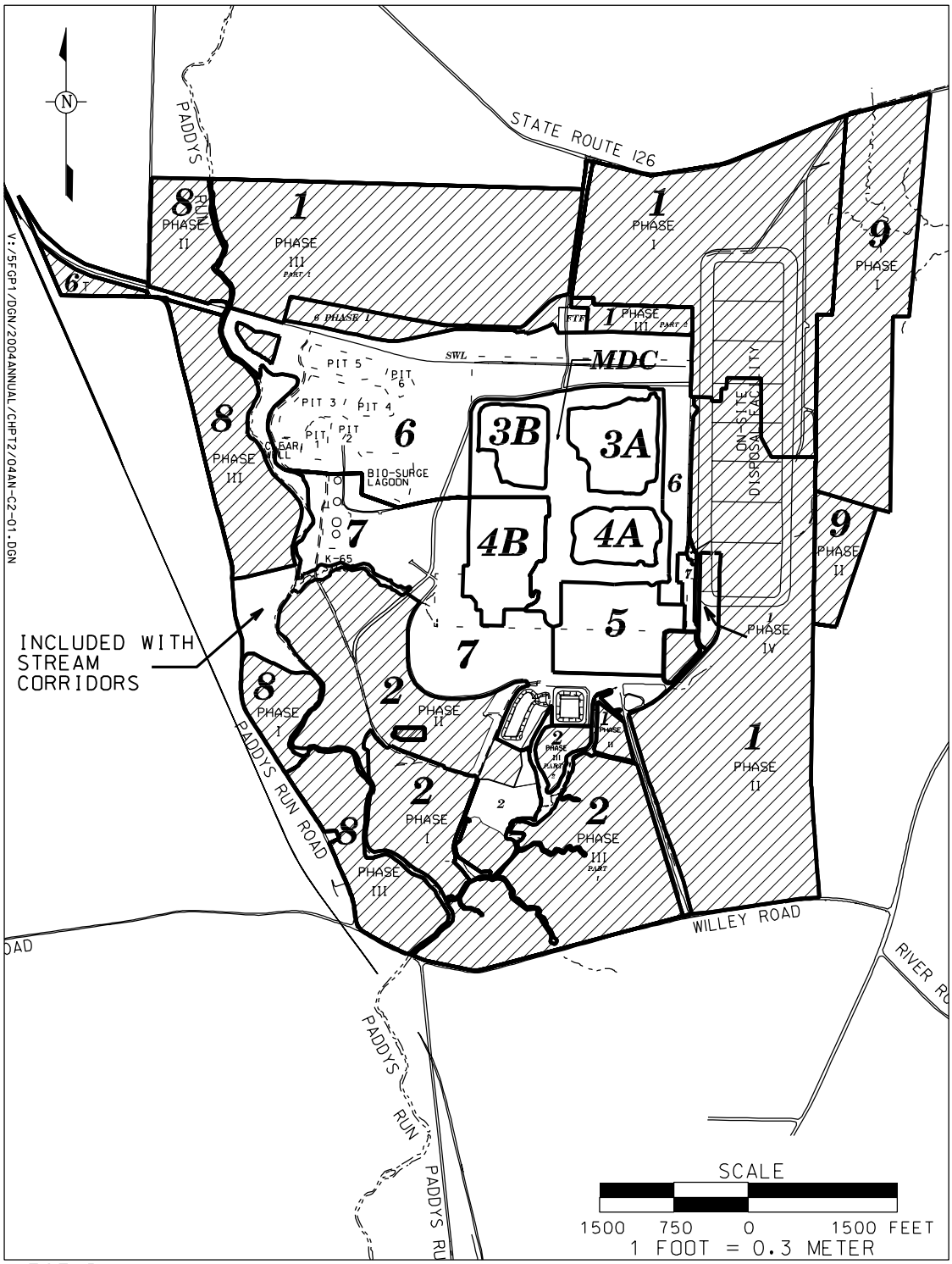
2.1.2.1 Soil and Disposal Facility Project

The Soil and Disposal Facility Project, which includes components of both Operable Units 2 and 5, is responsible for characterizing the extent of contamination in the soil, soil sampling, excavation of contaminated soil and at- and below-grade structures, treatment of soil if necessary, certifying that the soil meets the final remediation levels established in the Operable Units 2 and 5 Records of Decision, natural resource restoration, and the construction of on-site disposal facility cells and waste placement into those cells. (The on-site disposal facility's leachate and leak detection monitoring, as well as operation, maintenance, and monitoring of the leachate transmission system, are the responsibility of the Aquifer Restoration/Wastewater Project.)

For purposes of excavating contaminated soil, the Fernald site has been divided into nine separate soil remediation areas based on land use history and known contamination levels (refer to Figure 2-1). Area 9 includes all off-site soil that must be evaluated during remediation and/or certification. In addition, portions of the site's stream corridors (including Paddys Run) along with other potentially contaminated corridors will require remediation and are considered unique areas. Other utility corridors and access roads are not included with the remediation areas. These corridors will be addressed later in site remediation after completion of the aquifer restoration.



By the end of 2004, over 1.85 million yd^3 (1.4 million m^3) of soil and debris had been placed into the on-site disposal facility.



LEGEND:

—·—·— FERNALD SITE BOUNDARY

1 REMEDIATION AREA

REMEDIATION AREA BOUNDARIES

CERTIFIED AREA (THROUGH 2004)

FIGURE 2-1. SITEWIDE SOIL REMEDIATION AND CERTIFIED AREAS

Prior to soil remediation, real-time scanning and soil sampling are performed to gather information related to the extent of surface and subsurface contamination; to identify the impacted materials that meet the waste acceptance criteria for the on-site disposal facility; and to identify the materials that do not meet the on-site disposal facility waste acceptance criteria and, therefore, must be sent off site for disposal. Engineering personnel use this information to design soil and debris excavations. Materials that cannot be placed in the on-site disposal facility are stockpiled and/or containerized, monitored, and tracked for off-site disposal.

Volume Descriptions: Bank and In-Place

Soil/debris can be described as "bank" (in the ground before excavation) or "in-place" (placed and compacted in the on-site disposal facility). When soil is designed and estimated for excavation, the soil volume is calculated by length, width, and height. When the soil is placed in the on-site disposal facility, considerable compaction is achieved, which reduces the volume that is actually in-place at the on-site disposal facility.

In 2004, the Soil and Disposal Facility Project continued soil and debris excavations. Approximately 677,097 bank yd^3 (517,708 bank m^3) total soil and material were excavated in 2004. By the end of the year, over 1.85 million in-place yd^3 (1.4 million m^3) of soil and debris (including above-grade decontamination and demolition debris) had been excavated and placed into the on-site disposal facility since remediation began, and the planned soil remediation activities at the site were about 64 percent complete. The following soil remedial excavation activities took place in 2004:

- Area 2 (Phase II). Small-scale remedial excavations began adjacent to the west storm water retention basin.
- Area 3A/4A. Large-scale remedial excavations were mostly completed on the east side of the former production area.
- Area 3B/4B/5. Large-scale remedial excavations continued on the west side of the former production area and the east parking lot.
- Area 6. Remedial excavations continued between the waste pit operations and the former Plant 1 Pad, and the solid waste landfill as well as a portion of the Waste Pit 4 cap.

When contaminated soil and debris have been excavated from each area, pre-certification real-time scanning and certification sampling are performed to demonstrate that the residual levels of the constituents of concern for that area are below the site's FRLs. After statistical analyses of the laboratory results are reviewed to confirm that contaminants of concern are demonstrated to be below the site's FRLs, a certification report is submitted to EPA and OEPA, and upon their approval the area is certified as meeting the soil remediation goals.

Figure 2-1 identifies all remediation areas that have been certified as of December 31, 2004. During 2004, the following areas of the Fernald site were certified or were in the process of certification:

- Area 2 (Phase II). Approximately 57 acres (23 hectares) of the area southwest of the former production area were certified.
- Areas 3A and 3B. Approximately 27 acres (11 hectares) of the northern section of the former production area were in the process of certification; the certification report was submitted to the agencies on December 15.
- Area 4A. Approximately 11 acres (4.5 hectares) of the southeast quadrant of the former production area were in the process of certification.
- Area 9 (Phase II). Approximately 12 acres (4.9 hectares) of off-property land adjacent to the central portion of the eastern site boundary were certified.
- Area 9 (Phase III). The abandoned outfall line, that extended from the eastern edge of the Fernald site to the Great Miami River, was excavated and in the process of certification.

As of December 31, 2004, approximately 64 percent of the Fernald site had been certified. After an area of the site is certified, natural resource restoration activities can begin. Chapter 7 discusses the specific natural resource restoration activities that took place in 2004.

During 2004, approximately 513,000 in-place yd^3 (392,240 m^3) of waste (including some excavated material, debris, etc.) were placed in Cells 4, 5, 6, 7, and 8 of the on-site disposal facility. Cell 3 was capped according to construction drawings, and it should be noted that a small amount (approximately 2,700 in-place yd^3) of material was placed in this cell to meet fill requirements. Cell 4 has also been filled to its capacity and the final cover system construction was in progress as of the end of the year. Cell 5 has reached approximately 55 percent of its capacity. Cell 6 has reached approximately 44 percent of its capacity. Cell 7, constructed in 2004, has reached approximately 9 percent of its capacity. Cell 8, also constructed in 2004, has reached approximately 2 percent of its capacity.

Other activities regarding the on-site disposal facility included placement of protective and select material on the Cell 7 floor and side slopes, placement of protective material on the Cell 8 flow and side slope, and placement of select material in Cell 4 in accordance with the Impacted Material Placement Plan (GeoSyntec 1996). A discussion of the ongoing performance monitoring of the on-site disposal facility is provided in Chapter 3.

2.1.2.2 Decontamination and Demolition Project

The Decontamination and Demolition Project (Operable Unit 3) is responsible for decontaminating and dismantling the above-grade structures and facilities associated with production operations and remedial actions. This includes decontamination of facilities; isolation of utilities; demolition of buildings, equipment, and other facilities; removal of uranium and other material from former processing equipment; and shipment of material and equipment off site. The scope includes the collection and proper management of associated decontamination wastewater.

During 2004, decontamination and demolition activities were completed at the following facilities:

- 2B GR/RS Control Building
- 2C Bulk Lime Handling Building
- 2H Conveyor Tunnel
- 3A Maintenance Building
- 3E Hot Raffinate Building
- 3H Refinery Sump
- 3L Electrical Power Center Building
- 8A Recovery Plant
- 11 Services Building
- 13A Pilot Plant Wet Side
- 14A Administration Building
- 14B Building 14 EOC Generator Set
- 15A Laboratory
- 15B Laboratory Chemical Storage Building
- 15C Laboratory Garage
- 16B Electrical Substation
- 16F Trailer Substation 1
- 16G Trailer Substation 2
- 18B General Sump
- 19B Caustic Storage Tank Area
- 20D East Water Tower
- 20K Administration Area Cooling Towers
- 21A Haul Road Wheel Wash Facility
- 22G Main Gate Truck Scale
- 31A Vehicle Repair Garage
- 35A Silo 4
- 53B In Vivo Building
- 54A Six to Four Reduction Facility #1
- 60 Quonset Hut #1
- 61 Quonset Hut #2
- 77 Finished Products Warehouse
- 79 Plant 6 Warehouse
- 82B Fuel Loading/Unloading Facility
- TSS-8 Tension Support Structure #8
- TSS-12 Tension Support Structure #12

Additionally, 73 site trailers were dismantled and either shipped off-site or demolished in 2004.

Demolition of these 35 structures brings the total number of structures demolished at the Fernald site to 185 out of a total of 316 structures.

Structural demolition of the Administration Building.

2.1.3 Silos Projects

The Silos Project (Operable Unit 4) includes Silos 1 and 2 (also known as the K-65 Silos), Silos 3 and 4, and several nearby structures. Silos 1 and 2 contain radium-bearing residues from the processing of uranium ore and ore concentrates during the 1950s. Silo 3 contains cold metal oxides generated from uranium recovery operations, and Silo 4 has never been used. The Silos Project remediation activities will include the retrieval, processing, and off-site disposal of the residues stored in the silos, as well as decontamination and dismantling of the silo structures and associated facilities.

In 1997, DOE, EPA, and OEPA reached the decision to separate the remediation of Silo 3 material from the remediation of Silos 1 and 2 material, and to re-evaluate the treatment remedies for both materials. In addition, the Silos 1 and 2 Accelerated Waste Retrieval Project was initiated to provide control of radon in Silos 1 and 2 headspaces and treatment facilities, and safe storage of the Silos 1 and 2 material during the interim period until treatment and disposal can be implemented. Following is a summary of each project's major activities during the year.

2.1.3.1 Silos 1 and 2 Remediation

An Explanation of Significant Differences (ESD) document was prepared and completed formal public review in December 2004. The ESD, which will be submitted for final EPA approval in early 2005, will modify the remedies for Silos 1, 2, and 3 materials to allow for temporary off-site storage at an appropriately licensed facility prior to permanent off-site disposal. The remedies for Silos 1, 2, and 3 materials will require on-site processing and packaging of the material in accordance with the previous remedies, followed by off-site disposal at the Nevada Test Site or a permitted commercial facility. Construction and most of the necessary start-up testing of the necessary equipment and facilities for implementation of the revised remedy for Silos 1 and 2 was completed during 2004.

Operable Unit 4 (silos) remediation facilities.

The Silos 1 and 2 Project initiated the Accelerated Waste Retrieval Project in 1998. The purpose of this project is to address the increasing radon concentrations in the Silos 1 and 2 headspace, as well as issues regarding silo integrity and heterogeneity of the material for the final treatment facility. The project scope includes design, construction, testing, and operation of interim storage facilities to hold the Silos 1 and 2 material until treatment is implemented. The project also includes design, construction, and startup of the Radon Control System (RCS) to provide control of radon emissions during the construction and operation phases of the Accelerated Waste Retrieval Project, as well as during interim storage and operation of the Silos 1 and 2 full-scale treatment facility. Operation of the RCS to reduce radon concentrations in the Silos 1 and 2 headspaces and waste retrieval equipment continued through the end of the year. Construction and start-up of the equipment required for transfer of the Silos 1 and 2 material from the silos to the four 750,000-gallon tanks in the Transfer Tank Area was completed during 2004. The tanks will be used to receive and store the material from Silos 1 and 2 pending transfer to the remediation facility. Transfer of material from Silos 1 and 2 to the Transfer Tank Area was initiated September 22, 2004, and as of the end of the year, approximately 60 percent of the material from Silos 1 and 2 had been transferred. Waste retrieval will be completed in early 2005.

2.1.3.2 Silo 3 Project

In 2001, re-evaluation of alternatives for implementation of Silo 3 remediation was initiated with input from DOE, regulators, and stakeholders to identify the optimal path forward for remediation of the Silo 3 material. This process continued during 2004 and the Draft Revised Proposed Plan for Silo 3 (DOE 2002b) was submitted to the EPA and OEPA for review. Upon completion of the EPA/OEPA review and approval process, the proposed plan was submitted for formal public review in 2003. After completion of the public review, a Record of Decision Amendment was prepared and subsequently approved by the EPA on September 24, 2003 documenting the revised remedy, which consists of retrieval, conditioning to the extent practical to reduce dispersability and mobility, and off-site disposal. Construction and start-up testing of facilities for retrieval, conditioning, and packaging of the Silo 3 material was completed during 2004. Due to uncertainty in the availability of off-site disposal capacity, the facilities were maintained in a state of readiness to allow prompt start-up, when required, through the end of 2004. Efforts to secure disposal capacity at the Nevada Test Site or an appropriately permitted commercial facility, and allow start-up of the Silo 3 remediation facility, were ongoing through the end of 2004.

2.1.4 Aquifer Restoration/Wastewater Project

The Aquifer Restoration/Wastewater Project (Operable Unit 5) is responsible for the restoration of water quality in the affected portions of the Great Miami Aquifer, and for treating the site's extracted groundwater, storm water, sanitary wastewater, and remediation wastewater. These activities include the design, construction, operation, monitoring of, and reporting on the groundwater restoration and wastewater treatment systems at the Fernald site. This project is also responsible for managing the on-site disposal facility's leak detection monitoring program, as well as operation, maintenance, and monitoring of the leachate transmission system.

In May, EPA and OEPA approved the decision to reduce the size of the advanced wastewater treatment facility (AWWT); in June, they approved the decision to discontinue the use of well-base re-injection. Through September 24, 2004, the Aquifer Restoration/Wastewater Project continued to operate the South Plume Module (including the South Plume Optimization Module), the South Field Module, the Waste Storage Area Module, and the Re-injection Module. On September 25, 2004, well field operations were reduced to facilitate modifications to the water treatment system and re-injection operations were ceased. (Instead of restarting well-based re-injection after completion of the modifications to the water treatment system, other operational strategies to enhance the aquifer remedy will be explored, such as inducing infiltration to the Great Miami Aquifer through the Storm Sewer Outfall Ditch.) All extraction wells in the Waste Storage Area Module were shut down and pumping rates for the remaining operating modules (South Plume and South Field) were reduced. When increased water treatment capacity is available in 2005, it is expected that pumping rates from the various modules will increase.

In 2004, a total of 2,446 million gallons (9,258 million liters) of groundwater were extracted from the Great Miami Aquifer, 922 net pounds (419 kg) of uranium were removed from the aquifer, and 330 million gallons (1,249 million liters) of water were re-injected into the aquifer. Chapter 3 discusses groundwater monitoring.

During 2004, Phases I and II of the advanced wastewater treatment facility and the interim advanced wastewater treatment facility provided treatment of contaminated storm water, wastewater, and groundwater. The advanced wastewater treatment facility (Phase III) and the South Plume interim treatment facility were dedicated to treatment of contaminated groundwater associated with groundwater remediation. With site closure in 2006, several water treatment flows (remediation wastewater, sanitary wastewater, and storm water runoff) will be eliminated or reduced. Elimination or reduction of these flows provides an opportunity to reduce the size of the advanced wastewater treatment facility that will remain to service the aquifer restoration after site closure. Reducing the size of the treatment facility prior to site closure in 2006 will reduce the amount of impacted materials that may need future off-site disposal. On September 25, 2004 construction to downsize the advanced wastewater treatment facility began. It is anticipated that the new converted advanced wastewater treatment facility will be operational in early 2005.

Converted advanced wastewater treatment facility (CAWWT).

2.2 Summary of Compliance with Other Requirements

CERCLA requires compliance with other laws and regulations as part of remediation of the Fernald site. These other requirements are referred to as applicable or relevant and appropriate requirements (ARARs). ARARs that are pertinent to remediation of the site are specified in the record of decision for each operable unit. This section highlights some of the major requirements related to environmental monitoring and waste management, and how the FCP complied with these requirements in 2004.

The regulations discussed in this section have been identified as ARARs within the records of decision. The FCP must comply with these regulations while site remediation under CERCLA is underway; EPA and OEPA enforce compliance. Some of these requirements include permits for controlled releases, which are also discussed in this section.

2.2.1 Resource Conservation and Recovery Act (RCRA)

RCRA as amended regulates treatment, storage, and disposal of hazardous waste and the hazardous part of mixed waste (mixed waste contains both radioactive and hazardous waste components). Hazardous and mixed waste now generated at the site results from such activities as CERCLA remedial actions and maintenance activities. The Fernald site also has an inventory of mixed waste generated from former production activities. These wastes are regulated under RCRA and Ohio hazardous waste management regulations; therefore, the site must comply with legal requirements for managing hazardous and mixed wastes. OEPA has been authorized by EPA to enforce its hazardous waste management regulations in lieu of the federal RCRA program. In addition, hazardous waste management is subject to the 1988 Consent Decree and the 1993 Stipulated Amendment between the State of Ohio and DOE, as well as a series of Director's Final Findings and Orders issued by OEPA.

The FCP completed several administrative activities related to mixed waste storage and treatment during 2004, including:

- Submittal of the 2003 RCRA Annual Report (DOE 2004d), which describes hazardous waste activities for 2003.
- Submittal of the Fiscal Year 2004 Annual Update to the Site Treatment Plan (DOE 2004b) as required in the 1992 Federal Facility Compliance Act and the implementing Director's Findings and Orders issued by OEPA in October 1995.
- Submittal of several revisions to the RCRA Part B Permit Application

Additional details on projects involving treatment of mixed wastes are provided in subsection 2.2.1.4, Mixed Waste Treatment.

Based on a compliance inspection conducted by OEPA on November 18, 2004, OEPA found DOE to be in violation of OAC 3745-52-11 for failure to characterize certain wastes. OEPA issued a Notice of Violation on January 13, 2005. The rule states that any person who generated a waste, as defined in the Ohio Administrative Code, must determine if that waste is hazardous waste. There were approximately 30 containers of waste that had not been properly characterized. DOE has completed the required characterizations by OEPA as of March 31, 2005. No further enforcement action is expected.

2.2.1.1 RCRA Property Boundary Groundwater Monitoring

The Director's Findings and Orders, which were signed September 10, 1993, described an alternate groundwater monitoring system. A revision of this document was approved on September 7, 2000 to align with the groundwater monitoring strategy identified in the IEMP. The Property Boundary Groundwater Monitoring program is discussed in Chapter 3.

2.2.1.2 RCRA Closures

The 1993 Stipulated Amendment to Consent Decree required that DOE identify all hazardous waste management units at the site. As a result, burners, incinerators, furnaces, stills, process equipment, tank units, dust collectors, and other potential waste containment units were evaluated in the early 1990s to determine if they were hazardous waste management units or solid waste management units. This evaluation was completed in 1994. In 1996, OEPA issued Director's Findings and Orders to integrate RCRA closure requirements with CERCLA response actions for FCP hazardous waste management units. In 2004, the FCP initiated or completed the remediation of nine units: Pilot Plant Warehouse (Building 68), Nitric Acid Recovery System, Box Furnace, Oxidation Furnace #1, Plant 8 Warehouse (Building 80), Plant 8 Warehouse (Building 80), Fire Training Facility, Plant 1 Pad, and the Plant 6 Warehouse (Building 79).

2.2.1.3 Thorium Management

A thorium management strategy to improve the storage of thorium materials at the Fernald site, and a schedule to complete RCRA determinations of thorium materials, were developed as part of the Stipulated Amendment to the Consent Decree signed in 1991. This strategy is based on three primary objectives:

- To maintain environmentally stable interim storage of the thorium inventory while minimizing personnel radiation exposure.
- To implement actions required in order to complete RCRA evaluations of the thorium materials.
- To implement long-term storage and disposal alternatives.

The Thorium Overpacking Project was completed in 1997. It was under this project that the FCP removed 3,400 containers of thorium material and shipped 10,875 drum-equivalents (or 80,480 cubic feet (ft^3) [2,279 m^3]) of thorium material to the Nevada Test Site for disposal. The characterization documentation and formal RCRA waste determinations for the remaining estimated 8,500 containers of thorium legacy waste resumed in 1999.

In 2004, the FCP shipped 4,274 pounds (1,940 kg) of mixed thorium waste to Envirocare of Utah, Inc. for treatment and disposal, and 21,192 pounds (9,621 kg) of non-hazardous thorium waste to the Nevada Test Site for disposal. At the end of 2004, there were only a few containers of thorium waste remaining on site.

2.2.1.4 Mixed Waste Treatment

The FCP stores mixed wastes that are subject to RCRA land disposal restrictions. These restrictions currently prohibit the storage of certain hazardous waste streams for longer than one year, unless OEPA approves an extension.

The 1992 amendment to RCRA, the Federal Facilities Compliance Agreement (FFCA), provided DOE with an exemption from enforcement under the land disposal restrictions storage prohibition as long as DOE sites complied with the plans and schedules for mixed waste treatment. This is identified in the Site Treatment Plan, and the implementing Director's Findings and Orders issued by OEPA on October 4, 1995. The FCP submitted the first Site Treatment Plan Annual Update to OEPA in December 1996. These updates are due by December 31 of each year. Since then, eight additional annual updates have been submitted. The annual update describes the status of mixed waste treatment projects developed under the Site Treatment Plan. It also adds newly generated and newly identified mixed waste streams, and certifies that the FCP met all regulatory milestone dates for the treatment of mixed wastes identified in the plan and in the implementing Director's Findings and Orders.

In 2004, 336,049 pounds of mixed waste were shipped off site for treatment and/or disposal, or treated on site. These include the following waste streams:

- 82,985 pounds of liquid mixed waste was shipped to the K-25 Toxic Substances Control Act Incinerator in Oak Ridge, Tennessee for treatment.
- 2,631 pounds of treatability study residues were shipped to Waste Control Specialists in Andrews, Texas for treatment.
- 248,199 pounds of soil, sludge, debris, and other materials were shipped to Envirocare of Utah, Inc. for treatment and/or disposal.
- 2,314 pounds of liquid aqueous mixed wastes meeting NPDES Permit requirements were treated at the advanced wastewater treatment facility.

2.2.2 Clean Water Act

Under the Clean Water Act as amended, the FCP is governed by NPDES regulations that require the control of discharges of non-radiological pollutants to waters of the State of Ohio. The NPDES Permit, issued by the State of Ohio, specifies discharge and sample locations, sampling and reporting schedules, and discharge limitations. The FCP submits monthly reports on NPDES activities to OEPA. The Fernald site's current NPDES Permit, Permit No. 1IO00004*GD, became effective on July 1, 2003. Chapter 4 discusses the surface water and treated effluent information in detail.

2.2.3 Clean Air Act

NESHAP Subpart H imposes a limit of 10 millirem (mrem) per year on the effective dose equivalent to the maximally exposed individual as a result of all air emissions (with the exception of radon) from the facility in a single year. For 2004 the FCP was in compliance with the NESHAP dose limit as determined by ambient air monitoring at the site's fenceline boundary.

EPA regulates the Fernald site's radionuclide emission sources through NESHAP; OEPA has authority to enforce the State of Ohio's air standards including particulate, chemical, and toxic emission sources. In 2004, the FCP complied with all emissions standards, as discussed in Chapter 5. The NESHAP Annual Report for 2004 is included as Appendix D of this report.

Several remediation activities, including the waste pits remediation, decontamination and dismantling, soil excavation, and on-site disposal facility construction and waste placement, may result in the generation of fugitive dust, which is also regulated by OEPA. Compliance is accomplished by

implementing the Fugitive Dust Control Policy negotiated between DOE and OEPA in 1997. This policy is implemented in the Best Available Technology Determination for Remedial Construction Activities on the Fernald Environmental Management Project (DOE 1997b), the requirements of which are incorporated into each operable unit's remedial design and remedial action deliverables. The policy allows for visual observation of fugitive dust and implementation of dust control measures to determine compliance during remediation activities.

2.2.4 Superfund Amendments and Reauthorization Act of 1986

The Superfund Amendments and Reauthorization Act of 1986 (SARA) amended CERCLA and was enacted, in part, to clarify and expand CERCLA "Superfund" requirements. SARA Title III is also known as the Emergency Planning and Community Right-to-Know Act.

The SARA Title III, Section 312, Emergency and Hazardous Chemical Inventory Report for 2004 was submitted to OEPA, to the Local Emergency Planning Committees of Hamilton and Butler Counties, and to the Crosby Township Fire Department prior to the March 1, 2005 deadline. This report lists the amounts and locations of hazardous chemicals and substances stored or used in amounts greater than the minimum reporting threshold (generally 10,000 pounds for "hazardous chemicals," and 500 pounds for "extremely hazardous substances") at any time during the previous year. For 2004, several chemicals which had been reported in previous years, no longer exceeded reportable thresholds due to their use or disposition through transfers to other DOE sites, sales, or shipment off site for treatment and disposal. However, several chemicals increased above reportable thresholds due to their procurement for use in remediation operations, in particular the Silos 1 and 2 waste treatment project and the Silo 3 waste stabilization project.

Another SARA Title III report, the Section 313 Toxic Chemical Release Inventory Report (Form R), is required if the Fernald site exceeds an applicable threshold for any SARA 313 chemical. If required, the Toxic Chemical Release Inventory Report lists routine and accidental releases, as well as information about the activities, uses, and waste for each reported toxic chemical. No chemicals have exceeded the threshold for several years. An evaluation to determine if any chemicals used at the FCP during 2004 exceeded reporting thresholds will be completed and will be reported, if required, to EPA and OEPA prior to the July 1, 2005 compliance date.

Also under SARA Title III, any off-site release meeting or exceeding a reportable quantity as defined by SARA Title III, Section 304, requires that immediate notifications be made to local emergency planning committees and the state emergency response commission. Notifications are also made to the National Response Center and other appropriate federal, state, and local regulatory entities. All releases occurring at the Fernald site are evaluated and documented to ensure that proper notifications are made in accordance with SARA, and under CERCLA Section 103, RCRA, the Toxic Substances Control Act, the Clean Air Act, the Clean Water Act, and Ohio environmental laws and regulations.

In 2004, there was only one release at the Fernald site that met the reporting criteria under CERCLA. This was a release of fewer than 25 pounds of mixed waste from a 55-gallon drum inside a trailer parked on the site. The material did not reach off site; thus, it was not reportable under SARA Title III. Notification was made only to the National Response Center because it was a CERCLA, not a SARA, release. Other informational notifications (such as to the OEPA Southwest District Office, Division of Hazardous Waste Management) were made as deemed appropriate.

2.2.5 Other Environmental Regulations

The FCP is also required to comply with other environmental laws and regulations in addition to those described above. Table 2-2 summarizes compliance with each of these requirements for 2004.

2.2.6 Other Permits

Permits are the means by which certain environmental laws are implemented. The FCP has permits for controlled releases to surface water. The FCP's permit for discharging water under NPDES regulations is discussed in subsection 2.2.2, Clean Water Act. The only remaining facilities for which Permits to Install were obtained include the Storm Water Retention Basin and Bio-Surge Lagoon. Permits to Install govern the installation (and to a lesser degree, the operation) of specific wastewater treatment and control devices.

All sources previously covered by air Permits to Operate or Install have either been eliminated or are being addressed through the CERCLA remediation process. Due to this, the FCP has withdrawn all active air Permits to Operate. Therefore, the site no longer has any air permits associated with its operations.

TABLE 2-2
COMPLIANCE WITH OTHER ENVIRONMENTAL REGULATIONS

Regulation and Purpose	Background Compliance Issues	2004 Compliance Activities
Toxic Substances Control Act (TSCA)		
Regulates the manufacturing, use, storage, and disposal of toxic materials, including polychlorinated biphenyl (PCBs) and PCB items.	The last routine TSCA inspection of the FCP's program was conducted by EPA Region V on September 21, 1994. No violations of PCB regulations were identified during the inspection.	Non-radiologically contaminated PCBs and PCB items are shipped to TSCA-approved commercial disposal facilities for incineration on an as-needed basis. Radiologically contaminated PCB liquids were shipped to the TSCA-permitted DOE incinerator in Oak Ridge, Tennessee. Radiologically contaminated PCB solids were shipped off site for treatment by a commercial facility.
Ohio Solid Waste Act		
Regulates infectious waste.	The Fernald site was registered with OEPA as a generator of infectious waste (generating more than 50 pounds [23 kg] per month) until December 6, 1999, when OEPA concurred with the Fernald site's qualification as a small quantity generator.	All infectious wastes generated in the medical department were transported to a licensed treatment facility for incineration.
Federal Insecticide, Fungicide, and Rodenticide Act		
Regulates the registration, storage, labeling, and use of pesticides (such as insecticides, herbicides, and rodenticides).	The last inspection of the Federal Insecticide, Fungicide, and Rodenticide Act program conducted by EPA Region V on September 21, 1994, found the Fernald site to be in full compliance with the requirements mandated by Federal Insecticide, Fungicide, and Rodenticide Act.	Pesticide applications at the Fernald site were conducted according to federal and state regulatory requirements.
National Environmental Policy Act (NEPA)		
Requires the evaluation of environmental, socio-economic, and cultural impacts before any action, such as a construction or cleanup project, is initiated by a federal agency.	An environmental assessment for proposed final land use was issued for public review in 1998. It was prepared under DOE's guidelines for implementation of NEPA, 10 CFR 1021. The assessment requires consulting the public before any decisions on land use are made; it includes previous DOE commitments.	No NEPA activities were required in 2004.
Endangered Species Act		
Requires the protection of any threatened or endangered species found at the site as well as any critical habitat that is essential for the species' existence.	Ecological surveys conducted by Miami University and DOE, in consultation with the Ohio Department of Natural Resources, and the U.S. Fish and Wildlife Service, have established the following list of threatened and endangered species and their habitats existing on site: Cave salamander, state-listed endangered — marginal habitat, none found; Sloan's crayfish, state-listed threatened — found on northern sections of Paddys Run; Indiana brown bat, federally listed endangered — found in riparian areas along Paddys Run.	No endangered species surveys were conducted in 2004. Turbidity observations for the protection of Sloan's crayfish in Paddys Run were conducted until June 2004. No instances of increased sediment loading were observed. Turbidity observations ceased once grading activities for the Wetland Mitigation Project (Phase II) were completed.

TABLE 2-2
(Continued)

Regulation and Purpose	Background Compliance Issues	2004 Compliance Activities
Floodplains/Wetlands Review Requirements		
DOE regulations require a floodplain/wetland assessment for DOE construction and improvement projects.	A wetlands delineation of the FCP, completed in 1992 and approved by the U.S. Army Corps of Engineers in August 1993, identified 36 acres (15 hectares) of freshwater wetland on the Fernald site property. Updated delineations are conducted approximately every five years.	No assessments were performed in 2004.
National Historic Preservation Act		
Establishes a program for the protection, maintenance, and stewardship of federal prehistoric and historic properties.	The FCP is located in an area of sensitive historic and prehistoric cultural resources that are eligible for or on the National Register of Historic Places. These cultural resources include historic structures, buildings, and bridges, plus Native American villages and campsites.	No cultural resource surveys were necessary in 2004. Monitoring for unexpected discoveries was conducted during the Abandoned Outfall Line Project.
Native American Graves Protection and Repatriation Act		
Establishes a means for Native American Indians to request the return or "repatriation" of human remains and other cultural items. Federal agencies must return human remains, associated funerary objects, sacred objects, and objects of cultural patrimony to the Indian Nations or Tribes with cultural affiliation to the remains or material.	Native American Indian remains have been discovered during remediation activities at the FCP. Native American Indian remains and artifacts have been removed or left in place, with consultation from Native American Indian Nations, Tribes, and Groups.	No Native American remains were discovered or repatriated to Native American Indian Nations, Tribes, or Groups in 2004. As stated above, monitoring for unexpected discoveries was conducted during the Abandoned Outfall Line Project.
Natural Resource Requirements Under CERCLA and Executive Order 12580		
Requires DOE to act as a Trustee (i.e., guardian) for natural resources at its federal facilities.	DOE and the other Trustees, which include the U.S. Department of the Interior, the U.S. Fish and Wildlife Service, OEPA, the Ohio Attorney General's Office, and EPA, meet regularly to discuss potential impact to natural resources and to coordinate Trustee activities. The Trustees also interact with the Fernald Citizens Advisory Board and Community Reuse Organization.	In 2004, the Trustees and DOE continued to pursue settlement of the 1986 Natural Resource injury claim at Fernald. While the components of restoration have been established through a 2001 Memorandum of Understanding (DOE 2001c) and restoration of the site continues, the Trustees and DOE continue to negotiate issues such as maintenance and monitoring at the Fernald site.

2.2.7 Pollution Prevention and Source Reduction

The FCP is actively involved in an effort to reduce solid, hazardous, radioactive, and mixed-waste generation, and eliminate or minimize pollutant releases to all environmental media during site remediation. As part of the Annual Waste Reduction Report under DOE Order 5400.1 (DOE 1990), the FCP submitted the site's summary of waste generated and pollution prevention progress (DOE 2004a), which is available from the DOE's pollution prevention web site (http://www.eh.doe.gov/p2). This report includes 2004 data on waste quantities generated and avoided, as well as narrative text describing pollution prevention and waste minimization efforts and their effectiveness.

Various waste streams were recycled during 2004, including corrugated cardboard (approximately 62 tons [56 metric tons]), toner cartridges (approximately 0.19 tons [.17 metric tons]), scrap tires (approximately 1.8 tons [1.6 metric tons]), and scrap metal (approximately 384 tons [348 metric tons]). Additionally, the following approximate amounts of hazardous wastes were shipped to approved recycle centers or treatment facilities in 2004:

- 42,736 pounds (19,402 kg) of lead acid batteries for recycle
- 1,350 pounds (613 kg) of nickel-cadmium batteries for recycle
- 47,275 pounds (21,463 kg) of used oil for recycle
- 4,600 pounds (2,088 kg) of electrical waste (fluorescent light tubes) for recycle
- 335 pounds (152 kg) of photochemicals for silver recovery.

The FCP's affirmative procurement program involves source reduction and the use of EPA-designated materials to increase the market for recovered materials. In accordance with Executive Order 13101, Greening of the Government Through Waste Prevention, Recycling and Federal Acquisition, the FCP generates an annual report demonstrating compliance with this order.

2.2.8 Site-Specific Regulatory Agreements

2.2.8.1 Federal Facility Compliance Agreement

In July 1986, DOE entered into an FFCA with EPA, which requires the FCP to:

- Maintain a continuous sample collection program for radiological constituents at the treated effluent discharge points and report the results semi-annually to EPA, OEPA, and the Ohio Department of Health. The sampling program to address this requirement has been modified over the years and is currently governed by an agreement reached with EPA and OEPA that became effective May 1, 1996. This agreement requires sampling at the Parshall Flume (PF 4001), the point where treated effluent leaves the FCP, and the Storm Water Retention Basin spillway for radiological constituents. These data are reported through mid-year and annual reports (refer to Appendix B of this report) under the IEMP.

- Maintain a sampling program for daily flow and total uranium at the South Plume extraction wells and report the results semi-annually to the EPA, OEPA, and Ohio Department of Health. The sampling program conducted to address this requirement has also been modified over the years and is currently governed by the agreement reached with EPA and OEPA on May 1, 1996.

2.2.8.2 Federal Facility Agreement, Control, and Abatement of Radon-222 Emissions

The Federal Facility Agreement (FFA) between DOE and EPA, signed in November of 1991, ensures that DOE takes all necessary actions to control and abate radon-222 emissions at the Fernald site, under the authority of 40 CFR 61, Subpart Q. This agreement acknowledges that Silos 1 and 2 exceed the radon flux rate of 20 picoCuries per square meter per second (pCi/m^2/sec). But it allowed the FCP to address this exceedance by implementing a removal action (installation of a bentonite cap in 1991) to bring radon emissions from the silos to a level as low as reasonably achievable (ALARA), and to attain the NESHAP Subpart Q standard upon completion of final remediation. The FFA also requires demonstration of compliance with the Subpart Q standard upon completion of remedial actions for the waste pits, clearwell, and any other sources found to contain radium-226 in sufficient concentrations to emit radon in excess of 20 pCi/m^2/sec. Chapter 5 further discusses the results of the Radon Monitoring Program for 2004.

2.2.9 Environmental Management Systems Requirement

DOE has required that sites develop and implement Environmental Management Systems (EMS) as a means of systematically planning, implementing, evaluating, and improving processes and actions undertaken to achieve environmental goals. This requirement is specified in DOE Order 450.1, Environmental Protection Program (DOE 2005b), which directs that sites implement an EMS by December 2005. As a CERCLA remediation site, the Fernald site has progressed through, or is in the process of implementing, similar steps of investigation, risk evaluation, remedy selection, planning, execution, and evaluation. During 2004, the site conducted a cross-reference comparison of the elements of the EMS approach versus the systematic method of addressing environmental issues identified under the CERCLA-driven approach. The comparison demonstrated that the substantive elements of an EMS are satisfied through implementation of the CERCLA program at the Fernald site. In addition, the site's Integrated Safety Management System integrates environmental management into the overarching safety program in place at the site. The FCP's Safety Management System Description (DOE 2005c) defines "safety" as including all aspects of environmental, safety, and health including pollution prevention and waste minimization. Recognizing the remediation of the Fernald site through existing programs and processes as defined in the closure contract and CERCLA remediation documentation, the DOE Ohio Field Office has acknowledged that the site meets the intent of DOE Order 450.1 and no modification of the contract was required to incorporate the Order after its issue.

2.3 Split Sampling Program

Since 1987, DOE has participated in the split sampling program with the state. Split samples are obtained when technicians alternately add portions of a sample to two individual sample containers. This collection method helps ensure that both samples are as identical as possible. The split samples are then submitted to two different analytical laboratories; this allows for an independent comparison of data to ascertain laboratory analysis and field quality assurance. In addition to split sampling, OEPA performs some independent sampling. Results are provided in OEPA's Annual Report to the Public on the Fernald Closure Project.

In 2004, DOE and OEPA cooperated in the split sampling program. This time, samples of groundwater were split. The split sample locations for groundwater are shown in Figure 2-2. The results are provided in Table 2-3. The data from the split sampling program show reasonable agreement between DOE and OEPA results for groundwater.

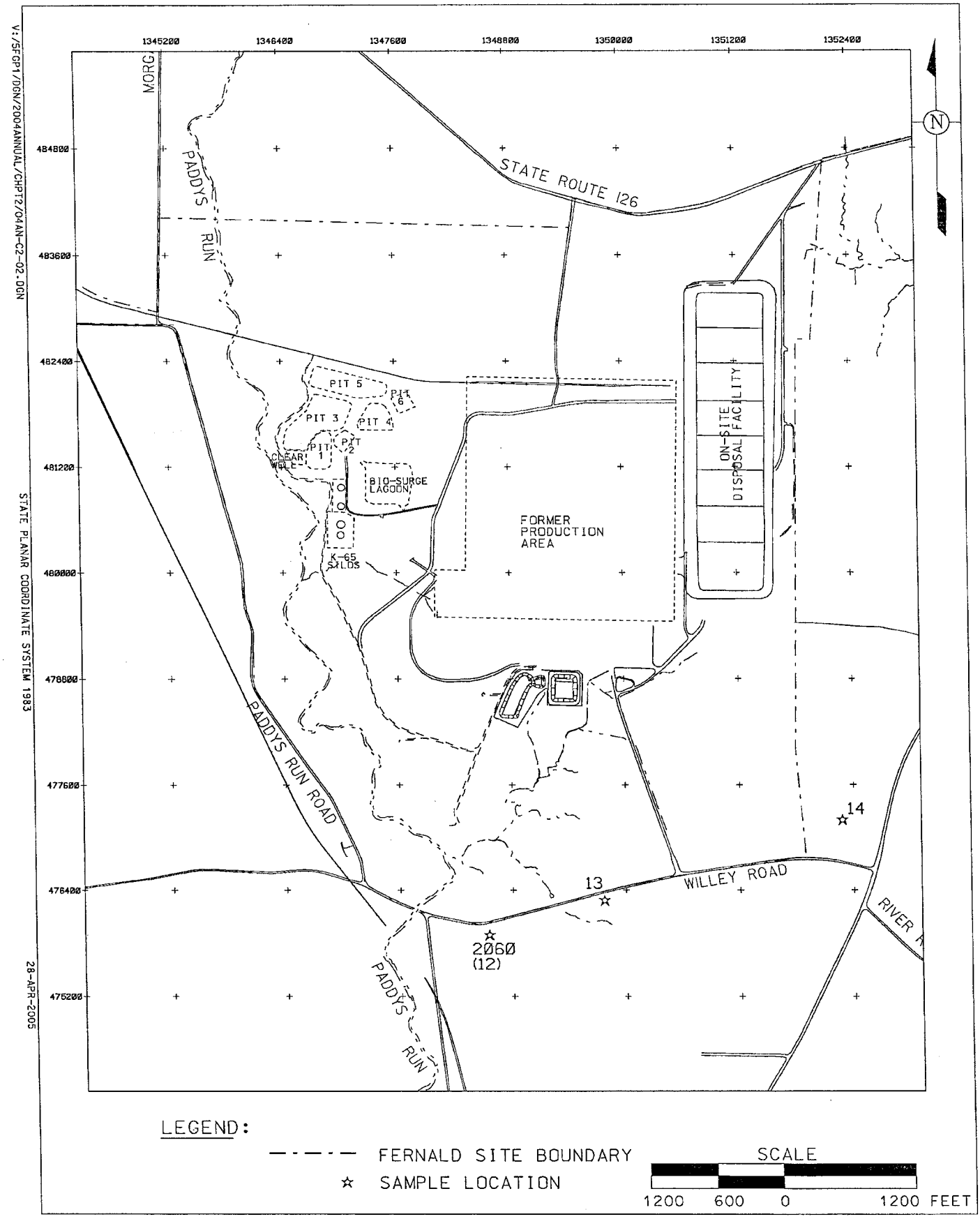


Figure 2-2. 2004 DOE and OEPA Groundwater Split Sample Locations

TABLE 2-3
2004 DOE/OEPA SPLIT SAMPLING COMPARISON

Media	Sample Location	Sample Date	Constituent	DOE Result	OEPA Result	FRL
Groundwater[a]				(µg/L)	(µg/L)	(µg/L)
	2060 (12)	April	Total Uranium	63.5	63.1	30
	2060 (12)	October	Total Uranium	68	78.6	30
	13	April	Total Uranium	16.8	16.4	30
	13	October	Total Uranium	12.7	16.3	30
	14	April	Total Uranium	3.24	3.17	30
	14	October	Total Uranium	3.59	4.28	30

[a]Refer to Figure 2-2 for groundwater split sample locations.

3.0 Groundwater Pathway

Results in Brief: 2004 Groundwater Pathway

Groundwater Remedy – At the start of 2004, active restoration of the Great Miami Aquifer continued at the following five groundwater restoration modules:

- South Plume Module, which became operational on August 27, 1993
- South Field Extraction (Phase I) Module, which became operational on July 13, 1998
- South Plume Optimization Module, which became operational on August 9, 1998
- Re-injection Module, which became operational on September 2, 1998
- Waste Storage Area Module, which became operational on May 8, 2002.

The decision was made to convert the advanced wastewater treatment facility (AWWT) into a smaller facility that would remain after site closure in 2006. Construction to convert the facility began in the fall of 2004. Periodic well field operational disruptions occurred during the construction period. Start-up of the converted advanced wastewater treatment facility (CAWWT) is scheduled for spring 2005.

Well-based groundwater re-injection was permanently shut down at the end of September 2004; the remaining two extraction wells in the Waste Storage Area Module were shut down for preventative maintenance, and to support construction of the CAWWT. Based on updated groundwater modeling and the results of the cost/benefit analysis, the decision was made in 2004 to discontinue well-based re-injection. Operations in 2005 will proceed without well-based re-injection. Other operational strategies to enhance the aquifer remedy will be explored (e.g., inducing recharge to the Great Miami Aquifer through the Storm Sewer Outfall Ditch). After Storm Water Outfall Ditch testing is completed, the groundwater remedy design will be modified to incorporate lessons learned.

Since 1993

- 16,686 million gallons (63,157 million liters) of water have been pumped from the Great Miami Aquifer
- 1,936 million gallons (7,328 million liters) of water have been re-injected into the Great Miami Aquifer
- 6,522 net pounds (2,961 kg) of uranium have been removed from the Great Miami Aquifer.

During 2004

- 2,446 million gallons (9,258 million liters) of water were pumped from the Great Miami Aquifer
- 330 million gallons (1,249 million liters) of water were re-injected into the Great Miami Aquifer
- 922 net pounds (419 kg) of total uranium were removed from the Great Miami Aquifer.

Groundwater Monitoring Results – Uranium concentrations within the footprint of the maximum uranium plume continue to decrease in response to pumping.

- Groundwater sampling in the Plant 6 area following the completion of surface excavation activities indicates that no additional groundwater recovery infrastructure needs to be installed in the area prior to site closure in 2006.
- Characterization work began in the waste storage area for the last remaining module design, the Waste Storage Area (Phase II) Design. A decision concerning the need for additional extraction wells in this area is scheduled for 2005. Installation of any additional extraction wells is scheduled for completion prior to site closure in 2006.

On-site Disposal Facility Monitoring – Leak detection monitoring continued in 2004 for Cells 1 through 6 and was initiated for Cells 7 and 8. For those constituents monitored to meet on-site disposal facility requirements, there were no exceedances of groundwater FRLs for either the horizontal till wells or the Great Miami Aquifer wells. Data collected from the cells indicate that the liner systems are performing well within the specifications outlined in the approved cell design.

This chapter provides background information on the nature and extent of groundwater contamination in the Great Miami Aquifer due to past operations at the Fernald site and summarizes:

- Aquifer restoration progress
- Groundwater monitoring activities and results for 2004.

Restoration of the affected portions of the Great Miami Aquifer and continued protection of the groundwater pathway are primary considerations in the accelerated remediation strategy for the Fernald site. The FCP will continue to monitor the groundwater pathway throughout remediation to ensure the protection of this primary exposure pathway.

3.1 Summary of the Nature and Extent of Groundwater Contamination

Groundwater Modeling at the Fernald Site

The Fernald site uses a computer model to make predictions about how the contaminants in the aquifer will look in the future. Because the model contains simplifying assumptions about the aquifer and the contaminants, the predictions about future behavior must be verified with field measurements obtained from groundwater monitoring activities.

If groundwater monitoring data indicate the need for operational changes to the groundwater remedy, the groundwater model is run to predict the effect those changes might have on the aquifer and the contaminants. If the predictions indicate the proposed changes would increase cleanup efficiency and reduce the cleanup time and cost, the operational changes are made and monitoring data are collected after the changes to verify whether model predictions were correct. If model predictions prove to be incorrect, modifications are made to the model to improve its predictive capabilities.

The nature and extent of groundwater contamination from operations at the Fernald site have been investigated, and the risk to human health and the environment from those contaminants has been evaluated in the Operable Unit 5 Remedial Investigation Report (DOE 1995d). As documented in that report, the primary groundwater contaminant at the site is uranium.

Groundwater contamination resulted from infiltration of contaminated surface water through the bed of Paddys Run, the Storm Sewer Outfall Ditch, and the Pilot Plant Drainage Ditch. In these areas, the glacial overburden is

eroded, creating a direct pathway between surface water and the sand and gravel of the aquifer. To a lesser degree, groundwater contamination also resulted where past excavations (such as the waste pits) removed some of the protective clay contained in the glacial overburden and exposed the aquifer to contamination.

3.2 Selection and Design of the Groundwater Remedy

While a remedial investigation and feasibility study was in progress, and a groundwater remedy was being selected, off-property contaminated groundwater was being pumped from the South Plume area by the South Plume Removal Action System (referred to as the South Plume Module). In 1993, this system was installed south of Willey Road and east of Paddys Run Road to stop the uranium plume in this area from migrating any farther to the south. Figure 3-1 shows the South Plume Module Extraction Wells 3924, 3925, 3926, and 3927. These extraction wells have successfully stopped further southern migration of the uranium plume beyond the wells and have contributed to significantly reducing total uranium concentrations in the off-property portion of the plume.

After the nature and extent of groundwater contamination were defined in the Operable Unit 5 Remedial Investigation Report, various remediation technologies were evaluated in the Feasibility Study Report for Operable Unit 5 (DOE 1995a). Remediation cost, efficiency, and various land-use scenarios were considered during the development of the preferred remedy for restoring the quality of the groundwater in the aquifer. The Operable Unit 5 Feasibility Study Report recommended a concentration-based, pump-and-treat remedy for the groundwater contaminated with uranium, consisting of 28 groundwater extraction wells located on and off property. Computer modeling suggested that the 28 extraction wells pumping at a combined rate of 4,000 gallons per minute (gpm) (15,140 liters per minute [Lpm]) would remediate the aquifer within 27 years.

The recommended groundwater remedy was presented to EPA, OEPA, and stakeholders in the Proposed Plan for Operable Unit 5 as the Preferred Groundwater Remedy (DOE 1995c). Once the Proposed Plan was approved, the Operable Unit 5 Record of Decision was presented to stakeholders and subsequently approved by EPA and OEPA in January 1996. The Operable Unit 5 Record of Decision (DOE 1996) formally defines the selected groundwater remedy and establishes FRLs for all constituents of concern.

Re-injection at the Fernald Site

From 1998 to 2004, re-injection was an enhancement to the groundwater remedy at the Fernald site, supplementing pump-and-treat operations. The term "well-based" refers to the injection of treated water through specially designed re-injection wells. Groundwater pumped from the aquifer is treated to remove contaminants and then re-injected into the aquifer at strategic well locations. Because the treatment process is not 100 percent efficient, a small amount of uranium is re-injected into the aquifer with the treated water. The re-injected groundwater increases the speed at which dissolved contaminants move through the aquifer and are pulled by extraction wells, thereby decreasing the overall remediation time. Based on updated groundwater modeling and the results of a cost/benefit analysis, re-injection was permanently shut down in 2004.

The Operable Unit 5 Record of Decision commits to an ongoing evaluation of innovative remediation technologies so that remedy performance can be improved as such technologies become available. As a result of this commitment, an enhanced groundwater remedy was presented in the Operable Unit 5 Baseline Remedial Strategy Report, Remedial Design for Aquifer Restoration (Task 1) (DOE 1997a). Groundwater modeling studies conducted in order to design the enhanced groundwater remedy suggested that, with the early installation of additional extraction wells and the use of re-injection technology, the remedy could potentially be reduced to 10 years. EPA and OEPA approved the enhanced groundwater remedy that relies on pump-and-treat and re-injection technology. As discussed below, the enhanced groundwater remedy is being used to clean up the Great Miami Aquifer. The enhanced groundwater remedy included the use of well-based re-injection up until September 2004.

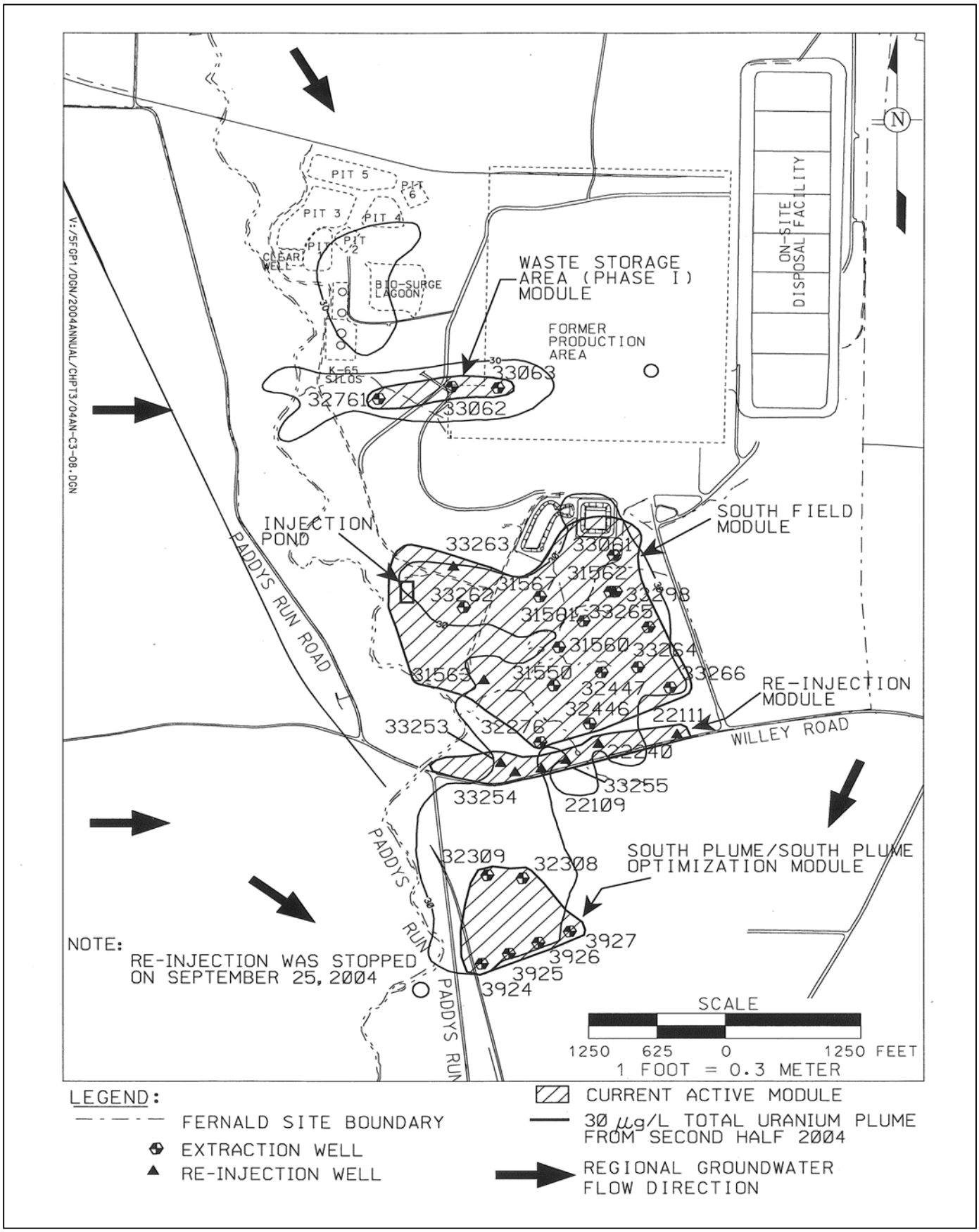


Figure 3-1. Extraction and Re-injection Wells Active in 2004

Evolution of the enhanced groundwater remedy has been documented through a series of approved designs. They are: The Operable Unit 5 Baseline Remedial Strategy Report, Remedial Design for Aquifer Restoration (Task 1), Design for Remediation of the Great Miami Aquifer in the Waste Storage and Plant 6 Areas (DOE 2001a), Design for Remediation of the Great Miami Aquifer South Field (Phase II) Module (DOE 2002a), Comprehensive Groundwater Strategy Report (DOE 2003a), and the Groundwater Remedy Evaluation and Field Verification Plan (DOE 2004c).

The enhanced groundwater remedy commenced in 1998 with the start-up of the South Field (Phase I), South Plume Optimization, and Re-injection Demonstration Modules. It focuses primarily on the removal of uranium, but has also been designed to limit the further expansion of the plume, achieve removal of all targeted contaminants to concentrations below designated FRLs, and prevent undesirable groundwater drawdown impacts beyond the site's boundary. Start-up of the enhanced groundwater remedy included a year-long re-injection demonstration that was initiated in September 1998. Through the years, additional extraction and re-injection wells have been added to these initial restoration modules.

In 2001, the EPA and OEPA approved the Design for Remediation of the Great Miami Aquifer in the Waste Storage and Plant 6 Areas. Approval of this design initiated the installation of the next planned aquifer restoration module. The design specified three extraction wells in the waste storage area to address contamination in the Pilot Plant Drainage Ditch plume (Phase I), and two extraction wells to address the remaining contamination after the waste pit excavation is completed (Phase II). One of the three Phase I waste storage area wells was installed in 2000 to support an aquifer pumping test to help determine the restoration well field design. The remaining two Phase I wells were installed in the summer of 2001 after the design was approved by EPA and OEPA. All three wells became operational on May 8, 2002. One was abandoned in 2004 in order to facilitate surface excavation work. A replacement well is scheduled for installation in 2005.

The Design for Remediation of the Great Miami Aquifer in the Waste Storage and Plant 6 Areas also provided data indicating that the uranium plume in the Plant 6 area was no longer present. It was believed that the uranium plume had dissipated to concentrations below the FRL as a result of the shut-down of plant operations in the late 1980s and the pumping of highly contaminated perched water as part of the Perched Water Removal Action #1 in the early 1990s. Because a uranium plume with concentrations above the groundwater FRL was no longer present in the Plant 6 area at the time of the design, a restoration module for the area was determined to be unnecessary. Groundwater monitoring continued in the Plant 6 area with one well in the area having sporadic total uranium FRL exceedances.

In 2002, the EPA and OEPA approved the next planned groundwater restoration design document, the Design for Remediation of the Great Miami Aquifer South Field (Phase II) Module. The Phase II design presents an updated interpretation of the uranium plume in the South Field area along with recommendations on how to proceed with remediation in the area, based on the updated plume interpretation. Installation of Phase II components was initiated in 2002. The overall system (Phases I and II) is referred to as the South Field Module.

In 2003, groundwater remediation approaches were evaluated to determine the most cost-effective groundwater remedy infrastructure, including the wastewater treatment facility, to remain after site closure. An evaluation of alternatives was put into the Comprehensive Groundwater Strategy Report. In October 2003, initial discussions were held with the regulators and the public concerning the various alternatives identified in the report. These discussions culminated in an identified path forward to work collaboratively with the Fernald Citizens Advisory Board, EPA, and OEPA to determine the most appropriate course of action for the ongoing aquifer restoration and water treatment activities at the Fernald site.

In 2004, a decision regarding the future aquifer restoration and wastewater treatment approach was made following regulatory and public input. In May, EPA and OEPA approved the decision to reduce the size of the AWWT; in June, they approved the decision to discontinue the use of well-based re-injection. Reducing the size of the AWWT provides the opportunity to dismantle and dispose of approximately 90 percent of the existing facility in the on-site disposal facility in time to meet the 2006 closure schedule, and results in a protective, more cost-effective, long-term water treatment facility to complete aquifer restoration. Well-based re-injection was discontinued based upon groundwater modeling cleanup predictions presented in the Comprehensive Groundwater Strategy Report and the Groundwater Remedy Evaluation and Field Verification Plan. The updated modeling indicated that the aquifer restoration time frame would likely be extended beyond dates previously predicted in part due to refined modeling input. The updated modeling also indicated that continued use of the groundwater re-injection wells would shorten the aquifer remedy by approximately three years. Therefore, the benefit of continuing re-injection did not justify the cost. Well-based re-injection was discontinued in September 2004 to support construction of the converted advanced wastewater treatment facility (CAWWT). The decision was made to not resume well-based re-injection once the CAWWT was operational in 2005. All re-injection wells are remaining in place as potential points for the groundwater remedy performance monitoring. Operations will proceed without well-based re-injection, and other operational strategies to enhance the aquifer remedy will be explored (e.g., inducing infiltration to the Great Miami Aquifer through the Storm Sewer Outfall Ditch). Testing to determine the feasibility of inducing infiltration to the Great Miami Aquifer through the Storm Sewer Outfall Ditch is scheduled for 2005. The controlling document for the testing is the Groundwater Remedy Evaluation and Field Verification Plan. The remedy design will be modified in 2005 to incorporate lessons learned from the testing.

During 2004, active remediation of the Great Miami Aquifer continued at the South Plume/South Plume Optimization, South Field, Waste Storage Area, and Re-injection Modules until September. As indicated above, well-based re-injection activities were discontinued in September. Additionally, the extraction wells in the waste storage area were shut down in September for preventative maintenance, and from October through December to support conversion of the AWWT to the CAWWT. Figure 3-1 shows the extraction and re-injection well locations that were active in 2004. The operational information associated with these modules is presented in the following subsections. Figure 3-2 identifies current and future extraction well locations. At the end of 2004, the only remaining planned enhanced groundwater remedy module component, pending design and installation, was the Phase II component of the Waste Storage Area Module. Characterization work began in the waste storage area for Waste Storage Area Module (Phase II) Design, and a decision concerning the need for additional extraction wells in this area is scheduled to be made in 2005. If additional extraction wells are needed, they will be installed and operational prior to site closure in 2006.

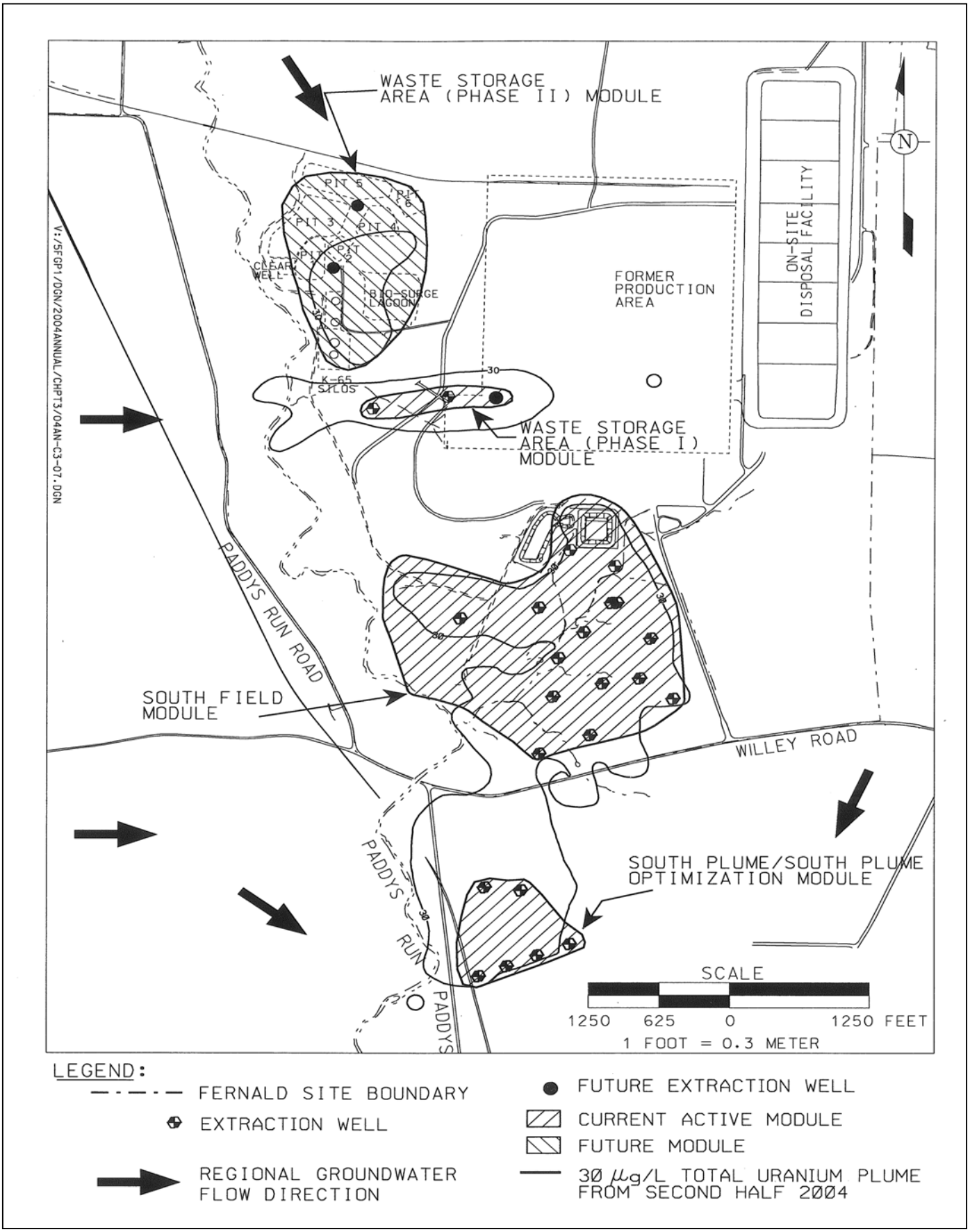


Figure 3-2. Current and Future Extraction and Re-injection Wells for the Enchanced Groundwater Remedy

3.3 Groundwater Monitoring Highlights for 2004

For this annual site report, groundwater monitoring results are discussed in terms of restoration and compliance monitoring.

The key elements of the Fernald site groundwater monitoring program design are described below. Note that with the implementation of the IEMP, Revision 3 (DOE 2003c), the groundwater monitoring approach was streamlined to focus on areas where exceedances (total uranium and non-uranium) were occurring while continuing to meet compliance requirements.

- **Sampling** – Sample locations, frequency, and constituents were selected to address operational assessment, restoration assessment, and compliance requirements. Selected wells are monitored for up to 50 groundwater FRL constituents. Monitoring is conducted to ascertain groundwater quality and groundwater flow direction. Figure 3-3 shows a typical groundwater monitoring well at the site and Figure 3-4 identifies the relative placement depths of groundwater monitoring wells at the site. As part of the comprehensive groundwater monitoring program specified in the IEMP, approximately 150 wells were monitored for water quality in 2004. Figures 3-5 and 3-6 identify the locations of the current water quality monitoring wells. In addition to water quality monitoring, approximately 170 wells were monitored quarterly for groundwater elevations. Figure 3-7 depicts the routine water level (groundwater elevation) monitoring wells, including extraction wells, as specified in the IEMP.

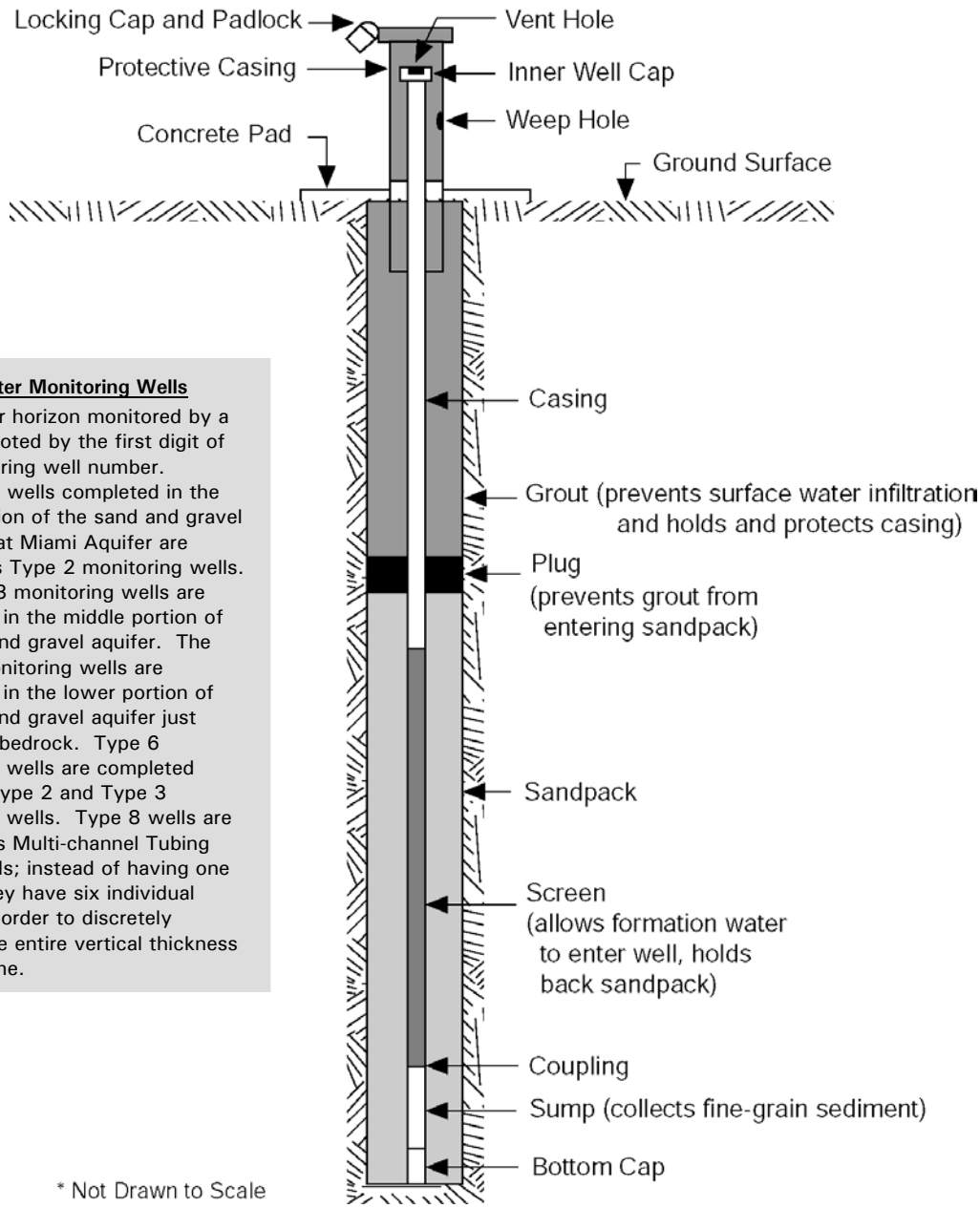
- **Data Evaluation** – The integrated data evaluation process involves review and analysis of the data collected from wells to determine capture and restoration of the uranium plume; capture and restoration of non-uranium FRL constituents; water quality conditions in the aquifer that indicate a need to modify the design and installation of restoration modules; and the impact of ongoing groundwater restoration on the Paddys Run Road Site plume (a separate contaminant plume south of the Fernald site along Paddys Run Road resulting from independent industrial activities in the area).

- **Reporting** – All data are reported through the IEMP program Mid-Year Data Summary Report and the annual Site Environmental Report.

3.3.1 Restoration Monitoring

In general, restoration monitoring tracks the progress of the groundwater remedy and water quality conditions. All operational modules were evaluated during the year to determine the progress of aquifer remediation. Concentration maps are developed from analytical data and compared with groundwater elevation maps depicting the location of capture zones.

More detailed information can be found in Appendix A of this report. Subsections that follow identify the specific attachment of Appendix A where the detailed information can be found.



Groundwater Monitoring Wells

The aquifer horizon monitored by a well is denoted by the first digit of the monitoring well number. Monitoring wells completed in the upper portion of the sand and gravel of the Great Miami Aquifer are denoted as Type 2 monitoring wells. The Type 3 monitoring wells are completed in the middle portion of the sand and gravel aquifer. The Type 4 monitoring wells are completed in the lower portion of the sand and gravel aquifer just above the bedrock. Type 6 monitoring wells are completed between Type 2 and Type 3 monitoring wells. Type 8 wells are Continuous Multi-channel Tubing (CMT) wells; instead of having one screen, they have six individual screens in order to discretely monitor the entire vertical thickness of the plume.

Figure 3-3. Diagram of a Typical Groundwater Monitoring Well

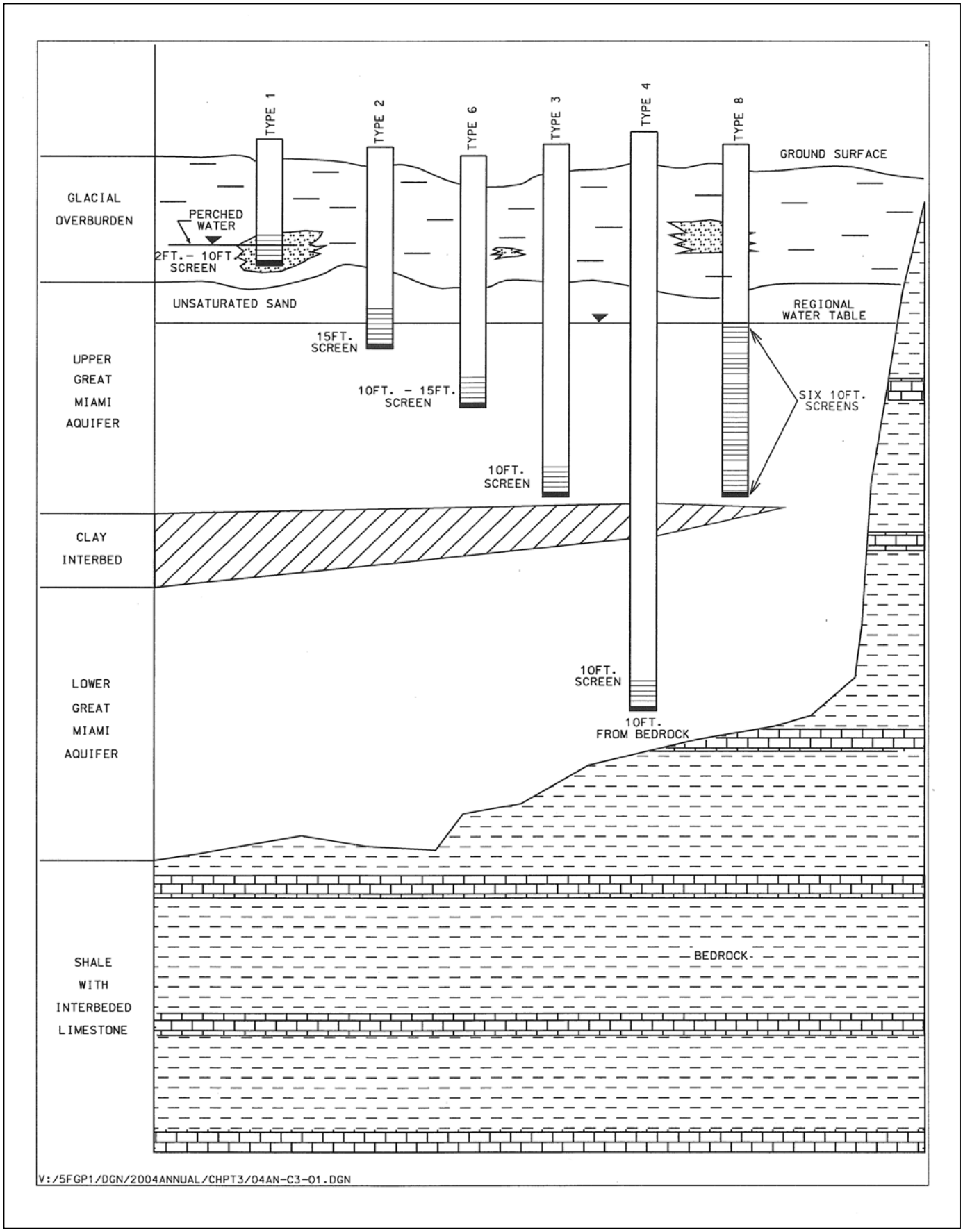


Figure 3-4. Monitoring Well Relative Depths and Screen Locations

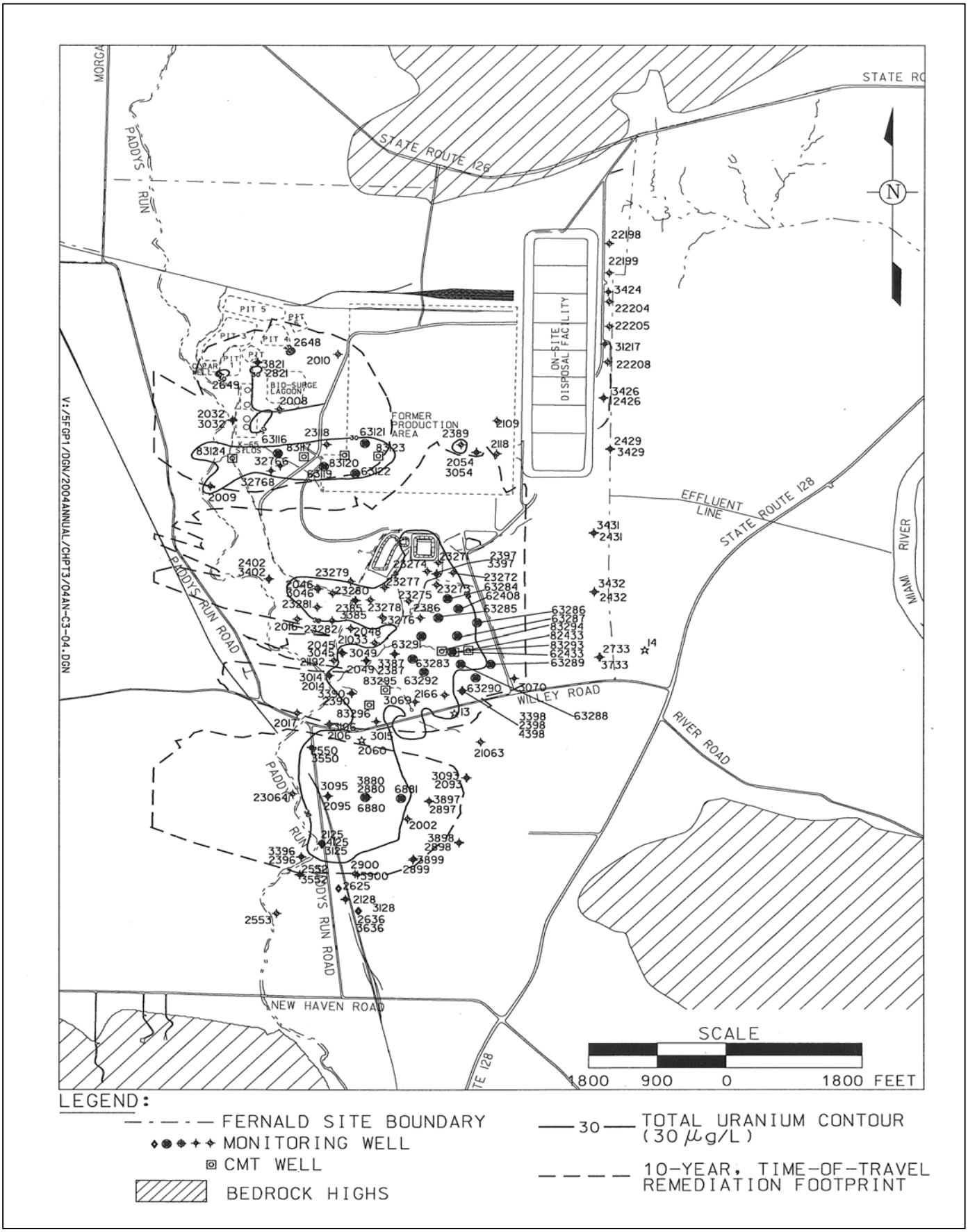


Figure 3-5. Locations for Semiannual Total Uranium Monitoring

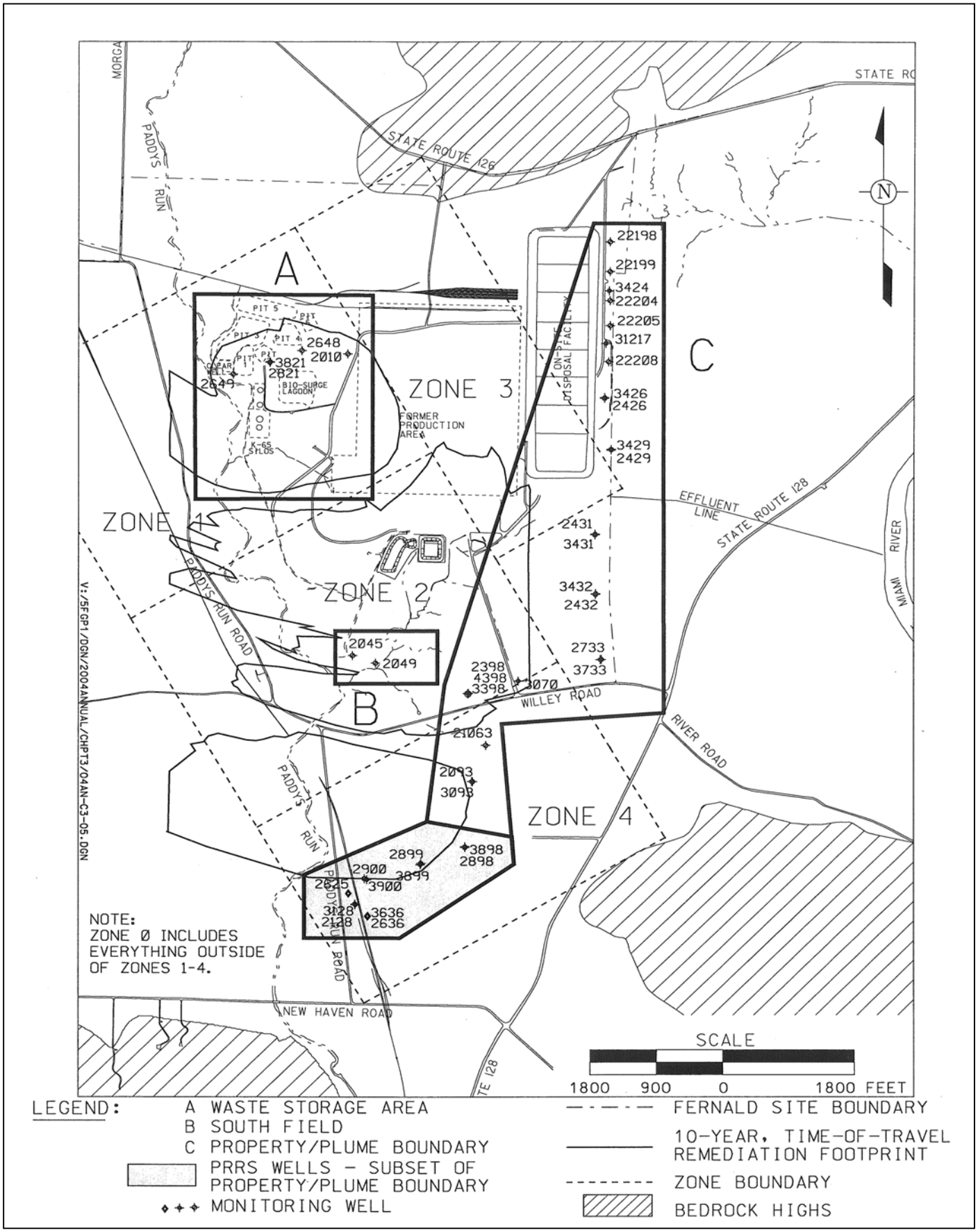


Figure 3-6. Locations for Semiannual Non-uranium Monitoring

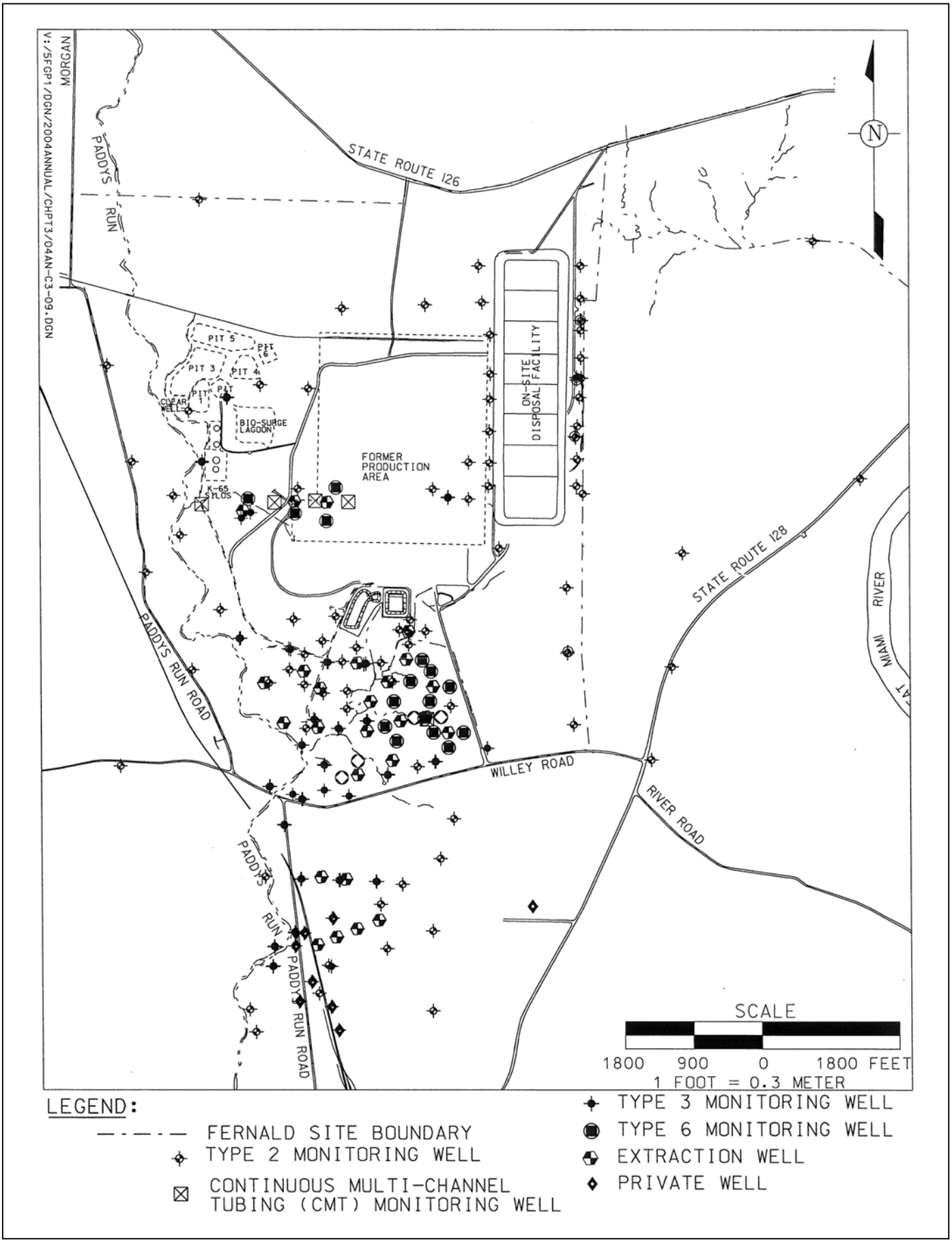


Figure 3-7. IEMP Groundwater Elevation Monitoring Wells

3.3.1.1 Operational Summary

Figure 3-1 shows the extraction and re-injection well locations associated with the restoration modules operating in 2004. With the exception of the waste storage area, all wells currently planned for the enhanced groundwater remedy have been installed. Table 3-1 summarizes the pounds of uranium removed, amount of groundwater pumped, pounds of uranium re-injected, and amount of treated groundwater re-injected by the active restoration modules during 2004. For reporting purposes, operational data for the re-injection wells located in the South Field as well as the Injection Pond (which is also located in the South Field) are tabulated with the Re-injection Module operational data in Table 3-1. Several operational disruptions were necessary during the period from October through December 2004 to facilitate construction of the CAWWT. Additional details are provided in the individual module operational summaries provided in Sections 3.3.1.2 through 3.3.1.5. Figure 3-8 identifies the yearly and cumulative pounds of uranium removed from the Great Miami Aquifer from 1993 through 2004.

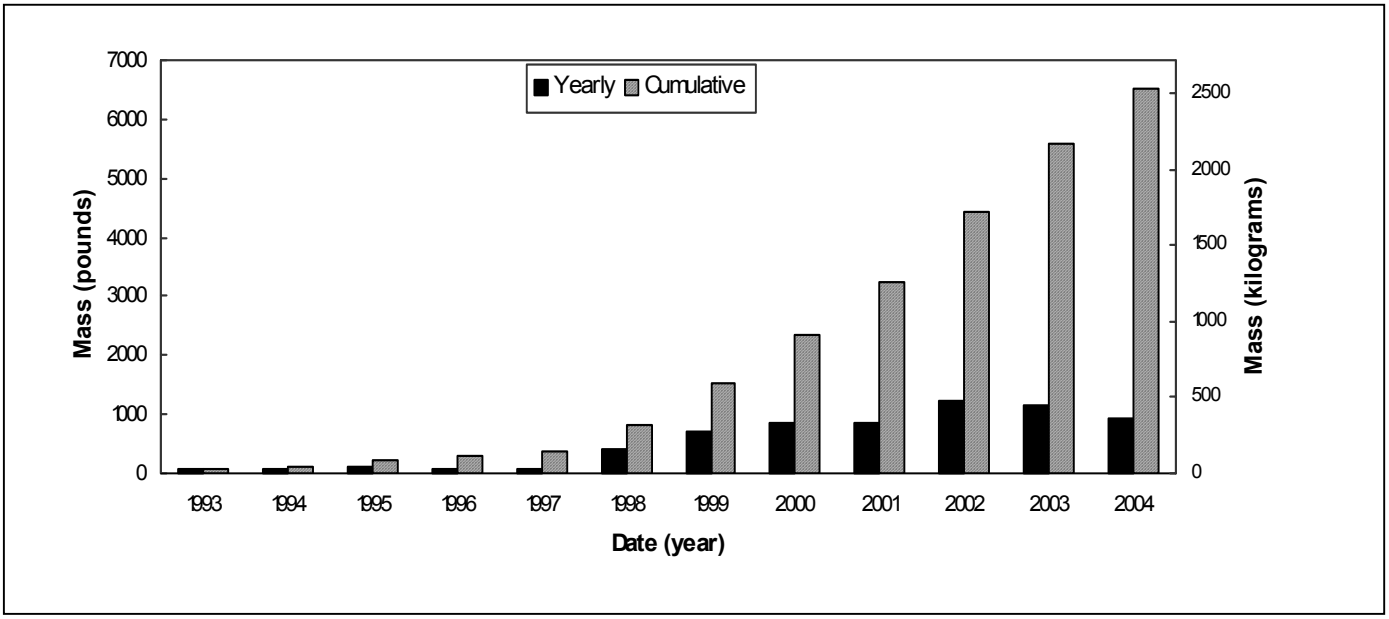


Figure 3-8. Net Pounds of Uranium Removed from the Great Miami Aquifer, 1993-2004

Since 1993:

- 16,686 million gallons (63,157 million liters) of water have been pumped from the Great Miami Aquifer
- 1,936 million gallons (7,328 million liters) of treated water have been re-injected into the Great Miami Aquifer
- 6,522 net pounds (2,961 kg) of total uranium have been removed from the Great Miami Aquifer.

Appendix A, Attachment A.1, of this report provides detailed operational information on each extraction and re-injection well, such as pumping and re-injection rates, uranium removal indices, and total uranium concentration graphs. Following is an overview of the individual modules.

TABLE 3-1
GROUNDWATER RESTORATION MODULE STATUS FOR 2004

Module	Restoration Wells	Target Pumping Rate		Gallons Pumped/ (Gallons Re-injected)		Uranium Removed/ (Re-injected)	
		gpm	Lpm	M gal	M liters	lbs	kg
South Plume/ South Plume Optimization Module	3924	1,900	7,191.50	750	2,838.75	159	72.19
	3925						
	3926						
	3927						
	32308						
	32309						
South Field Module	31550	3,365[j]	12,736.53	1,341	5,075.69	599	271.95
	31560						
	31561						
	31562[a]						
	31563[b]						
	31564[c]						
	31565[d]						
	31566[e]						
	31567						
	32276						
	32446						
	32447						
	33061						
	33298						
	33262						
	33264						
	33265						
	33266						
Waste Storage Area Module	32761	1,100[k]	4,163.5	355	1,343.68	176	79.90
	33062						
	33063						
Re-injection Module and South Field Re-injection Wells and Pond	22107[f]	(1,425)[l]	(5,393.63)	(330)	(1,249.05)	(11.74)	(5.33)
	22108[g]						
	22109						
	22240						
	33253						
	33254						
	33255						
	33263[h]						
	31563[h]						
	Injection Pond[i]						
Aquifer Restoration System Totals							
Pumped		6,365	24,091.53	2,446	9,258.11	934	424.04
(Re-injected)		(1,425)	(5,393.63)	(330)	(1,249.05)	(11.74)	(5.33)
Net		4,940	18,697.9	2,116	8,009.06	922	418.59

[a]Extraction Well 31562 began operating in July 1998. It was removed from service in March 2003 and was replaced by Extraction Well 33298 which became operational on July 29, 2003.

[b]Extraction Well 31563 began operating in July 1998. It was removed from service in December 2002.

[c]Extraction Well 31564 began operating in July 1998. It was removed from service in December 2001.

[d]Extraction Well 31565 began operating in July 1998. It was removed from service in May 2001.

[e]Extraction Well 31566 began operating in July 1998. It was removed from service in August 1998.

[f]Re-injection Well 22107 began operating in August 1998. It was replaced by Re-injection Well 33253 in November 2002.

[g]Re-injection Well 22108 began operating in August 1998. It was replaced by Re-injection Well 33254 in November 2002.

[h]Re-injection Wells 33263 and 31563 are located in the South Field.

[i]Injection Pond is located in the South Field.

[j]Target pumping rate from January 1, 2004 through September 24, 2004. Target pumping rate from September 25, 2004 through December 31, 2004 was 2,675 gallons (10,125 liters).

[k]In July 2004, Extraction Well 33063 was shut down so that it could be plugged and abandoned to facilitate surface excavation activities. From September through the remainder of the year, the two remaining extraction wells were shut down for preventive maintenance and to facilitate CAWWT construction.

[l]Well-based re-injection was permanently shut down in September 2004.

3.3.1.2 South Plume/South Plume Optimization Module Operational Summary

The four extraction wells of the South Plume Module (Extraction Wells 3924, 3925, 3926, and 3927) began operating in August 1993. The two extraction wells of the South Plume Optimization Module (Extraction Wells 32308 and 32309) began operating in August 1998. Figure 3-9 illustrates the uranium plume capture observed for the South Plume/South Plume Optimization Module in the fourth quarter of 2004. During 2004, 750 million gallons (2,839 million liters) of groundwater and 159 pounds (72 kg) of uranium were removed from the Great Miami Aquifer by the South Plume/South Plume Optimization Module. Pumping in the South Plume Module was disrupted in October and December 2004 to facilitate CAWWT construction. Based on analysis of the data in 2004, the module continues to meet its primary objectives as demonstrated by the following:

- Southward movement of the uranium plume beyond the southern most extraction wells has not been detected.
- Active remediation of the central portion of the off-property uranium plume continues to reduce plume concentration. Nearly the entire off-property uranium plume concentration is now below 100 µg/L. At the start of pumping in 1993, areas in the off-property uranium plume had concentrations over 300 µg/L.
- Paddys Run Road Site plume, located south of the extraction wells, is not being adversely affected by the pumping.

3.3.1.3 South Field Module Operational Summary

The South Field Module was constructed in two phases. Phase I began operating in July 1998 and Phase II began operating in July 2003. The 10 original extraction wells installed under Phase I were 31550, 31560, 31561, 31562, 31563, 31564, 31565, 31566, 31567, and 32276. Five of the original 10 wells have been shutdown (31564, 31565, 31566, 31563, and 31562). Extraction Wells 31564 and 31565 were shut down in December 2001 and May 2001, respectively, to accommodate soil remedial activities. Extraction Well 31566 was shut down in August 1998, and was replaced by Extraction Well 33262, which was installed as part of South Field (Phase II) Module. Extraction Well 31563 was shut down in December 2002 and converted to a re-injection well that began operating in 2003. Extraction Well 31562 was shut down in March 2003 and replaced by Extraction Well 33298.

Three new extraction wells (Extraction Wells 32446, 32447, and 33061) were added to the South Field Module between 1998 and 2002. These three new extraction wells were installed in the eastern, downgradient portion of the South Field plume, at locations where total uranium concentrations were considerably above the associated FRL. Two of the three new wells (Extraction Wells 32446 and 32447) were installed in late 1999 and began pumping in February 2000. The third (Extraction Well 33061) was installed in 2001 and became operational in 2002.

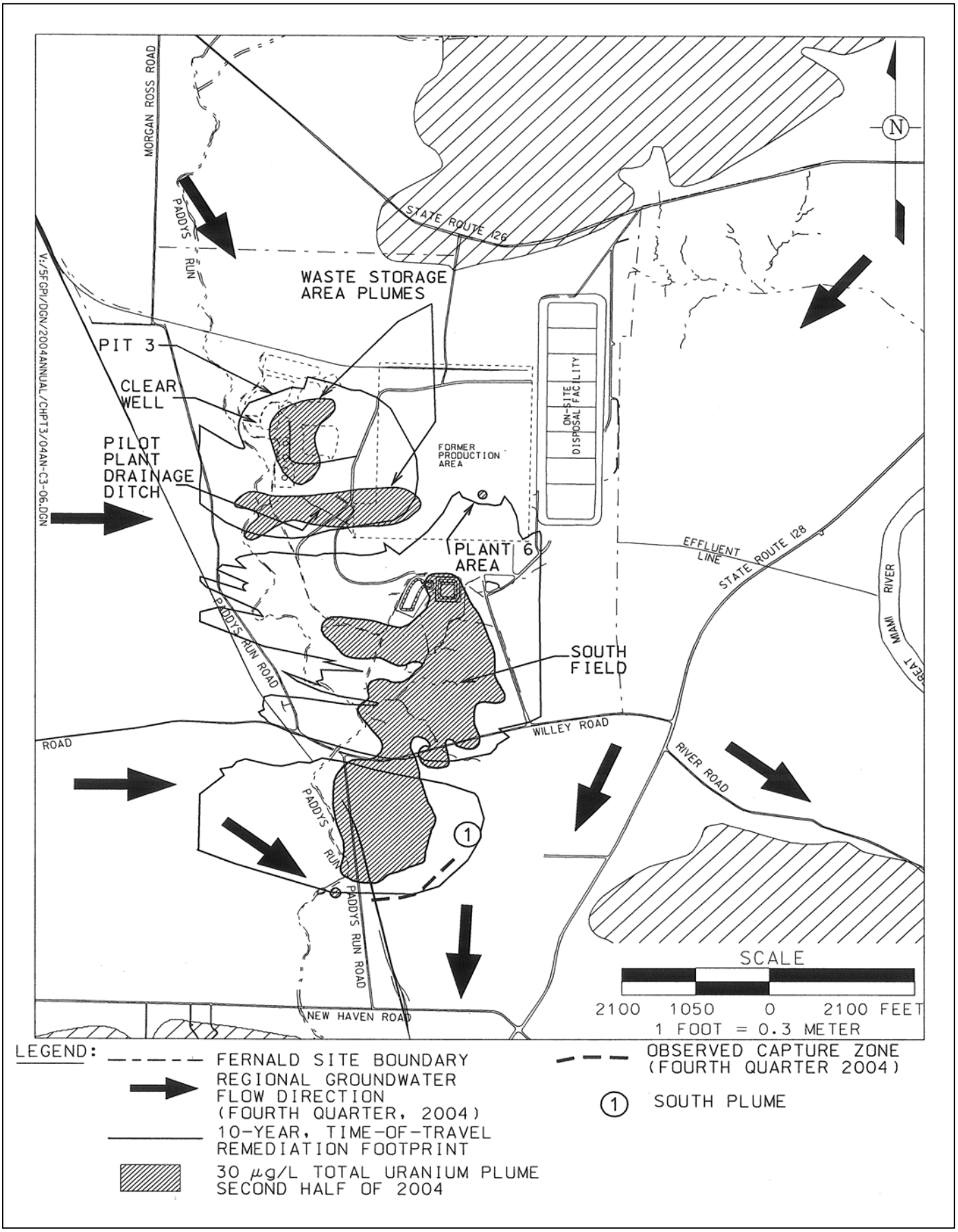


Figure 3-9. Total Uranium Plume in the Aquifer with Concentrations Greater than 30 μg/L at the End of 2004

Phase II components of the South Field Module are described in the Design for Remediation of the Great Miami Aquifer, South Field (Phase II) Module, which was issued in May of 2002. The design provides an updated characterization of the uranium plume in the Great Miami Aquifer beneath the southern portion of the Fernald site and a modeled design for the South Field Module located in that area. All Phase II design components became operational in 2003. The components include:

- Four additional extraction wells, one in the Southern Waste Unit area (Extraction Well 33262), and three along the eastern edge of the on-property portion of the southern uranium plume (Extraction Wells 33264, 33265, and 33266).
- One additional re-injection well in the Southern Waste Units area (Re-injection Well 33263).
- A converted extraction well (Extraction Well 31563), which was converted into a re-injection well.
- An injection pond, which is located in the western portion of the Southern Waste Units excavations.

During 2004, 1,341 million gallons (5,076 million liters) of groundwater and 599 pounds (272 kg) of uranium were removed from the Great Miami Aquifer by the South Field Module. Wells in the South Field Module were shut down at various times from October through December to facilitate CAWWT construction.

3.3.1.4 Re-injection Module Operational Summary

The use of re-injection at the Fernald site began with a demonstration test that was conducted from September 2, 1998 to September 2, 1999. The demonstration indicated that re-injection was a viable technology for the aquifer remedy. Based on the success of the demonstration, it was decided to incorporate re-injection technology into the aquifer remedy. The Re-injection Demonstration Test Report detailing the demonstration was issued to EPA and OEPA on May 30, 2000.

The original Re-injection Module consisted of five re-injection wells (Re-injection Wells 22107, 22108, 22109, 22111, and 22240). Residual plugging of the re-injection wells became a concern in the last half of 2000. During 2001, the re-injection wells were subjected to the new treatment method and this new process was economically viable in three of the five original wells (Re-injection Wells 22109, 22111, and 22240). It was determined that it was more cost effective to replace the other two wells (Re-injection Wells 22107 and 22109) rather than attempt another treatment.

Re-injection Well 22107 was replaced by Re-injection Well 33253. Re-injection Well 22108 was replaced by Re-injection Well 33254. These two new replacement wells began operating in November 2002. In addition to the two new replacement wells, a sixth re-injection well (Re-injection Well 33255) was added to the module. This new re-injection well is located half way between Re-injection Wells 22109 and 22240, and began operating on May 22, 2003. During 2004, 330 million gallons (1,249 million liters) of groundwater and 11.74 pounds (5.33 kg) of uranium were re-injected into the Great Miami Aquifer by the Re-injection Module wells and re-injection wells, and the Injection Pond in the South Field Module. Re-injection Module wells operated less frequently in 2004 than in previous years.

During the first quarter of 2004, the wells were often turned off in order to meet discharge limits at the Parshall Flume and, as previously stated, well-based re-injection was permanently shut down in September of 2004. Groundwater modeling presented in the Comprehensive Groundwater Strategy Report predicts that continued use of large-scale re-injection using current re-injection wells would shorten the aquifer remedy by only three years. These results indicate limited benefit to maintaining the infrastructure for large-scale, well-based re-injection. Re-injection wells will not be plugged and abandoned so they can serve as future aquifer monitoring locations.

3.3.1.5 Waste Storage Area (Phase I) Operational Summary

The Waste Storage Area Module became operational on May 8, 2002, nearly 17 months ahead of the start date of October 1, 2003 established in the Operable Unit 5 Remedial Action Work Plan. The module consisted of three extraction wells: 32761, 33062, and 33063. These three wells were installed to remediate a uranium plume in the Pilot Plant Drainage Ditch area, according to the Design for Remediation of the Great Miami Aquifer in the Waste Storage and Plant 6 Areas. In July 2004, Extraction Well 33063 was plugged and abandoned to make way for surface excavation activities. Additionally, monitoring wells that hindered surface excavation activities (Monitoring Wells 83120, 83123, 63121, and 63122) were plugged and abandoned in 2004. The remaining two extraction wells in the Waste Storage Area Module were shut down at the end of September for preventative maintenance and from October through December to facilitate construction of the CAWWT. Upon completion of the CAWWT in 2005, the extraction wells will become operational once again. A replacement for Extraction Well 33063 is planned for 2005. Other monitoring wells will also be replaced in 2005 as necessary. During 2004, 355 million gallons (1,344 million liters) and 176 pounds (80 kg) of uranium were removed from the Great Miami Aquifer by the Waste Storage Area Module.

3.3.1.6 Monitoring Results for Total Uranium

The 10-year, time-of-travel remediation footprint is an updated model prediction. It illustrates how far a particle of water will travel in response to pumping over a 10-year time period using current pumping locations and target pumping rates for 2003. It replaces the 10-year, uranium-based restoration footprint that was prepared several years ago based on previous model predictions using previous pumping locations and rates that are no longer relevant.

Total uranium is the primary FRL constituent because it is the most prevalent site contaminant and has impacted the largest area of the aquifer. Figure 3-9 shows general groundwater flow directions observed during the fourth quarter of 2004 and the interpretation of the uranium plume in the aquifer updated through the second half of 2004. The shaded areas represent the interpreted size of the maximum uranium plume that is above the 30-µg/L groundwater FRL for total uranium. As of December 31, 2004, approximately 196 acres (79 hectares) of the Great Miami Aquifer were contaminated above the 30-µg/L groundwater FRL for total uranium, identified as an increase of 17 acres from the 179-acre area identified in 2003. The increase was due to additional characterization work in the Waste Storage Area (Phase II) Module Design. Capture zones observed during the fourth quarter of 2004 for the active restoration modules are also identified on Figure 3-9. These capture zones indicate that the South Plume is being captured by the existing system and that farther movement of uranium to the south of the extraction wells is being prevented. Figure 3-9 also depicts the 10-year, time-of-travel remediation footprint that was predicted using 2003 target pumping rates and no well-based re-injection.

Geoprobe® (Direct-Push Sampling)

The Geoprobe®, a hydraulically powered, direct-push sampling tool, is used at the Fernald site to obtain groundwater samples at specific intervals without installing a permanent monitoring well. Direct-push means that the tool employs the weight of the vehicle it is mounted on and percussive force to push into the ground without drilling (or cutting) to displace soil in the tool's path. The Fernald site uses this technique to collect data on the progress of aquifer restoration and to determine the optimal location and depth of additional monitoring and extraction wells that may be installed in the future.

Waste Storage Area – In 2004, the footprint of the maximum uranium plume in the waste storage area was revised to incorporate new data collected from existing monitoring wells and from five direct-push sampling locations, sampled as part of the Waste Storage Area Module (Phase II) Design. The new outline of the 30-ug/L uranium plume is shown in Figure 3-9. Phase II of the Waste Storage Area Module is currently being designed to address the plume in the Waste Storage Area that is not already being addressed by the Waste Storage Area (Phase I) Module. Additional direct-push sampling for the Waste Storage Area (Phase II) Design will be completed in 2005. A final design for the Waste Storage Area (Phase II) Module will be issued in 2005.

Plant 6 Area – During 2004, surface excavation work in the Plant 6 area was completed. As a follow-up to the excavation work, direct-push groundwater sampling was conducted in the Plant 6 area to determine if any groundwater FRL exceedances for uranium or technetium-99 were present in the Great Miami Aquifer that might require the installation of an extraction well prior to site closure in 2006. Each direct-push sampling location was sampled at different depths below the water table in order to obtain a depth/concentration profile. The direct-push data indicate that no additional extraction wells are needed. However, groundwater monitoring results in the second half of 2004 indicated that an FRL exceedance for uranium was detected at Monitoring Well 2389. Monitoring Well 2389 has had a history of sporadic uranium FRL exceedances. It appears that a thin layer of uranium contamination is present in the upper foot of the aquifer at this location. There is not enough contamination to require the installation of a groundwater extraction well, but continued groundwater monitoring in the area is warranted.

South Field and South Plume Areas – Data collected in 2004 indicate that uranium concentrations continue to decrease in the South Field and South Plume areas in response to remediation activities. The outline of the maximum uranium plume updated through 2004 is provided in Figure 3-9. In the second half of 2004, a uranium FRL exceedance was detected south of the main body of the plume. Data collected in 2004 also provide evidence for concentration rebound occurring in the South Field. In 2004, uranium concentrations increased in Monitoring Well 2045 with a correlating rise in water level. The rise in water level is attributed to seasonal water table fluctuations due to recharge, and to shutting down a nearby extraction well. The source of the uranium is attributed to uranium partitioned to aquifer sediment in the vadose zone. Concentration rebounds after pumping stops are common for pump-and-treat remediation operations. Concentration rebounds are expected to occur at other monitoring locations when extraction wells are shut down, and will be factored into future operational decisions.

Appendix A, Attachment A.2, provides individual monitoring well total uranium results and detailed uranium plume maps for 2004. Appendix A, Attachment A.3, provides quarterly groundwater elevation maps and capture zone interpretations, along with graphical displays of groundwater elevation data.

3.3.1.7 Monitoring Results for Non-uranium Constituents

Although the enhanced groundwater remedy is primarily targeting remediation of the uranium plume, other FRL constituents contained within the uranium plume are also being monitored. Figure 3-10 identifies the locations of the wells that had non-uranium FRL exceedances, and Table 3-2 summarizes the results of monitoring for non-uranium FRL exceedances. Table 3-2 shows the number of wells exceeding the FRL in 2004; the number of wells exceeding the FRL outside the 10-year, time-of-travel remediation footprint; the groundwater FRL; and the range of 2004 data inside or outside the 10-year, time-of-travel remediation footprint.

TABLE 3-2
NON-URANIUM CONSTITUENTS WITH RESULTS ABOVE FINAL REMEDIATION LEVELS DURING 2004

Constituent	Number of Wells Exceeding the FRL	Number of Wells Exceeding the FRL Outside the 10-Year, Time-of-Travel Remediation Footprint	Groundwater FRL	Range of 2004 Data Inside the 10-Year, Time-of-Travel Remediation Footprint[a]	Range of 2004 Data Outside the 10-Year, Time-of-Travel Remediation Footprint[a]
General Chemistry			**(mg/L)**	**(mg/L)**	**(mg/L)**
Nitrate/Nitrite	2	0	11[b]	16.6 to 102	NA
Inorganics					
Antimony	1	1	0.0060	NA	0.00741
Arsenic	1	1	0.050	NA	0.051
Manganese	6	3	0.90	1.59 to 6.14	1.34 to 1.44
Molybdenum	1	0	0.10	0.436 to 0.539	NA
Zinc	1	1	0.021	NA	0.155
Volatile Organics			**(µg/L)**	**(µg/L)**	**(µg/L)**
Carbon disulfide	1	0	5.5	7.79	NA
Trichloroethene	1	0	5.0	54.7 to 56.5	NA
Radionuclides			**(pCi/L)**	**(pCi/L)**	**(pCi/L)**
Technetium-99	2	0	94	233 to 906	NA

[a]NA = not applicable
[b]FRL based on nitrate, from Operable Unit 5 Record of Decision, Table 9-4; however, the sampling results are for nitrate/nitrite.

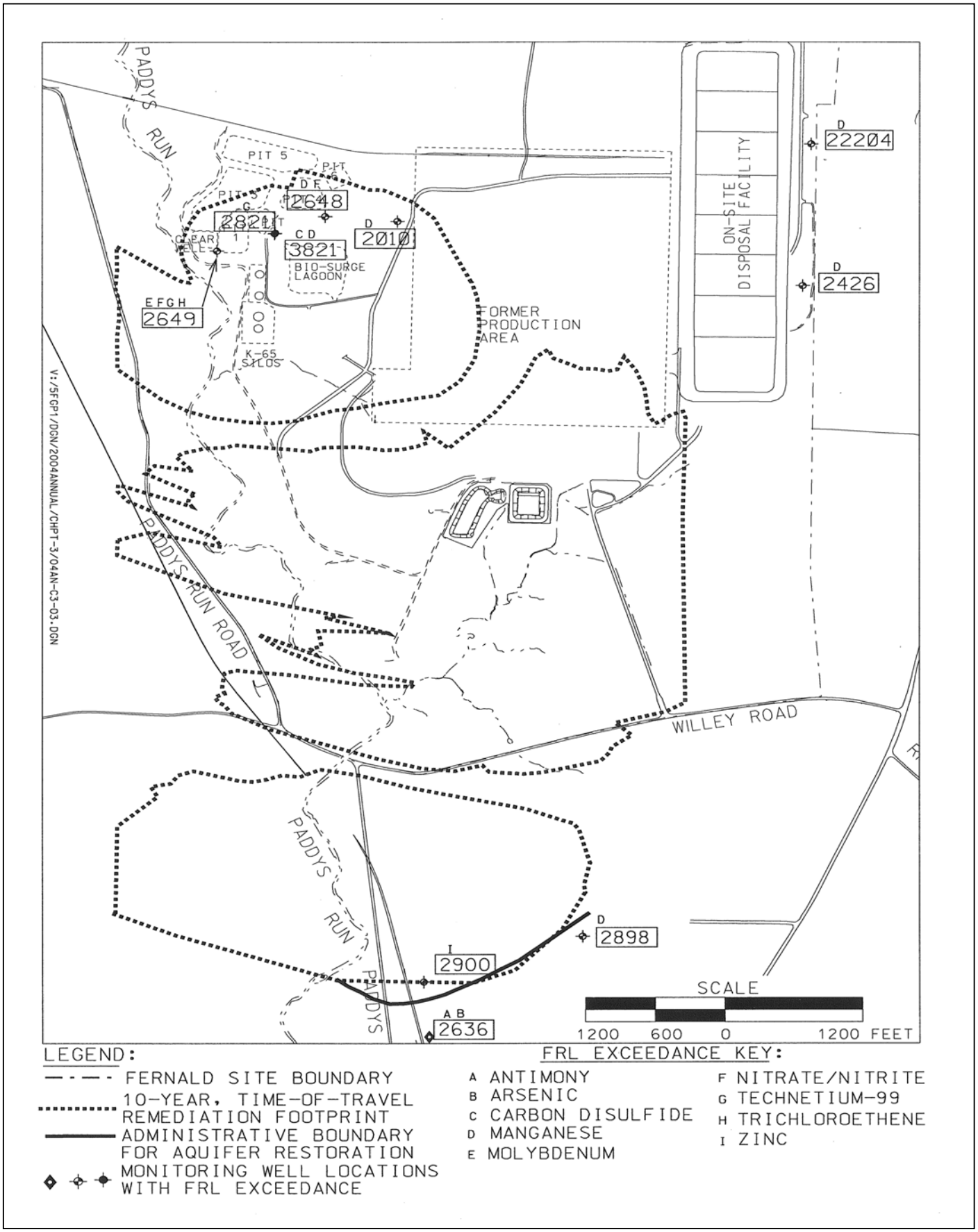


Figure 3-10. Non-uranium Constituents with 2004 Results Above Final Remediation Levels

During 2004, non-uranium FRL exceedances were observed at 10 monitoring well locations as shown in Figure 3-10. A total of nine non-uranium FRL constituents exceeded FRLs in 2004. The waste storage area exceedances will be further evaluated in the design of the Waste Storage Area (Phase II) Module. The exceedance locations along the eastern Fernald site boundary and in the South Plume area are outside the 10-year, time-of-travel remediation footprint. No plumes for the above-FRL constituents at the locations outside the 10-year, time-of-travel remediation footprint were identified in the extensive groundwater characterization efforts evaluated as part of the Remedial Investigation Report for Operable Unit 5.

The constituents with FRL exceedances at the well locations outside the 10-year, time-of-travel remediation footprint were further evaluated to determine whether they were random events or if they were persistent according to criteria discussed in Appendix A, Attachment A.4. Two of the exceedances in 2004 were classified as persistent: arsenic at Monitoring Well 2636, and manganese at Monitoring Well 2426. In past years, exceedances identified as persistent became non-persistent in later years. Appendix A, Attachment A.4, provides detailed information on non-uranium FRL exceedances and the persistence of these exceedances.

Note that Monitoring Well 2636 is located south of the administrative boundary in the Paddys Run Road Site contaminant plume area. The administrative boundary is located between the Fernald site uranium plume and the Paddys Run Road Site contaminant plumes. The Paddys Run Road Site consists of documented releases of inorganic compounds (including arsenic), volatile organic compounds, and semi-volatile organic compounds. FCP groundwater monitoring is occurring south of the administrative boundary to assess the impact of pumping the South Plume Extraction Wells on the Paddys Run Road Site plumes.

3.3.2 Other Monitoring Commitments

Two other groundwater monitoring activities are included in the IEMP: private well monitoring and property boundary monitoring.

As stated earlier, the groundwater data from these activities, along with the data from all other IEMP groundwater monitoring activities, are collectively evaluated for total uranium and, where necessary, non-uranium constituents of concern. The discussion that follows provides additional details on the two compliance monitoring activities.

The three private wells (Monitoring Wells 2060 [12], 13, and 14) located along Willey Road are monitored under the IEMP to assist in the evaluation of the uranium plume migration (for well locations, refer to Figure 2-2 in Chapter 2). It was at one of these private wells that off-property groundwater contamination was initially detected in 1981. Monitoring stopped at the other private wells in 1997 because a DOE-sponsored public water supply became available to Fernald site neighbors who were affected by off-property groundwater contamination.

The availability of the public water supply resulted in the discontinued monitoring of many private wells in the affected off-property areas where groundwater is being remediated. Data from the three private wells sampled under the IEMP were incorporated into the uranium plume map shown in Figure 3-9.

During 2004, Property/Plume Boundary Monitoring was comprised of 35 monitoring wells located downgradient of the Fernald site, along the eastern and southern portions of the property boundary. Twenty-four Type 2 and 3 wells were monitored along the eastern Fernald site boundary and slightly downgradient of the South Plume to determine if any contaminant excursions were occurring. Eleven Type 2 and 3 wells were monitored in the Paddys Run Road Site area to document the influence, or lack thereof, that pumping in the South Plume was having on the Paddys Run Road Site Plume. Data from the property/plume boundary wells were integrated with other groundwater data for 2004 and were incorporated into the uranium plume maps shown Figure 3-9 and in Attachment A.2. Non-uranium data from these wells were included above in the section on monitoring results for non-uranium constituents.

Director's Findings and Orders were issued by OEPA on September 7, 2000. These orders specify that the site's groundwater monitoring activities will be implemented in accordance with the IEMP. The revised language allows modification of the groundwater monitoring program as necessary, via the IEMP revision process (subject to OEPA approval), without issuance of a new Director's Order. As determined by OEPA, the IEMP will remain in effect throughout the remedial actions.

3.4 On-site Disposal Facility Monitoring

Groundwater monitoring for the cells of the on-site disposal facility is conducted in the glacial till (perched water) and in the Great Miami Aquifer. Groundwater monitoring in support of the on-site disposal facility continued in 2004. This monitoring program is designed to accomplish the following:

- Establish a baseline of groundwater conditions in both the perched groundwater and the Great Miami Aquifer beneath each cell of the on-site disposal facility. The baseline data will be used to evaluate future changes in perched groundwater and Great Miami Aquifer groundwater quality to help determine if the changes are due to on-site disposal facility operations.

- Continue routine groundwater sampling following waste placement and cell capping as part of the comprehensive leak detection monitoring program for the on-site disposal facility. This information will be used to help verify the ongoing performance and integrity of the on-site disposal facility.

Table 3-3 summarizes the groundwater, leachate collection system, and leak detection system monitoring information associated with the on-site disposal facility. Table 3-3 provides information for Cells 1 through 8 along with sample information and range of total uranium concentrations. In 2004, monitoring continued for Cells 1 through 6 and was initiated for Cells 7 and 8. During 2004, no constituents sampled to meet on-site disposal facility monitoring requirements exceeded groundwater FRL exceedances; however, one non-uranium constituent (manganese), which is sampled to meet IEMP requirements, exceeded its FRL at Monitoring Well 22204, as identified in Section 3.3.1.7.

The final anticipated on-site disposal facility dimensions are: capacity of 2.9 million cubic yards (yd^3); maximum height of approximately 65 feet (ft); and an estimated area coverage of 80 acres of the northeastern area of the Fernald site. At the end of 2004, approximately 1.85 million in-place yd^3 of waste were placed in the OSDF, of which in 2004 approximately 513,000 in-place yd^3 of waste (including some excavated material, debris, etc.) were placed in Cells 4, 5, 6, 7, and 8 of the OSDF. Cells 1 through 3 were 100 percent full and capped. Cell 4 was also filled to its capacity in 2004 and the final cover system construction was in progress as of the end of the year. Cell 5 reached approximately 55 percent of its capacity. Cell 6 reached approximately 44 percent of its capacity.

TABLE 3-3
ON-SITE DISPOSAL FACILITY GROUNDWATER, LEACHATE, AND LEAK DETECTION SYSTEM MONITORING SUMMARY

Cell (Waste Placement Start Date)	Monitoring Location	Monitoring Zone	Date Sampling Started	Total Number of Samples	Range of Total Uranium Concentrations[a] (µg/L)
Cell 1	12338C	Leachate Collection System	February 17, 1998	33	ND – 142.186
(December 1997)	12338D	Leak Detection System	February 18, 1998	28	1.5 – 23.2
	12338	Glacial Till	October 30, 1997	53	ND – 19
	22201	Great Miami Aquifer	March 31, 1997	56	ND – 8.33
	22198	Great Miami Aquifer	March 31, 1997	80	0.513 – 12.7
Cell 2	12339C	Leachate Collection System	November 23, 1998	27	4.51 – 71.6
(November 1998)	12339D	Leak Detection System	December 14, 1998	30	8.69 – 22.3[b]
	12339	Glacial Till	June 29, 1998	50	ND – 8.07
	22200	Great Miami Aquifer	June 30, 1997	46	ND – 1.11
	22199	Great Miami Aquifer	June 25, 1997	51	ND– 12.1
Cell 3	12340C	Leachate Collection System	October 13, 1999	22	9.27 – 83.7
(October 1999)	12340D	Leak Detection System	August 26, 2002	9	15.1 – 27.7[b]
	12340	Glacial Till	July 28, 1998	48	ND – 29.3
	22203	Great Miami Aquifer	August 24, 1998	45	ND – 7.92
	22204	Great Miami Aquifer	August 24, 1998	48	ND – 5.99
Cell 4	12341C	Leachate Collection System	November 4, 2002	8	4.41 – 165
(November 2002)	12341D	Leak Detection System	November 4, 2002	9	5.45 – 16.4
	12341	Glacial Till	February 26, 2002	21	4.89 – 7.91
	22206	Great Miami Aquifer	November 6, 2001	28	ND – 5.78
	22205	Great Miami Aquifer	November 5, 2001	36	0.446 – 19.7
Cell 5	12342C	Leachate Collection System	November 4, 2002	11	3.39 – 128
(November 2002)	12342D	Leak Detection System	November 4, 2002	7	2.93 – 15.7
	12342	Glacial Till	February 26, 2002	21	8.51 – 21.1
	22207	Great Miami Aquifer	November 6, 2001	29	ND – 4.48
	22208	Great Miami Aquifer	November 5, 2001	34	ND – 2.1
Cell 6	12343C	Leachate Collection System	October 27, 2003	7	7.95 – 141
(November 2003)	12343D	Leak Detection System	October 27, 2003	5	3.1 – 18
	12343	Glacial Till	March 14, 2003	17	ND – 10.9
	22209	Great Miami Aquifer	December 16, 2002	26	ND – 2.38
	22210	Great Miami Aquifer	December 16, 2002	23	ND – 1.02
Cell 7	12344C	Leachate Collection System	September 2, 2004	3	4.65 – 68.4
(September 2004)	12344D	Leak Detection System	September 2, 2004	1	12.2 – 12.2
	12344	Glacial Till	February 24, 2004	9	0.674 – 3.65
	22212	Great Miami Aquifer	January 21, 2004	12	ND – 3.41
	22211	Great Miami Aquifer	January 21, 2004	13	ND – 0.751
Cell 8	12345C	Leachate Collection System	October 18, 2004	1	1.51 – 1.51
(December 2004)	12345D	Lead Detection System	October 18, 2004	2	0.888 – 9.38
	12345	Glacial Till	May 19, 2004	5	3.48 – 5.54
	22213	Great Miami Aquifer	March 31, 2004	10	ND – 0.374
	22214	Great Miami Aquifer	March 31, 2004	10	ND – 1.3

[a]ND = not detectable
[b]Some data not considered representative of true leak detection system uranium concentrations in Cell 2 (December 14, 1998 through May 23, 2000 data set) due to malfunction in the Cell 2 leachate pipeline and the resultant mixing of individual flows. Additionally, it is suspected that some November 2004 samples (i.e., 12339C and 12339D, 12340C and 12340D) were switched. If data from these events were included above, the maximum total uranium concentrations would be 71 µg/L for 12339D and 72.4 µg/L for 12340D.

Cell 7, constructed in 2004, reached approximately 9 percent of its capacity. Cell 8, also constructed in 2004, reached approximately 2 percent of its capacity.

Figure 3-11 identifies the on-site disposal facility footprint and monitoring well locations for Cells 1 through 8. For additional information on the groundwater leak detection and leachate sampling results for the on-site disposal facility, refer to Appendix A, Attachment A.5.

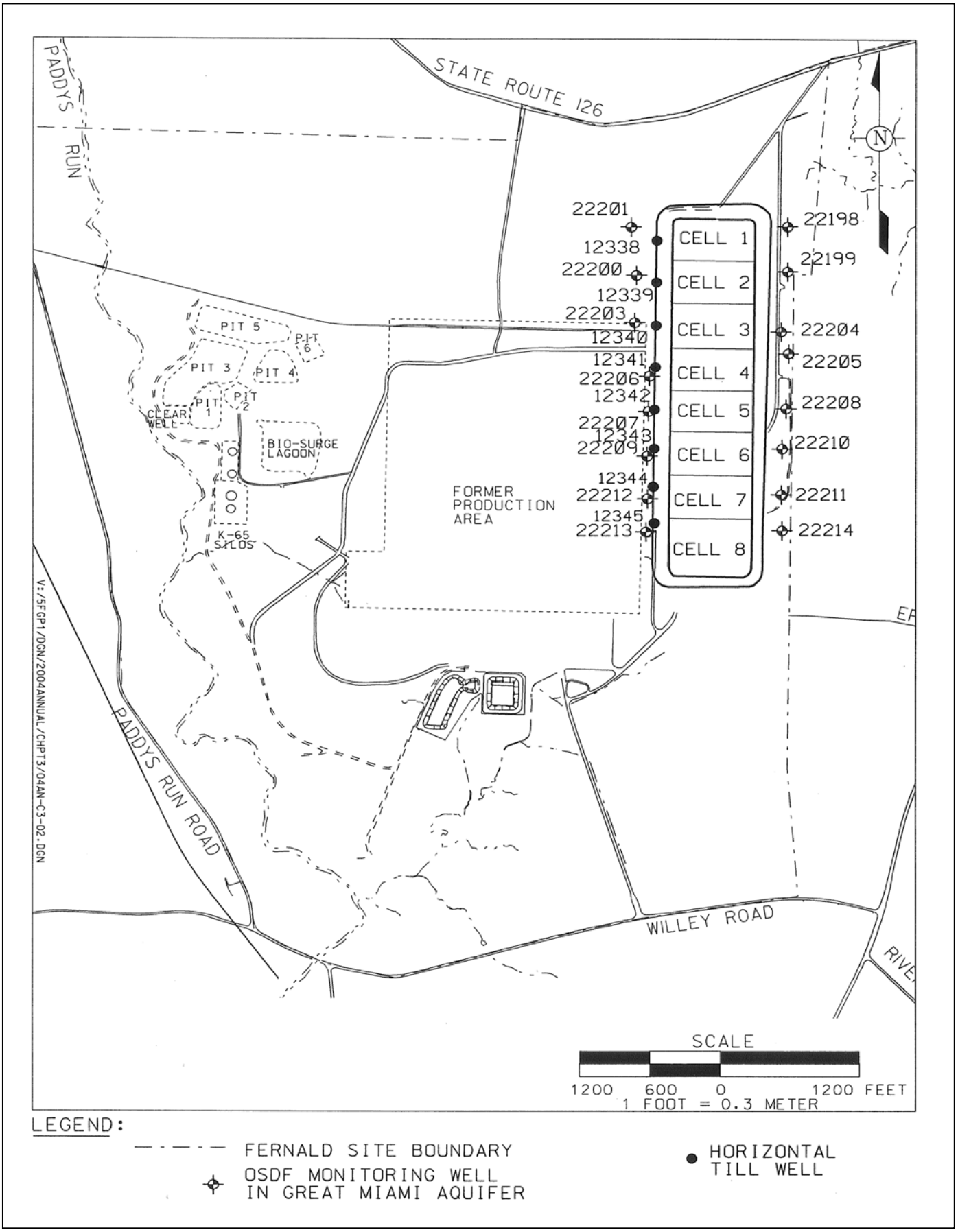


Figure 3-11. On-site Disposal Facility Footprint and Monitoring Well Locations

4.0 Surface Water and Treated Effluent Pathway

Results in Brief: 2004 Surface Water and Treated Effluent Pathway

Surveillance Monitoring — No surface water or treated effluent analytical results from samples collected in 2004 exceeded the surface water FRL for total uranium, the primary site contaminant. In addition, there were no FRL exceedances for any other monitored parameter that can be attributable to the Fernald site.

Uranium Discharges — In 2004, 509 pounds (231 kg) of uranium were discharged in treated effluent to the Great Miami River. Approximately 104 pounds (47 kg) of uranium were released to the environment through uncontrolled storm water runoff. The estimated total pounds of uranium released through the surface water and treated effluent pathway (approximately 613 pounds [278 kg]) decreased 10 percent from the 2003 estimate.

Sediment — There were no FRL exceedances for any sediment result in 2004.

This chapter presents the 2004 monitoring activities and results for surface water, treated effluent, and sediment to determine the effects of remediation activities on the surface water pathway.

In general, low levels of contaminants enter the surface water pathway at the Fernald site by two primary mechanisms: treated effluent that is monitored as it is discharged to the Great Miami River, and uncontrolled runoff entering the site's drainages from areas with low levels of soil contamination. Because these discharges will continue throughout remediation, the surface water and sediment pathways will continue to be monitored. Effective use of the site's wastewater treatment capabilities, and implementation of runoff and sediment controls, minimize the site's impact on the surface water pathway.

4.1 Summary of Surface Water and Treated Effluent Pathway

To assist in the understanding of this chapter, the following key definitions are provided:

- **Controlled runoff** is contaminated storm water that is collected and, under normal circumstances, treated and discharged to the Great Miami River as treated effluent.
- **Uncontrolled runoff** is storm water that is not collected for treatment, but enters the site's natural drainages.
- **Treated effluent** is water from numerous sources at the site, which is treated through one of the site's wastewater treatment facilities, then discharged to the Great Miami River.
- **Surface water** is water that flows within natural drainage features.

The treated effluent pathway is comprised of those flows discharged to the Great Miami River via the Parshall Flume (PF 4001). Discharges through this point are considered under the control of wastewater operations. Under normal operation this combined flow is comprised of:

- Storm water runoff collected from the former production area and the waste pit area
- Treated and untreated groundwater from the South Plume, South Field, and Waste Storage Area Aquifer Restoration Modules
- Treated remediation wastewater, such as on-site disposal facility leachate, decontamination rinse water generated during building decontamination and dismantling activities, and wastewater generated from pit dewatering and the operation of the Waste Pits Project dryer facility
- Treated sanitary wastewater from the sewage treatment plant.

During periods of heavy or sequential rainfall events when the Storm Water Retention Basin is close to overflowing, untreated storm water is bypassed directly to the Great Miami River in order to minimize or prevent the Storm Water Retention Basin from overflowing into Paddys Run.

The volume and flow rate of uncontrolled runoff depends on the amount of precipitation within any given period of time. Figure 1-10 in Chapter 1 shows monthly precipitation totals for 2004. Figure 4-1 shows the site's natural drainage features and defines the areas from which runoff is either controlled or uncontrolled. The site's natural surface water drainages include several tributaries to Paddys Run (e.g., Pilot Plant Drainage Ditch and Storm Sewer Outfall Ditch) as well as the northeast drainage that flows to the Great Miami River. The arrows on Figure 4-1 indicate the general flow direction of uncontrolled runoff that is determined from the topography. Uncontrolled runoff from the Fernald site leaves the property via two drainage pathways: Paddys Run and the northeast drainage.

4.2 Remediation Activities Affecting Surface Water Pathway

Major remediation activities in 2004 that affected (or had the potential to affect) the surface water pathway include:

- Construction activities associated with the on-site disposal facility including excavation, screening, and hauling activities in the on-site disposal facility borrow area
- Waste hauling and placement activities associated with the on-site disposal facility
- Soil excavation activities conducted by the Soil and Disposal Facility Project (refer to Chapter 2)
- Activities associated with the Waste Pits Project including dryer operation, pit excavation and waste material handling, and railcar loading
- Construction activities associated with the Accelerated Waste Retrieval; RCS; Silos 1 and 2 Project; and Silo 3 Project.

To minimize the effects of remediation on the environment, engineered and administrative controls are used at the Fernald site to reduce the amount of sediment entering the surface water drainages during rainfall events. As water flows over soil, contaminants typically move with the water either by being adsorbed to sediment eroded from the land surface or dissolved in the water itself. The chosen sediment control method varies based on the contaminants expected during excavation, the topography of the area, and the size and duration of the excavation.

Engineered sediment controls can include the construction of sedimentation basins (lined or unlined), silt fences, check dams, and permanent or temporary seeding. Diversion ditches are also constructed as an engineered control to divert clean water from upgradient areas away from areas of remediation. Ditches are sometimes lined with riprap (large rocks) and/or synthetic liners to control erosion. Administrative controls include limiting the duration of open excavations, as well as routinely inspecting each of the engineered controls used.

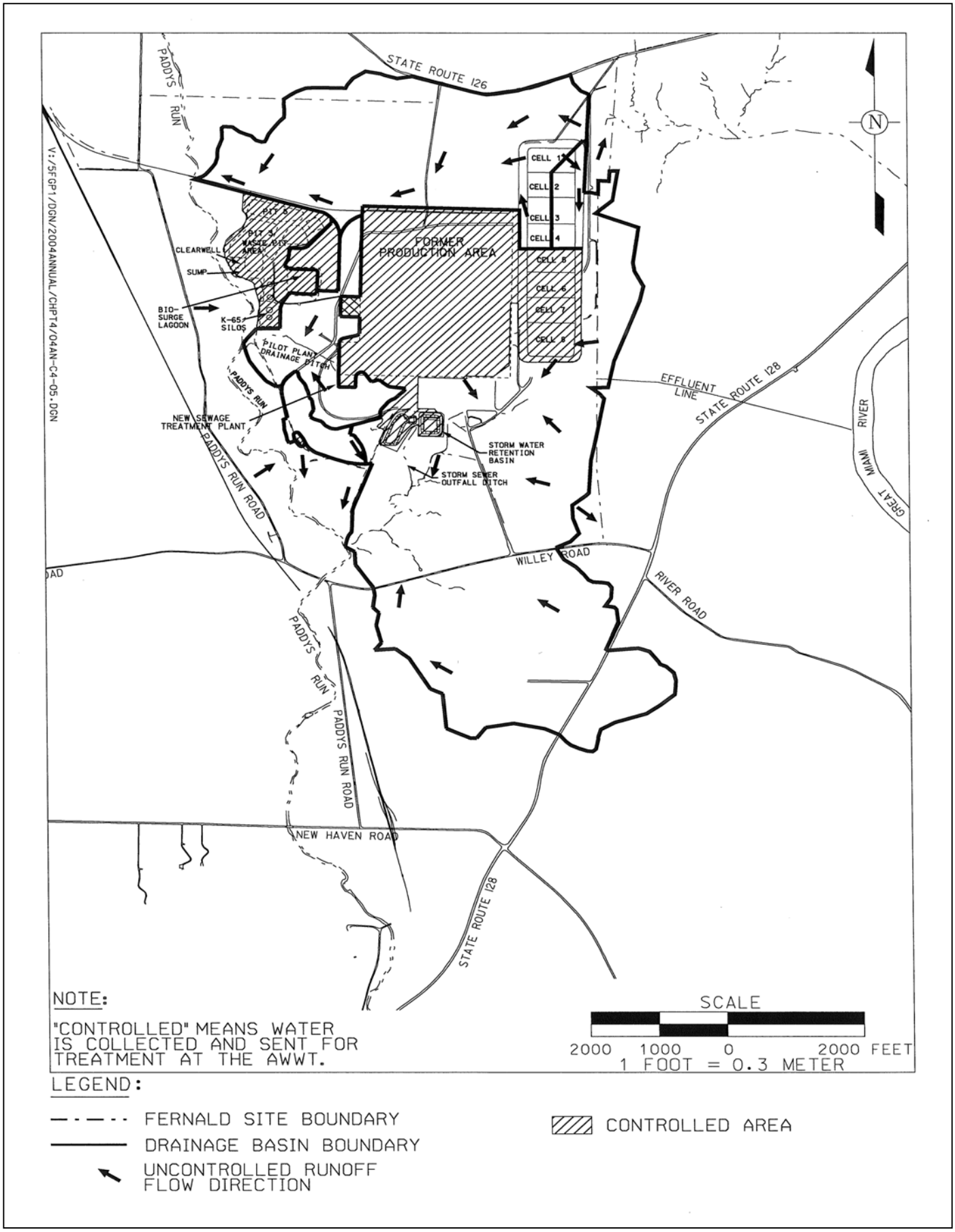


Figure 4-1. Controlled Surface Water Areas and Uncontrolled Runoff Flow Directions

Each remediation project is responsible for constructing and maintaining the engineered control structures required under its remedial design. All engineered sediment and surface water controls are inspected at least once a week, and within 24 hours of any rain event measuring greater than 0.5 inch (1.3 cm) of rain in a 24-hour period. Discharge points for uncontrolled runoff to Paddys Run are also inspected periodically to assess the effectiveness of upgradient controls in preventing significant impacts to Paddys Run. Minor maintenance activities (e.g., silt fencing repairs and reseeding of eroded areas) were performed in 2004 as a result of these inspections. Though no new storm water controls were installed in 2004, many engineered controls installed during previous years were still used and maintained.

4.3 Surface Water, Treated Effluent, and Sediment Monitoring Program for 2004

Surface water, treated effluent, and sediment are sampled to determine the effect of the Fernald site's remediation activities on the environment. Surface water is sampled at several locations in the site's drainages and analyzed for various radiological and non-radiological constituents. Treated effluent is sampled prior to discharge into the Great Miami River. Sediment is sampled for radiological constituents in the major site drainages (i.e., Paddys Run and Storm Sewer Outfall Ditch), and in the Great Miami River.

Following is a description of the key elements of the surface water and treated effluent program design:

- **Sampling** – Sample locations, frequency, and constituents were selected to address the requirements of the NPDES Permit, FFCA, and the Operable Unit 5 Record of Decision, and to provide a comprehensive assessment of surface water quality at 16 key locations including two background locations (refer to Figures 4-2 and 4-3). Surface water is monitored for up to 55 FRL constituents (refer to Table 2-1 in Chapter 2).

- **Data Evaluation** – The integrated data evaluation process focuses on tracking and evaluating data compared with background and historical ranges, FRLs, and NPDES limits. This information is used to assess impacts on surface water due to site remediation activities affecting uncontrolled runoff or treated effluent. The assessment also includes identifying the potential for impacts from surface water to the groundwater in the underlying Great Miami Aquifer. The ongoing data evaluation is designed to support remedial action decision-making by providing timely feedback to the remediation project organizations on the effectiveness of storm water runoff controls and treatment processes.

- **Reporting** – Surface water and treated effluent data are reported under the IEMP program and annual site environmental reports. Monthly discharge monitoring reports required by the NPDES Permit are submitted to OEPA.

The IEMP sediment monitoring program includes an annual sampling program with data reported through annual site environmental reports.

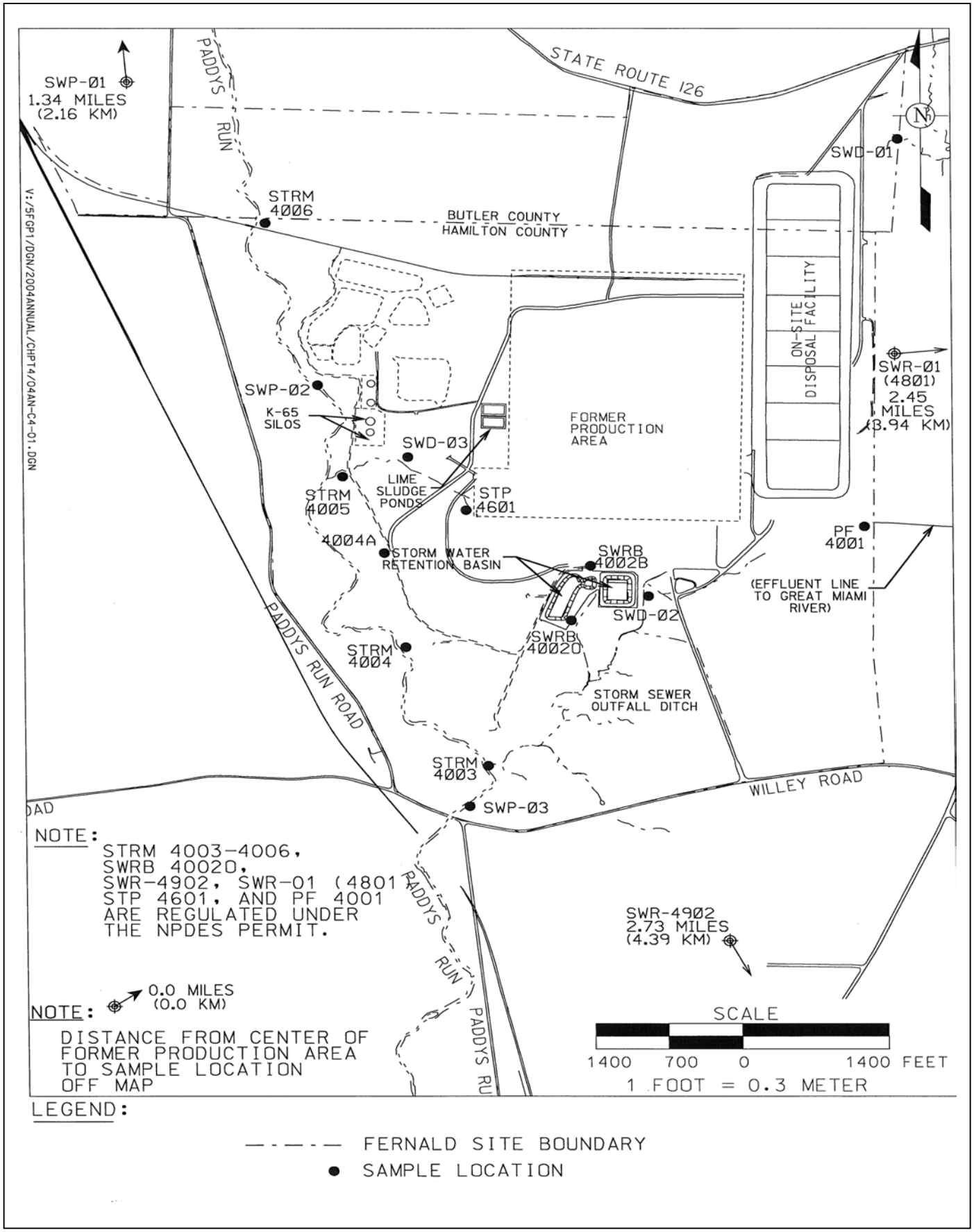


Figure 4-2. IEMP/NPDES Surface Water and Treated Effluent Sample Locations

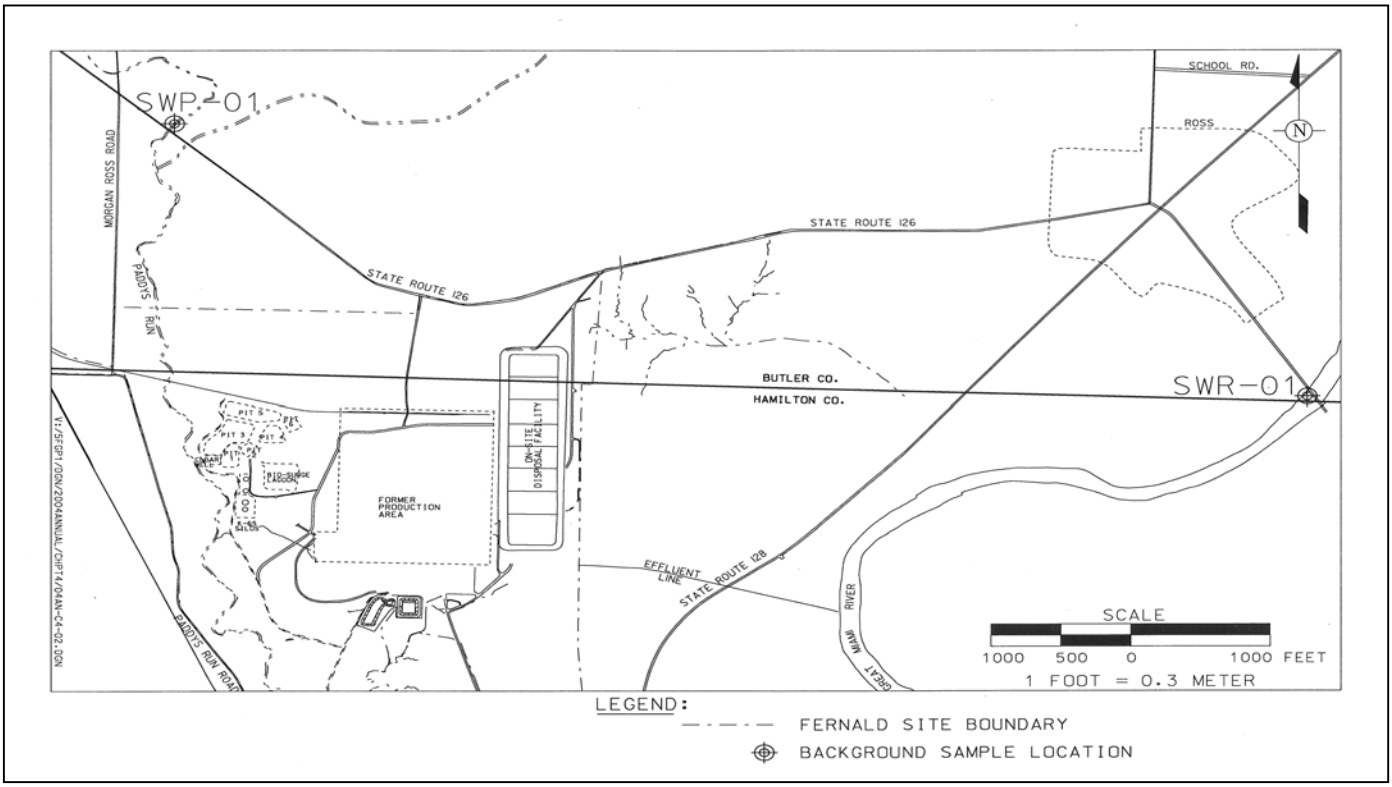


Figure 4-3. IEMP Background Surface Water Sample Locations

Data from samples collected under the IEMP are used to fulfill both surveillance and compliance monitoring functions. Surveillance monitoring results of the IEMP surface water and treated effluent program are used to assess the collective effectiveness of site storm water controls and wastewater treatment processes in preventing unacceptable impacts to the surface water and groundwater pathways. Compliance monitoring includes sampling at storm water and treated effluent discharge points into the surface water, and is conducted to comply with provisions in the NPDES Permit, the FFCA, and the Operable Unit 5 Record of Decision. The data are routinely evaluated to identify any unacceptable trends and to trigger corrective actions when needed to ensure protection of these critical environmental pathways. Figure 4-2 depicts IEMP/NPDES surface water and treated effluent sample locations; Figure 4-3 shows IEMP background sample locations.

Treated effluent is discharged to the Great Miami River through the effluent line identified on Figure 4-1. Samples of the treated effluent are collected at the Parshall Flume (PF 4001). The resulting data are used to calculate the concentration of each FRL constituent after the effluent water mixes with the water in the Great Miami River.

4.3.1 Surveillance Monitoring

Data resulting from 2004 sampling efforts were evaluated to provide surveillance monitoring of remediation activities. This evaluation showed that during 2004, there were no exceedances of the surface water total uranium FRL (530 µg/L) detected in any of the surface water and treated effluent samples. There were two non-uranium constituents with FRL exceedances. Table 4-1 summarizes these exceedances and Figure 4-4 identifies the locations of these exceedances.

Both of the non-uranium FRL exceedances occurred at the Great Miami background location SWR-01, which is situated upstream and outside the influence of Fernald site discharges. The background data are used to distinguish impacts from site activities against upstream water quality conditions. Therefore, concentrations at the background location (Great Miami River [SWR-01]) are not attributable to the Fernald site.

TABLE 4-1
CONSTITUENTS WITH RESULTS ABOVE SURFACE WATER FRLs DURING 2004

Constituent	Number of Locations Exceeding FRL	Surface Water FRL	Range of 2004 Data Above FRL
Inorganics		(mg/L)	(mg/L)
Copper	1	0.012	0.0216
Semi-Volatile Organics		(µg/L)	(µg/L)
Dibenzo(a,h)anthracene	1	1.0	1.9

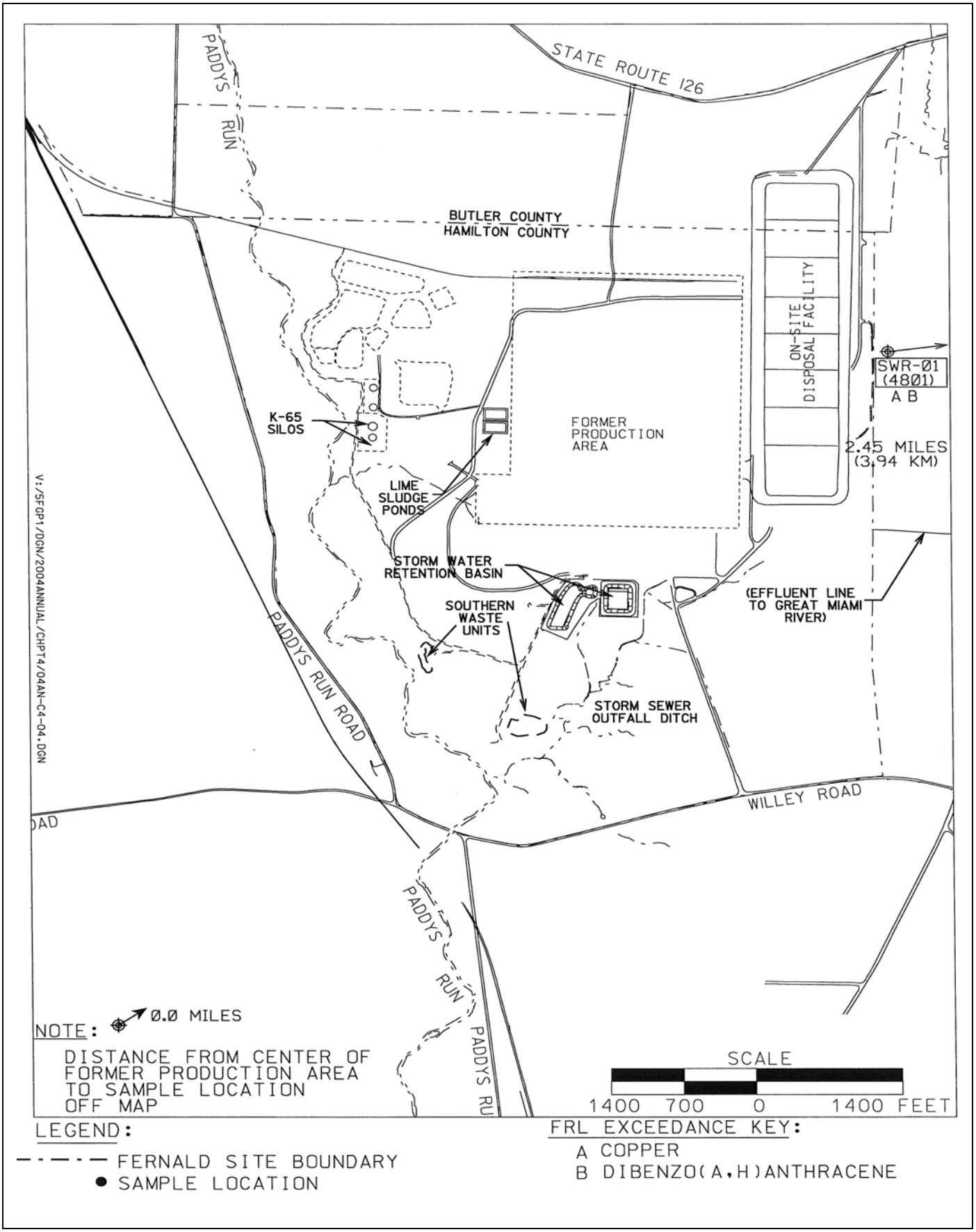


Figure 4-4. Constituents with 2004 Results Above Final Remediation Levels

Additional details of the FRL exceedances are presented in Appendix B, Attachment B.1, of this report.

The following two key sample locations represent points where surface water or treated effluent leaves the site:

- Paddys Run at the Willey Road property boundary (sample location SWP-03)
- Parshall Flume (PF 4001) located at the entry point of the effluent line leading to the Great Miami River.

Evaluation of the data from these locations is especially important because the locations represent points beyond which direct exposure to the public is possible. There were no FRL exceedances during 2004 at these two locations.

The maximum total uranium concentration at SWP-03 during 2004 was 2.8 µg/L, which is below the surface water total uranium FRL of 530 µg/L. Figure 4-5 shows the annual average total uranium concentration in Paddys Run at Willey Road for the period 1985 through 2004. This figure illustrates the decrease of the total uranium concentration in Paddys Run from 1986 following completion of the Storm Water Retention Basin, which collects contaminated storm water from the former production area.

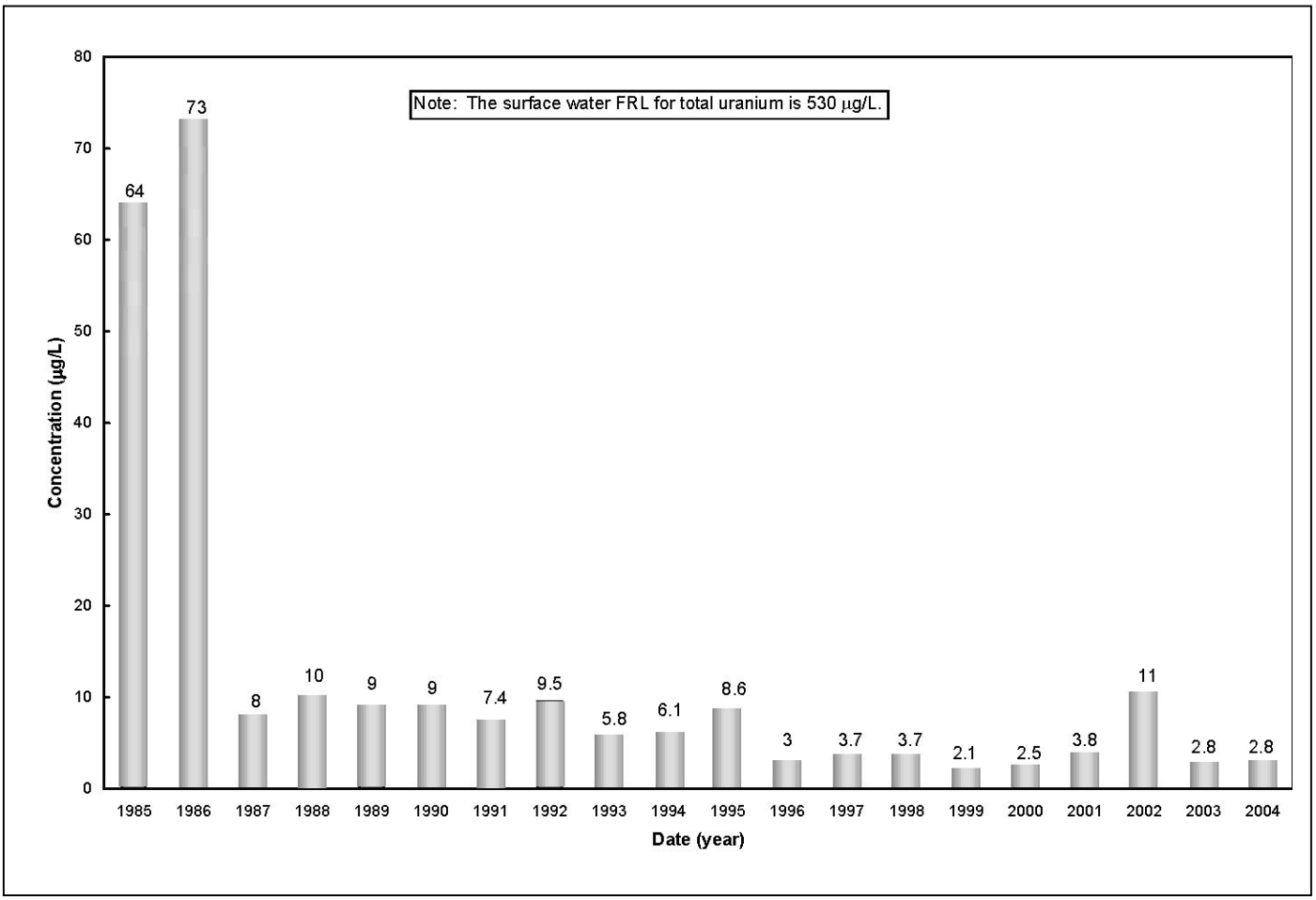


Figure 4-5. Annual Average Total Uranium Concentrations in Paddys Run at Willey Road (SWP-03) Sample Location, 1985-2004

Samples collected at the Parshall Flume (PF 4001) are used in the surveillance evaluation because this is the last point where treated effluent is sampled prior to discharge to the Great Miami River. Data collected from this location cannot directly be compared to the surface water FRL without considering the effect of the effluent waters mixing with the Great Miami River. This is done through the use of a mixing equation.

The maximum daily total uranium concentration at the Parshall Flume (PF 4001) in 2004 prior to discharge through the effluent line to the Great Miami River was 57.3 µg/L. After the water from the Parshall Flume (PF 4001) mixed with the water in the Great Miami River, the concentration would have been approximately 1.24 µg/L. Both concentrations, those from the Parshall Flume (PF 4001) and after mixing with the Great Miami River, were well below the surface water total uranium FRL of 530 µg/L. Contaminant concentrations observed at the Parshall Flume (PF 4001) in 2004 are discussed further in the compliance monitoring section.

Evaluation of surface water data is also performed in order to provide an ongoing assessment of the potential for cross-media impacts from surface water to the underlying Great Miami Aquifer. In areas where there is no glacial overburden, a direct pathway exists for contaminants to reach the aquifer. This contaminant pathway to the aquifer was considered in the design of the groundwater remedy, and includes placing groundwater extraction wells downgradient of these areas where direct infiltration occurs in order to mitigate any potential cross-media impacts during surface remediation. To provide this assessment, sample locations were selected to evaluate contaminant concentrations in surface water just upstream of, or within, those areas where site drainages have eroded through the protective glacial overburden. This includes locations SWP-02, SWD-02, SWD-03, STRM 4005, and the Storm Water Retention Basin overflow (SWRB 4002O).

During 2004, two of the five surface water locations evaluated (SWD-03 and STRM 4005) had results that exceeded the total uranium groundwater FRL of 30 µg/L. Table 4-2 summarizes these total uranium cross-media exceedances. Additionally, of the locations evaluated, only SWD-03 had a result that exceeded the groundwater FRL for a constituent other than uranium. This groundwater FRL exceedance was for zinc from a sample collected on April 13, 2004 (0.0317 mg/L versus groundwater FRL of 0.021 mg/L).

TABLE 4-2
SURFACE WATER TOTAL URANIUM RESULTS EXCEEDING THE GROUNDWATER FRL AT CROSS-MEDIA IMPACT LOCATIONS DURING 2004

Location	Number of Surface Water Results Exceeding the Groundwater FRL for Total Uranium[a]	Total Number of Samples	Range of 2004 Data above FRL (µg/L)
STRM 4005	3	4	62.3 – 304.9
SWD-03	1	4	40.7

[a]The surface water result is compared to the groundwater FRL of 30 µg/L for the purpose of evaluating potential cross-media impacts.

4.3.2 Compliance Monitoring

4.3.2.1 FFCA and Operable Unit 5 Record of Decision Compliance

The FCP is required to monitor treated effluent discharges at the Parshall Flume (PF 4001) for total uranium mass discharges and total uranium concentrations. This requirement is identified in the July 1986 FFCA and the Operable Unit 5 Record of Decision. The Operable Unit 5 Record of Decision requires treatment of effluent so that the mass of total uranium discharged to the Great Miami River through the Parshall Flume (PF 4001) does not exceed 600 pounds (272 kg) per year. The Operable Unit 5 Record of Decision and subsequent approval of the Explanation of Significant Differences also require that the monthly average total uranium concentration in the effluent must be at or below 30 µg/L.

The Operable Unit 5 Record of Decision allows the Fernald site to discharge water from the Storm Water Retention Basin directly to the Great Miami River during periods of heavy precipitation. This is allowed in order to reduce the possibility of an overflow condition for the Storm Water Retention Basin. An overflow condition has the potential to generate cross-media impacts as described above.

To comply with the monthly average total uranium concentration limit during these types of bypasses, the FCP is allowed to deduct these uranium concentrations from the monthly average total uranium calculation at the Parshall Flume (PF 4001) for up to 10 significant precipitation bypass days per year. However, the mass of total uranium discharged during these 10 days per year is still considered in the total discharge mass in order to ensure the discharge limit of 600 pounds (272 kg) per year is not exceeded.

In addition to significant precipitation-related bypasses, the site is also allowed to bypass water from the Storm Water Retention Basin during certain scheduled wastewater treatment plant maintenance activities. These maintenance bypasses must be pre-approved by the regulatory agencies. The total uranium concentration in the discharge related to maintenance activities may be deducted from the monthly average calculation demonstrating compliance with the total uranium monthly average concentration limit. However, the mass of total uranium discharged during these maintenance bypasses is still considered in the total discharge mass to ensure the discharge limit of 600 pounds (272 kg) per year is not exceeded.

During 2004, there were no bypass events as a result of significant precipitation or for maintenance activities. Figure 4-6 shows that the cumulative mass of total uranium discharged to the Great Miami River during 2004 was 508.75 pounds (230.97 kg), which is below the annual discharge limit of 600 pounds (272 kg). Figure 4-7 shows that the total uranium monthly average concentration limit was met every month during 2004.

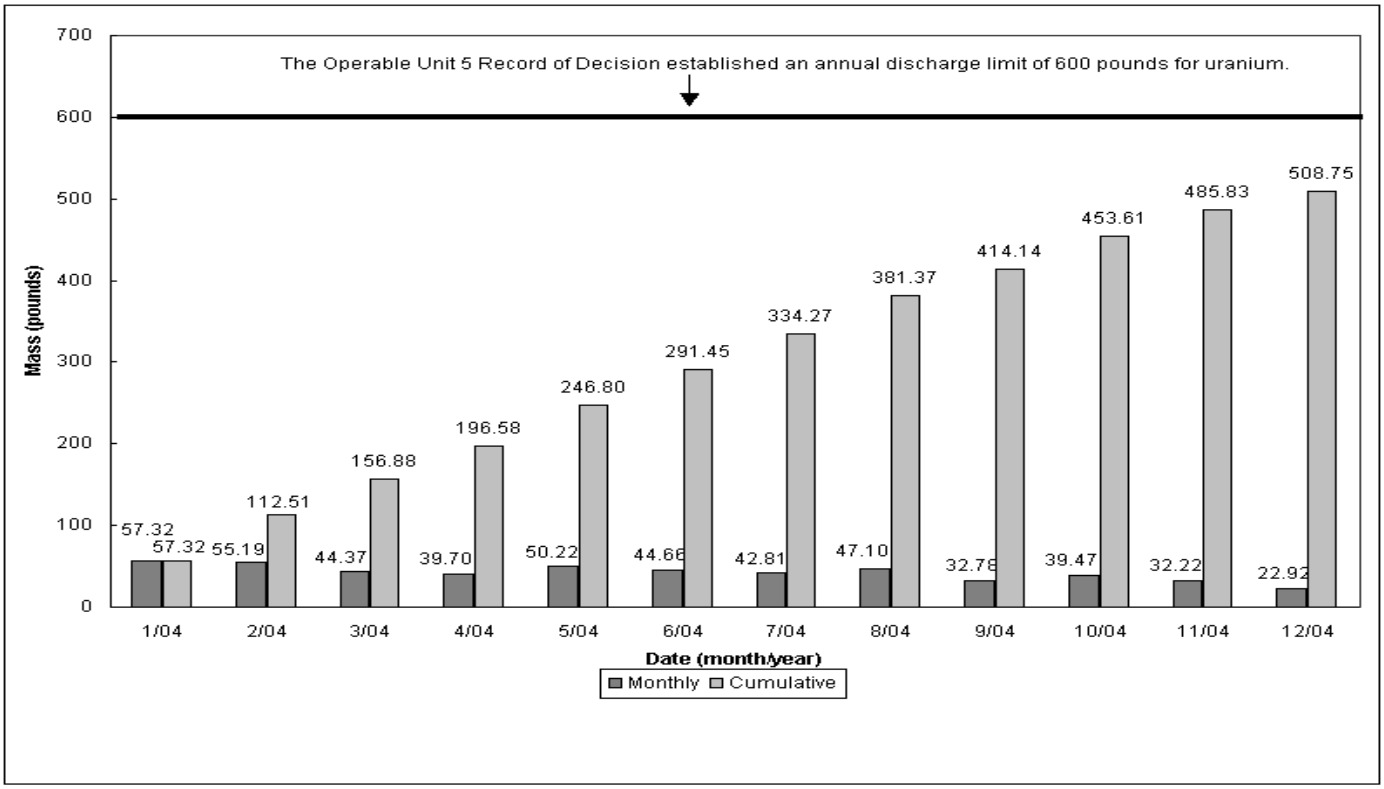


Figure 4-6. Pounds of Uranium Discharged to the Great Miami River from the Parshall Flume (PF-4001) in 2004

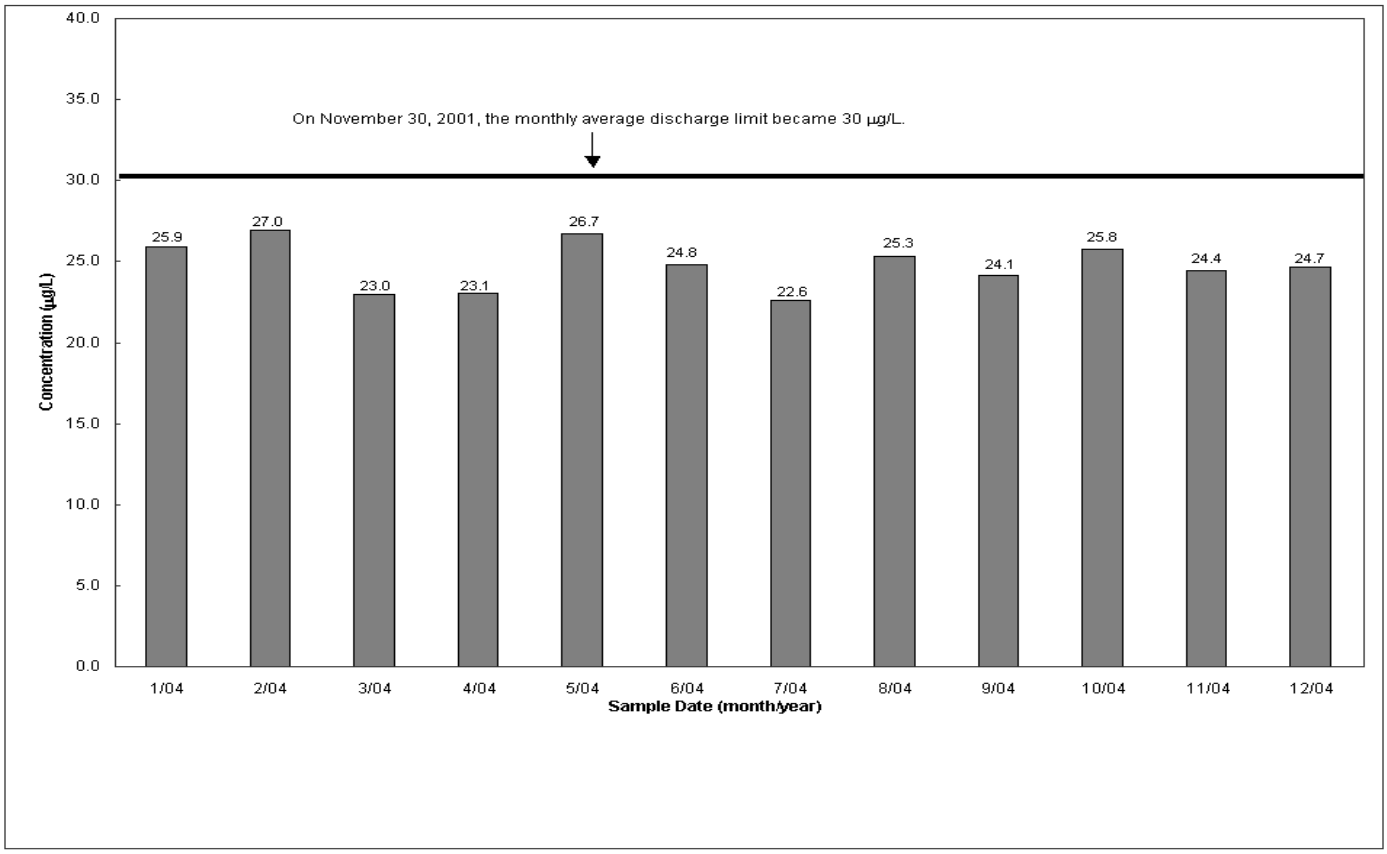


Figure 4-7. 2004 Monthly Average Total Uranium Concentration in Water Discharged from the Parshall Flume (PF 4001) to the Great Miami River

4.3.2.2 NPDES Permit Compliance

Compliance sampling, consisting of sampling for non-radiological pollutants from uncontrolled runoff and treated effluent discharges from the Fernald site, is regulated under the state-administrated NPDES program. The current permit became effective on July 1, 2004, and expires on June 30, 2008. The permit specifies discharge and sample requirements, as well as discharge limits for several constituents. Figure 4-2 identifies NPDES sample locations. A total of eight non-compliances were reported to OEPA pursuant to the terms of the NPDES Permit, as summarized in Table 4-3.

TABLE 4-3

EXCEEDANCES OF THE NPDES PERMIT DURING 2004

Date/ Month	Location	Parameter	Permit Limit	Actual Result	Possible Cause	Corrective Action
January	STP 4601 (Sewage Treatment Plant Effluent)	Total Suspended Solids (average)	20 mg/L	22.5 mg/L	Cold temperatures affecting performance	None. Continue to monitor and observe.
2/17	STP 4601 (Sewage Treatment Plant Effluent)	Total Suspended Solids	40 mg/L	52.0 mg/L	Cold temperatures affecting performance	None. Continue to monitor and observe.
2/24	STP 4601 (Sewage Treatment Plant Effluent)	Total Suspended Solids	40 mg/L	65.0 mg/L	Cold temperatures affecting performance	None. Continue to monitor and observe.
2/26	STP 4601 (Sewage Treatment Plant Effluent)	Total Suspended Solids	40 mg/L	53.0 mg/L	Cold temperatures affecting performance	None. Continue to monitor and observe.
February	STP 4601 (Sewage Treatment Plant Effluent)	Total Suspended Solids (average)	20 mg/L	34.2 mg/L	Cold temperatures affecting performance	None. Continue to monitor and observe.
March	STP 4601 (Sewage Treatment Plant Effluent)	Total Suspended Solids (average)	20 mg/L	26.1 mg/L	Cold temperatures affecting performance	None. Continue to monitor and observe.
4/4	STP 4601 (Sewage Treatment Plant Effluent)	Total Suspended Solids	40 mg/L	48.0 mg/L	Cold temperatures affecting performance	None. Continue to monitor and observe.
April	STP 4601 (Sewage Treatment Plant Effluent)	Total Suspended Solids (average)	20 mg/L	26.1 mg/L	Cold temperatures affecting performance	None. Continue to monitor and observe.

4.3.3 Uranium Discharges in Surface Water and Treated Effluent

As identified in Figure 4-6, 508.75 pounds (230.97 kg) of uranium in treated effluent were discharged to the Great Miami River through the Parshall Flume (PF 4001) in 2004. In addition to the treated effluent, uncontrolled runoff is also contributing to the amount of uranium entering the environment. Figure 4-8 presents the pounds of uranium from the uncontrolled runoff and controlled discharges from 1993 through 2004.

Beginning in 1999, estimates of uncontrolled runoff have been calculated using a loading term of 2.6 pounds (1.2 kg) of uranium discharged to Paddys Run for every inch (2.54 cm) of rainfall. This term was revised in 1999 based on analytical data reflecting the decreasing total uranium concentrations measured at points discharging to Paddys Run. Total uranium concentrations have been decreasing due to significant improvements in the capture of contaminated storm water by the Pilot Plant Drainage Sump, southern waste unit source removal, and excavation and placement of contaminated soils into the on-site disposal facility. During 2004, 40.06 inches (101.75 cm) of precipitation fell at the Fernald site; therefore, an estimated 104.16 pounds (47.29 kg) of uranium entered the environment through uncontrolled runoff.

The estimated total amount of uranium discharged to the surface water pathway for the year, including both controlled treated effluent discharges and uncontrolled runoff, was approximately 612.91 pounds (278.26 kg).

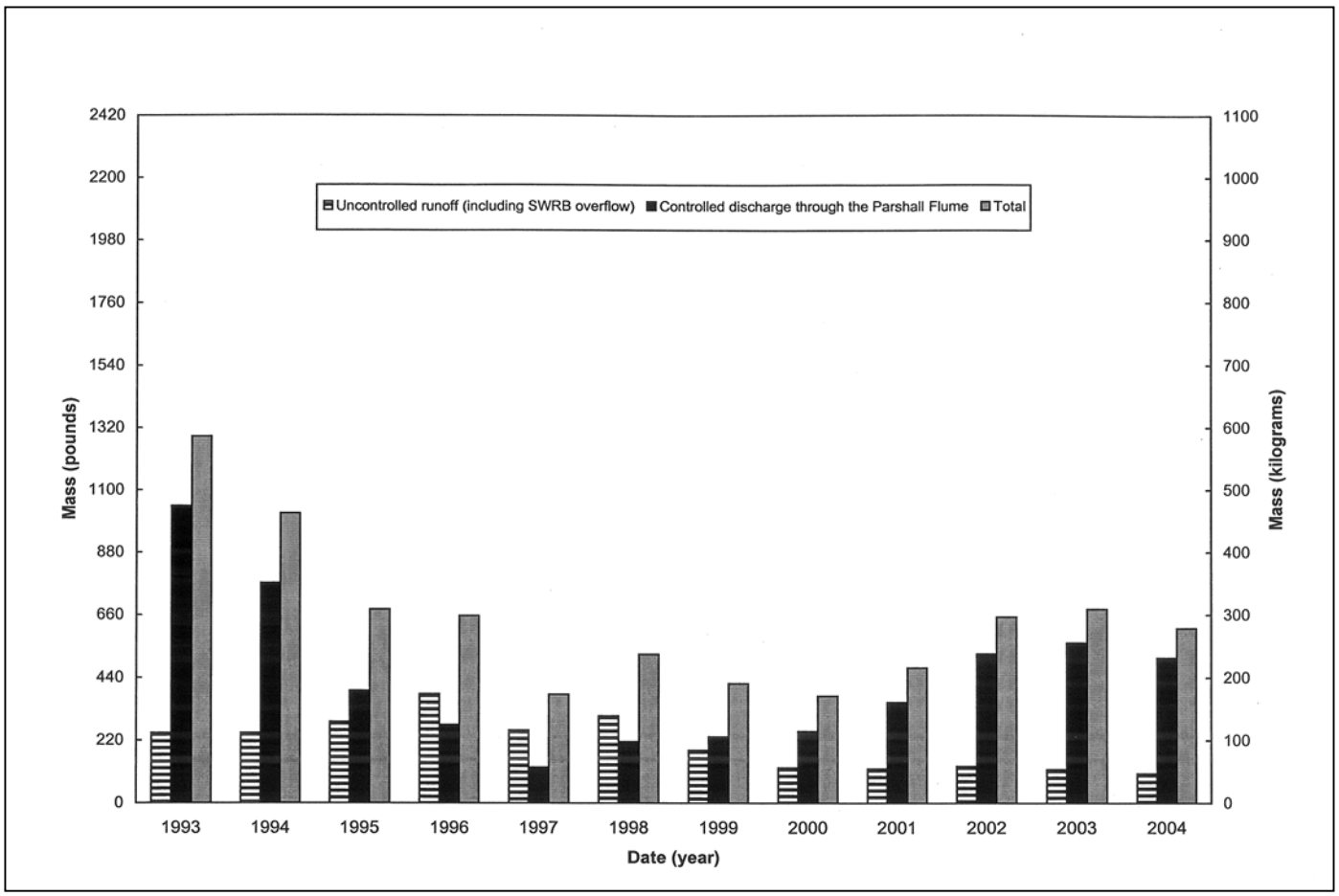


Figure 4-8. Uranium Discharged Via the Surface Water Pathway, 1993-2004

4.4 Sediment Monitoring

Sediment is a secondary exposure pathway and is monitored annually to assess the impact of remediation activities on sediments deposited along surface water drainages. Sediment is collected at strategic locations to ensure that the most recently deposited sediment is collected.

Sediment samples were collected in August and September 2004 at 16 locations along Paddys Run, the Storm Sewer Outfall Ditch, and the Great Miami River (refer to Figure 4-9). All of these samples were analyzed for total uranium. Samples collected from the Storm Sewer Outfall Ditch, Paddys Run, and the Paddys Run background location were also analyzed for radium-226, radium-228, thorium-228, thorium-230, and thorium-232. Table 4-4 presents analytical results of samples collected from the Storm Sewer Outfall Ditch, Paddys Run, and the Great Miami River in 2004. Note that some locations referenced above were sampled under the Stream Corridors Project as indicated on Table 4-4 and Figure 4-9.

Table 4-4 shows all constituents results were below their respective sediment FRLs. Final certification of the on-site drainage ways is expected to occur in 2005 or early 2006. Appendix B, Attachment B.2, of this report contains additional details of the sediment monitoring results.

TABLE 4-4
2004 SUMMARY STATISTICS FOR SEDIMENT MONITORING PROGRAM

Radionuclide	Sediment FRL	No. of Samples[a]	2004 Results – Concentration (dry weight) Minimum[a,b,c,d] pCi/g)	(mg/kg)	Maximum[a,b,c] (pCi/g)	(mg/kg)
Great Miami River, North of the Effluent Line (G2)						
Total Uranium	210 mg/kg	1	1.75	(2.59)	NA	NA
Great Miami River, South of the Effluent Line (G4)						
Total Uranium	210 mg/kg	1	2.95	(4.37)	NA	NA
Paddys Run Background, North of S.R. 126 (P1)						
Radium-226	2.9 pCi/g	1	0.615	NA	NA	NA
Radium-228	4.8 pCi/g	1	0.394	NA	NA	NA
Thorium-228	3.2 pCi/g	1	0.323	NA	NA	NA
Thorium-230	18,000 pCi/g	1	0.714	NA	NA	NA
Thorium-232	1.6 pCi/g	1	0.337	NA	NA	NA
Total Uranium	210 mg/kg	1	1.13	(1.67)	NA	NA
Paddys Run, North of the Storm Sewer Outfall Ditch (PN1-PN5)[e]						
Radium-226	2.9 pCi/g	5	0.639	NA	0.908	NA
Radium-228	4.8 pCi/g	5	0.306	NA	0.611	NA
Thorium-228	3.2 pCi/g	5	0.302	NA	0.631	NA
Thorium-230	18,000 pCi/g	5	0.65	NA	2.58	NA
Thorium-232	1.6 pCi/g	5	0.306	NA	0.611	NA
Total Uranium	210 mg/kg	5	0.96	(1.42)	2.97	(4.39)
Storm Sewer Outfall Ditch (D1-D5)						
Radium-226	2.9 pCi/g	5	0.512	NA	0.852	NA
Radium-228	4.8 pCi/g	5	0.263	NA	1.01	NA
Thorium-228	3.2 pCi/g	5	0.342	NA	1.13	NA
Thorium-230	18,000 pCi/g	5	0.714	NA	1.45	NA
Thorium-232	1.6 pCi/g	5	0.275	NA	0.832	NA
Total Uranium	210 mg/kg	5	1.56	(2.31)	4.03	(5.96)
Paddys Run, South of the Storm Sewer Outfall Ditch (PS1-PS3)[e]						
Radium-226	2.9 pCi/g	2	0.503	NA	0.564	NA
Radium-228	4.8 pCi/g	2	0.294	NA	0.322	NA
Thorium-228	3.2 pCi/g	2	0.308	NA	0.308	NA
Thorium-230	18,000 pCi/g	2	0.79	NA	1.53	NA
Thorium-232	1.6 pCi/g	2	0.294	NA	0.322	NA
Total Uranium	210 mg/kg	3	1.24	(1.83)	2.34	(3.47)

[a]If more than one sample is collected per sample location (e.g., split or duplicate), then only one sample is counted for the number of samples, and the sample with the maximum concentration is used for determining the summary statistics (minimum and maximum).
[b]If the number of samples is greater than or equal to two, then the minimum and maximum are reported. If the number of samples is equal to one, then the result is reported as the minimum.
[c]NA = not applicable
[d]Where concentrations are below the detection limit, each result used in the summary statistics is set at half the detection limit.
[e]Locations PN1, PN2, PN3, PN4, PN5, PS1, and PS2 were sampled under the Stream Corridors Project using locations PRT-29, PRT-28, PRT-23, PRT-19, PRT-10, PRT-30, and PRT-32, respectively. These locations are immediately downstream of the original locations.

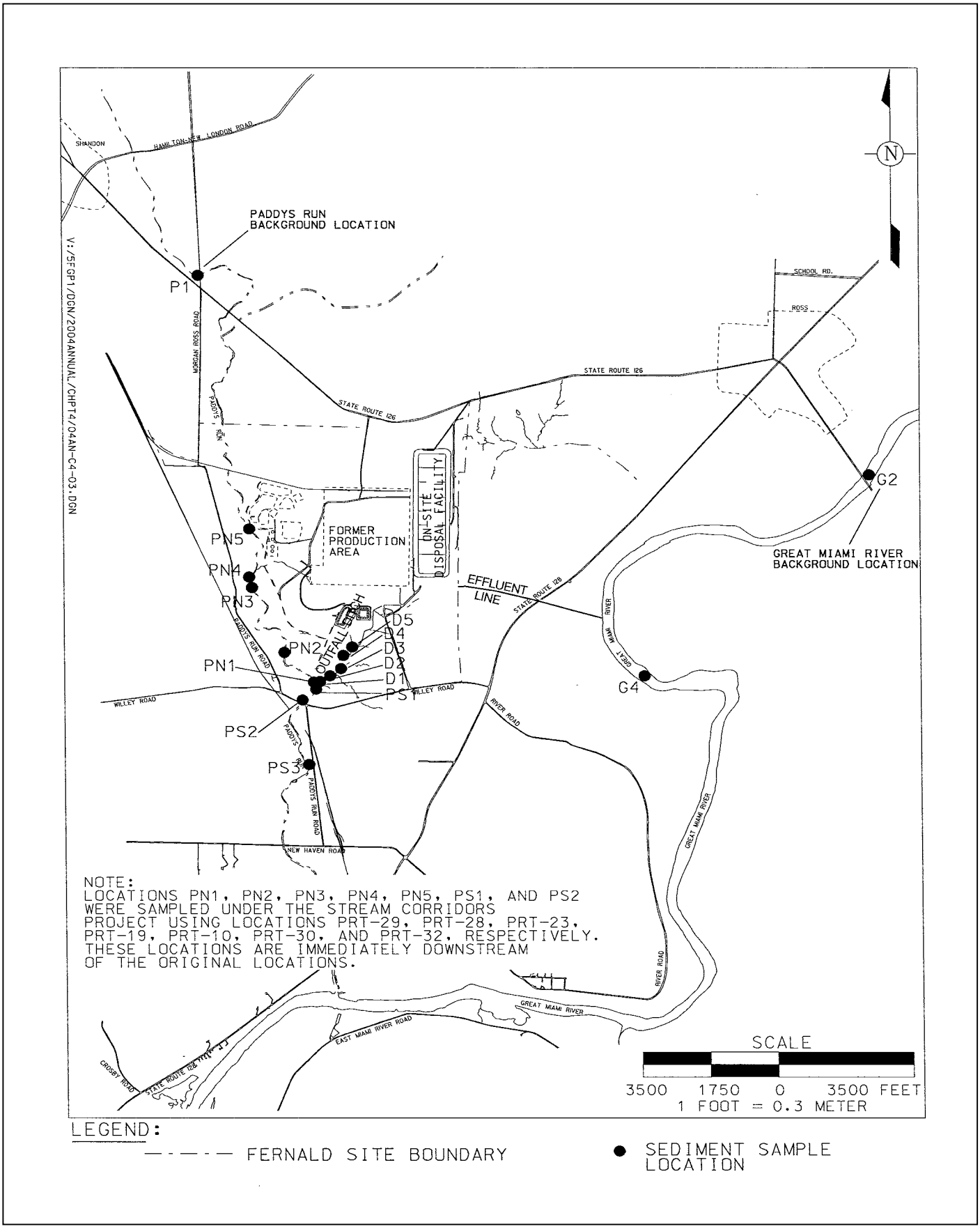


Figure 4-9. 2004 Sediment Sample Locations

5.0 Air Pathway

This chapter describes the air pathway monitoring program used to track and evaluate airborne emissions from the Fernald site. It includes a discussion of radiological air particulates, radon, and direct radiation. In addition, this chapter provides a summary of radiological emissions from stacks and vents, as well as non-radiological emissions associated with the combustion of fossil fuel.

Results in Brief: 2004 Air Pathway

Radiological Air Particulates — Data collected from fenceline air monitoring stations show that average concentrations for each radionuclide monitored were less than 1 percent of the corresponding DOE-derived concentration guide.

Radon — There were no exceedances of the DOE standard (3 pCi/L annual average above background) at the site fenceline and off-property locations. The maximum annual average concentration at the FCP fenceline measured by continuous radon monitors was 0.3 pCi/L above background.

Direct Radiation — Direct radiation measurements at the site fenceline and the K-65 Silos boundary were similar to those in 2003. This was attributed to the continuing operation of the Radon Control System (RCS).

Air pathway monitoring focuses on airborne pollutants that may be carried from the site as a particle or gas, and how these pollutants are distributed in the environment. The physical form and chemical composition of pollutants influence how they are dispersed in the environment and how they may deliver radiation doses. For example, fine particles and gases remain suspended, while larger, heavier particles tend to settle and deposit on the ground. Chemical properties determine whether the pollutant will dissolve in water, be absorbed by plants and animals, or settle in sediment and soil.

Monitoring the air pathway is critical to ensuring the continued protection of the public and the environment during the remediation process because airborne contaminants can potentially migrate beyond the Fernald site. The site's air monitoring approach (presented in the IEMP) provides an ongoing assessment of the collective emissions originating from remediation activities. The results of this assessment are used to provide feedback to remediation project organizations regarding the site-wide effectiveness of project-specific emission controls relative to DOE, EPA, and OEPA standards. In response to this feedback, project organizations modify or maintain emission controls.

5.1 Remediation Activities Affecting the Air Pathway

When the mission of the Fernald site changed from production to remediation, work activities also changed. This change in work scope altered the characteristics of sources that emit pollutants in the environment via the air pathway. During the production years, the primary emission sources were point sources (i.e., stacks and vents) from process facilities. Today the dominant emission sources are associated with remediation activities in the form of fugitive emissions (i.e., excavation, hauling and processing of waste and contaminated soil, demolition of production facilities, and general construction activities supporting the remediation process), and the storage of radon-generating waste materials.

The following primary emission sources were active during 2004:

- Decontamination and demolition activities, most notably Plant 2/3, Pilot Plant (Building 54A), and the Pilot Plant Warehouse (Operable Unit 3)
- Excavation of the waste pits and the associated waste processing and rail car load-out operations at the Waste Pits Project (Operable Unit 1)
- Excavation of contaminated soil and debris (Operable Unit 5)

- Construction activities associated with the on-site disposal facility including excavation, screening, and hauling activities in the on-site disposal facility borrow area (Operable Unit 2)

- Transportation and placement of contaminated material in the on-site disposal facility and interim storage at the on-site material transfer area (Operable Unit 2)

- Radon Control System (RCS) and Silos 1 and 2 Waste Retrieval operations (Operable Unit 4).

Each project is responsible for designing and implementing engineered and administrative controls for each remediation activity. The fugitive emissions control policy mandates that fugitive emissions be visually monitored and controls be implemented as necessary. The following types of controls are used to keep point source and fugitive emissions to a minimum.

- **Engineered Controls** − Typical engineered controls include physical barriers, wetting agents, filtration, fixatives, sealants, dust suppressants and control, collection, and treatment systems. Engineered designs help reduce point source and fugitive emissions by using the best available technology. The selection of the best available technology for controlling project emissions is conducted during the design process and frequently includes the evaluation of several treatment alternatives.

- **Administrative Controls** − Typical administrative controls include management and control procedures; record keeping; periodic assessments; and established speed limits, control zones, and construction zones.

5.2 Air Monitoring Program Summary for 2004

The site's air monitoring program, as defined in the IEMP, is comprised of three distinct components:

- Radiological air particulate monitoring
- Radon monitoring
- Direct radiation monitoring.

Each component of the air monitoring program is designed to address a unique aspect of air pathway monitoring, and as such, reflects distinct sampling methodologies and analytical procedures. The key elements of the air monitoring program design are:

- **Sampling** – Sample locations, frequency, and the constituents were selected to address DOE and EPA requirements for assessing radiological emissions from the Fernald site. Key considerations in the design of the sampling program included prevailing wind directions, location of potential sources of emissions, and the location of off-property receptors. The IEMP program includes monitoring radiological air particulates at 18 locations, radon measurements at 32 locations, and direct radiation at 37 locations on and off the property.

- **Data Evaluation** – The data evaluation process focuses on tracking and trending data against historical ranges and DOE, EPA, and OEPA standards. Each section in this chapter presents an evaluation of data and a comparison to applicable standards and guidelines.

- **Reporting** – All data are reported through the IEMP program and annual site environmental reports.

5.3 Radiological Air Particulate Sampling Results

As described in the IEMP, Revision 3, a network of 18 high-volume air particulate monitoring stations is used to measure the collective contributions from all fugitive and point source particulate emissions from the site. The current monitoring network includes 16 monitoring locations on the fenceline and one background location. In addition, one thorium monitor was operated on the western fenceline. Figure 5-1 provides the locations of the IEMP air monitoring stations.

The sampling and analysis program for the 16 fenceline and background locations consists of biweekly total uranium and total particulate analyses, and monthly composites (eight times per year) for isotopic thorium analyses, in addition to a quarterly composite sample. The quarterly composite sample is analyzed for the expected major contributors (i.e., uranium, thorium, and radium) to the radiological air inhalation dose at the site's boundary. The thorium monitor includes biweekly particulate and monthly isotopic thorium analyses. Analytical data from this program are used to assess the effectiveness of the emission control practices throughout the year to ensure particulate emissions remain below health protective standards.

The radiological air particulate monitoring program is designed to demonstrate compliance with the following:

- NESHAP Subpart H requirements which stipulate that radionuclide emissions (not including radon) to the ambient air from DOE facilities shall not exceed those amounts that would cause any member of the public to receive an effective dose equivalent of 10 millirem (mrem) in a year above background levels. This dose is reported in the annual NESHAP Subpart H compliance report and is included as Appendix D of this report.

- DOE Order 5400.5, Radiation Protection of the Public and the Environment (DOE 1993), guidelines for concentrations of radionuclides in air emissions. These guidelines, referred to as derived concentration guide values, are concentrations of radionuclides that, under conditions of continuous exposure for one year by one exposure mode (e.g., inhalation or ingestion), would result in a dose of 100 mrem to the public. These derived concentration guide values are not limits, but serve as reference values to assist in evaluating the radiological air particulate data.

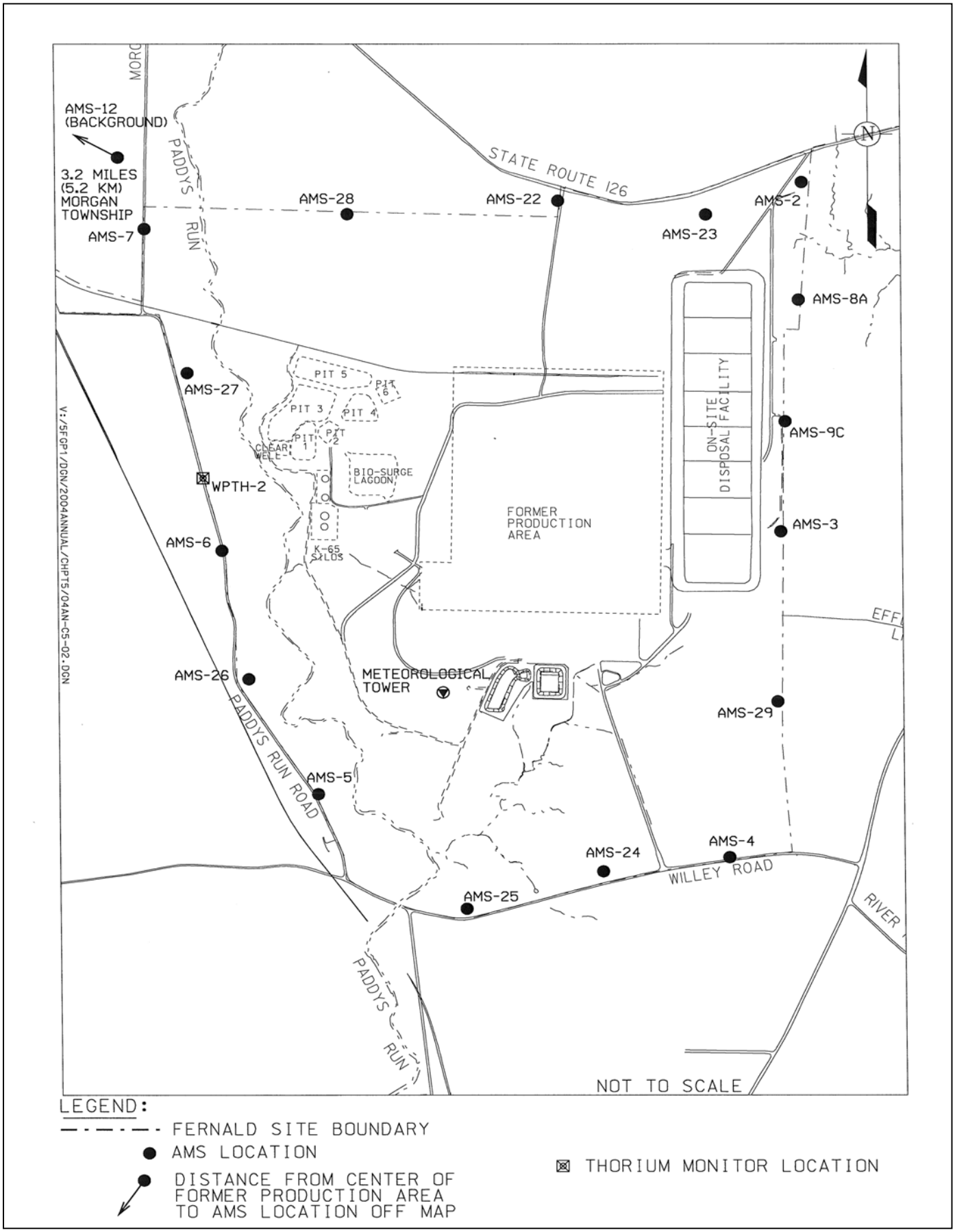


Figure 5-1. Radiological Air Monitoring Locations

Table 5-1 presents a summary of the minimum, maximum, and average concentrations for total uranium, thorium-230, and total particulate in 2003 and 2004 based on the biweekly and monthly sample results used for monitoring air emission trends. For 2004, the annual average concentrations of total uranium at all fenceline air monitoring stations were less than 1 percent of the DOE derived concentration guide (DCG) value (0.1 picoCuries per cubic meter [pCi/m^3]). In 2004, total uranium at all air monitoring locations ranged from non-detectable at the background monitor to 1.3E-02 pCi/m^3 at AMS-23.

TABLE 5-1

SUMMARY OF BIWEEKLY TOTAL URANIUM, TOTAL PARTICULATE, AND MONTHLY THORIUM-230 CONCENTRATIONS IN AIR

Location	2004 Total Uranium (pCi/m^3)	2003 Total Uranium (pCi/m^3)	2004 Total Particulate (µg/m^3)	2003 Total Particulate (µg/m^3)	2004 Thorium-230 (pCi/m^3)	2003 Thorium-230 (pCi/m^3)
Fenceline Locations						
Minimum	1.3E-006	3.3E-06	8	5	1.9E-006	0.0E+00
Maximum	1.3E-002	2.3E-03	102	124	4.2E-004	2.1E-04
Average	2.5E-004	1.7E-04	35	34	4.6E-005	6.0E-05
Background Locations						
Minimum	0.0E+000	3.2E-06	6	14	0.0E+000	0.0E+00
Maximum	1.1E-004	4.0E-05	42	48	2.7E-005	3.6E-05
Average	1.6E-005	1.4E-05	26	25	1.1E-005	1.2E-05

Biweekly thorium monitoring at the fenceline provides timely feedback on project engineered and administrative controls that are implemented to control fugitive emissions, primarily at the Waste Pits Project. The fenceline concentrations of thorium-230 (the primary thorium isotope of concern in the waste pit material being excavated) ranged from less-than-detectable to 4.2E-04 pCi/m^3, which was detected at the WPTH-2 project monitor.

In addition to the total uranium and isotopic thorium analyses, total particulate measurements are also obtained from each filter every two weeks as summarized in Table 5-1. Total particulate concentrations at the fenceline ranged from 8 micrograms per cubic meter (µg/m^3) to a maximum of 102 µg/m^3 at AMS-3. There are no general or site-specific regulatory limits associated with total particulate measurements used in the data evaluation process.

Total particulate, total uranium, and thorium-230 data were collectively evaluated to identify any increasing trends that may be related to remediation activities. Several temporary increases of these three constituents were observed at various monitoring locations; however, the short-lived increases did not pose a potential exceedance of the NESHAP dose limit of 10 mrem or DOE guidelines. The majority of increases in total uranium and thorium-230 concentrations were detected in the northeast quadrant of the site. Figures 5-2 and 5-3 show total uranium and thorium-230 concentrations, respectively, at the selected fenceline locations (AMS-22, AMS-23, and AMS-8A). These temporary increases were due to the remediation activities associated with the Waste Pits Project, on-site disposal facility and its associated material transfer area, and decontamination and demolition activities. The radiological air particulate data are discussed with remediation project personnel to ensure that emission controls are operating as expected and to consider actions as necessary. Appendix C, Attachment C.1, of this report provides graphical displays of the 2004 total uranium, thorium-230, and total particulate data.

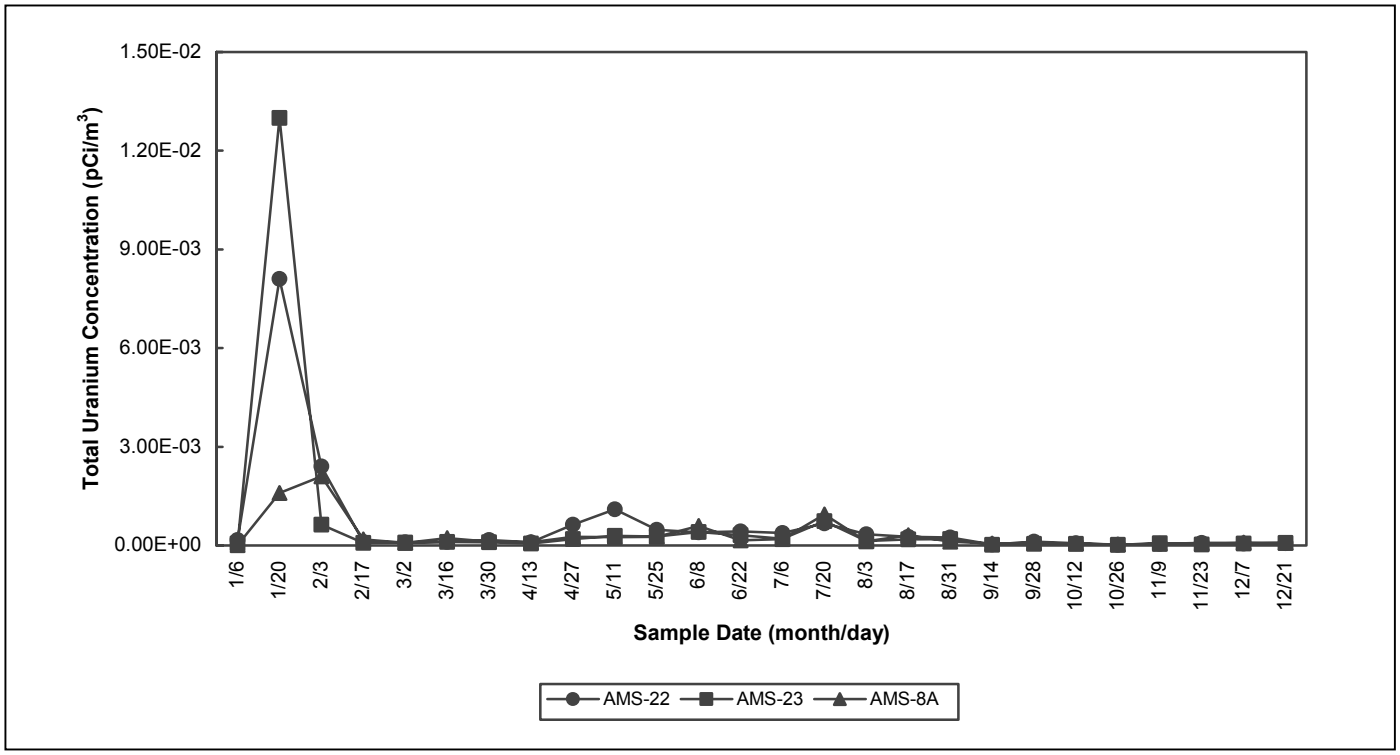


Figure 5-2. 2004 Total Uranium Concentrations in Air at Selected East Fenceline Monitors (AMS-3, AMS-8A, and AMS-9C)

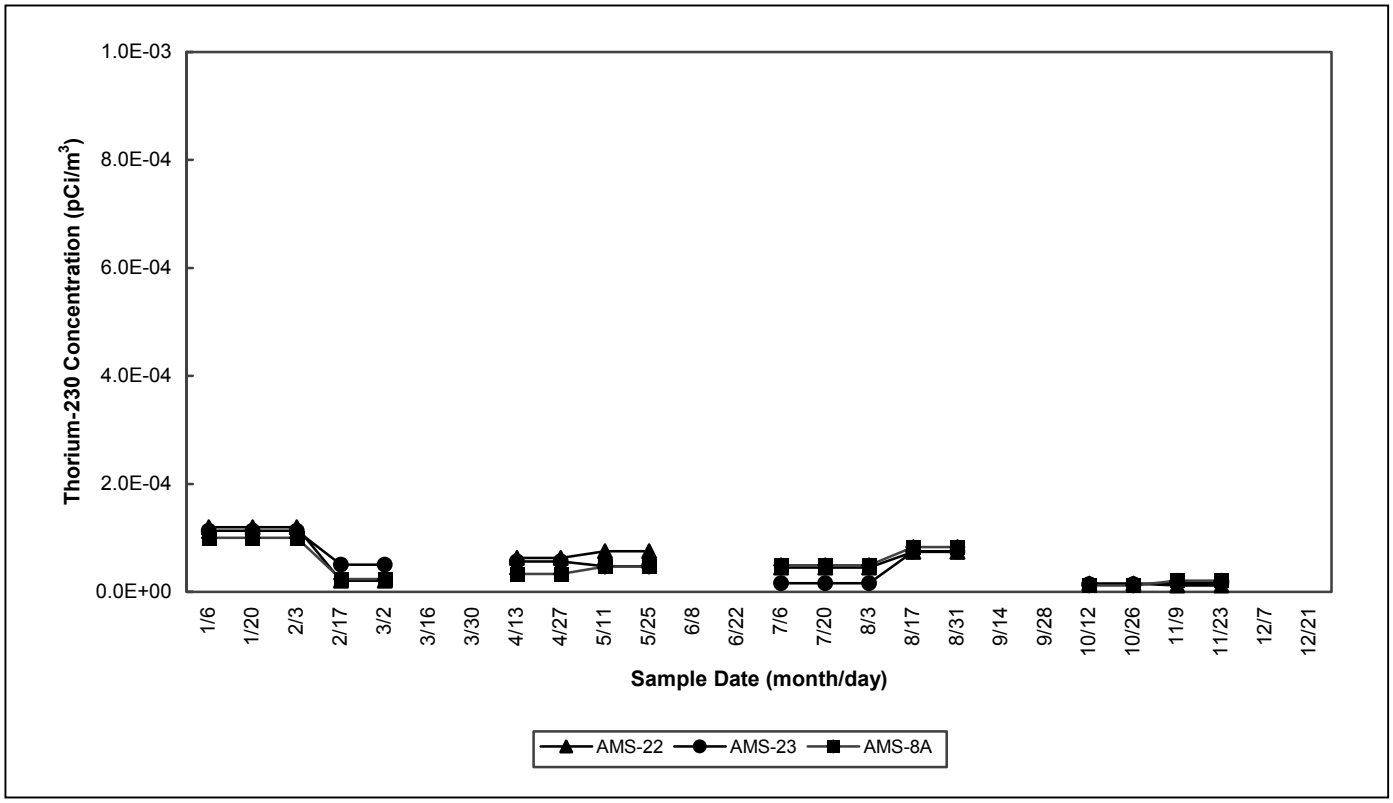


Figure 5-3. 2004 Thorium-230 Concentrations in Air at Selected East Fenceline Monitors (AMS-3, AMS-8A, and AMS-9C)

Quarterly composite air filter samples were formed from the biweekly samples at each IEMP air monitoring station during 2004 to determine the radiological air inhalation dose for each location. The samples were analyzed for isotopes of radium, thorium, and uranium. The quarterly results were used to track compliance with the NESHAP 10-mrem dose limit throughout the year and to demonstrate compliance with the limit at the end of 2004. The maximum dose associated with the quarterly composite results for 2004 was 0.65 mrem (compared to the 10-mrem limit) and occurred at AMS-23. The composite results from the fenceline monitors show that, on average, thorium isotopes contribute 54 percent of the dose from 2004 airborne emissions. Isotopes of uranium and radium account for 42 and 1.5 percent of the dose, respectively. The higher percentage of dose from thorium isotopes is a result of thorium-230 becoming the major dose contributor through fugitive emissions from Waste Pits Project operations. Thorium-230 became the major dose contributor beginning in 2000 with the commencement of Waste Pits Project excavation activities. Given the methods required to excavate, transport, and process waste pit material, fugitive emissions were expected to increase the average concentration of thorium-230 at the fenceline. Although the project used several environmental compliance-based dust abatement practices and controls, some fugitive emissions were expected from the project based on the large-scale waste handling operations. Chapter 6 and Appendix D of this report provide more detailed information on the dose associated with the composite results.

The annual average radionuclide concentrations at each air monitoring station, as determined from the quarterly composite results, were compared to the DOE-derived concentration guide values. At each monitoring station, the annual average radionuclide concentrations were below 1 percent of the corresponding DOE-derived concentration guide values.

The WPTH-2 fenceline monitor was installed in late 1998 on the west property boundary to specifically monitor thorium emissions from the Waste Pits Project. Measured airborne concentrations of thorium-228 and thorium-232 were comparable to background concentrations throughout 2004. These fenceline data reflect that, in comparison to thorium-230, the concentrations of thorium-228 and thorium-232 in the waste pit material were relatively low in 2004. Appendix C, Attachment C.1, of this report provides graphical displays of the isotopic thorium data from the WPTH-2 monitor.

5.4 Radon Monitoring

Radon-222 (referred to in this section as radon) is a naturally occurring radioactive gas. It is produced by radioactive decay of radium-226, which can be found in varying concentrations in the earth's crust. Radon is also chemically inert, and tends to diffuse from the earth's crust to the atmosphere. The concentration of radon in the environment is dynamic and exhibits daily, seasonal, and annual variability.

Many factors influence the concentration of radon in the environment, including the distribution of radium-226 in the ground, porosity of the soil, weather conditions, etc. For instance, radon diffusion from the ground is minimized by the presence of precipitation and snow cover. Alternatively, elevated temperatures and the absence of precipitation can produce cracks in the ground and changes in porosity that increase the rate at which radon escapes. A summary of meteorological data from 2004 is presented in Figures 1-7 through 1-10 in Chapter 1, and Appendix C, Attachment C.4, of this report.

Environmental radon concentrations are also influenced by atmospheric conditions. During periods of calm winds and temperature inversions (when the air near the earth's surface is cooler than the air above it), air is held near the earth's surface, minimizing the mixing of air. Consequently, radon's movement is limited vertically and concentrations tend to increase near the ground.

Waste material that produces radon is stored at the Fernald site. This waste was generated from uranium extraction processes performed decades ago and contains radium-226. This material is contained in K-65 Silos 1 and 2, and Silo 3 (part of the Operable Unit 4 remediation) and the waste pits (currently being remediated per the Operable Unit 1 Record of Decision).

DOE Order 5400.5 provides radiological protection requirements; and guidelines for cleanup of residual radioactive material, for management of resulting wastes and residues, and for the release of radiological property. Radon limits at interim storage facilities (such as at the Fernald site) are also defined under DOE Order 5400.5 and must not exceed:

- 100 pCi/L at any given location and any given time
- Annual average concentration of 30 pCi/L (above background) over the facility
- Annual average concentration of 3 pCi/L (above background) at and beyond the facility fenceline.

Figure 5-4 illustrates the continuous radon monitoring network used in 2004 for determining compliance with the above limits. The continuous monitoring network provides frequent feedback to remediation projects, regulatory agencies, and stakeholders on trends in ambient radon concentrations, while providing sufficient radon monitoring to ensure compliance with DOE Order 5400.5 requirements. Access to real-time radon monitoring data is available at the Public Environmental Information Center.

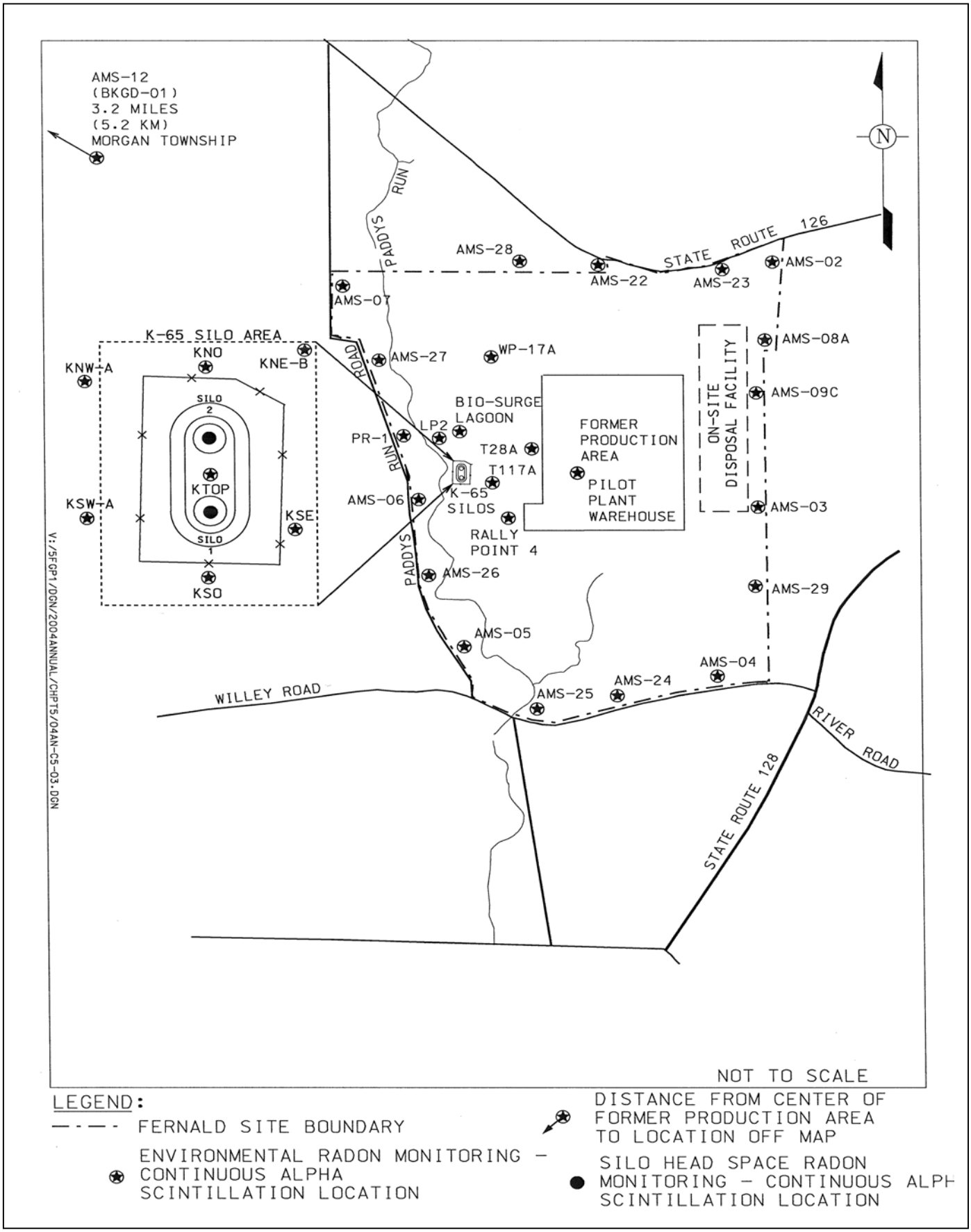


Figure 5-4. Radon Monitoring Locations

In general, monitoring locations were selected near radon-emitting sources, at the property fenceline, and a background location. The FFA identifies additional environmental radon monitoring locations, as well as continuous measurement of radon concentrations in the headspace of the K-65 Silos. DOE guidance and EPA air monitor siting criteria were considered when selecting monitoring locations.

5.4.1 Continuous Radon Monitors

Continuous radon monitors use scintillation cells to continuously monitor environmental radon concentrations based on an hourly average. Radon gas in ambient air diffuses into the scintillation cell through a foam barrier without the aid of a pump (this technique is called passive sampling). Inside the cell, radon decays into more radioactive material (progeny products), which gives off alpha particles. The alpha particles interact with the scintillation material inside the cell, producing light pulses. The light pulses are amplified and counted. The number of light pulses counted is proportional to the radon concentration inside the cell.

Continuous monitors reveal important information regarding the dynamics of radon concentrations at different times during the day, and at various locations on and off site. These monitors allow for timely review of radon concentrations, which may indicate concentrations are significantly changing from day to day and week to week. However, the use of these monitors is restricted by certain conditions. For example, potential monitoring sites are limited by the availability of electricity.

Table 5-2 provides monthly average radon concentration data from the continuous radon monitors for 2004. The data are used to track radon concentrations throughout the year to ensure the DOE limits are not exceeded. In addition to the summary data presented here, Appendix C, Attachment C.2, of this report provides graphical displays of monthly average radon concentrations from continuous radon monitors during 2003 and 2004.

Results from the fenceline monitoring locations indicate radon levels for 2004 were within historical ranges and well below the DOE limit of 3 pCi/L above background. The maximum annual average site fenceline net radon concentration for 2004 was 0.3 pCi/L, which is below the proposed 10 CFR 834 site boundary limit of 0.5 pCi/L above background. The annual average radon concentration at the background monitoring location was 0.3 pCi/L. A review of site fenceline data suggests that during 2004, Waste Pits Project operations did not significantly impact the radon concentrations at the site fenceline (refer to Table 5-2).

TABLE 5-2
CONTINUOUS ENVIRONMENTAL RADON MONITORING MONTHLY AVERAGE CONCENTRATIONS[a]

Location[b]	2004 Summary Results[c] (Instrument Background Corrected) (pCi/L)			2003 Summary Results[c] (Instrument Background Corrected) (pCi/L)		
	Min.	Max.	Avg.	Min.	Max.	Avg.
Fenceline						
AMS-02	0.2	1.3	0.5	0.1	0.6	0.3
AMS-03	0.2	1.3	0.5	0.1	0.5	0.3
AMS-04	0.2	0.7	0.3	0.2	0.6	0.4
AMS-05	0.1	1.2	0.6	0.2	0.9	0.4
AMS-06	0.2	0.6	0.3	0.3	0.8	0.5
AMS-07	0.3	1.3	0.6	0.3	0.9	0.6
AMS-08A	0.2	1.0	0.5	0.2	0.4	0.3
AMS-09C	0.2	0.9	0.5	0.2	0.5	0.4
AMS-22	0.1	0.5	0.3	0.1	0.4	0.2
AMS-23	0.2	0.5	0.3	0.2	0.4	0.3
AMS-24	0.3	1.4	0.6	0.3	0.7	0.5
AMS-25	0.2	0.9	0.4	0.2	0.6	0.3
AMS-26	0.2	0.6	0.3	0.2	0.6	0.4
AMS-27	0.3	0.9	0.5	0.2	0.8	0.5
AMS-28	0.2	0.7	0.4	0.3	0.9	0.5
AMS-29	0.2	0.5	0.3	0.2	0.5	0.4
Background						
AMS-12	0.2	0.6	0.3	0.2	0.4	0.3
On Site						
KNE-B	0.3	0.8	0.4	0.4	2.9	1.1
KN0	0.3	1.1	0.6	0.4	3.1	1.0
KNW-A	0.3	1.2	0.6	0.4	1.4	0.7
KSE	0.2	0.8	0.4	0.3	4.0	1.0
KSO	0.3	0.8	0.5	0.3	0.8	0.6
KSW-A	0.3	1.2	0.7	0.4	1.5	0.9
KTOP	0.3	1.5	0.8	0.4	12	3.3
LP2	0.3	0.7	0.4	0.4	0.9	0.7
Pilot Plant Warehouse[d]	0.2	0.4	0.3	0.2	0.8	0.4
PR-1	0.2	1.1	0.5	0.3	0.8	0.5
Rally Point 4	0.2	0.6	0.3	0.3	0.7	0.5
Surge Lagoon	0.3	0.8	0.4	0.2	0.8	0.5
T117A	0.2	0.7	0.4	0.2	0.5	0.4
T28A	0.2	0.7	0.4	0.2	0.9	0.6
WP-17A	0.3	1.1	0.5	0.1	0.8	0.4

[a]Monthly average radon concentrations are calculated from the daily average concentrations.
[b]Refer to Figure 5-4 for sample locations.
[c]Instrument background changes as monitors are replaced.
[d]Pilot Plant Warehouse monitor removed from service in May 2004.

In accordance with the FFA, radon concentrations within the headspace of K-65 Silos 1 and 2 are continuously monitored to assess the effectiveness of control measures in reducing radon emissions. From 1993 to 2002, there was a gradual upward trend in silo headspace radon concentrations. The increases in the headspace concentration were attributable to degradation of the 1991 application of bentonite clay to the surface of the K-65 Silo residues. In December 2002, the headspace radon concentrations were temporarily lowered through the initial short-term test of the RCS. During 2003 and 2004, the RCS operated continuously with the exception of short-term shut-downs for maintenance activities. Due to the operation of the RCS, radon headspace concentrations indicated a sharp drop, which has lasted through 2004. Appendix C, Attachment C.2, of this report provides a graphical display of monthly average radon concentrations from continuous radon monitors for 2003 and 2004.

During 2004 as well as in 2003, there were no exceedance events related to the 100-pCi/L DOE limit measured on site, as compared with 10 recorded in 2002. The decrease in the exceedance events is attributable to the operation of the K-65 Silos RCS.

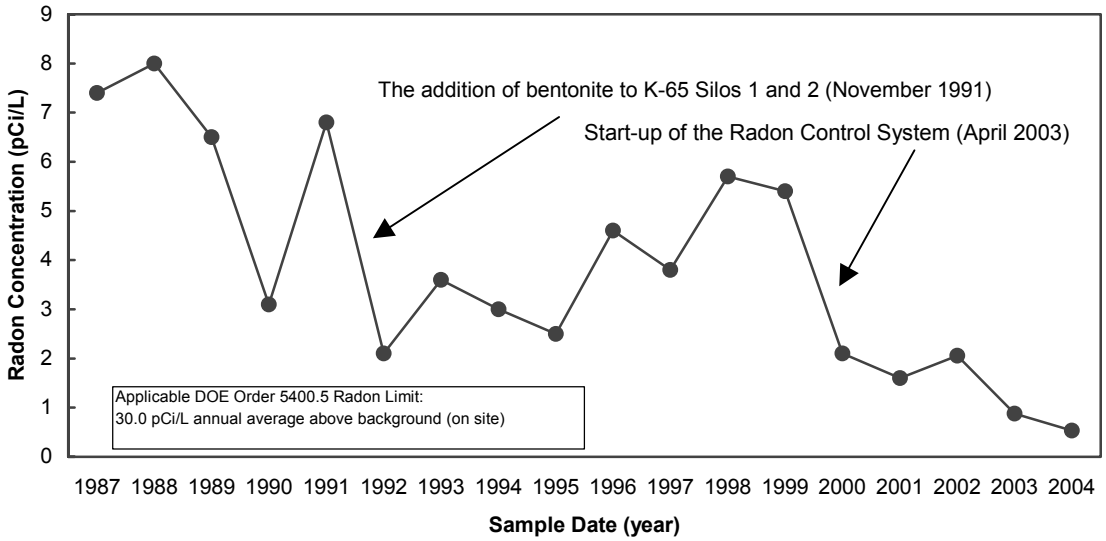
Long-term comparisons are performed on average radon concentrations recorded at the K-65 Silos exclusion fence locations. Historical alpha track-etch and continuous alpha scintillation detector data were used for this comparison (refer to Figure 5-5). The average concentrations adjacent to the K-65 Silos remain below the levels observed prior to the addition of bentonite to the K-65 Silos in 1991.

Long-term comparisons are also performed on average radon concentrations at western property fenceline locations and background locations as a basis for comparison to the 3-pCi/L annual average limit. In 2004, a marginal difference in radon concentrations was observed between background and western property fenceline monitoring locations (refer to Figure 5-6). The on-property monitoring locations also recorded radon levels well below the applicable DOE annual average limit of 30 pCi/L.

5.5 Monitoring for Direct Radiation

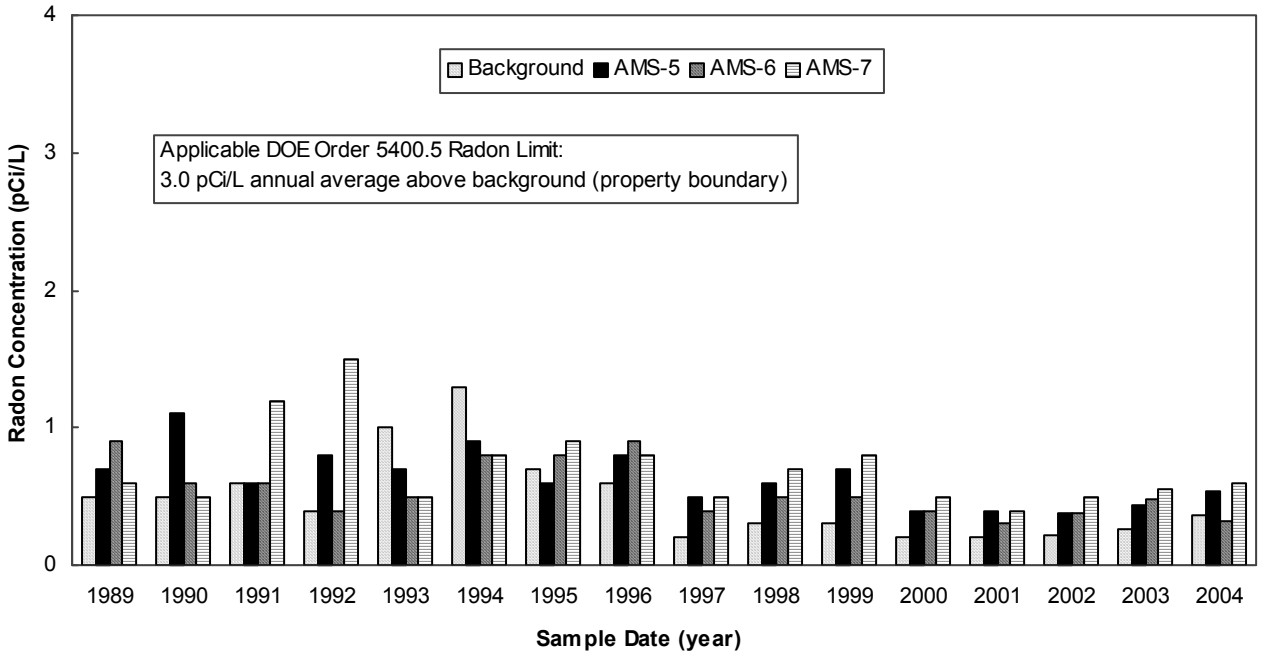
Direct radiation (e.g., X rays, gamma rays, energetic beta particles, and neutrons) originates from sources such as cosmic radiation, naturally occurring radionuclides in soil, as well as radioactive materials at the Fernald site. The largest source of direct radiation is the material stored in K-65 Silos 1 and 2. Gamma rays and X rays are the dominant types of radiation emitted from the silos. Energetic beta particles, alpha particles, and neutrons are not a significant component of direct radiation at the Fernald site because uranium, thorium, and their decay products do not emit these types of radiation at levels that create a public exposure concern.

Direct radiation levels at and around the Fernald site were continuously measured at 37 locations with thermoluminescent dosimeters (TLDs) during 2004. TLDs absorb and store the energy of direct radiation within the thermoluminescent material. By heating the thermoluminescent material under controlled conditions in a laboratory, the stored energy is released as light, measured, and correlated to the amount of direct radiation. During 2004 and previous years, this process of reading the TLDs was performed at the onsite dosimetry laboratory. For 2005, this process will be outsourced. TLD location 32 was established to measure possible affects from the irradiation process, a quality control process of exposing the TLDs to a know radiation source to verify an accurate correlation. Therefore, with the outsourcing of the TLD reading process and completion of the irradiation process, TLD 32 was removed from service at the end of 2004. Figure 5-7 identifies the TLD monitoring locations. These monitoring locations were selected based on the need to monitor the K-65 Silos, the fenceline, and background locations. Table 5-3 provides summary level information pertaining to direct radiation measurements for 2004 and 2003.



Note: The data from 1987 through 1996 are based on the alpha track-etch detectors and averaging locations corresponding to continuous radon monitors. The data from 1997 through 2003 are based on the average radon concentration from continuous radon monitors at the K-65 exclusion fence. The 2004 average includes KNO and KSO data.

Figure 5-5. Annual Average Radon Concentrations at K-65 Silos Exclusion Fence, 1987-2004



Note: The data from 1989 through 1996 are based on the alpha track-etch detectors,and the data from 1997 through 2004 are based on the continuous radon monitors.

Figure 5-6. Annual Average Radon Concentrations at Selected Radon Locations, 1989-2004

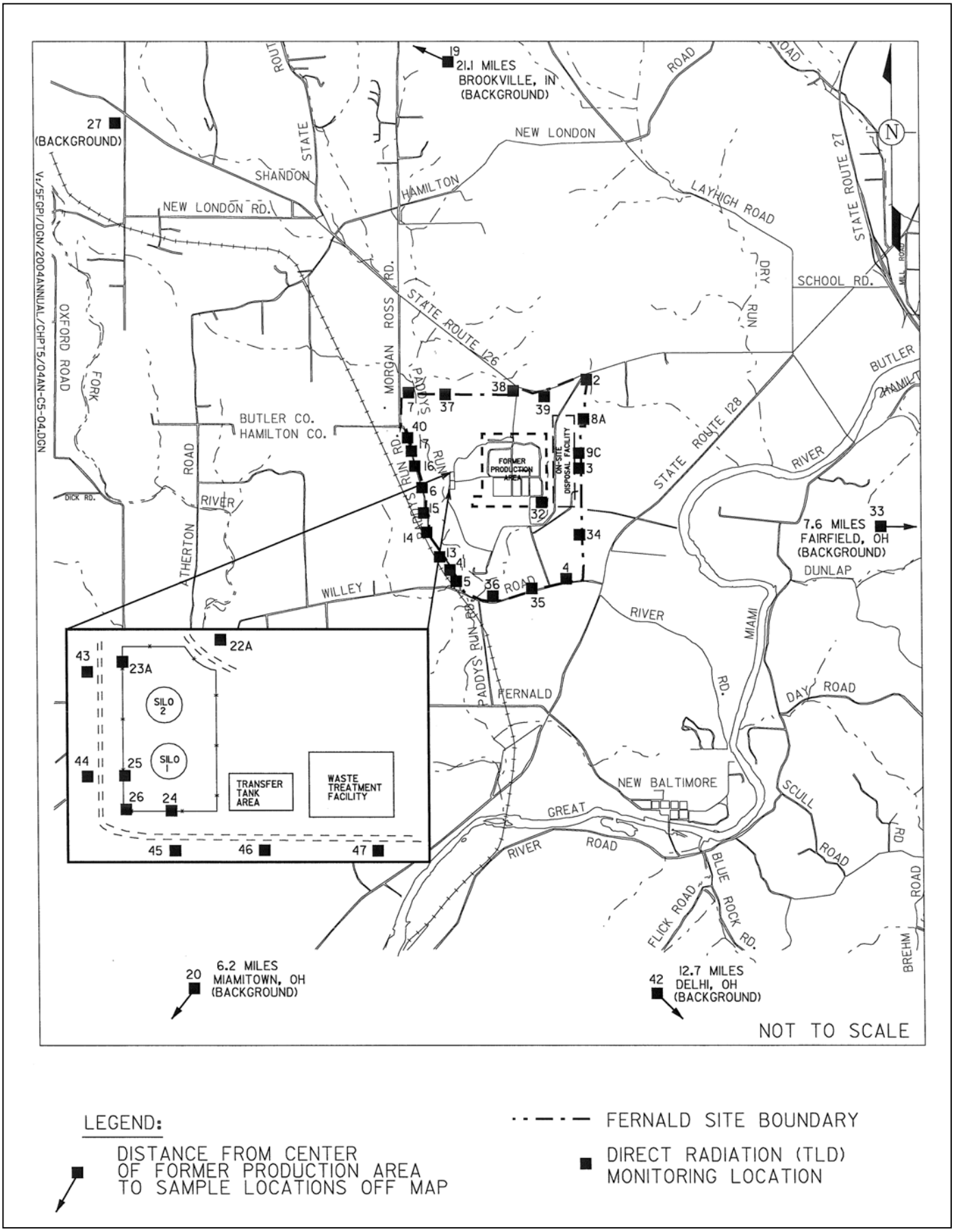


Figure 5-7. Direct Radiation (TLD) Monitoring Locations

TABLE 5-3
DIRECT RADIATION (THERMOLUMINESCENT DOSIMETER) MEASUREMENT SUMMARY

	Direct Radiation (mrem)	
TLD Location	**Summary of 2004 Results**	**Summary of 2003 Results**
Fenceline (21 locations)		
Minimum	64	64
Maximum	81	76
On Site (11 locations)		
Minimum (Health and Safety Bldg.)	52	56
Maximum (K-65 Silo area)	216	445
Background (5 locations)		
Minimum	63	61
Maximum	75	71

All monitoring results from TLDs for 2004 were within historical or expected ranges. From 1993 to 2001, there was a gradual upward trend in direct radiation measurements in the immediate area of the K-65 Silos, which stabilized in 2002 (refer to Figure 5-8). During 2003, there was a significant decrease in the direct radiation levels, followed by a continuing decrease in 2004. This was attributed to a reduction of the radon concentrations and associated decay products within the K-65 Silos' headspace. This reduction was accomplished through operations of the Silos Project RCS. Furthermore, a slight upward trend was noted at the end of 2004. This was most likely due to initiation of pumping operations to transfer K-65 Silo materials to the Transfer Tank Area.

The increasing trend in direct radiation levels at the site's western fenceline (1998 through 2001) also stabilized in 2002. During 2003, there was a significant decrease, particularly at TLD location 6, which is closest to the K-65 Silos, followed by a continuing decrease in 2004 (refer to Figure 5-9). These changes at the fenceline are also attributable to the reduction of radon concentrations and associated decay products within the K-65 Silos' headspace by the operation of the RCS. Similar to the direct radiation levels in the immediate area of the K-65 Silos, the radiation levels along the site's western fenceline also indicated a slight upward trend at the end of 2004 due to Transfer Tank Area pumping operations.

Historically, the maximum net radiation levels were measured at the site's western fenceline; for 2004, the maximum radiation level was monitored in the northeast quadrant of the site. This is reflective of the changing conditions at the Fernald site and is a result of decreasing radiation levels near the silos headspace (site's western fenceline). Chapter 6 provides more information on the dose associated with the direct radiation results. Detailed results of direct radiation measurements for 2004 and 2003 are provided in Appendix C, Attachment C.3, of this report.

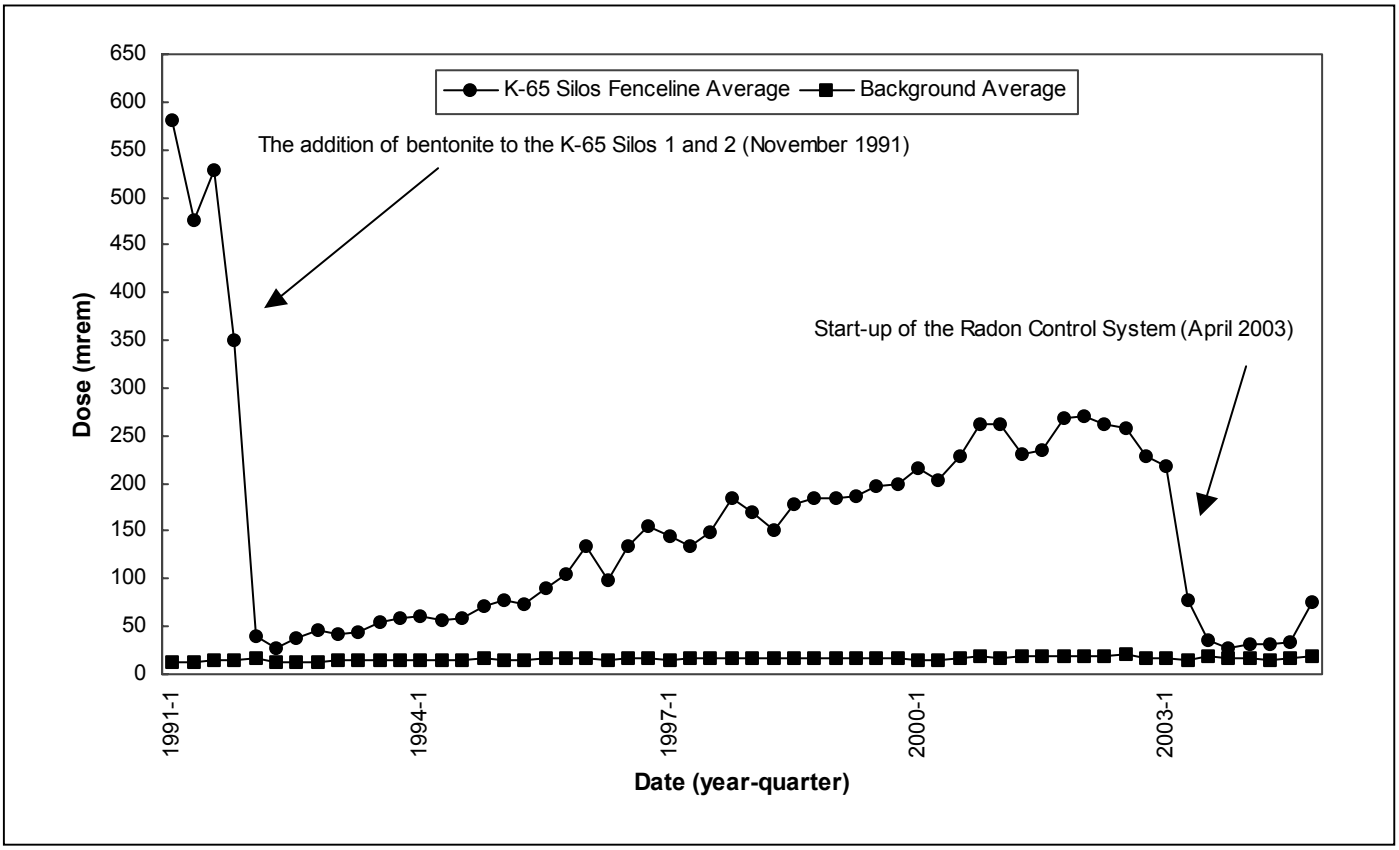


Figure 5-8. Direct Radiation (TLD) Measurements at K-65 Silos Boundary, 1991-2004 (K-65 Silos Fenceline Average vs. Background Average)

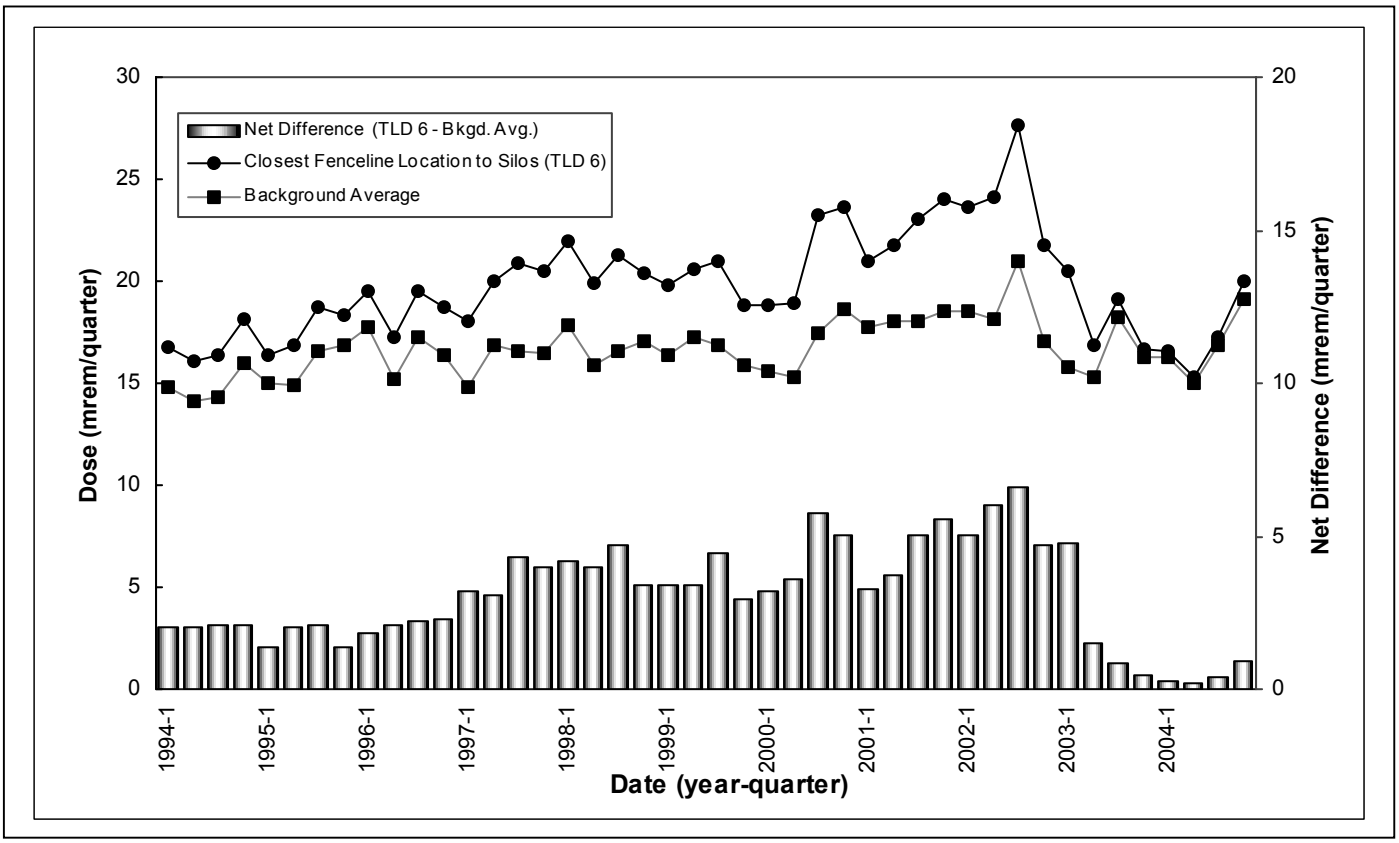


Figure 5-9. Direct Radiation (TLD) Measurements, 1994-2004 (Location 6 vs. Background Average)

5.6 Stack Monitoring for Radionuclide Emissions

During 2004, there were three stacks (or vents) that were monitored for radionuclide emissions as part of the requirements under the NESHAP Subpart H. The locations of the three stacks are show in Figure 5-10. Stack sampling systems typically consist of a continuously operating pump that draws a representative volume of air from the stack through a filter or, in the case of radon monitoring, through a detector. Periodically, the filter is exchanged and analyzed for radiological contaminants that have the potential to be released during remediation activities or processes.

The Waste Pits Project dryer stack particulate filters were analyzed for isotopes of uranium, thorium, and radium. The results confirmed that Waste Pits Project stack particulate emissions were very low and not the primary source of thorium-230 concentrations at the site fenceline. The stack also contained a continuous radon monitor (for radon-220 and radon-222). The maximum hourly release rate of radon (radon-220 and radon-222) during 2004 was 5,019 microCuries per hour (μCi/hr), which is below the estimated maximum hourly release rate of 13,000 μCi/hr (DOE 1998a) for radon-222. Note there were no exceedances in 2004 of the 13,000 μCi/hr value. The total annual release of radon through the stack was estimated to be 7,390,000 microCuries (μCi). The Waste Pits Project dryer stack was removed from service in October 2004, at the completion of dryer operations.

In 2004, the Waste Pits Project pugmill ventilation stack (PVS) particulate filters were analyzed for isotopes of uranium, thorium, and radium. The results confirmed that Waste Pits Project PVS particulate emissions were very low and not the primary source of thorium-230 concentrations at the site fenceline. The Waste Pits Project pugmill stack was also removed from service in October 2004.

In 2004, the Silos Project RCS stack particulate filters were analyzed for total particulates, isotopes of uranium, thorium, radium, and polonium, in addition to radon monitoring. The results confirm that the Silos RCS stack particulate and radon emissions were very low. The maximum instantaneous measurement of radon being released from the stack was 1,039 μCi, and the total annual release of radon through the stack was estimated to be 14,900,000 μCi.

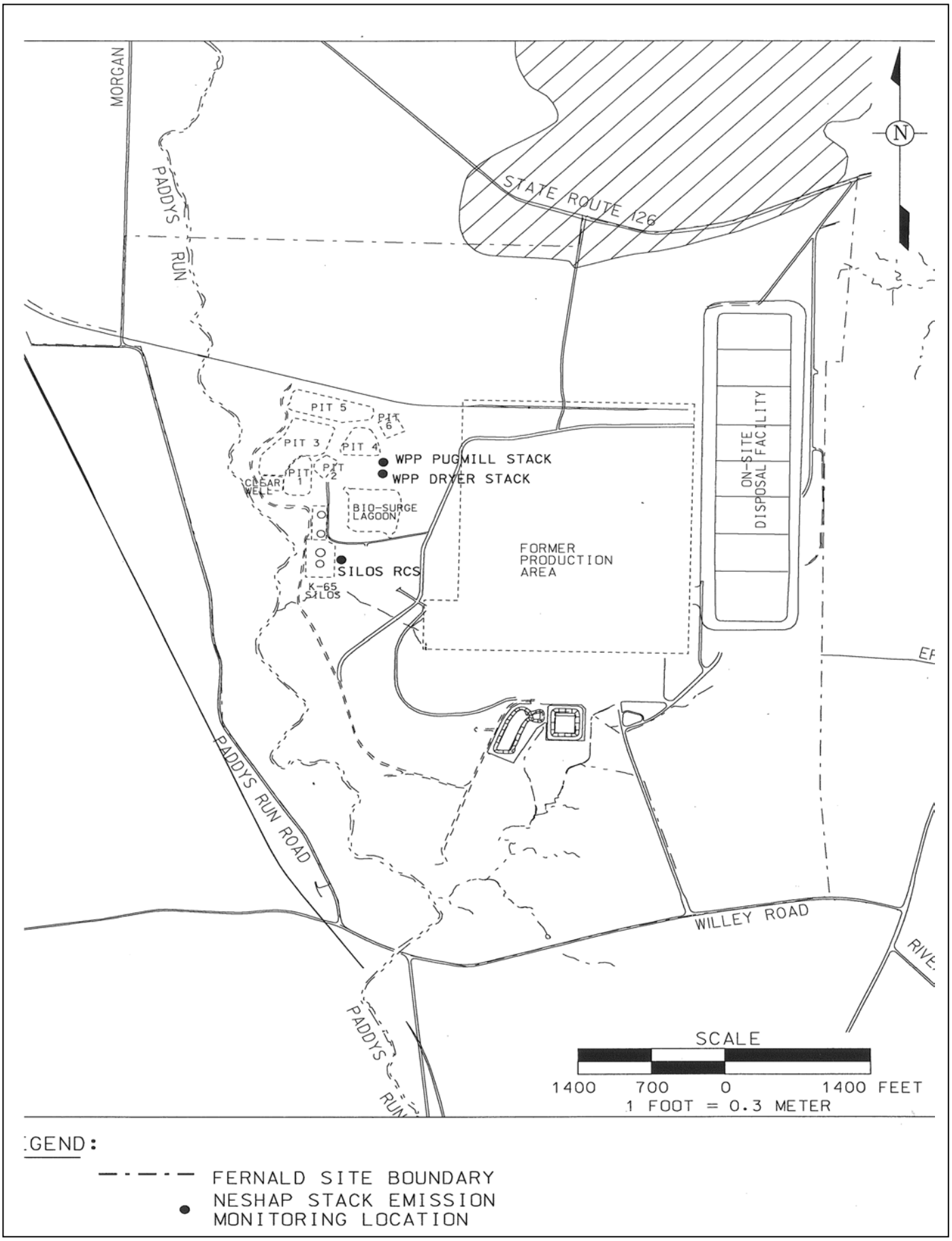


Figure 5-10. NESHAP Stack Emission Monitoring Locations

Table 5-4 presents the 2004 stack results for total particulates, radionuclides, and radon measurements. Typically, post-production era (i.e., 1990 and later) monitoring data have shown stack emissions of radionuclides to be very low or not detectable. The use of high-efficiency particulate air (HEPA) filtration systems in many remediation activities and processes effectively controls stack emissions and limits the release of airborne contaminants. In summary, the 2004 stack emissions are consistent with the low stack emission data for the post-production period.

TABLE 5-4
2004 NESHAP STACK EMISSIONS

Radionuclide (Unit)	Waste Pits Project Dryer Stack[a,b]	Waste Pits Project PVS Stack[a,b]	Silos RCS Stack[a,c]
Total Uranium (lbs/yr)			
Uranium-238 (lbs/yr)	5.6E-05	1.1E-03	3.8E-05
Uranium-235/236 (lbs/yr)	3.4E-07	5.9E-06	5.2E-06
Uranium-234 (lbs/yr)	1.1E-09	1.8E-08	3.5E-09
Thorium-232 (lbs/yr)	1.3E-05	1.9E-04	1.6E-04
Thorium-230 (lbs/yr)	1.1E-09	3.2E-08	3.9E-09
Thorium-228 (lbs/yr)	1.5E-15	2.2E-14	2.0E-14
Thorium-227 (lbs/yr)	NS	NS	ND
Radium-226 (lbs/yr)	2.2E-13	8.1E-12	1.5E-11
Polonium-210 (lbs/yr)	NS	NS	1.0E-14
Total Particulates (lbs/yr)	NS	NS	1.1E-01
Total Radon (mCi/yr)	7,390	NS	14,900

[a]Includes probe rinse results.
[b]NS = not sampled
ND = not detectable

5.7 Monitoring for Non-radiological Pollutants

The FCP continued to operate the Waste Pits Project gas-fired dryers and other minor gas-fired sources during 2004. The estimated emissions from these combined operations were based on emission factors from the AP-42 technical reference document (Compilation of Air Pollution Emission Factors, Volume 1, Stationary Point and Area Sources, [EPA 1995]). The sulfur dioxide emissions were estimated to be 155 pounds (70 kg). Nitrogen oxide emissions for 2004 were estimated to be 12,900 pounds (5,857 kg). Carbon monoxide emissions were estimated to be 21,672 pounds (9,839 kg). The estimate for particulate as PM10 (particles with an aerodynamic diameter less than or equal to a nominal 10 micron) was 1,961 pounds (890 kg). Non-methane total organic compound emissions for 2004 were estimated to be 2,245 pounds (1,019 kg). There are no regulatory limits associated with non-radiological pollutants; however, each source is required to employ the best available technology to limit emissions. In order to meet the best available technology requirement, burners designed to lower emissions of nitrogen oxides are used in the dryers.

Table 5-5 provides a comprehensive list of 2004 emissions from the Waste Pits Project dryers and other minor gas-fired sources.

TABLE 5-5
CHEMICAL EMISSIONS FROM WASTE PITS PROJECT DRYERS OR GAS-FIRED SOURCES

Chemical Name	Emissions (lb/kg)	Sources of Emissions	Basis of Estimate[a]
Particulates	1,961/890	Fossil Fuel Combustion	AP-42 Emission Factors
Sulfur Dioxide	155/70	Fossil Fuel Combustion	AP-42 Emission Factors
Nitrogen Oxide	12,900/5,857	Fossil Fuel Combustion	AP-42 Emission Factors
Carbon Monoxide	21,672/9,839	Fossil Fuel Combustion	AP-42 Emission Factors
Non-Methane Total Organic Compounds	2,245/1,019	Fossil Fuel Combustion	AP-42 Emission Factors

[a]Compilation of Air Pollution Emission Factors, Volume 1; Stationary Point and Area Sources (Section 1.3, Fuel Oil Combustion, Final Section, Supplement E, September 1998; and Section 1.4, Natural Gas Combustion, Final Section, Supplement D, July 1998).

5.0 Air Pathway

This chapter describes the air pathway monitoring program used to track and evaluate airborne emissions from the Fernald site. It includes a discussion of radiological air particulates, radon, and direct radiation. In addition, this chapter provides a summary of radiological emissions from stacks and vents, as well as non-radiological emissions associated with the combustion of fossil fuel.

Results in Brief: 2004 Air Pathway

Radiological Air Particulates — Data collected from fenceline air monitoring stations show that average concentrations for each radionuclide monitored were less than 1 percent of the corresponding DOE-derived concentration guide.

Radon — There were no exceedances of the DOE standard (3 pCi/L annual average above background) at the site fenceline and off-property locations. The maximum annual average concentration at the FCP fenceline measured by continuous radon monitors was 0.3 pCi/L above background.

Direct Radiation — Direct radiation measurements at the site fenceline and the K-65 Silos boundary were similar to those in 2003. This was attributed to the continuing operation of the Radon Control System (RCS).

Air pathway monitoring focuses on airborne pollutants that may be carried from the site as a particle or gas, and how these pollutants are distributed in the environment. The physical form and chemical composition of pollutants influence how they are dispersed in the environment and how they may deliver radiation doses. For example, fine particles and gases remain suspended, while larger, heavier particles tend to settle and deposit on the ground. Chemical properties determine whether the pollutant will dissolve in water, be absorbed by plants and animals, or settle in sediment and soil.

Monitoring the air pathway is critical to ensuring the continued protection of the public and the environment during the remediation process because airborne contaminants can potentially migrate beyond the Fernald site. The site's air monitoring approach (presented in the IEMP) provides an ongoing assessment of the collective emissions originating from remediation activities. The results of this assessment are used to provide feedback to remediation project organizations regarding the site-wide effectiveness of project-specific emission controls relative to DOE, EPA, and OEPA standards. In response to this feedback, project organizations modify or maintain emission controls.

5.1 Remediation Activities Affecting the Air Pathway

When the mission of the Fernald site changed from production to remediation, work activities also changed. This change in work scope altered the characteristics of sources that emit pollutants in the environment via the air pathway. During the production years, the primary emission sources were point sources (i.e., stacks and vents) from process facilities. Today the dominant emission sources are associated with remediation activities in the form of fugitive emissions (i.e., excavation, hauling and processing of waste and contaminated soil, demolition of production facilities, and general construction activities supporting the remediation process), and the storage of radon-generating waste materials.

The following primary emission sources were active during 2004:

- Decontamination and demolition activities, most notably Plant 2/3, Pilot Plant (Building 54A), and the Pilot Plant Warehouse (Operable Unit 3)
- Excavation of the waste pits and the associated waste processing and rail car load-out operations at the Waste Pits Project (Operable Unit 1)
- Excavation of contaminated soil and debris (Operable Unit 5)

- Construction activities associated with the on-site disposal facility including excavation, screening, and hauling activities in the on-site disposal facility borrow area (Operable Unit 2)

- Transportation and placement of contaminated material in the on-site disposal facility and interim storage at the on-site material transfer area (Operable Unit 2)

- Radon Control System (RCS) and Silos 1 and 2 Waste Retrieval operations (Operable Unit 4).

Each project is responsible for designing and implementing engineered and administrative controls for each remediation activity. The fugitive emissions control policy mandates that fugitive emissions be visually monitored and controls be implemented as necessary. The following types of controls are used to keep point source and fugitive emissions to a minimum.

- **Engineered Controls** − Typical engineered controls include physical barriers, wetting agents, filtration, fixatives, sealants, dust suppressants and control, collection, and treatment systems. Engineered designs help reduce point source and fugitive emissions by using the best available technology. The selection of the best available technology for controlling project emissions is conducted during the design process and frequently includes the evaluation of several treatment alternatives.

- **Administrative Controls** − Typical administrative controls include management and control procedures; record keeping; periodic assessments; and established speed limits, control zones, and construction zones.

5.2 Air Monitoring Program Summary for 2004

The site's air monitoring program, as defined in the IEMP, is comprised of three distinct components:

- Radiological air particulate monitoring
- Radon monitoring
- Direct radiation monitoring.

Each component of the air monitoring program is designed to address a unique aspect of air pathway monitoring, and as such, reflects distinct sampling methodologies and analytical procedures. The key elements of the air monitoring program design are:

- **Sampling** – Sample locations, frequency, and the constituents were selected to address DOE and EPA requirements for assessing radiological emissions from the Fernald site. Key considerations in the design of the sampling program included prevailing wind directions, location of potential sources of emissions, and the location of off-property receptors. The IEMP program includes monitoring radiological air particulates at 18 locations, radon measurements at 32 locations, and direct radiation at 37 locations on and off the property.

- **Data Evaluation** – The data evaluation process focuses on tracking and trending data against historical ranges and DOE, EPA, and OEPA standards. Each section in this chapter presents an evaluation of data and a comparison to applicable standards and guidelines.

- **Reporting** – All data are reported through the IEMP program and annual site environmental reports.

5.3 Radiological Air Particulate Sampling Results

As described in the IEMP, Revision 3, a network of 18 high-volume air particulate monitoring stations is used to measure the collective contributions from all fugitive and point source particulate emissions from the site. The current monitoring network includes 16 monitoring locations on the fenceline and one background location. In addition, one thorium monitor was operated on the western fenceline. Figure 5-1 provides the locations of the IEMP air monitoring stations.

The sampling and analysis program for the 16 fenceline and background locations consists of biweekly total uranium and total particulate analyses, and monthly composites (eight times per year) for isotopic thorium analyses, in addition to a quarterly composite sample. The quarterly composite sample is analyzed for the expected major contributors (i.e., uranium, thorium, and radium) to the radiological air inhalation dose at the site's boundary. The thorium monitor includes biweekly particulate and monthly isotopic thorium analyses. Analytical data from this program are used to assess the effectiveness of the emission control practices throughout the year to ensure particulate emissions remain below health protective standards.

The radiological air particulate monitoring program is designed to demonstrate compliance with the following:

- NESHAP Subpart H requirements which stipulate that radionuclide emissions (not including radon) to the ambient air from DOE facilities shall not exceed those amounts that would cause any member of the public to receive an effective dose equivalent of 10 millirem (mrem) in a year above background levels. This dose is reported in the annual NESHAP Subpart H compliance report and is included as Appendix D of this report.

- DOE Order 5400.5, Radiation Protection of the Public and the Environment (DOE 1993), guidelines for concentrations of radionuclides in air emissions. These guidelines, referred to as derived concentration guide values, are concentrations of radionuclides that, under conditions of continuous exposure for one year by one exposure mode (e.g., inhalation or ingestion), would result in a dose of 100 mrem to the public. These derived concentration guide values are not limits, but serve as reference values to assist in evaluating the radiological air particulate data.

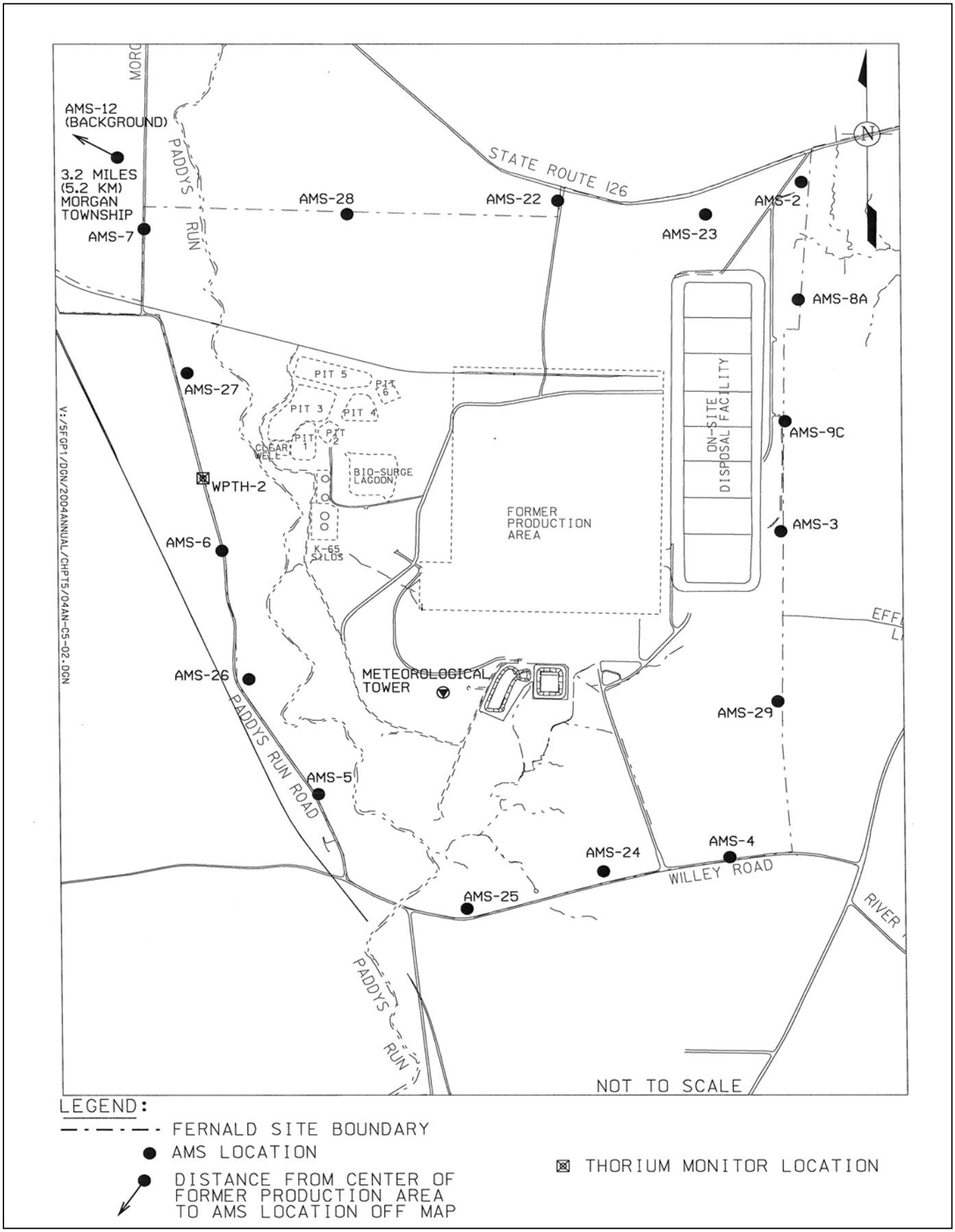


Figure 5-1. Radiological Air Monitoring Locations

Table 5-1 presents a summary of the minimum, maximum, and average concentrations for total uranium, thorium-230, and total particulate in 2003 and 2004 based on the biweekly and monthly sample results used for monitoring air emission trends. For 2004, the annual average concentrations of total uranium at all fenceline air monitoring stations were less than 1 percent of the DOE derived concentration guide (DCG) value (0.1 picoCuries per cubic meter [pCi/m^3]). In 2004, total uranium at all air monitoring locations ranged from non-detectable at the background monitor to 1.3E-02 pCi/m^3 at AMS-23.

TABLE 5-1

SUMMARY OF BIWEEKLY TOTAL URANIUM, TOTAL PARTICULATE, AND MONTHLY THORIUM-230 CONCENTRATIONS IN AIR

Location	2004 Total Uranium (pCi/m^3)	2003 Total Uranium (pCi/m^3)	2004 Total Particulate (µg/m^3)	2003 Total Particulate (µg/m^3)	2004 Thorium-230 (pCi/m^3)	2003 Thorium-230 (pCi/m^3)
Fenceline Locations						
Minimum	1.3E-006	3.3E-06	8	5	1.9E-006	0.0E+00
Maximum	1.3E-002	2.3E-03	102	124	4.2E-004	2.1E-04
Average	2.5E-004	1.7E-04	35	34	4.6E-005	6.0E-05
Background Locations						
Minimum	0.0E+000	3.2E-06	6	14	0.0E+000	0.0E+00
Maximum	1.1E-004	4.0E-05	42	48	2.7E-005	3.6E-05
Average	1.6E-005	1.4E-05	26	25	1.1E-005	1.2E-05

Biweekly thorium monitoring at the fenceline provides timely feedback on project engineered and administrative controls that are implemented to control fugitive emissions, primarily at the Waste Pits Project. The fenceline concentrations of thorium-230 (the primary thorium isotope of concern in the waste pit material being excavated) ranged from less-than-detectable to 4.2E-04 pCi/m^3, which was detected at the WPTH-2 project monitor.

In addition to the total uranium and isotopic thorium analyses, total particulate measurements are also obtained from each filter every two weeks as summarized in Table 5-1. Total particulate concentrations at the fenceline ranged from 8 micrograms per cubic meter (µg/m^3) to a maximum of 102 µg/m^3 at AMS-3. There are no general or site-specific regulatory limits associated with total particulate measurements used in the data evaluation process.

Total particulate, total uranium, and thorium-230 data were collectively evaluated to identify any increasing trends that may be related to remediation activities. Several temporary increases of these three constituents were observed at various monitoring locations; however, the short-lived increases did not pose a potential exceedance of the NESHAP dose limit of 10 mrem or DOE guidelines. The majority of increases in total uranium and thorium-230 concentrations were detected in the northeast quadrant of the site. Figures 5-2 and 5-3 show total uranium and thorium-230 concentrations, respectively, at the selected fenceline locations (AMS-22, AMS-23, and AMS-8A). These temporary increases were due to the remediation activities associated with the Waste Pits Project, on-site disposal facility and its associated material transfer area, and decontamination and demolition activities. The radiological air particulate data are discussed with remediation project personnel to ensure that emission controls are operating as expected and to consider actions as necessary. Appendix C, Attachment C.1, of this report provides graphical displays of the 2004 total uranium, thorium-230, and total particulate data.

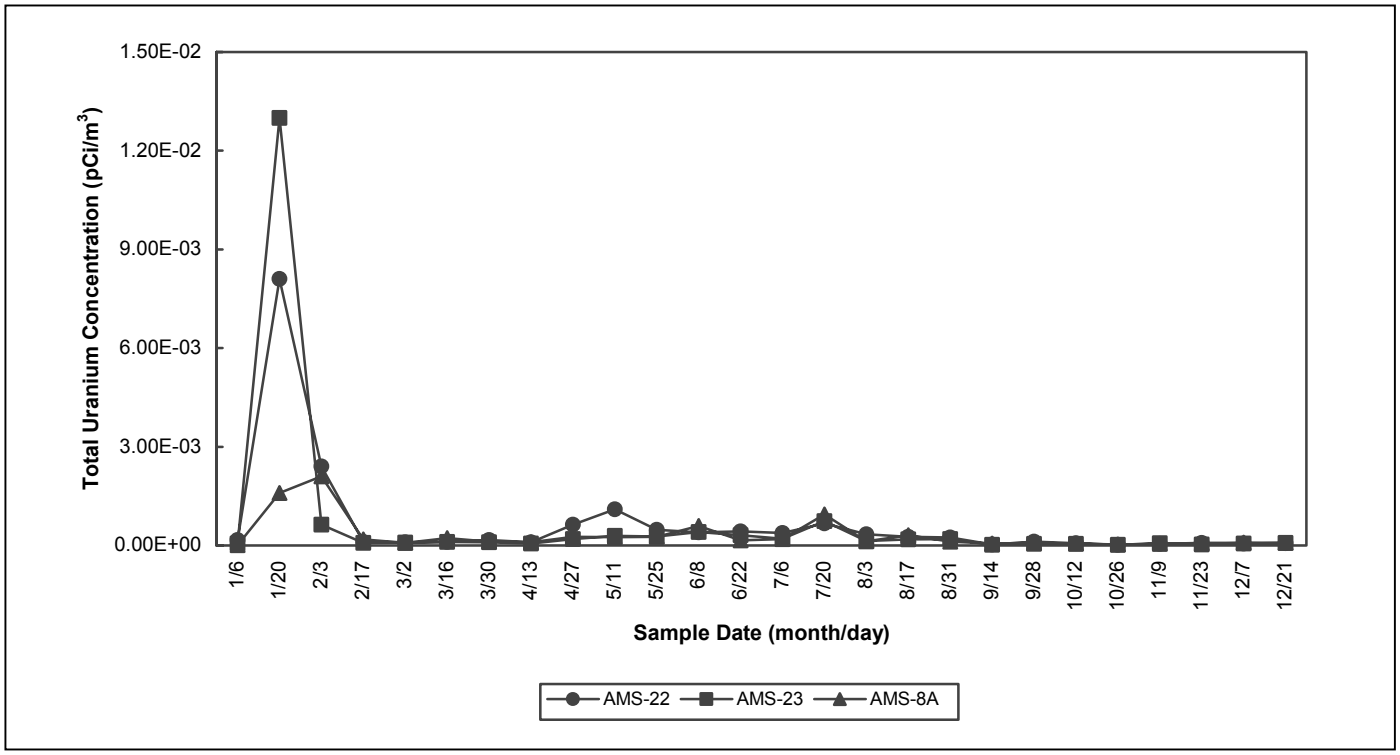


Figure 5-2. 2004 Total Uranium Concentrations in Air at Selected East Fenceline Monitors (AMS-3, AMS-8A, and AMS-9C)

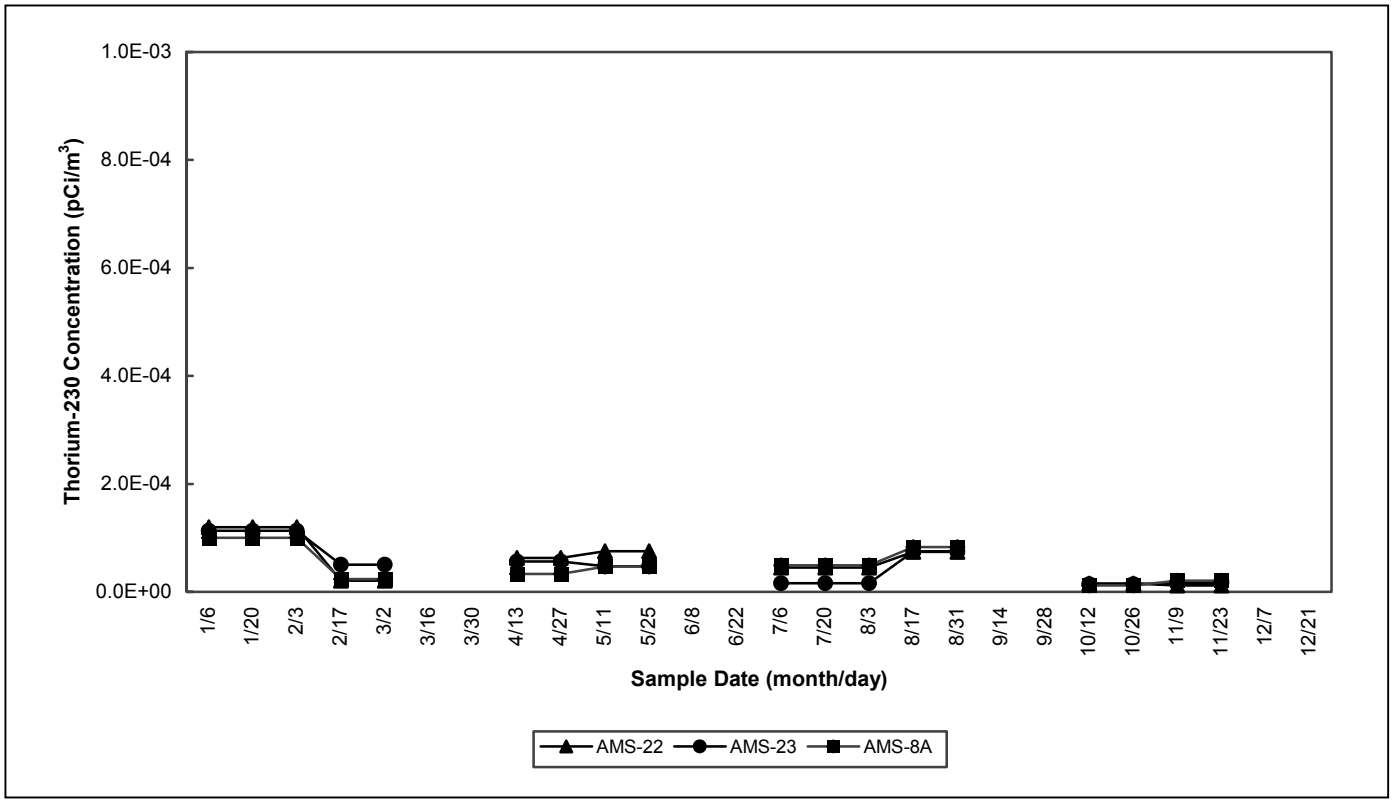


Figure 5-3. 2004 Thorium-230 Concentrations in Air at Selected East Fenceline Monitors (AMS-3, AMS-8A, and AMS-9C)

Quarterly composite air filter samples were formed from the biweekly samples at each IEMP air monitoring station during 2004 to determine the radiological air inhalation dose for each location. The samples were analyzed for isotopes of radium, thorium, and uranium. The quarterly results were used to track compliance with the NESHAP 10-mrem dose limit throughout the year and to demonstrate compliance with the limit at the end of 2004. The maximum dose associated with the quarterly composite results for 2004 was 0.65 mrem (compared to the 10-mrem limit) and occurred at AMS-23. The composite results from the fenceline monitors show that, on average, thorium isotopes contribute 54 percent of the dose from 2004 airborne emissions. Isotopes of uranium and radium account for 42 and 1.5 percent of the dose, respectively. The higher percentage of dose from thorium isotopes is a result of thorium-230 becoming the major dose contributor through fugitive emissions from Waste Pits Project operations. Thorium-230 became the major dose contributor beginning in 2000 with the commencement of Waste Pits Project excavation activities. Given the methods required to excavate, transport, and process waste pit material, fugitive emissions were expected to increase the average concentration of thorium-230 at the fenceline. Although the project used several environmental compliance-based dust abatement practices and controls, some fugitive emissions were expected from the project based on the large-scale waste handling operations. Chapter 6 and Appendix D of this report provide more detailed information on the dose associated with the composite results.

The annual average radionuclide concentrations at each air monitoring station, as determined from the quarterly composite results, were compared to the DOE-derived concentration guide values. At each monitoring station, the annual average radionuclide concentrations were below 1 percent of the corresponding DOE-derived concentration guide values.

The WPTH-2 fenceline monitor was installed in late 1998 on the west property boundary to specifically monitor thorium emissions from the Waste Pits Project. Measured airborne concentrations of thorium-228 and thorium-232 were comparable to background concentrations throughout 2004. These fenceline data reflect that, in comparison to thorium-230, the concentrations of thorium-228 and thorium-232 in the waste pit material were relatively low in 2004. Appendix C, Attachment C.1, of this report provides graphical displays of the isotopic thorium data from the WPTH-2 monitor.

5.4 Radon Monitoring

Radon-222 (referred to in this section as radon) is a naturally occurring radioactive gas. It is produced by radioactive decay of radium-226, which can be found in varying concentrations in the earth's crust. Radon is also chemically inert, and tends to diffuse from the earth's crust to the atmosphere. The concentration of radon in the environment is dynamic and exhibits daily, seasonal, and annual variability.

Many factors influence the concentration of radon in the environment, including the distribution of radium-226 in the ground, porosity of the soil, weather conditions, etc. For instance, radon diffusion from the ground is minimized by the presence of precipitation and snow cover. Alternatively, elevated temperatures and the absence of precipitation can produce cracks in the ground and changes in porosity that increase the rate at which radon escapes. A summary of meteorological data from 2004 is presented in Figures 1-7 through 1-10 in Chapter 1, and Appendix C, Attachment C.4, of this report.

Environmental radon concentrations are also influenced by atmospheric conditions. During periods of calm winds and temperature inversions (when the air near the earth's surface is cooler than the air above it), air is held near the earth's surface, minimizing the mixing of air. Consequently, radon's movement is limited vertically and concentrations tend to increase near the ground.

Waste material that produces radon is stored at the Fernald site. This waste was generated from uranium extraction processes performed decades ago and contains radium-226. This material is contained in K-65 Silos 1 and 2, and Silo 3 (part of the Operable Unit 4 remediation) and the waste pits (currently being remediated per the Operable Unit 1 Record of Decision).

DOE Order 5400.5 provides radiological protection requirements; and guidelines for cleanup of residual radioactive material, for management of resulting wastes and residues, and for the release of radiological property. Radon limits at interim storage facilities (such as at the Fernald site) are also defined under DOE Order 5400.5 and must not exceed:

- 100 pCi/L at any given location and any given time
- Annual average concentration of 30 pCi/L (above background) over the facility
- Annual average concentration of 3 pCi/L (above background) at and beyond the facility fenceline.

Figure 5-4 illustrates the continuous radon monitoring network used in 2004 for determining compliance with the above limits. The continuous monitoring network provides frequent feedback to remediation projects, regulatory agencies, and stakeholders on trends in ambient radon concentrations, while providing sufficient radon monitoring to ensure compliance with DOE Order 5400.5 requirements. Access to real-time radon monitoring data is available at the Public Environmental Information Center.

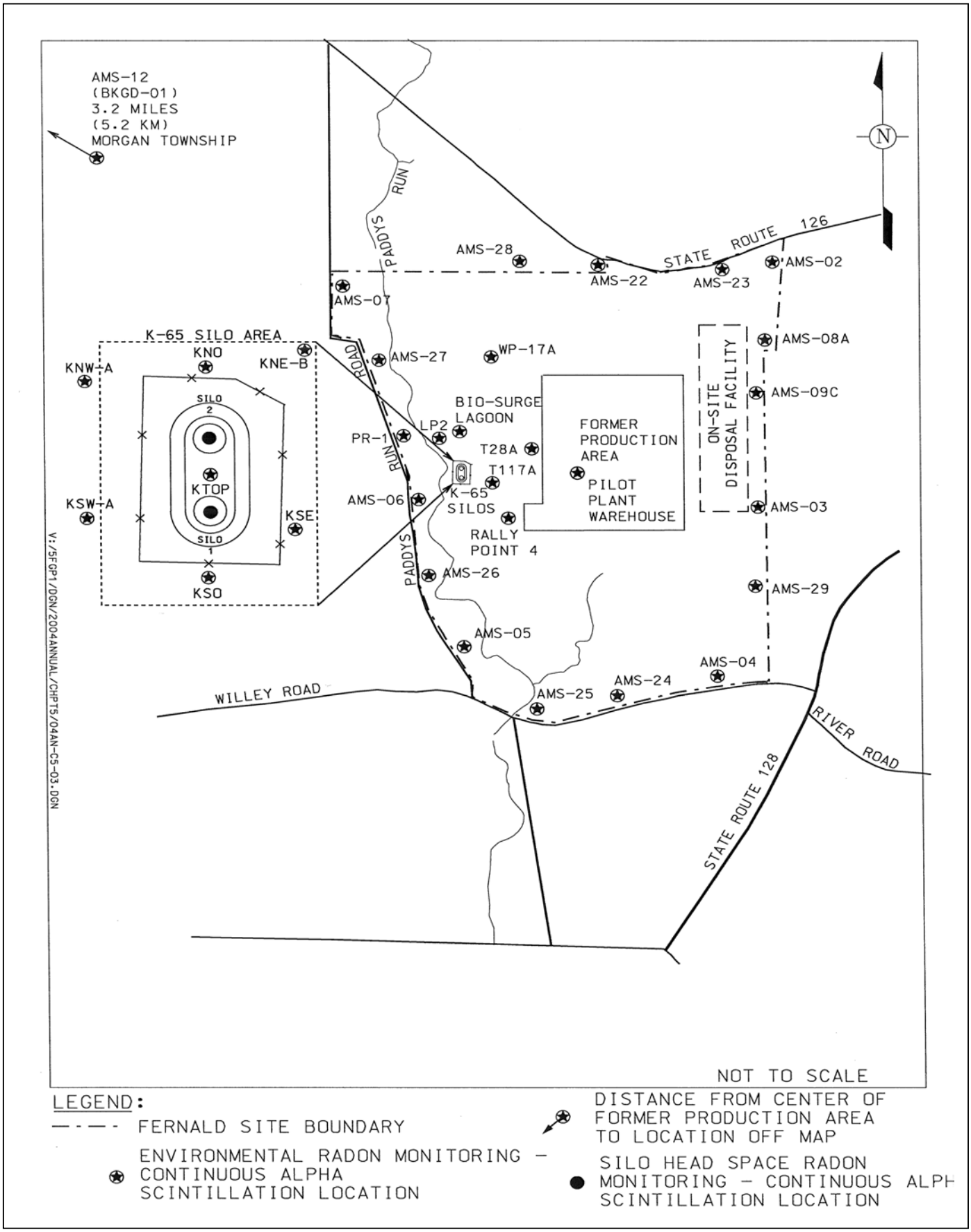


Figure 5-4. Radon Monitoring Locations

In general, monitoring locations were selected near radon-emitting sources, at the property fenceline, and a background location. The FFA identifies additional environmental radon monitoring locations, as well as continuous measurement of radon concentrations in the headspace of the K-65 Silos. DOE guidance and EPA air monitor siting criteria were considered when selecting monitoring locations.

5.4.1 Continuous Radon Monitors

Continuous radon monitors use scintillation cells to continuously monitor environmental radon concentrations based on an hourly average. Radon gas in ambient air diffuses into the scintillation cell through a foam barrier without the aid of a pump (this technique is called passive sampling). Inside the cell, radon decays into more radioactive material (progeny products), which gives off alpha particles. The alpha particles interact with the scintillation material inside the cell, producing light pulses. The light pulses are amplified and counted. The number of light pulses counted is proportional to the radon concentration inside the cell.

Continuous monitors reveal important information regarding the dynamics of radon concentrations at different times during the day, and at various locations on and off site. These monitors allow for timely review of radon concentrations, which may indicate concentrations are significantly changing from day to day and week to week. However, the use of these monitors is restricted by certain conditions. For example, potential monitoring sites are limited by the availability of electricity.

Table 5-2 provides monthly average radon concentration data from the continuous radon monitors for 2004. The data are used to track radon concentrations throughout the year to ensure the DOE limits are not exceeded. In addition to the summary data presented here, Appendix C, Attachment C.2, of this report provides graphical displays of monthly average radon concentrations from continuous radon monitors during 2003 and 2004.

Results from the fenceline monitoring locations indicate radon levels for 2004 were within historical ranges and well below the DOE limit of 3 pCi/L above background. The maximum annual average site fenceline net radon concentration for 2004 was 0.3 pCi/L, which is below the proposed 10 CFR 834 site boundary limit of 0.5 pCi/L above background. The annual average radon concentration at the background monitoring location was 0.3 pCi/L. A review of site fenceline data suggests that during 2004, Waste Pits Project operations did not significantly impact the radon concentrations at the site fenceline (refer to Table 5-2).

TABLE 5-2
CONTINUOUS ENVIRONMENTAL RADON MONITORING MONTHLY AVERAGE CONCENTRATIONS[a]

Location[b]	2004 Summary Results[c] (Instrument Background Corrected) (pCi/L)			2003 Summary Results[c] (Instrument Background Corrected) (pCi/L)		
	Min.	Max.	Avg.	Min.	Max.	Avg.
Fenceline						
AMS-02	0.2	1.3	0.5	0.1	0.6	0.3
AMS-03	0.2	1.3	0.5	0.1	0.5	0.3
AMS-04	0.2	0.7	0.3	0.2	0.6	0.4
AMS-05	0.1	1.2	0.6	0.2	0.9	0.4
AMS-06	0.2	0.6	0.3	0.3	0.8	0.5
AMS-07	0.3	1.3	0.6	0.3	0.9	0.6
AMS-08A	0.2	1.0	0.5	0.2	0.4	0.3
AMS-09C	0.2	0.9	0.5	0.2	0.5	0.4
AMS-22	0.1	0.5	0.3	0.1	0.4	0.2
AMS-23	0.2	0.5	0.3	0.2	0.4	0.3
AMS-24	0.3	1.4	0.6	0.3	0.7	0.5
AMS-25	0.2	0.9	0.4	0.2	0.6	0.3
AMS-26	0.2	0.6	0.3	0.2	0.6	0.4
AMS-27	0.3	0.9	0.5	0.2	0.8	0.5
AMS-28	0.2	0.7	0.4	0.3	0.9	0.5
AMS-29	0.2	0.5	0.3	0.2	0.5	0.4
Background						
AMS-12	0.2	0.6	0.3	0.2	0.4	0.3
On Site						
KNE-B	0.3	0.8	0.4	0.4	2.9	1.1
KN0	0.3	1.1	0.6	0.4	3.1	1.0
KNW-A	0.3	1.2	0.6	0.4	1.4	0.7
KSE	0.2	0.8	0.4	0.3	4.0	1.0
KSO	0.3	0.8	0.5	0.3	0.8	0.6
KSW-A	0.3	1.2	0.7	0.4	1.5	0.9
KTOP	0.3	1.5	0.8	0.4	12	3.3
LP2	0.3	0.7	0.4	0.4	0.9	0.7
Pilot Plant Warehouse[d]	0.2	0.4	0.3	0.2	0.8	0.4
PR-1	0.2	1.1	0.5	0.3	0.8	0.5
Rally Point 4	0.2	0.6	0.3	0.3	0.7	0.5
Surge Lagoon	0.3	0.8	0.4	0.2	0.8	0.5
T117A	0.2	0.7	0.4	0.2	0.5	0.4
T28A	0.2	0.7	0.4	0.2	0.9	0.6
WP-17A	0.3	1.1	0.5	0.1	0.8	0.4

[a]Monthly average radon concentrations are calculated from the daily average concentrations.
[b]Refer to Figure 5-4 for sample locations.
[c]Instrument background changes as monitors are replaced.
[d]Pilot Plant Warehouse monitor removed from service in May 2004.

In accordance with the FFA, radon concentrations within the headspace of K-65 Silos 1 and 2 are continuously monitored to assess the effectiveness of control measures in reducing radon emissions. From 1993 to 2002, there was a gradual upward trend in silo headspace radon concentrations. The increases in the headspace concentration were attributable to degradation of the 1991 application of bentonite clay to the surface of the K-65 Silo residues. In December 2002, the headspace radon concentrations were temporarily lowered through the initial short-term test of the RCS. During 2003 and 2004, the RCS operated continuously with the exception of short-term shut-downs for maintenance activities. Due to the operation of the RCS, radon headspace concentrations indicated a sharp drop, which has lasted through 2004. Appendix C, Attachment C.2, of this report provides a graphical display of monthly average radon concentrations from continuous radon monitors for 2003 and 2004.

During 2004 as well as in 2003, there were no exceedance events related to the 100-pCi/L DOE limit measured on site, as compared with 10 recorded in 2002. The decrease in the exceedance events is attributable to the operation of the K-65 Silos RCS.

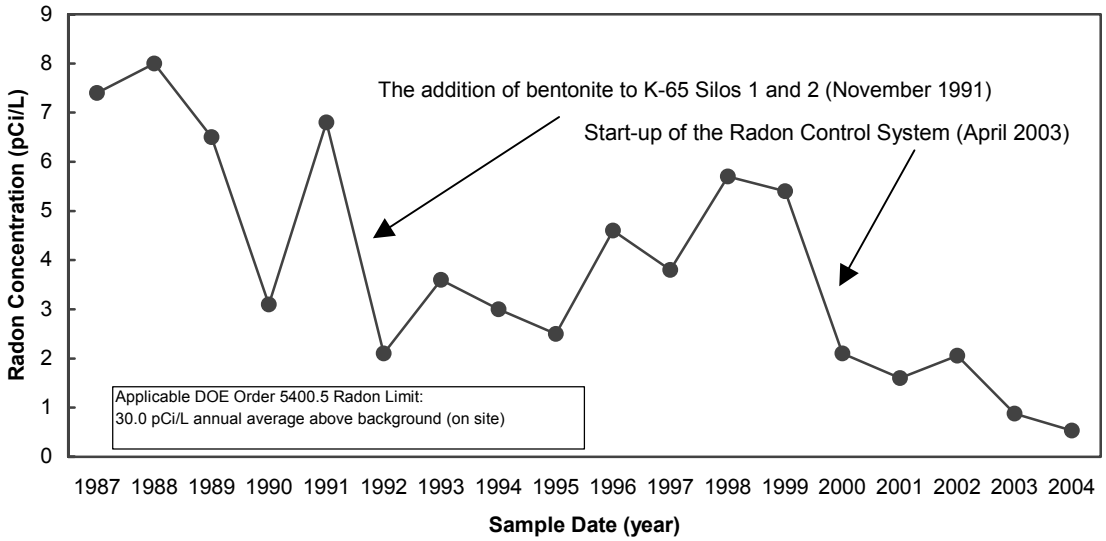
Long-term comparisons are performed on average radon concentrations recorded at the K-65 Silos exclusion fence locations. Historical alpha track-etch and continuous alpha scintillation detector data were used for this comparison (refer to Figure 5-5). The average concentrations adjacent to the K-65 Silos remain below the levels observed prior to the addition of bentonite to the K-65 Silos in 1991.

Long-term comparisons are also performed on average radon concentrations at western property fenceline locations and background locations as a basis for comparison to the 3-pCi/L annual average limit. In 2004, a marginal difference in radon concentrations was observed between background and western property fenceline monitoring locations (refer to Figure 5-6). The on-property monitoring locations also recorded radon levels well below the applicable DOE annual average limit of 30 pCi/L.

5.5 Monitoring for Direct Radiation

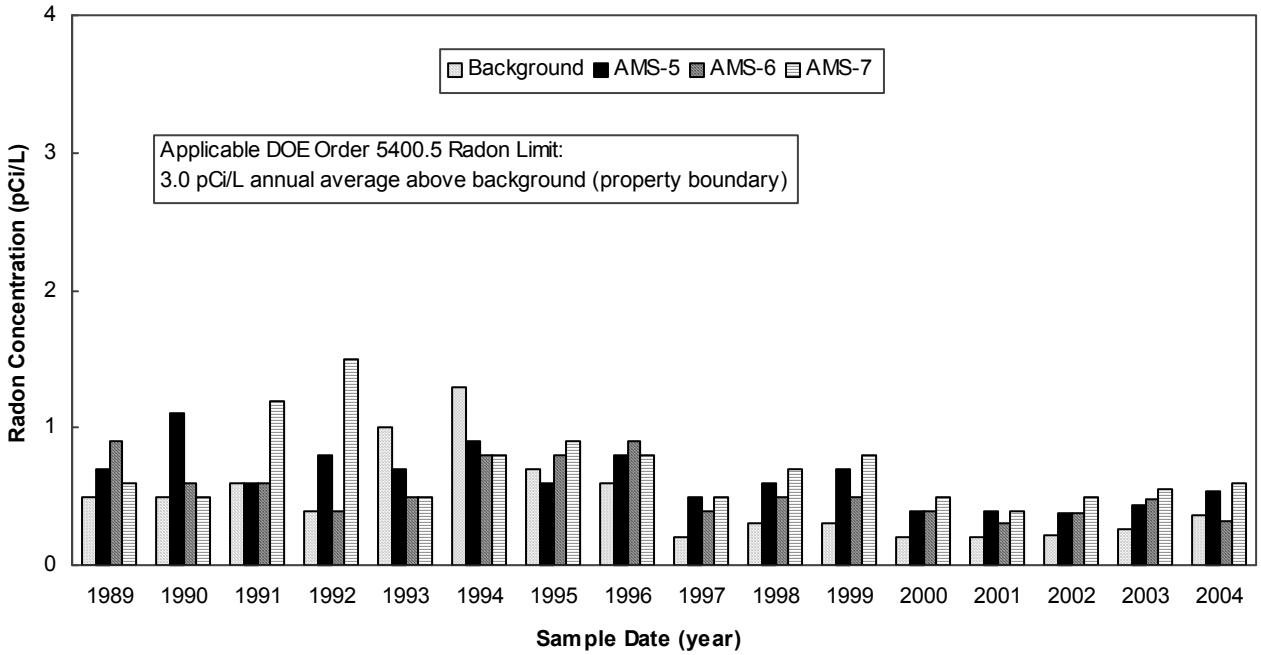
Direct radiation (e.g., X rays, gamma rays, energetic beta particles, and neutrons) originates from sources such as cosmic radiation, naturally occurring radionuclides in soil, as well as radioactive materials at the Fernald site. The largest source of direct radiation is the material stored in K-65 Silos 1 and 2. Gamma rays and X rays are the dominant types of radiation emitted from the silos. Energetic beta particles, alpha particles, and neutrons are not a significant component of direct radiation at the Fernald site because uranium, thorium, and their decay products do not emit these types of radiation at levels that create a public exposure concern.

Direct radiation levels at and around the Fernald site were continuously measured at 37 locations with thermoluminescent dosimeters (TLDs) during 2004. TLDs absorb and store the energy of direct radiation within the thermoluminescent material. By heating the thermoluminescent material under controlled conditions in a laboratory, the stored energy is released as light, measured, and correlated to the amount of direct radiation. During 2004 and previous years, this process of reading the TLDs was performed at the onsite dosimetry laboratory. For 2005, this process will be outsourced. TLD location 32 was established to measure possible affects from the irradiation process, a quality control process of exposing the TLDs to a know radiation source to verify an accurate correlation. Therefore, with the outsourcing of the TLD reading process and completion of the irradiation process, TLD 32 was removed from service at the end of 2004. Figure 5-7 identifies the TLD monitoring locations. These monitoring locations were selected based on the need to monitor the K-65 Silos, the fenceline, and background locations. Table 5-3 provides summary level information pertaining to direct radiation measurements for 2004 and 2003.



Note: The data from 1987 through 1996 are based on the alpha track-etch detectors and averaging locations corresponding to continuous radon monitors. The data from 1997 through 2003 are based on the average radon concentration from continuous radon monitors at the K-65 exclusion fence. The 2004 average includes KNO and KSO data.

Figure 5-5. Annual Average Radon Concentrations at K-65 Silos Exclusion Fence, 1987-2004



Note: The data from 1989 through 1996 are based on the alpha track-etch detectors,and the data from 1997 through 2004 are based on the continuous radon monitors.

Figure 5-6. Annual Average Radon Concentrations at Selected Radon Locations, 1989-2004

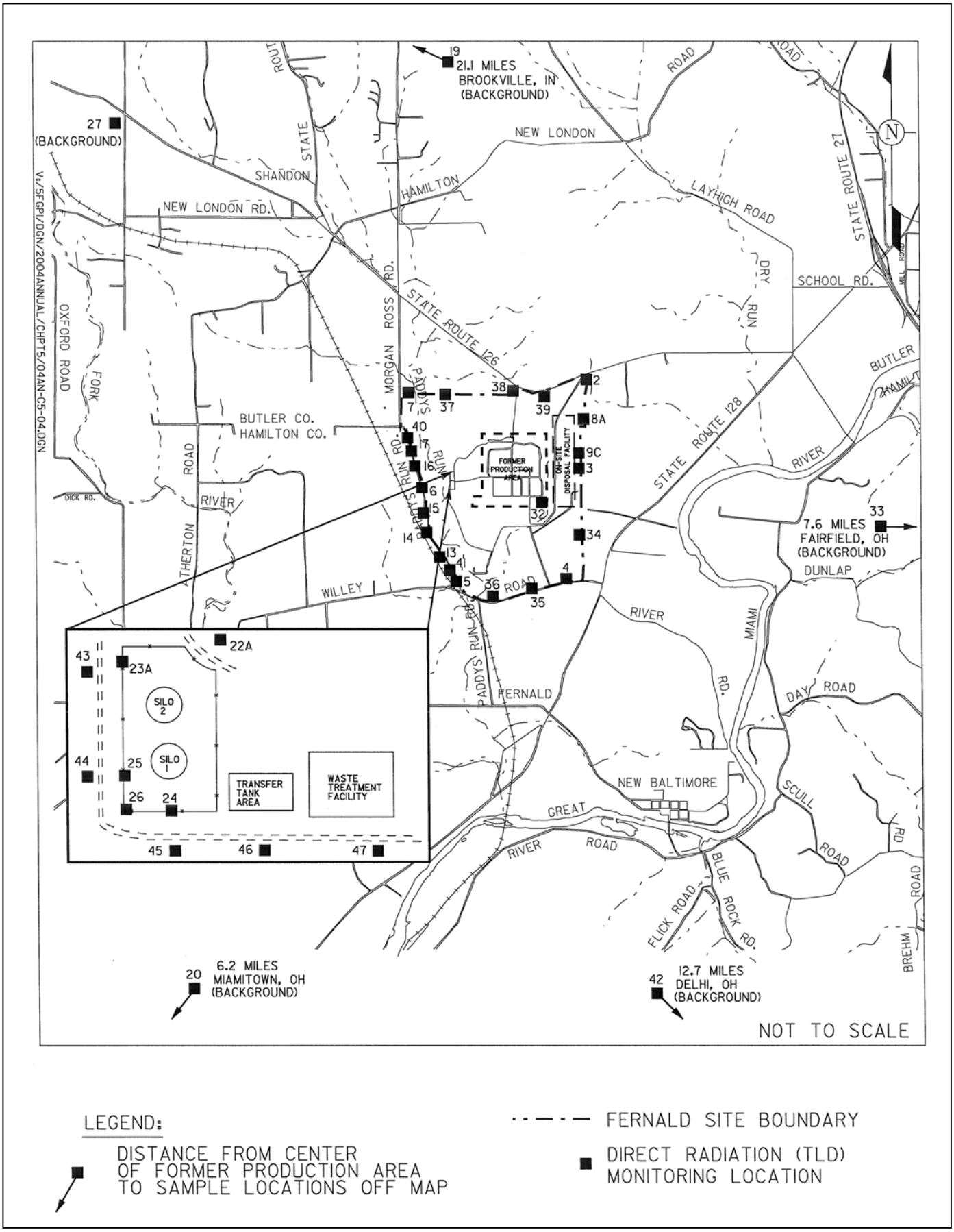


Figure 5-7. Direct Radiation (TLD) Monitoring Locations

TABLE 5-3
DIRECT RADIATION (THERMOLUMINESCENT DOSIMETER) MEASUREMENT SUMMARY

	Direct Radiation (mrem)	
TLD Location	**Summary of 2004 Results**	**Summary of 2003 Results**
Fenceline (21 locations)		
Minimum	64	64
Maximum	81	76
On Site (11 locations)		
Minimum (Health and Safety Bldg.)	52	56
Maximum (K-65 Silo area)	216	445
Background (5 locations)		
Minimum	63	61
Maximum	75	71

All monitoring results from TLDs for 2004 were within historical or expected ranges. From 1993 to 2001, there was a gradual upward trend in direct radiation measurements in the immediate area of the K-65 Silos, which stabilized in 2002 (refer to Figure 5-8). During 2003, there was a significant decrease in the direct radiation levels, followed by a continuing decrease in 2004. This was attributed to a reduction of the radon concentrations and associated decay products within the K-65 Silos' headspace. This reduction was accomplished through operations of the Silos Project RCS. Furthermore, a slight upward trend was noted at the end of 2004. This was most likely due to initiation of pumping operations to transfer K-65 Silo materials to the Transfer Tank Area.

The increasing trend in direct radiation levels at the site's western fenceline (1998 through 2001) also stabilized in 2002. During 2003, there was a significant decrease, particularly at TLD location 6, which is closest to the K-65 Silos, followed by a continuing decrease in 2004 (refer to Figure 5-9). These changes at the fenceline are also attributable to the reduction of radon concentrations and associated decay products within the K-65 Silos' headspace by the operation of the RCS. Similar to the direct radiation levels in the immediate area of the K-65 Silos, the radiation levels along the site's western fenceline also indicated a slight upward trend at the end of 2004 due to Transfer Tank Area pumping operations.

Historically, the maximum net radiation levels were measured at the site's western fenceline; for 2004, the maximum radiation level was monitored in the northeast quadrant of the site. This is reflective of the changing conditions at the Fernald site and is a result of decreasing radiation levels near the silos headspace (site's western fenceline). Chapter 6 provides more information on the dose associated with the direct radiation results. Detailed results of direct radiation measurements for 2004 and 2003 are provided in Appendix C, Attachment C.3, of this report.

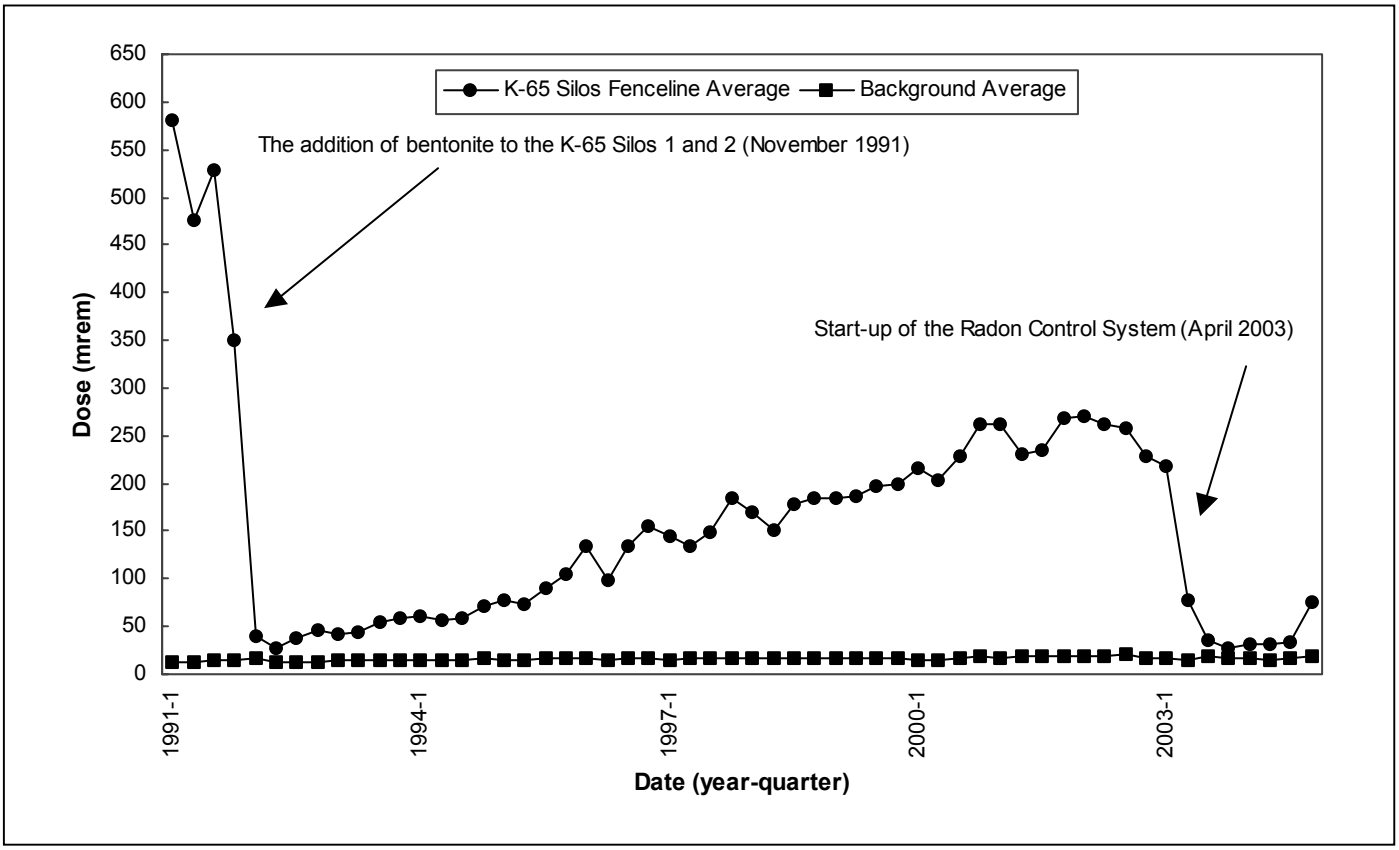


Figure 5-8. Direct Radiation (TLD) Measurements at K-65 Silos Boundary, 1991-2004 (K-65 Silos Fenceline Average vs. Background Average)

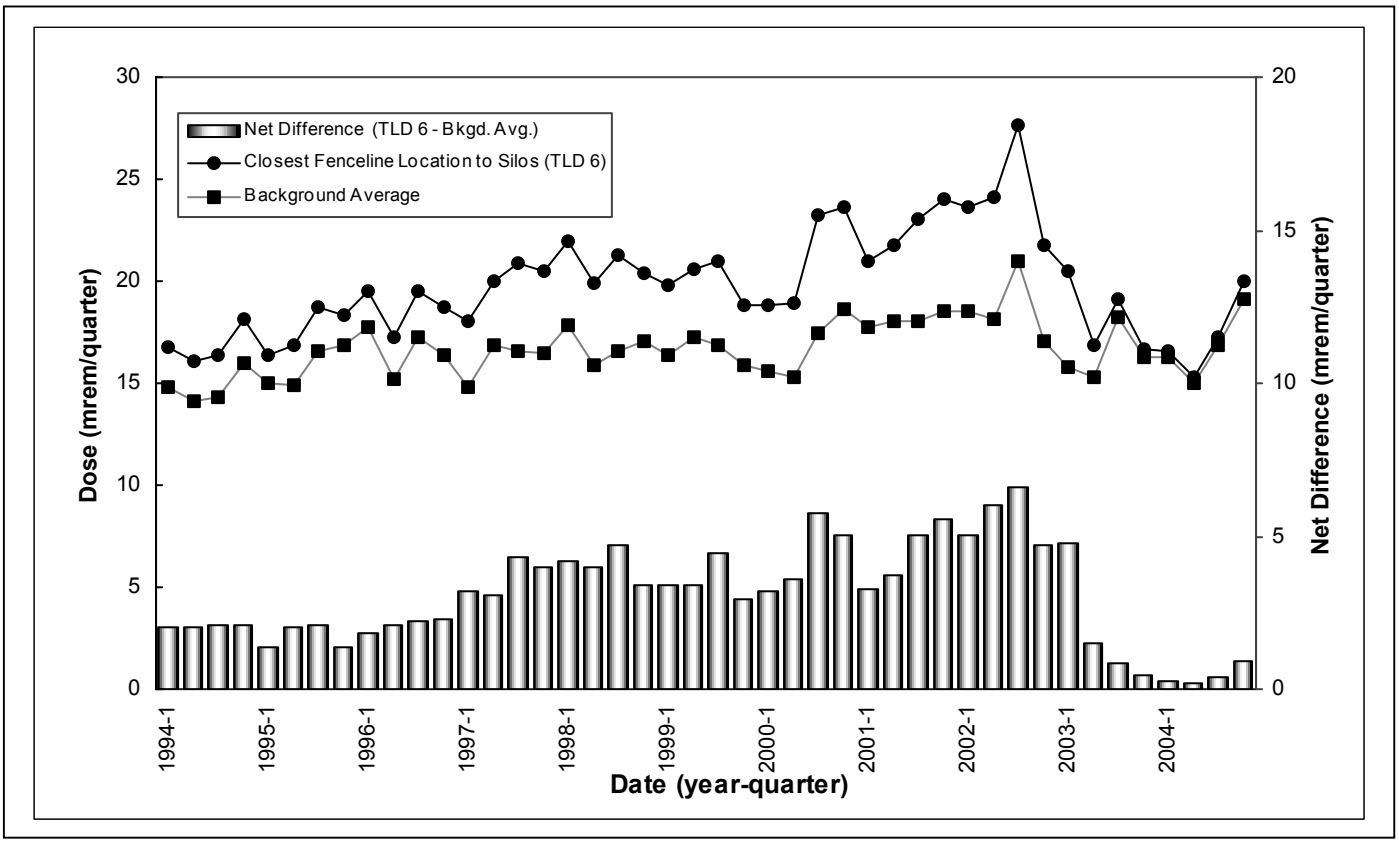


Figure 5-9. Direct Radiation (TLD) Measurements, 1994-2004 (Location 6 vs. Background Average)

5.6 Stack Monitoring for Radionuclide Emissions

During 2004, there were three stacks (or vents) that were monitored for radionuclide emissions as part of the requirements under the NESHAP Subpart H. The locations of the three stacks are show in Figure 5-10. Stack sampling systems typically consist of a continuously operating pump that draws a representative volume of air from the stack through a filter or, in the case of radon monitoring, through a detector. Periodically, the filter is exchanged and analyzed for radiological contaminants that have the potential to be released during remediation activities or processes.

The Waste Pits Project dryer stack particulate filters were analyzed for isotopes of uranium, thorium, and radium. The results confirmed that Waste Pits Project stack particulate emissions were very low and not the primary source of thorium-230 concentrations at the site fenceline. The stack also contained a continuous radon monitor (for radon-220 and radon-222). The maximum hourly release rate of radon (radon-220 and radon-222) during 2004 was 5,019 microCuries per hour (μCi/hr), which is below the estimated maximum hourly release rate of 13,000 μCi/hr (DOE 1998a) for radon-222. Note there were no exceedances in 2004 of the 13,000 μCi/hr value. The total annual release of radon through the stack was estimated to be 7,390,000 microCuries (μCi). The Waste Pits Project dryer stack was removed from service in October 2004, at the completion of dryer operations.

In 2004, the Waste Pits Project pugmill ventilation stack (PVS) particulate filters were analyzed for isotopes of uranium, thorium, and radium. The results confirmed that Waste Pits Project PVS particulate emissions were very low and not the primary source of thorium-230 concentrations at the site fenceline. The Waste Pits Project pugmill stack was also removed from service in October 2004.

In 2004, the Silos Project RCS stack particulate filters were analyzed for total particulates, isotopes of uranium, thorium, radium, and polonium, in addition to radon monitoring. The results confirm that the Silos RCS stack particulate and radon emissions were very low. The maximum instantaneous measurement of radon being released from the stack was 1,039 μCi, and the total annual release of radon through the stack was estimated to be 14,900,000 μCi.

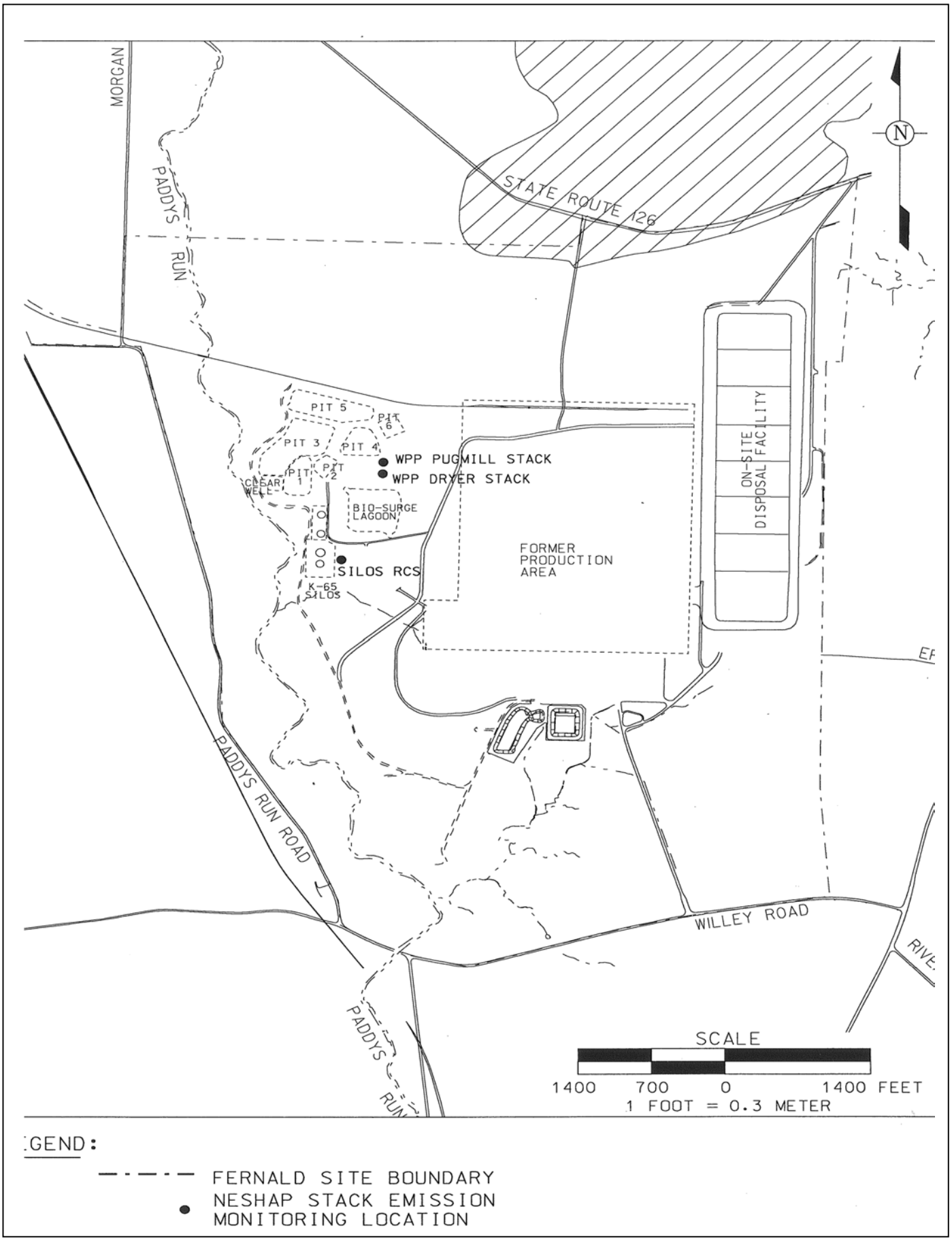


Figure 5-10. NESHAP Stack Emission Monitoring Locations

Table 5-4 presents the 2004 stack results for total particulates, radionuclides, and radon measurements. Typically, post-production era (i.e., 1990 and later) monitoring data have shown stack emissions of radionuclides to be very low or not detectable. The use of high-efficiency particulate air (HEPA) filtration systems in many remediation activities and processes effectively controls stack emissions and limits the release of airborne contaminants. In summary, the 2004 stack emissions are consistent with the low stack emission data for the post-production period.

TABLE 5-4
2004 NESHAP STACK EMISSIONS

Radionuclide (Unit)	Waste Pits Project Dryer Stack[a,b]	Waste Pits Project PVS Stack[a,b]	Silos RCS Stack[a,c]
Total Uranium (lbs/yr)			
Uranium-238 (lbs/yr)	5.6E-05	1.1E-03	3.8E-05
Uranium-235/236 (lbs/yr)	3.4E-07	5.9E-06	5.2E-06
Uranium-234 (lbs/yr)	1.1E-09	1.8E-08	3.5E-09
Thorium-232 (lbs/yr)	1.3E-05	1.9E-04	1.6E-04
Thorium-230 (lbs/yr)	1.1E-09	3.2E-08	3.9E-09
Thorium-228 (lbs/yr)	1.5E-15	2.2E-14	2.0E-14
Thorium-227 (lbs/yr)	NS	NS	ND
Radium-226 (lbs/yr)	2.2E-13	8.1E-12	1.5E-11
Polonium-210 (lbs/yr)	NS	NS	1.0E-14
Total Particulates (lbs/yr)	NS	NS	1.1E-01
Total Radon (mCi/yr)	7,390	NS	14,900

[a]Includes probe rinse results.
[b]NS = not sampled
ND = not detectable

5.7 Monitoring for Non-radiological Pollutants

The FCP continued to operate the Waste Pits Project gas-fired dryers and other minor gas-fired sources during 2004. The estimated emissions from these combined operations were based on emission factors from the AP-42 technical reference document (Compilation of Air Pollution Emission Factors, Volume 1, Stationary Point and Area Sources, [EPA 1995]). The sulfur dioxide emissions were estimated to be 155 pounds (70 kg). Nitrogen oxide emissions for 2004 were estimated to be 12,900 pounds (5,857 kg). Carbon monoxide emissions were estimated to be 21,672 pounds (9,839 kg). The estimate for particulate as PM10 (particles with an aerodynamic diameter less than or equal to a nominal 10 micron) was 1,961 pounds (890 kg). Non-methane total organic compound emissions for 2004 were estimated to be 2,245 pounds (1,019 kg). There are no regulatory limits associated with non-radiological pollutants; however, each source is required to employ the best available technology to limit emissions. In order to meet the best available technology requirement, burners designed to lower emissions of nitrogen oxides are used in the dryers.

Table 5-5 provides a comprehensive list of 2004 emissions from the Waste Pits Project dryers and other minor gas-fired sources.

TABLE 5-5
CHEMICAL EMISSIONS FROM WASTE PITS PROJECT DRYERS OR GAS-FIRED SOURCES

Chemical Name	Emissions (lb/kg)	Sources of Emissions	Basis of Estimate[a]
Particulates	1,961/890	Fossil Fuel Combustion	AP-42 Emission Factors
Sulfur Dioxide	155/70	Fossil Fuel Combustion	AP-42 Emission Factors
Nitrogen Oxide	12,900/5,857	Fossil Fuel Combustion	AP-42 Emission Factors
Carbon Monoxide	21,672/9,839	Fossil Fuel Combustion	AP-42 Emission Factors
Non-Methane Total Organic Compounds	2,245/1,019	Fossil Fuel Combustion	AP-42 Emission Factors

[a]Compilation of Air Pollution Emission Factors, Volume 1; Stationary Point and Area Sources (Section 1.3, Fuel Oil Combustion, Final Section, Supplement E, September 1998; and Section 1.4, Natural Gas Combustion, Final Section, Supplement D, July 1998).

6.0 Radiation Dose

Results in Brief: 2004 Estimated Doses

Airborne Emissions — The estimated maximum effective dose equivalent at the site fenceline from 2004 airborne emissions (excluding radon) was calculated to be 0.65 mrem (6.5E-03 millSievert [mSv]), which is 6.5 percent of the EPA NESHAP 10-mrem annual dose limit.

Direct Radiation — The estimated 2004 effective dose equivalent at an off-site receptor location near the north-northeastern fenceline of the site was 10.4 mrem (1.04E-01 mSv).

Dose to the Maximally Exposed Individual — The dose to the maximally exposed individual for 2004 was estimated to be 11.1 mrem (1.11E-01 mSv) at an off-site receptor location near the north-northeastern fenceline of the site. This is 11.1 percent of the 100-mrem (1-mSv) DOE limit.

This chapter provides estimated doses to the public from the air and direct radiation pathways for 2004 as a result of remedial actions taken at the Fernald site. EPA NESHAP regulations require the FCP to demonstrate that the site's radionuclide airborne emissions are low enough to ensure that no one in the public receives an effective dose of 10 mrem (0.1 milliSievert [mSv]) or more in any one year. Moreover, to determine whether the Fernald site is within the DOE effective dose limit of 100 mrem (1 mSv) per year from all exposure pathways (excluding radon), estimates of dose due to direct radiation are combined with airborne emissions to estimate the total dose to the maximally exposed individual. This estimate reflects the incremental dose above background that is attributable to the site.

The DOE limits for radon and its decay products in air are provided in terms of concentrations rather than dose limits, and are addressed independently of the all-pathway dose limit. A concentration-based limit is used because dose calculations associated with radon and its decay products are highly sensitive to input parameters which are difficult to confirm with environmental measurements. Nevertheless, dose estimates for radon have been included in response to stakeholders' interest in radon exposures. A number of different radon dose calculations are presented to demonstrate the variation of radon doses based on each method of calculation. The radon dose estimates in this chapter can also be compared with radon dose estimates presented in previous annual site environmental reports and other radon dose studies, such as the study that resulted from the Fernald Dosimetry Reconstruction Project (RAC 1996).

This chapter also provides an assessment of dose to aquatic organisms that may be affected by the site's effluent to nearby streams and rivers. An assessment of dose to biota (i.e., aquatic and terrestrial organisms) is one of the requirements of DOE Order 5400.5 (DOE 1993). By limiting the dose to aquatic organisms, DOE Order 5400.5 seeks to limit the severity and likelihood of off-site environmental impacts attributable to the cleanup and restoration efforts at the Fernald site. The dose assessment to biota is performed through the use of a computer model which estimates dose based on concentrations of radionuclides measured in effluent discharged to the Great Miami River.

6.1 Estimated Dose from Airborne Emissions

The estimated dose from 2004 airborne emissions was calculated from annual average radionuclide concentrations measured at the 17 IEMP air particulate monitoring locations (one background and 16 fenceline locations [refer to Figure 5-1 in Chapter 5 for the location of the air particulate monitoring locations]). The annual average background concentration was subtracted from the fenceline concentrations in order to account for the natural occurrence of airborne radionuclides. Dose estimates were determined by converting the net annual average radionuclide concentrations measured at each fenceline monitoring location to doses using values listed in 40 CFR 61 (NESHAP) Subpart H, Appendix E, Table 2.

The maximum effective dose at the fenceline from 2004 airborne emissions was estimated to be 0.65 mrem (6.5E-03 mSv) per year and occurred at AMS-23 along the north-northeastern fenceline of the site. The dose estimate is based on the conservative assumption that a person remains outdoors at the AMS-23 location for 100 percent of the time during the year. Recognizing that the nearest residence is located approximately 765 feet (233 meters) downwind from AMS-23 (north-northeast from the site), the actual dose received by this receptor would be lower than 0.65 mrem (6.5E-03 mSv) per year.

The maximum fenceline dose of 0.65 mrem (6.5E-03 mSv) in 2004 is 20 percent lower than the maximum fenceline dose of 0.82 mrem (8.2E-03 mSv) in 2003. This 20 percent reduction in air emissions is most likely due to the site nearing project completion. In addition, with 35 structures demolished during 2004, the air emission patterns are changing. Historically, the downwind monitors east-northeast to east-southeast (AMS-8A, AMS-9C, and AMS-3) have been the location for the maximum fenceline dose. For 2004, the north-northeast location (AMS-23) of the maximum dose is most likely due to the changing topography of the site.

Figure 6-1 provides a comparison between the air-pathway doses at the background and maximum fenceline locations with the annual NESHAP limit of 10 mrem (0.1 mSv). The background and maximum fenceline doses shown in Figure 6-1 are primarily attributable to the airborne concentration of uranium, thorium, and radium, and exclude contributions from radon (dose from radon is excluded from the annual NESHAP limit of 10 mrem [0.1 mSv]). The maximum air-pathway dose of 0.65 mrem (6.5E-03 mSv) above background (which is in addition to the air-pathway background dose of 0.24 mrem [2.4E-03 mSv]) is 6.5 percent of the annual NESHAP limit. The estimated dose for each radionuclide from airborne emissions measured at each fenceline air monitor is provided in Appendix D of this report.

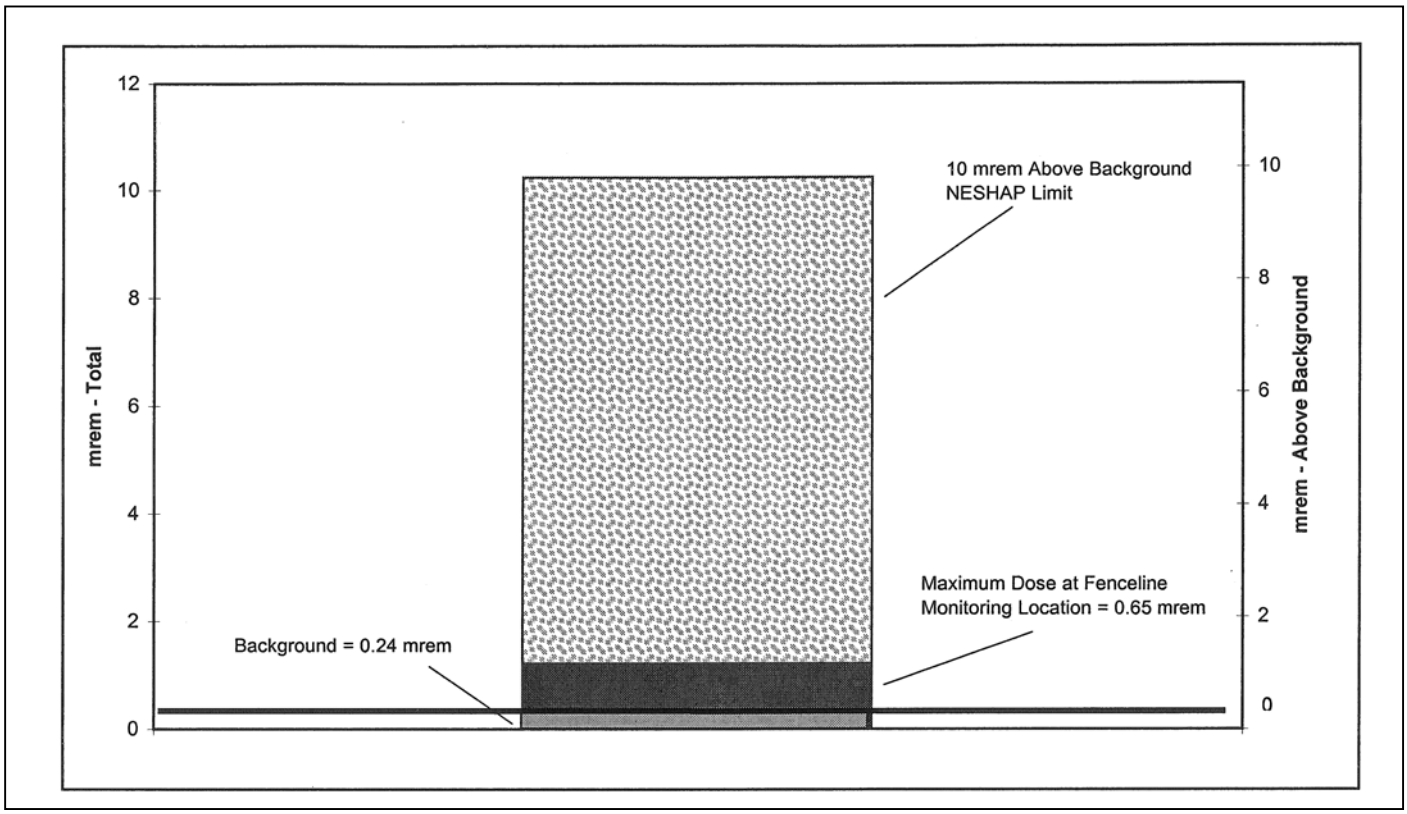


Figure 6-1. Comparison of 2004 Air-Pathway Doses and Allowable Limits

The collective effective dose from 2004 airborne emissions (not including radon) to the population within 50 miles (80 km) of the Fernald site was estimated to be 3.87 person-rem (3.87E-02 person-Sievert [person-Sv]) for a population of 2.7 million. The collective effective population dose for all pathways (air and direct radiation) was estimated to be 4.34 person-rem (4.34E-02 person-Sv). The collective effective dose provides an aggregate measure of the impact of airborne emissions from the Fernald site to the population in the area. For comparison, the same group of people received an estimated collective effective dose of 300,000 person-rem (3,000 person-Sv) from background radiation, excluding radon.

6.2 Direct Radiation Dose

Direct radiation dose is the result of gamma and X ray radiation emitted from radionuclides stored on site. The largest source of direct radiation at the site is the waste stored in the K-65 Silos. As the waste in the silos undergoes radioactive decay, gamma rays and X rays are emitted. Direct radiation from the decay of radon progeny in the silos' headspace contributes a major fraction of the direct radiation from the K-65 Silos.

As discussed in Chapter 5, there was a decrease in the radiation levels during 2004, particularly at TLD location 6, which is closest to the K-65 Silos (refer to Figure 5-9). These changes at the fenceline are also attributable to the reduction of radon concentrations and associated decay products within the K-65 Silos' headspace by the operation of the Silos Project RCS. Similar to the direct radiation levels in the immediate area of the K-65 Silos, the radiation levels along the site's western fenceline also indicated a slight upward trend at the end of 2004 due to Transfer Tank Area pumping operations.

The direct radiation dose for 2004 at the fenceline was estimated using the highest dose from the fenceline monitoring locations and subtracting the background dose. This method provides a conservative estimate of direct radiation dose and measures the impact of radiation levels near the silos and the fenceline due to radon and its associated decay products in the silo headspace (refer to Chapter 5). From the data in Table 5-3, the maximum fenceline measurement was 80.6 mrem (8.06E-01 mSv) per year and occurred at TLD location 39. The average background dose from the five background TLD locations was 67.4 mrem (6.74E-01 mSv). The difference in these values (13.2 mrem [1.32E-01 mSv]) is the estimated fenceline direct radiation dose for a hypothetical individual who stands at the fenceline, specifically TLD location 39, for the entire year. In accordance with DOE Order 5400.5, which requires that realistic exposure conditions be used for conducting dose evaluations, an estimate of direct radiation dose was calculated for the residence nearest TLD location 39. This dose was estimated by using the net fenceline TLD measurement at TLD location 39, and accounting for the distance between the fenceline TLD location and the residence (approximately 752 feet [229 meters]), which would lower the direct radiation dose to approximately 10.4 mrem (1.04E-01 mSv). This estimate remains extremely conservative in that it assumes a resident at this location is present 24 hours per day for a full year and does not account for shielding provided by the structure of the house.

6.3 Total of Doses to Maximally Exposed Individual

The maximally exposed individual is the member of the public who receives the highest estimated effective dose equivalent based on the sum of the individual pathway doses. As shown in Table 6-1, the 2004 dose to the maximally exposed individual is the sum of the estimated doses from direct radiation and airborne emissions (excluding radon). The conservative assumptions used throughout the dose calculation process ensure that the dose to the maximally exposed individual is the maximum

possible dose any member of the public could receive. The 2004 dose to the maximally exposed individual is estimated to be 11.1 mrem (1.11E-01 mSv).

The contributions to this all-pathway dose are:

- 10.4 mrem (1.04E-01 mSv) from direct radiation to an off-site receptor located near the north-northeastern fenceline of the site

- 0.65 mrem (6.5E-03 mSv) from air inhalation dose, as measured at AMS-23, to an off-site receptor located near the north-northeastern fenceline of the site.

The estimate represents the incremental dose above background attributable to the Fernald site, exclusive of the dose received from radon. Figure 6-2 provides a comparison between the average background radiation dose at background locations (67.4 mrem [6.74E-01 mSv]) and the all-pathway dose to the maximally exposed individual (11.1 mrem [1.11E-01 mSv]). Figure 6-2 also provides a graphical comparison to the annual DOE all-pathway limit of 100 mrem (1 mSv).

TABLE 6-1
DOSE TO MAXIMALLY EXPOSED INDIVIDUAL

Pathway	Dose Attributable to the Fernald Site	Applicable Limit
Direct radiation	10.4 mrem	100 mrem (total of all pathways)
Airborne emissions at AMS-23 (excluding radon)	0.65 mrem	10 mrem (air pathway)
Maximally exposed individual	11.1 mrem	100 mrem (total of all pathways)

6.4 Significance of Estimated Radiation Doses for 2004

One method of evaluating the significance of the estimated doses is to compare them with doses received from background radiation. Background radiation yields approximately 100 mrem (1 mSv) per year from natural sources, excluding radon. For example, the dose received each year from cosmic and terrestrial background radiation contributes approximately 26 mrem (2.6E-01 mSv) and 28 mrem (2.8E-01 mSv), respectively. In addition, the background radiation dose will vary in different parts of the country. Living in the Cincinnati area contributes an annual dose of approximately 110 mrem (1.1 mSv), whereas living in the Denver area would contribute approximately 125 mrem (1.25 mSv) from background radiation (NAS 1980, NCRP 1987). Comparing the maximally exposed individual dose to the background dose demonstrates that, even with the conservative estimates, the dose to the nearest resident from the Fernald site is much less than the natural background radiation dose. Although the estimated dose will be received in addition to the background dose, this comparison provides a basis for evaluating the significance of the estimated doses.

Another method of determining the significance of the estimated doses is to compare them with dose limits developed to protect the public. The International Commission on Radiological Protection (ICRP) has recommended that members of the public receive no more than 100 mrem (1 mSv) per year above background. As a result of this recommendation, DOE has incorporated 100 mrem (1 mSv) per year above background as the limit in DOE Order 5400.5. The sum of all estimated doses from site operations for 2004 (11.1 mrem [1.11E-01 mSv]) was significantly below this limit.

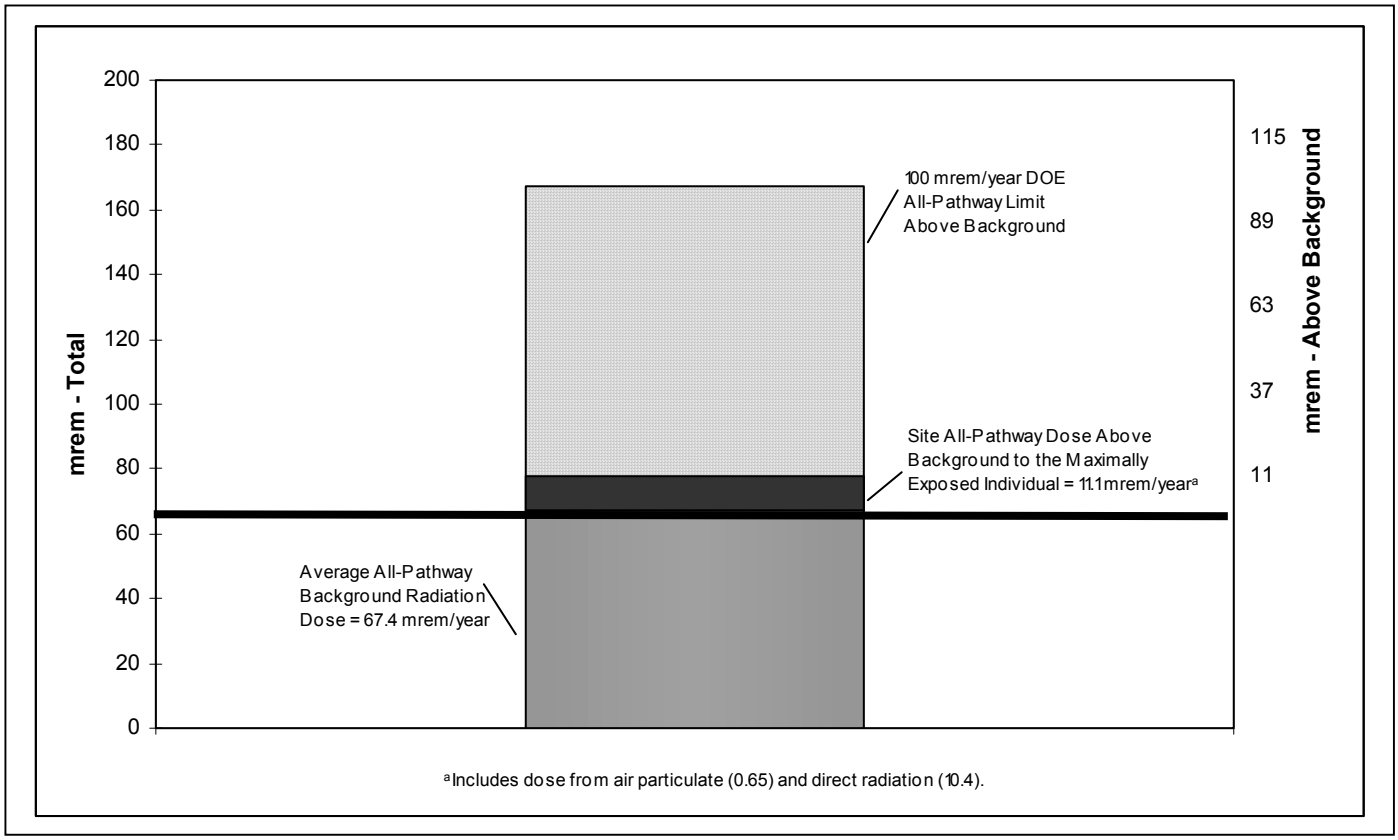


Figure 6-2. Comparison of 2004 All-Pathway Doses and Allowable Limits

6.5 Estimated Dose from Radon

Radon in the air decays to produce more radioactive material, known as daughter products. Airborne daughter products attach to dust particles that may be inhaled and deposited within the lungs. As the daughter products decay, they emit electrostatically charged particles (alpha and beta particles) that may damage sensitive tissues of the lung. For exposures to radon and its daughters, the target organ for the radiation dose is the lung.

Radon dose estimate methodologies from the ICRP and National Council on Radiation Protection (NCRP) have been revised and updated over the years with the primary effect being a decrease in the estimated health damage (detriment) per unit of radiation exposure. The revisions were based on re-evaluations of studies examining the detrimental health effects (e.g., epidemiological studies) on highly exposed worker populations (e.g., uranium miners). Therefore, radon dose estimates were generated for this report using the following four different calculation methods:

- Working level-month determination
  Historically, radon daughter exposure rates have been measured in the units of working levels, a measure of the activity concentration of the radon daughters in air. A working level is approximately equivalent to a radioactivity concentration of 100 pCi/L of radon in 100 percent equilibrium with its daughters. An individual exposure is then determined by multiplying the working level by the number of 170-hour periods (i.e., a work month) at that level, yielding the exposure unit working level-month. Working level-months of exposure are provided because all dose conversion factors and detriment coefficients used in estimating a dose from radon and its daughters are derived from this fundamental unit.

- NCRP 78 Report (NCRP 1984)
  This document, in part, provides equations for converting exposure resulting from inhalation of radon daughter products to an equivalent lung dose. This method considered the whole lung as the target organ for the radiation exposure. A number of dose conversion factors and assumptions are used to equate the lung dose to a whole body radiation dose (i.e., effective dose equivalent). Equations from this report were used in previous annual site environmental reports and are presented here for direct comparison to previous years' estimates.

- ICRP 66 (ICRP 1994a) Tissue Weighting Factor Modification to NCRP 78 Equation
  ICRP 66 introduced a specific tissue-weighting factor representing the localized radiation exposure to the bronchial epithelium (a specific region of the lung thought to be the source for lung cancer) from inhalation of radon daughter products. Using the NCRP 78 equations, this new weighting factor results in a reduction of the effective dose by a factor of three. Incorporation of factors from this report allows comparison to dose estimates provided in the Fernald Dosimetry Reconstruction Project performed by Risk Assessments Corporation under contract with the Centers for Disease Control.

- ICRP 65 Report (ICRP 1994b)
  This report suggests the use of detriment coefficients for estimating dose from exposure to radon daughter products. These detriment coefficients are based on epidemiological studies of the lung cancer rates among uranium miners. The new coefficients result in a dose conversion factor of approximately 500 mrem per working level-month. This report was released in 1994 and represents a more recent methodology for calculating radon dose.

Table 6-2 presents the 2004 radon dose estimates, and includes concentration values for fenceline and background locations as well as DOE radon concentration limit values. Estimated working level-month exposures are given for each concentration value, as well as effective dose equivalents using the NCRP 78, ICRP 66, and ICRP 65 methods. Doses were calculated from annual average continuous radon data (assuming the suggested environmental radon daughter product equilibrium concentration of 70 percent). All dose estimates are for a hypothetical maximally exposed reference man of average body size and breathing rate who continuously breathed air at the site's fenceline while engaged in light, physical activity 24 hours a day for the entire year. This exposure scenario is highly conservative, but suggests that in using the ICRP 65 methodology the maximum dose from radon emissions at the site fenceline is 55 mrem (0.55 mSv) per year above background.

Although there are no regulatory limits for dose from radon and its daughters, the radon concentration limits imposed by DOE Order 5400.5 provide a benchmark for evaluating the estimated doses from radon at the Fernald site boundary. In DOE Order 5400.5, the annual average radon concentration limit at the facility boundary is 3 pCi/L above background. Using the ICRP 65 methodology, a concentration of 3 pCi/L equates to an effective dose equivalent of 547 mrem (5.47 mSv). As presented in Table 6-2, the maximum measured radon concentration and corresponding dose at the Fernald site boundary are well below the limits associated with DOE Order 5400.5.

TABLE 6-2
2004 RADON DOSE ESTIMATE[a]

Location	Radon Concentration[b] (pCi/L)	Exposure in Working Level-Months[b]	NCRP 78 Effective Dose Equivalent Equation (mrem)[b,c]	NCRP 78 Effective Dose Equivalent Equation (mrem)[b,d]	ICRP 65 Effective Dose Equivalent (mrem)[b,e]
Background	0.4	0.144	288	96	73
Fernald Site Fenceline Nearest Receptor (net, above background)	ND	NA	NA	NA	NA
Maximum Fenceline (net, above background)	0.3	0.108	216	72	55
DOE Order 5400.5 Limit (net, above background)	3.0	1.08	2,160	720	547

[a]Assuming the suggested environmental radon daughter product equilibrium concentration of 70 percent.
[b]ND = non-detectable
NA = not applicable
[c]NCRP 78 suggests whole lung tissue weighting factor of 0.12.
[d]NCRP 78 calculation using the ICRP 66 bronchial epithelium weighting factor of 0.04.
[e]Using the dose conversion factor for the maximally exposed reference man.

6.6 Estimated Dose to Biota

DOE Order 5400.5 requires that populations of aquatic biota be protected at a dose limit of 1 rad/day (10 milliGray per day [mGy/day]). The DOE has issued a technical standard entitled, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota" (DOE 2002c), and supporting software (RAD-BCG) for use in the evaluating and reporting of compliance with biota dose limits.

In general, the dose and compliance assessment process involves comparing concentrations of contaminants measured in surface water and/or sediment samples to established Biota Concentration Guides (BCGs) for specific radionuclides. More specifically, the measured contaminant concentration in water and/or sediment is divided by the appropriate BCG value. If the resulting fraction is less than 1.0, compliance with the biota dose limit is assured. The BCGs were set so that real biota exposed to such concentrations would not be expected to exceed the biota dose limit of 1 rad/day (10 mGy/day) during a calendar year. BCGs have been established for a set of radionuclides that are relatively common constituents in past radionuclide releases to the environment from DOE facilities. At facilities such as Fernald, where multiple contaminants (e.g., uranium, radium, and thorium) can be released, a "sum of the fractions" rule applies. Compliance with the biota dose limit is assured if the sum of the fractions from multiple contaminants is less than 1.0.

For 2004, compliance with the dose limit to aquatic biota was determined by using the maximum concentrations of applicable radionuclides found in effluent discharged to the Great Miami River (refer to Chapter 4) as input into the RAD-BCG computer model. The results of the assessment indicate that the sum of the fractions was 0.059, which is well below the compliance threshold value of 1.0.

7.0 Natural Resources

This chapter provides background information on the natural resources associated with the Fernald site and summarizes the activities in 2004 relating to these resources. Included in this chapter is a discussion of the following:

- Threatened and endangered species
- Impacted habitat areas
- Ecological restoration activities
- Cultural resources.

Much of the 1,050 acres (425 hectares) of the Fernald site property is undeveloped land that provides habitat for a variety of animals and plants. Wetlands, deciduous and riparian (stream side) woodlands, old fields, grasslands, and aquatic habitats are among the site's natural resources. Some of these areas provide habitat for state and federal endangered species. Cultural resources, such as prehistoric archaeological sites, can also be found at the Fernald site. Monitoring of these natural and cultural resources is addressed in the Natural Resource Monitoring Plan, which is included in the IEMP. This document presents an approach for monitoring and reporting the status of several priority natural resources in order to remain in compliance with the pertinent regulations and agreements.

7.1 Threatened and Endangered Species

Sloan's Crayfish - The state-listed threatened Sloan's crayfish (*Orconectes sloanii*) is found in southwest Ohio and southeast Indiana. It prefers streams with constant (though not necessarily fast) current flowing over rocky bottoms. A large, well-established population of Sloan's crayfish is found at the Fernald site in the northern reaches of Paddys Run.

Indiana Brown Bat - The federally listed endangered Indiana brown bat (*Myotis sodalis*) forms colonies in hollow trees and under loose tree bark along riparian (stream side) areas during the summer. Excellent habitat for the Indiana brown bat has been identified at the Fernald site along the wooded banks of the northern reaches of Paddys Run. The habitat provides an extensive mature canopy of older trees and water throughout the year. One Indiana brown bat was captured and released on property in August of 1999.

Running Buffalo Clover - The federally listed endangered running buffalo clover (*Trifolium stoloniferum*) is a member of the clover family whose flower resembles that of the common white clover. Its leaves, however, differ from white clover in that they are heart-shaped and a lighter shade of green. Running buffalo clover has not been identified at the Fernald site; however, because running buffalo clover is found nearby in the Miami Whitewater Forest, the potential exists for this species to become established at the site. The running buffalo clover prefers habitat with well-drained soil, filtered sunlight, and limited competition from other plants and periodic disturbance. Suitable habitat areas include partially shaded grazed areas along Paddys Run and the Storm Sewer Outfall Ditch.

Spring Coral Root - The state-listed threatened spring coral root (*Corallorhiza wisteriana*) is a white and red orchid that blooms in April and May, and grows in partially shaded areas of forested wetlands and wooded ravines. This plant has not been identified at the Fernald site; however, suitable habitat exists in portions of the northern woodlot.

The Endangered Species Act requires the protection of any federally listed threatened or endangered species, as well as any habitat critical for the species' existence. Several Ohio laws mandate the protection of state-listed endangered species as well. Since 1993 a number of surveys have been conducted to determine the presence of any threatened or endangered species at the Fernald site. As a result of these surveys, the federally endangered Indiana brown bat and the state-threatened Sloan's crayfish have been found at the Fernald site. In addition, suitable habitat exists at the site for the federally endangered running buffalo clover and the state-threatened spring coral root. Neither of these species has been found on the property, but their habitat ranges encompass the site. Figure 7-1 shows the habitats and potential habitats of these species. Based on provisions set forth in the IEMP, any threatened or endangered species habitat will be surveyed prior to any remediation or restoration activities. If threatened or endangered species are present, appropriate avoidance or mitigation efforts will be undertaken. No surveys were conducted in 2004.

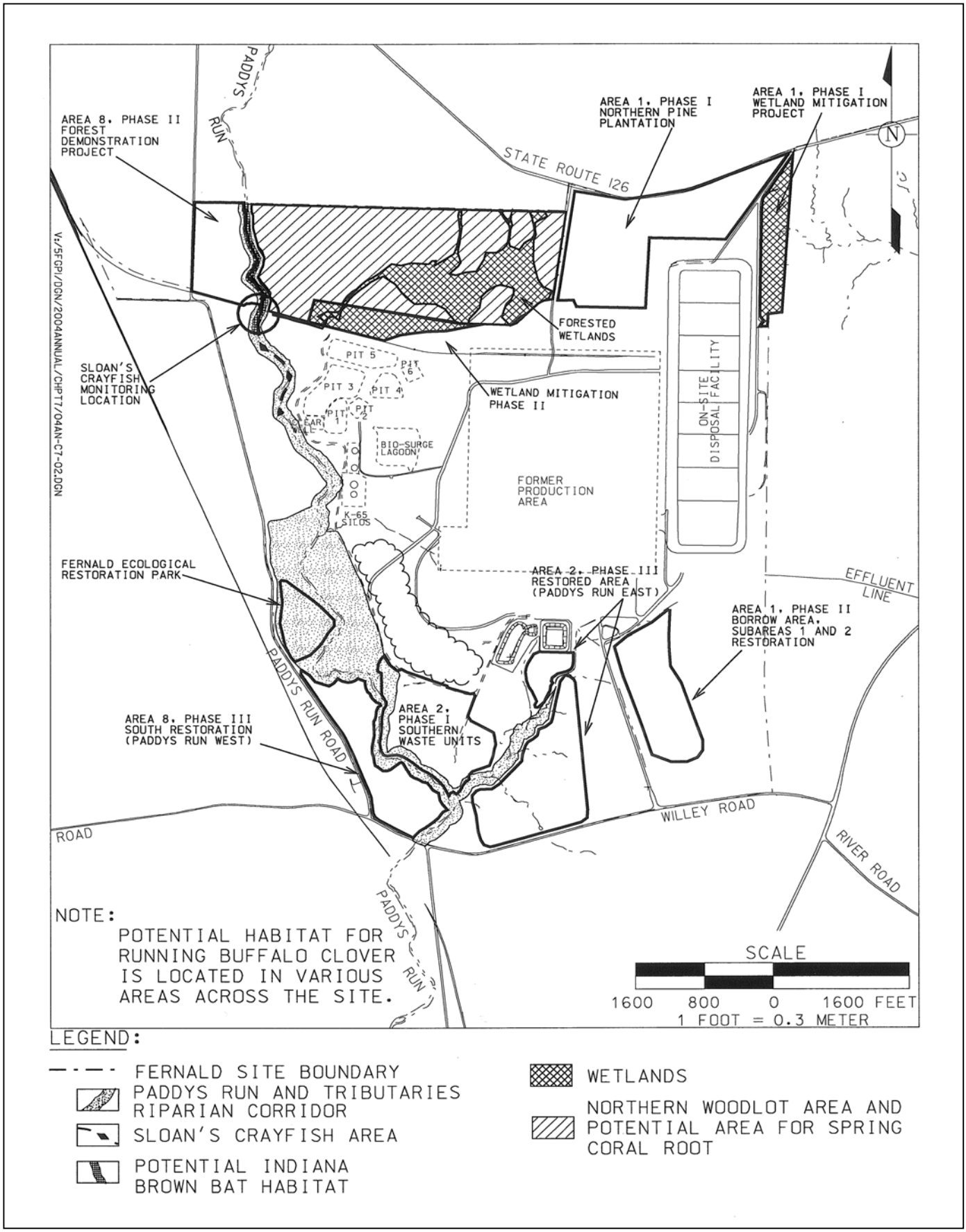


Figure 7-1. Priority Natural Resource Areas

7.1.1 Sloan's Crayfish Monitoring and Provisions for Protection

A Sloan's crayfish survey was conducted in August 2001 in order to determine if there were any impacts following debris removal near Paddys Run in Area 1 (Phase III). The survey results from the 2001 sampling effort demonstrated that the Paddys Run Sloan's crayfish population was not impacted by the debris removal operation. A large number of individuals were observed both downstream and upstream of the project area. Researchers did note a general decline in the ratio between Sloan's crayfish and *Orconectes rusticus*, which is a larger, more aggressive crayfish species that often competes with the Sloan's crayfish. Similar trends are observed statewide, and are attributed to the aggressive nature of *Orconectes rusticus*.

The IEMP originally required that visual field inspections of sediment loading be conducted within one day of a "significant rain event," which is considered to be 0.5 inch (1 cm) or more of rain in one 24-hour period. The purpose of this field-inspection monitoring is to determine if there is an increase of sediment in the northern reaches of Paddys Run due to remediation activities. Sediment loading can adversely impact the Sloan's crayfish by restricting its ability to "breathe" in water. If remediation activities cause sustained (four to five days) increased sediment loading to Sloan's crayfish habitat in Paddys Run, alternatives such as crayfish relocation are considered. Figure 7-1 identifies the Sloan's crayfish monitoring location.

The Sloan's crayfish monitoring program was suspended in 2002 because construction activities in the area decreased and episodes of increased sediment loading were rare. However, the program was resumed briefly in February 2003 due to railyard expansion activities and again in November 2003 when grading activities for the Wetland Mitigation Project (Phase II) commenced. Turbidity monitoring continued until June 2004, once the Wetland Mitigation Project (Phase II) was completed. No instances of increased sediment loading were observed during 2004 monitoring efforts.

7.2 Impacted Habitat

DOE and the Natural Resource Trustees tentatively agreed that it would not be necessary to quantitatively assess habitat impacted through remediation because DOE will be conducting natural resource restoration on approximately 884 acres (358 hectares) of the site. Therefore, a summary of the year's habitat impacts is presented here.

About 0.5 acre of riparian (stream side) habitat was disturbed along the Great Miami River in order to remove a portion of the abandoned outfall line. Vegetation consisted mostly of weedy, non-native species. The area was reseeded with a native grass and wildflower mix once field activities were completed.

7.3 Ecological Restoration Activities

For 2004, ecological restoration of the Wetland Mitigation Project (Phase II) was completed; Paddys Run West and the borrow area continued; and Paddys Run East was initiated. These projects are described in more detail below and are identified on Figure 7-1. Figure 7-1 also shows the location for previous restoration projects implemented at the Fernald site. Ecological restoration monitoring activities for several projects also continued in 2004.

The Wetland Mitigation Project (Phase II) involved the restoration of an 8-acre (3.2-hectare) former borrow area north of the waste pits. Three shallow basins were constructed and planted with a variety of wetland grasses, sedges, rushes, and wildflowers. Water enters the basins from adjacent wetlands of

the Northern Woodlot. Water control structures are used to regulate the depth of water within each basin. The Wetland Mitigation Project (Phase II) will contribute about 5 acres (2 hectares) toward the site wetland mitigation requirements. In 2004, grading of the basins and spillways was completed, and the water control structures were installed. Approximately 1,700 trees and shrubs were planted across the project area. In wetland areas, about 1,600 herbaceous plants were installed as well. Clearing of invasive plants in the Northern Woodlot was undertaken to prepare for tree planting and seeding. Invasive plants are non-native species that can quickly overtake an area by out-competing native vegetation for available resources. For instance, bush honeysuckle aggressively invades semi-shaded woodlands and forest edges. These shrubs grow so dense that native wildflowers, shrubs, and tree seedlings cannot get enough light to survive. As a result, native plant diversity is severely reduced and secondary succession (the process of natural habitat regeneration) is permanently altered. Field personnel use several methods to clear invasive species: mowing, cutting, pulling, and/or spraying with herbicide.

The Paddys Run West restoration project encompasses Area 8 (Phase III) South and North. Restoration objectives involve converting former pastures into tallgrass prairies and expanding the forested corridor along Paddys Run. In 2004, over 1,100 trees and shrubs were planted east of Paddys Run Road. Also, roughly nine acres of tallgrass prairie were seeded within Area 8 (Phase III) South. Work will continue in 2005 with the completion of planting and seeding across the remainder of the project area.

Borrow area restoration involves the creation of wetlands and tallgrass prairies across the southeast portion of the Fernald site. Grading and seeding for Sub-areas 1 and 2 of this project was completed in 2003. In 2004, tree and shrub installation for this area was initiated. Additional grading, vegetation installation, and seeding will be conducted in 2005.

The Paddys Run East restoration project involves the enhancement and expansion of existing forested areas along the southern on-property portion of Paddys Run and its tributaries. The project area encompasses all of Area 2 (Phases II and III). In addition to forest restoration, several tallgrass prairies will be seeded. In 2004, restoration activities focused on plant installation within Area 2 (Phase III). Approximately 1,300 trees and shrubs were installed across the project area. Work will continue in 2005 with additional tree and shrub planting, prairie seeding, and clearing of invasive species.

Ecological restoration monitoring has been divided into two phases: the Implementation Phase and the Functional Phase. Implementation Phase monitoring is conducted to ensure that restoration projects are completed as intended in their designs. This effort involves the mortality counts and herbaceous cover estimates that are conducted after a project is completed. Functional Phase monitoring is more general and considers projects in terms of their contribution to the ecological community as a whole. This is accomplished by comparing projects to pre-remediation baseline conditions and to ideal reference sites. Mortality and herbaceous cover thresholds are described in the 2002 Consolidated Monitoring Report for Restored Areas at the Fernald Closure Project (DOE 2003b).

In 2004, implementation monitoring was conducted for the Northern Pine Plantation restoration project. Mortality counts and herbaceous cover estimates were calculated across the project area. Overall plant survival within the Northern Pines is approximately 70 percent. As with other projects, plant survival was primarily influenced by deer pressure. Portions of the Northern Pines are protected with deer exlosure fencing. In these areas, survival was much better than surrounding areas, at around 85 percent. These findings have resulted in the increased use of deer exclosure fencing across the Fernald site. Herbaceous cover estimates for the Northern Pine Plantation demonstrated that native grasses and wildflowers have quickly established within the restored area.

Functional Phase monitoring at the Fernald site involved the characterization of restored prairie and savanna communities. Upland prairie vegetation in the Area 1 Wetland Mitigation Project (Phase I), the Area 8 Forest Demonstration Project (Phase II), and the Eco Park Prairie were compared to baseline and reference sites. Each of these areas showed considerable progress. In general, the diversity and quality of native vegetation present in these restored areas is much improved when compared to baseline conditions. In 2005, several restored forest areas will be evaluated.

A family of hooded mergansers makes the Area 1 Wetland Mitigation Project (Phase I) their home.

7.4 Cultural Resources

The Fernald site and surrounding area are located in a region of rich soil and many sources of water, such as the Great Miami River. Because of its advantageous location, the area was settled repeatedly throughout prehistoric and historic time, resulting in richly diverse cultural resources. In summary, 148 prehistoric and 40 historic sites have been identified within 1.24 miles (2 km) of the Fernald site.

Several laws have been established to protect cultural resources during remedial activities at the Fernald site. The National Historic Preservation Act requires DOE to take into consideration the effects of its actions on sites that are listed or eligible for listing on the National Register of Historic Places. The Native American Graves Protection and Repatriation Act requires that prehistoric human remains and associated artifacts be identified and returned to the appropriate Native American tribe.

To comply with these laws, DOE conducts archeological surveys prior to remediation activities in undeveloped areas of the Fernald. Figure 7-2 shows that the majority of the site has been surveyed. These surveys have resulted in the identification of six sites that may be eligible for listing on the National Register of Historic Places. None of these sites was impacted by remediation activities and no additional surveys were needed in 2004.

DOE also keeps track of unexpected discoveries of cultural resources during remediation activities at the Fernald site. One prehistoric and nine historic artifacts were encountered in 2004. None of the findings was significant, and no impacts to cultural resources occurred. Due to the proximity of several known cultural resource sites, monitoring was conducted during excavation of the abandoned outfall line. Most of the historic artifacts were found during this project. They consisted primarily of ceramic stoneware. The prehistoric artifact was a piece of pottery uncovered during borrow area operations in Area 1 (Phase II).

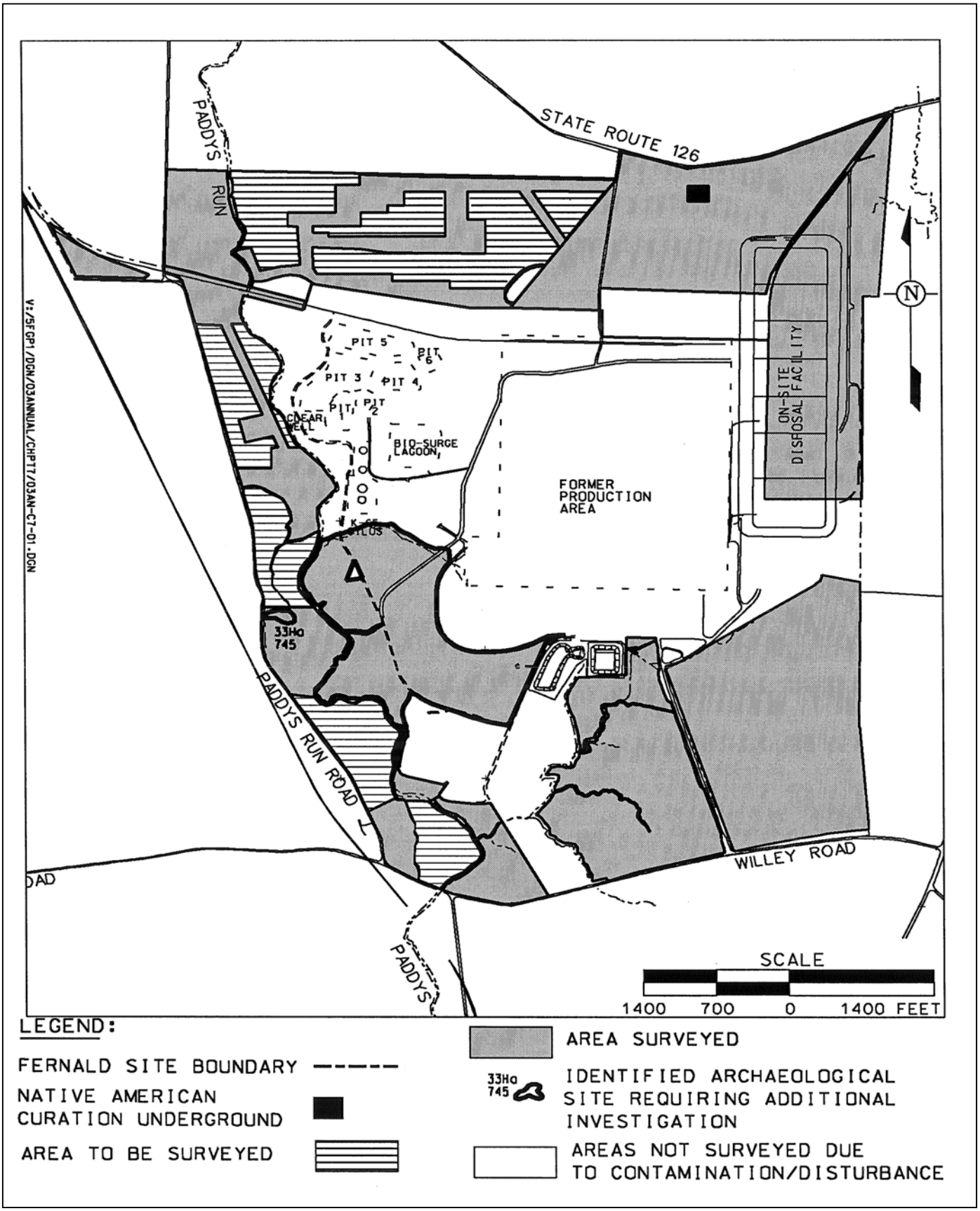


Figure 7-2. Cultural Resource Survey Areas

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Glossary

ALARA An acronym for "as low as reasonably achievable." Used to describe an approach to radiation exposure and emissions control or management, whereby exposures and resulting doses to workers and the public are maintained as far below the specified limits as economic, technical, and practical considerations will permit.

Alpha Particle Type of particulate radiation emitted from the nucleus of an atom. It consists of two protons and two neutrons. It does not travel long distances and loses its energy quickly.

Aquifer A geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield economical quantities of water to wells and springs.

ARARs An acronym for "applicable or relevant and appropriate requirements." Requirements set forth in regulations that implement environmental and public health laws and must be attained or exceeded by a selected remedy unless a waiver is invoked. ARARs are divided into three categories: chemical-specific, location-specific, and action-specific, based on whether the requirement is triggered by the presence or emission of a chemical, by a vulnerable or protected location, or by a particular action.

Background Radiation Particle or wave energy spontaneously released from atomic nuclei in the natural environment, including cosmic rays and such releases from naturally radioactive elements both outside and inside the bodies of humans and animals, and fallout from nuclear weapons tests.

Beta Particle Type of particulate radiation emitted from the nucleus of an atom that has a mass and charge equal in magnitude to that of the electron.

Bypass Events A bypass event occurs when storm water is diverted around treatment and is directly discharged to the Great Miami River via the Fernald site effluent line. Bypass events can occur during significant precipitation or when water treatment facilities are down for maintenance. Bypassing treatment is only implemented when the site's storm water retention capacity is in danger of being exceeded.

Capture Zone Estimated area that is being "captured" by the pumping of groundwater extraction wells. The definition of the capture zone is important in ensuring that the uranium plumes targeted for cleanup are being remediated.

Certification The process by which a soil remediation area is certified as clean. Samples from the area are collected and analyzed, and the contaminant levels compared to the final remedial levels established in the Operable Unit 5 Record of Decision. Not all soil remediation areas at the Fernald site require excavation before certification is done.

Contaminant A substance that when present in air, surface water, sediment, soil, or groundwater above naturally occurring (background) levels causes degradation of the media.

Controlled Runoff Contaminated storm water requiring treatment; it is collected, treated, and eventually discharged to the Great Miami River as treated effluent.

Curie (Ci) Unit of radioactivity that measures the rate of spontaneous, energy-emitting transformations in the nuclei of atoms.

Dose Quantity of radiation absorbed in tissue.

Ecological Receptor A biological organism selected by ecological risk assessors to represent a target species most likely to be affected by site-related chemicals, especially through bioaccumulation. Such organisms may include terrestrial and aquatic species.

Effective Dose Equivalent The sum of the products of the dose equivalent received by specified tissues of the body and tissue-specific weighting factor. This sum is a risk-equivalent value and can be used to estimate the risk of health effects to the exposed individual. The tissue-specific weighting factor represents the fraction of the total health risk resulting from uniform whole-body irradiation that would be contributed by that particular tissue. The effective dose equivalent includes the committed effective dose equivalent from internal deposition of radionuclides and the effective dose equivalent due to penetrating radiation from sources external to the body. Effective dose equivalent is expressed in units of rem (or Sievert).

Exposure Pathway A route by which materials could travel between the point of release and the point of delivery of a radiation or chemical dose to a receptor organism.

Flyash The ash remaining after the burning of coal in a boiler plant.

Gamma Ray Type of electromagnetic radiation of discrete energy emitted during radioactive decay of many radioactive elements.

Glacial Overburden/Glacial Till Silt, sand, gravel, and clay deposited by glacial action on top of the Great Miami Aquifer and surrounding bedrock highs.

Great Miami Aquifer Sand and gravel deposited by the meltwaters of Pleistocene glaciers within the entrenched ancestral Ohio and Miami rivers. This is also called a buried channel, or sand and gravel aquifer.

Groundwater Water in a saturated zone or stratum beneath the surface of land.

Head Works Includes the various flow equalization basins and/or preliminary treatment units that serve as the central collection and distribution points to the wastewater treatment operations in the main facility.

Mixed Waste Hazardous waste that has been contaminated with low-level radioactive materials.

Opacity The amount of light that is blocked by particulates present in stack emissions.

Overpacking The act of placing a deteriorating drum inside a new, larger drum to prevent further deterioration or the possible release of contaminants during storage.

Point Source The single defined point (origin) of a release such as a stack, vent, or other discernable conveyance.

Radiation The energy released as particles or waves when an atom's nucleus spontaneously loses or gains neutrons and/or protons. The three main types are alpha particles, beta particles, and gamma rays.

Radioactive Material Refers to any material or combination of materials that spontaneously emits ionizing radiation.

Radionuclide Refers to a radioactive nuclide. There are several hundred known radionuclides, both artificially produced and naturally occurring. Radionuclides are characterized by the number of neutrons and protons in an atom's nucleus and their characteristic decay processes.

Receptors Individuals or organisms that are or could be impacted by contamination.

Remedial Action The actual construction and implementation phase of a Superfund site cleanup that follows the remedy selection process and remedial design.

Remedial Investigation/Feasibility Study The first major event in the remedial action process which serves to assess site conditions and evaluate alternatives to the extent necessary to select a remedy.

Removal Action A short-term cleanup or removal of released hazardous substances from the environment. This occurs in the event of a release or the imminent threat of release of hazardous substances into the environment.

Roentgen Equivalent Man (Rem) A special unit of dose equivalent that expresses the effective dose calculated for all radiation on a common scale; the absorbed dose in rads multiplied by certain modifying factors (e.g., quality factor); 100 rem = 1 Sievert.

Sediment The unconsolidated inorganic and organic material that is suspended in surface water and is either transported by the water or has settled out and become deposited in beds.

Source A controlled source of radioactive material used to calibrate radiation detection equipment. Can also be used to refer to any source of contamination (e.g., a point source such as the stack on the waste pits stack, a source of radon such as the silos' headspace, etc.).

Surface Water Water that is flowing within natural drainage features.

Treated Effluent Water from numerous sources at the site which is treated through one of the site's wastewater treatment facilities and discharged to the Great Miami River.

Thermoluminescent Dosimeter A device used to monitor the amount of radiation to which it has been exposed.

Uncontrolled Runoff Storm water that is not collected by the site for treatment, but enters the site's natural drainages.

Volatile Organic Compound A hydrocarbon compound, except methane and ethane, with a vapor pressure equal to or greater than 0.1 millimeter of mercury.

Waste Acceptance Criteria Disposal facilities specify the types and sizes of materials, acceptable levels of constituents, and other criteria for all material that will be disposed in that facility. These are known as waste acceptance criteria. Off-site disposal facilities that will dispose of Fernald waste (such as the Nevada Test Site) have specific waste acceptance criteria. In addition, the on-site disposal facility has waste acceptance criteria that have been approved by the regulatory agencies. The Waste Acceptance Organization is responsible for ensuring that all waste to be placed in the on-site disposal facility meets all these criteria before waste placement.