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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.

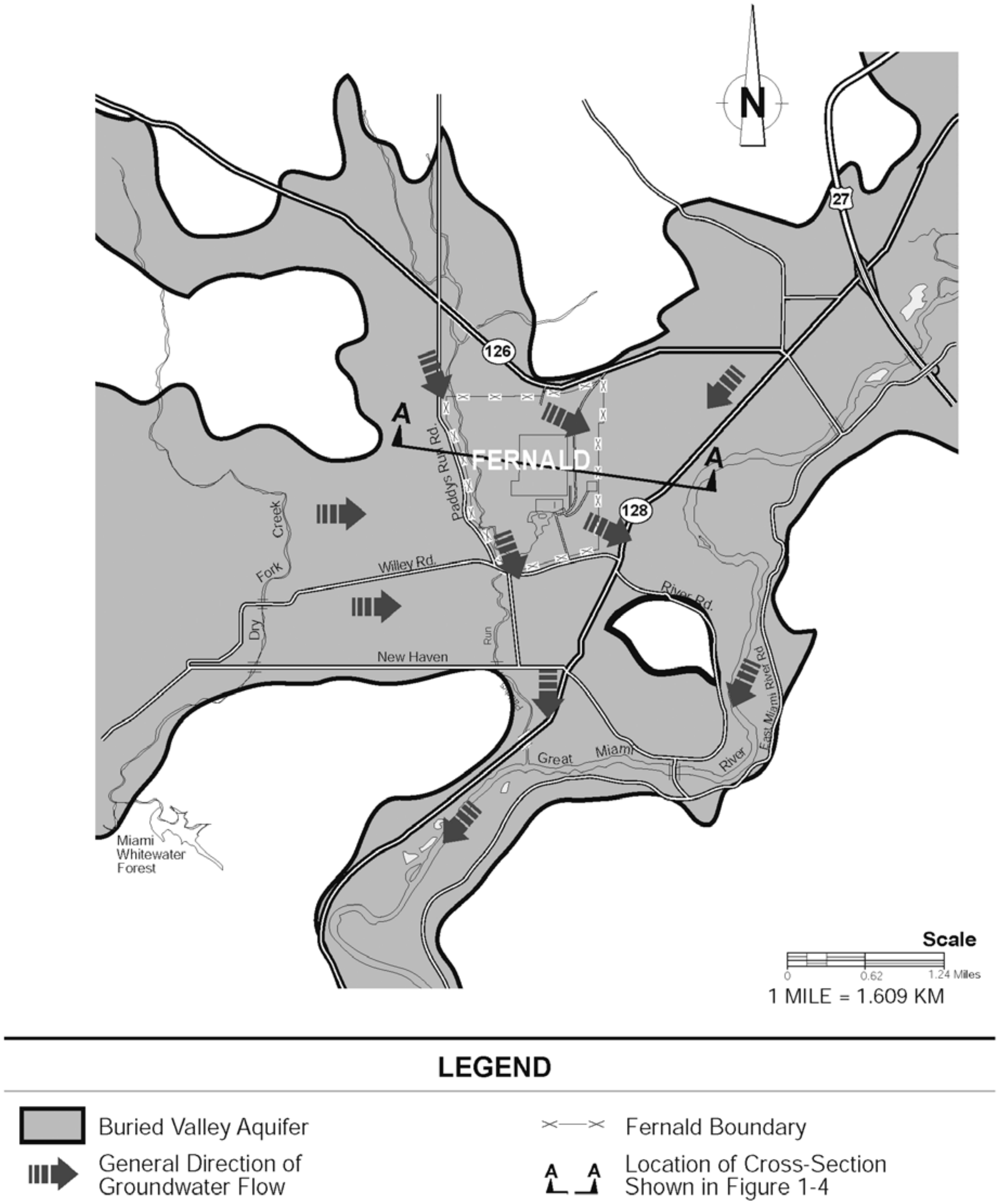


Figure 1-5. Regional Groundwater Flow in the Great Miami Aquifer

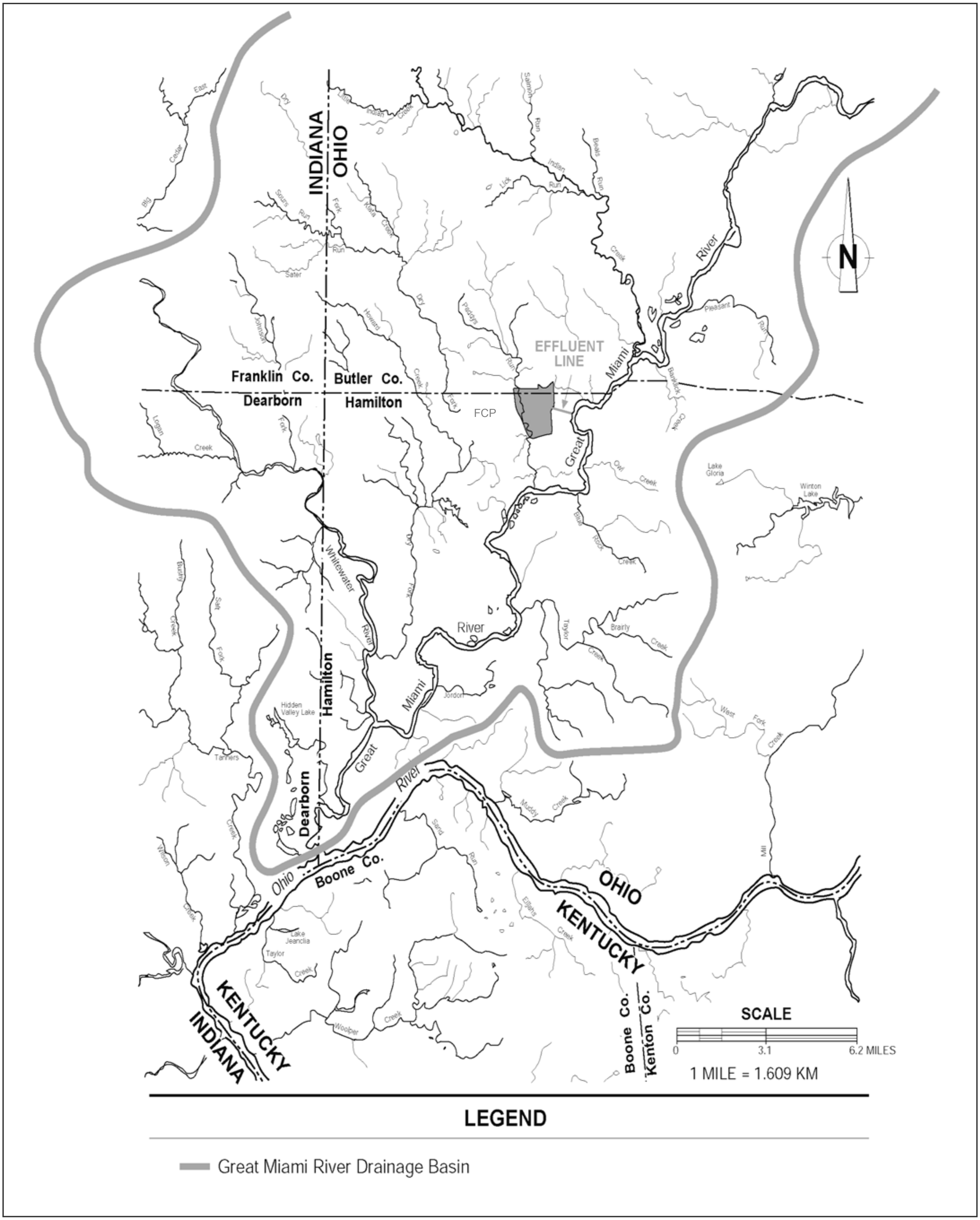


Figure 1-6. Great Miami River Drainage Basin

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.

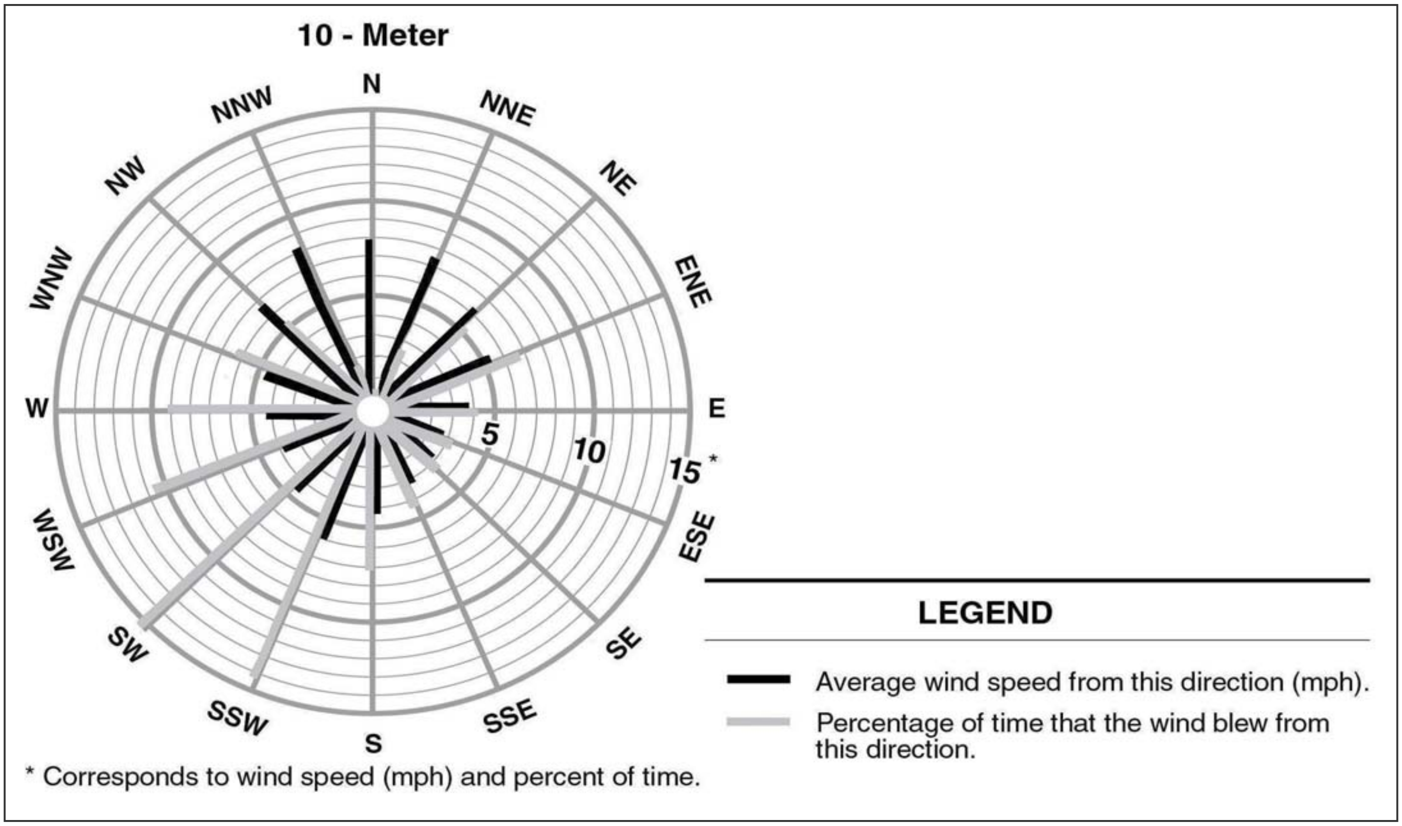


Figure 1-7. 2004 Wind Rose, 33-Foot (10-Meter) Height

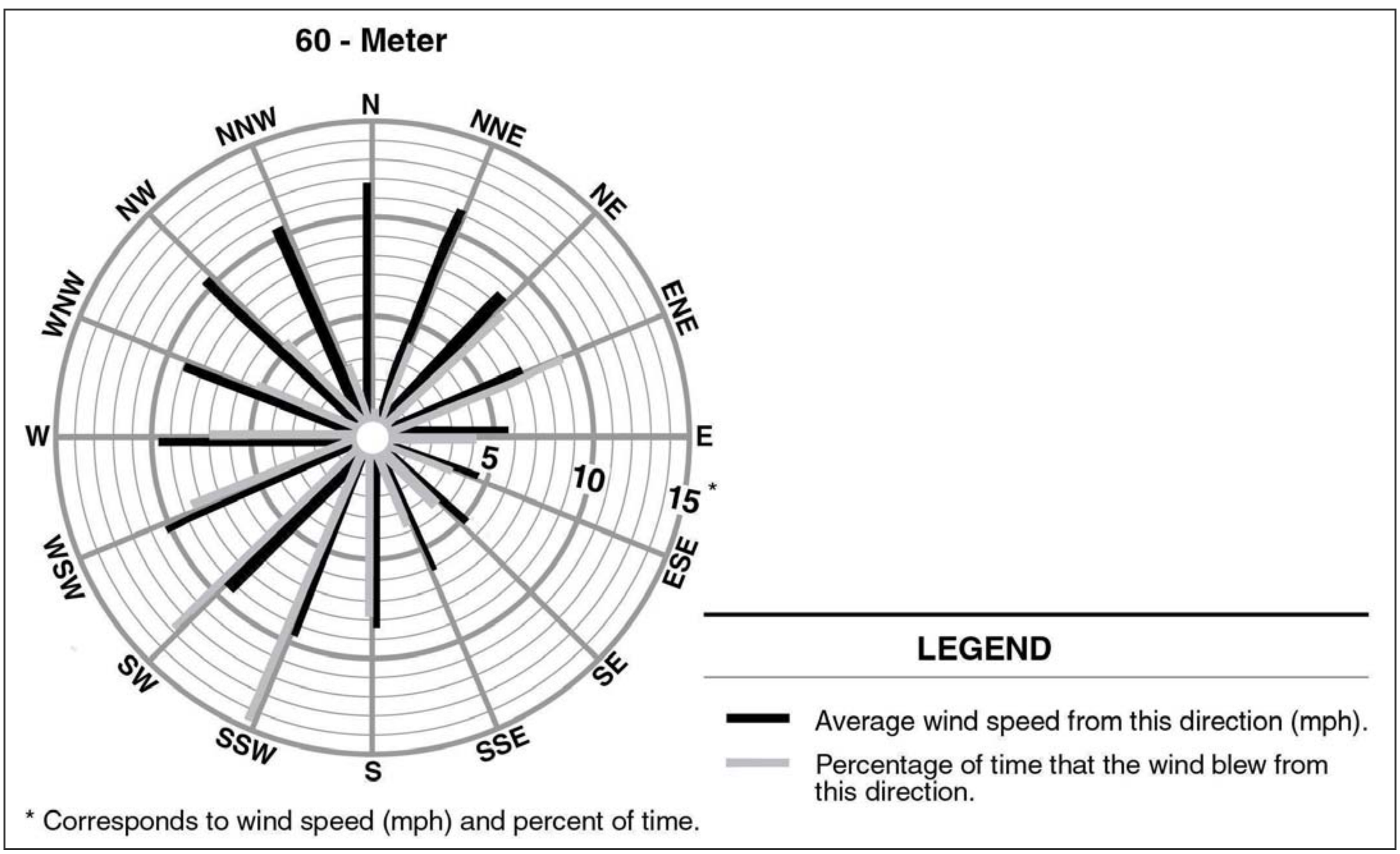


Figure 1-8. 2004 Wind Rose, 197-Foot (60-Meter) Height

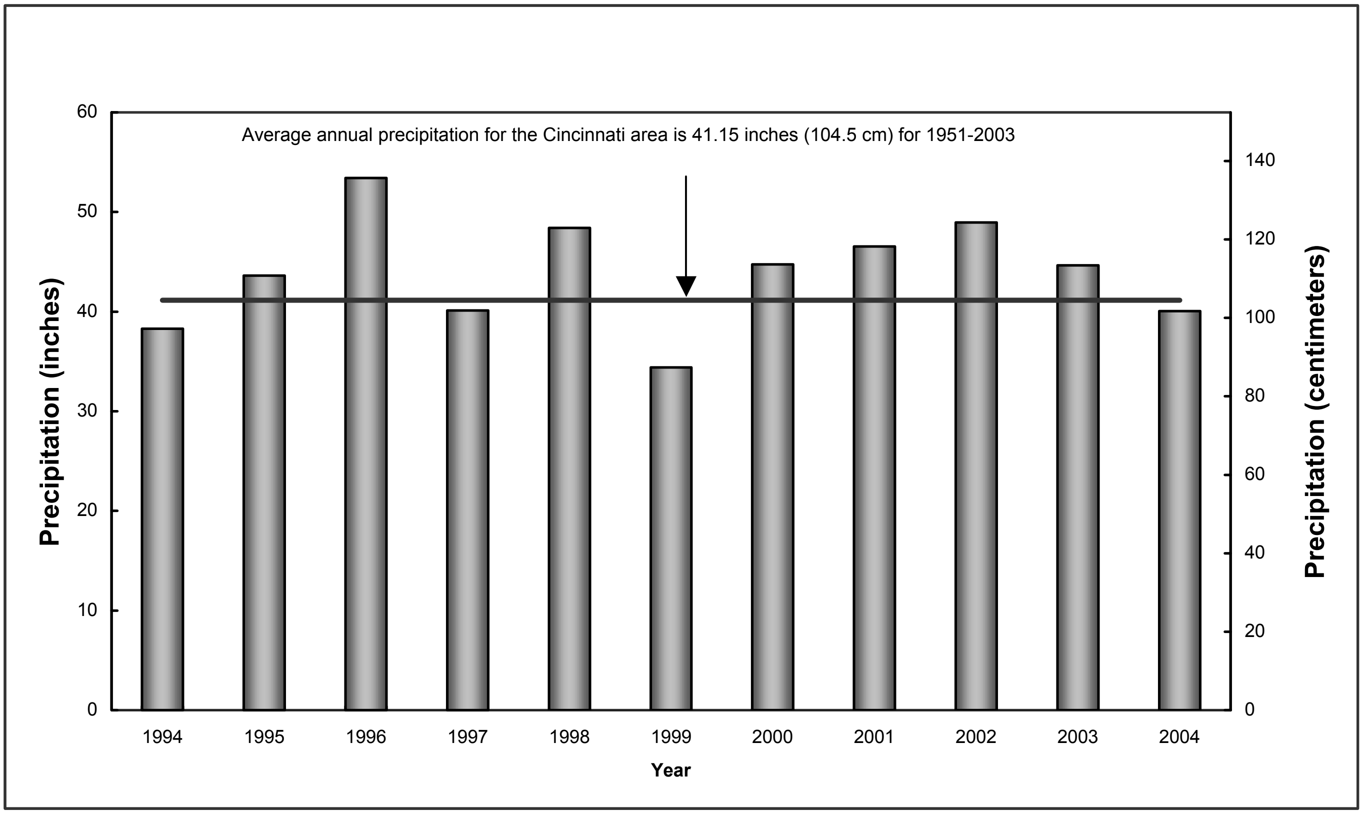


Figure 1-9. Average Annual Precipitation, 1991-2004

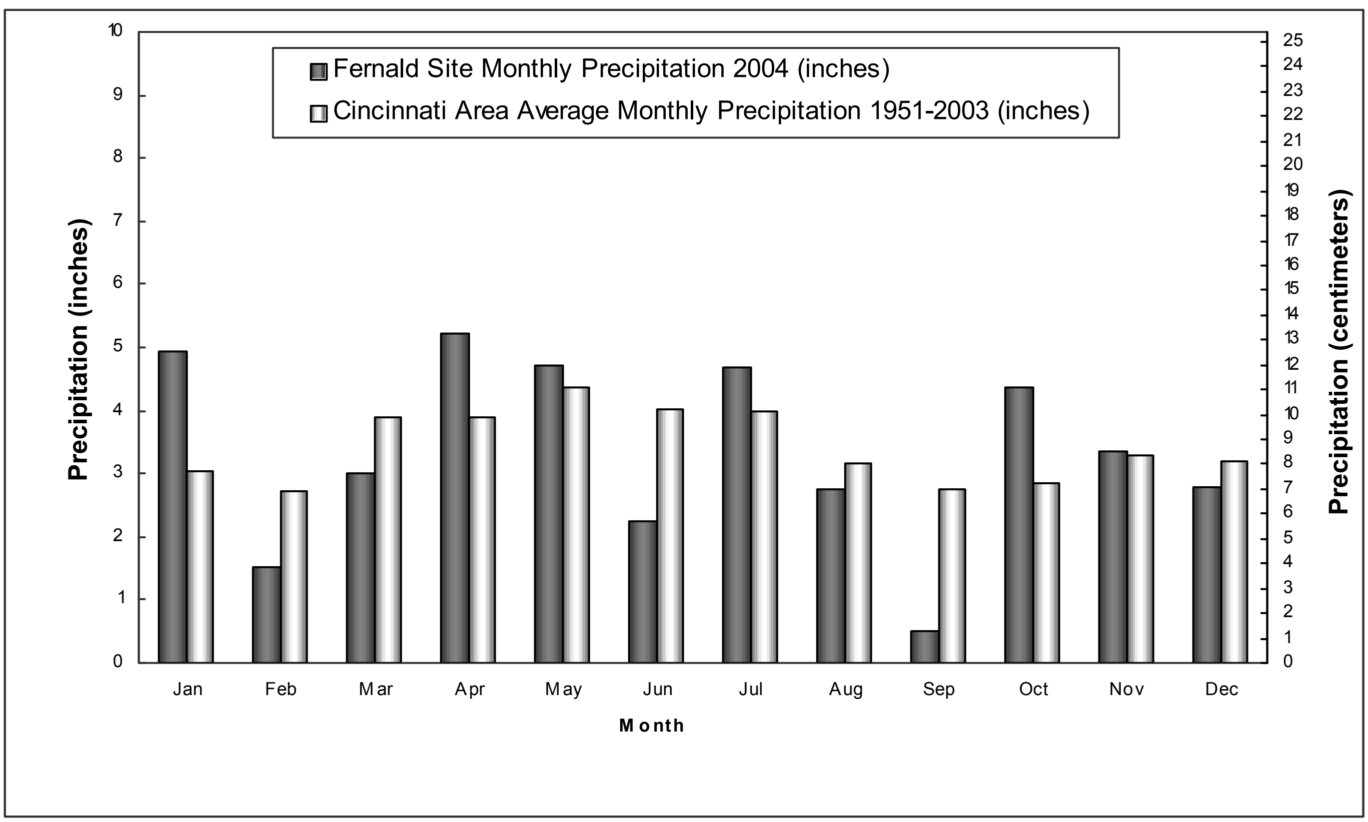


Figure 1-10. Monthly Precipitation for 2004 and Annual Average Precipitation for 1951-2003

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.

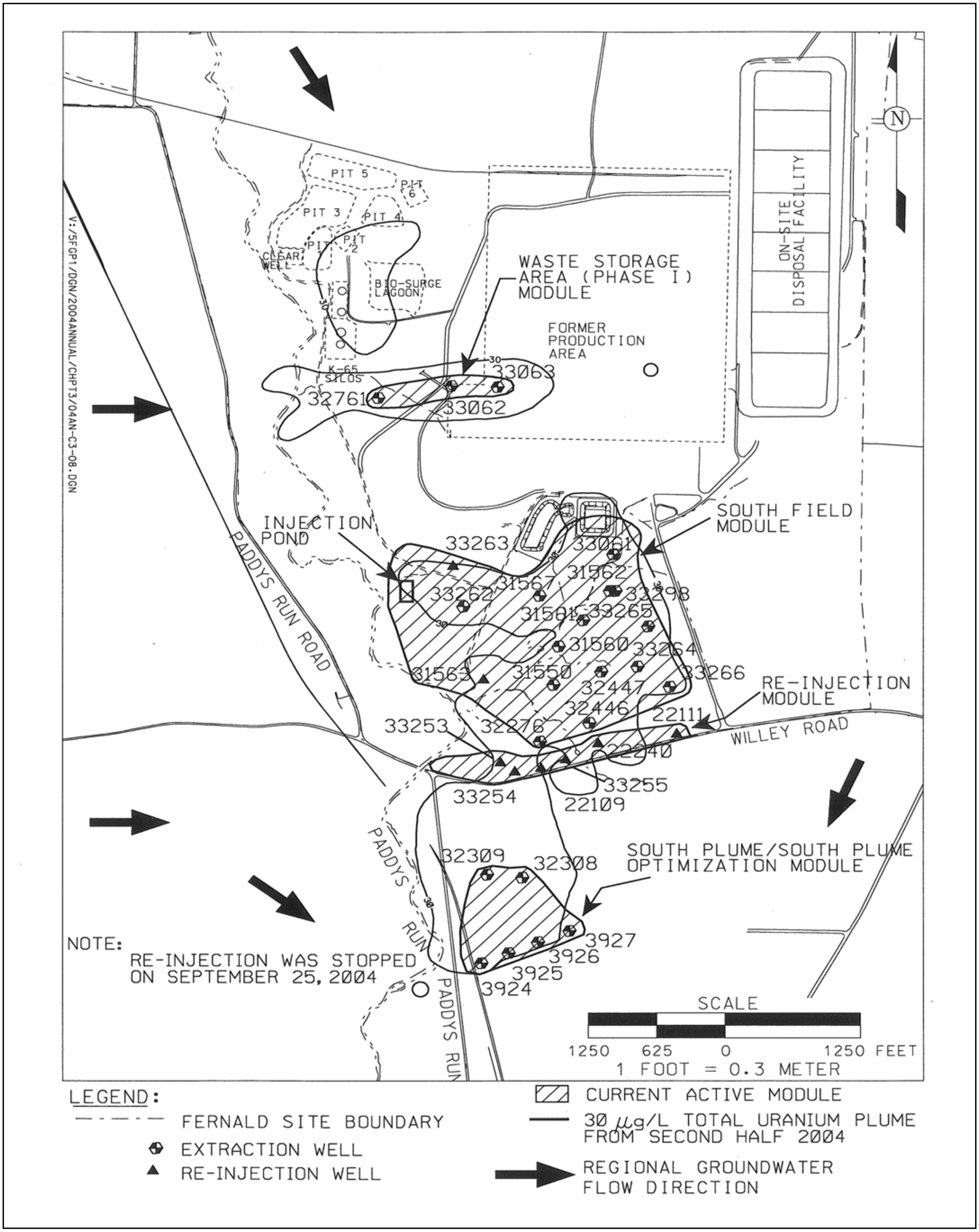


Figure 3-1. Extraction and Re-injection Wells Active in 2004

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.

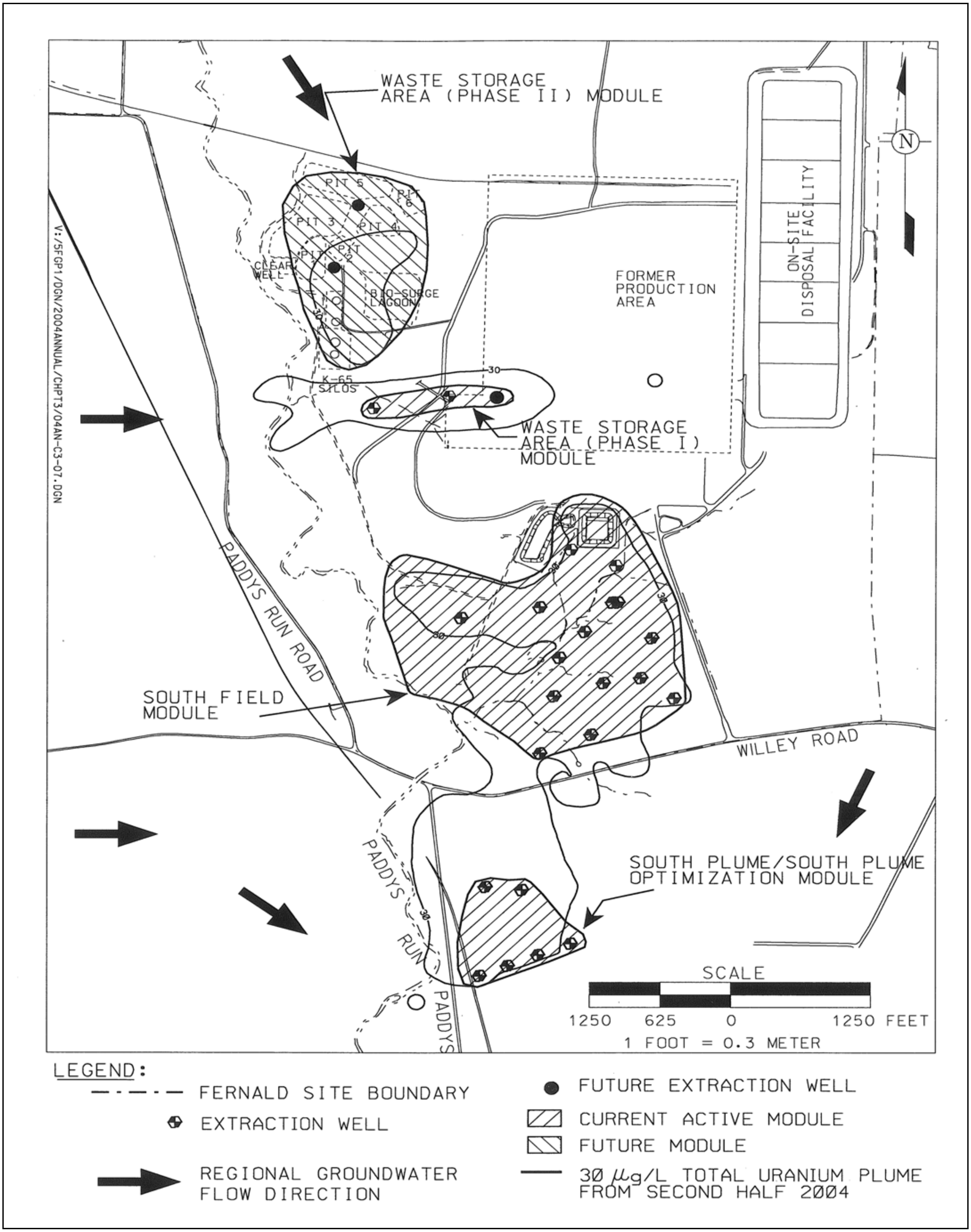


Figure 3-2. Current and Future Extraction and Re-injection Wells for the Enchanced Groundwater Remedy

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.

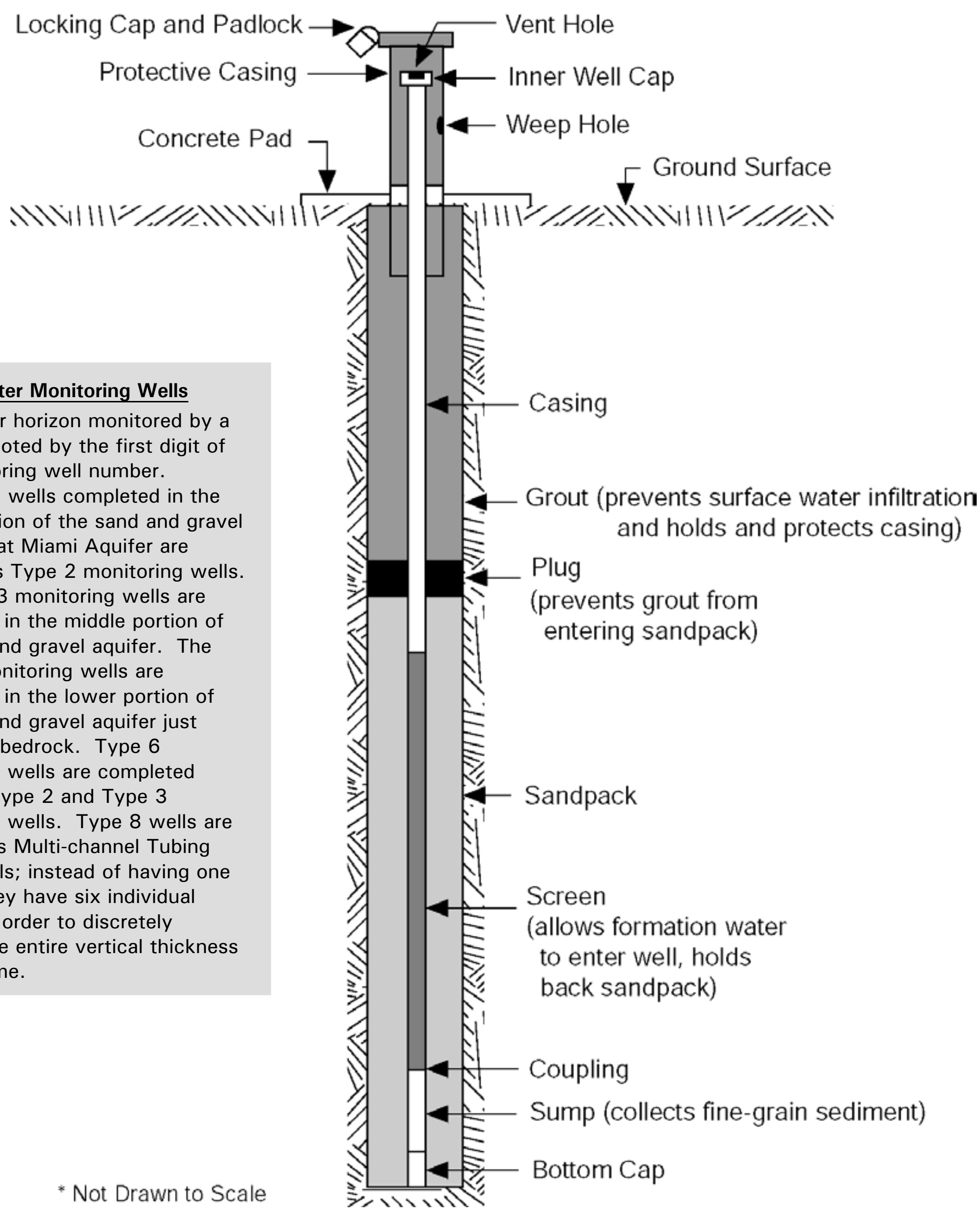
- **Data Evaluation** – The integrated data evaluation process involves review and analysis of the data collected from wells to determine capture and restoration of the uranium plume; capture and restoration of non-uranium FRL constituents; water quality conditions in the aquifer that indicate a need 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

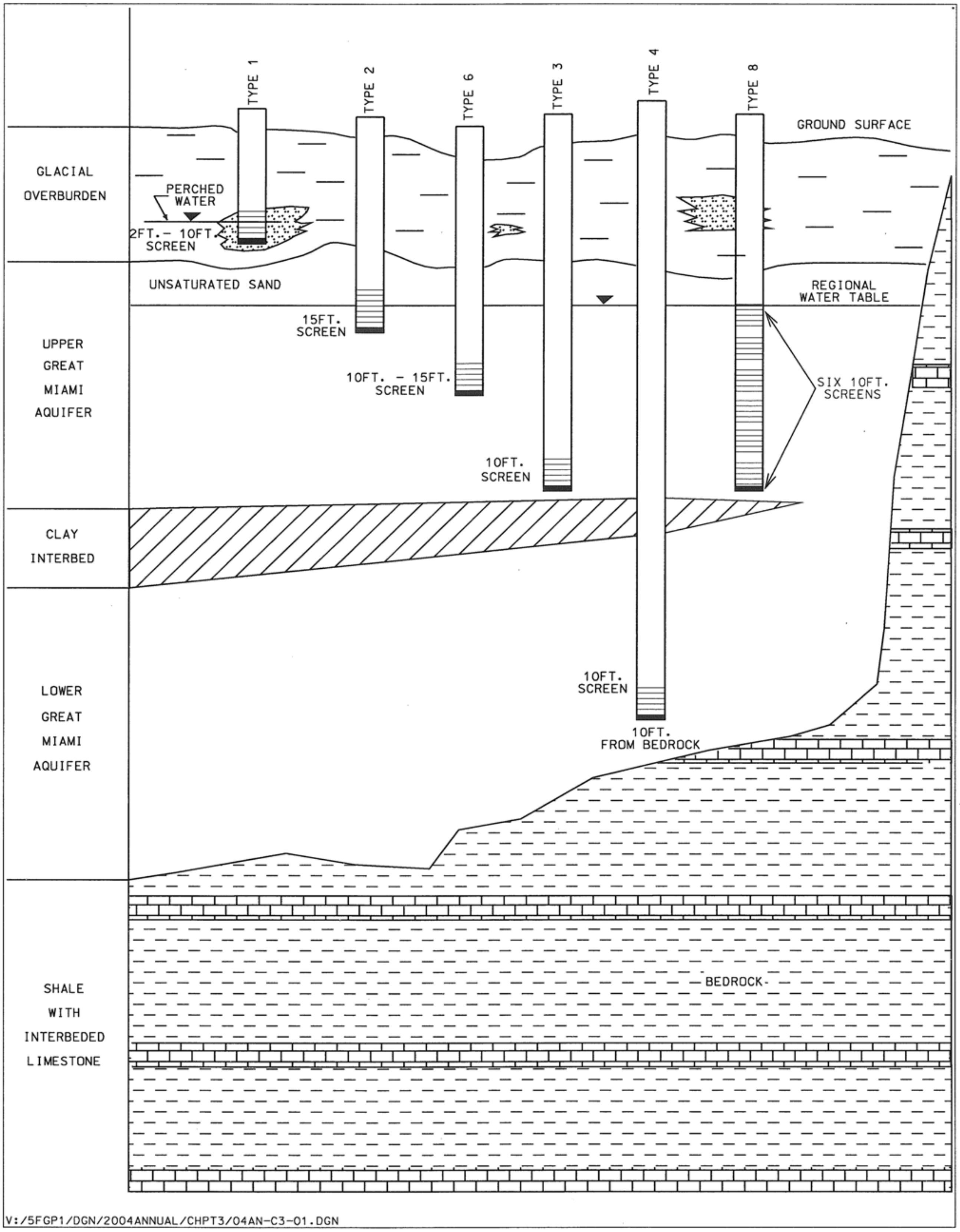


Figure 3-4. Monitoring Well Relative Depths and Screen Locations

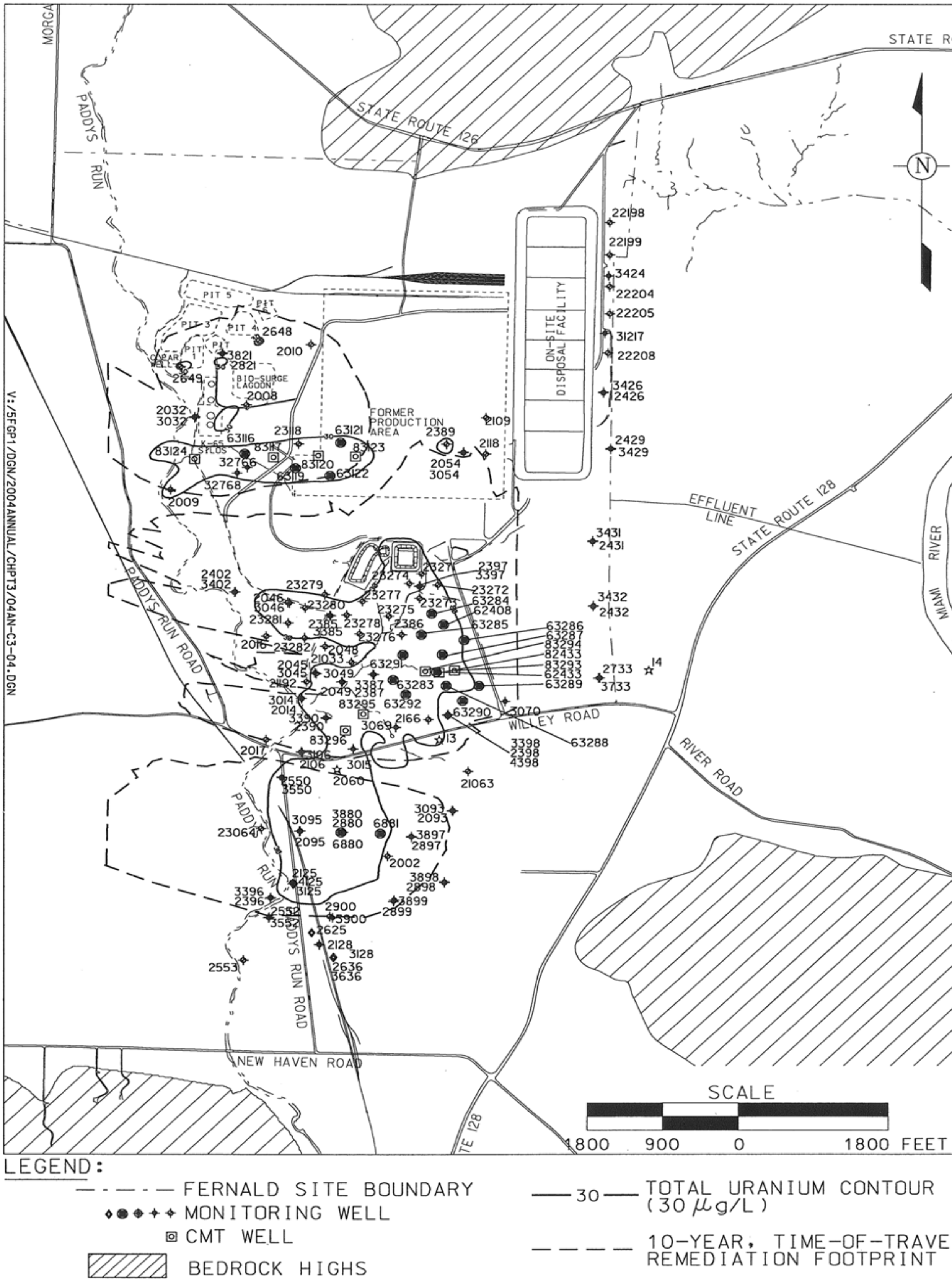


Figure 3-5. Locations for Semiannual Total Uranium Monitoring

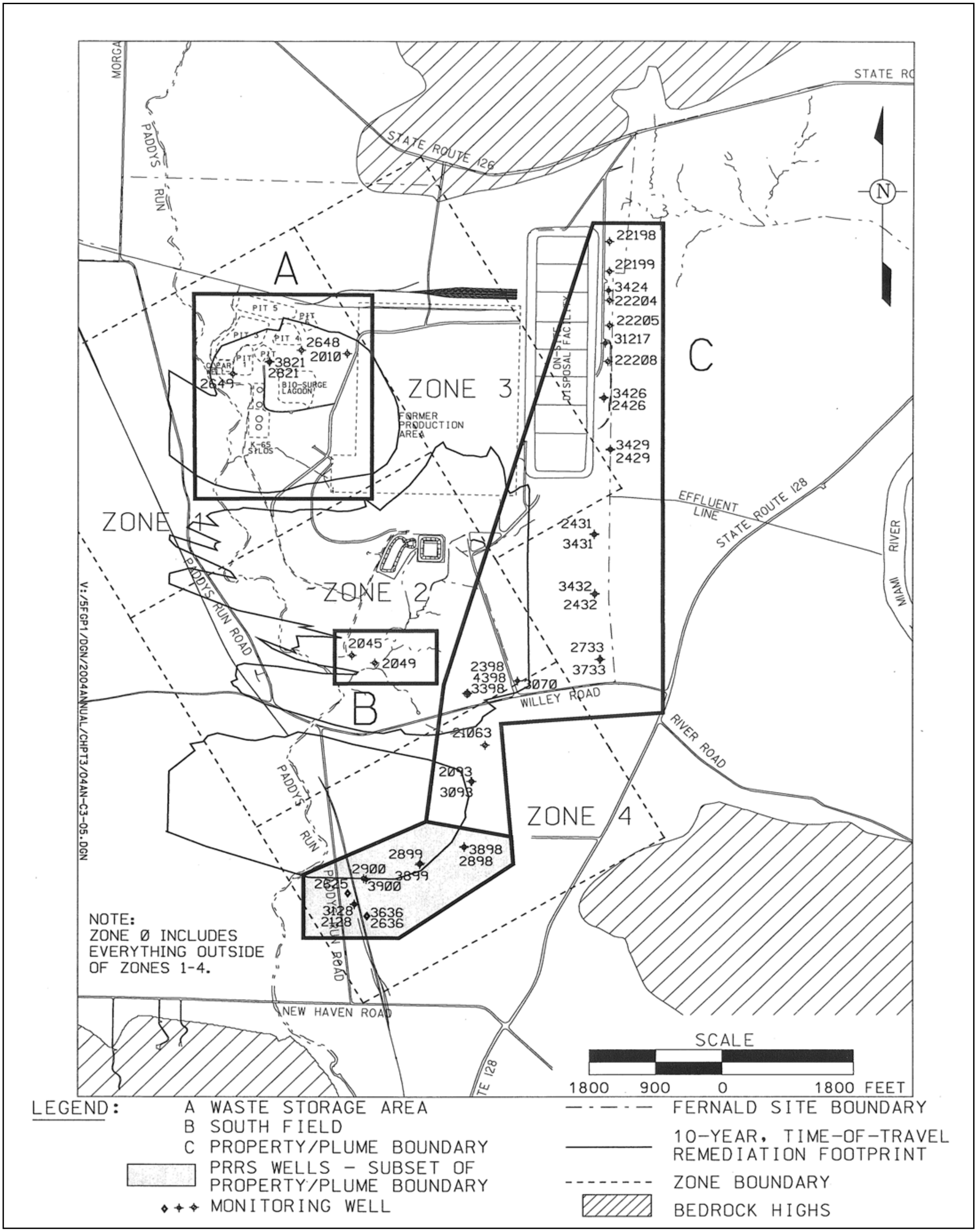


Figure 3-6. Locations for Semiannual Non-uranium Monitoring

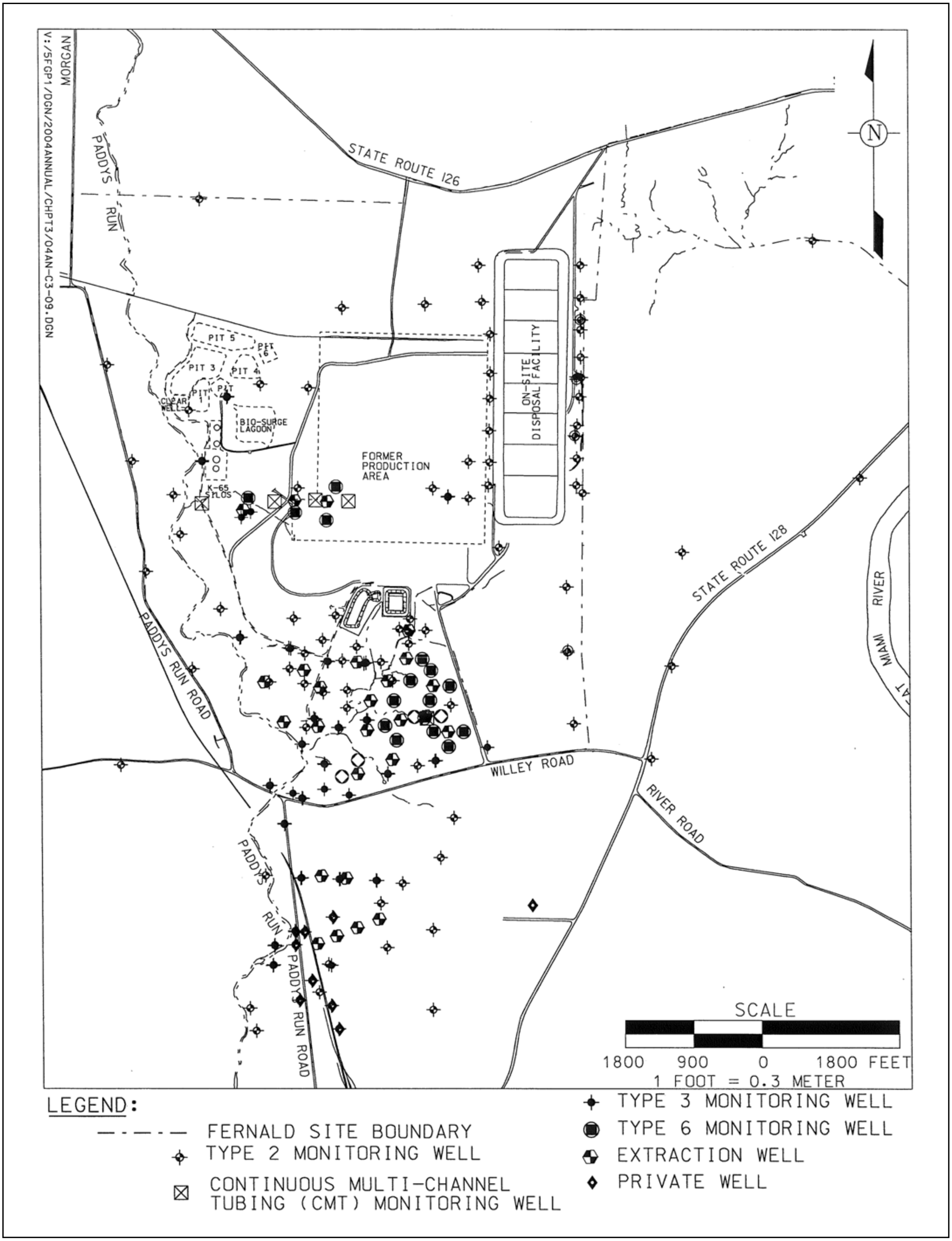


Figure 3-7. IEMP Groundwater Elevation Monitoring Wells

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.

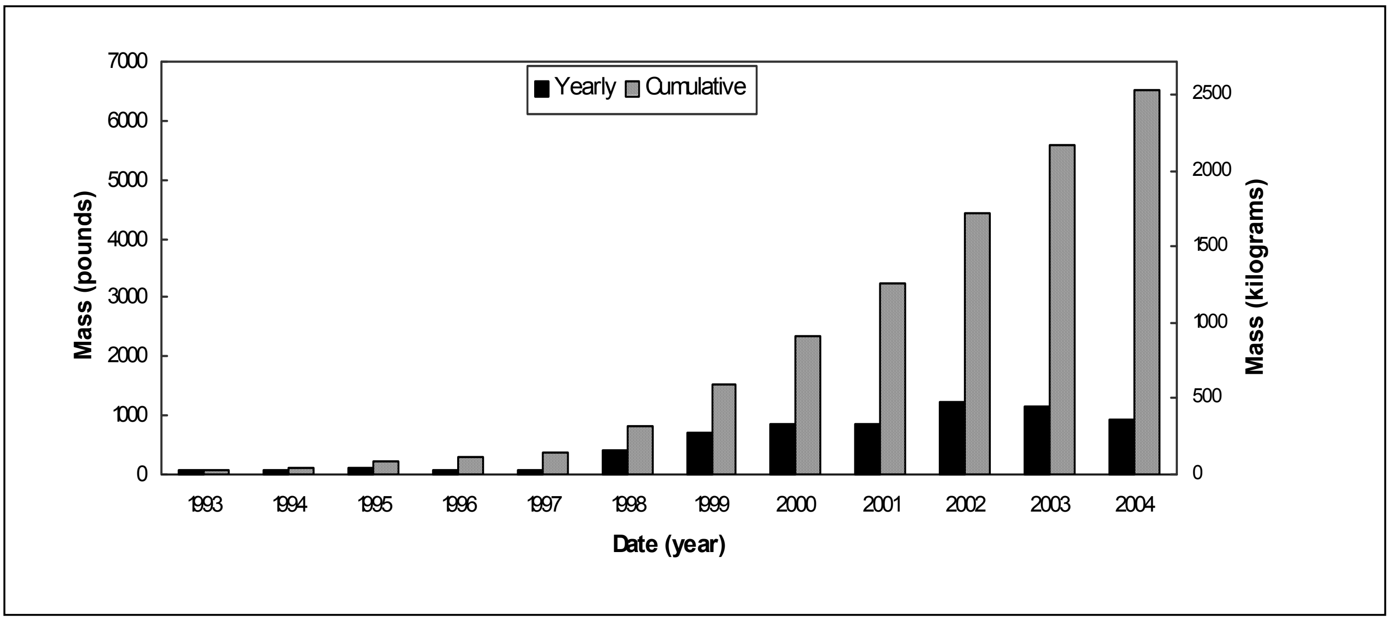


Figure 3-8. Net Pounds of Uranium Removed from the Great Miami Aquifer, 1993-2004

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.

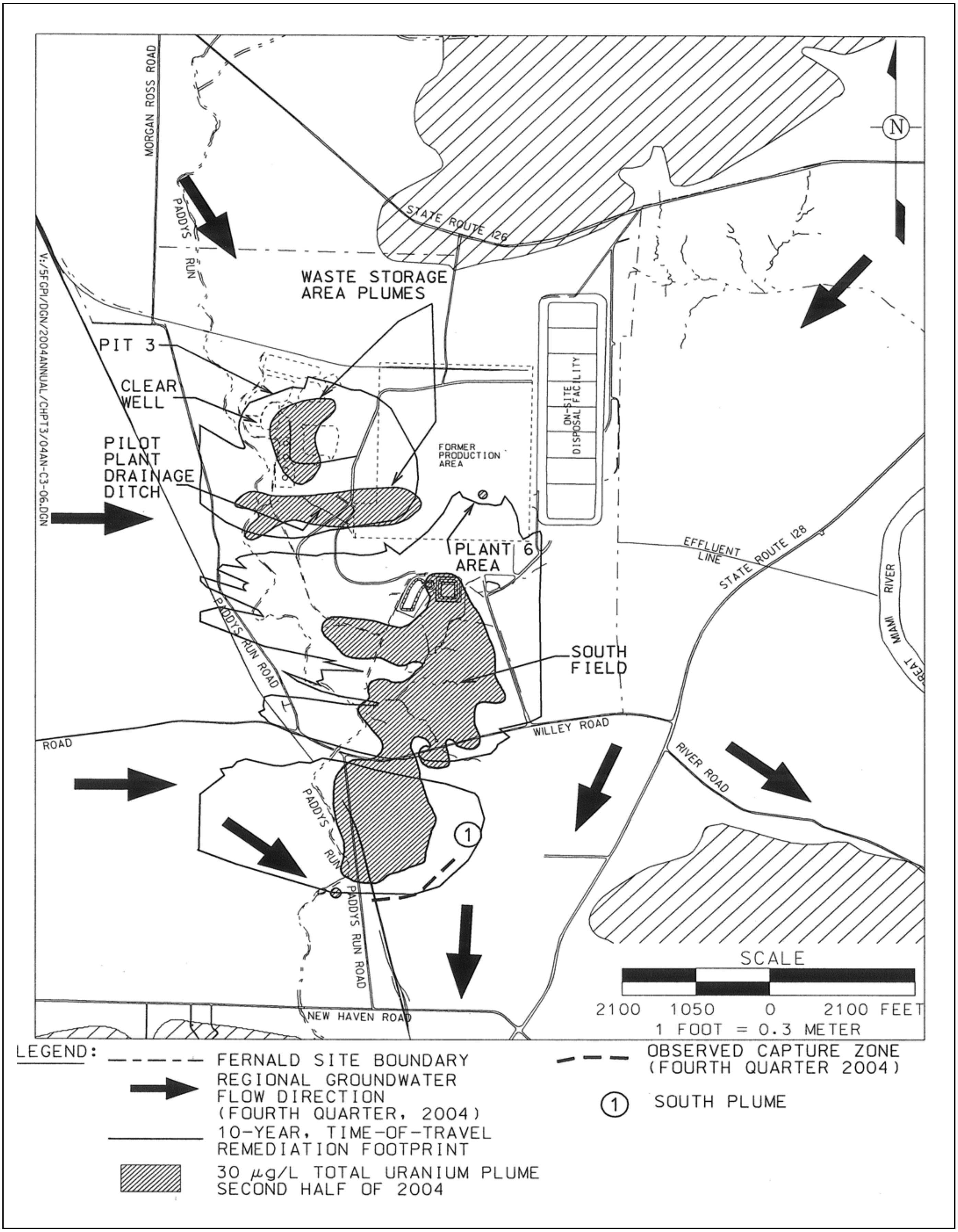


Figure 3-9. Total Uranium Plume in the Aquifer with Concentrations Greater than 30 µg/L at the End of 2004

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.

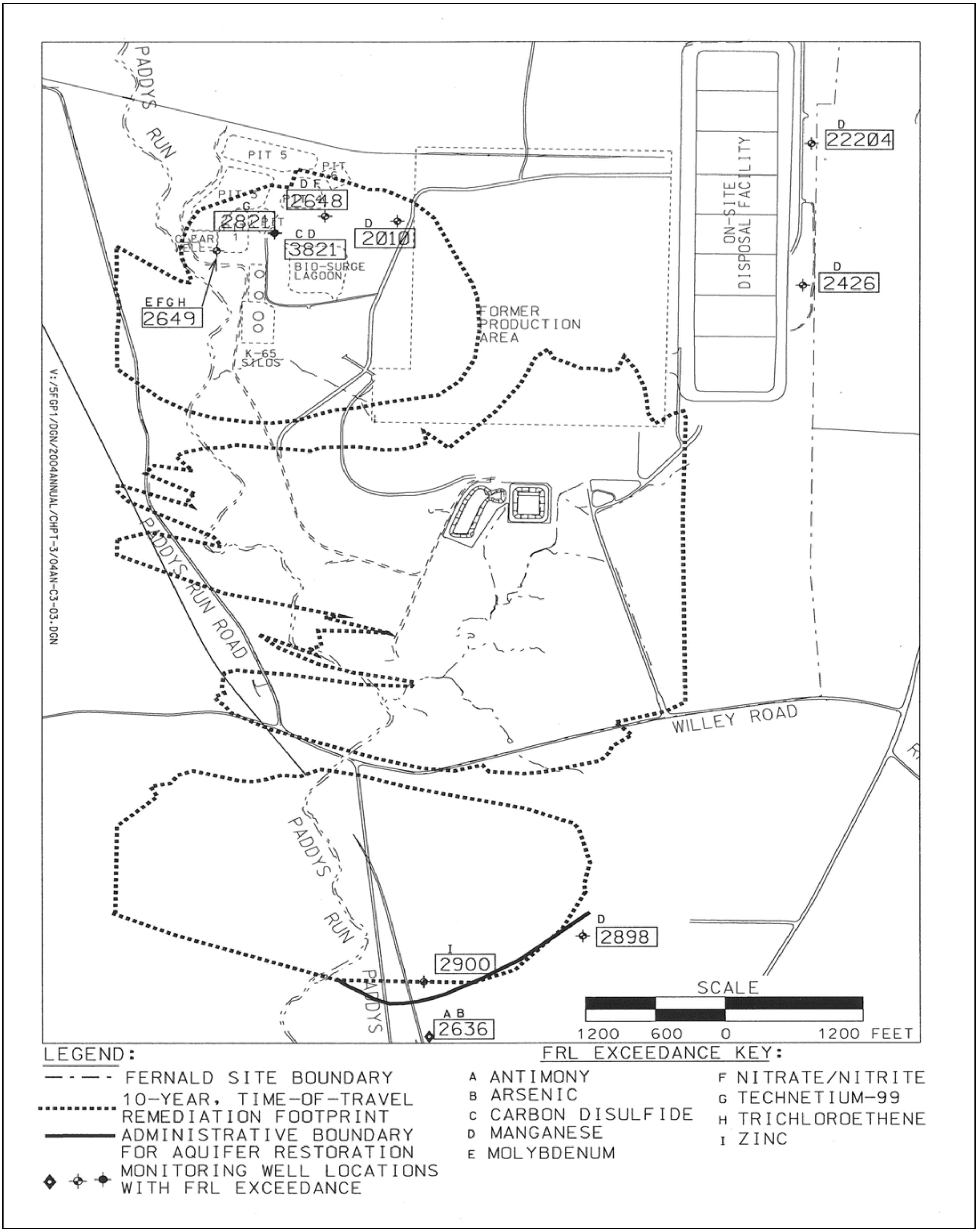


Figure 3-10. Non-uranium Constituents with 2004 Results Above Final Remediation Levels

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.

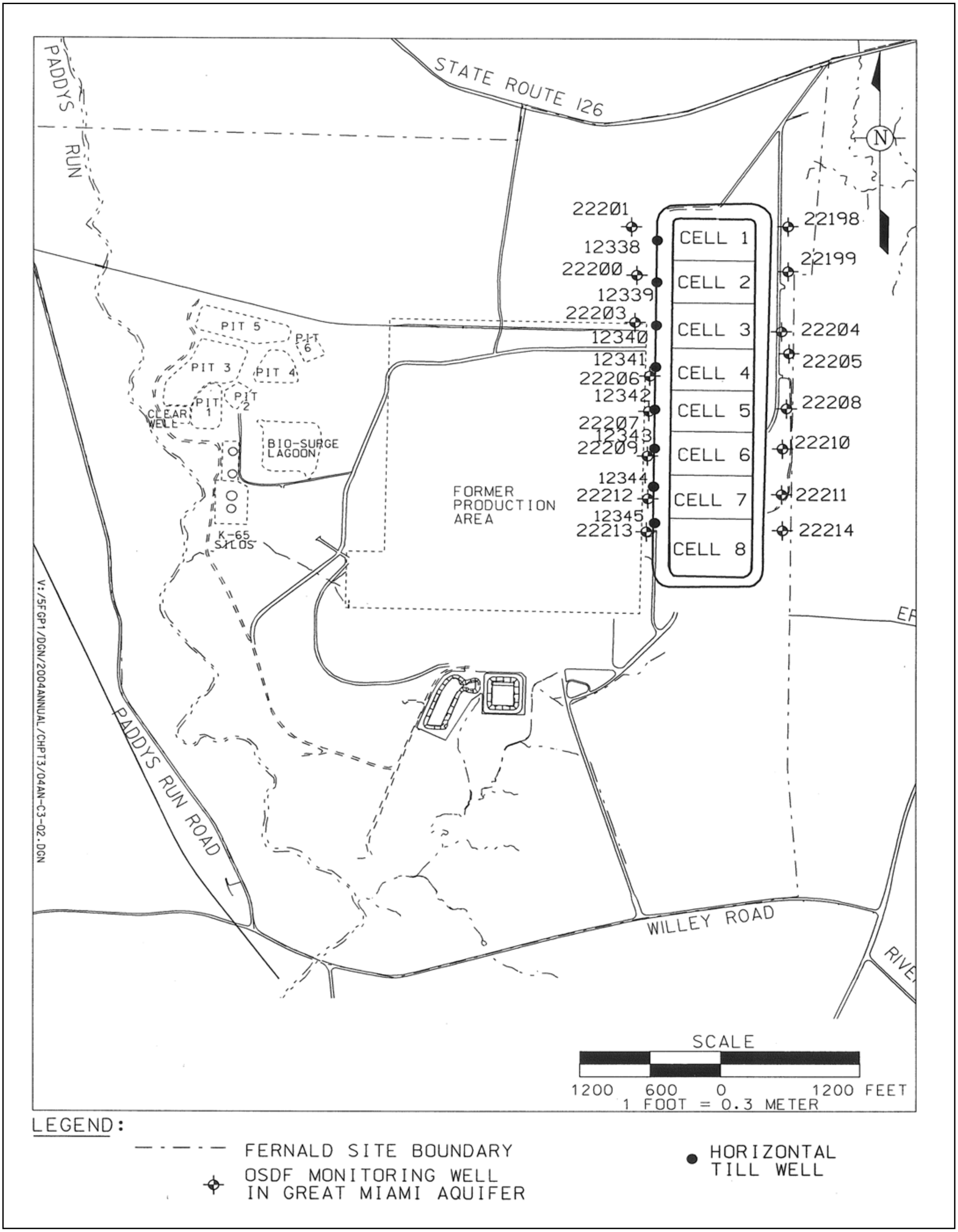


Figure 3-11. On-site Disposal Facility Footprint and Monitoring Well Locations

4.3.3 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).

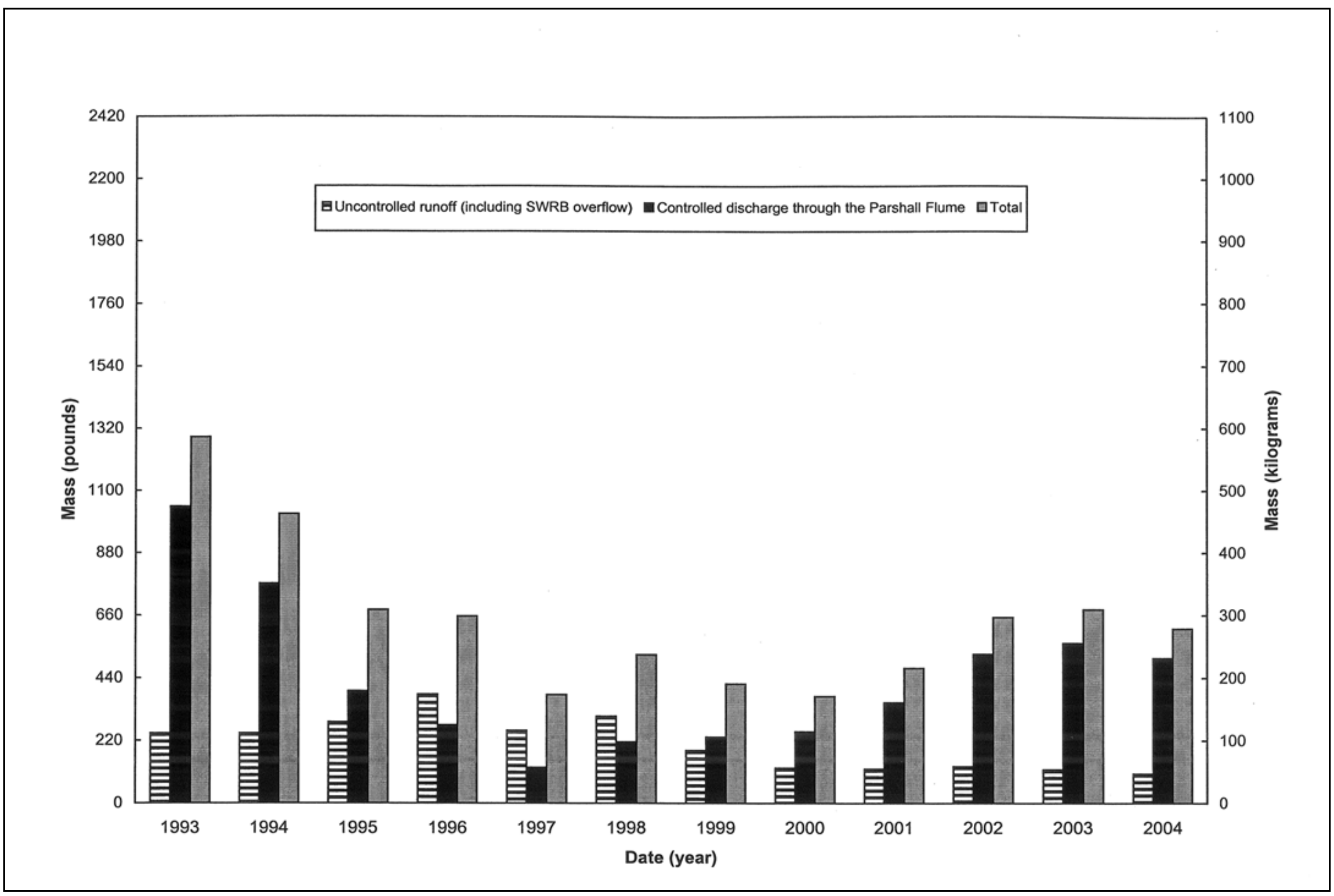


Figure 4-8. Uranium Discharged Via the Surface Water Pathway, 1993-2004

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.

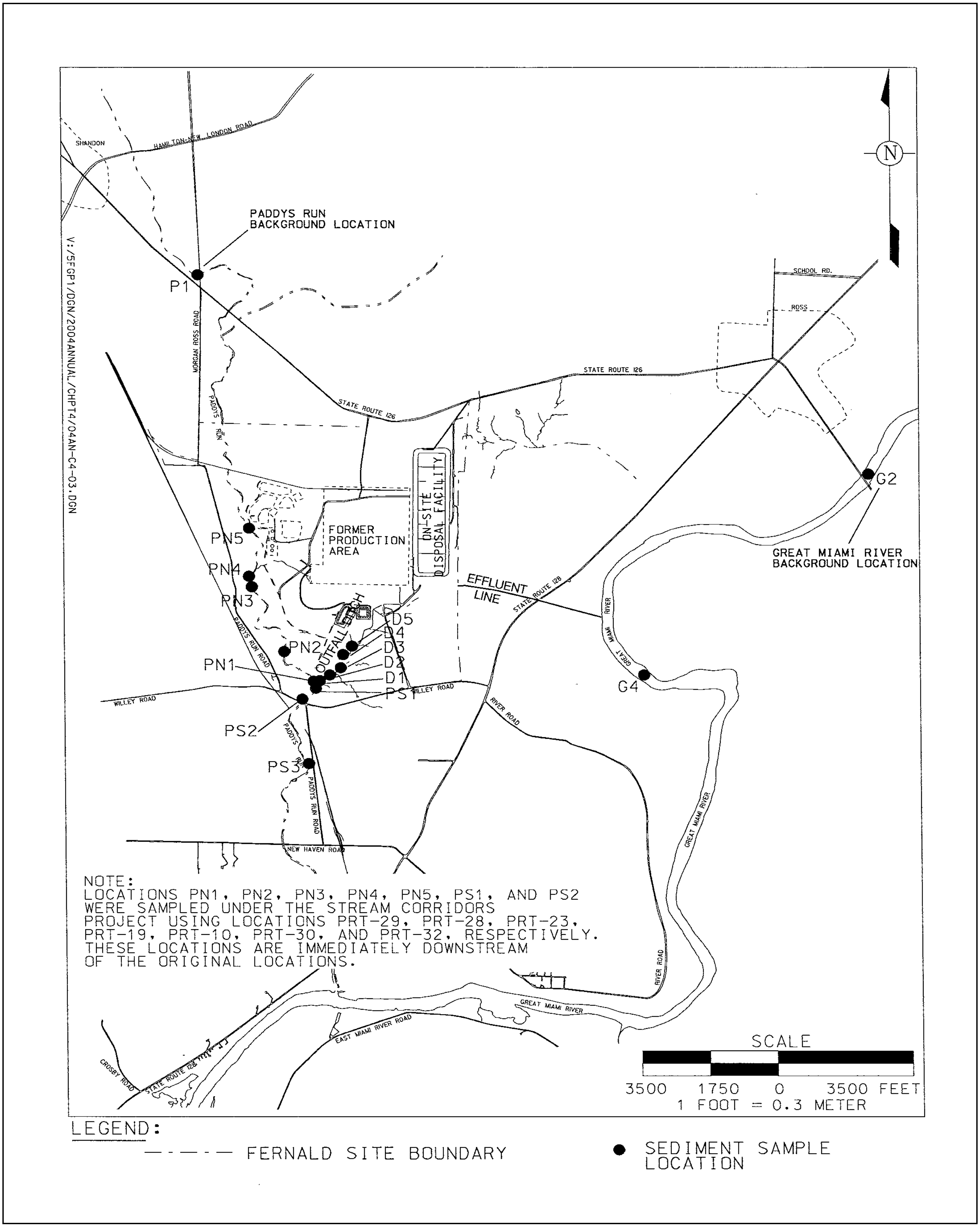


Figure 4-9. 2004 Sediment Sample Locations

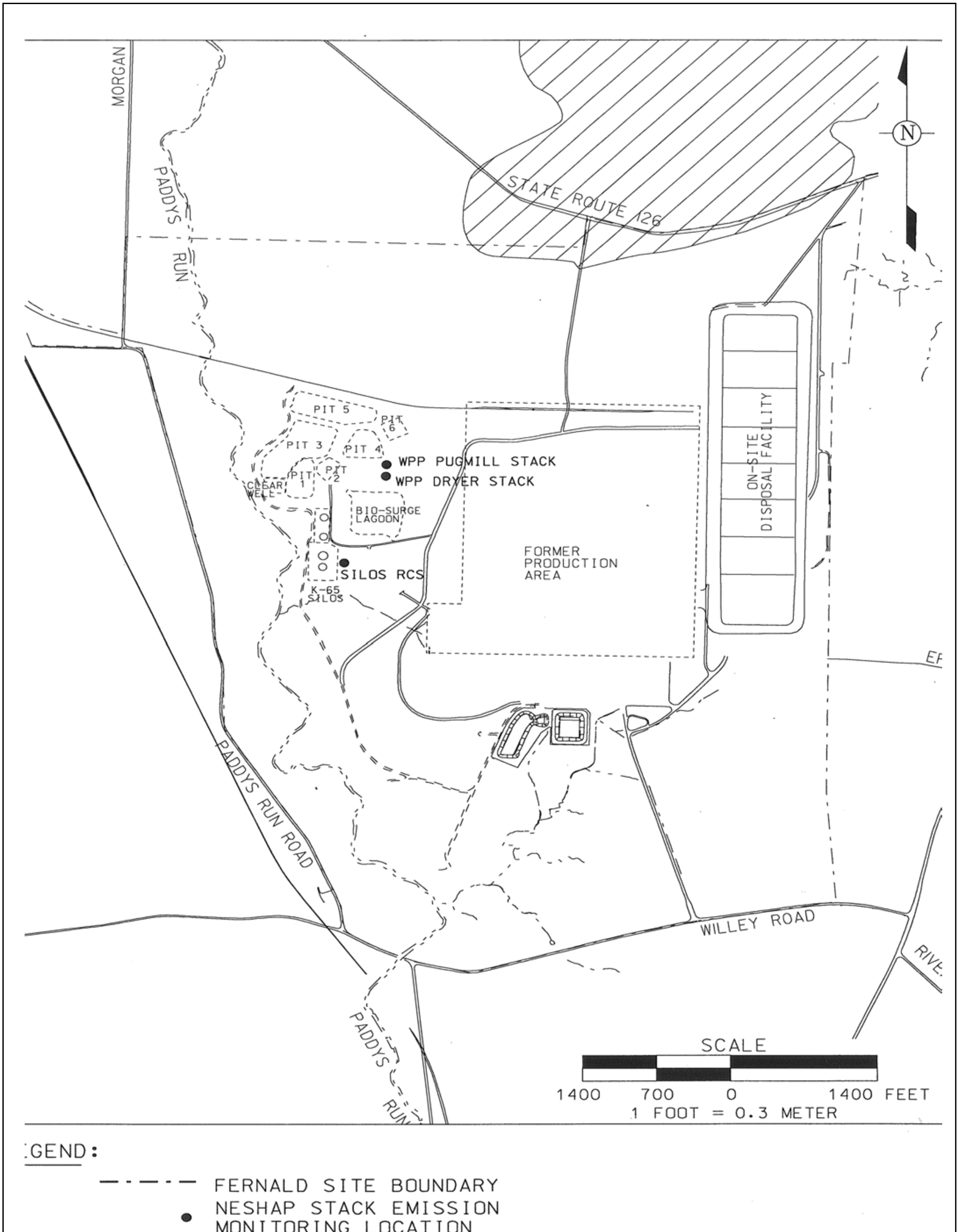


Figure 5-10. NESHAP Stack Emission Monitoring Locations

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.

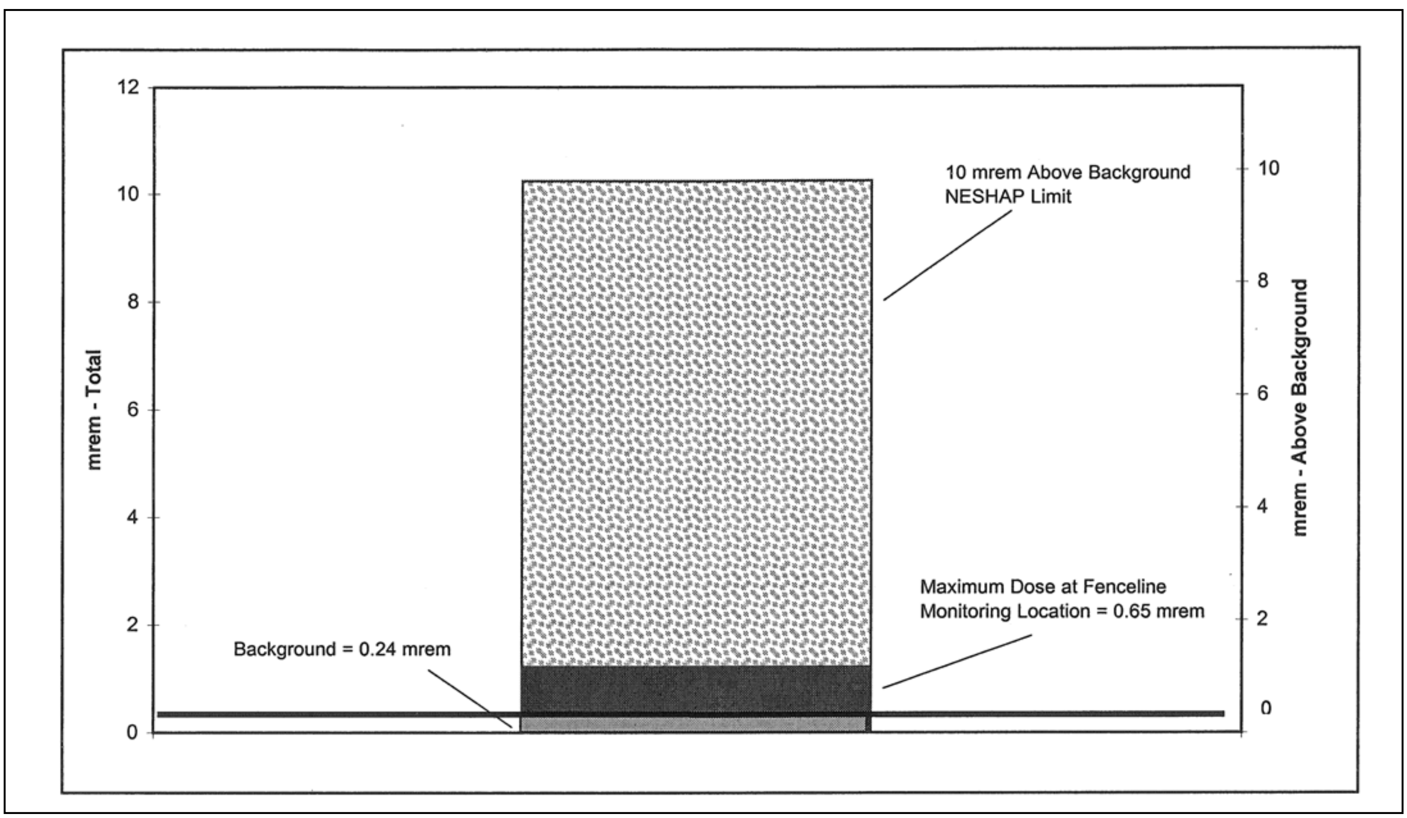


Figure 6-1. Comparison of 2004 Air-Pathway Doses and Allowable Limits

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.

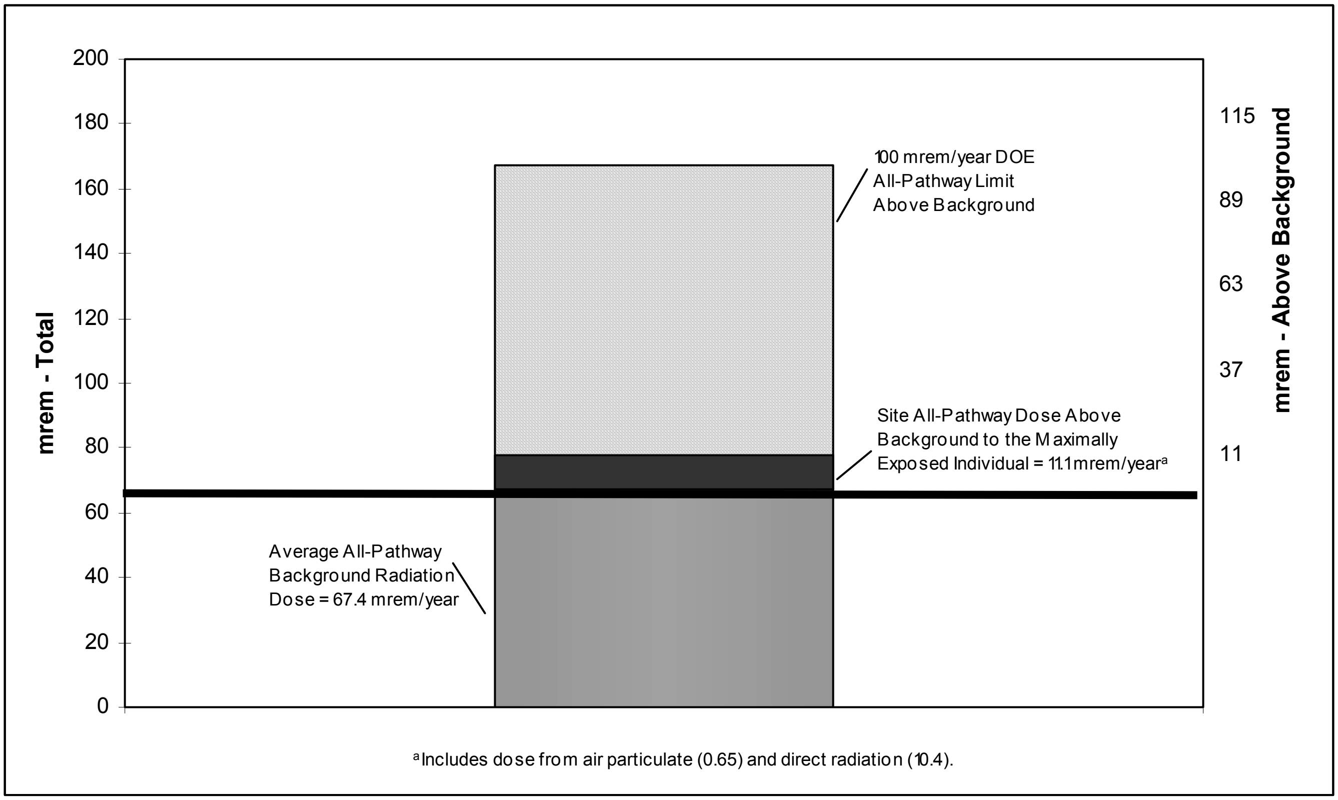


Figure 6-2. Comparison of 2004 All-Pathway Doses and Allowable Limits

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

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.

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.

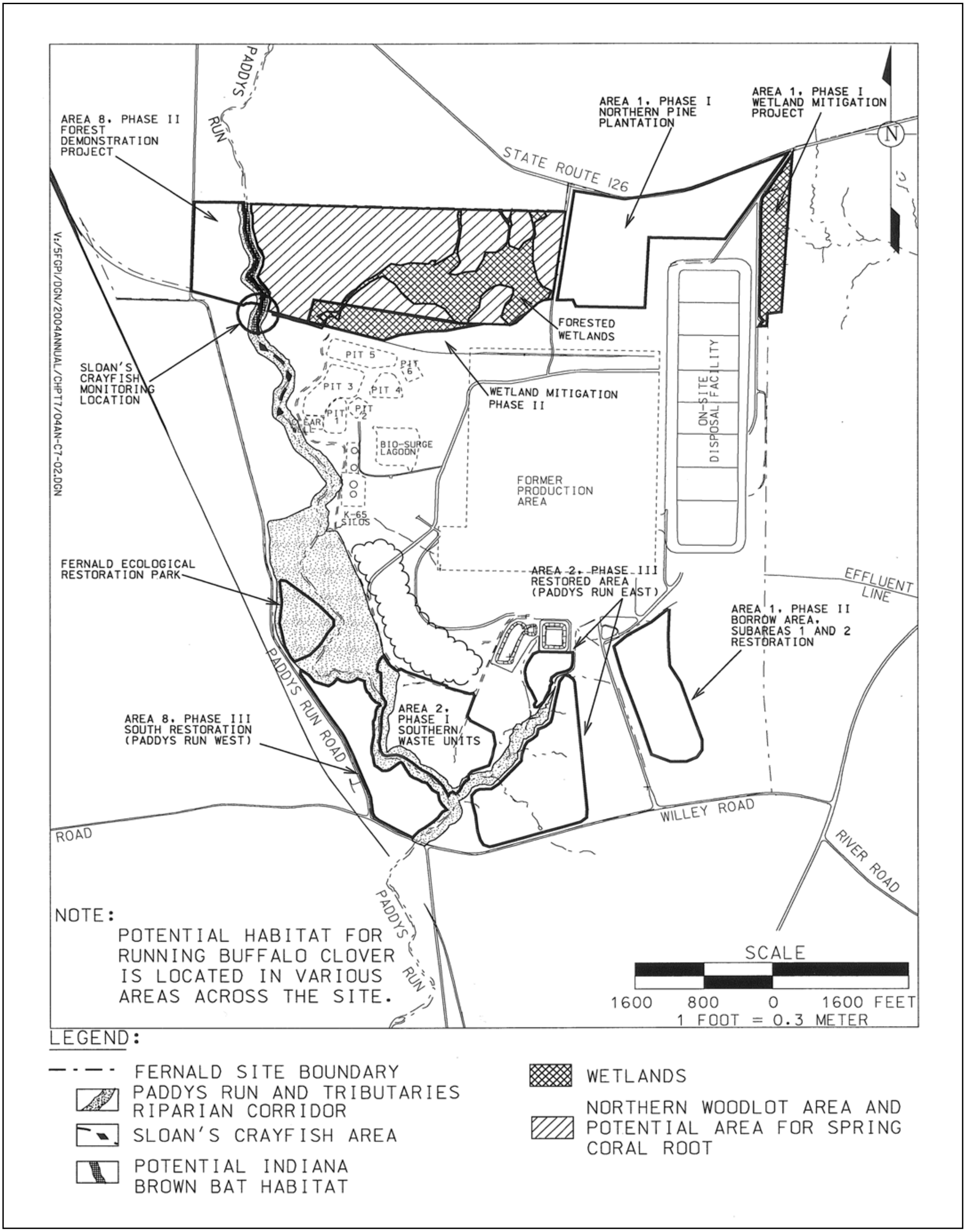


Figure 7-1. Priority Natural Resource Areas

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).

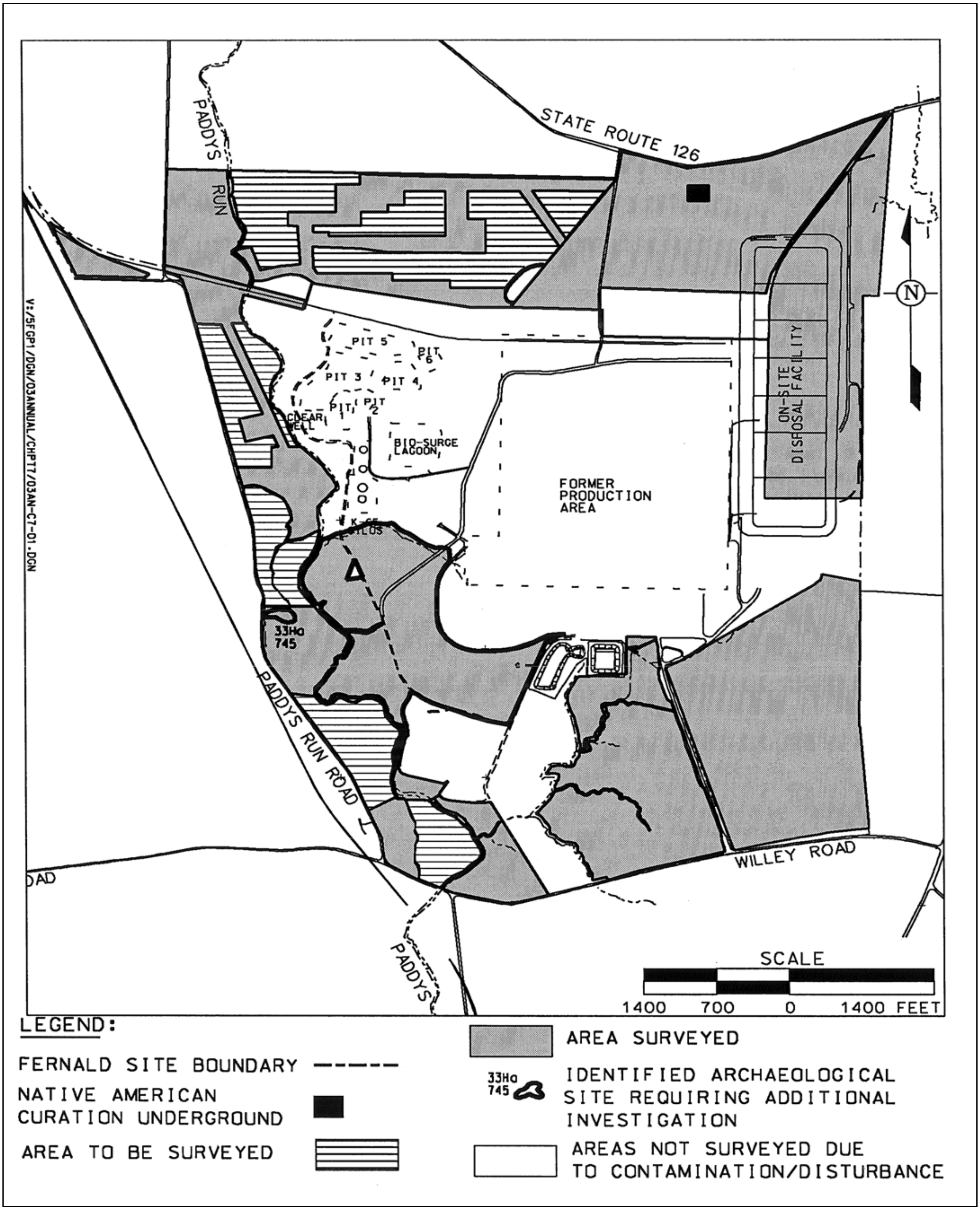


Figure 7-2. Cultural Resource Survey Areas

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.

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