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2001 Site Environmental Report

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FERNALD
Environmental Management Project

By Fluor Fernald, Inc.
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List of Acronyms

ALARA	as low as reasonably achievable
AMS	air monitoring station
ARARs	applicable or relevant and appropriate requirements
BTV	benchmark toxicity value
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ESD	Explanation of Significant Differences
FEMP	Fernald Environmental Management Project
FFA	Federal Facility Agreement
FFCA	Federal Facility Compliance Agreement
FRL	final remediation level
gpm	gallons per minute
ICRP	International Commission on Radiological Protection
IEMP	Integrated Environmental Monitoring Plan
mrem	millirem
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
OEPA	Ohio Environmental Protection Agency
PCB	polychlorinated biphenyl
RAC	Radiological Assessments Corporation
RCRA	Resource Conservation and Recovery Act
SARA	Superfund Amendment and Reauthorization Act
TLD	thermoluminescent dosimeter
TSCA	Toxic Substance Control Act

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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	10^{12}	pCi
pCi/L	10^{-6}	microcuries per liter (μCi/L)	μCi/L	10^{6}	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
rem	0.01	Sievert	Sv	100	rem
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

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Executive Summary

Executive Summary

The Fernald Environmental Management Project's 2001 Site Environmental Report provides stakeholders with the results from Fernald's environmental monitoring programs for 2001, along with a summary of DOE's progress toward final remediation of the site. In addition, this report provides a summary of Fernald'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 summary report and the supporting appendices. This report has been prepared in accordance with U.S. Department of Energy (DOE) Order 5400.1, General Environmental Protection Program, and Fernald's Integrated Environmental Monitoring Plan (IEMP), Revision 2 (DOE 2001).

During 2001 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 (Operable Unit 5) and materials from the southern waste units (Operable Unit 2)
- 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)
- 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 2001. The on-site disposal facility Cell 1 was capped. Also, remedial excavations at the southern waste units were completed.

The following sections highlight the results of environmental monitoring activities conducted during 2001.

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Liquid Pathway Highlights

Groundwater Pathway

The groundwater pathway is routinely monitored at the Fernald site 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.

An Explanation of Significant Differences pertaining to the site groundwater remedy was approved by EPA on November 30, 2001. This document amended the Operable Unit 5 Record of Decision by adopting the Safe Drinking Water Act Maximum Contaminant Level for uranium of 30 µg/L as both the final remediation level for groundwater restoration and the uranium effluent discharge limit to the Great Miami River.

During 2001 active restoration of the Great Miami Aquifer continued within each of the following groundwater restoration modules:

- South Field Extraction (Phase I) Module - continued pumping from 11 extraction wells. During 2001, two extraction wells were shut down and one more was added, which will become operational in 2002.

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

- Re-Injection Module - continued injecting water into the aquifer via five re-injection wells.

In addition, approximately 135 monitoring wells were sampled at various frequencies to determine water quality. Water elevations were measured quarterly in up to 137 monitoring wells. The following highlights describe the key findings from the 2001 groundwater data:

- 2,010 million gallons (7,608 million liters) of groundwater were pumped from the Great Miami Aquifer and 147 million gallons (556 million liters) of water were re-injected into the aquifer. As a result of these restoration activities, 867 pounds (394 kilograms) of uranium were removed from the aquifer.

- The results of 2001 groundwater capture analysis and monitoring for total uranium and non-uranium constituents indicate that the design of the enhanced groundwater remedy for the aquifer restoration system is appropriate for capture of the plume. Ongoing refinement of the wellfield configuration continues based on new monitoring data. Installation of the additional extraction wells was necessary to support the accelerated aquifer remediation schedule.

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- 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.

- Re-injection remains a viable component of the groundwater remediation strategy, as efforts to alleviate plugging of the re-injection wells appears to be effective.

- Installation of the three Waste Storage Area (Phase I) Module extraction wells was completed during 2001, and these wells are scheduled to begin operating in 2002.

Leak detection monitoring at Cells 1, 2 and 3 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.

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 2001, 16 surface water and treated effluent locations were sampled at various frequencies and 16 sediment locations were monitored. The following highlights describe the key findings from the 2001 surface water, treated effluent and sediment monitoring programs:

- The uranium released to the Great Miami River through the treated effluent pathway was an estimated 353 pounds, well below the 600 pounds per year limit. Uranium released through the uncontrolled runoff pathway was estimated at 121 pounds. Therefore, the total amount of uranium released through the treated effluent and uncontrolled surface water pathways during 2001 was estimated to be 474 pounds.

- No surface water or treated effluent analytical results from samples collected in 2001 exceeded the final remediation level for total uranium, the site's primary contaminant. Final remediation level exceedances were limited to three constituents, while Benchmark Toxicity Value exceedances were limited to one constituent. These occasional, sporadic exceedances are expected to occur until site remediation is complete.

- Discharges were in compliance with effluent limits identified in the current National Pollutant Discharge Elimination System (NPDES) Permit well over 99 percent of the time during 2001.

- The 2001 sediment data showed concentrations within historical ranges, and there were no final remediation level exceedances.

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 regulatio and DOE Orders.

Radiological Air Particulate Monitoring

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

- As in 2000, thorium-230 continued to be the major dose contributor to the air inhalation do in 2001. This is the result of fugitive emissions from the Waste Pits Remedial Action Project operations where thorium-230 is the primary isotope of concern.

- The maximum effective dose at the fenceline from 2001 airborne emissions (excluding radon) was estimated to be 0.8 millirem (mrem) per year and occurred at AMS-3 along th eastern fenceline of the site. This represents eight percent of the annual National Emissio Standards for Hazardous Air Pollutants Subpart H limit of 10 mrem per year. This is a decrease compared to the 2000 maximum effective dose of 1.1 mrem.

Radon Monitoring

In 2001 a network of 34 continuous radon monitors was used for determining compliance with the applicable limits. The annual average radon concentration recorded at the site's fenceline ranged from 0.2 picoCuries per liter (pCi/L) to 0.4 pCi/L (inclusive of background concentrations). Annual average background concentrations measured in 2001 ranged betwe 0.1 pCi/L and 0.3 pCi/L. Fenceline results were well below the DOE radon standard of 3.0 pCi/L above background concentrations.

- The annual average radon concentrations in the vicinity of Silos 1 and 2 (Operable Unit 4) during 2001 were comparable to the average concentrations measured in 2000. There w 15 exceedance events of the DOE limit of 100 pCi/L in 2001, compared to six exceedanc events in 2000. As in past years, these exceedance events were observed during periods atmospheric inversion.

- Radon concentrations within the silo headspace showed a marginal increase in 2001 versu 2000, continuing the upward trend since 1991. This is likely due to the protective layer of bentonite clay (placed over the silo material in 1991 to lower headspace concentrations) continuing to dry out and lose effectiveness.

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Direct Radiation Monitoring

As in years past, measurements of direct radiation in 2001 increase with proximity to Silos 1 and 2. The direct radiation measurements correlate with the slowly increasing radon concentrations and associated decay products in the headspaces of these silos. However, these levels are approximately 49 percent lower than radiation levels measured in 1991 prior to the addition of the bentonite layer to Silos 1 and 2.

Estimated Dose for 2001

In 2001 the maximally exposed individual living nearest the Fernald site in a west direction could have hypothetically received a maximum dose of approximately 11.7 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 were 0.2 mrem from air inhalation dose and 11.5 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.

Natural Resources

Natural resources include the diversity of plant and animal life and their supporting habitats found in and around the Fernald site. During 2001 the following activities associated with natural resource monitoring and restoration occurred.

- The Area 8, Phase II Forest Demonstration Project was completed in the spring of 2001 with the planting of some additional tree seedlings.
- Monitoring began at the Area 1, Phase I wetland mitigation site. Data from this effort will be used as a baseline to monitor the health and progress of the wetland over time. Also, mortality counts of planted vegetation continued in order to assess the impacts of deer in the area, and additional plantings were completed as appropriate.
- The four ecological restoration research projects, conducted as part of the Operable Unit 4 dispute resolution agreement, are providing valuable information for future natural resource restoration efforts at the Fernald site.

Fernald also has a number of archeological and historical sites representative of the cultural resources of the area. To protect these valuable resources, cultural resource surveys are conducted prior to soil excavation activities in designated areas of the site. During 2001, surveys conducted on the Fernald site identified nine previously undocumented archaeological finds and a total of 30 prehistoric artifacts.

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Chapter 1

The Fernald Environmental Management Project

The Fernald Environmental Management Project

Abbreviated Timeline

1951 Construction of the Feed Materials Production Center began.

1952 Uranium production started.

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

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

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

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

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

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

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

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

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

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

CERCLA Remedial Process

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

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

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

Remedial Design and Remedial Action - This phase of the CERCLA process includes the detailed design and implementation of the remedy.

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

Long-term Stewardship will take place at the Fernald site following completion of CERCLA activities. This means that DOE will assume the long-term monitoring and maintenance of the FEMP after site closure in order to ensure continued protection of human health and the environment. The previously mentioned five-year review process will continue in order to provide long-term stewardship information to the public.

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

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

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With the conclusion of the FEMP's uranium production mission and completion of the CERCLA remedy selection process, focus is now being directed to the safe and efficient implementation of FEMP environmental remediation activities and facility decontamination and dismantling operations. In recognition of this shift in emphasis toward remedy implementation, the environmental monitoring program was revised in 1997 to align with the remediation activities planned for the FEMP.

The site's current environmental monitoring program is described in the Integrated Environmental Monitoring Plan (IEMP), Revision 2 (DOE 2001b). The IEMP is updated at a minimum of every two years to keep pace with the site's monitoring needs as remediation progresses. The 2001 Site Environmental Report summarizes the findings from the IEMP monitoring program and provides a status on the progress toward final site restoration. This report consists of the following:

Summary Report This summary report (Chapters 1 through 7) documents the results of environmental monitoring activities at the FEMP in 2001. It includes a discussion of remediation activities and summaries of environmental data from groundwater, surface water and treated effluent, sediment, air, and natural resources monitoring programs. It also condenses and summarizes the information contained in the appendices.

Appendices The detailed appendices provide the 2001 environmental monitoring data for the various media, primarily in the form of graphs and tables. The National Emission Standards for Hazardous Air Pollutants (NESHAP) (40 Code of Federal Regulations 61 Subpart H) (EPA 1985) compliance report is also included. The appendices are generally distributed only to the regulatory agencies. However, a complete copy of the appendices is available at the Public Environmental Information Center, which is located a half mile south of the FEMP on Oakridge Drive in the Delta Building.

The remainder of this introductory chapter provides:

- A brief overview of the FEMP's current environmental remediation operations and a description of its current cleanup mission, organization, and major remediation activities
- A description of environmental monitoring activities at the FEMP
- A description of the physical, ecological, and human characteristics of the area.

The Path to Site Closure

In 1986 the FEMP began working through the CERCLA process to characterize the nature and extent of contamination at the site, establish risk-based cleanup standards, and select the appropriate remediation technologies to achieve those standards. To facilitate this process, the FEMP was organized into five operable units in 1991. The purpose of the operable unit concept under CERCLA is to organize site components based on their location and/or the potential for similar technologies to be used for environmental remediation. The remedy selection process culminated in 1996 with approval of the final records of decision for each of the five operable units. However, the Record of Decision Amendment for Operable Unit 4 Silos 1 and 2 Remedial Actions was issued in July of 2000, and an Explanation of Significant Differences for Silo 3 was issued in March 1998.

Following approval of the initial records of decision, work began on the design and implementation of the operable unit remedies. In order to align sitewide responsibilities and regulatory obligations of each operable unit and to most efficiently execute remedial design and remedial action, the FEMP established integrated project organizations in 1996. Realignment into project organizations reflected the actual work processes and operations necessary to complete remediation while meeting the requirements of the records of decision. Table 1-1 describes each operable unit and its associated remedy and provides a crosswalk between each operable unit and the project organizations responsible for implementing each remedy. For purposes of this document, references to a project organization also include the references to the applicable operable unit, as identified in the Table 1-1 description.

Environmental Monitoring Program

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

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

Refer to Chapter 6 for information pertaining to 2001 dose calculations from all pathways.

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

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

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

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

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TABLE 1-1
FEMP OPERABLE UNIT REMEDIES AND ASSOCIATED PROJECT RESPONSIBILITIES

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

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(CONTINUED)

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

[a]Source of information is each operable unit's record of decisions and remedial design documents.

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

- The IEMP consolidates routine reporting of environmental data under a system consistin of quarterly data summary reports and a comprehensive annual report.

Characteristics of the Site and Surrounding Area

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

Land Use and Demography

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

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

Geography

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

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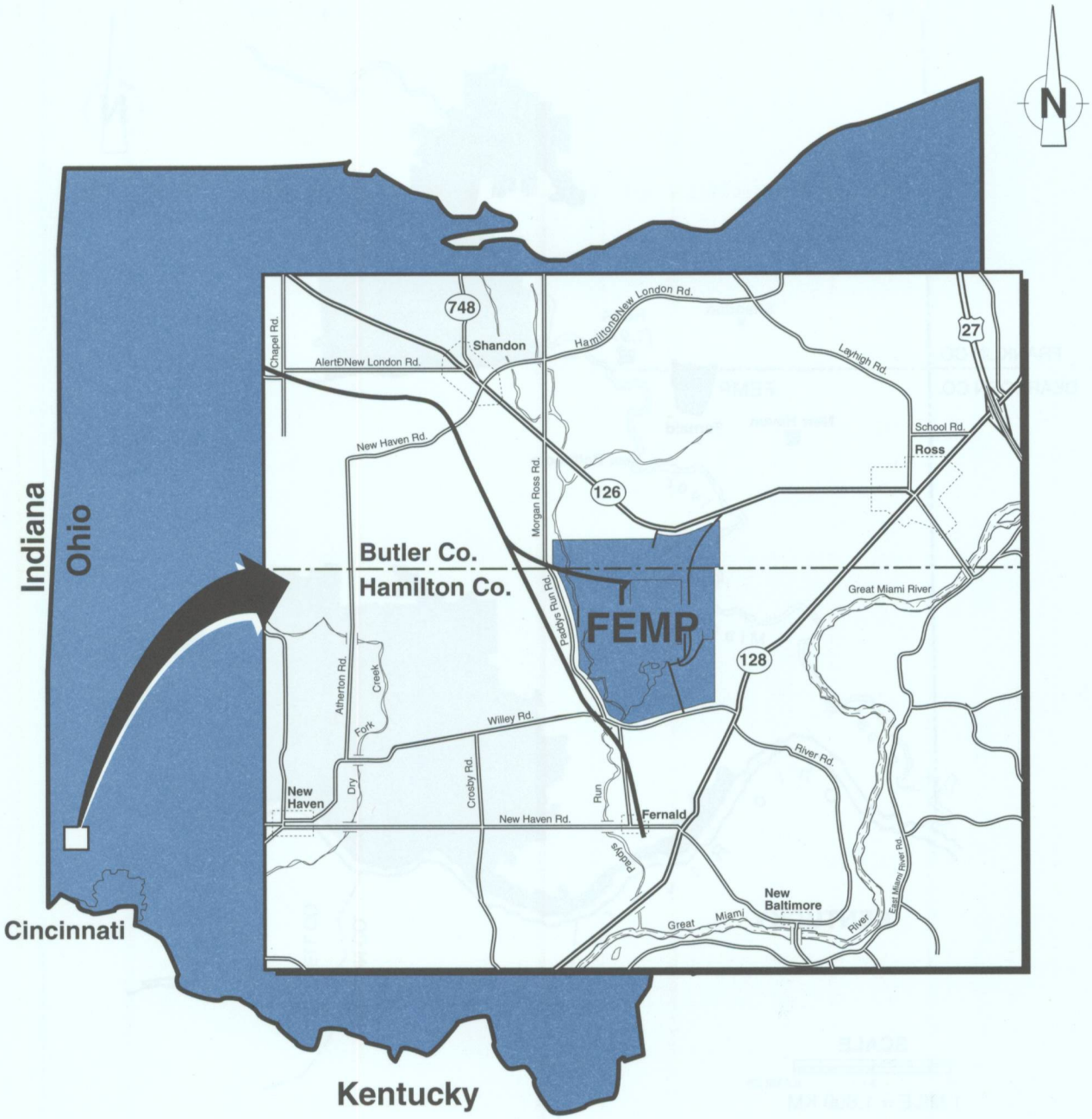

The FEMP covers about 1,050 acres (425 hectares).

Figure 1-1. FEMP and Vicinity

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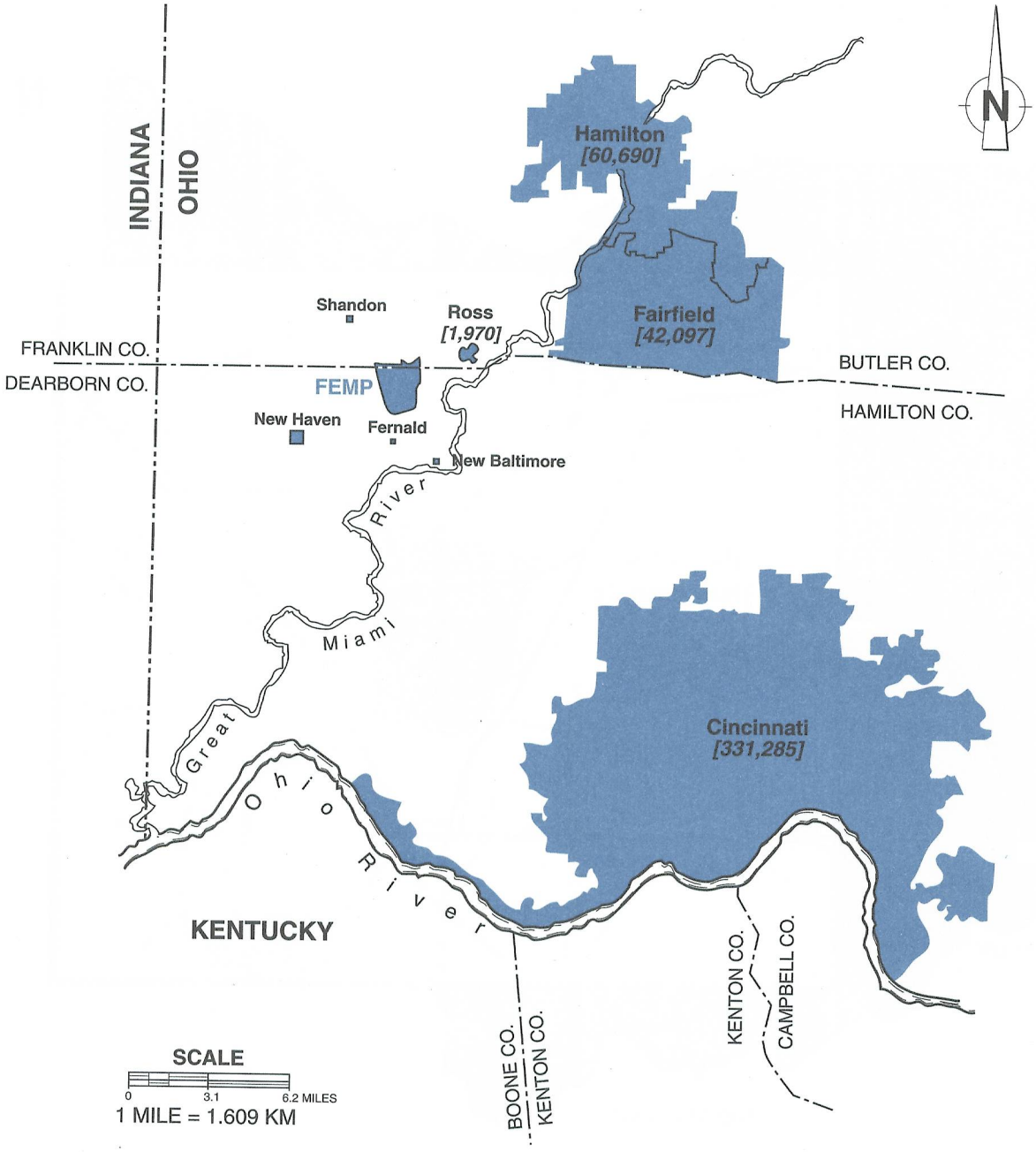

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Populations (shown in brackets) are estimated from 2000 U.S. Census Bureau figures.

Figure 1-2. Major Communities in Southwestern Ohio

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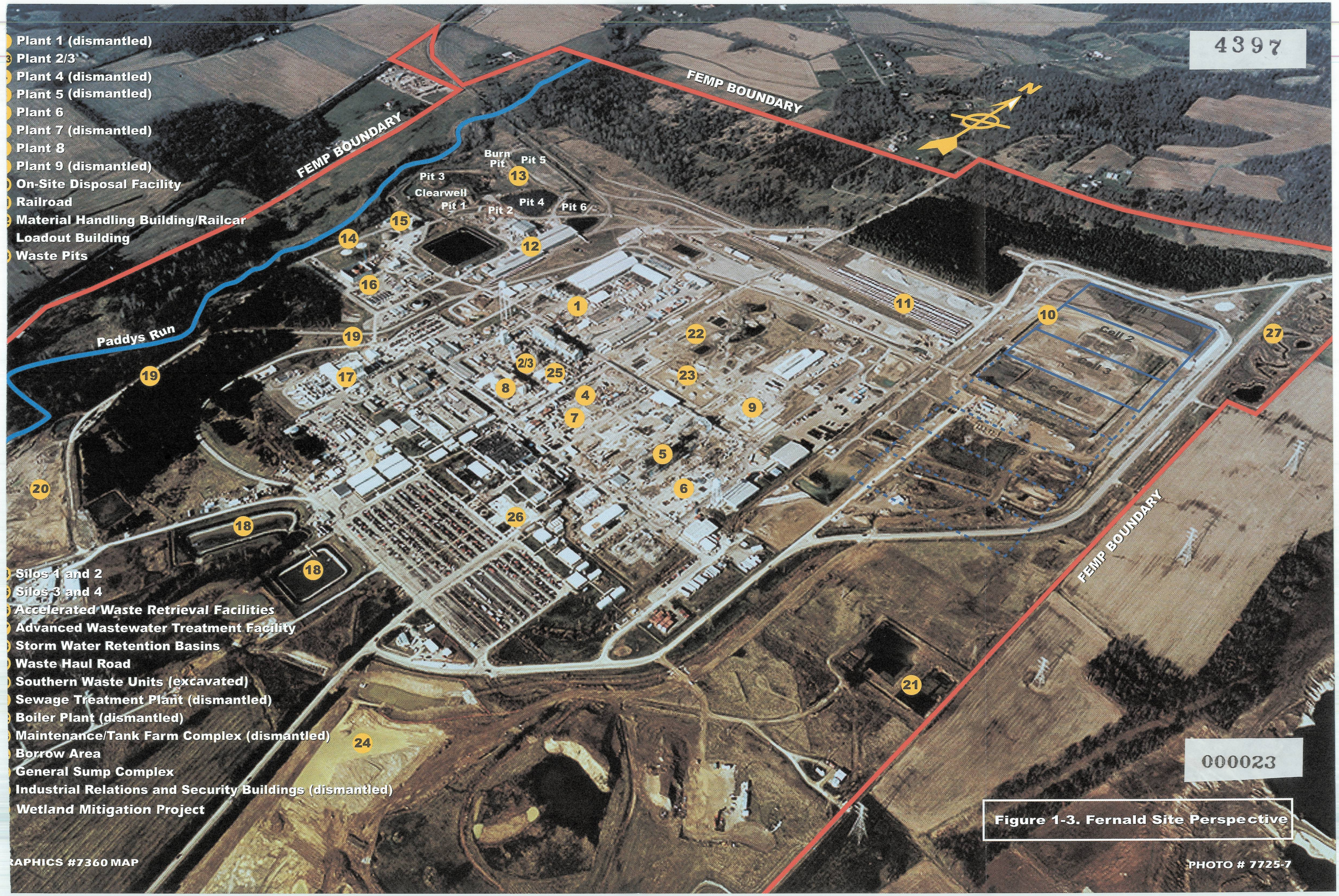

Figure 1-3. Fernald Site Perspective

Geology

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

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

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

Surface Hydrology

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

In addition to natural drainage through Paddys Run, FEMP surface water runoff from the former production area, 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 FEMP, runs in a southerly direction and flows into the Ohio River about 24 miles (39 km) downstream of the FEMP. The segment of the river between the FEMP and the Ohio River is not used as a source of public drinking water.

The average flow rate for the Great Miami River in 2001 was 2,788 cubic feet per second (ft^3/sec) (78.95 cubic meters per second [m^3/sec]). This is based on daily measurements collected approximately 10 river miles (16 river km) upstream of the FEMP's effluent discharge.

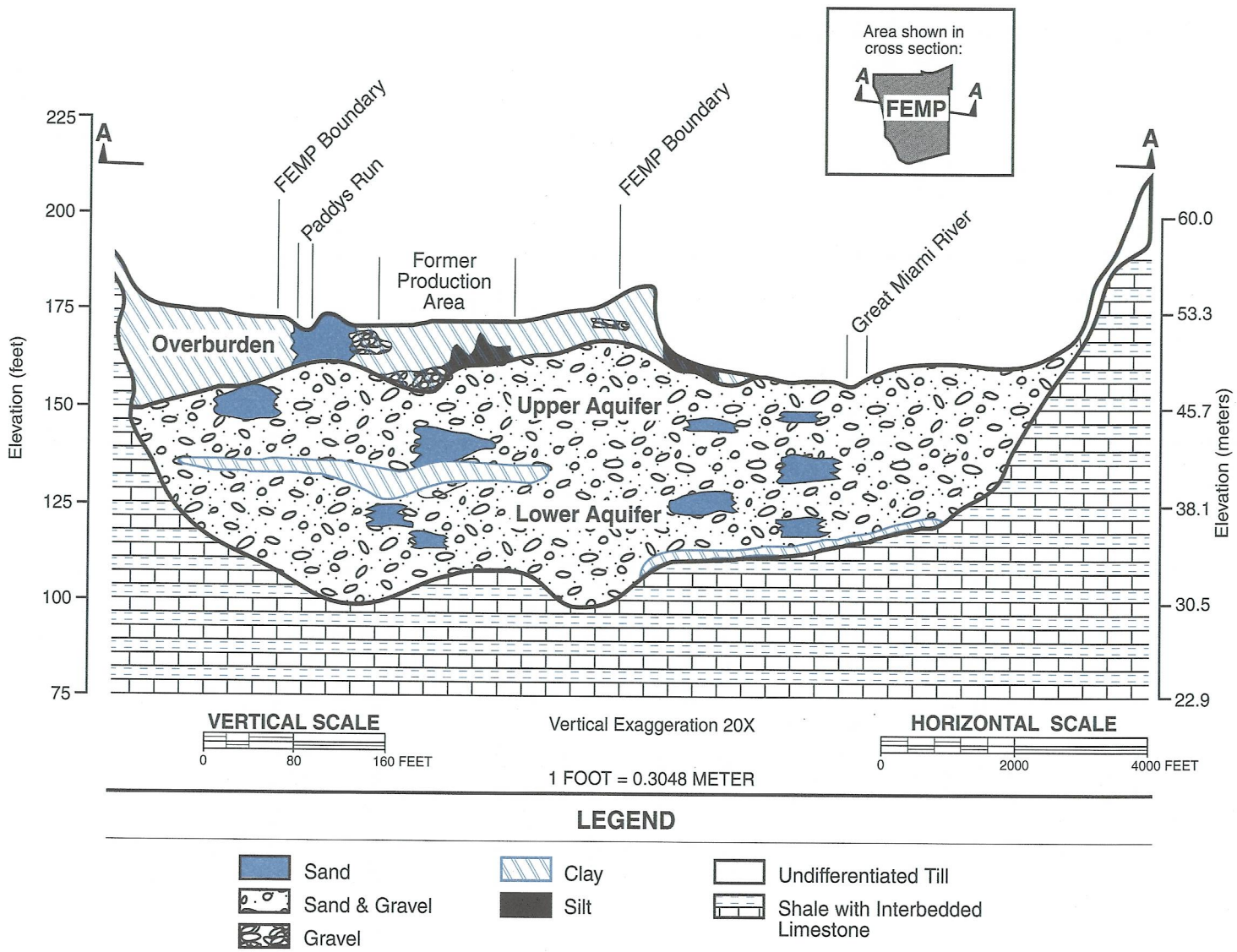

Figure 1-4. Cross-Section of the New Haven Trough, Looking North

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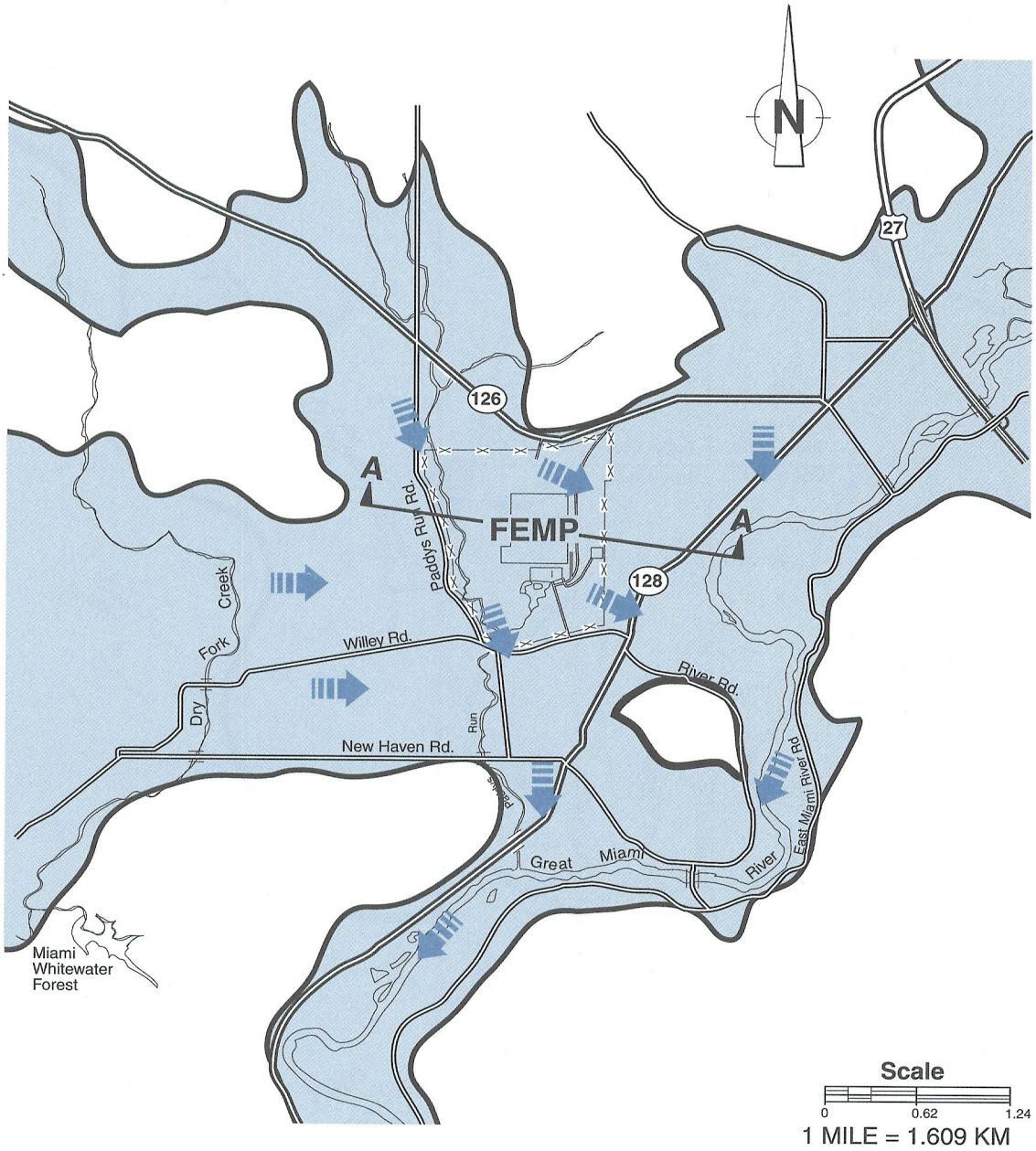

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- Buried Valley Aquifer
- General Direction of Groundwater Flow
- FEMP Boundary
- A A Location of Cross-Section Shown in Figure 1-4

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

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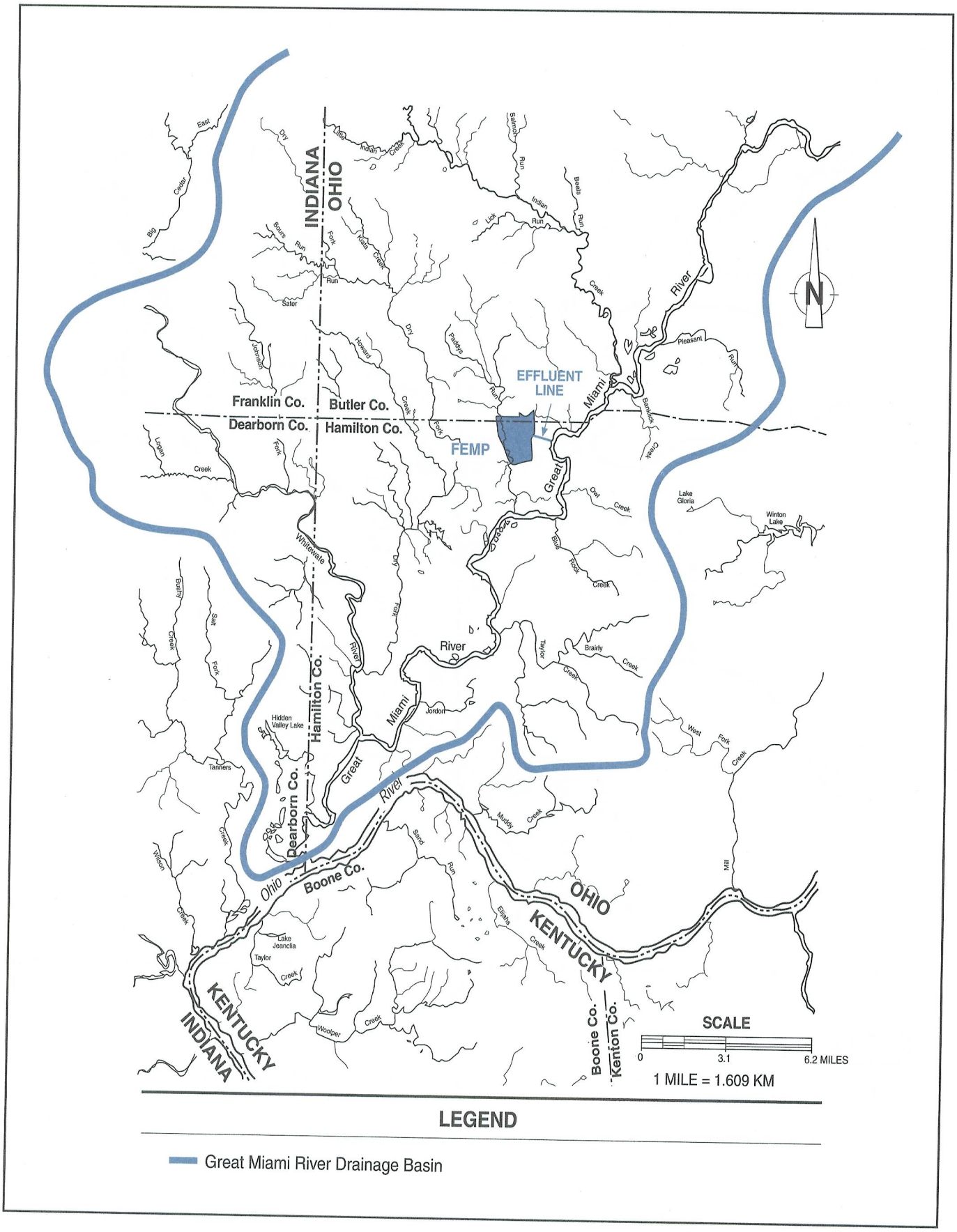

Figure 1-6. Great Miami River Drainage Basin

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Meteorological Conditions

Meteorological data are gathered at the FEMP 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 2001 measured at the 33-foot (10-meter) and 197-foot (60-meter) levels, respectively, in wind rose format. The prevailing winds were from the west through south-southwest approximately 40 percent of the time at both the 33- and 197-foot (10- and 60-meter) levels. Tables in Appendix C, Attachment 5, of this report present meteorological data for 2001, including wind direction and average speed.

In 2001, 46.55 inches (118.2 centimeters [cm]) of precipitation were measured at the FEMP. This is slightly higher than the average annual precipitation of 40.95 inches (104.0 cm) for 1951 through 2000. Figure 1-9 shows 2001 total precipitation for the area in relation to the annual precipitation amounts recorded from 1991 through 2001. (Precipitation totals from 1990 through 1992 were taken from the measurements made at the Greater Cincinnati/Northern Kentucky International Airport because of a computer software problem at the FEMP meteorological tower.) Figure 1-10 shows 2001 precipitation by month at the FEMP compared to the Cincinnati area average precipitation by month from 1951 through 2000, based on data collected at the Greater Cincinnati/Northern Kentucky International Airport.

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 FEMP. 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 detailed discussion of the site's diverse ecological habitats and cultural resources.

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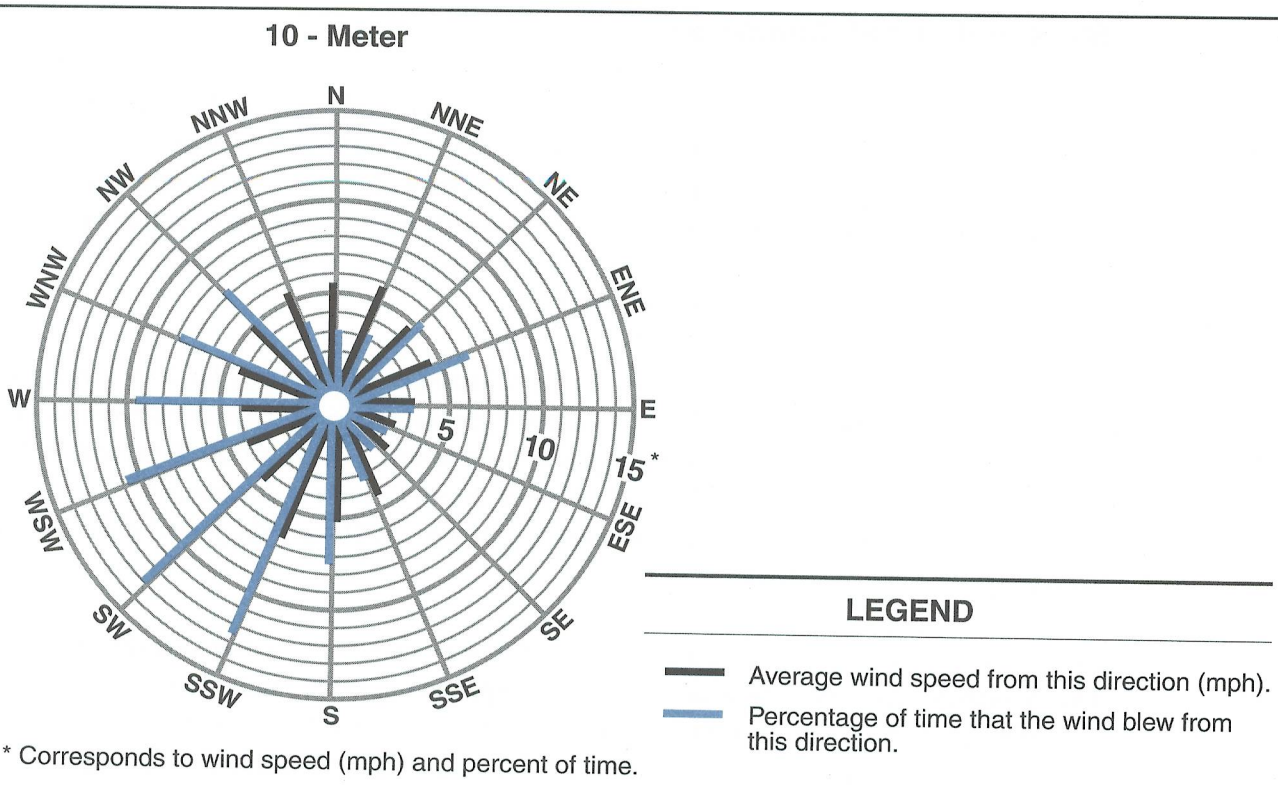

Figure 1-7. 2001 Wind Rose Data, 33 Foot (10 Meter) Height

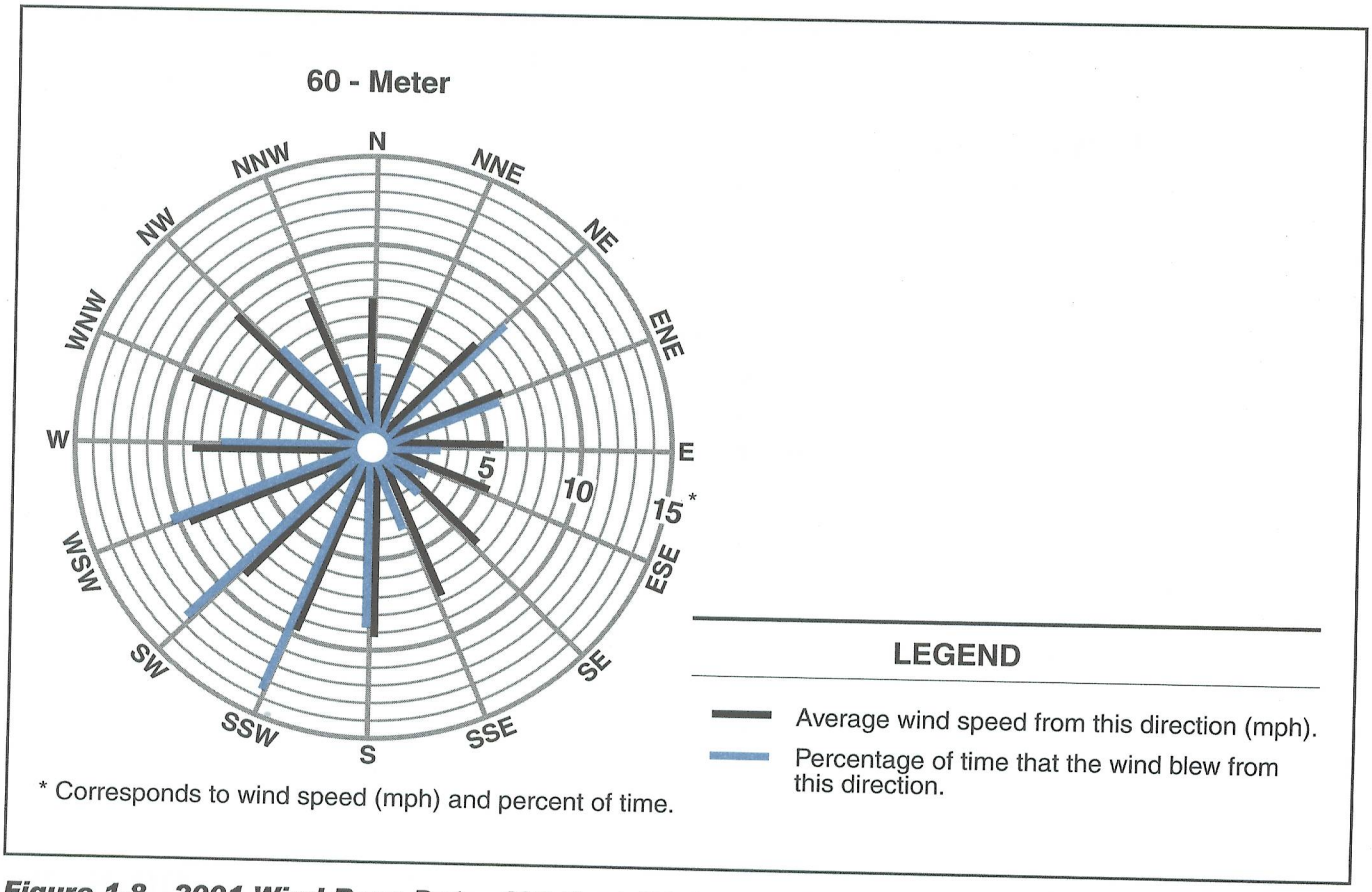

Figure 1-8. 2001 Wind Rose Data, 197 Foot (60 Meter) Height

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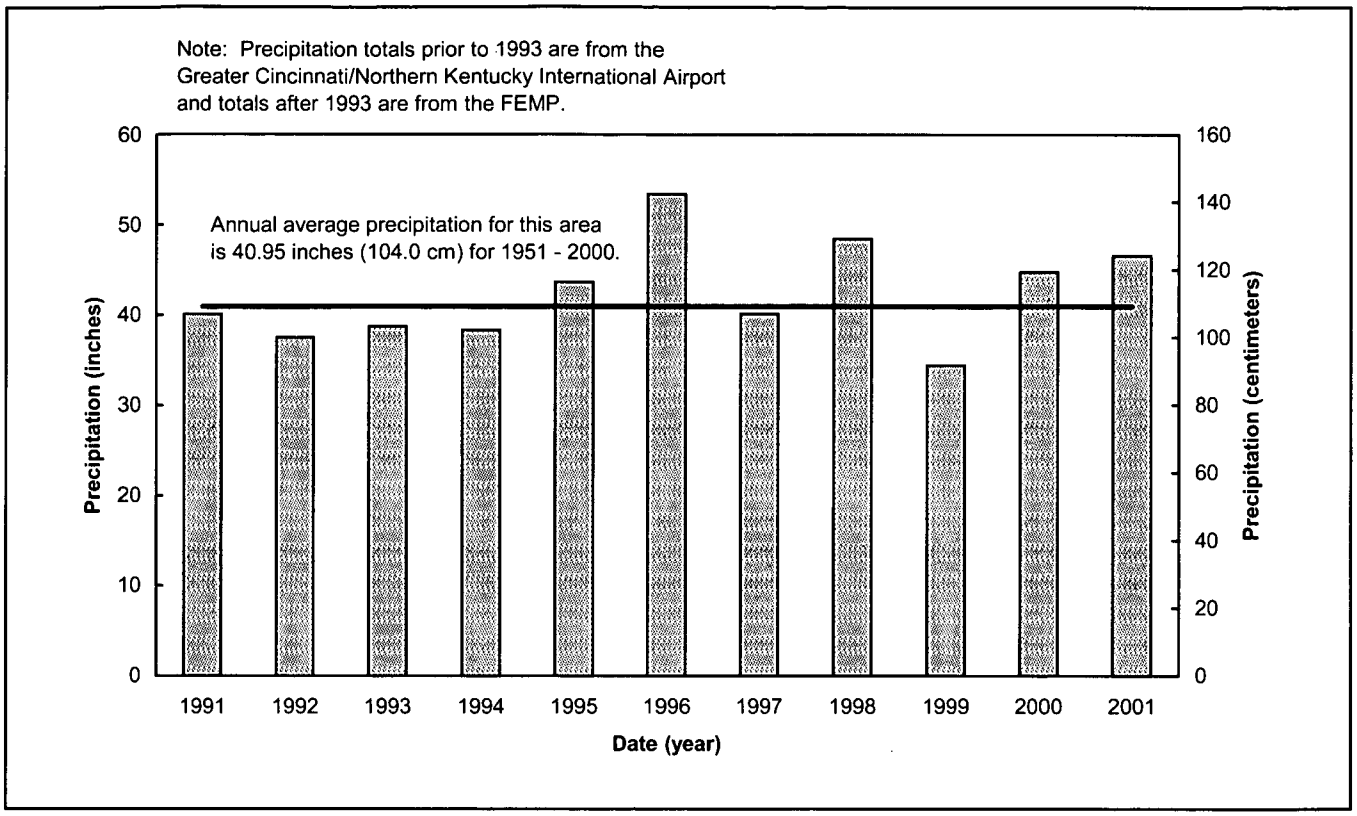

Figure 1-9. Annual FEMP Precipitation Data, 1991 - 2001

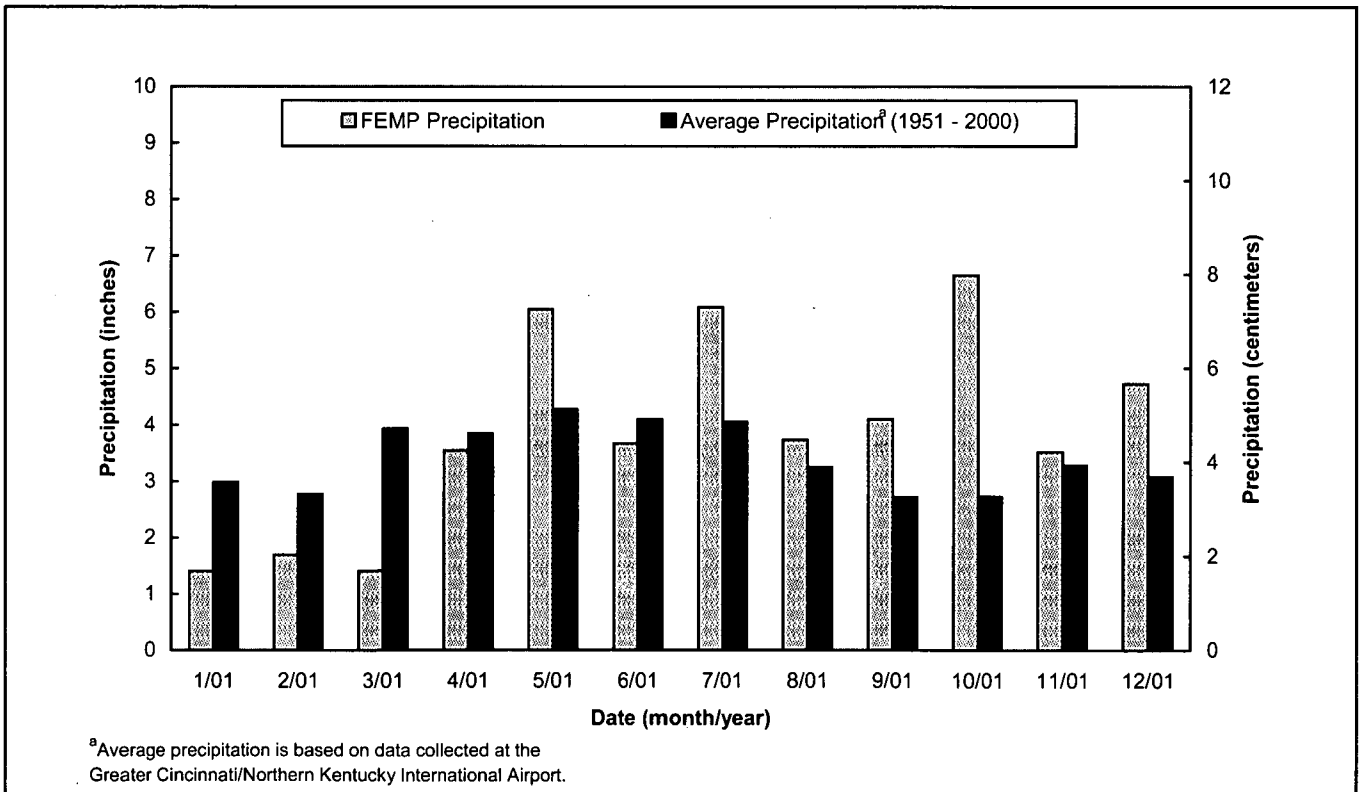

Figure 1-10. 2001 FEMP Monthly Precipitation Data

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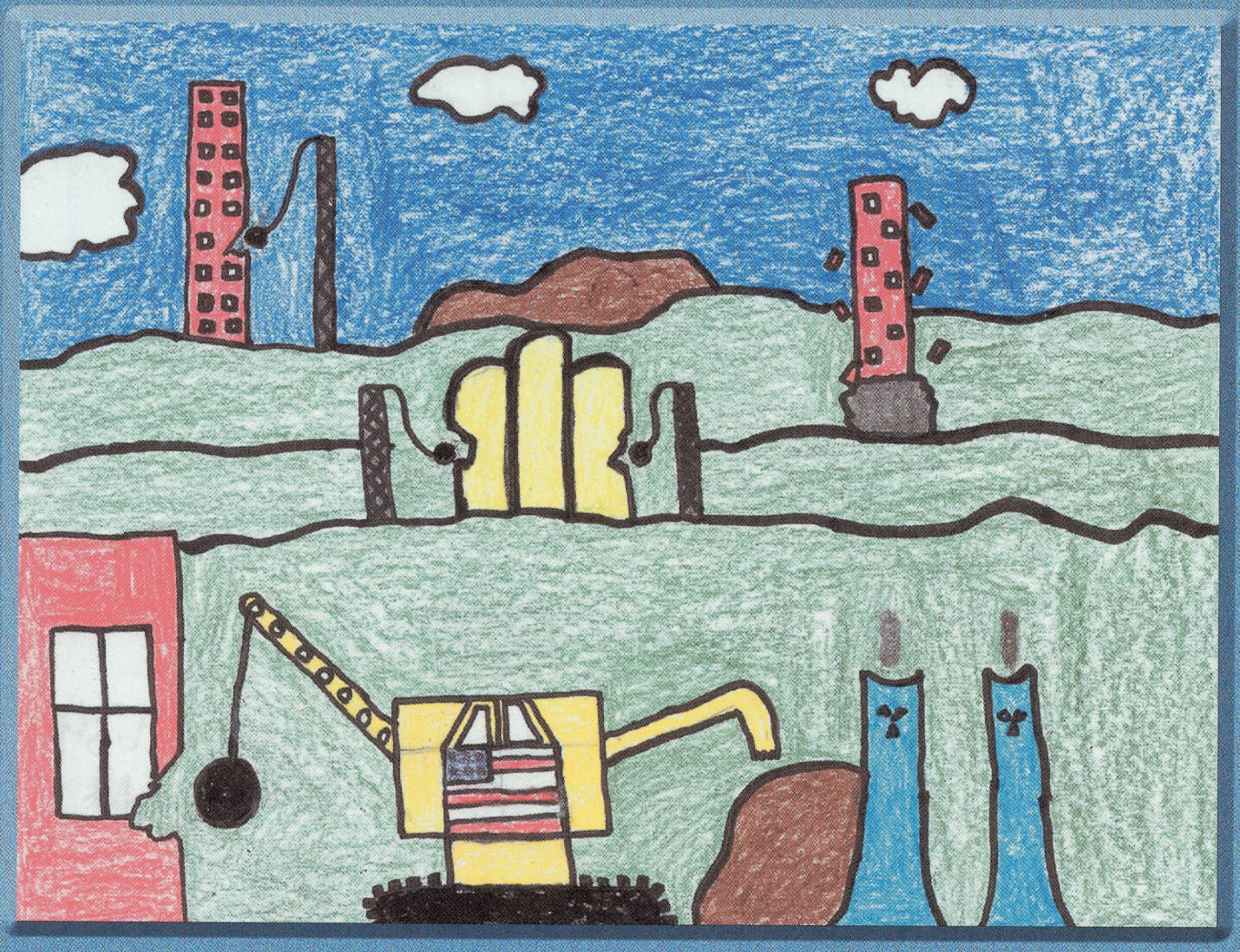
Chapter 2

Remediation Status and Compliance Summary



Remediation Status and Compliance Summary

This chapter provides a summary of CERCLA remediation activities in 2001 for each project, and summarizes compliance activities with other applicable environmental laws, regulations, and legal agreements. CERCLA, the "Superfund Act", is the primary driver for environmental remediation of the FEMP.

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

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

CERCLA Remediation Status

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

The FEMP is currently involved in the implementation phase of CERCLA remediation, which includes remedial design, remedial action (construction and implementation of the remedy), certification of soil and groundwater to verify that the remedy was effective, and ultimately, site closure. Remediation activities, documents, and schedules are identified in each operable unit's remedial design and remedial action work plan. Progress has been made toward certification of soil remediation areas, as the Soil and Disposal Facility Project certified several more areas during 2001, as described later in this chapter under the Soil and Disposal Facility Project section.

Each phase of the CERCLA remediation process requires documentation. The documents produced reflect the input of stakeholders who have helped form the remediation strategy at the FEMP. Many documents that describe specific remediation activities were issued and/or approved in 2001, as mentioned throughout this report. All clean-up related CERCLA documentation, including a copy of the Administrative Record, is available to the public at the Public Environmental Information Center located near the FEMP. A copy of the administrative record is also located at EPA's Region V office in Chicago, Illinois. The progress made by each remedial project toward CERCLA cleanup is summarized later in this chapter.

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

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

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

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

Acceptable levels for constituents of ecological concern were established in the Operable Unit 5 Sitewide Ecological Risk Assessment (Appendix B of the Operable Unit 5 Remedial Investigation Report). The Sitewide Ecological Risk Assessment established benchmark toxicity values (BTVs) for protection of ecological receptors. Through the BTV screening process presented in Appendix C of the Final Sitewide Excavation Plan (DOE 1998), three constituents of ecological concern (barium, cadmium, and silver) were selected to be evaluated in the surface water pathway to be protective of aquatic receptors. Chapter 4 discusses BTVs for surface water.

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

	FRL[a]		
Constituent	Groundwater	Surface Water	Sediment
General Chemistry	(mg/L)	(mg/L)	(mg/kg)
Cyanide	NA[b]	0.012	NA
Fluoride	4[c]	2.0	NA
Nitrate[d]	11	2,400	NA
Inorganics	(mg/L)	(mg/L)	(mg/kg)
Antimony	0.0060	0.19	NA
Arsenic	0.050	0.149	94
Barium	2	100	NA
Beryllium	0.0040	0.0012	33
Boron	0.33	NA	NA
Cadmium	0.014	0.0098	71
Chromium VI[d]	0.022	0.010	3,000
Cobalt	0.17	NA	36,000
Copper	1.3	0.012	NA
Lead	0.015[c]	0.010	NA
Manganese	0.900	1.5	410
Mercury	0.0020	0.00020	NA
Molybdenum	0.10	1.5	NA
Nickel	0.10	0.17	NA
Selenium	0.050	0.0050	NA
Silver	0.050	0.0050	NA
Thallium	NA	NA	88
Vanadium	0.038	3.1	NA
Zinc	0.021	0.11	NA
Radionuclides	(pCi/L)	(pCi/L)	(pCi/g)
Cesium-137	NA	10	7.0
Neptunium-237	1.0	210	32
Lead-210	NA	11	390
Plutonium-238	NA	210	1,200
Plutonium-239/240	NA	200	1,100
Radium-226	20	38	2.9
Radium-228	20	47	4.8
Strontium-90	8.0	41	7,100
Technetium-99	94	150	200,000
Thorium-228	4.0	830	3.2
Thorium-230	15	3500	18,000
Thorium-232	1.2	270	1.6
	(µg/L)	(µg/L)	(mg/kg)
Total Uranium[e]	30[f]	530	210

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TABLE 2-1
(Continued)

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

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

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Waste Pits Remedial Action Project

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

The Waste Pits Remedial Action Project involves the pre-treatment (e.g., crushing, sorting, and shredding) of waste pit materials, drying (as necessary), and the loadout of railcars with pit material for shipment to Envirocare of Utah, Inc. During 2001, 19 unit trains left the FEMP carrying approximately 125,000 tons (95,575 metric tons) of material. From the time the first rail shipment left the FEMP in April of 1999 through December 2001, the Waste Pits Remedial Action Project has shipped 51 unit trains carrying approximately 320,000 tons (244,672 metric tons) of material to Envirocare of Utah, Inc. for disposal. At the end of 2001, remediation of Pit 1was nearly complete, and Pits 2 and 3 were approximately 25 percent and 45 percent complete, respectively.

Waste Pits Remedial Action Project Rail Operations

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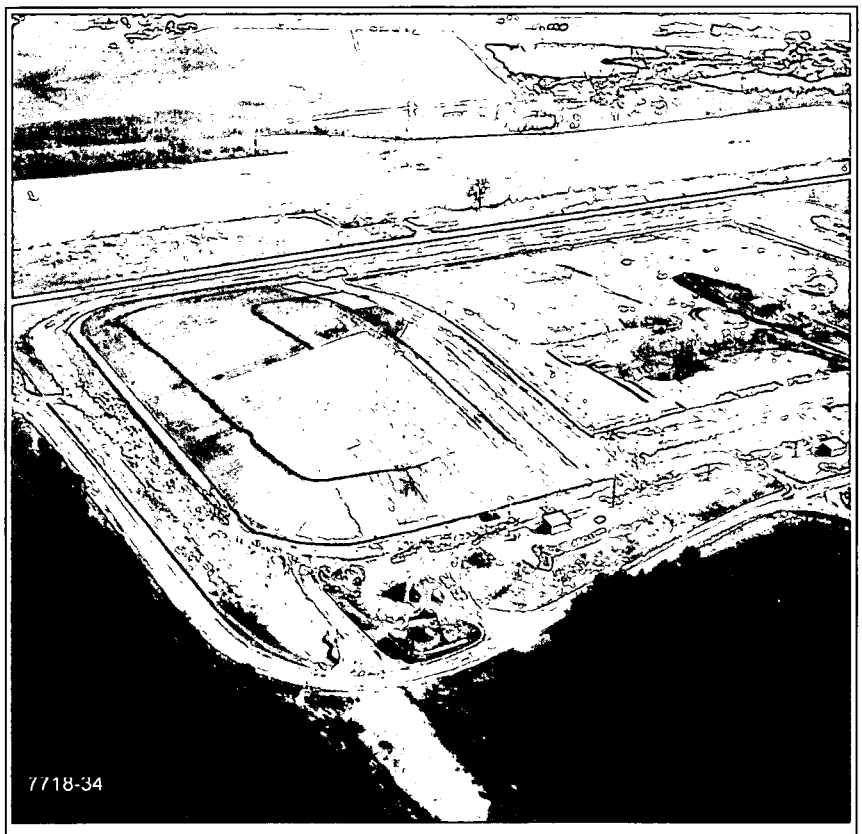
Soil and Disposal Facility Project

The Soil and Disposal Facility Project, which includes components of both Operable Units 2 and 5, is responsible for soil characterization sampling, excavation of contaminated soil, natural resource restoration, and the construction of on-site disposal facility cells and waste placement into those cells. Of note, the on-site disposal facility's leachate and leak detection monitoring, as well as operation, maintenance and monitoring of the leachate transmission system is the responsibility of the Aquifer Restoration Project.

For purposes of excavating contaminated soil, the FEMP has been divided into 10 main soil remediation areas. Figure 2-1 depicts Remediation Areas 1 through 9. Area 10, which is not shown on Figure 2-1, consists of potentially contaminated corridors such as haul routes, utility corridors and access roads. Area 10 will not be addressed until the end of both soil and aquifer remediation.

Prior to remediation, real-time scanning and soil sampling are performed to support engineering designs to determine the extent of contaminated soil for remediation, and to identify the materials that meet the waste acceptance criteria for the on-site disposal facility. Materials that cannot be placed in the on-site disposal facility are stockpiled, monitored, and tracked for off-site disposal.



The Capping of Cell 1 of the On-Site Disposal Facility

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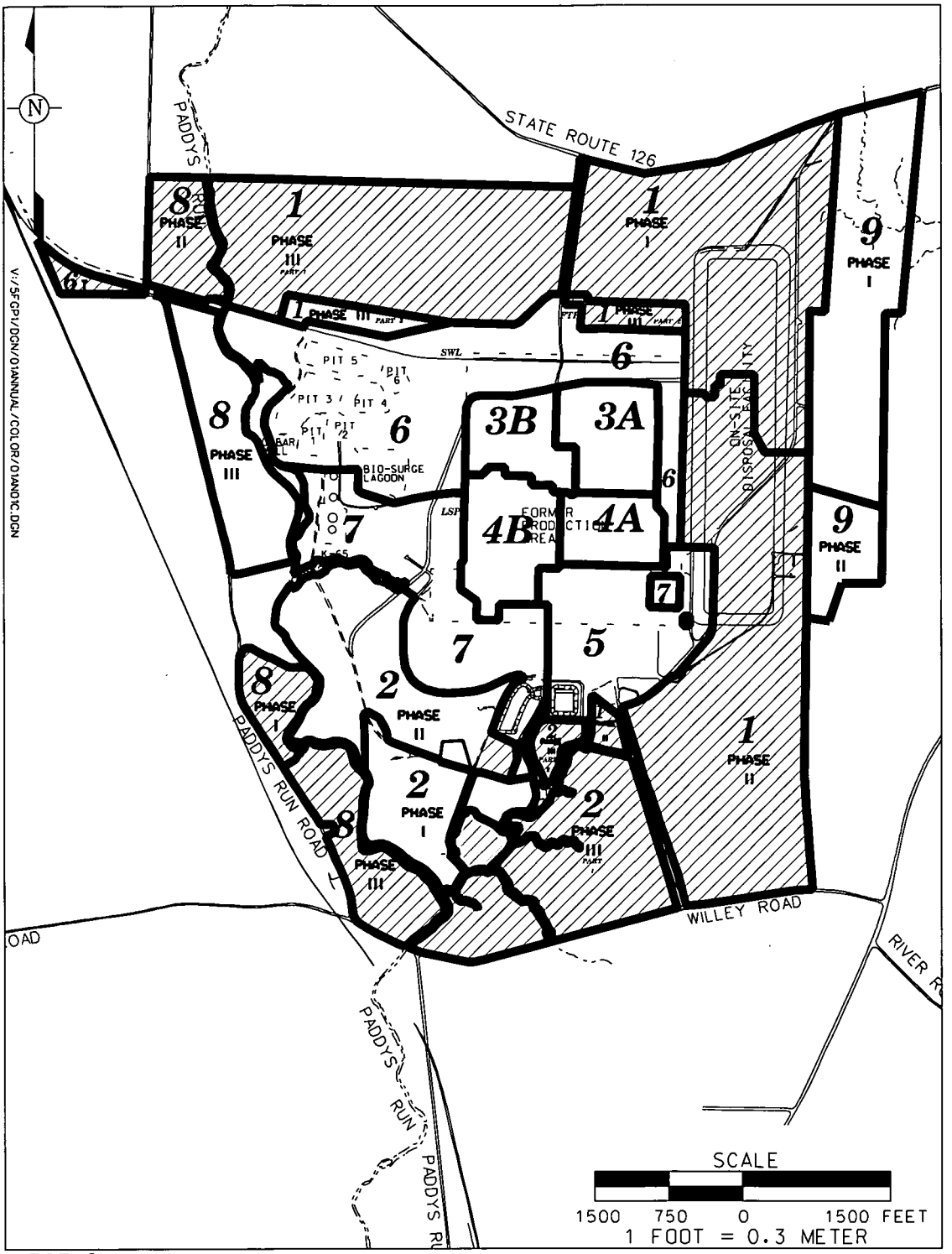

LEGEND:

FEMP BOUNDARY

1 REMEDIATION AREA

REMEDIATION AREA BOUNDARIES

CERTIFIED AREA (THROUGH 2001)

Figure 2-1. Sitewide Soil Remediation Areas and Certified Areas

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In 2001 the Soil and Disposal Facility Project continued soil and debris excavations. By the end of 2001, nearly one million yd^3 (764,600 m^3) of soil had been excavated since remediation began, and the planned soil excavations at the site were approximately 30 percent complete. The following soil remedial excavation activities took place in 2001:

- Area 1, Phase III. Localized areas of construction debris were removed from the southern and western perimeters of this area.
- Area 2, Phase I. Final excavation of the southern waste units was completed.
- Areas 3A/4A. The large-scale excavation of the eastern side of the former production area began in late 2001.

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

During 2001 the following areas of the site were certified:

- Several small areas near the former sewage treatment plant in Area 1, Phase II
- Area 1, Phase III, Parts 1 and 2
- The footprint of the former active flyash pile in Area 2, Phase I
- The Soil Pile 3 footprint just northeast of the southern waste units in Area 2, Phase II.

As of December 31, 2001, slightly more than 50 percent of the FEMP property has been certified. Figure 2-1 identifies the areas that have been certified as of December 31, 2001. After an area is certified, natural resource restoration activities can begin. Chapter 7 discusses the specific natural resource restoration activities that took place in 2001.

At the on-site disposal facility, another important milestone was reached in 2001 with the capping of Cell 1. Also, waste placement into Cells 2 and 3 continued throughout 2001. By year's end, Cell 2 was at 67 percent capacity and Cell 3 was at 27 percent capacity. In addition, construction of the enhanced permanent leachate transmission system was completed in 2001. Chapter 3 discusses the activities associated with the monitoring of the on-site disposal facility.

000039

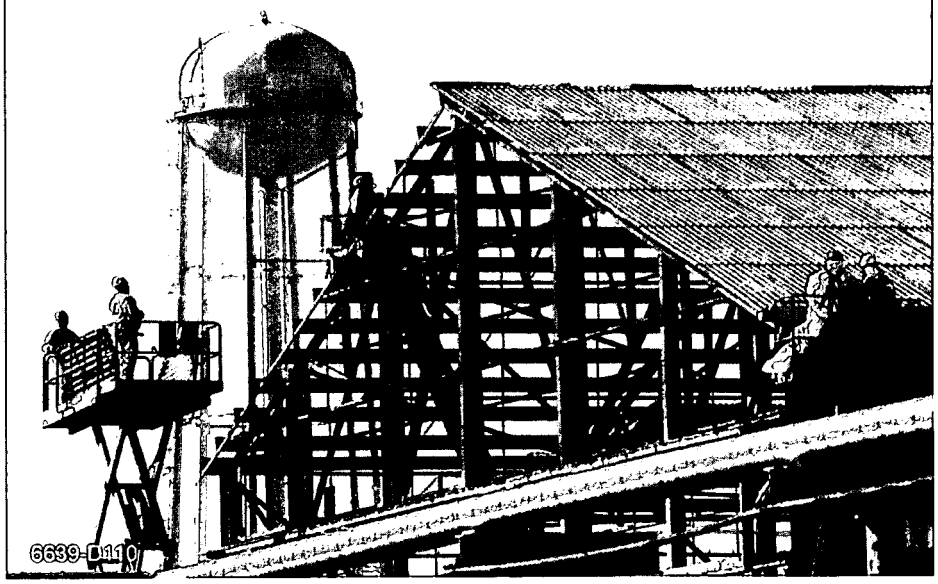
Decontamination and Demolition Project

The Decontamination and Demolition Project (Operable Unit 3) is responsible for decontamination and dismantling of the above-grade portion of structures and facilities associated with production operations and remedial action facilities. This includes decontamination of facilities, isolation of utilities, demolition of buildings, equipment, and other facilities, and removing uranium and other material from former processing equipment and shipping material and equipment off site. The scope includes the collection and proper management of associated decontamination wastewater. In October 2001, MACTEC Inc., was awarded the demolition closure contract, and will be responsible for all remaining above-grade demolition of structures at the FEMP.

During 2001 decontamination and dismantlement activities were completed at the following facilities:

- 3B Ozone Building
- 3C NAR Control House
- 5A Metals Production Plant
- 5D West Derby Breakout
- 6A Metals Fabrication Plant
- 6G Plant 6 Sump Building
- 8D Plant 8 Railroad Filter Building
- 8E Drum Conveyor Shelter
- 62 Quonset Hut #3.

Demolition of these nine structures brings the total number of structures demolished at the FEMP to 99.



Demolition of Plant 6

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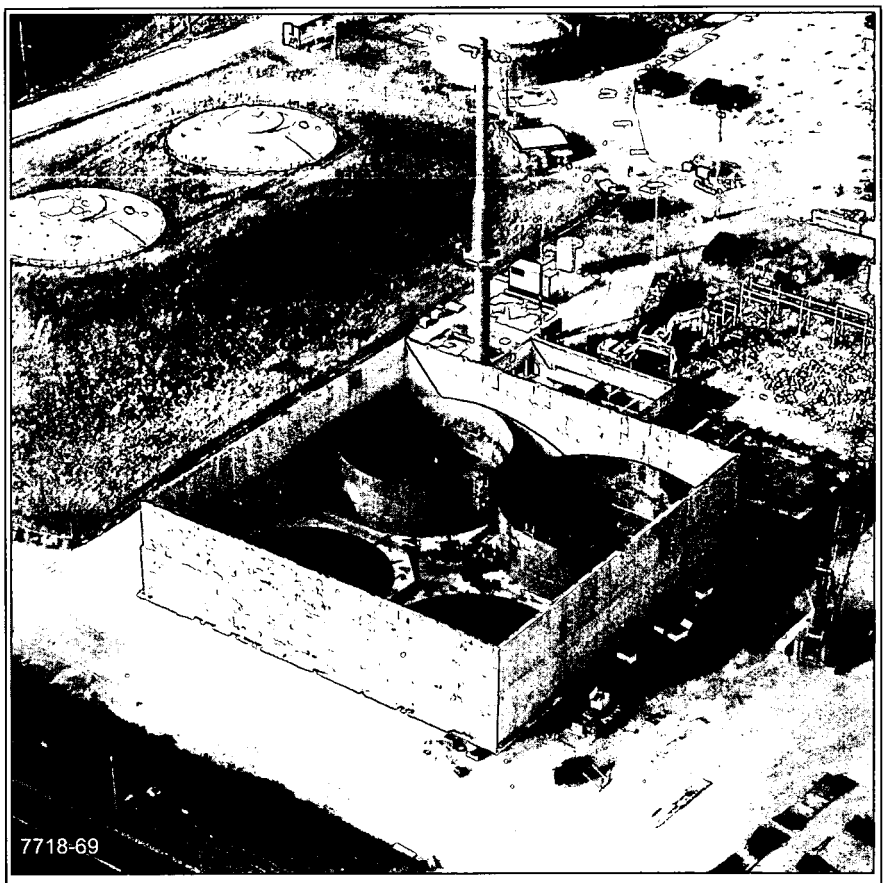
Silos Projects

The Silos Project (Operable Unit 4) includes Silos 1 and 2, also known as the K-65 Silos, Silos 3 and 4, and several nearby structures. Silos 1 and 2 contain low-level radium-bearing residues dating back to the 1950s. Silo 3 contains cold metal oxides, and Silo 4 has never been used. Silos Project remediation activities will include the retrieval, stabilization, and off-site disposal of the residues stored in the silos, as well as decontamination and dismantling of the silo structures and associated facilities.

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

Silos 1 and 2 Remediation

An Amendment to the Record of Decision for Operable Unit 4 Silos 1 and 2 Remedial Actions was approved by the EPA in July of 2000, thus establishing a revised remedy for treatment of Silos 1 and 2 material. The final revised remedy consists of on-site chemical stabilization of the Silos 1 and 2 material followed by off-site disposal at the Nevada Test Site. Design of the necessary facilities for implementation of the revised remedy for Silos 1 and 2 was initiated in 2001.



The Accelerated Waste Retrieval Facility adjacent to Silos 1 and 2

The Silos 1 and 2 Project initiated the Accelerated Waste Retrieval Project in 1998. The purpose of this project is to address the increasing radon concentrations in the Silos 1 and 2 headspace, as well as issues with silo integrity and heterogeneity of the material for the final treatment facility. The project scope includes design, construction, testing, and operation of interim storage facilities to hold the Silos 1 and 2 material until treatment is implemented. The project also includes design, construction, and startup of a Radon Control System to provide control of radon emissions during construction and operation phases of the Accelerated Waste Retrieval Project, as well as during interim storage and operation of the Silos 1 and 2 full-scale treatment facility. A contract for implementation of the Silos 1 and 2 Accelerated Waste Retrieval Project was awarded to Foster Wheeler Environmental Corporation in 1999. During 2001 a decision was made to transition to a direct-execution approach where Fluor Fernald and its teaming partners would directly execute the remaining design, construction, and operations activities. A Due Diligence review of the Foster Wheeler design was completed and implementation of the resulting design changes was initiated. Construction activities completed during 2001 included erection of the Radon Control System exhaust stack, initial carbon bed installation, and initiation of the erection of the Transfer Tank Area.

Silo 3 Project

A contract for the Silo 3 stabilization/solidification facility was awarded to Rocky Mountain Remediation Services in December 1998. In late 2000, Fluor Fernald's contract with Rocky Mountain Remedial Services was terminated by agreement of both parties. In 2001 evaluation of alternatives for implementation of Silo 3 remediation was initiated and a revised path forward was developed with input from DOE, regulators, and FEMP stakeholders. Design of the necessary facilities was initiated in 2001.

Supplemental Environmental Projects

As a result of missed Operable Unit 4 enforceable milestones in 1996, the dispute resolution agreement with EPA required DOE to perform the following supplemental environmental projects:

- Grants for ecological restoration research
- Creation of a wild bird/wildflower habitat area
- Railroad track recycling
- Structural steel debris recycling.

These supplemental environmental projects are being performed under the scopes of other projects. The wild bird/wildflower habitat area and recycling projects are now complete. Chapter 7 reports the progress on the ecological restoration research in 2001.

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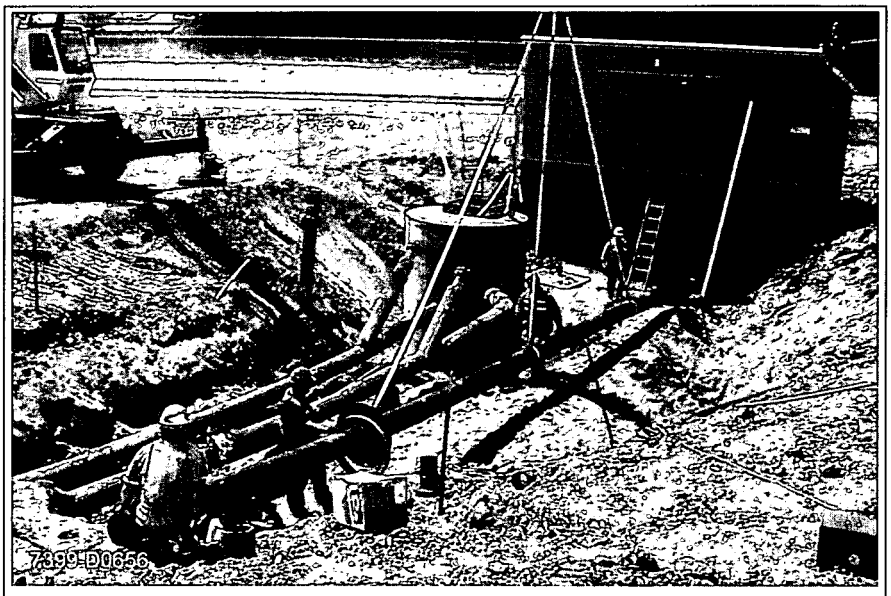
Aquifer Restoration and Wastewater Project

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

In 2001 the Aquifer Restoration and Wastewater Project continued to operate the South Plume Module (including the South Plume Optimization Module), the South Field Extraction (Phase I) Module, and the Re-Injection Module. In addition, construction of three new extraction wells began; two in support of the Waste Storage Area Extraction Module, and one in support of the South Field Extraction (Phase I) Module. These wells began operating in early 2002. Also, direct push sampling activities were conducted using the Geoprobe® in the South Field to support the groundwater remedy performance monitoring and design of the South Field Phase II Module.

In 2001 a total of 2,009 million gallons (7,604 million liters) of groundwater were extracted from the Great Miami Aquifer, 867 net pounds (394 kg) of uranium were removed from the aquifer, and 147 million gallons (556 million liters) of water were re-injected into the aquifer. Chapter 3 discusses groundwater monitoring.

Phases 1 and 2 of the advanced wastewater treatment facility and the interim advanced wastewater treatment facility provide final treatment of FEMP contaminated storm water and wastewater. The advanced wastewater treatment facility Phase 3 and the South Plume interim treatment facility are dedicated to treatment of contaminated groundwater associated with FEMP groundwater remediation. In 2001 improvements to the site's wastewater storage, conveyance, and treatment systems included completion of the enhanced permanent leachate transmission system for the on-site disposal facility, and completion of the alternative remedial action subcontractor approach Basin Re-Route Project. This will enable storm water to be routed from the waste pit area to the Storm Water Retention Basin.



Aquifer Restoration and Wastewater Project - Construction of the Enhanced Permanent Leachate Transmission System

Summary of Compliance with Other Requirements

CERCLA requires compliance with other laws and regulations as part of remediation of the FEMP. These other requirements are referred to as applicable or relevant and appropriate requirements, or ARARs. ARARs that are pertinent to remediation of the site are specified in the record of decision for each operable unit. This section highlights some of the major requirements related to environmental monitoring and waste management and how the FEMP complied with these requirements in 2001.

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

Resource Conservation and Recovery Act (RCRA)

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

The FEMP completed several administrative activities related to mixed waste storage and treatment during 2001, including:

- Submittal of the 2000 RCRA Annual Report (DOE 2001), which describes hazardous waste activities for 2000
- Revisions to several sections of the RCRA Part A and B permit application
- Submittal of the Fiscal Year 2001 Annual Update to the Site Treatment Plan (DOE 2001d) as required in the 1992 Federal Facility Compliance Act and the implementing Director's Findings and Orders issued by OEPA in October 1995.

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

RCRA Property Boundary Groundwater Monitoring

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

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RCRA Closures

The 1993 Stipulated Amendment to Consent Decree required that DOE identify all hazardous waste management units at the site. As a result, burners, incinerators, furnaces, stills, process equipment, tank units, dust collectors, and other potential waste containment units were evaluated in the early 1990s to determine if they were hazardous waste management units or solid waste management units. This evaluation was completed in 1994. In 1996 OEPA issued a Director's Findings and Orders to integrate RCRA closure requirements with CERCLA response actions for FEMP hazardous waste management units. In 2001 the FEMP finalized plans for the remediation of eight units: the Nitric Acid Recovery System, Box Furnace, Oxidation Furnace #1, Plant 8 Warehouse, Uranyl Nitrate Hexahydrate Tanks (three locations), and the storage pad located north of Plant 6.

Thorium Management

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

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

The Thorium Overpacking Project, in which the FEMP removed 3,400 containers of thorium material and shipped 10,875 drum-equivalents, or 80,480 ft^3 (2,279 m^3), of thorium material to the Nevada Test Site for disposal, was completed in 1997. The characterization documentation and formal RCRA waste determinations for the remaining estimated 8,500 containers of thorium legacy waste were continued in 1999. Through the end of 2001, over 6,400 of these containers were shipped to Nevada Test Site for disposal. This shipping effort removed over 1,000,000 pounds (454,000 kg) of thorium from the total site thorium inventory. The following activities are planned for the future:

- Low-level radioactive, non-RCRA thorium legacy waste will continue to be prepared and shipped to the Nevada Test Site for disposal.
- The thorium legacy waste determined to be hazardous under RCRA will be prepared and shipped for treatment to meet land disposal restrictions, and upon analytical confirmation, will be shipped from the treatment facility to an approved disposal facility.
- Non-RCRA thorium waste that contains free liquids and hydrogen-generating waste will require treatment and repackaging to meet Nevada Test Site waste acceptance criteria and will then be shipped to the Nevada Test Site for disposal.

The treatment activities for thorium legacy waste are planned for completion by December 31, 2002.

Mixed Waste Treatment

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

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

Mixed waste is defined under RCRA as waste containing both a hazardous waste subject to RCRA, and a source, special nuclear, or radioactive byproduct material subject to the Atomic Energy Act, as amended. RCRA mixed wastes at the FEMP are stored in consolidation tanks until they are shipped to the incinerator at Oak Ridge, Tennessee. The consolidation tanks at the FEMP hold approximately 20,000 gallons of material, which constitutes a "batch". Batches may contain oils, solvents or a combination of the two.

In 2001, 1,706 gallons (6,458 liters) of liquid mixed waste were bulked into batch 11 storage tanks, and 18,550 gallons (70,212 liters) of liquid mixed waste were bulked into batch 12 storage tanks. The following mixed wastes were shipped during 2001:

- 14,017 gallons (53,054 liters) of liquid mixed waste from batch 10 were shipped to the K-25 Toxic Substances Control Act Incinerator in Oak Ridge, Tennessee.
- 2,034 ft^3 (58 m^3) below-treatment-standard mixed waste were shipped to Envirocare of Utah, Inc. for disposal.
- 904 ft^3 (26 m^3) of First Article Test waste under the Organic Treatment Project were shipped to Materials & Energy Corporation in Oak Ridge, Tennessee under the DOE Broad Spectrum Contract.
- 2,239 ft^3 (63 m^3; under specific Waste Generator Services treatment campaigns) of liquid aqueous low level radioactive and mixed wastes meeting National Pollutant Discharge Elimination System (NPDES) Permit requirements were treated at the advanced wastewater treatment facility.

The following hazardous/recyclable wastes were shipped to approved recycle centers and/or treatment facilities in 2001:

- 576 ft^3 (16 m^3) of lead acid batteries
- 854 ft^3 (24 m^3) of lab packs and non-bulk chemicals
- 560 ft^3 (16 m^3) of electrical waste (fluorescent light tubes), 96 ft^3 (3 m^3) of electrical waste (ballasts), 24 ft^3 (less than 1 m^3) of electrical waste (Ni-cad batteries)
- 38 ft^3 (1 m^3) of photographic waste.

Clean Water Act

Under the Clean Water Act, as amended, the FEMP is governed by NPDES regulations that require the control of discharges of non-radiological pollutants to waters of the State of Ohio. The NPDES Permit, issued by the State of Ohio, specifies discharge and sample locations, sampling and reporting schedules, and discharge limitations. The FEMP submits monthly reports on NPDES activities to OEPA. The FEMP's current NPDES Permit, Permit No. 1IO00004*FD, became effective on March 1, 2000. Chapter 4 discusses the surface water and treated effluent information in detail.

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Clean Air Act

NESHAP Subpart H imposes a limit of 10 millirem (mrem) per year on the effective dose equivalent to the maximally exposed individual as a result of all air emissions (with the exception of radon) from the facility in a single year. For 2001 the FEMP was in compliance with the NESHAP dose limit, as determined by ambient air monitoring at the FEMP fenceline boundary.

EPA regulates the FEMP's radionuclide emission sources through NESHAP; OEPA has authority to enforce the State of Ohio's air standards including particulate, chemical, and toxic emission sources. In 2001 the FEMP complied with all emissions standards, as discussed in Chapter 5. The NESHAP Annual Report for 2001 is included as Appendix D.

Several remediation activities, including the waste pits remediation, decontamination and dismantling, soil excavation, and on-site disposal facility construction and waste placement, may result in the generation of fugitive dust, which is also regulated by OEPA. Compliance is accomplished by implementing the Fugitive Dust Control Policy negotiated between DOE and OEPA in 1997. This policy is implemented in the Best Available Technology Determination for Remedial Construction Activities on the Fernald Environmental Management Project (DOE 1997), the requirements of which are incorporated into each operable unit's remedial design and remedial action deliverables. The policy allows for visual observation of fugitive dust and implementation of dust control measures to determine compliance during remediation activities.

Superfund Amendments and Reauthorization Act of 1986

The Superfund Amendments and Reauthorization Act of 1986 (SARA) amended CERCLA and was enacted, in part, to clarify and expand CERCLA "Superfund" requirements. SARA Title III is also known as the Emergency Planning and Community Right-to-Know Act (EPCRA). SARA Title III, Section 312, Emergency and Hazardous Chemical Inventory Report (DOE 2001) for 2001 was submitted to OEPA and other local emergency planning/response organizations in February 2002. The report lists the amount and location of hazardous chemicals/substances stored or used in amounts greater than the minimum reporting threshold at any time during the previous year.

The SARA Title III, Section 313, Toxic Chemical Release Inventory Report will be submitted, as required, to OEPA and EPA before July 1, 2002. This report, called Form R, is required if the FEMP meets certain criteria and an applicable threshold for any SARA 313 chemical is reached.

The Toxic Chemical Release Inventory Report lists routine and accidental releases, as well as information about the activities, uses, and waste for each reported toxic chemical. During 2001 an evaluation began to determine if the FEMP has any chemicals that meet the SARA 313 manufactured, processed, or otherwise used reporting threshold requirements. The regulatory reporting threshold has changed for several chemicals; thus, a thorough review of chemicals at the FEMP will be conducted. The evaluation will be completed in June of 2002, and will be reported prior to the July 1, 2002 compliance date, as applicable. Should reporting criteria not be met, a letter to this effect will be forwarded to the appropriate agencies.

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Any off-site release meeting or exceeding a reportable quantity as defined by SARA Title III, Section 304, requires immediate notifications to local emergency planning committees and the state emergency response commission. Depending on the respective requirements, notifications are also made to the National Response Center and to the appropriate federal, state, and local regulatory entities. All releases occurring at the FEMP are evaluated and documented to ensure that proper notifications are made in accordance with SARA. In addition to SARA, releases are also evaluated for notification under CERCLA Section 103, RCRA, the Toxic Substances Control Act, the Clean Air Act, the Clean Water Act, and Ohio environmental laws and regulations. In 2001 no releases occurred at the FEMP that required reporting to regulatory or other agencies, under any of the above regulations. Table 2-2 summarizes the FEMP's compliance with SARA Title III (i.e., EPCRA) reporting requirements during 2001.

TABLE 2-2
SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT, TITLE III (EMERGENCY PLANNING AND COMMUNITY RIGHT-TO-KNOW ACT) COMPLIANCE REPORTING, 2001[a]

Sections of the Act	Yes	No	Not Required
302-303: Planning notification	X		
304: Extremely hazardous substances release notification			X
311-312: Material safety data sheet/chemical inventory	X		
313: Toxic chemical release inventory reporting (for calendar year 2000)	X		

[a]"Yes" indicates that notifications were provided and/or reports were issued under the applicable provisions. "No" indicates that notifications or reports should have been provided but were not. "Not Required" indicates that no actions were required under the applicable provisions, either because triggering thresholds were not exceeded or no releases occurred.

Other Environmental Regulations

The FEMP is also required to comply with other environmental laws and regulations in addition to those described above. Table 2-3 summarizes compliance with each of these requirements for 2001.

Other Permits

Permits are the means by which some environmental laws are implemented. The FEMP has permits for controlled releases to surface water and air. The FEMP's permit for discharging water under the NPDES regulations is discussed in the Clean Water Act section of this chapter. The active Permits to Install remaining for the FEMP wastewater treatment system include those for the Storm Water Retention Basin and Bio-Surge Lagoon. Permits to Install govern the installation (and to a lesser degree, the operation) of specific wastewater treatment and control devices.

The FEMP has six current air Permits to Operate and three associated Permits to Install. These permits cover four boilers, a diesel storage tank, and a gasoline dispensing facility. EPA and OEPA approve other air emission sources and wastewater systems related to remedial activities through the review and approval of CERCLA remedial design packages or CERCLA-allowed permit information summaries.

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TABLE 2-3

COMPLIANCE WITH OTHER ENVIRONMENTAL REGULATIONS

Regulation and Purpose	Background Compliance Issues	2001 Compliance Activities
Toxic Substances Control Act (TSCA)		
Regulates the manufacturing, use, storage, and disposal of toxic materials, including polychlorinated biphenyl (PCBs) and PCB items	The last routine TSCA inspection of the FEMP's program was conducted by EPA Region V on September 21, 1994. No violations of PCB regulations were identified during the inspection.	Non-radiologically contaminated PCBs and PCB items are shipped to TSCA-approved commercial disposal facilities for incineration on an "as-needed basis". Radiologically contaminated PCB liquids were bulked for shipment to the TSCA permitted DOE incinerator in Oak Ridge, TN. Most radiologically contaminated PCB solids currently have no treatment or disposal options and remain in storage on site.
Ohio Solid Waste Act		
Regulates infectious waste	The FEMP was registered with OEPA as a generator of infectious waste (generating more than 50 pounds [23 kg] per month) until December 6, 1999, when OEPA concurred with the FEMP's qualification as a small quantity generator.	All infectious wastes generated in the medical department were transported to a licensed treatment facility for incineration.
Federal Insecticide, Fungicide, and Rodenticide Act		
Regulates the registration, storage, labeling, and use of pesticides (such as insecticides, herbicides, and rodenticides)	The last inspection of the Federal Insecticide, Fungicide, and Rodenticide Act program conducted by EPA Region V on September 21, 1994, found the FEMP to be in full compliance with the requirements mandated by Federal Insecticide, Fungicide, and Rodenticide Act.	Pesticide applications at the FEMP were conducted according to Federal and State regulatory requirements.
National Environmental Policy Act (NEPA)		
Requires the evaluation of environmental socio-economic, and cultural impacts before any action, such as a construction or cleanup project, is initiated by a federal agency	An environmental assessment for proposed final land use was issued for public review in 1998. It was prepared under DOE's guidelines for implementation of NEPA, 10 Code of Federal Regulations 1021. It also addresses previous DOE commitments to consult with the public prior to any decisions on land use.	No NEPA activities were conducted in 2001.
Endangered Species Act		
Requires the protection of any threatened or endangered species found at the site as well as any critical habitat that is essential for the species' existence	Ecological surveys conducted by Miami University and DOE, in consultation with the Ohio Department of Natural Resources and U.S. Fish and Wildlife Service, have established the following list of threatened and endangered species and their habitats existing on site: *Cave salamander, state-listed endangered* - marginal habitat, none found; Sloan's crayfish, state-listed threatened - found on northern sections of Paddys Run; Indiana brown bat, federally listed endangered - species found in riparian areas along Paddys Run.	A survey of the site's state-threatened Sloan's crayfish population was conducted in 2001. As discussed in Chapter 7, this survey identified population levels consistent with previous surveys.

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TABLE 2-3
(Continued)

Regulation and Purpose	Background Compliance Issues	2001 Compliance Activities
Floodplains/Wetlands Review Requirements		
DOE regulations require a floodplain/wetland assessment for DOE construction and improvement projects.	A wetlands delineation of the FEMP, completed in 1992 and approved by the U.S. Army Corps of Engineers in August 1993, identified 36 acres (15 hectares) of freshwater wetland on the FEMP property. Updated delineations are conducted approximately every five years.	No assessments were performed in 2001.
National Historic Preservation Act		
Mandates protection of historic and prehistoric cultural resources	The FEMP is within an area rich in historic and prehistoric cultural resources. These cultural resources include 148 prehistoric sites within 1.24 miles (2 km) of the FEMP and 40 historic sites.	Activities were conducted to avoid and address impacts to cultural resources (refer to Chapter 7).
Native American Graves Protection and Repatriation Act		
Requires the identification and preservation of cultural resources on federal lands, and consultation with Native American Tribes on removal and management of inadvertently discovered Native American cultural items	Historical remains and artifacts were discovered during a 1994 construction project. The Native American remains, which included an adolescent boy and his dog, were discovered during installation of pipelines for the Public Water Supply project. Partial remains of approximately 20 more people and numerous artifacts were also found.	No Native American remains were discovered or interred in 2001. Cultural resources were identified as a result of surveys performed (refer to Chapter 7).
National Resource Requirements Under CERCLA and Executive Order 12580		
Requires DOE to act as a Trustee (i.e., guardian) for natural resources at its federal facilities.	DOE and the other Trustees, which include U.S. Department of the Interior, U.S. Fish and Wildlife Service, OEPA, Ohio Attorney General's Office, and EPA, meet regularly to discuss potential impact to natural resources and to coordinate Trustee activities. The Trustees also interact with the Fernald Citizens Advisory Board and Community Reuse Organization.	The Trustees and stakeholders continued to discuss the scope of Natural Resource Restoration activities at the FEMP, and the integration of public use and long-term stewardship at the FEMP. In 2001, the Trustees agreed to and signed a Memorandum of Understanding.

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Site-Specific Regulatory Agreements

Federal Facility Compliance Agreement

In July 1986 DOE entered into a Federal Facility Compliance Agreement (FFCA) with EPA, which requires the FEMP to:

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

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

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

The Federal Facility Agreement (FFA) between DOE and EPA, signed in November of 1991, ensures that DOE takes all necessary actions to control and abate radon-222 emissions at the FEMP, under the authority of 40 Code of Federal Regulations 61, Subpart Q. This agreement acknowledges that Silos 1 and 2 exceed the radon flux rate of 20 picoCuries per square meter per second (pCi/m^2/sec). But it allowed the FEMP to address this exceedance by implementing a removal action (installation of a bentonite cap in 1991) to bring radon emissions from the silos to a level as low as reasonably achievable (ALARA), and to attain the NESHAP Subpart Q standard upon completion of final remediation. The FFA also requires demonstration of compliance with the Subpart Q standard upon completion of remedial actions for the waste pits, clearwell, and any other sources found to contain radium-226 in sufficient concentrations to emit radon in excess of 20 pCi/m^2/sec. Chapter 5 further discusses the results of the FEMP Radon Monitoring Program for 2001.

Split/Co-Located Sampling Program

In 2001 DOE and OEPA cooperated in a program in which samples of groundwater, surface water, and sediment, were "split" and sent to different analytical laboratories, or "co-located," meaning samples were collected from the same location but at different times. Split samples are obtained when technicians alternately add portions of a sample to two individual sample containers. This collection method helps ensure that both samples are as identical as possible. Split samples are then submitted to two independent laboratories for analysis. The FEMP has participated in this program with the state since 1987.

This program allows for an independent comparison of data to ascertain laboratory analysis and field quality assurance. The data from the split/co-located sampling program show reasonable agreement between DOE and OEPA results for groundwater, surface water, and sediment samples. The slight differences in DOE and OEPA sample results presented for 2001 do not impact the FEMP's compliance with federal or state regulations. The detailed results for the 2001 split/co-located samples are presented in Appendix E of this report.

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Chapter 3
Groundwater Pathway

Groundwater Pathway

Results in Brief: 2001 Groundwater Pathway

Enhanced Groundwater Remedy - During 2001 active restoration of the Great Miami Aquifer continued at the following four 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.

Since 1993

- 9,525 million gallons (36,052 million liters) of water have been pumped from the Great Miami Aquifer.
- 1,006 million gallons (3,808 million liters) of water have been re-injected into the Great Miami Aquifer.
- 3,223 net pounds (1,463 kg) of total uranium have been removed from the Great Miami Aquifer.

During 2001

- 2,010 million gallons (7,608 million liters) of water were pumped from the Great Miami Aquifer.
- 147 million gallons (556 million liters) of water were re-injected into the Great Miami Aquifer.
- 867 net pounds (393 kg) of total uranium were removed from the Great Miami Aquifer.

An Explanation of Significant Differences (ESD) pertaining to the site groundwater remedy was approved by EPA on November 30, 2001. The ESD amended the Operable Unit 5 Record of Decision by adopting the Safe Drinking Water Act Maximum Contaminant Level for uranium (30 µg/L) as both the final remediation level (FRL) for groundwater restoration and the uranium effluent discharge limit to the Great Miami River.

Waste Storage Area Module: Phase I of this module consists of three extraction wells in the Pilot Plant Drainage Ditch plume. By the close of 2001, all three wells had been installed along with part of the associated piping and infrastructure. The wells will begin pumping in 2002.

Groundwater Re-Injection: A new treatment method to alleviate well plugging was developed and adopted in 2001. The new method is much more effective than the previous methods used and has allowed for the resumption of re-injection in three of the five property boundary re-injection wells. The two remaining wells are being replaced in 2002.

Groundwater Monitoring Results - Groundwater sampling data in the South Field Module area continue to indicate total uranium concentration reductions in the western portion of this plume. These reductions are attributed to surface source removal, flushing of the contaminants toward the extraction wells by infiltrating surface water, and pumping of the extraction wells. However, in the eastern portion of the South Field Module, some monitoring wells have steady or increasing total uranium concentrations. An additional extraction well was installed in this portion of the plume in 2001 for operation beginning in 2002 and more new wells are planned for this area as part of the South Field Phase II Module.

On-Site Disposal Facility Monitoring - Leak detection monitoring during 2001 indicated that the liner systems for Cells 1, 2, and 3 are performing within the specifications outlined in the approved on-site disposal facility design documents.

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

- Significant achievements realized by the Operable Unit 5 Aquifer Restoration and Wastewater Project in 2001
- Groundwater monitoring activities and results for 2001.

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 FEMP. The FEMP will continue to monitor the groundwater pathway throughout remediation to ensure the protection of this primary exposure pathway.

Groundwater Modeling at the FEMP

The FEMP uses computer models 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, then 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 clean-up efficiency and reduce the clean-up time and cost, then 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, then modifications are made to the model to improve its predictive capabilities.

Summary of the Nature and Extent of Groundwater Contamination

The nature and extent of groundwater contamination from operations at the FEMP 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. As documented in that report, the primary groundwater contaminant at the FEMP is uranium. Approximately 169 acres (68 hectares) of the Great Miami Aquifer are currently contaminated above the 30 µg/L groundwater FRL for total uranium.

Contamination of the groundwater resulted from infiltration 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, and the sand and gravel of the aquifer are in direct contact with uranium-contaminated surface water from the FEMP. 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.

Selection and Design of the Groundwater Remedy

After the nature and extent of groundwater contamination was defined, various remediation technologies were evaluated in the Feasibility Study Report for Operable Unit 5 (DOE 1995). 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 pump-and-treat remedy for the groundwater contaminated with uranium. The remedy consisted 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 gpm (15,000 L/min) would remediate the aquifer within 27 years. The recommended groundwater remedy was presented to EPA, OEPA, and FEMP stakeholders in the Proposed Plan for Operable Unit 5 (DOE 1995c).

Once the preferred groundwater remedy was identified and approved in the Operable Unit 5 Proposed Plan, the Operable Unit 5 Record of Decision was presented to FEMP stakeholders and subsequently approved by EPA and OEPA in January 1996. The Operable Unit 5 Record Decision formally defined the selected groundwater remedy and established FRLs for all constituents of concern. The Operable Unit 5 Record of Decision committed to ongoing evaluation of innovative remediation technologies so that remedy performance could be improve 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).

The enhanced groundwater remediation strategy, which relies on pump-and-treat and re-injectio technology, is being used to conduct a concentration-based clean up of the Great Miami Aquifer The restoration strategy focuses primarily on the removal of uranium, but also has been designe to limit the further expansion of the plume, achieve removal of all targeted contaminants to concentrations below designated FRLs, and prevent undesirable groundwater drawdown impac beyond the FEMP property.

Re-Injection at the FEMP

Re-injection is an enhancement to the groundwater remedy. Groundwater pumped from the aquifer is treated to remove contaminants and then re-injected back into the aquifer at strategic locations. The re-injected groundwater increases the speed at which contaminants move through the aquifer and are pulled by extraction wells, thereby decreasing the overall remediation time.

A groundwater re-injection demonstration was initiated at the FEMP in September 1998. Following completion of the re-injection demonstratic in September of 1999, the Re-Injection Demonstration Test Report (DOE 2000a) was issued to EPA and OEPA on May 30, 2000. The report detailed the demonstration and recommended its incorporation in the FEMP's aquifer restoration strategy. Based on the results of the demonstration, re-injection is continuing at the FEMP. The Re-Injectio Module Operational Summary section within this chapter provides mor discussion of this topic.

The enhanced groundwater remedy also included additional extraction wells in on-site areas of aquifer contamination. Groundwater modeling studies conducted in support of the enhanced groundwater remedy suggested that, with the early installation of additional extraction wells and re-injection technology, the remedy could potentially be reduced to 10 years. EPA and OEPA approved the enhanced groundwater remedy.

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While the remedial investigation and feasibility study process 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 total uranium plume in this area from migrating any further 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 total uranium plume beyond the wells and have contributed to significantly reducing total uranium concentrations in the off-property portion of the plume.

During 2001 active remediation of the Great Miami Aquifer continued at the following groundwater restoration modules: South Plume/South Plume Optimization Module, South Field Extraction (Phase I) Module, and Re-Injection Module. Figure 3-1 depicts the current extraction and re-injection well locations. The operational information associated with these modules is presented in subsequent subsections.

The EPA and OEPA approved the Design for Remediation of the Great Miami Aquifer in the Waste Storage and Plant 6 Areas in 2001. The design specified three extraction wells in the waste storage area (Phase I) to address contamination in the Pilot Plant Drainage Ditch plume and two extraction wells to address the remaining contamination after the waste pit excavation is completed (Phase II). One of the three Phase I wells was installed in 2000 to support an aquifer pumping test to help determine the restoration wellfield design. The remaining two Phase I wells were installed in the summer of 2001 after the design was approved by EPA and OEPA. These three wells will become operational in 2002. The design report also provided data indicating that the total uranium plume in the Plant 6 area was no longer present. It is believed that the total uranium plume had dissipated to concentrations below the FRL as a result of the shutdown 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 total uranium plume with concentrations above the groundwater FRL is no longer present in the Plant 6 area, a restoration module for this area was determined to be unnecessary and is no longer planned. However, groundwater monitoring will continue in the Plant 6 area until the groundwater in this area is certified as clean. The characterization performed for the design also indicated the total uranium plume in the waste storage area is smaller than what was estimated during the remedial investigation/feasibility study. However, a portion of the waste storage area total uranium plume in the vicinity of the confluence of Paddys Run and the Pilot Plant Drainage Ditch has been re-defined as extending farther to the east than previously estimated. In addition, total uranium concentrations up to 566 µg/L were found in this area.

Figure 3-2 identifies current and future extraction and re-injection well locations. The location of the future wells in the South Field were based on the Baseline Remedial Strategy Report. The actual location of future extraction wells will be based on the most up-to-date characterization and modeling efforts.

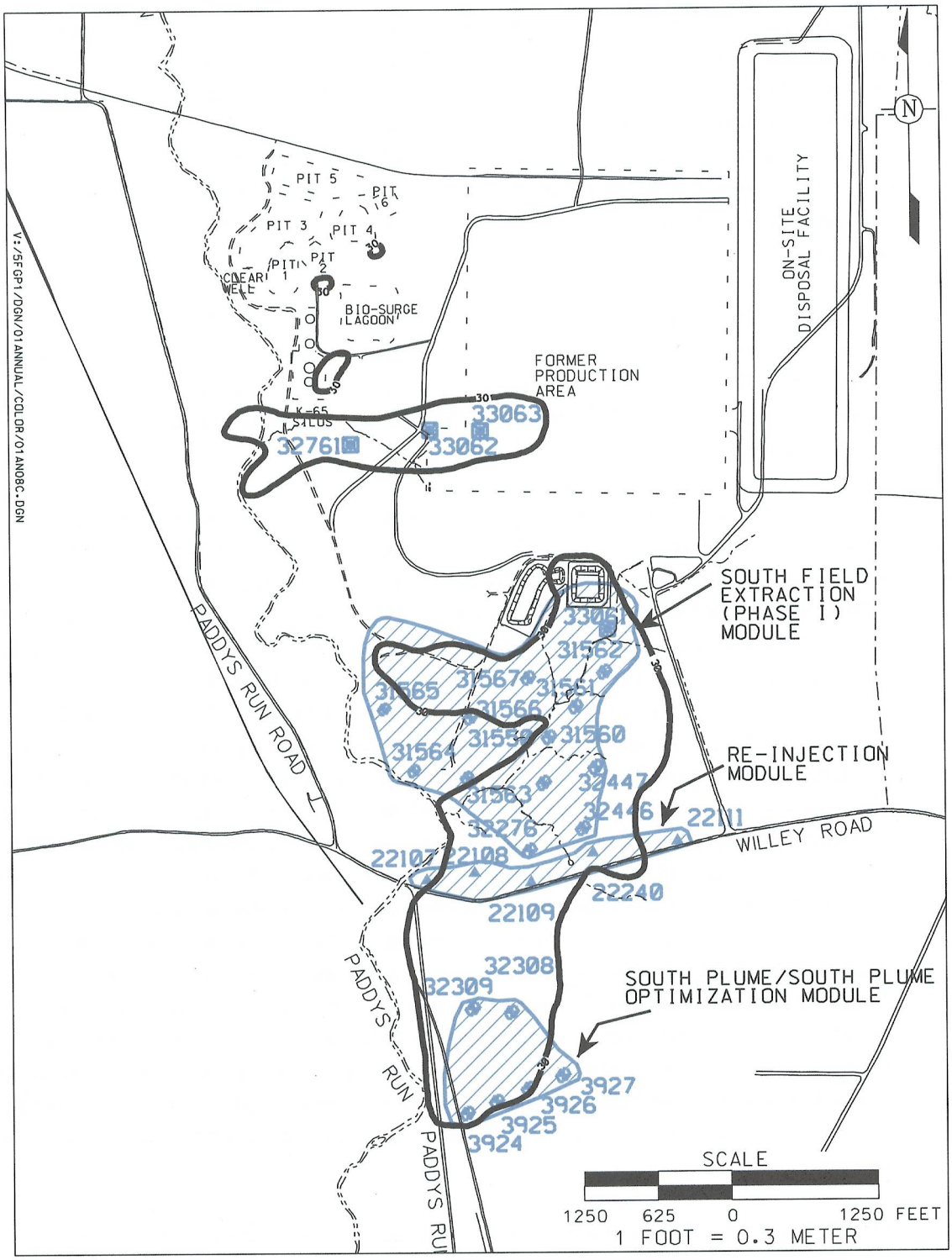

Figure 3-1. Current Extraction and Re-Injection Wells

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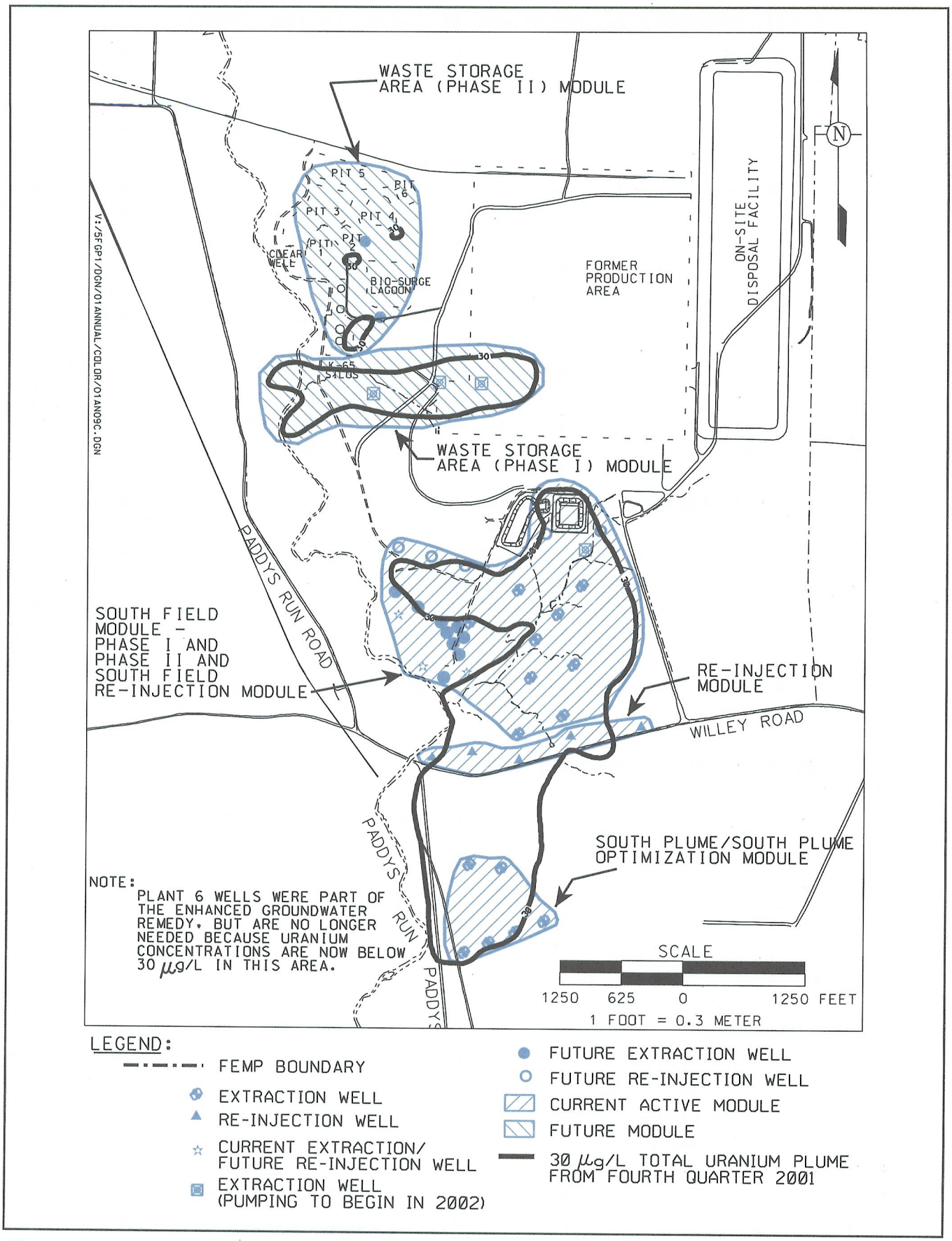

Figure 3-2. Current and Future Extraction and Re-Injection Wells for the Enhanced Groundwater Remedy

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Groundwater Monitoring Highlights for 2001

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

The key elements of the FEMP groundwater monitoring program design are described below:

- **Sampling** - Sample locations, frequency, and the constituents were selected to address operatic assessment, restoration assessment, and compliance requirements. Selected wells are monitore for up to 50 groundwater FRL constituents as identified in Table 2-2. Monitoring is conducted t ascertain groundwater quality and groundwater flow direction. Figure 3-3 shows a typical groundwater monitoring well at the FEMP and Figure 3-4 identifies the relative placement deptl of groundwater monitoring wells at the FEMP. As part of the comprehensive IEMP groundwa monitoring program, approximately 135 wells were monitored for water quality in 2001. Figure 3-5 identifies the location of the current IEMP water quality monitoring wells, including extraction wells. In addition to water quality monitoring, approximately 137 wells were monitor quarterly for groundwater elevations. Figure 3-6 depicts the IEMP routine water-level (groundwater elevation) monitoring wells, including extraction wells.

- **Data Evaluation** - The integrated data evaluation process looks at the data collected from well to determine: capture and restoration of the total uranium plume, capture and restoration of nor uranium FRL constituents, water quality conditions in the aquifer that indicate a need to modify design and installation of restoration modules, and the impact of on-going groundwater restoratic on the Paddys Run Road Site plume (a separate contaminant plume south of the FEMP propert along Paddys Run Road resulting from independent industrial activities in the area).

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

Restoration Monitoring

In general, restoration monitoring tracks the progress of the groundwater remedy and water quality conditions. Restoration monitoring is discussed in the following subsections:

- Operational Summary
  - South Plume/South Plume Optimization Module
  - South Field Extraction (Phase I) Module
  - Re-Injection Module
- Monitoring Results for Total Uranium
- Monitoring Results for Non-Uranium Constituents.

All operational modules were evaluated quarterly. The evaluation was done by collecting and mapp groundwater quality and groundwater elevation data and then analyzing the results. Concentration maps are developed from analytical data and compared with groundwater elevation maps depicting location of the capture zone.

More detailed information on the above can be found in Appendix A of this report. Each subsectior below identifies the specific Attachment of Appendix A where the detailed information can be foun

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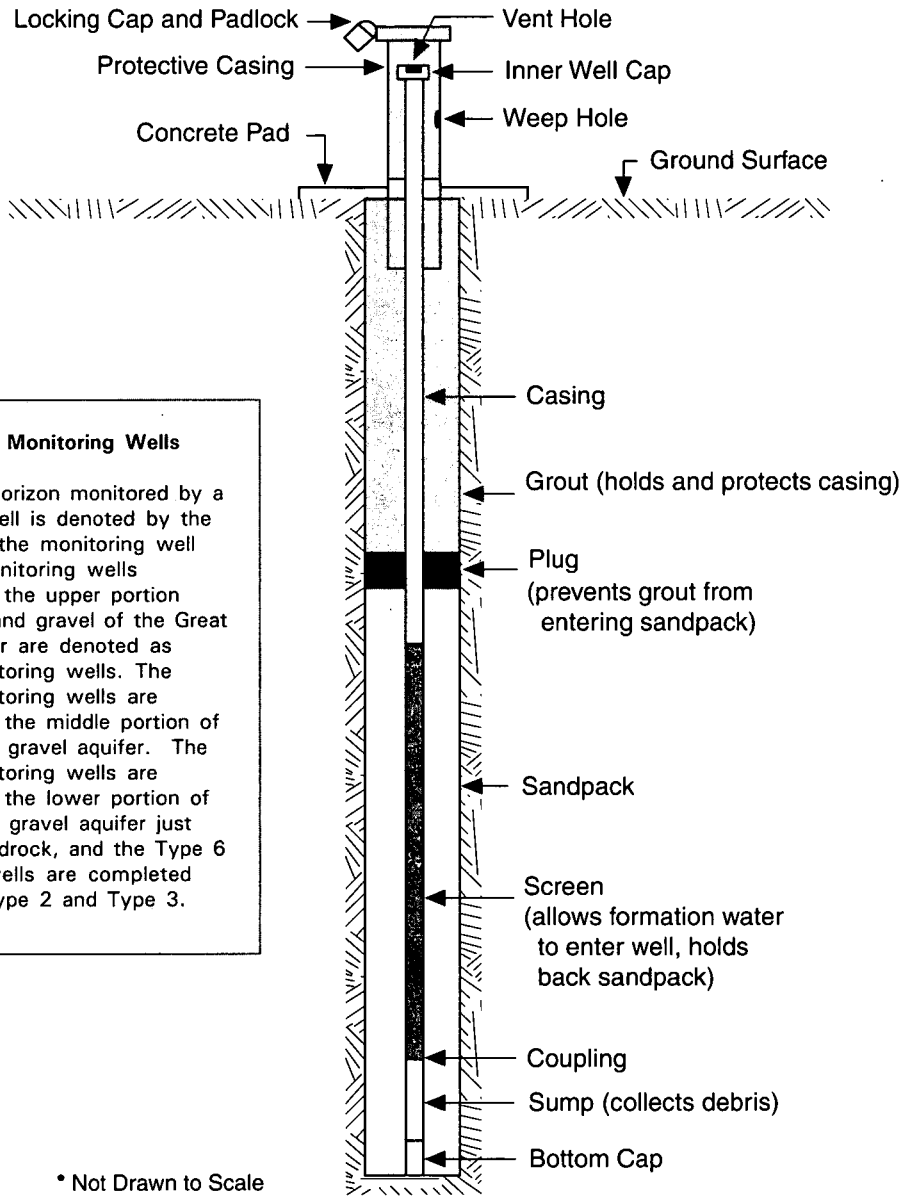

Groundwater Monitoring Wells

The aquifer horizon monitored by a monitoring 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, and the Type 6 monitoring wells are completed between a Type 2 and Type 3.

Figure 3-3. Typical Groundwater Monitoring Well Diagram

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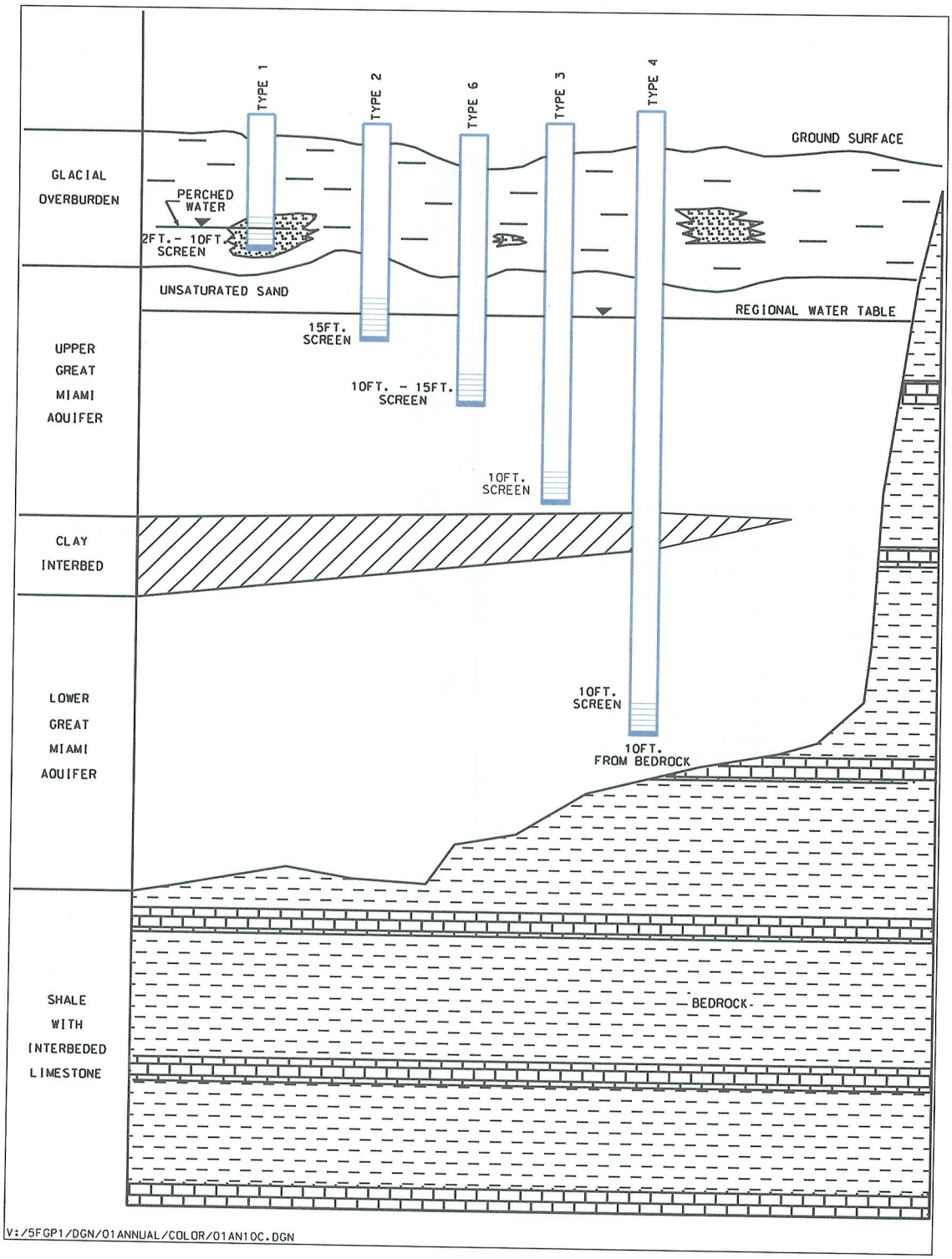

Figure 3-4. Monitoring Well Relative Depths and Screen Locations

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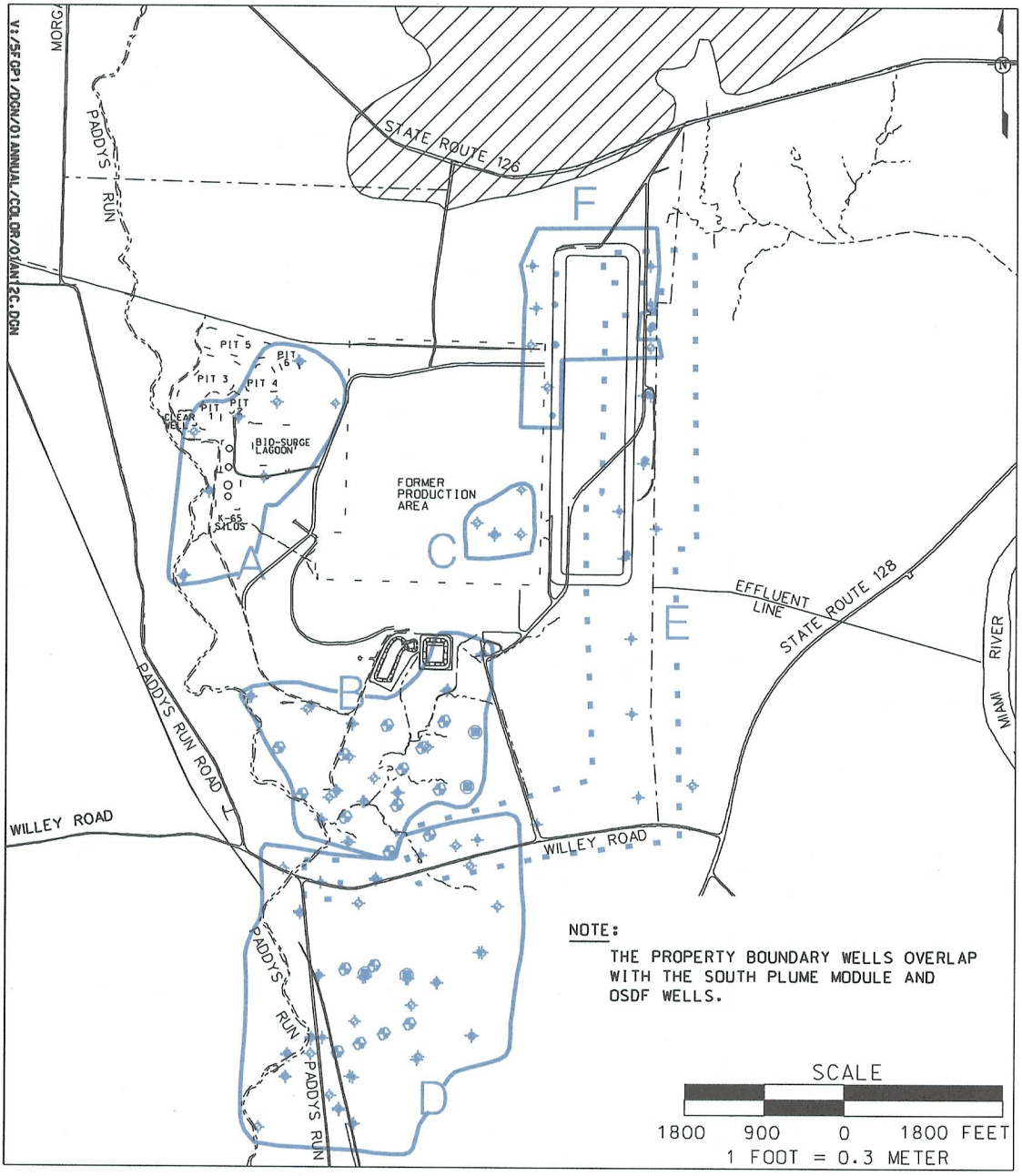

LEGEND:

- A - WASTE STORAGE AREA
- B - SOUTH FIELD EXTRACTION AREA
- C - PLANT 6 AREA
- D - SOUTH PLUME AREA
- E - PROPERTY BOUNDARY WELLS
- F - OSDF MONITORING WELLS
- FEMP BOUNDARY
- MONITORING WELL
- EXTRACTION WELL
- HORIZONTAL TILL WELL

Figure 3-5. IEMP Water Quality Monitoring Wells

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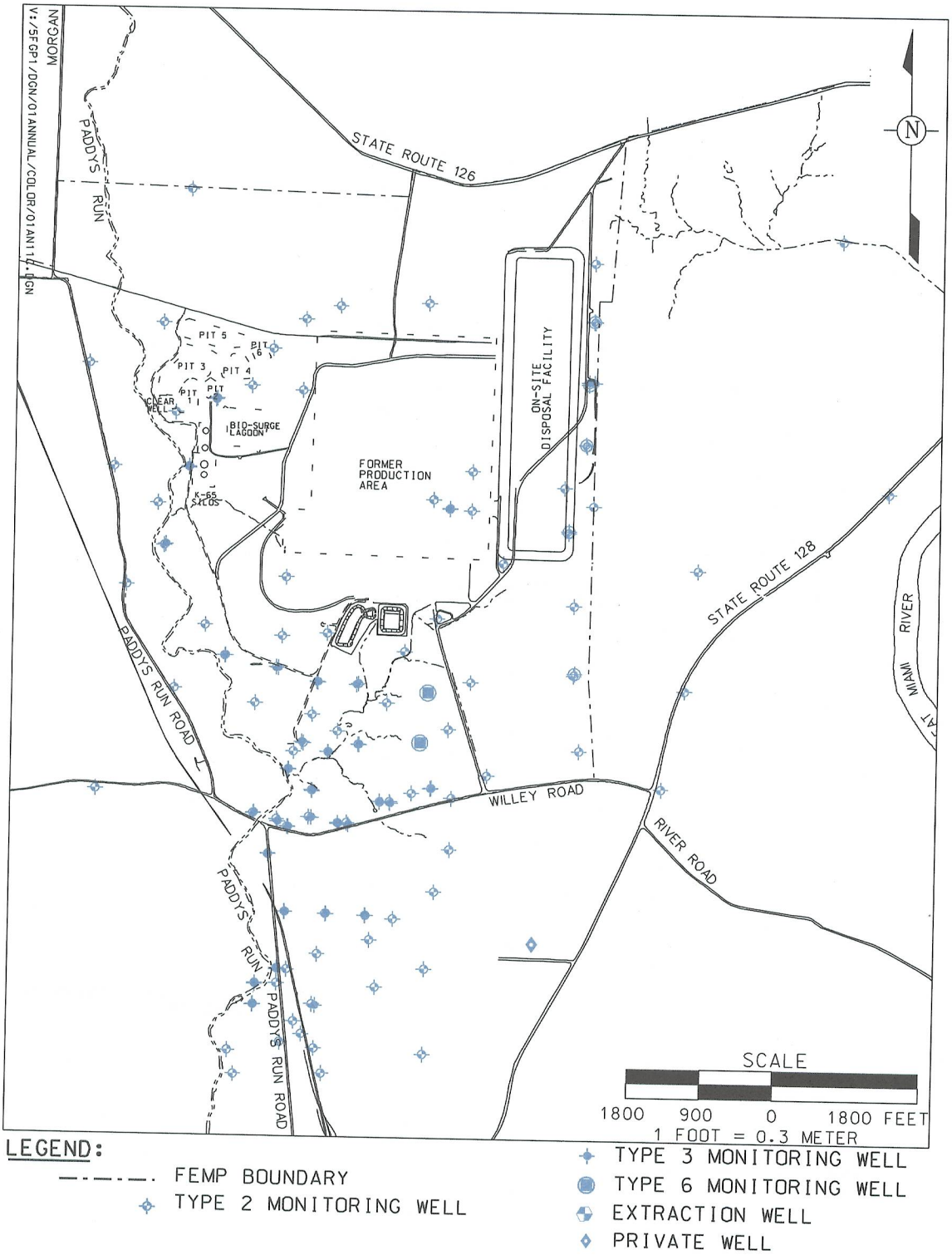

Figure 3-6. IEMP Groundwater Elevation Monitoring Wells

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Operational Summary

Figure 3-1 shows the extraction and re-injection well locations associated with the current restoration modules. Table 3-1 summarizes the pounds of uranium removed and the amount of groundwater pumped by the three restoration modules during 2001. Figure 3-7 identifies the yearly and cumulative pounds of uranium removed from the Great Miami Aquifer from 1993 through 2001. Since 1993:

- 9,525 million gallons (36,052 million liters) of water have been pumped from the Great Miami Aquifer.
- 1,006 million gallons (3,808 million liters) of treated water have been re-injected into the Great Miami Aquifer.
- 3,223 net pounds (1,463 kg) of total uranium have been removed from the Great Miami Aquifer.

Appendix A, Attachment 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. The following subsections provide information on the individual modules.

TABLE 3-1
GROUNDWATER RESTORATION MODULE STATUS FOR 2001

			Target Pumping Rate		Gallons Pumped/ Re-Injected		Uranium Removed/ Re-Injected	
Module	Restoration Wells	Operational Status	Gpm	Lpm	M gal.	M Liters	lbs	kg
South Plume/ South Plume Optimization Module	3924	Operating since	1,500	5,700	967	3,660	269	122
	3925	August 1993						
	3926							
	3927							
	32308	Operating since	500	1,900				
	32309	August 1998						
South Field Extraction (Phase I) Module	31550	Operating since	2,040	7,721	1,043	3,948	604	274
	31560	July 1998						
	31561							
	31562							
	31563							
	31564[a]							
	31565[b]							
	31566[c]							
	31567							
	32276							
	32446	Operating since						
	32447	February 2000						
Re-Injection Module	22107	Operating since	1,000	3,785	147	556	6.39	2.90
	22108	September 1998						
	22109							
	22111							
	22240							
Aquifer Restoration System Totals								
pumped			4,040	14,800	2,010	7,608	873	396
(re-injected)			1,000	3,800	147	556	6.39	2.90
net			3,040	11,000	1,863	7,052	867	393

[a]Extraction well removed from service in December 2001.
[b]Extraction well removed from service in May 2001.
[c]Extraction well removed from service in August 1998.

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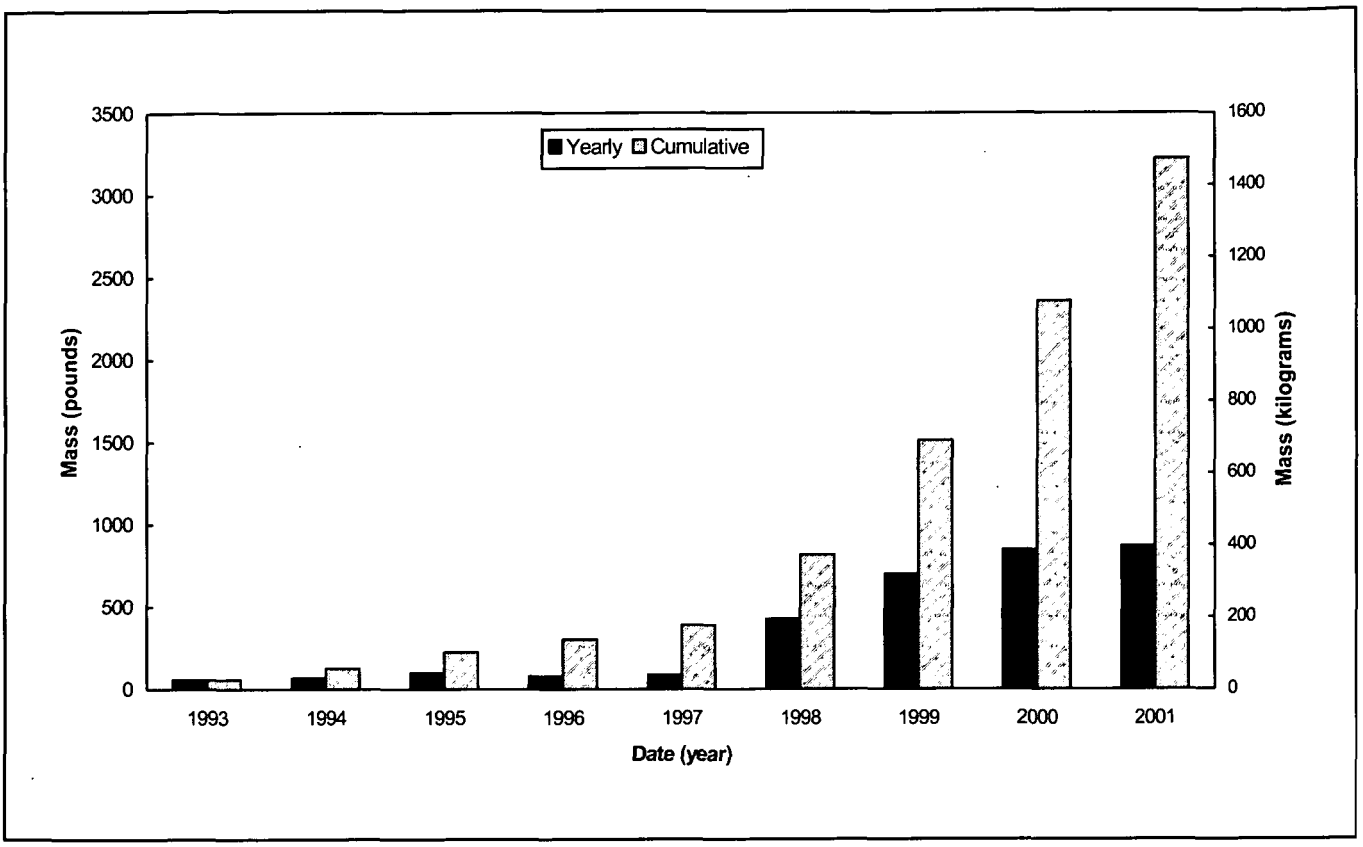

Figure 3-7. Net Pounds of Uranium Removed from the Great Miami Aquifer, 1993 - 2001

South Plume/South Plume Optimization Module Operational Summary

The four extraction wells of the South Plume Module include Extraction Wells 3924, 3925, 3926, and 3927, which began operating in August 1993. The two extraction wells of the South Plume Optimization Module include Extraction Wells 32308 and 32309, that began operating in August 1998. Figure 3-8 illustrates capture zones associated with the South Plume/South Plume Optimization Module. Based on analysis of the data in 2001, the module continues to meet its primary objectives in that the:

- Southward movement of the total uranium plume beyond the extraction wells has not been detected
- Active remediation of the central portion of the off-property total uranium plume continues
- Paddys Run Road Site plume, located south of the extraction wells, is not being adversely affected by the pumping.

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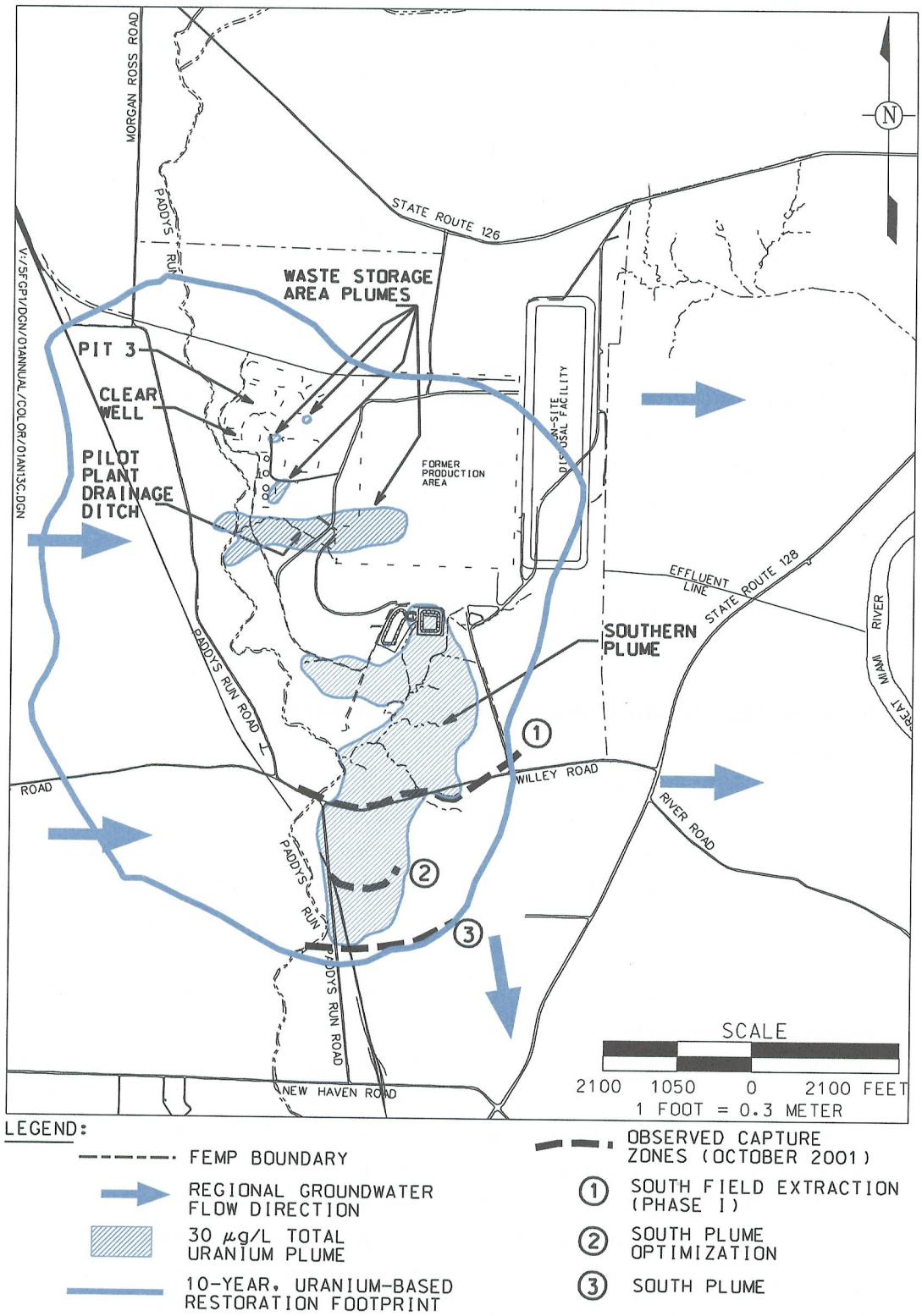

Figure 3-8. Total Uranium Plume in the Aquifer with Concentrations Greater than 30 µg/L at the End of 2001

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South Field Extraction (Phase I) Module Operational Summary

The 10 extraction wells of the South Field Extraction (Phase I) Module include Extraction Wells 31550, 31560, 31561, 31562, 31563, 31564, 31565, 31566, 31567, and 32276, which began operating on July 13, 1998. Since then three new extraction wells have been added to the module and three of the original wells have been shut down. The three extraction wells that were shutdown (31566, 31564, and 31565) are all located in the upgradient area of the plume where total uranium concentrations in the Great Miami Aquifer are now below the FRL. Additionally, Extraction Wells 31564 and 31565 were removed from service to accommodate soil remedial activities in the vicinity of the wells. Extraction Well 31566 was removed from service in 1998, Extraction Well 31564 was removed from service in May 2001, and Extraction Well 31565 was removed from service in December 2001.

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

Figure 3-8 illustrates the capture zone associated with the South Field Extraction (Phase I) Module.

Re-Injection Module Operational Summary

A groundwater re-injection demonstration test was conducted at the FEMP from September 2, 1998 to September 2, 1999. The Re-Injection Module consists of Re-Injection Wells 22107, 22108, 22109, 22111, and 22240. After this demonstration in September of 1999, 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 evaluation indicated that the testing results were favorable regarding the viability of re-injection at the FEMP, that a reliable source of injection water can be maintained, and that an acceptable injection rate can be sustained without negative effects on the plume or aquifer. However, residual plugging of the re-injection wells became a concern in the last half of 2000. In late 2000, the increased plugging had precipitated the need for more aggressive treatment of the re-injection wells. A revised treatment method utilizing concentrated hydrochloric acid, sodium hypochlorite, and calcium hypochlorite was approved and implemented in early December 2000. Although initial results of the aggressive treatment were encouraging, by early 2001, only one of three wells treated with the aggressive method was rehabilitated such that re-injection could resume at the design rate of 200 gallons per minute. Because the more aggressive treatment had mixed results, it was concluded that another alternative solution needed to be explored. This plugging, which occurs outside the well screens in the surrounding formation, resulted in a substantial amount of downtime in 2000 and 2001, and was expected to limit the actual injection rate to somewhat less than the design rate until it was resolved.

Therefore, in 2001, the FEMP solicited the help of recognized subject experts to determine alternate rehabilitation treatment methods to regain re-injection efficiency. In 2001 samples were collected from two of the re-injection wells for chemical and bacterial analysis. Interpretation of these results, including recommendations regarding well treatments was discussed with EPA and OEPA in June 2001. A key component of the recommended treatment was a biodegradable polymeric acid enhancer.

During 2001 the re-injection wells were subjected to the new treatment method and this new process appears to be economically viable in three of the five wells (Re-Injection Wells 22111, 22240, and 22109). However, due to rapid plugging after treatment, plans are being implemented to replace Re-Injection Wells 22107 and 22108 in 2002.

Monitoring Results for Total Uranium

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 3-8 shows general groundwater flow directions and the interpretation of the total uranium plume in the aquifer, and is updated with data collected through 2001. The shaded areas represent the interpreted size of the total uranium plume that is above the 30 µg/L groundwater FRL for total uranium. The fourth quarter 2001 observed capture zones for the South Field Extraction (Phase I), South Plume, and South Plume Optimization Modules are also identified on Figure 3-8. These capture zones indicate that the southern plume is being captured by the existing system and that further movement of uranium to the south of the extraction wells is being prevented. Figure 3-8 also depicts that the total uranium concentrations greater than the FRL are within the 10-year, uranium-based restoration footprint which was defined in the 1997 Baseline Remedial Strategy Report.

Geoprobe®

The Geoprobe® is a hydraulically powered, direct-push sampling tool that is used at the FEMP 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 FEMP 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.

The 2001 interpretation of the 30 µg/L total uranium plume boundary in the area of the South Field has changed in shape somewhat from the 20 µg/L plume boundary interpretation. The plume shape and concentration contours have been modified to reflect the new uranium FRL for groundwater and additional Geoprobe® sampling data in the western, on-property area of the southern plume (refer to Figure 3-8). These data were collected as part of South Field Phase II Module pre-design characterization effort. The Geoprobe® data, along with routine IEMP monitoring well data in the South Field area, continue to indicate reducing total uranium concentrations in the western portion of this plume, particularly beneath the former Inactive Flyash Pile. Factors contributing to the reduction in total uranium concentrations include surface source removal, flushing of the contaminants toward the extraction wells by infiltrating surface water and by natural groundwater flow, and pumping of the extraction wells. However, some monitoring wells in the eastern portion of the South Field Extraction (Phase I) Module area continue to have steady or increasing total uranium concentrations. An additional extraction well (33061) was installed in this portion of the plume in 2001 (refer to Figure 3-1) and more new extraction and monitoring wells are planned for this area as part of the South Field Phase II Module. The design for this module will be prepared and transmitted to the EPA and OEPA for review and approval in 2002. After the Phase II design is approved by EPA and OEPA, the new wells will be installed.

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As previously noted in the Selection and Design of the Groundwater Remedy section, the Plant 6 plume appears to have dissipated to concentrations below the uranium FRL and the waste storage area plume interpretation has been revised based on the pre-design characterization completed. These revised interpretations are reflected in the total uranium plume outline on Figure 3-8.

Appendix A, Attachment 2, of this report provides individual monitoring well total uranium results and two total uranium plume maps for 2001. Appendix A, Attachment 3, of this report provides capture zone evaluations based on groundwater flow directions interpreted from groundwater elevation data. It includes quarterly groundwater elevation maps and graphical displays of groundwater elevation data.

Monitoring Results for Non-Uranium Constituents

Although the enhanced groundwater remedy is primarily targeting remediation of the total uranium plume, other FRL constituents (Table 2-2) contained within the total uranium plume are also being monitored.

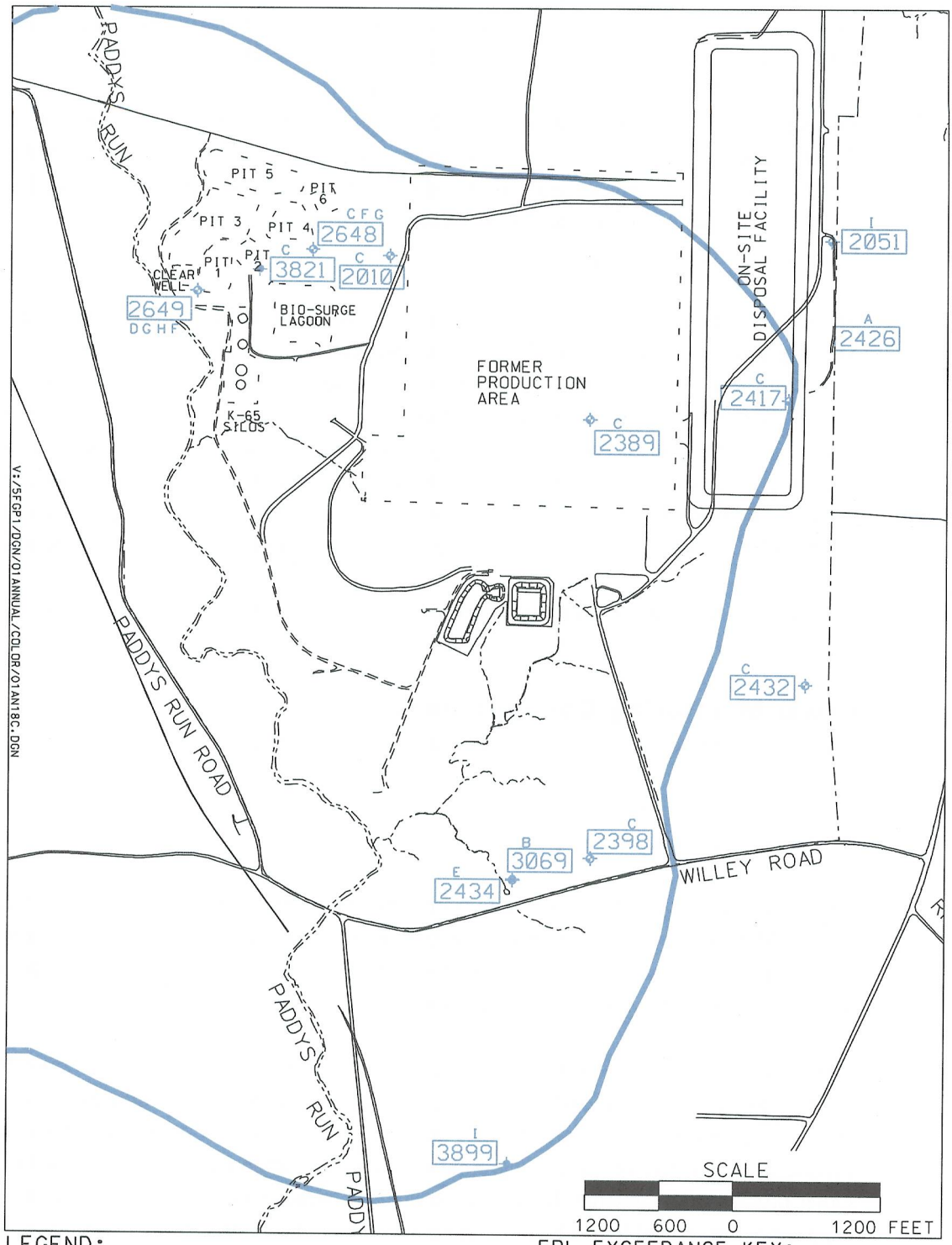
Groundwater monitoring in 2001 included analysis for all of the "<N" groundwater FRL constituents. "<N" constituents are those which have not been detected in the aquifer at concentrations greater than their established FRL and are not considered mobile and persistent (refer to Appendix A.4 for further details). Monitoring of all "<N" constituents occurs once every five years under the current IEMP groundwater sampling program.

Table 3-2 summarizes the results of monitoring for non-uranium constituents above FRL, and Figure 3-9 identifies the locations of the wells that had non-uranium FRL exceedances. Table 3-2 shows the number of wells exceeding the FRL for 2001, the number of wells with 2001 FRL exceedances outside the Baseline Remedial Strategy Report 10-year, uranium-based restoration footprint, and the range of 2001 data above the FRL from wells inside or outside this footprint.

TABLE 3-2
NON-URANIUM CONSTITUENTS WITH
RESULTS ABOVE FINAL REMEDIATION LEVELS DURING 2001

Constituent	Number of Wells Exceeding the FRL	Number of Wells Exceeding the FRL Outside the BRSR[a] 10-Year, Uranium-Based Restoration Footprint	Groundwater FRL	Range of 2001 Data Inside the BRSR[a] 10-Year, Uranium-Based Restoration Footprint above the FRL[b]	Range of 2001 Data Outside the BRSR[a] 10-Year, Uranium-Based Restoration Footprint above the FRL[b]
General Chemistry			(mg/L)	(mg/L)	(mg/L)
Nitrate/Nitrite	2	0	11[c]	12.4 to 74.5	NA
Inorganics					
Antimony	1	1	0.0060	NA	0.0076
Manganese	6	1	0.900	0.919 to 2.04	1.26 to 1.27
Molybdenum	1	0	0.10	0.207	NA
Nickel	1	0	0.10	1.54	NA
Zinc	2	1[d]	0.021	0.0347	0.0227
Volatile Organics			(µg/L)	(µg/L)	(µg/L)
Carbon disulfide	1	0	5.5	6	NA
Trichloroethene	1	0	5.0	58	NA
Radionuclides			(pCi/L)	(pCi/L)	(pCi/L)
Technetium-99	2	0	94	101.08 to 554	NA

[a]Baseline Remedial Strategy Report (DOE 1997a)
[b]NA = not applicable
[c]FRL based on nitrate, from Operable Unit 5 Record of Decision, Table 9-4; however, the sampling results are for nitrate/nitrite.
[d]Additional 2002 data are needed from Monitoring Well 2051 before a determination of persistence can be made.



LEGEND:

- FEMP BOUNDARY
- 10-YEAR, URANIUM-BASED RESTORATION FOOTPRINT
- MONITORING WELL LOCATIONS WITH FRL EXCEEDANCE

FRL EXCEEDANCE KEY:

- A ANTIMONY
- B CARBON DISULFIDE
- C MANGANESE
- D MOLYBDENUM
- E NICKEL
- F NITRATE/NITRITE
- G TECHNETIUM-99
- H TRICHLOROETHENE
- I ZINC

Figure 3-9. Non-Uranium Constituents with 2001 Results Above Final Remediation Levels

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During 2001 non-uranium FRL exceedances were observed at 13 monitoring well locations as shown in Figure 3-9. A total of nine non-uranium FRL constituents exceeded FRLs in 2001. All these exceedances were within the Baseline Remedial Strategy Report 10-year, uranium-based restoration footprint, except for the following: one exceedance each for antimony and zinc at well locations along the eastern property boundary and one exceedance for manganese (refer to Figure 3-9). No plumes for the above-FRL constituents at the locations outside the 10-year, uranium-based restoration 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, uranium-based restoration footprint were further evaluated to determine if they were random events or if they were persistent according to criteria discussed in Appendix A, Attachment 4, of this report. One exceedance (manganese at Monitoring Well 2432) was classified as persistent. The cause of these exceedances is not fully understood at this time. All former exceedances that were classified as persistent have disappeared with subsequent sampling. Also, as footnoted in Table 3-2, one 2001 FRL exceedance (zinc at Monitoring Well 2051) requires additional data to be collected in 2002 before a determination of persistence can be made.

Appendix A, Attachment 4, of this report provides detailed information of non-uranium FRL exceedances and the persistence of these exceedances.

Other Monitoring Commitments

Two other groundwater monitoring activities are included in the IEMP:

- Private Well Monitoring
- 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 below 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 total uranium plume migration (refer to Appendix A, Attachment A.2, Figure A.2-1 for well locations). One of these private wells is where off-property groundwater contamination was initially detected in 1981. Other private wells ceased to be monitored in 1997 because a DOE-sponsored public water supply became available to FEMP neighbors who have been affected by off-property groundwater contamination. The availability of the public water supply resulted in the plugging and abandonment 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 total uranium plume map shown in Figure 3-8.

Property Boundary Monitoring is comprised of 33 monitoring wells located downgradient of the FEMP, along the eastern and southern portions of the property boundary. Twenty-seven Type 2 and 3 wells are monitored quarterly for 27 of the most mobile FRL constituents in order to determine if contaminant excursions at the property boundary are occurring during the remediation process. During 2000, the frequency of monitoring the six property boundary Type 4 wells was decreased to once every five years due to lack of contamination in the aquifer at the depth these wells monitor. Data from the property boundary wells were integrated with other IEMP data for 2001 and were incorporated into the total uranium plume map shown in Figure 3-8. 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 duration of remedial actions.

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 2001. 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.

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Table 3-3 summarizes the groundwater monitoring information associated with the on-site disposal facility. Table 3-3 also summarizes leachate collection system and leak detection system monitoring information. Sampling of the leachate collection system and the leak detection system is generally initiated after waste placement, while groundwater sampling is initiated before waste is placed in a particular cell. Table 3-3 provides information for Cells 1, 2, and 3, along with sample information and range of total uranium concentrations.

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

Cell (Waste Placement Start Date)	Monitoring Location	Monitoring Zone	Data Sampling Started	Total Number of Samples	Range of Total Uranium Concentrations[a] (µg/L)
Cell 1 (December 1997)	22201	Great Miami Aquifer	March 31, 1997	31	ND - 6.384
	22198	Great Miami Aquifer	March 31, 1997	47	0.557 - 8.474
	12338	Glacial Till	October 30, 1997	36	ND - 19
	12338C	Leachate Collection System	February 17, 1998	16	ND - 142.186
	12338D	Leak Detection System	February 18, 1998	15	1.5 - 20.17
Cell 2 (November 1998)	22200	Great Miami Aquifer	June 30, 1997	26	ND - 1.11
	22199	Great Miami Aquifer	June 25, 1997	26	0.259 - 12.1
	12339	Glacial Till	June 29, 1998	35	ND - 3.61
	12339C	Leachate Collection System	November 23, 1998	13	4.51 - 68.6
	12339D	Leak Detection System	December 14, 1998	13	8.69 - 71[b]
Cell 3 (November 1999)	22203	Great Miami Aquifer	August 24, 1998	24	ND - 4.75
	22204	Great Miami Aquifer	August 24, 1998	24	ND - 5.924
	12340	Glacial Till	July 28, 1998	28	ND - 9.23
	12340C	Leachate Collection System	October 13, 1999	10	9.27 - 58.582
	12340D	Leak Detection System	NS[c]		

[a]ND = not detectable
[b]Data not considered reliable (December 14, 1998 through May 23, 2000 data set) due to malfunction in the leachate pipeline and the resultant mixing of individual flows.
[c]NS = not sampled due to lack of water yield

At the end of 2000, baseline groundwater sampling of perched water and the Great Miami Aquifer concluded for Cells 1, 2, and 3. These data are being used to establish the initial groundwater conditions against which future sample results will be compared as part of the leak detection data evaluation process. A data package to initiate establishment of the groundwater baseline conditions for Cells 1, 2, and 3 was prepared in 2001 and submitted to the EPA and OEPA in January 2002 for review. In 2002 the data package will be finalized and a Technical Memorandum establishing baseline groundwater conditions for Cells 1, 2, and 3 will be issued. In 2001 post-baseline groundwater sampling for the first three cells began. Figure 3-10 identifies the on-site disposal facility footprint and monitoring well locations for Cells 1 through 5.

Placement of contaminated soil and debris in Cell 1 concluded at the end of December 2000 (Cell 1 was 100 percent full), and cap material was placed on Cell 1 through November 2001. Soil and debris placement continued in Cells 2 and 3 during 2001. At the end of December 2001, Cell 2 was approximately 67 percent full and Cell 3 was approximately 27 percent full. Based on 2001 leak detection flow monitoring data associated with the on-site disposal facility, the liner systems for Cells 1, 2, and 3, are performing within the specifications outlined in the approved cell design.

In all the samples collected from the horizontal till wells and Great Miami Aquifer wells, none of the constituents analyzed exceeded the groundwater FRLs. For additional information on the groundwater, leak detection and leachate sampling results for the on-site disposal facility, refer to Appendix A, Attachment 5, of this report.

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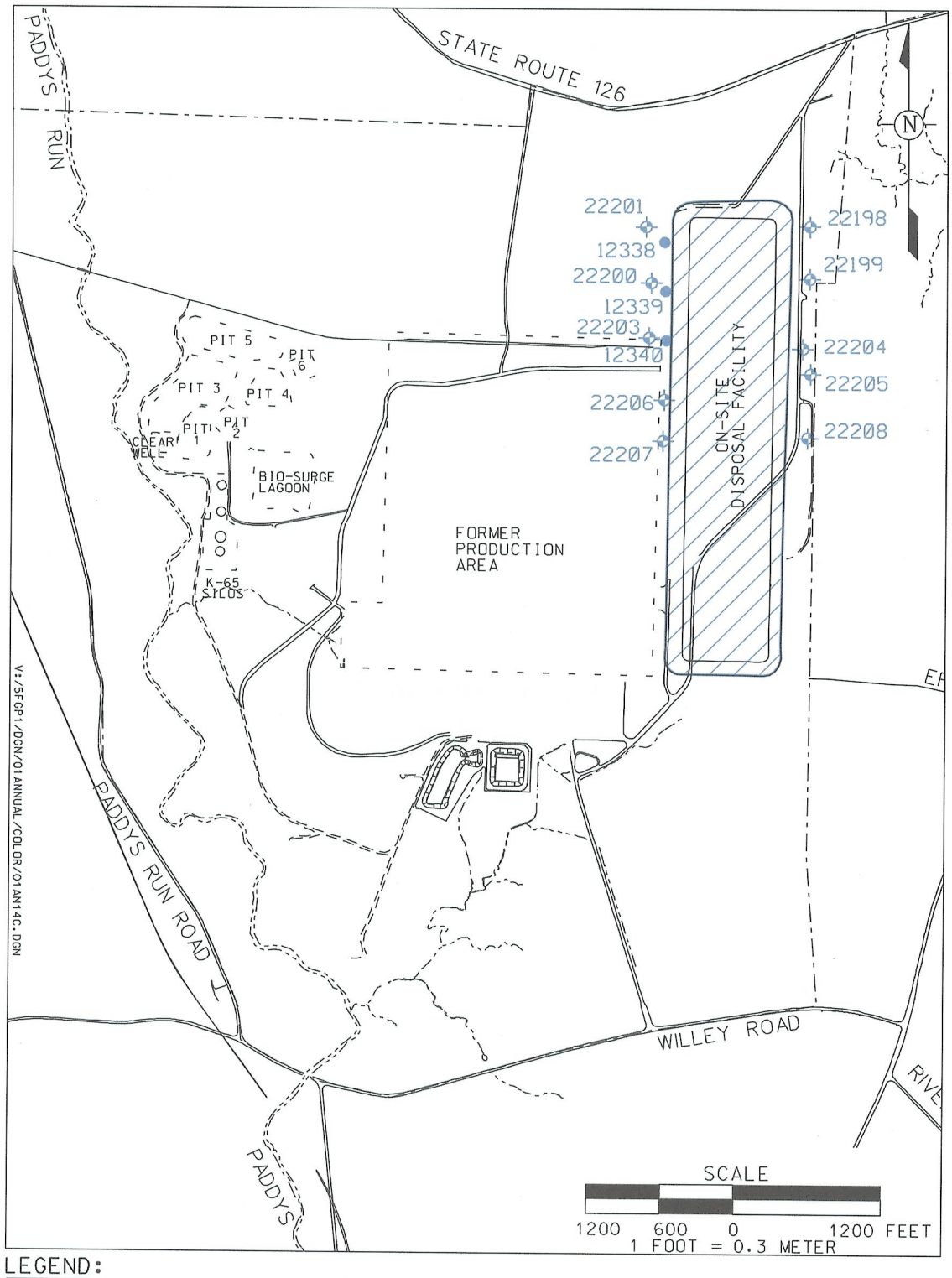

LEGEND:

FEMP BOUNDARY

OSDF MONITORING WELL IN GREAT MIAMI AQUIFER

HORIZONTAL TILL WELL

Figure 3-10. On-Site Disposal Facility Footprint and Monitoring Well Locations

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Chapter 4

Surface Water and Treated Effluent Pathway

Surface Water and Treated Effluent Pathway

Results in Brief: 2001 Treated Effluent and Surface Water Pathway

Surveillance Monitoring - No surface water or treated effluent analytical results from samples collected in 2001 exceeded the surface water FRL for total uranium, the primary site contaminant. FRL exceedances that may be attributable to the FEMP were limited to three constituents and two locations while BTV exceedances that may be attributable to the FEMP were limited to one constituent at one location. Occasional, sporadic FRL and BTV exceedances are to be expected until site remediation is complete.

Uranium Discharges - In 2001, 353 pounds (160 kg) of uranium were discharged in treated effluent to the Great Miami River. Approximately 121 pounds (55 kg) of uranium were released to the environment through uncontrolled storm water runoff. The estimated total pounds of uranium released through the surface water and treated effluent pathway (approximately 474 pounds [215 kg]) increased 21 percent from the 2000 estimate.

An ESD pertaining to the site groundwater remedy was approved by EPA on November 30, 2001. The ESD amended the Operable Unit 5 Record of Decision by adopting the Safe Drinking Water Act Maximum Contaminant Level for uranium (30 μg/L) as both the uranium effluent discharge limit to the Great Miami River and the FRL for groundwater restoration.

Sediment - The 2001 sediment results are within the range of historical concentrations. In addition, there were no FRL exceedances for any sediment result in 2001.

This chapter presents the 2001 monitoring activities and results for surface water, treated effluent, and sediment to determine the effects of remediation activities on the surface water pathway.

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

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

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

Summary of Surface Water and Treated Effluent Pathway

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

- Storm water runoff collected from the former production area, waste pit area and the southern waste unit excavation area (runoff from the southern waste unit area became uncontrolled in January 2002)
- Treated and untreated groundwater from the South Plume and South Field Extraction (Phase I) Aquifer Restoration Modules
- Treated remediation wastewater, such as on-site disposal facility leachate, decontamination rinse water generated during building decontamination and dismantling activities, and wastewater generated from the operation of the Waste Pits Remedial Action Project dryer facility (runoff from on-site disposal facility Cell 1 became uncontrolled in late 2001 with the completion of the Cell 1 cap)
- Treated sanitary wastewater from the sewage treatment plant.

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

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The volume and flow rate of uncontrolled runoff depends on the amount of precipitation within any given period of time. Figure 1-10 in Chapter 1 shows monthly precipitation totals for 2001. Figure 4-1 shows the site's natural drainage features and defines the areas from which runoff is either controlled or uncontrolled. The site's natural surface water drainages include several tributaries to Paddys Run (e.g., Pilot Plant Drainage Ditch, Storm Sewer Outfall Ditch) as well as the northeast drainage that flows to the Great Miami River. The arrows on this figure indicate the general flow direction of uncontrolled runoff that is determined from the topography. Uncontrolled runoff from the FEMP leaves the property via two drainage pathways, Paddys Run and the northeast drainage.

Remediation Activities Affecting Surface Water Pathway

Major remediation activities in 2001 that affected (or had the potential to affect) the surface water pathway included:

- Construction activities associated with the on-site disposal facility including the construction of the Cell 1 cap and excavation, screening, and hauling activities in the on-site disposal facility borrow area
- Waste hauling and placement activities associated with the on-site disposal facility
- Soil excavation activities conducted by the Soil and Disposal Facility Project (refer to Chapter 2)
- Activities associated with the Waste Pits Remedial Action Project including dryer operation, pit excavation and waste material handling, and railcar loading
- Construction activities associated with construction activities for the Accelerated Waste Retrieval, Radon Control System, and Silo 3 Projects.

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

Engineered sediment controls can include the construction of sedimentation basins (lined or unlined), silt fences, check dams, and permanent or temporary seeding. Diversion ditches are also constructed as an engineered control to divert clean water from upgradient areas away from areas of remediation. Ditches are sometimes lined with riprap (large rocks) and/or synthetic liners to control erosion. In areas where remediation activities may expose contaminated materials (e.g., the southern waste units), contaminated runoff is collected in lined basins and routed for treatment at one of the FEMP's wastewater treatment facilities. Administrative controls include limiting the duration of open excavations, as well as routinely inspecting each of the engineered controls used.

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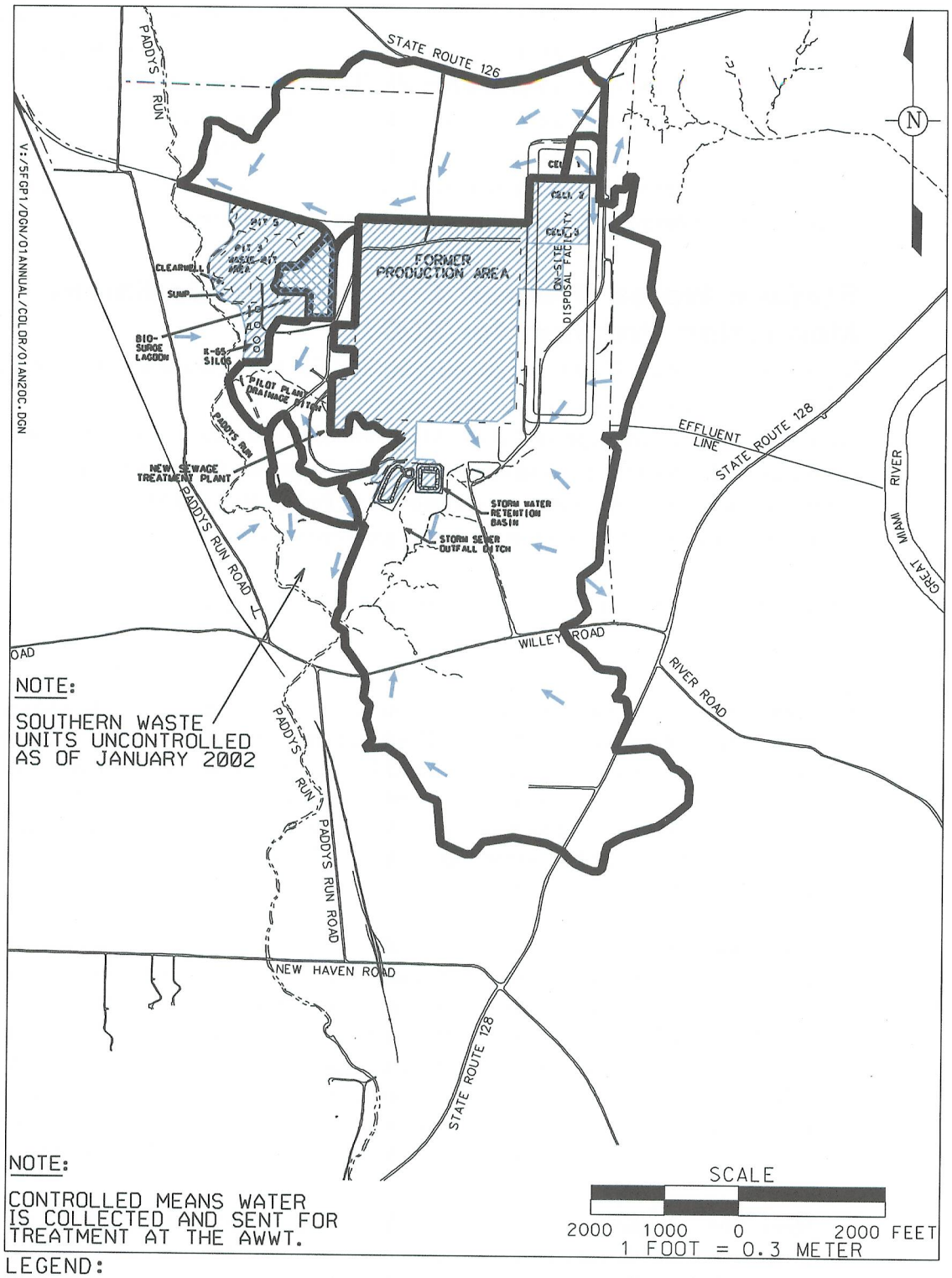

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Figure 4-1. Controlled Surface Water Areas and Uncontrolled Runoff Flow Directions

Each remediation project is responsible for constructing and maintaining the engineered control structures required under their remedial design. All engineered sediment and surface water controls are inspected at least once a week, and within 24 hours of any rain event measuring greater than 0.5 inch (1.3 cm) of rain in a 24-hour period. Discharge points for uncontrolled runoff to Paddys Run are also inspected periodically to assess the effectiveness of upgradient controls in preventing significant impacts to Paddys Run. Minor maintenance activities (e.g., silt fencing repairs, reseeding of eroded areas) were performed in 2001 as a result of these inspections. Though no new storm water controls were installed in 2001, many engineered controls installed during previous years were still used and maintained.

Surface Water, Treated Effluent, and Sediment Monitoring Program for 2001

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

The key elements of the surface water and treated effluent program design are described below:

- **Sampling** - Sample locations, frequency, and constituents were selected to address the requirements of the National Pollution Discharge and Elimination Systems (NPDES) Permit, Federal Facilities Compliance Agreement (FFCA), and Operable Unit 5 Record of Decision, and to provide a comprehensive assessment of surface water quality at 16 key locations including two background locations (refer to Figures 4-2 and 4-3). Surface water is monitored for up to 55 FRL constituents (refer to Table 2-2 in Chapter 2) and three BTV constituents (barium, cadmium, and silver).

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

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

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

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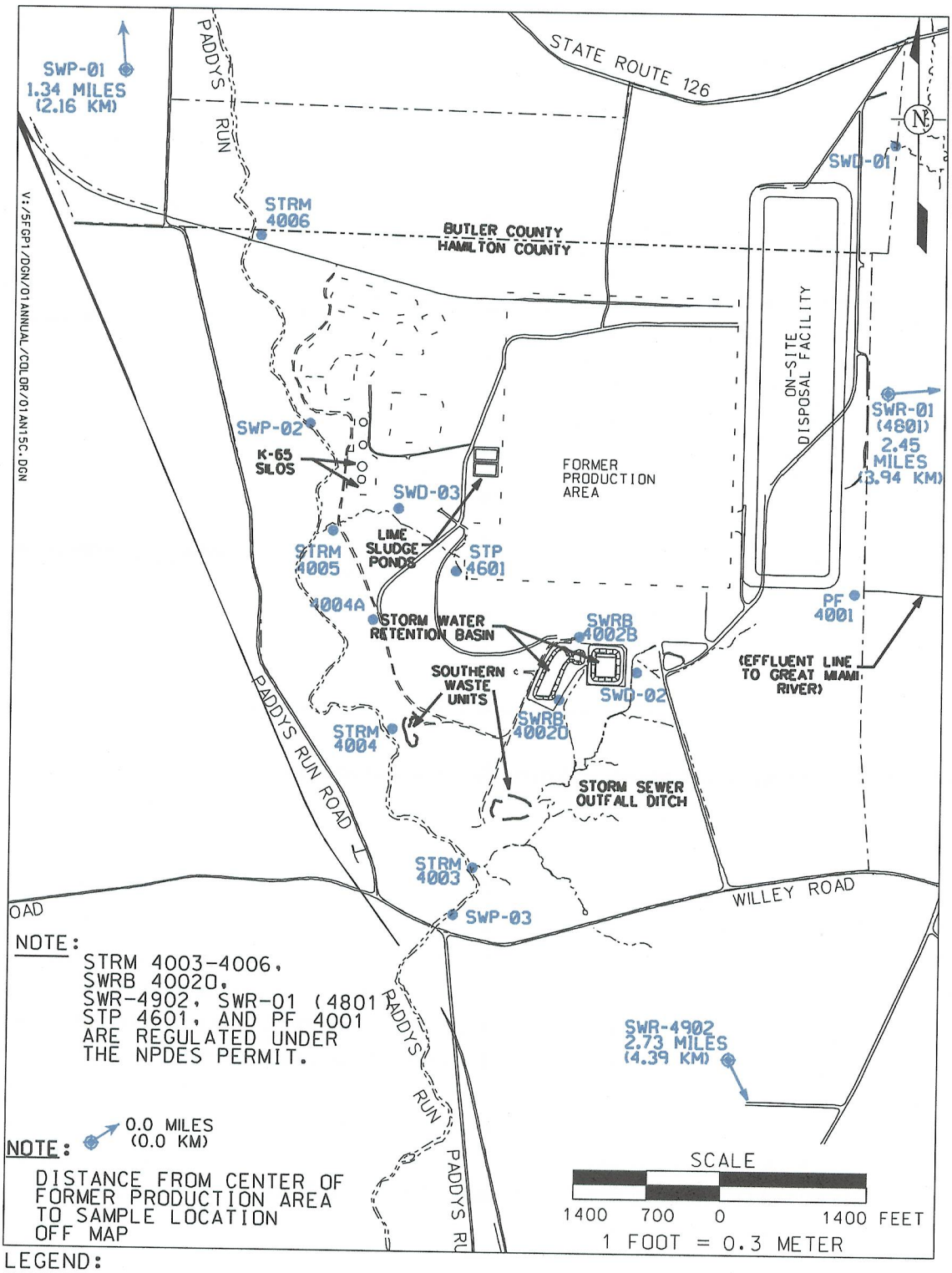

NOTE:
STRM 4003-4006, SWRB 4002D, SWR-4902, SWR-01 (4801 STP 4601, AND PF 4001 ARE REGULATED UNDER THE NPDES PERMIT.

NOTE: 0.0 MILES (0.0 KM)
DISTANCE FROM CENTER OF FORMER PRODUCTION AREA TO SAMPLE LOCATION OFF MAP

LEGEND:
FEMP BOUNDARY
SAMPLE LOCATION

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

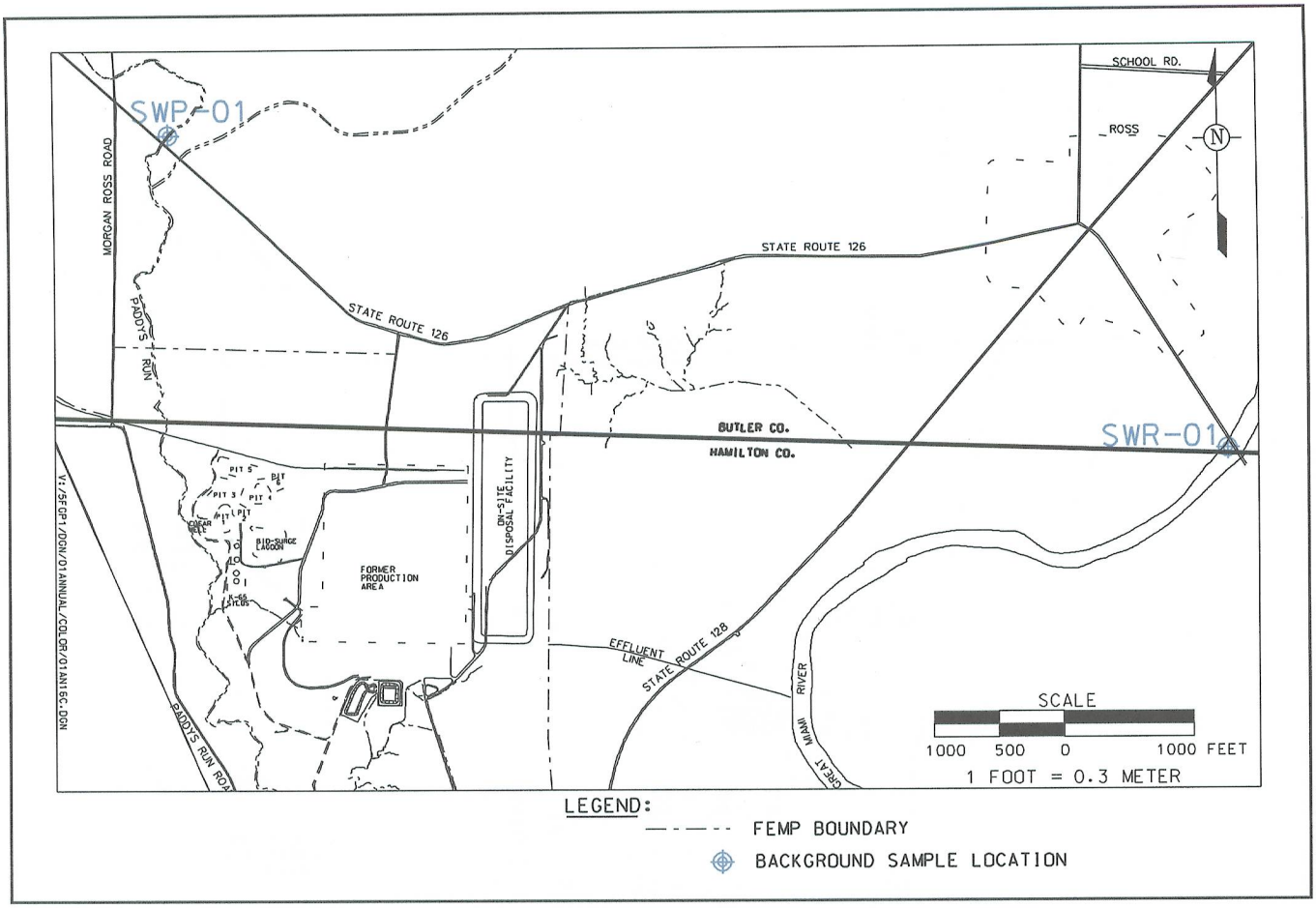

Figure 4-3. IEMP Background Surface Water Sample Locations

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

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

Surveillance Monitoring

Data resulting from 2001 sampling efforts were evaluated to provide surveillance monitoring of remediation activities. This evaluation showed that during 2001, there were no exceedances of the surface water total uranium FRL (530 µg/L) detected in any of the surface water and treated effluent samples. There were four non-uranium constituents with FRL exceedances, and one constituent with a BTV exceedance. Table 4-1 summarizes these exceedances and Figure 4-4 identifies the locations of these exceedances.

There were three FRL exceedances in 2001 at location SWR-01. The FRL exceedances were for chromium, copper, and lead. There was also one BTV exceedance for cadmium at this location. Location SWR-01 is a background monitoring location upstream of the FEMP effluent line on the Great Miami River. Background monitoring locations are situated upstream and outside the influence of FEMP discharges. The background data are used to distinguish impacts from FEMP activities against upstream water quality conditions. Therefore, concentrations at the background locations (Paddys Run [SWP-01] and Great Miami River [SWR-01]) are not attributable to the FEMP.

TABLE 4-1
CONSTITUENTS WITH RESULTS ABOVE SURFACE WATER FRLs OR BTVs DURING 2001

Constituent	Number of Locations Exceeding FRL	Number of Locations Exceeding BTV[a]	Surface Water FRL	Surface Water BTV[a]	Range of 2001 Data above FRL[a]	Range of 2001 Data above BTV[a]
Inorganics			(mg/L)	(mg/L)	(mg/L)	(mg/L)
Cadmium	0	2	0.0098	0.0035	NA	0.0036 to 0.0098[b]
Chromium	1	NA	0.010[c]	NA	0.017	NA
Copper	3	NA	0.012	NA	0.0138 to 0.0337	NA
Lead	2	NA	0.010	NA	0.0104 to 0.0178	NA
Zinc	1	NA	0.11	NA	0.144	NA

[a]NA = not applicable
[b]The cadmium BTV exceedances in the Great Miami River occurred after using the mixing equation (from the Parshall Flume [PF 4001] data); however, this is because the mixing equation uses the background number of 0.0098 mg/L, which is above the associated BTV.
[c]FRL based on hexavalent chromium, from Operable Unit 5 Record of Decision, Table 9-5; however, due to holding time considerations, total chromium is analyzed which is acceptable because total chromium provides a more conservative result.

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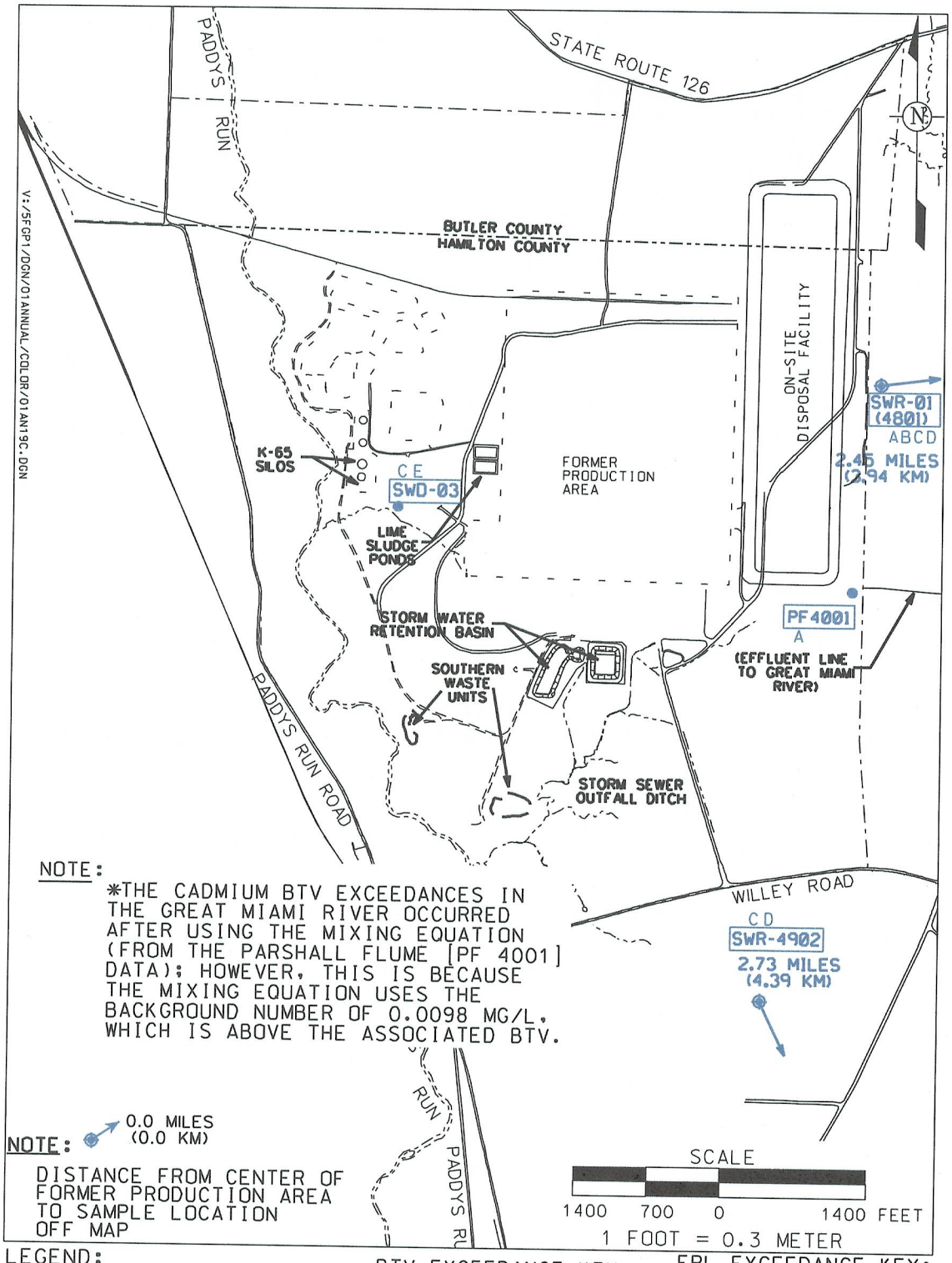

Figure 4-4. Constituents with 2001 Results Above FRLs or BTVs

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The remaining FRL/BTV exceedances which may be attributable to FEMP activities were sporadic in nature and do not indicate any significant impacts to the environment or operational problems with the FEMP's storm water and sediment control systems. There were two FRL exceedances at location SWD-03, one for copper and one for zinc. There were also two FRL exceedances at location SWR-4902, one for copper and one for lead. Finally, there were three exceedances of the cadmium BTV at the Parshall Flume (PF 4001), as discussed later in this chapter.

Even with the FEMP's implementation of storm water and sediment controls, sporadic FRL and BTV exceedances can be expected to occur until final remediation of contaminated source areas (soils and sediments) are complete. A Mann-Kendall statistical test for trend was run for each 2001 FRL exceedance at each location where the exceedance occurred, and no statistically significant trends were identified. The FRL and BTV exceedances will continue to be evaluated for persistence and increasing trends through the IEMP sampling program throughout remediation. This information will be used to provide feedback to the remediation projects on the collective effectiveness of their storm water and sediment controls. Additional details of the FRL and BTV exceedances are presented in Appendix B, Attachment 1, of this report.

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

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

Evaluation of the data from these locations is especially important because it represents points beyond which direct exposure to the public is possible.

There were no FRL/BTV exceedances for any constituent monitored at location SWP-03 during 2001. The maximum total uranium concentration at SWP-03 during 2001 was 5.25 μg/L, which was well below the surface water total uranium FRL of 530 μg/L. Figure 4-5 shows the annual average total uranium concentration in Paddys Run at Willey Road for the period 1985 through 2001. This figure illustrates the decrease of the total uranium concentration in Paddys Run from 1986 following completion of the Storm Water Retention Basin, which collects contaminated storm water from the former production area.

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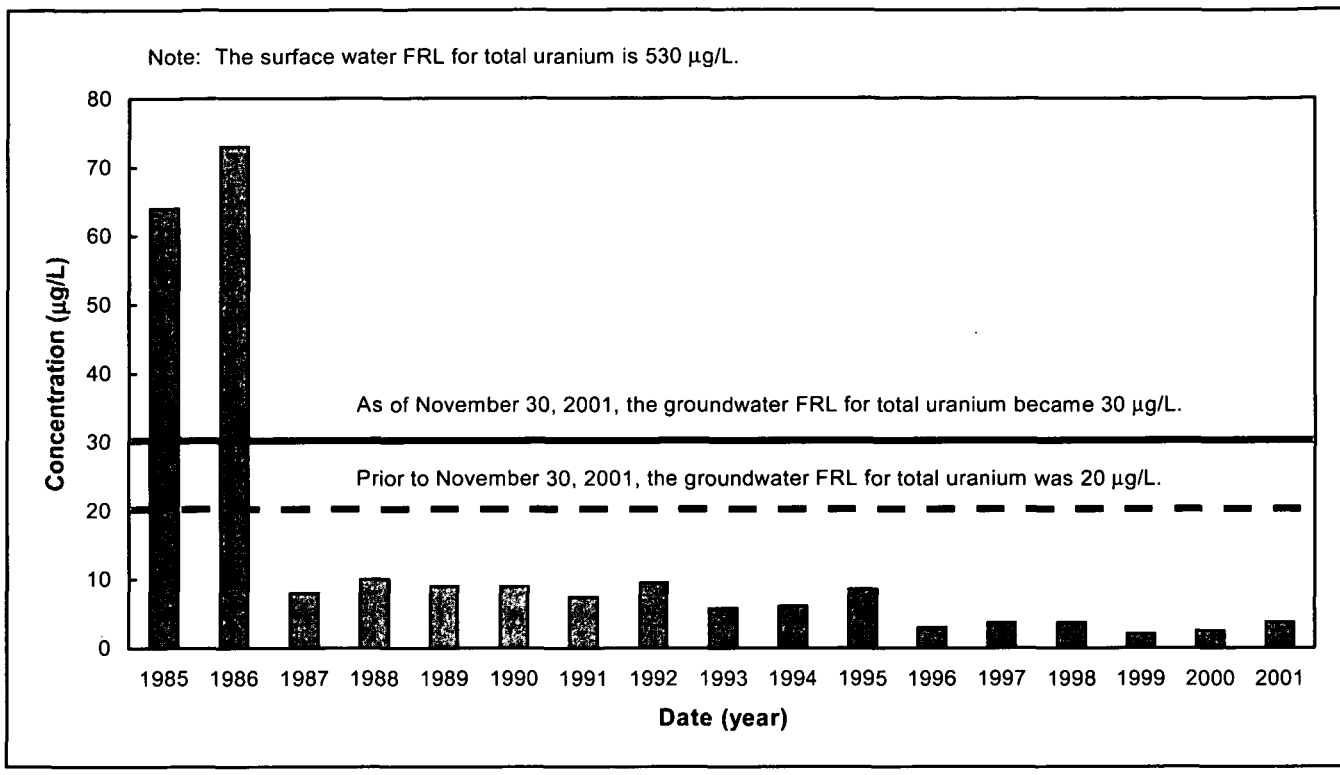

Figure 4-5. Annual Average Total Uranium Concentrations in Paddys Run at Willey Road (SWP-03) Sample Location, 1985 - 2001

Samples collected at the Parshall Flume (PF 4001) are used in the surveillance evaluation because this is the last point where treated effluent is sampled prior to discharge to the Great Miami River. Data collected from this location cannot directly be compared to the surface water FRL without considering the effect of the effluent waters mixing with the Great Miami River. This is done through the use of a mixing equation. After applying the mixing equation, there were no FRL exceedances at the Parshall Flume (PF 4001) but there were three BTV exceedances, all of which were for cadmium, as mentioned above. The FRL for cadmium is based on the background number of 0.0098 mg/L, and the BTV is 0.0035 mg/L, which is lower than the FRL. The cadmium BTV exceedances in the Great Miami River occurred after using the mixing equation (from the Parshall Flume [PF 4001] data); however, this is because the mixing equation uses the background number which is above the associated BTV.

There were no surface water FRL exceedances for uranium in the Great Miami River outside the FEMP mixing zone during 2001. The maximum daily total uranium concentration at the Parshall Flume (PF 4001) prior to discharge through the effluent line to the Great Miami River was 296.9 µg/L. After the water from the Parshall Flume (PF 4001) mixed with the water in the Great Miami River, the concentration would have been approximately 5.15 µg/L. Both concentrations, those from the Parshall Flume (PF 4001) and after mixing with the Great Miami River, were well below the surface water total uranium FRL of 530 µg/L. Contaminant concentrations observed at the Parshall Flume (PF 4001) in 2001 are further discussed in the compliance monitoring section.

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

During 2001, three of the five surface water locations evaluated (STRM 4005, SWD-02, and SWD-03) had results that exceeded the total uranium groundwater FRL of 30 µg/L. Table 4-2 summarizes the total uranium cross-media exceedances. Of the locations evaluated, only SWD-03 had a result that exceeded the groundwater FRL for a constituent other than uranium. The SWD-03 zinc result of 0.144 mg/L exceeded the respective groundwater FRL of 0.021 mg/L.

TABLE 4-2
SURFACE WATER TOTAL URANIUM RESULTS EXCEEDING THE GROUNDWATER FRL AT CROSS-MEDIA IMPACT LOCATIONS DURING 2001

Location	Number of Surface Water Results Exceeding the Groundwater FRL for Total Uranium[a]	Total Number of Samples	Range of 2001 Data above FRL (µg/L)
STRM4005	4	4	57.3 - 127.618
SWD-02	2	13	34.294 - 43.87
SWD-03	11	15	34.6 - 125.707

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

Both surface water and groundwater data from monitoring wells will continue to be collected at these sensitive areas under the IEMP to address the cross-media concern. Additional details concerning the cross-media impacts are presented in Appendix B, Attachment 1, of this report.

Compliance Monitoring

FFCA and Operable Unit 5 Record of Decision Compliance

The FEMP is required to monitor treated effluent discharges at the Parshall Flume (PF 4001) for total uranium mass discharges and total uranium concentrations. These requirements are identified in the July 1986 FFCA and the Operable Unit 5 Record of Decision. The Operable Unit 5 Record of Decision requires treatment of effluent so that the mass of total uranium discharged to the Great Miami River through the Parshall Flume (PF 4001) does not exceed 600 pounds (272 kg) per year. The Operable Unit 5 Record of Decision also required that the monthly average total uranium concentration in the effluent must be at or below 20 µg/L. This 20 µg/L concentration limit became effective January 1, 1998; however, on November 30, 2001, it was revised to 30 µg/L as a result of EPA's approval of the ESD. This ESD maintains the mass limit of 600 pounds per year.

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The Operable Unit 5 Record of Decision allows the FEMP to discharge water from the Storm Water Retention Basin directly to the Great Miami River during periods of heavy precipitation. This is allowed in order to reduce the possibility of an overflow condition for the Storm Water Retention Basin. An overflow condition has the potential to generate cross-media impacts as described above. To comply with the monthly average total uranium concentration limit during these types of bypasses, the FEMP is allowed to deduct the uranium concentration from the total uranium monthly average at the Parshall Flume (PF 4001) calculation for up to 10 significant precipitation bypass days per year. However, the mass of total uranium discharged during these 10 days per year is still considered in the total discharge mass to ensure the 600 pound (272 kg) per year discharge limit is not exceeded.

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

During 2001 there were two bypasses as a result of significant precipitation, and one bypass event for maintenance activities that were required. Table 4-3 summarizes these Storm Water Retention Basin treatment bypass events during 2001. Figure 4-6 shows that the cumulative mass of total uranium discharged to the Great Miami River during 2001 was 353 pounds (160 kg), which is below the 600 pound (272 kg) annual discharge limit. Figure 4-7 shows that the total uranium monthly average concentration limit was met every month during 2001 with the exception of April 2001. An upset in one of the clarifiers at Phase II of the advanced wastewater treatment facility resulted in an elevated total uranium concentration on April 25, 2001 resulting in a monthly average concentration of 24.3 µg/L.

Appendix B, Attachment 1, of this report provides more detail on the bypass days deleted from the monthly average calculation to determine compliance with the monthly average total uranium concentration limit.

TABLE 4-3
2001 SIGNIFICANT PRECIPITATION AND TREATMENT PLANT MAINTENANCE BYPASS EVENTS

Event	Duration (hours)	Number of Bypass Days[a]	Cumulative Number of Bypass Days	Total Uranium Discharged (pounds)	Total Water Discharged (millions of gallons)
Significant Precipitation Bypasses				**(to Great Miami River)**	**(to Great Miami River)**
October 24 through October 26	47.75	2	2	14.48	2.867
December 17 through December 19	41	1	3	12.47	2.258
Treatment Plant Maintenance Bypasses [b]					
November 4 through November 7	96	4	4	2.77	12.264

[a]Days are counted according to the definition provided in the Operations and Maintenance Master Plan for the Aquifer Restoration and Wastewater Treatment Project.
[b]Typically during planned maintenance outages, pumping and treatment systems are taken off-line in stages and returned to service in stages. There were portions of all four days where pumping and/or treatment systems were off-line due to maintenance. Therefore, information is provided for these four days in total.

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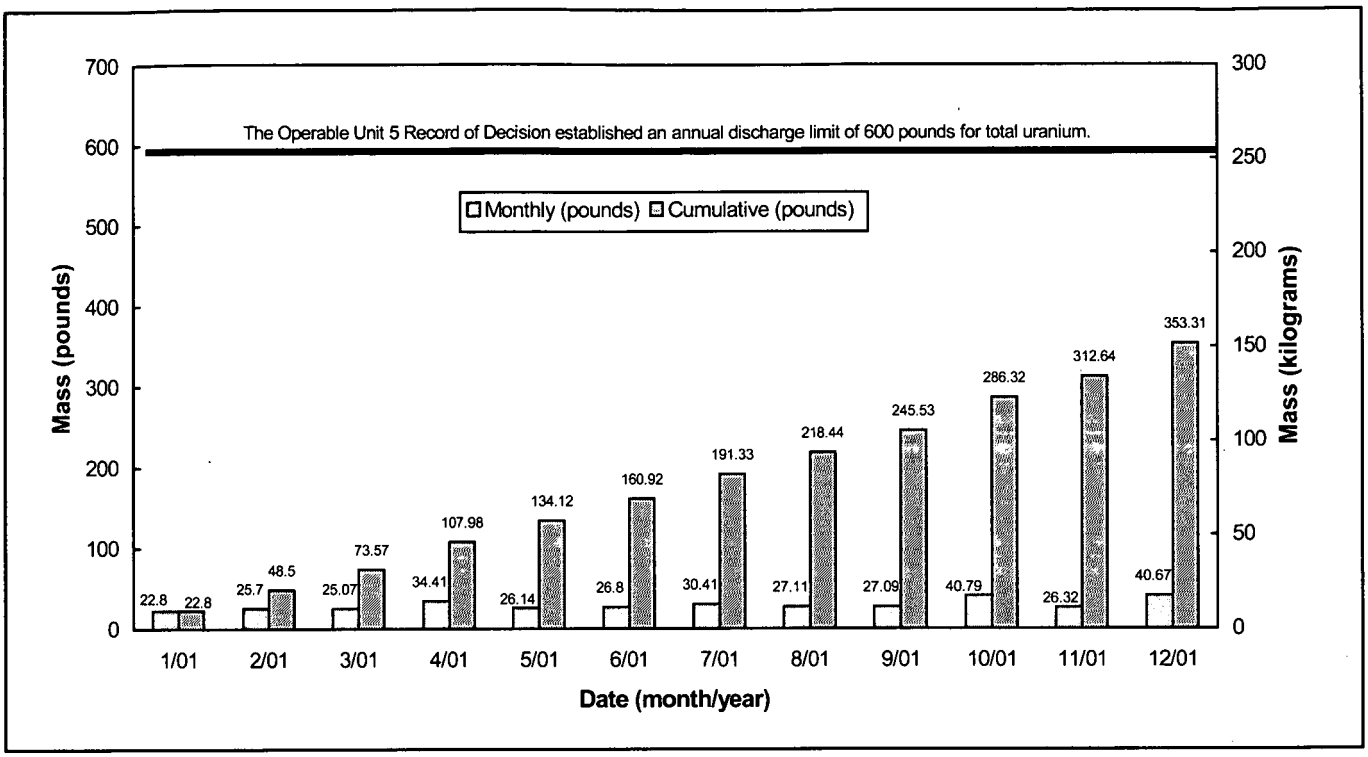
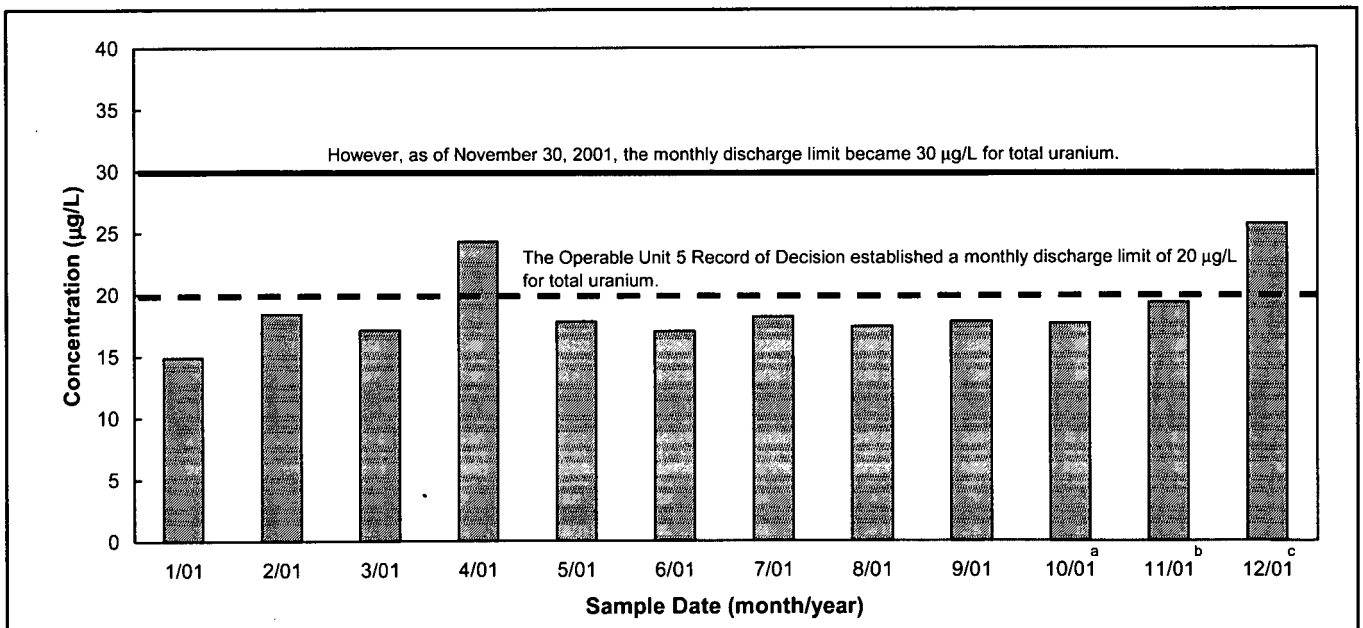


Figure 4-6. Pounds of Uranium Discharged to the Great Miami River from the Parshall Flume (PF 4001) in 2001



[a]Actual concentration was 30.7 µg/L. Eliminating 1 "significant precipitation" bypass day reduces average to 25.7 µg/L.
[b]Actual concentration was 20.0 µg/L. Eliminating 3 "treatment plant maintenance" bypass days reduces average to 19.3 µg/L.
[c]Actual concentration was 30.7 µg/L. Eliminating 1 "significant precipitation" bypass day reduces average to 25.7 µg/L.

Figure 4-7. 2001 Monthly Average Total Uranium Concentration in Water Discharged from the Parshall Flume (PF 4001) to the Great Miami River

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NPDES Permit Compliance

Compliance sampling, consisting of sampling for non-radiological pollutants from uncontrolled runoff and treated effluent discharges from the FEMP, is regulated under the state-administrated NPDES program. The current permit became effective on March 1, 2000, and expires on October 31, 2002. The permit specifies discharge and sample requirements, as well as discharge limits for several constituents. Figure 4-2 identifies NPDES sample locations.

During 2001, wastewater and uncontrolled runoff discharges from the FEMP were in compliance with the NPDES Permit requirements in well over 99 percent of the samples collected. A total of 19 noncompliances were reported to OEPA pursuant to the terms of the NPDES Permit, as summarized in Table 4-4.

TABLE 4-4

EXCEEDANCES OF THE FEMP NPDES PERMIT DURING 2001

Date/ Month	Location	Parameter	Permit Limit	Actual Result	Possible Cause	Corrective Action
4/25	PF 4001 (Parshall Flume-Treated Effluent)	Total Suspended Solids	20 mg/L	40.8 mg/L	AWWT Phase II Clarifier upset	Installation of turbidity meters for earliest possible warning
4/25	PF 4001 (Parshall Flume-Treated Effluent)	Total Suspended Solids	473 kg/d	828.4 kg/d	AWWT Phase II Clarifier upset	Installation of turbidity meters for earliest possible warning
5/21	STP 4601 (Sewage Treatment Plant Effluent)	Total Suspended Solids	40 mg/L	77.0 mg/L	Excessive infiltration or fluctuating temperatures	None. Continue to monitor and observe
5/21	STP 4601 (Sewage Treatment Plant Effluent)	Total Suspended Solids	24.2 kg/d	25.36 kg/d	Excessive infiltration or fluctuating temperatures	None. Continue to monitor and observe
5/28	STP 4601 (Sewage Treatment Plant Effluent)	Total Suspended Solids	40 mg/L	60.0 mg/L	Excessive infiltration or fluctuating temperatures	None. Continue to monitor and observe
May	STP 4601 (Sewage Treatment Plant Effluent)	Total Suspended Solids (monthly average)	20 mg/L	29.11 mg/L	Excessive infiltration or fluctuating temperatures	None. Continue to monitor and observe
6/18	PF 4001 (Parshall Flume-Treated Effluent)	Oil and Grease	105 kg/d	135.7 kg/d	Unknown	None. Continue to monitor and observe
6/22	PF 4001 (Parshall Flume-Treated Effluent)	Oil and Grease	105 kg/d	193.2 kg/d	Unknown	None. Continue to monitor and observe
11/25	PF 4001 (Parshall Flume-Treated Effluent)	Oil and Grease	10 mg/L	41.14 mg/L	Unknown	None. Continue to monitor and observe
11/25	PF 4001 (Parshall Flume-Treated Effluent)	Oil and Grease	105 kg/d	771.8 kg/d	Unknown	None. Continue to monitor and observe
11/28	PF 4001 (Parshall Flume-Treated Effluent)	Oil and Grease	10 mg/L	137 mg/L	Unknown	None. Continue to monitor and observe
11/28	PF 4001 (Parshall Flume-Treated Effluent)	Oil and Grease	105 kg/d	2863.2 kg/d	Unknown	None. Continue to monitor and observe
Nov.	PF 4001 (Parshall Flume-Treated Effluent)	Oil and Grease (monthly average)	10 mg/L	25.0 mg/L	Unknown	None. Continue to monitor and observe
Nov.	PF 4001 (Parshall Flume-Treated Effluent)	Oil and Grease (monthly average)	105 kg/d	537.1 kg/d	Unknown	None. Continue to monitor and observe
Nov.	STP 4601 (Sewage Treatment Plant Effluent)	Total Suspended Solids (monthly average)	20 mg/L	23.4 mg/L	Excessive infiltration or fluctuating temperatures	None. Continue to monitor and observe
12/14	PF 4001 (Parshall Flume-Treated Effluent)	CBOD	14 mg/L	26.3 mg/L	Unknown	None. Continue to monitor and observe
12/14	PF 4001 (Parshall Flume-Treated Effluent)	CBOD	315 kg/d	447 kg/d	Unknown	None. Continue to monitor and observe
12/17	STP 4601 (Sewage Treatment Plant Effluent)	Total Suspended Solids	40 mg/L	50.4 mg/L	Excessive infiltration or fluctuating temperatures	None. Continue to monitor and observe
Dec.	STP 4601 (Sewage Treatment Plant Effluent)	Total Suspended Solids (monthly average)	20 mg/L	26.8 mg/L	Excessive infiltration or fluctuating temperatures	None. Continue to monitor and observe

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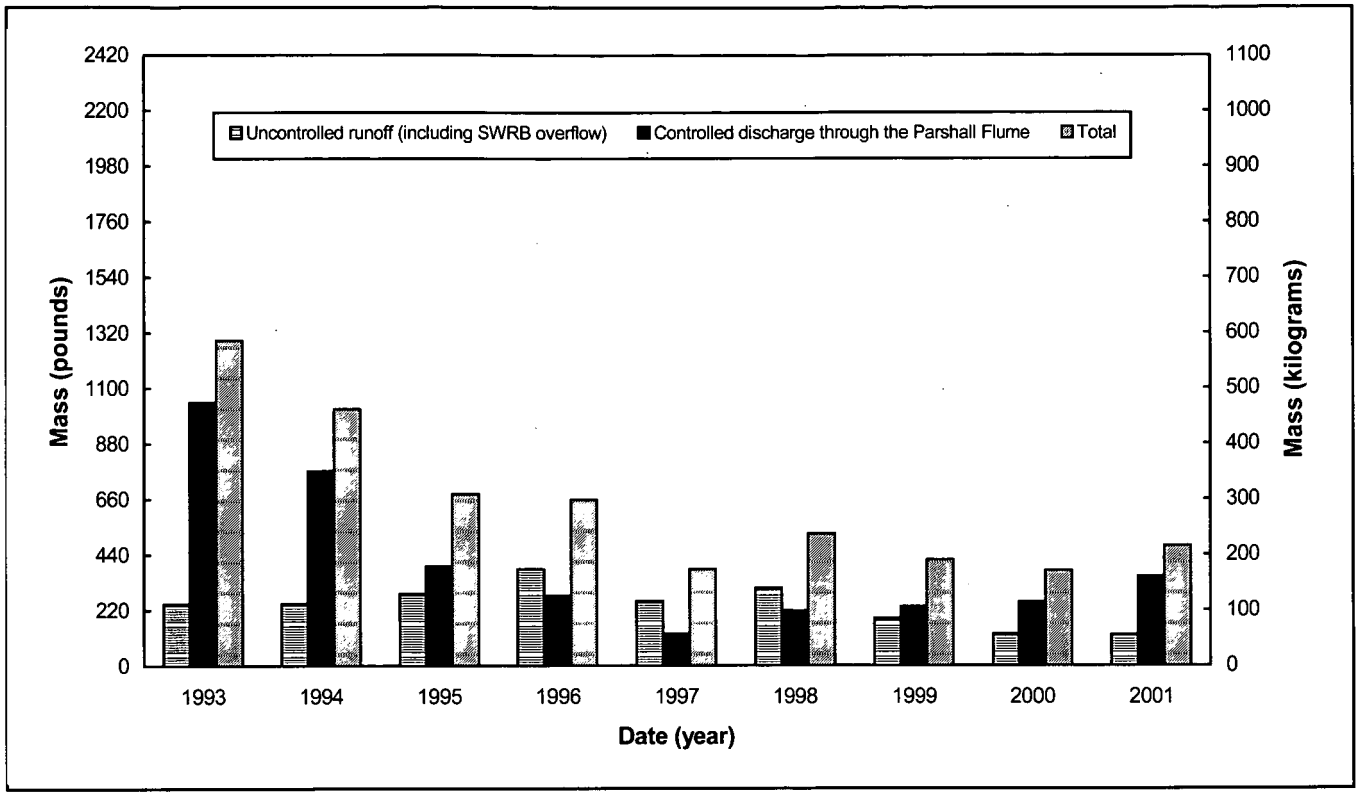

Figure 4-8. Uranium Discharged from the FEMP Via the Surface Water Pathway, 1993 - 2001

Uranium Discharges in Surface Water and Treated Effluent

As identified in Figure 4-6, 353 pounds (160 kg) of uranium in treated effluent were discharged to the Great Miami River through the Parshall Flume (PF 4001) in 2001. 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 2001.

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 surface water control system and source removal, and excavation and placement of contaminated soils into the on-site disposal facility.

During 2001, 46.55 inches (118.2 cm) of precipitation fell at the FEMP; therefore, an estimated 121 pounds (55 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 474 pounds (215 kg).

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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 2001 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 (north and south of the outfall ditch), and from the Paddys Run background location were also analyzed for radium-226, radium-228, thorium-228, thorium-230, and thorium-232.

Figure 4-9 illustrates specific sample locations that are summarized below:

- **Storm Sewer Outfall Ditch**: five samples collected along the Storm Sewer Outfall Ditch from its confluence with Paddys Run to immediately south of the Storm Water Retention Basin (D1 through D5)

- **Paddys Run**: five samples collected upstream (north) of the confluence with the Storm Sewer Outfall Ditch (PN1 through PN5), three samples collected down stream (south) of the confluence (PS1 through PS3), and one background sample collected upgradient (north) of the site (P1)

- **Great Miami River**: one sample collected north of the effluent line (background location, G2) and one sample collected south of the effluent line (G4).

Table 4-5 presents analytical results of samples collected from the Storm Sewer Outfall Ditch, Paddys Run, and the Great Miami River in 2001. All results for all constituents were below the respective sediment FRL, and consitent with data collected in previous years.

Monitoring of sediment will continue under the IEMP to determine the effectiveness of the engineered controls designed to reduce erosion from the FEMP and sedimentation of Paddys Run and its tributaries. Appendix B, Attachment 2, of this report contains additional details of the sediment monitoring results.

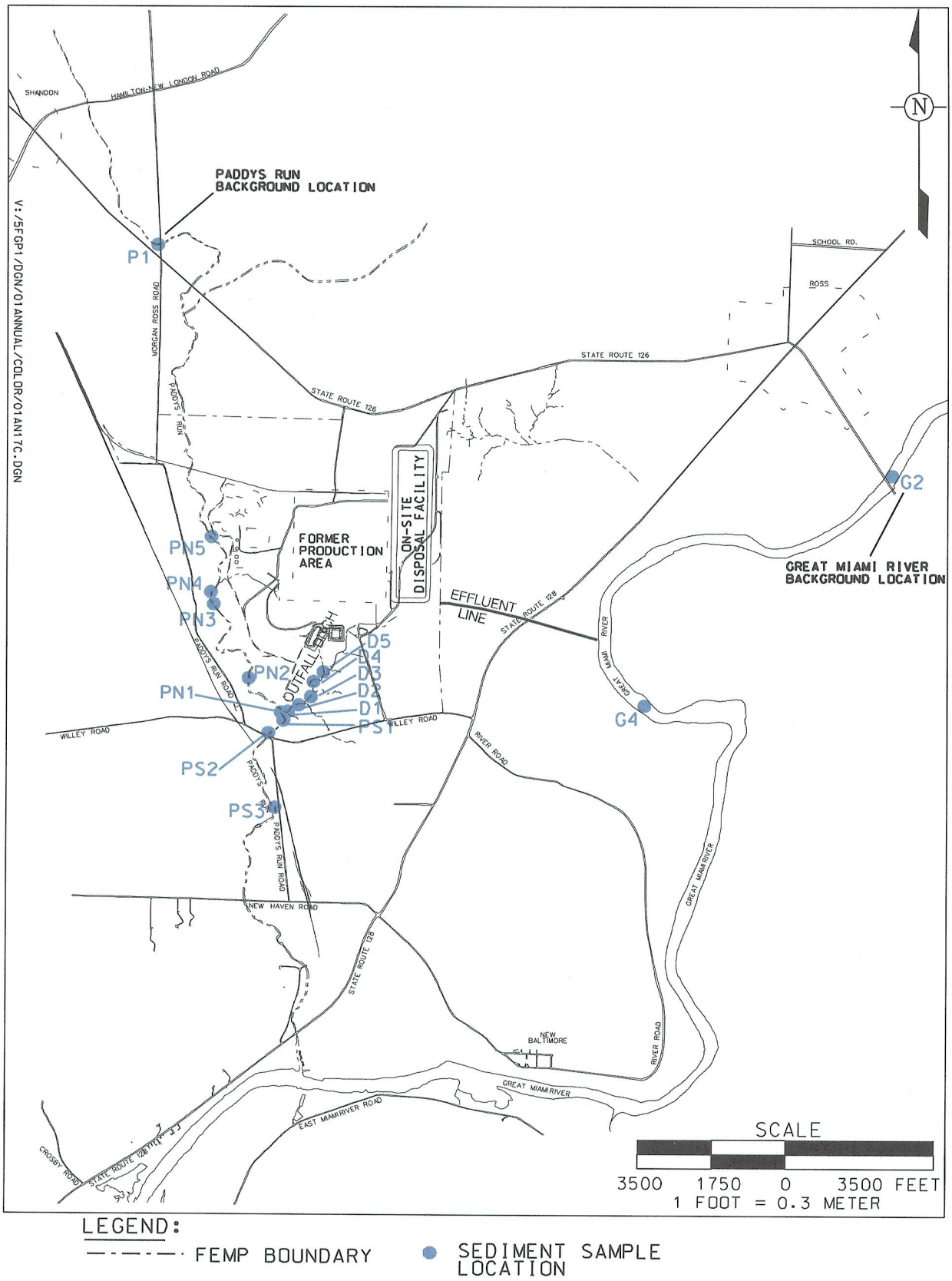

Figure 4-9. 2001 Sediment Sample Locations

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TABLE 4-5
2001 SUMMARY STATISTICS FOR SEDIMENT MONITORING PROGRAM

			2001 Results - Concentration (dry weight)					
			Minimum[a,b,c,d]		Maximum[a,b,c]		Average[a,b,c,d]	
Radionuclide	Sediment FRL	No. of Samples[a]	pCi/g	mg/kg	pCi/g	mg/kg	pCi/g	mg/kg
Great Miami River, North of the Effluent Line (G2)								
Total Uranium	210 mg/kg	1	1.268	1.876	NA	NA	NA	NA
Great Miami River, South of the Effluent Line (G4)								
Total Uranium	210 mg/kg	1	1.720	2.546	NA	NA	NA	NA
Paddys Run Background, North of S.R. 126 (P1)								
Radium-226	2.9 pCi/g	1	0.556	NA	NA	NA	NA	NA
Radium-228	4.8 pCi/g	1	0.373	NA	NA	NA	NA	NA
Thorium-228	3.2 pCi/g	1	0.370	NA	NA	NA	NA	NA
Thorium-230	18,000 pCi/g	1	0.614	NA	NA	NA	NA	NA
Thorium-232	1.6 pCi/g	1	0.346	NA	NA	NA	NA	NA
Total Uranium	210 mg/kg	1	0.898	1.329	NA	NA	NA	NA
Paddys Run, North of the Storm Sewer Outfall Ditch (PN1-PN5)								
Radium-226	2.9 pCi/g	5	0.425	NA	0.739	NA	0.593	NA
Radium-228	4.8 pCi/g	5	0.279	NA	0.581	NA	0.462	NA
Thorium-228	3.2 pCi/g	5	0.240	NA	0.775	NA	0.505	NA
Thorium-230	18,000 pCi/g	5	0.577	NA	1.18	NA	0.782	NA
Thorium-232	1.6 pCi/g	5	0.219	NA	0.758	NA	0.446	NA
Total Uranium	210 mg/kg	5	0.932	1.380	1.374	2.034	1.200	1.776
Storm Sewer Outfall Ditch (D1-D5)								
Radium-226	2.9 pCi/g	5	0.553	NA	0.925	NA	0.732	NA
Radium-228	4.8 pCi/g	5	0.463	NA	0.816	NA	0.696	NA
Thorium-228	3.2 pCi/g	5	0.406	NA	1.170	NA	0.715	NA
Thorium-230	18,000 pCi/g	5	0.687	NA	1.410	NA	1.088	NA
Thorium-232	1.6 pCi/g	5	0.425	NA	0.889	NA	0.587	NA
Total Uranium	210 mg/kg	5	1.897	2.807	6.498	9.617	3.775	5.587
Paddys Run, South of the Storm Sewer Outfall Ditch (PS1-PS3)								
Radium-226	2.9 pCi/g	1	0.629	NA	NA	NA	NA	NA
Radium-228	4.8 pCi/g	1	0.576	NA	NA	NA	NA	NA
Thorium-228	3.2 pCi/g	1	0.507	NA	NA	NA	NA	NA
Thorium-230	18,000 pCi/g	1	0.689	NA	NA	NA	NA	NA
Thorium-232	1.6 pCi/g	1	0.416	NA	NA	NA	NA	NA
Total Uranium	210 mg/kg	3	1.661	2.458	2.947	4.361	2.309	3.417

[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, maximum, and average).
[b]If the number of samples is greater than or equal to three, then the minimum, maximum, and average 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 in the summary statistics is set at half the detection limit.

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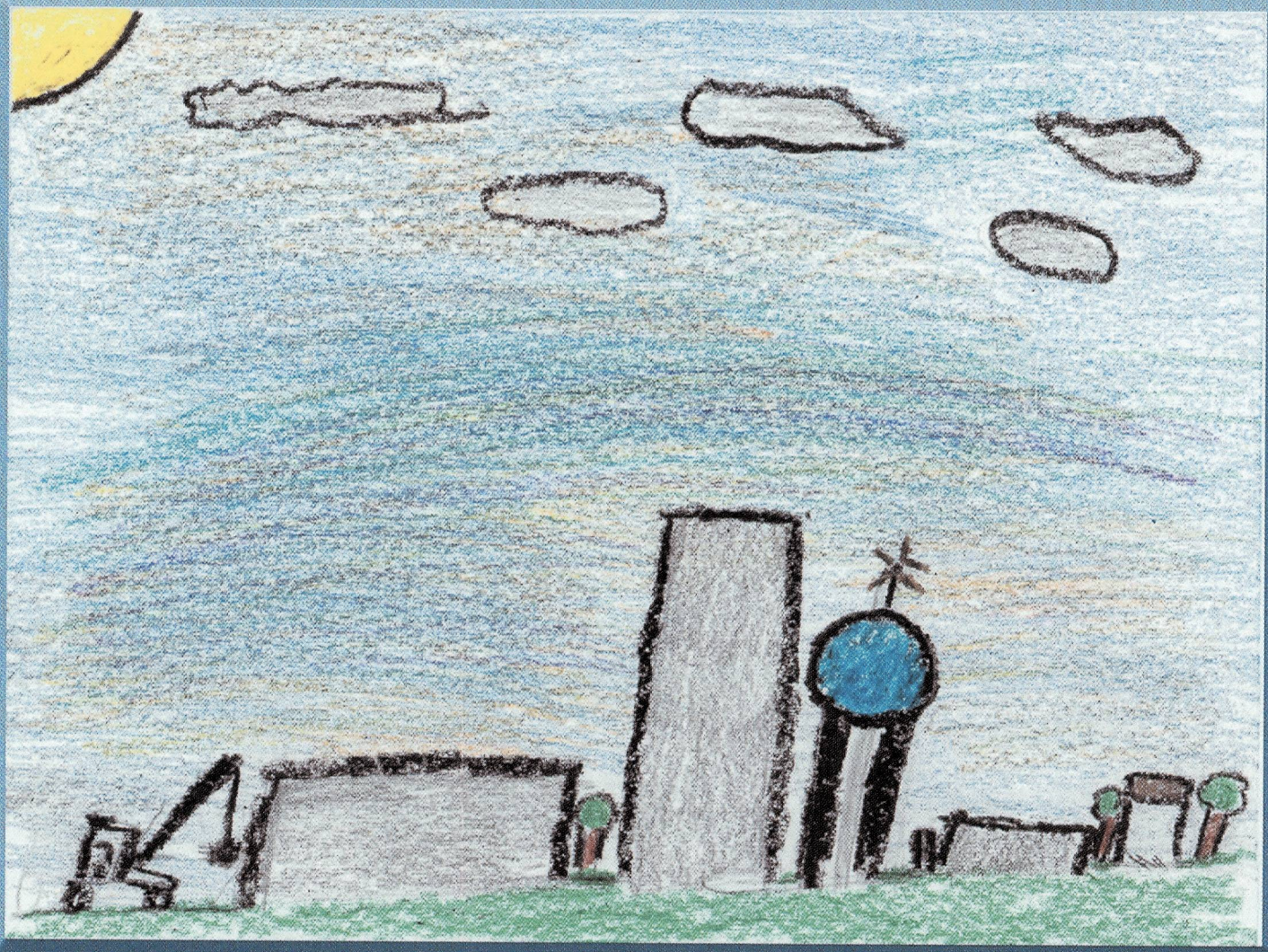
Chapter 5
Air Pathway



Air Pathway

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

Results in Brief: 2001 Air Pathway

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

Radon - There were no exceedances of the DOE standard (3 pCi/L annual average above background) at the FEMP fenceline and off-property locations. The maximum annual average concentration at the FEMP fenceline measured by continuous radon monitors was 0.2 pCi/L above background.

Direct Radiation - Direct radiation measurements increased slightly at the FEMP fenceline and the K-65 Silos boundary when compared to 2000. However, the K-65 Silos boundary levels are still approximately 49 percent lower than the radiation levels measured in 1991 prior to the addition of the bentonite layer within the K-65 Silos. These measurements are consistent with the fact that the K-65 Silos contain radium and its decay products, which contribute to direct radiation levels.

Boiler Plant - There were no opacity excursions reported during 2001.

As discussed in Chapter 1, the public may be exposed to radiation from the FEMP through the air pathway. This pathway includes emissions from specific point sources, such as plant stacks, as well as fugitive dust from soil excavations and other remediation activities. When production operations were suspended in July 1989, the major point source emissions from the FEMP were eliminated. Since then, the principal sources of airborne emissions have been fugitive dust from environmental remediation activities, laboratory fume hoods, which contain low levels of uranium, and wind blown fugitive dust.

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

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

Remediation Activities Affecting the Air Pathway

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

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The following primary emission sources were active during 2001:

- Decontamination and Dismantlement Project activities, most notably Plants 5 and 6 (Operable Unit 3)
- Excavation of the waste pits and the associated waste processing and rail car load-out operations at the Waste Pits Remedial Action Project (Operable Unit 1)
- Excavation of contaminated soil and debris (Operable Units 2 and 5)
- Construction activities associated with the on-site disposal facility including excavation, screening, and hauling activities in the on-site disposal facility borrow area (Operable Unit 2)
- Transportation and placement of contaminated material in the on-site disposal facility and interim storage at the on site material transfer area (Operable Unit 2).

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

- Administrative Controls - typical administrative controls include management and control procedures, record keeping, periodic assessments, and establishing speed limits, control zones, and construction zones.
- Engineered Controls - typical engineered controls include physical barriers, wetting agents, filtration, fixatives, sealants, dust suppressants and control, collection, and treatment systems. Engineered designs help reduce point source and fugitive emissions by using the best available technology. The selection of the best available technology for controlling project emissions is conducted during the design process and frequently includes the evaluation of several treatment alternatives.

Air Monitoring Program Summary for 2001

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

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

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

- **Sampling** - Sample locations, frequency, and the constituents were selected to address DOE and EPA requirements for assessing radiological emissions from the site. Key considerations in the design of the sampling program included prevailing wind directions, location of potential sources of emissions, and the location of off-property receptors. The IEMP program includes monitoring radiological air particulates at 19 locations, radon measurements at 34 locations, and direct radiation at 32 locations on and off the FEMP property.

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

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

Radiological Air Particulate Sampling Results

As described in the IEMP, the FEMP utilizes a network of 19 high-volume air particulate monitoring stations to measure the collective contributions from all fugitive and point source particulate emissions from the site. This monitoring network includes 16 monitoring locations on the FEMP fenceline and two background locations. In addition, one thorium monitor was operated on the western FEMP fenceline. Figure 5-1 provides the locations of the IEMP air monitoring stations.

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

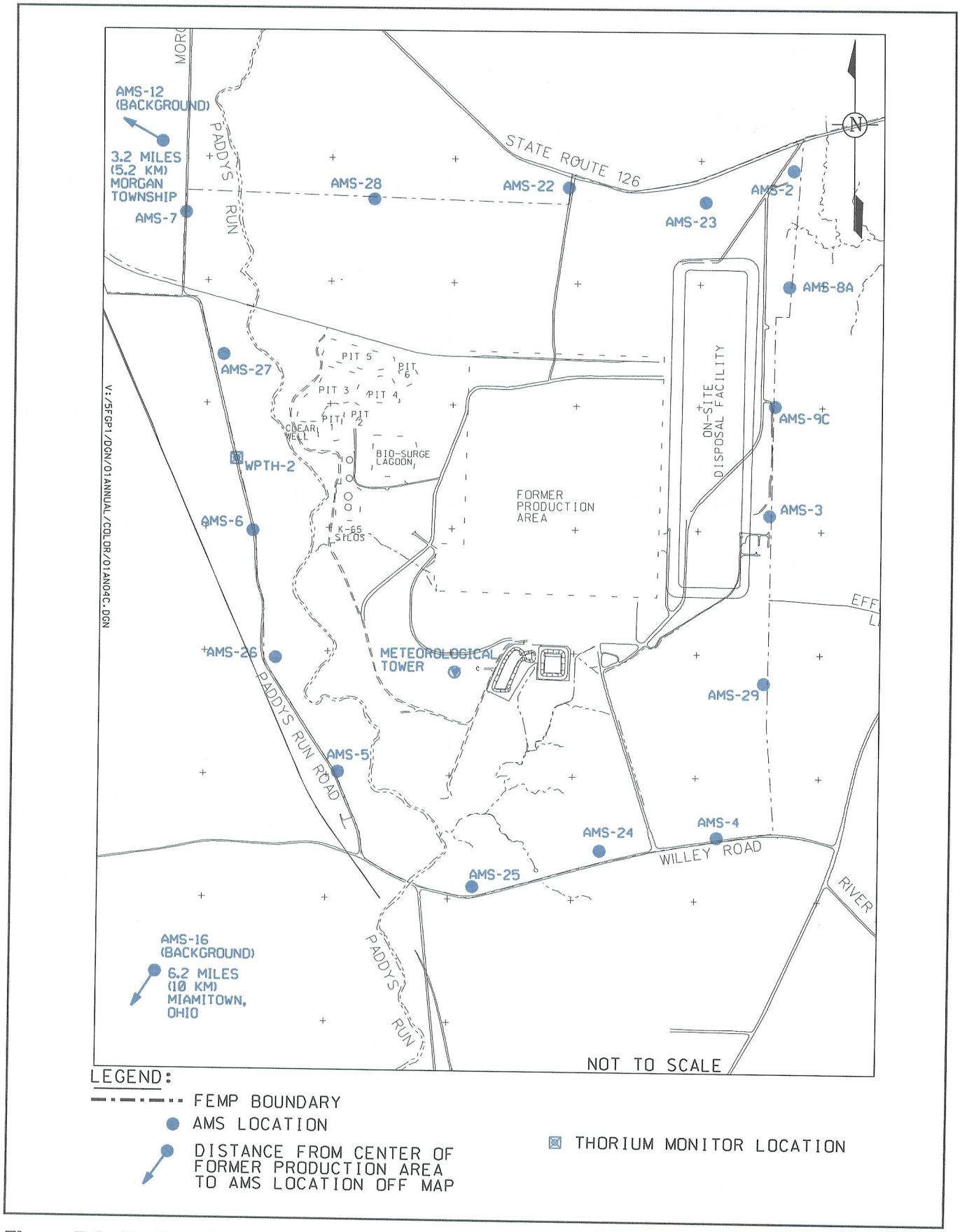

Figure 5-1. Radiological Air Monitoring Locations

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

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

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

Table 5-1 presents a summary of the minimum, maximum, and average concentrations for total uranium, thorium-230 and total particulate in 2001 and 2000 based on the biweekly sample results used for monitoring air emission trends. For 2001, the annual average concentrations of total uranium at all fenceline air monitoring stations were less than one percent of the DOE-derived concentration guide value (0.1 picoCuries per cubic meter [pCi/m^3]). In 2001, total uranium at all air monitoring locations ranged from less than detectable concentrations to a maximum concentration of 9.9E-04 pCi/m^3 at AMS-9C. For comparison, background locations ranged from less than detectable to 5.6E-05 pCi/m^3 at AMS-16.

TABLE 5-1
SUMMARY OF TOTAL URANIUM, TOTAL PARTICULATE, AND THORIUM-230 CONCENTRATIONS IN AIR FOR 2000 AND 2001

Location	2001 Total Uranium (pCi/m^3)	2000 Total Uranium (pCi/m^3)	2001 Total Particulate (µg/m^3)	2000 Total Particulate (µg/m^3)	2001 Thorium-230 (pCi/m^3)	2000 Thorium-230 (pCi/m^3)
Fenceline Locations						
Minimum	0.0E+00	0.0E+00	3.0	5.4	0.0E+00	0.0E+00
Maximum	9.9E-04	9.9E-04	82	72	7.4E-04	5.6E-04
Average	1.1E-04	8.5E-05	33	31	5.1E-05	2.9E-05
Background Locations						
Minimum	0.0E+00	0.0E+00	14	17	0.0E+00	0.0E+00
Maximum	5.6E-05	1.4E-04	62	52	4.2E-05	1.8E-05
Average	2.0E-05	1.6E-05	34	33	9.5E-06	6.3E-06

Biweekly thorium monitoring at the fenceline provides timely feedback on project engineering and administrative controls that are implemented to control fugitive emissions, primarily at the Waste Pits Remedial Action Project. The fenceline concentrations of thorium-230, the primary thorium isotope of concern in the waste pit material being excavated, ranged from less than detectable to 7.4E-04 pCi/m^3, which was detected at AMS-3. For comparison, background locations ranged from less than detectable to 4.2E-05 pCi/m^3 at AMS-12.

In addition to the total uranium and isotopic thorium analyses, total particulate measurements are also obtained from each filter every two weeks as summarized in Table 5-1. Total particulate concentrations ranged from 3.0 micrograms per cubic meter (µg/m^3) to a maximum of 82 µg/m^3 at AMS-27. There are no general or site-specific regulatory limits associated with total particulate measurements used in the data evaluation process.

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Total particulate, total uranium, and thorium-230 data were collectively evaluated to identify any increasing trends that may be related to remediation activities. Several temporary increases of these three constituents were observed at various monitoring locations; however, the short-livec increases did not pose a potential exceedance of the NESHAP dose limit of 10 mrem or DOE guidelines. The majority of increases in total uranium and thorium-230 concentrations were detected at some of the air monitoring stations on the eastern fenceline (AMS-3, AMS-8A, and AMS-9C) during the first and last quarters of 2001 but also throughout the year on a less frequent basis. Figures 5-2 and 5-3 show total uranium and thorium concentrations, respectivel at the selected eastern fenceline locations. These temporary increases were due to the remediation activities associated with the Waste Pits Remedial Action Project, on-site disposal facility and its associated material transfer area, and Decontamination and Dismantlement Project activities. The radiological air particulate data are discussed with the remediation project personnel to ensure that emission controls are operating as expected and to consider actions as necessary. Appendix C, Attachment 1, of this report provides graphical displays of the 2001 total uranium, thorium-230, and total particulate data.

Quarterly composite air filter samples were formed from the biweekly samples at each IEMP air monitoring station during 2001 to determine the radiological air inhalation dose for each location. The samples were analyzed for isotopes of radium, thorium, and uranium. The quarterly results were used to track compliance with the NESHAP 10 mrem dose limit throughout the year and to demonstrate compliance with the limit at the end of 2001. The maximum dose associated with the quarterly composite results for 2001 was 0.8 mrem, compared to the 10 mrem limit, and occurred at AMS-3. The composite results from the fenceline monitors show that, on average, thorium isotopes contribute 57 percent of the dose from 2001 airborne emissions. Isotopes of uranium and radium account for 29 and 12 percent of the dose, respectively. The higher percentage of dose from thorium isotopes is a result of thorium-230 becoming the major dose contributor through fugitive emissions from the Waste Pi Remedial Action Project operations. Thorium-230 became the major dose contributor beginnin in 2000 with the commencement of Waste Pits Remedial Action Project excavation activities. Given the methods required to excavate, transport, and process waste pit material, fugitive emissions were expected to increase the average concentration of thorium-230 at the fenceline Although the project uses several environmental compliance-based dust abatement practices and controls, some fugitive emissions are expected to be generated from the project based on the large-scale waste handling operations. Chapter 6 and Appendix D of this report provide more detailed information on the dose associated with the composite results.

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

The WPTH-2 fenceline monitor was installed in late 1998 on the west property boundary to specifically monitor thorium emissions from the Waste Pits Remedial Action Project on a biweekly basis. Measured airborne concentrations of thorium-228 and thorium-232 were comparable to background concentrations throughout 2001. These fenceline data reflect the fact that, in comparison to thorium-230, the concentrations of thorium-228 and thorium-232 in the waste pit material are relatively low thus far into the excavation of waste. The Waste Pits Remedial Action Project operations are not expected to significantly impact the fenceline concentrations of thorium-228 and thorium-232. Appendix C, Attachment 1, of this report provides graphical displays of the isotopic thorium data from the WPTH-2 monitor.

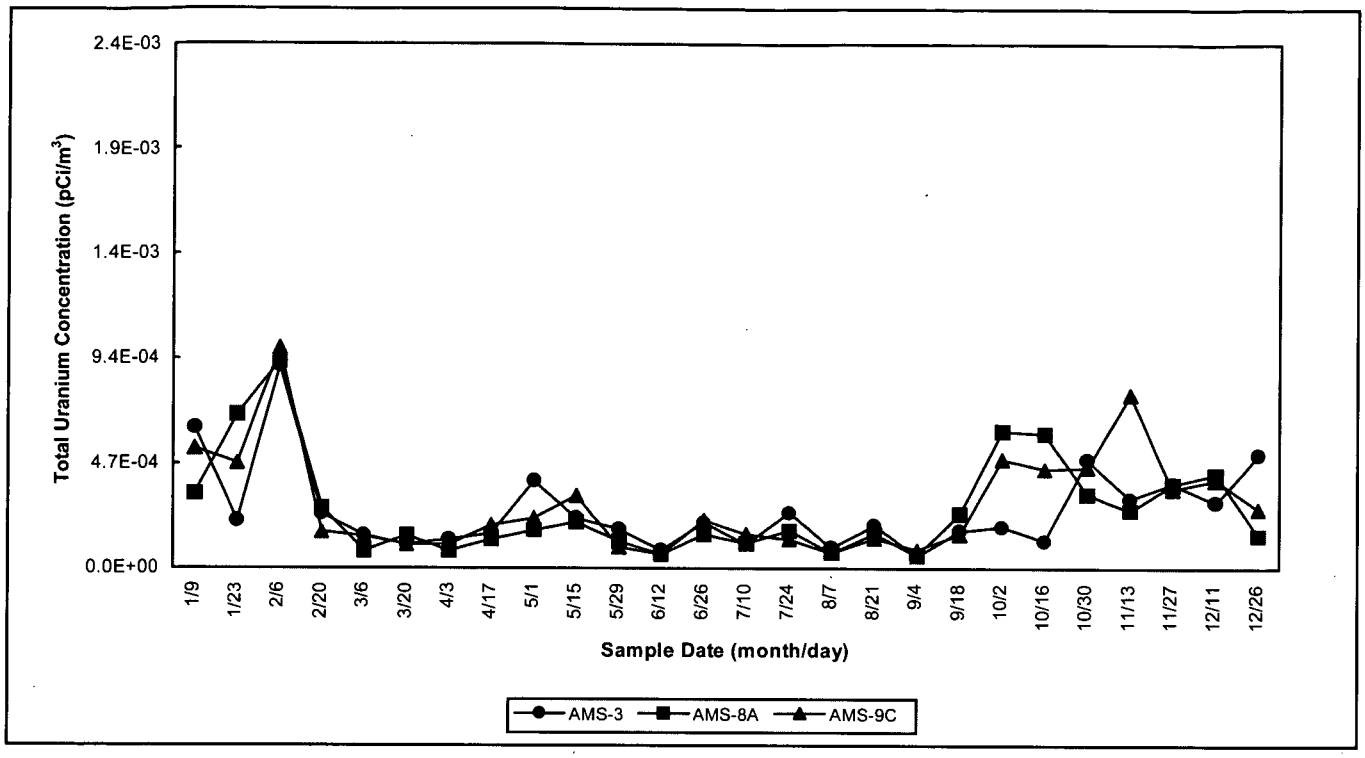

Figure 5-2. 2001 Total Uranium Concentrations in Air at Selected East Fenceline Monitors (AMS-3, AMS-8A, and AMS-9C)

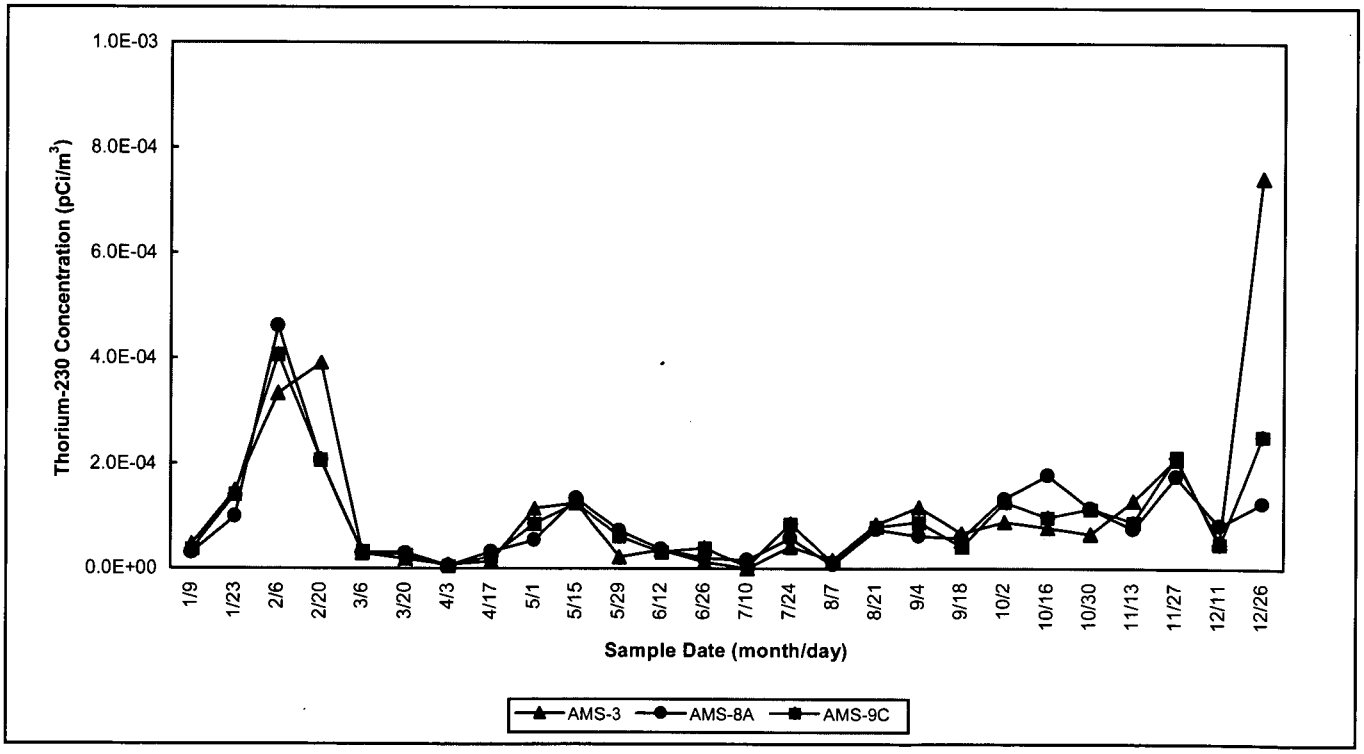

Figure 5-3. 2001 Thorium-230 Concentrations in Air at Selected East Fenceline Monitors (AMS-3, AMS-8A, and AMS-9C)

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Radon Monitoring

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

Many factors influence the concentration of radon in the environment, including the distribution of radium-226 in the ground, porosity of the soil, weather conditions, etc. For instance, radon diffusion from the ground is minimized by the presence of precipitation and snow cover. Alternatively, elevated temperatures and the absence of precipitation can produce cracks in the ground and changes in porosity that increase the rate at which radon escapes. Summary level meteorological data from 2001 are presented in Appendix C, Attachment 5, and Figures 1-7 through 1-10 of this report.

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

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

DOE Order 5400.5, Radiation Protection of the Public and the Environment, defines radiological protection requirements, guidelines for cleanup of residual radioactive material, management of resulting wastes and residues, and the release of radiological property. Radon limits above interim storage facilities (such as the FEMP) are also defined under DOE Order 5400.5 and must not exceed:

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

Figure 5-4 illustrates the continuous radon-monitoring network used in 2001 for determining compliance with the above limits. The continuous monitoring network provides for frequent feedback to remediation projects, regulatory agencies, and FEMP stakeholders on trends in ambient radon concentrations, while providing sufficient radon monitoring to ensure compliance with DOE Order 5400.5 requirements. Access to real-time radon monitoring data from selected continuous radon monitoring locations is available at the FEMP Public Environmental Information Center.

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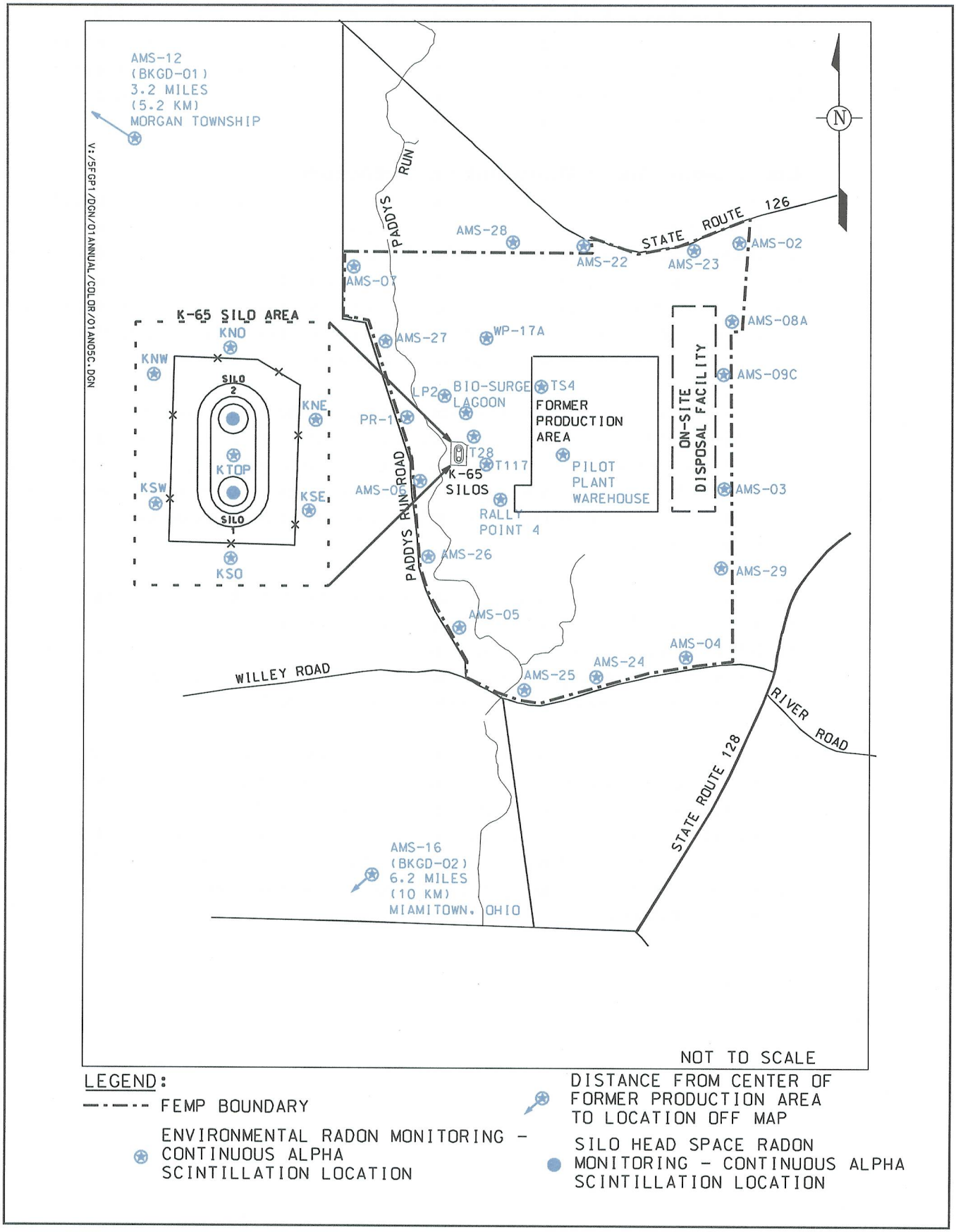

Figure 5-4. Radon Monitoring - Continuous Alpha Scintillation Locations

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

Continuous Alpha Scintillation Detectors

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

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

Table 5-2 provides monthly average radon concentration data from the continuous radon monitors for 2001. The data are used to track radon concentrations through the year to ensure the DOE limits are not exceeded. In addition to the summary data presented here, Appendix C, Attachment 2, of this report provides graphical displays of monthly average radon concentrations from continuous radon monitors during 2001 and 2000.

Results from the fenceline monitoring locations indicate radon levels for 2001 were within historical ranges and well below the DOE limit of 3 pCi/L above background. The annual average radon concentrations at the fenceline ranged from 0.2 to 0.4 pCi/L. The annual average radon concentrations at the background monitoring locations ranged from 0.1 to 0.3 pCi/L. A review of site fenceline data suggests that during 2001, the Waste Pits Remedial Action Project operations did not significantly impact the radon concentrations at the site fenceline (refer to Table 5-2).

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

	2001 Summary Results[c] (Instrument Background Corrected) (pCi/L)			2000 Summary Results[c] (Instrument Background Corrected) (pCi/L)		
Location[b]	Min.	Max.	Avg.	Min.	Max.	Avg.
Fenceline						
AMS-02	0.1	0.6	0.3	0.2	0.6	0.4
AMS-03	0.1	0.7	0.3	0.3	1.0	0.6
AMS-04	0.1	0.5	0.3	0.2	0.8	0.4
AMS-05	0.1	0.8	0.4	0.2	0.7	0.4
AMS-06	0.1	0.6	0.3	0.2	0.7	0.4
AMS-07	0.2	0.8	0.4	0.3	0.9	0.5
AMS-08A	0.1	0.7	0.4	0.2	0.6	0.4
AMS-09C	0.0	0.8	0.3	0.1	0.8	0.4
AMS-22	0.1	0.3	0.2	0.1	0.5	0.3
AMS-23	0.1	0.3	0.2	0.1	0.3	0.2
AMS-24	0.1	0.7	0.3	0.2	0.8	0.4
AMS-25	0.1	0.7	0.3	0.2	0.6	0.3
AMS-26	0.2	0.5	0.3	0.2	0.7	0.4
AMS-27	0.1	0.8	0.4	0.2	0.8	0.4
AMS-28	0.1	0.6	0.3	0.2	0.6	0.3
AMS-29	0.1	0.5	0.2	0.2	0.7	0.4
Background						
AMS-12	0.1	0.5	0.3	0.1	0.5	0.3
AMS-16	0.0	0.3	0.1	0.1	0.4	0.2
On Site						
KNE	1.1	13.1	3.9	1.5	3.6	2.2
KNO[d]	0.9	2.3	1.9	1.3	3.7	2.7
KNW-A	0.4	1.9	0.8	1.0	4.2	1.9
KSE	0.9	4.5	2.1	1.3	4.7	2.8
KSO[d]	0.3	1.6	0.6	0.3	0.9	0.5
KSW-A	0.2	1.8	0.8	1.0	2.4	1.6
KTOP	3.0	9.0	5.5	1.8	11.8	4.7
LP2[e]	0.3	1.2	0.6	0.4	0.5	0.4
Pilot Plant Warehouse	0.3	0.8	0.4	0.1	1.1	0.4
PR-1[f]	0.3	0.9	0.6	0.3	1.0	0.6
Rally Point 4	0.2	0.7	0.4	0.3	0.8	0.4
Surge Lagoon	0.2	1.4	0.6	0.2	0.6	0.4
T117[e]	0.2	1.3	0.5	0.2	0.4	0.3
T28	0.3	1.1	0.6	0.7	1.2	1.0
TS4	0.2	1.0	0.5	0.1	0.7	0.3
WP-17A	0.2	0.7	0.4	0.2	1.0	0.4

[a]Monthly average radon concentrations are calculated from daily average concentrations. Daily average concentrations are calculated by summing all hourly count data, treating the sum as a single daily measurement, and then converting the sum to a (daily average) concentration.
[b]Refer to Figure 5-4 for sample locations
[c]Instrument background changes as monitors are replaced.
[d]Unit was placed in service in April 2000.
[e]Unit was placed in service in November 2000.
[f]Unit was placed in service in March 2000.

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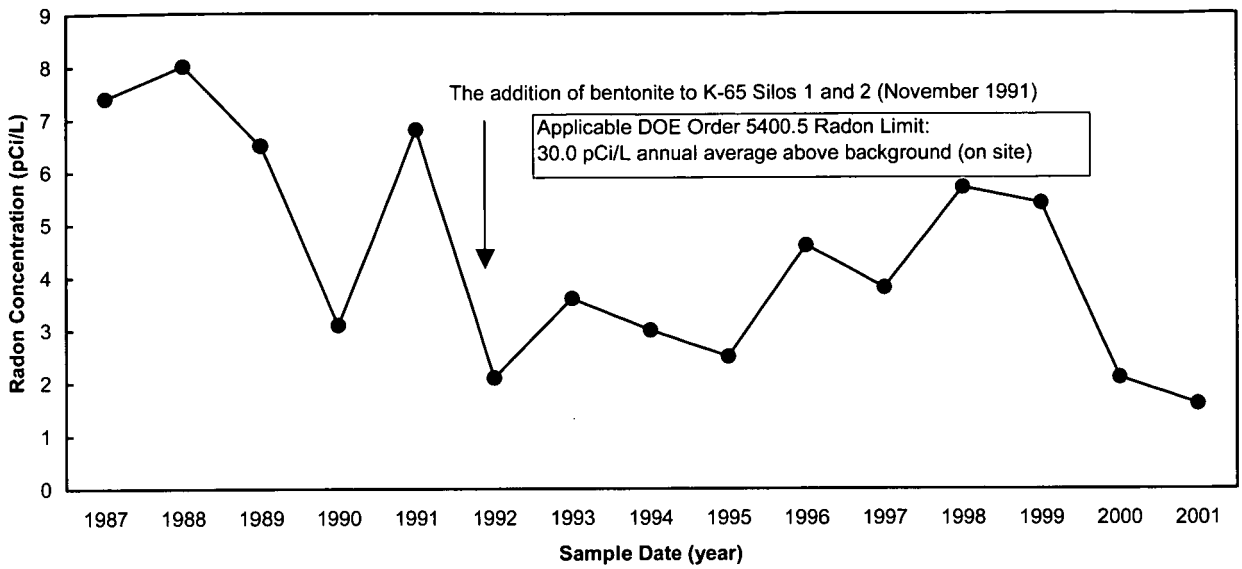
In accordance with the FFA, radon concentrations within the headspace of K-65 Silos 1 and 2 are continuously monitored to assess the effectiveness of control measures in reducing radon emissions. Over the past eight years (1993 to 2001), radon concentrations in the silo headspace have been trending upward. These increases in headspace concentration are attributable to degradation of the 1991 application of bentonite clay to the surface of the K-65 Silo residues. Appendix C, Attachment 2, of this report provides a graphical display of quarterly average headspace radon concentrations from 1992 to 2001. During 2001 there were 15 exceedance events related to the 100 pCi/L DOE limit measured on site (refer to Table C.2-1) compared with six recorded in 2000. As in past years, the exceedances were observed at monitoring locations adjacent to the K-65 Silos and occurred during periods of atmospheric inversions.

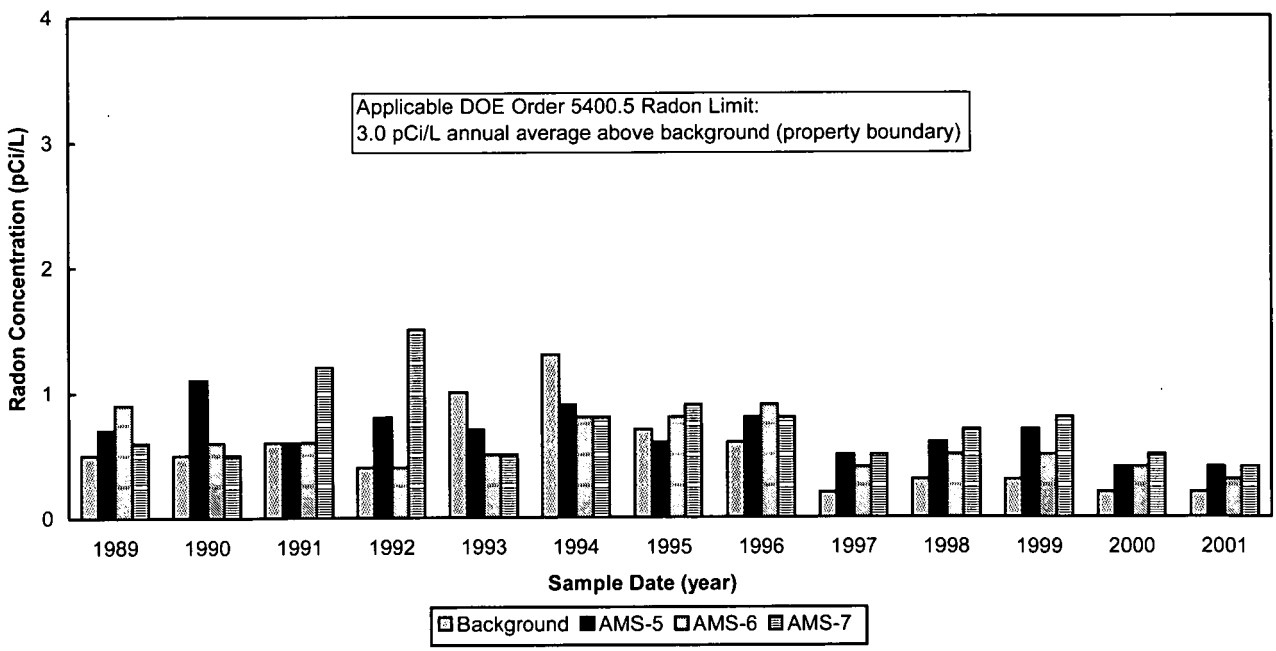
Long-term comparisons are performed on average radon concentrations recorded at the K-65 Silos exclusion fence locations (historical alpha track-etch and alpha scintillation detector data were used for this comparison) (Figure 5-5). The average concentrations adjacent to the K-65 Silos are still below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

Long-term comparisons are also performed on average radon concentrations at western property fenceline locations and background locations as a basis for comparison to the 3 pCi/L annual average limit. In 2001 a marginal difference in radon concentrations was observed between background and western property fenceline monitoring locations (refer to Figure 5-6). The on-property monitoring locations also recorded radon levels well below the applicable DOE limit of 30 pCi/L annual average.



Note: The 1987 through 1996 data are based on the alpha track-etch detectors and averaging locations corresponding to continuous radon monitors. The 1997 through 2001 data are based on the average radon concentration from continuous radon monitors at the K-65 exclusion fence.

Figure 5-5. Annual Average Radon Concentrations at K-65 Silos Exclusion Fence, 1987 - 2001



Note: The 1989 through 1996 data are based on the alpha track-etch detectors and the 1997 through 2001 data are based on the continuous radon monitors.

Figure 5-6. Annual Average Radon Concentrations at Selected Radon Locations, 1989 - 2001

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Monitoring for Direct Radiation

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

Direct radiation levels at and around the FEMP were continuously measured at 32 locations with thermoluminescent dosimeters (TLDs) during 2001. TLDs absorb and store the energy of direct radiation within the thermoluminescent material. By heating the thermoluminescent material under controlled conditions in a laboratory, the stored energy is released as light, measured, and correlated to the amount of direct radiation. Figure 5-7 identifies the TLD monitoring locations. These monitoring locations were selected based on the need to monitor the K-65 Silos, the FEMP fenceline, and background locations. Table 5-3 provides summary level information pertaining to direct radiation measurements for 2001 and 2000.

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

	Direct Radiation (mrem)	
TLD Location	Summary of 2001 Results	Summary of 2000 Results
Fenceline (21 locations)		
Minimum	69	65
Maximum	90	85
On Site (6 locations)		
Minimum (Health & Safety Bldg.)	58	58
Maximum (K-65 Silo area)	1,204	1,084
Background (5 locations)		
Minimum	67	62
Maximum	79	77

All monitoring results from TLDs for 2001 were within historical ranges. However, there is an increasing trend in direct radiation measurements in the immediate area of the K-65 Silos (refer to Figure 5-8). This increasing trend is attributable to a corresponding increase in radon concentrations (from 1993 through 2001) and associated decay products within the K-65 Silos' headspace. The direct radiation measurements adjacent to K-65 Silos are still well below the levels observed prior to the addition of bentonite to the K-65 Silos in 1991.

A slight increasing trend in direct radiation levels has also been detected at the FEMP western fenceline over the past five years (1997 through 2001), particularly at TLD location 6 which is located closest to the K-65 Silos (refer to Figure 5-9). The relatively small increases in direct radiation levels at the fenceline are difficult to measure consistently due to small variations in the sensitivity and accuracy of the environmental TLDs. These increases at the fenceline are also attributable to the increase in radon concentrations and associated decay products within the K-65 Silos' headspace. The slight upward trend in background radiation levels shown in Figure 5-9 is attributed to changes in the laboratory processing of the TLDs. These trends will continue to be monitored and presented through the IEMP, including the annual site environmental reports.

Chapter 6 provides more information on the dose associated with the direct radiation results. Detailed results of direct radiation measurements for 2001 and 2000 are provided in Appendix C, Attachment 3, of this report.

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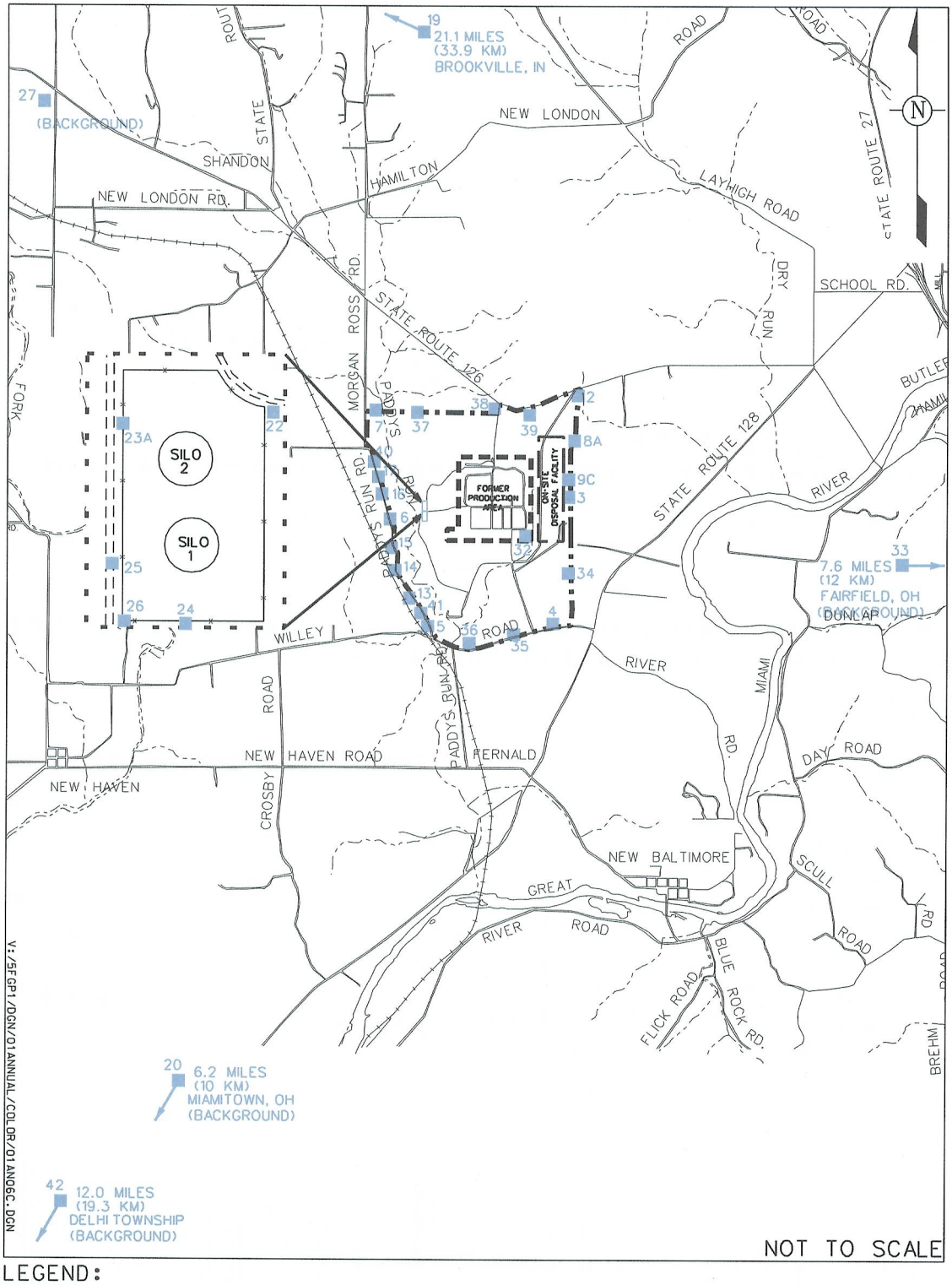

Figure 5-7. Direct Radiation (TLD) Monitoring Locations

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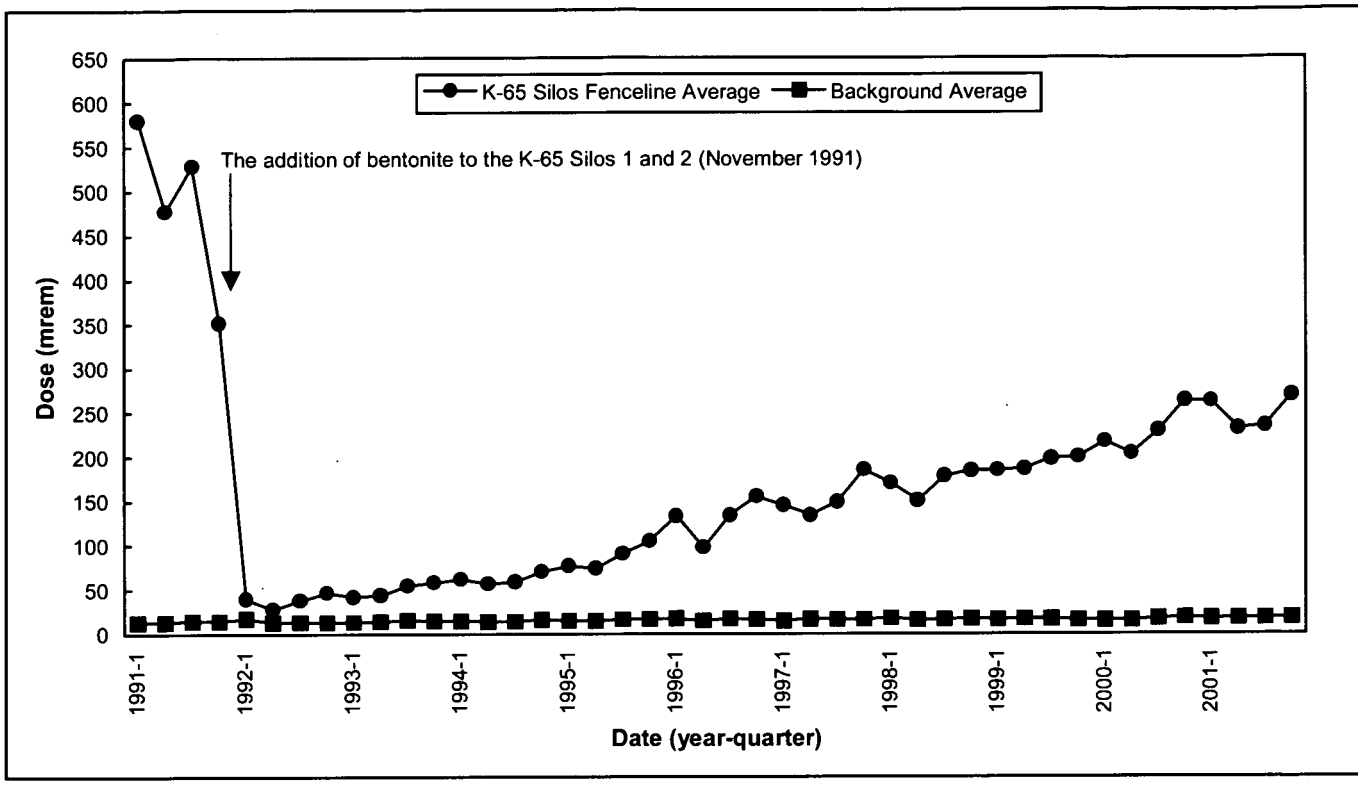

Figure 5-8. Direct Radiation (TLD) Measurements at K-65 Silos Boundary, 1991 - 2001 (K-65 Silos Fenceline Average Versus Background Average)

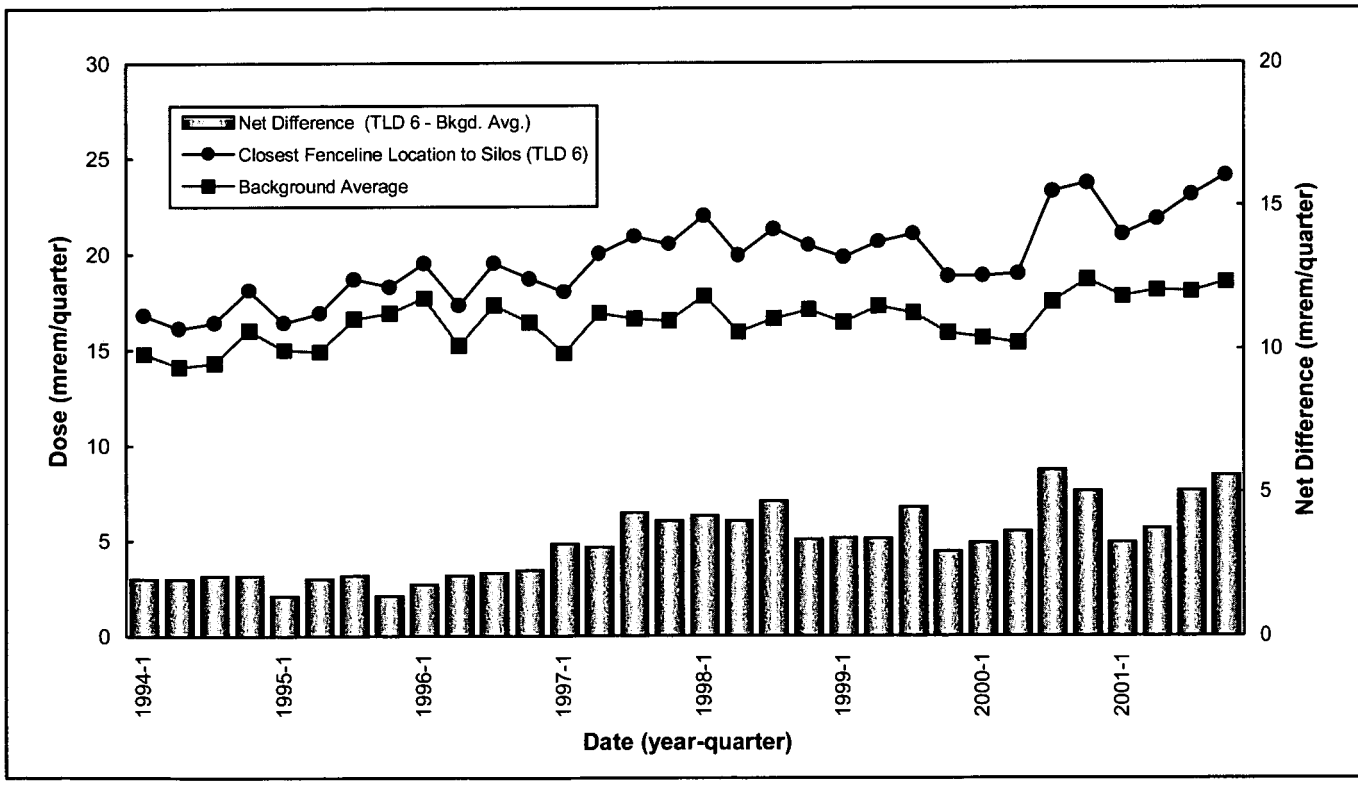

Figure 5-9. Direct Radiation (TLD) Measurements, 1994 - 2001 (Location 6 Versus Background Average)

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Stack Monitoring for Radionuclide Emissions

With the transition from uranium production to full-scale remediation activities, there was a significant reduction in the number of stacks and vents (point sources) which require monitoring. Two stack monitors, Building 71 and the Waste Pits Remedial Action Project dryer stack, were in operation during 2001. No significant changes in source operations associated with the Building 71 stack were noted during 2001.

The Waste Pits Remedial Action Project dryer stack particulate filters were analyzed for isotopes of uranium, thorium, and radium. The results confirmed that Waste Pits Remedial Action Project stack particulate emissions are very low and are not the primary source of the increases in thorium-230 concentrations at the fenceline. The stack also contains a continuous radon monitor (i.e., radon-220 and radon-222). The maximum daily release of radon (radon-220 and radon-222) during 2001 was 52,027 µCi. This equates to 2,168 µCi/hr, which is below the estimated maximum hourly release rate of 13,000 µCi/hr (DOE 1998a) for radon-222. The average daily release rate of radon for 2001 was 3,449 µCi, which equates to 144 µCi/hr, and is well below the estimated maximum hourly release rate of 13,000 µCi/hr for radon-222. Table 5-4 summarizes the FEMP stack emissions for 2001 and Figure 5-10 shows the monitored stack locations.

Typically, post-production era (1990 and later) monitoring data have shown stack emissions of uranium and thorium to be very low or not detectable. The 2001 stack emissions are consistent with historically low stack emission data for the post-production period.

TABLE 5-4
2001 NESHAP STACK EMISSIONS

Radionuclide (Unit)	WPRAP Dryer Stack[a]	Building 71 Stack[a]
Uranium, Total (lbs/yr.)	NS	3.4E-05
Uranium-238 (lbs/yr.)	5.6E-05	NS
Uranium-235 (lbs/yr.)	9.3E-07	NS
Uranium-234 (lbs/yr.)	2.0E-09	NS
Thorium-232 (lbs/yr.)	1.5E-05	4.5E-05
Thorium-230 (lbs/yr.)	1.0E-09	1.5E-09
Thorium-228 (lbs/yr.)	1.5E-15	NS
Radium-226 (lbs/yr.)	1.6E-12	NS
Particulates, Total (lbs/yr.)	NS	4.6E-02
Radon, Total (µCi)	3449[b]	NS

[a]NS = not sampled
[b]Value represents a daily average.

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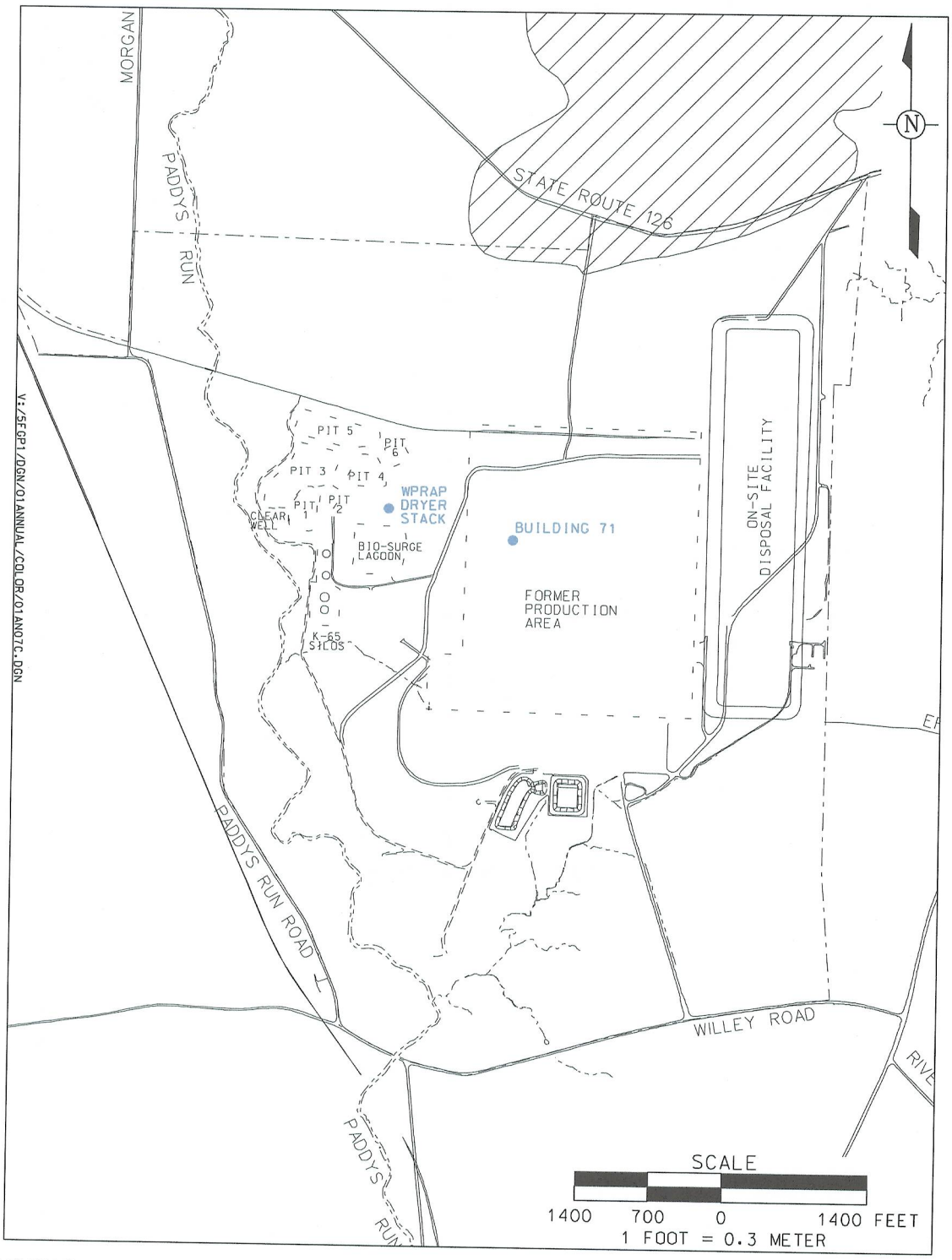

LEGEND:

FEMP BOUNDARY

NESHAP STACK EMISSION MONITORING LOCATION

Figure 5-10. NESHAP Stack Emission Monitoring Locations

000109

Monitoring for Non-Radiological Pollutants

The FEMP operated the Waste Pits Remedial Action Project gas-fired dryer during 2001. The estimated emissions from the dryer operation were based on emission factors from AP-42 Compilation of Air Pollution Emissions Factors, Volume 1. The sulfur dioxide emissions were estimated to be 111 pounds (51 kg). Nitrogen oxide emissions for 2001 were estimated to be 15,039 pounds (6,828 kg). Carbon monoxide emissions were estimated to be 11,326 pounds (5,142 kg). Estimates for particulate as PM10 (particles with an aerodynamic diameter less than or equal to a nominal 10 micron) was 2,544 pounds (1,155 kg). Total organic compound emissions for 2001 were estimated to be 1,077 pounds (489 kg). There are no regulatory limits associated with non-radiological pollutants from the dryers, however, the dryers are 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.

OEPA requires an estimate of emissions from the boiler plant as part of the FEMP's effort to demonstrate compliance with the Clean Air Act. The boilers at the FEMP are dual fired by natural gas and diesel fuel. Non-radiological pollutants from boiler operations include particulate matter, sulfur dioxide, nitrogen oxides, and carbon monoxide, and non-methane volatile organic compounds. Opacity is a measure of how much light is blocked by particulate matter present in stack emissions. Excursions occur when regulatory limits for opacity are exceeded. There were no opacity excursions at the boilers for 2001. There have been no excursions since the FEMP converted from coal-fired boilers to natural gas/diesel-fired boilers in 1997.

In order to estimate sulfur dioxide emissions, scientists determine the sulfur and heat content of the fuel. Using this information and the total amount of fuel burned, the amount of sulfur dioxide emissions can be calculated. For 2001 sulfur dioxide emissions from all boilers were calculated to be 70 pounds (32 kg). This was well below the allowable limit of over 79 tons (72 metric tons) per year calculated from information in the permits issued by OEPA.

The nitrogen oxide emissions are estimated using data obtained from stack emission test results. Nitrogen oxide emissions for all boilers for 2001 were estimated to be 10,493 pounds (4,764 kg). Particulate matter emissions, based on emission factors from AP-42 for all boilers in 2001, were estimated to be 1,583 pounds (719 kg). This was well below the allowable limit of over 6.3 tons (5.7 metric tons) per year calculated from information in the permits issued by OEPA. Carbon monoxide emissions, based on emission factors from AP-42 for all boilers in 2001, were estimated to be 4,162 pounds (1,890 kg). To date, OEPA has not set nitrogen oxide or carbon monoxide limits for the FEMP. Table 5-5 provides a comprehensive list of 2001 boiler plant emissions.

TABLE 5-5
BOILER PLANT EMISSIONS

Chemical Name	Type of Release	Quantity Released (lb/kg)	Major Release Sources	Basis of Estimate
Particulates	Stack of Emissions	1,583/719	Fossil Fuels Combustion	AP-42 Emission Factors[a]
Sulfur Dioxide	Stack of Emissions	70/32	Fossil Fuels Combustion	Chemical analysis of fuels sulfur content
Nitrogen Oxide	Stack of Emissions	10,493/4,764	Fossil Fuels Combustion	Stack Emission Test Results for natural gas or AP-42 Emission Factors[a] for diesel fuel
Carbon Monoxide	Stack of Emissions	4,162/1,890	Fossil Fuels Combustion	AP-42 Emission Factors[a]
Non-Methane Volatile Organic Compounds	Stack of Emissions	281/128	Fossil Fuels Combustion	AP-42 Emission Factors[a]

[a]Compilation of Air Pollution Emission Factors, Vol. 1; Stationary Point and Area Sources, 5th edition, January 1995 (USEPA 1995)

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Chapter 6
Radiation Dose

Radiation Dose

Results in Brief: 2001 Estimated Doses

Airborne Emissions - The estimated maximum effective dose equivalent at the site fenceline from 2001 airborne emissions (excluding radon) was calculated to be 0.8 mrem, which is 8 percent of the EPA NESHAP 10 mrem annual dose limit.

Direct Radiation - The estimated 2001 effective dose equivalent at an off-site receptor location near the western fenceline of the FEMP was 11.5 mrem.

Dose to the Maximally Exposed Individual - The dose to the maximally exposed individual for 2001 was estimated to be 11.7 mrem at an off-site receptor location near the western fenceline of the FEMP. This is 11.7 percent of the 100 mrem DOE limit.

This chapter provides estimated doses to the public from the air and direct radiation pathways for 2001 as a result of remedial actions taken at the FEMP. EPA NESHAP regulations require the FEMP to demonstrate that its radionuclide airborne emissions are low enough to ensure that no one in the public receives an effective dose of 10 mrem or more in any one year. Moreover, to determine whether the FEMP is within the DOE effective dose limit of 100 mrem 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 FEMP.

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. Nonetheless, dose estimates for radon have been included in this section in response to FEMP stakeholders' interests in radon exposures. A number of different radon dose calculations are presented in this section to demonstrate the variation of radon doses based on each method of calculation. The radon dose estimates in this section can also be compared with radon dose estimates presented in previous annual site environmental reports and other radon dose studies (i.e., Fernald Dosimetry Reconstruction Project [RAC 1996]).

Estimated Dose from Airborne Emissions

The estimated dose from 2001 airborne emissions was calculated from annual average radionuclide concentrations measured at the 18 IEMP air particulate monitoring locations (two background and 16 fenceline locations [refer to Figure 5-1 in Chapter 5 for the location of the air particulate monitoring locations]). Annual average background concentrations were 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 Code of Federal Regulations 61 (NESHAP) Subpart H, Appendix E, Table 2.

The maximum effective dose at the fenceline from 2001 airborne emissions was estimated to be 0.8 mrem per year and occurred at AMS-3 along the eastern fenceline of the site. The dose estimate is based on the conservative assumption that a person remains outdoors at the AMS-3 location for 100 percent of the time during the year. Recognizing that the nearest residence is located approximately 1,500 feet (450 meters) downwind from AMS-3 (east-southeast from the site), the actual dose received by this receptor would be substantially lower than 0.8 mrem per year.

The maximum fenceline dose of 0.8 mrem in 2001 is lower than the maximum fenceline dose of 1.1 mrem in 2000 and well below the NESHAP annual limit of 10 mrem. The decrease is attributable to increased emission control efforts from remediation activities associated with the Waste Pits Remedial Action Project, on-site disposal facility and its associated material transfer area, and the Plant 6 Decontamination and Dismantlement Project. Fugitive emissions from the Waste Pits Remedial Action Project waste processing activities, and specifically thorium-230 emissions, were the major contributors to the maximum fenceline dose in 2001.

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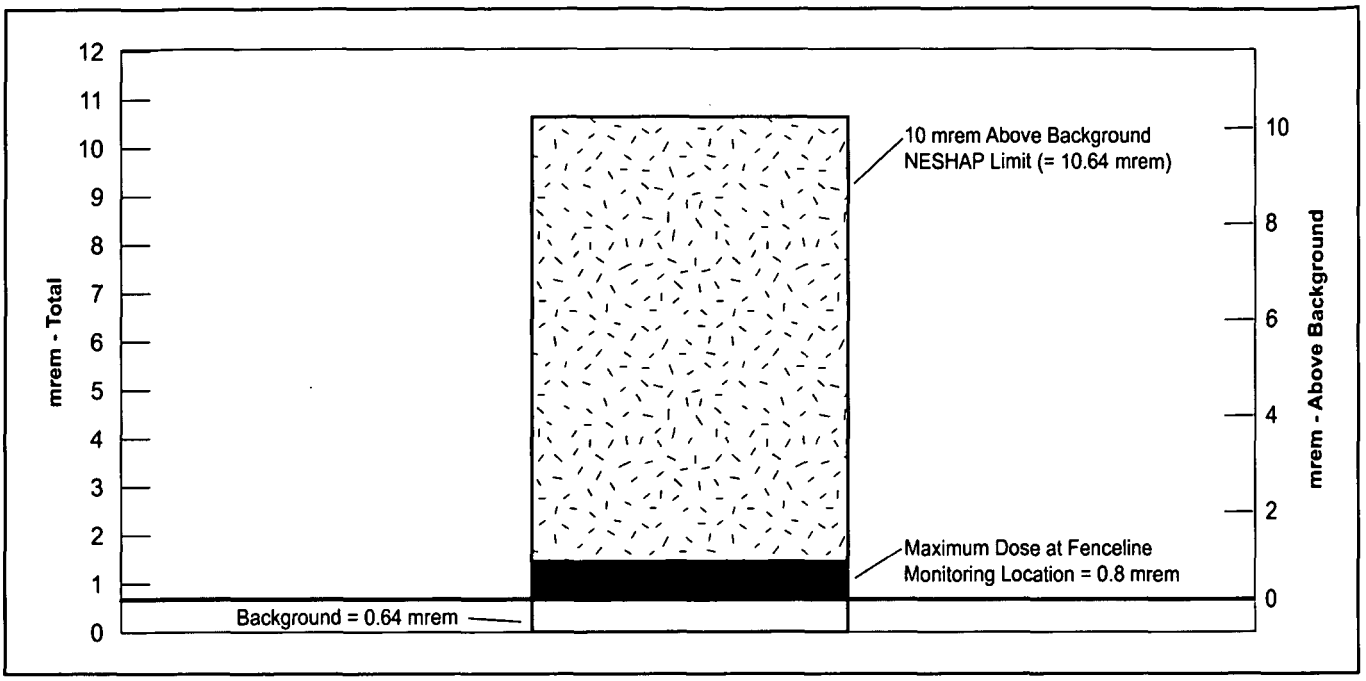

Figure 6-1. Comparison of 2001 Air Pathway Doses and Allowable Limits

Figure 6-1 provides a comparison between the air pathway doses at the average background and maximum fenceline locations with the annual NESHAP limit of 10 mrem. The average backgrour 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). The maximum air pathway dose (0.8 mrem above background, (which is in addition to the average air pathway background dose of 0.64 mrem) is 8 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.

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 FEMP 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. Direc radiation from the decay of radon progeny in the silo headspace contributes a major fraction of the direct radiation from the K-65 Silos. As the headspace radon concentrations have increased over the last nine years (1993 through 2001), the direct radiation from the silos has also increased. Direct radiation levels at the K-65 Silos and site fenceline are monitored by a network of environmental TLDs. Chapter 5 provides a description of the direct radiation monitoring.

The direct radiation dose for 2001 at the fenceline was estimated using the highest dose from the fenceline monitoring locations and subtracting the average dose measured at background TLD locations. This method provides a conservative estimate of direct radiation dose and measures the impact of increasing radiation levels near the silos and the fenceline due to increasing levels of radon and associated decay products in the silo headspace (refer to Chapter 5). From the data in Table 5-3, the maximum fenceline measurement was 90 mrem per year and occurred at TLD location 16. The average background dose from the six background TLD locations was 72 mrem The difference in these values (18 mrem) is the estimated fenceline direct radiation dose for a hypothetical individual who stands at the fenceline, specifically TLD location 16, for the entire yea

In accordance with DOE Order 5400.5, Radiation Protection of the Public and the Environment, which requires that realistic exposure conditions be used for conducting dose evaluations, an estimate of direct radiation dose was calculated for a residence nearest the K-65 Silos. This dose was estimated by using the net fenceline TLD measurement at TLD 16 and accounting for the distance between the fenceline TLD location and the residence (approximately 326 feet [99 meters]) which would lower the direct radiation dose to approximately 11.5 mrem. 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.

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 2001 dose to the maximally exposed individual is the sum of the estimated doses from direct radiation dose 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 2001 dose to the maximally exposed individual is estimated to be 11.7 mrem. The contributions to this all-pathway dose are:

- 11.5 mrem from direct radiation to an off-site receptor located near the western fenceline of the FEMP
- 0.2 mrem from air inhalation dose, as measured at AMS-6, to an off-site receptor located near the western fenceline of the FEMP.

This estimate represents the incremental dose above background attributable to the FEMP, exclusive of the dose received from radon. Figure 6-2 provides a comparison between the average background radiation dose at background (72.6 mrem) and the all-pathway dose to the maximally exposed individual (11.7 mrem). Figure 6-2 also provides a graphical comparison to the annual DOE all-pathway limit of 100 mrem.

TABLE 6-1
DOSE TO MAXIMALLY EXPOSED INDIVIDUAL

Pathway	Dose Attributable to the FEMP	Applicable Limit
Air		
Airborne emissions at AMS-6 (excluding radon)	0.2 mrem	10 mrem (air pathway)
Direct radiation	11.5 mrem	100 mrem (total of all pathways)
Maximally exposed individual	11.7 mrem	100 mrem (total of all pathways)

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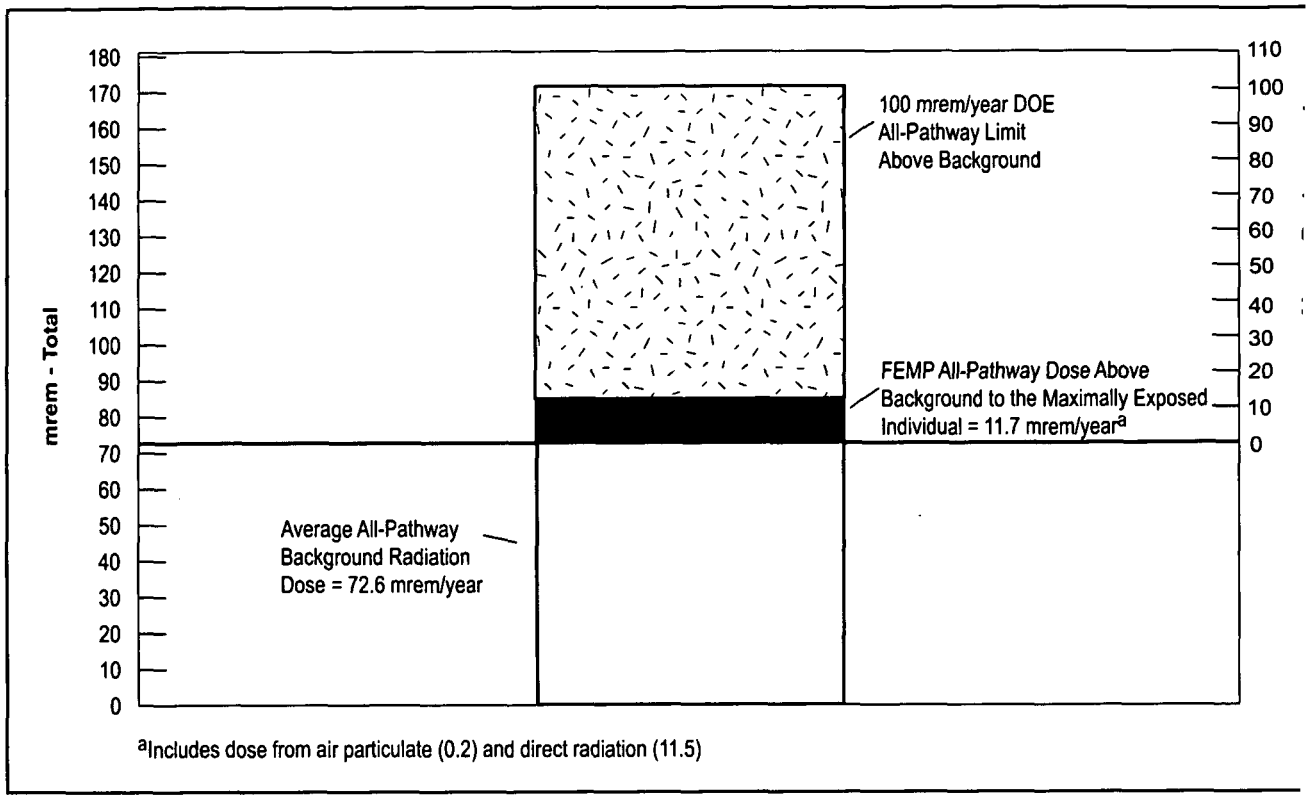

Figure 6-2. Comparison of 2001 All Pathway Doses and Allowable Limits

Significance of Estimated Radiation Doses for 2001

One method of evaluating the significance of the estimated doses is to compare them with c received from background radiation. Background radiation yields approximately 100 mrem year from natural sources, excluding radon. For example, the dose received each year fron cosmic and terrestrial background radiation contributes approximately 26 and 28 mrem, 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 mrer whereas living in the Denver area would contribute approximately 125 mrem from backgrou radiation (U.S. National Academy of Science 1980) (National Council on Radiation Protect and Measurements 1987). Comparing the maximally exposed individual dose to the backgr dose demonstrates that, even with the conservative estimates, the dose to a member of the public (nearest resident) from the FEMP 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 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 per year above background. As a result of this recommendation, DOE has incorporated 100 mrem per year above background as the limit in DOE Order 5400.5, Radi Protection of the Public and the Environment. The sum of all estimated doses from FEMP operations for 2001 (11.7 mrem) was significantly below this limit.

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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 (i.e., epidemiological studies) on highly exposed worker populations (i.e., 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
  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 utilized to equate the lung dose to a whole body radiation dose (i.e., effective dose equivalent). Equations from this report were utilized in previous annual site environmental reports and are presented here for direct comparison to previous years' estimates.

- ICRP 66 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 Radiological Assessments Corporation under contract with the Centers for Disease Control.

- ICRP 65 report
  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.

000116

Table 6-2 presents the 2001 radon dose estimates, and includes concentration values for fenceline and background locations, as well as DOE radon concentration limit values. Estim working level-month exposures are given for each concentration value, as well as effective equivalents utilizing 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 whc continuously breathed air at the FEMP fenceline while engaged in light, physical activity 24 hours a day for the entire year. This exposure scenario is highly conservative, but sugge that in using the ICRP 65 methodology the dose from FEMP radon emissions at the fencelin monitor nearest a public receptor is 18 mrem 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 FEMP boundary. In DOE Order 5400.5, the annual aver 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. As presented in Table 6-2, the maximum measured radon concentration and corresponding dose at the FEMP boundary are well below the limits associated with DOE Order 5400.5.

TABLE 6-2
2001 RADON DOSE ESTIMATE[a]

Location	Radon Concentration (pCi/L)	Exposure in Working Level-Months (WLM)	NCRP 78 Effective Dose Equivalent Equation (mrem)[b]	NCRP 78 Effective Dose Equivalent Equation (mrem)[c]	ICRP 65 Effec Dose Equival (mrem)[d]
Average Background	0.2	0.072	144	48	36
Fenceline Monitor Nearest Receptor (net, above background)	0.1	0.036	72	24	18
Maximum Fenceline (net, above background)	0.2	0.072	144	48	36
DOE Order 5400.5 Limit (net, above background)	3	1.08	2,106	720	547

[a]Assuming the suggested environmental radon daughter product equilibrium concentration of 70 percent
[b]NCRP 78 suggests whole lung tissue weighting factor of 0.12
[c]NCRP 78 calculation using the ICRP 66 bronchial epithelium weighting factor of 0.04
[d]Utilizing the dose conversion factor for the maximally-exposed reference man

000117

Chapter 7
Natural Resources

ıtural Resources

This chapter provides background information on the natural resources associated with the FEMP and summarizes the activities in 2001 relating to these resources. Included in this chapter is a discussion of the following:

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

Much of the 1,050 acres (425 hectares) of the FEMP 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 FEMP's natural resources. Some of these areas provide habitat for state and/or federal endangered species. Cultural resources, such as prehistoric archaeological sites, can also be found at the FEMP. These resources are considered 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.

Threatened and Endangered Species

ɔan's Crayfish - The state-listed threatened Sloan's crayfish *rconectes sloanii)* is found in southwest Ohio and southeast diana. It prefers streams with constant (though not necessarily st) current flowing over rocky bottoms. A large, well-established pulation of Sloan's crayfish is found at the FEMP in the northern aches of Paddys Run.

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

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

ɔring Coral Root - The state-listed threatened spring coral root *orallorhiza wisteriana)* is a white and red orchid which blooms in ɔril and May and grows in partially shaded areas of forested etlands and wooded ravines. This plant has not been identified at e FEMP; however, suitable habitat exists in portions of the rthern woodlot.

The Endangered Species Act requires the protection of any federally listed threatened or endangered species, as well as any habitat critical for the species' existence. Several Ohio laws mandate the protection of state-listed endangered species as well. Since 1993 several surveys have been conducted to determine the presence of any threatened or endangered species at the FEMP. As a result of these surveys, the federally endangered Indiana brown bat and the state-threatened Sloan's crayfish have been found at the FEMP. In addition, suitable habitat exists at the FEMP for the federally endangered running buffalo clover and the state-threatened spring coral root. Neither of these species has been found on FEMP property, but their habitat ranges encompass the FEMP. 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, then appropriate avoidance or mitigation efforts will be undertaken. The IEMP identifies surveys for the Indiana brown bat and the Sloan's crayfish in 2002. However, in order to ensure that there were no impacts associated with debris removal along the northern reaches of Paddys Run, the FEMP Sloan's crayfish population was surveyed in August 2001.

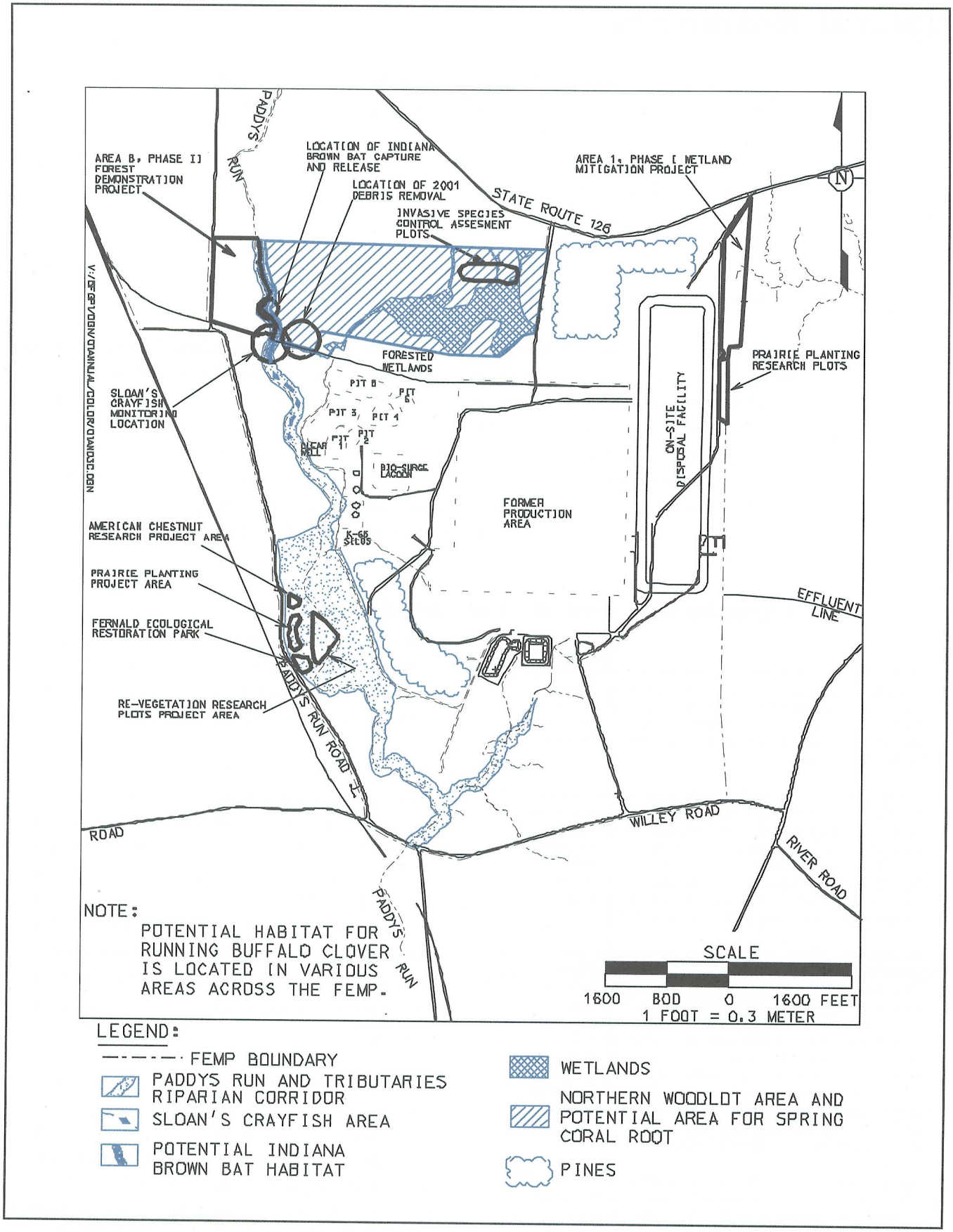

Figure 7-1. Priority Natural Resource Areas

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Sloan's Crayfish Monitoring and Provisions for Protection

The survey results from the August 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 requires that visual field inspections of sediment loading be conducted within 24 hours of a "significant rain event", which is considered to be 0.5 inch (1 cm) or more of rain in one storm event. 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, then alternatives such as crayfish relocation are considered. Figure 7-1 identifies the Sloan's crayfish monitoring location.

The monitoring effort in 2001 yielded similar findings to previous years. Results of visual field inspections indicated that sediment loading from remediation activities has not impacted Sloan's crayfish habitat in Paddys Run. One isolated instance of increased sediment loading from the northern drainage ditch was observed in 2001. As in previous years, it is unlikely that there was an impact because of their relatively short duration. DOE will continue to observe the northern drainage ditch following rain events, and will notify OEPA when there is an increase in turbidity.

Impacted Habitat Areas

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.

Within Area 1, Phase III, approximately 3 acres (1 hectare) of early successional woodlot habitat were cleared to remove debris from an area north of the rail line and just east of Paddys Run. By maintaining the existing overstory trees to the extent possible, habitat impacts from this activity were minimized. After debris removal, the area was re-graded to promote water retention in shallow depressions. Also, the area was seeded with native grasses and wildflowers.

There was also a small (less than 1 acre [0.4047 hectare]) area along the Storm Sewer Outfall Ditch that was disturbed to install piping for a groundwater extraction well. The drainage channel was restored, and the banks were seeded with native grasses and wildflowers.

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Ecological Restoration Activities

Ecological restoration activities focused primarily on monitoring and maintenance in 2001. S planting and seeding activities were conducted at the FEMP in several areas along the north portion of the site. 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 undertaken a the FEMP.

The Area 8, Phase II Forest Demonstration Project involved the ecological restoration of a formerly grazed pasture located in the northwest corner of the FEMP along Morgan-Ross R in Butler County. Over 1,300 sapling trees, 475 shrubs, and 2,300 seedlings were planted ac the 18-acre (7.3-hectare) site, resulting in the restoration of several habitats native to southv Ohio, including beech-maple, oak-maple, and mesophytic forests, a tallgrass savanna, and th enhancement of the existing riparian corridor along Paddys Run. Also, several ponds and wetlands, including a vernal pool, were constructed and planted with the appropriate wetland grasses and wildflowers. Bioengineering techniques were implemented to repair cow paths were accelerating erosion along the western bank of Paddys Run. In 2001, several species seedlings were planted within the mesophytic and beech-maple forest habitats. The spring 2 fieldwork resulted in the completion of planting activities within the Forest Demonstration Project.

Monitoring activities were also initiated in 2001. DOE is required to attain 80 percent surviv planted vegetation within restoration projects. In Area 8, Phase II, most areas achieved 80 percent survival, except for a few areas where heavy deer pressure was encountered. Herbaceous cover was also evaluated, and the results were very encouraging. For most are native grasses and wildflowers have established well within Area 8, Phase II. The amount c native vegetation in the savanna could be improved.

Wetland mitigation monitoring efforts continued in Area 1, Phase I during 2001 to partially fu DOE's 16.5-acre (6.68-hectare) mitigation requirement. DOE must restore or create 16.5 a (6.68 hectares) of wetlands in order to compensate for the loss of existing site wetlands duri remediation. In 1999 a formerly grazed pasture was converted to a 12-acre (4.9-hectare) ecosystem containing eight wetland basins that are connected by gravity flow streams (the Area 1, Phase I Wetland Mitigation Project). The wetland portion of this ecosystem covers approximately 6 acres (2.5 hectares). Vegetative cover (i.e., forest, shrubland, prairie, and marsh) was installed for both wet and dry conditions.

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In 2001, monitoring of the Area 1, Phase I Wetland Mitigation Project continued. Pond and subsurface water levels were determined in each of the eight wetland basins. Water quality samples were also collected and analyzed for pH, dissolved oxygen, conductivity, temperature, turbidity, odor, and color. Over time, this information will be used to assess the health of the wetland system. Initial results show that the wetland is healthy and progressing as planned.

Mortality counts of vegetation planted during construction of the wetland were continued in 2001. Due to continued heavy deer pressure, survival was less than 80 percent within several areas of the wetland project.

DOE plans to adjust its planting strategy for these projects. For the Forest Demonstration Project, DOE will avoid additional plantings in the southeast portion of the project area, where deer pressure is greatest. For the Wetland Mitigation Project, future activities will focus on expanding the extent of native herbaceous cover within wet areas. Additional shrubs will be planted in an area that was restored in 2000 just south of the Storm Water Retention Basin. These shrubs are easily transplanted from cuttings or seeds, so they will serve as a potential source of plant material for future restoration projects. DOE will also consult with local deer control experts in order to devise strategies to minimize deer impacts to site restoration projects.

Area 1, Phase I Wetland Mitigation Project

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Ecological Restoration Research Projects

Monitoring continued in 2001 for the Invasive Plant Control Research Project, the Prairie Pl Project, and the American Chestnut Research Project. These projects are being conducted under an ecological research grant as part of the 1996 Operable Unit 4 dispute resolution agreement.

Results from these efforts assist in the development of ecological restoration designs at the FEMP. Researchers have made several interesting findings. For the Invasive Plant Control Research Project, herbicide injection appears to be the best method for controlling honeysuc Results from the Prairie Planting Research Project indicate that wood chip mulch accelerate prairie establishment and retards weed growth. Results from the American Chestnut Resea Project are not yet available, but are expected in the next several years. The Area 8, Phase Re-vegetation Research Plots Project was completed in 2001. The focus of research in this project shifted to an evaluation of plant survival in light of heavy deer pressure. The data indicate that deer preferred some species to others, and that protective tree tubes were effective in reducing the amount of damage caused by deer.

Cultural Resources

Factors such as geologic setting, surface water, soil, vegetation, and climate determine the population and cultural growth of an area. The FEMP and surrounding area are located in a region of rich soil and many sources of water, such as the Great Miami River. Because of it advantageous location, the area was settled repeatedly throughout prehistoric and historic tim resulting in richly diverse cultural resources.

This section presents information on the known cultural history of the FEMP and surroundin area based on information obtained from available literature and cultural resource surveys preformed at the site. At this time six major periods have been defined in the Great Miami River Valley and at the site: Paleo-Indian (12,000 to 8,000 BC); Archaic (8,000 to 1,000 BC) Woodland Traditions (1,000 BC to 1,000 AD); Mississippian Tradition (1,000 AD to 1,660 A Ethnohistoric; and Historic Euro-American. Through 2001, 140 Native American villages an sites spanning these periods have been recorded at the site or on federal projects (off site) supporting the clean-up effort. This information is presented below in chronological order.

Dating from 12,000 to 8,000 BC, the Paleo-Indian period is typically characterized by the presence of small numbers of certain distinctive fluted and unfluted projectile points (or "arrowheads") such as clovis and cumberland, as well as various lancealate forms. Social structure in this period is typically interpreted as consisting of highly mobile, small nuclear families which engaged in hunting and gathering activities. Although rather limited numbers temporally diagnostic projectile points dating to this period have been found in the Great Mia River Valley, 12 have been recovered from a Paleo site at the FEMP. This Paleo site is estimated to date at 10,000 BC.

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The Archaic period is divided into Early, Middle, and Late, dating from 8,000 to 1,000 BC. The Archaic sites on the FEMP property range in size from little more than lithic scatters to large habitation sites. The majority of prehistoric sites date to the Archaic period. A variety of serrated, beveled, barbed, and stemmed projectile points, drills, hide scrapers, and hammer stones have been recovered from the site.

The Woodland period dates from 1,000 BC to 1,000 AD at the site. It is comprised of three cultures: Adena, Hopewell, and Woodland. These cultures witnessed the development of agriculture, the usage of pottery, and the spread of mortuary ceremonialism. Construction of earthen and stone mounds as repository of the socially high-ranking dead dominates the area at and in the vicinity of Fernald.

Within the site and surrounding area, the late prehistoric period (dating from 1,000 AD to 1,660 AD) is known as the Fort Ancient Culture. Characterized by sedentary village life, the economy was oriented toward the farming of corn, beans, and squash, with supplemental food sources derived from hunting and gathering activities. One such Fort Ancient village was impacted by the cleanup efforts at the site. It is a well-preserved 13th to 15th century village, oval in shape with domestic structure and activity zones arranged around a central plaza, and enclosed by a log palisade. Fernald cultural resource experts estimate that the population of the village was about 250 individuals, and believe to the best of their knowledge that the semi-subterranean house structure is the first such subterranean dwelling in the Ohio Valley.

Ethnohistoric occupation at the site suggests that the predominate Indian tribes to occupy this area during the mid-to-late 18th century were the Shawnee and Miami, although other groups such as Wyandot, Delaware, Ottawa, Chippewa, Potawantomi, and other smaller groups may have been present.

Historically and presently, much of western Hamilton County remains rural in nature and continues to be devoted to agricultural usage. The following recorded historic structures are situated near the site, and are of historical value.

Listed on the National Register of Historic Places:

- Vaughan-Francis House (c1814)
- Thomas Select School (c1810)
- Shaw Farm (c1804)

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Determined eligible for inclusion on the National Register of Historic Places:

- Rainbow Arch Bridge (c1931)

Other historic structures:

- Abner Atherton House (c1845)
- Blue Rock Street Bridge (c1914)
- Clinton D. Buell House (c1830)
- A. Reed Stone House (c1830)
- Joseph Sater Farm (c1876)
- William Sater Farm (c1831)
- Joal Whipple House (c1840)
- Daniel Welkins (c1845)
- Israel B. Weley House (c1910)

The National Historic Preservation Act requires that DOE take into consideration the effects its actions on sites that are listed or eligible for listing on the National Register of Historic Places.

During 2001 a Phase I Archaeological Investigation took place in support of the debris remov and bank stabilization along the northern reaches of Paddys Run at the site. This resulted in t identification of nine previously undocumented archaeological finds. A total of 30 prehistoric artifacts were recovered for analysis. An updated map of cultural resource survey areas is shown in Figure 7-2.

There were also two unexpected cultural resource discoveries in 2001, which is summarized i Table 7-1.

TABLE 7-1
UNEXPECTED CULTURAL RESOURCE DISCOVERIES FOUND IN 2001

Unexpected Discovery[a]	Time Period	Location of Discovery[b]
Worked Bone Artifact	Prehistoric	Area 1, Phase I
Worked Bone Artifact	Prehistoric	Area 8, Phase III

[a]No further excavation is warranted.
[b]Identified by soil remediation area (refer to Figure 2-1)

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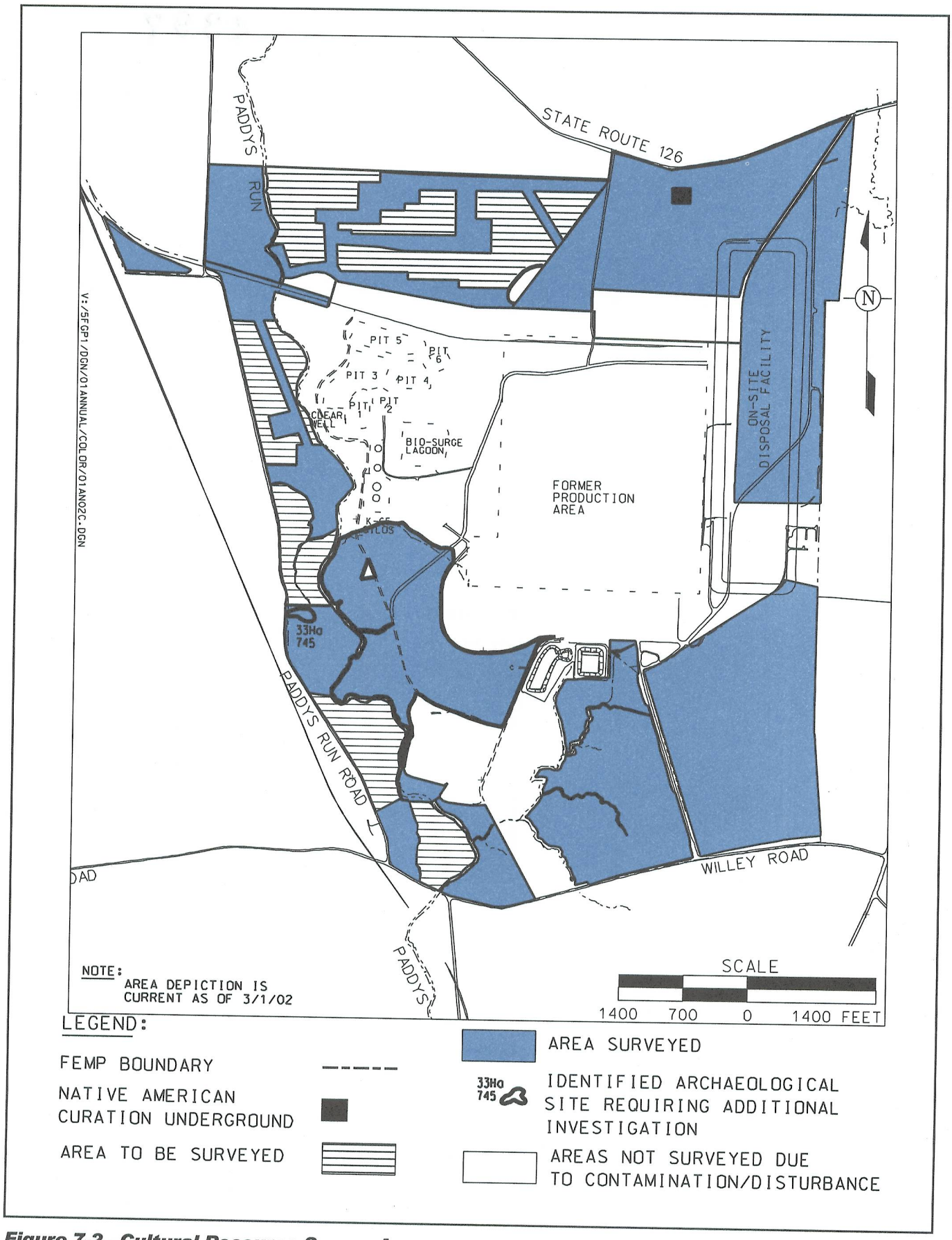

Figure 7-2. Cultural Resource Survey Areas

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Glossary

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.

Remedial Response — A long-term action potentially involving site characterization, risk assessment, a technology treatability study, a feasibility study, a remedial design, and remedial implementation.

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 FEMP'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 FEMP waste (such as the Nevada Test Site) have specific waste acceptance criteria. In addition, the FEMP on-site disposal facility has waste acceptance criteria that have been approved by the regulatory agencies. The FEMP Waste Acceptance Organization is responsible for ensuring that all waste to be placed in the on-site disposal facility meet all these criteria before waste placement.

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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 c 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 rive This is also called a buried channel or sand and gravel aquife

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

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

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

Opacity — How much light is blocked by particulates present in stack emissions.

Overpacking — The act of placing a deteriorating drum inside a new, larger d 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 o neutrons and protons in an atom's nucleus and their characte decay processes.

Receptors — Individuals or organisms that are or could potentially be impa by contamination.

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

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ture Zone — Estimated area that is being "captured" by pumping of groundwater extraction wells. Definition of capture zone is important in ensuring that the uranium plumes targeted for clean up are being remediated.

tification — The process by which a soil remediation area is certified as clean. Samples from the area are collected, 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 on site require excavation before certification is done.

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

trolled Runoff — Contaminated storm water requiring treatment that is collected, treated, and eventually discharged to the Great Miami River as treated effluent.

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

e — Quantity of radiation absorbed in tissue.

logical 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.

ctive 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 health-effects risk of 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).

osure 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.

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

Glossary

10-year, Uranium-based Restoration Footprint

The 10-year, uranium-based restoration footprint shows the anticipat areal extent of the effects of aquifer restoration activities on the Gre Miami Aquifer over the 10-year duration of the remediation as prese in aquifer restoration remedial design documents. The boundary of impact was developed using groundwater modeling results which sh the composite groundwater capture zone derived from the capture z for each extraction well.

ALARA

A phrase and acronym (As Low As Reasonably Achievable) used t describe an approach to radiation exposure and emissions control or management whereby exposures and resulting doses to workers and 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. I consists of two protons and two neutrons. It does not travel long distances and loses its energy quickly.

Applicable or Relevant and Appropriate Requirements (ARARs)

Requirements set forth in regulations that implement environmental a 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.

Aquifer

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

Background Radiation

Particle or wave energy spontaneously released from atomic nuclei i 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 tha has a mass and charge equal in magnitude to that of the electron.

Bypass Events

A bypass event occurs when storm water is bypassed around treatm and is directly discharged to the Great Miami River via the FEMP effluent line. Bypass events can occur during "significant precipitati or when water treatment facilities are down for maintenance. Bypa treatment is only implemented when the FEMP's storm water retent capacity is in danger of being exceeded.

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