LMS/FER/43783

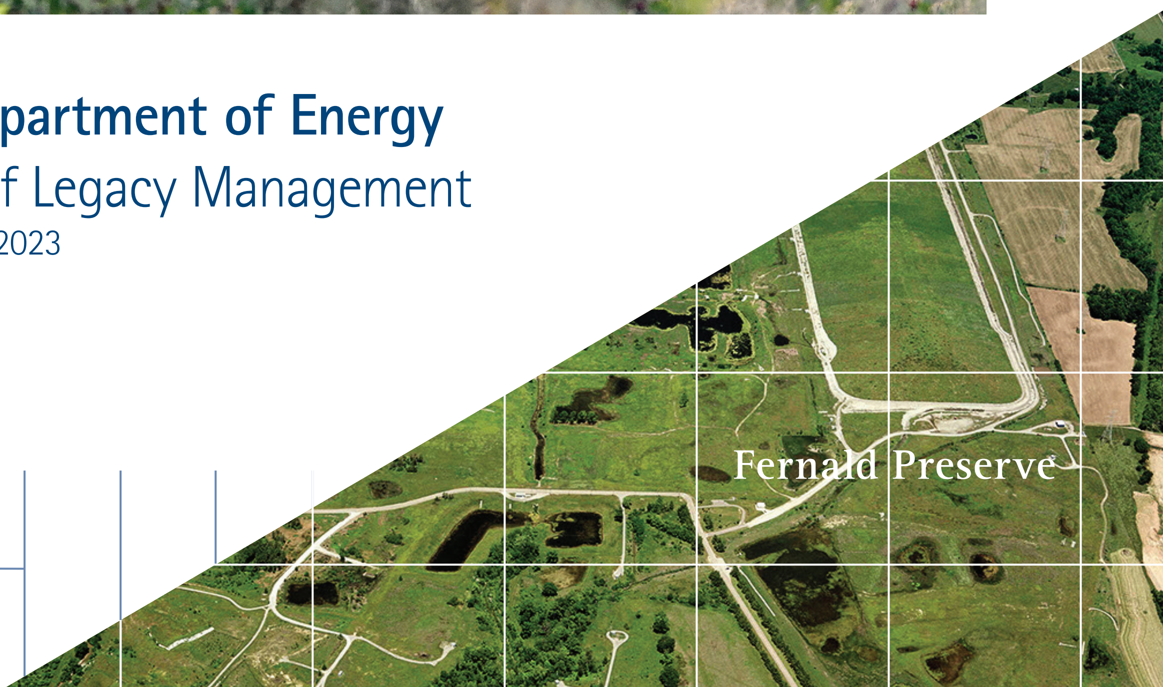
FERNALD PRESERVE

2022 Site Environmental Report

U.S. Department of Energy

Office of Legacy Management

Issued May 2023



Electronic versions of Fernald Preserve documents are available at
https://www.energy.gov/lm/fernald-preserve-ohio-site.
U.S. Department of Energy Office of Legacy Management's Geospatial Environmental Mapping System (GEMS) application is available at https://gems.lm.doe.gov/#site=FER

Contents

Figures

Tables

Appendixes

Abbreviations

ARAR	applicable or relevant and appropriate requirement
CAWWT	Converted Advanced Wastewater Treatment
CC	coefficient of conservatism
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FFCA	Federal Facility Compliance Agreement
FQAI	Floristic Quality Assessment Index
FRL	final remediation level
IEMP	Integrated Environmental Monitoring Plan
LCS	leachate collection system
LDS	leak detection system
LM	Department of Energy, Office of Legacy Management
LMICP	*Comprehensive Legacy Management and Institutional Controls Plan*
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRMP	*Fernald Preserve, Ohio, Site Natural Resource Management Plan*
NRRP	Natural Resource Restoration Plan
ODNR	Ohio Department of Natural Resources
Ohio EPA	Ohio Environmental Protection Agency
OSDF	On-Site Disposal Facility
OU5 ROD	Operable Unit 5 Record of Decision
PFAS	per- and polyfluoroalkyl substances
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
PPDD	Pilot Plant Drainage Ditch
RAMP	Restored Area Maintenance Plan
RCRA	Resource Conservation and Recovery Act
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act of 1986
SSOD	storm sewer outfall ditch
USC	*United States Code*

Executive Summary

The *Fernald Preserve 2022 Site Environmental Report* provides stakeholders with the results from the Fernald Preserve, Ohio, Site's environmental and ecological monitoring programs for 2022; a summary of U.S. Department of Energy (DOE) activities conducted onsite; a status of the ongoing groundwater remediation; and a summary of the site's compliance with the various environmental regulations, compliance agreements, and DOE policies that govern site activities. This report has been prepared in accordance with the Integrated Environmental Monitoring Plan, which is Attachment D of the *Comprehensive Legacy Management and Institutional Controls Plan* (LMICP).

Remediation of the Fernald Preserve has been successfully completed, with the exception of the groundwater. During 2022, activities at the Fernald Preserve included the following:

- Environmental monitoring activities related to groundwater and surface water
- Monitoring as specified in the site's National Pollutant Discharge Elimination System (NPDES) permit
- Extraction, monitoring, and treatment of contaminated groundwater from the Great Miami Aquifer (Operable Unit 5)
- On-Site Disposal Facility (OSDF) leak detection monitoring and collection, monitoring, and treatment of leachate from the OSDF
- Ecological restoration monitoring and maintenance, as well as inspections, care, and monitoring of the site and the OSDF to ensure that provisions of the LMICP are fully implemented
- Ongoing operation of the Fernald Preserve Visitors Center, associated outreach, and educational activities

Environmental monitoring programs were developed to ensure that the remedy remains protective of the environment. The requirements of these programs are described in detail in the LMICP and reported in this Site Environmental Report as outlined below.

Liquid Pathway Highlights

Groundwater Pathway

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

- Verify that hydraulic capture of the total uranium plume is maintained; track the aquifer restoration in the area of the plume, including non-uranium constituents; and evaluate water quality conditions in the aquifer that may indicate a need to modify the design or the operation of the well field.
- Meet compliance-based groundwater monitoring obligations.

During 2022, active restoration of the Great Miami Aquifer continued. A total of 93 groundwater monitoring wells were sampled to determine water quality. Aquifer water elevations were measured in 172 groundwater monitoring wells. The following highlights describe the key findings from the 2022 groundwater data:

- A total of 2 billion gallons of groundwater was extracted from the Great Miami Aquifer, and 354 pounds (lb) of uranium were removed from the aquifer in 2022.
- Since 1993, 55 billion gallons of water have been pumped from the Great Miami Aquifer, and 15,751 net pounds of uranium have been removed from the Great Miami Aquifer. Net pounds of uranium removed include a small amount of uranium that was reinjected into the aquifer between 1998 and 2004.
- Data collected in 2022 indicate that uranium concentrations within the footprint of the 30 micrograms per liter (µg/L) maximum uranium plume continue to decrease in response to pumping. The footprint of the maximum uranium plume in 2022 was approximately 74.0 acres, a decrease of 1 acre or approximately 1.3% from what was mapped in 2021. Since 2005, the area of the total uranium plume has decreased from 196.1 acres to 74.0 acres (62.3%).
- The results of the groundwater capture analysis and monitoring for total uranium and non-uranium constituents indicate that the design of the groundwater remedy for the aquifer restoration system remains appropriate for capture of the plume.
- 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.

Groundwater Remedy

The current Operational Design for the groundwater remedy has been in effect since design changes were implemented on July 1, 2014. Three extraction wells that were no longer providing benefit to the remediation were shut down, and the pumping capacity from these wells was reallocated to extraction wells in the South Plume and southern portion of the South Field to accelerate cleanup of those areas. The system pumping rate was increased 300 gallons per minute (gpm) from 4,775 gpm to 5,075 gpm.

The current Operational Design is more aggressive than the previous design because, for the first 9 years, the target system pumping rate is 300 gpm higher. The current Operational Design is also more efficient because pumping rates are initially higher in the more concentrated areas of the plume, resulting in lower overall pumping rates as the remedy progresses. No planned operational changes to the groundwater remediation occurred in 2022, but two South Plume extraction wells were shut down permanently due to maintenance issues. As discussed below, DOE is planning to install two new extraction wells in the South Plume.

Data collected in 2022 show that more uranium was removed from the aquifer than the model predicted would be removed. This indicates that pumping remains effective in removing uranium, but that the cleanup will take longer than the model predicted. Higher pumping rates are also taking a toll on some of the extraction wells. Chemical treatments, to combat iron fouling in the extraction wells, are becoming less effective over time, and the chemical used in the treatments is slowly compromising the integrity of the metal components of the extraction wells.

As reported in the 2020 Site Environmental Report (DOE 2021), additional groundwater modeling was needed to determine whether the system could be optimized again, as it was in 2014. Modeling was completed in early 2022. The groundwater model was updated with uranium concentrations measured in the first half of 2021. Updated cleanup date predictions for the South Plume, the South Field and the Waste Storage Area were determined to be 2025, 2038, and 2045, respectively. These new cleanup time predictions assume that the no wellfield pumping changes are made to the current operational design. Continued use of the existing South Plume wells to complete remediation of the South Plume carried unacceptable risk. The aging extraction wells in the South Plume are no longer dependable. Some have been operating for over 28 years. Also, due to remediation progress, the wells are no longer located in optimal locations to complete remediation of the remaining South Plume.

DOE completed additional modeling in 2022 that provides an alternate operational approach to completing remediation of the South Plume. DOE is planning to install two new extraction wells in the South Plume. These two new wells are scheduled to be operational in 2024. When operational, the remaining old South Plume wells will no longer be needed to maintain capture of the South Plume or to complete the remediation of the South Plume.

DOE collaborated with the DOE National Laboratory Network in 2021 through two focus groups to determine ways to address the continuing issues with the aging aquifer restoration infrastructure (Focus Group 1) and improve the efficiency of the aquifer cleanup (Focus Group 2). DOE has begun implementing National Laboratory Network recommendations. With approval from the U.S. Environmental Protection Agency (EPA) and the Ohio Environmental Protection Agency (Ohio EPA), DOE conducted a small-scale field test on two recently rehabilitated extraction wells to determine whether routine chemical treatment with a biocide agent might improve biofouling issues in the wells better than periodic treatment with acid. The small-scale test ran for approximately 6 months from fall 2021 to late spring 2022. Based on the field test results, it was determined that the tested routine process provided no improvement in specific capacity (i.e., gallons of water pumped per foot of water drawdown in the well) than the periodic treatment has provided. DOE will continue to investigate ways to address maintenance issues of an aging system of extraction wells. All three National Laboratory Network recommendations from the first focus group pertain to extending the life of an extraction well. Considering the age of the existing extraction wells, rather than trying to prolong their lives further, the best option may be to just begin to strategically replace them. DOE will revisit all three of Focus Group 1 recommendations as deemed appropriate when replacement of an extraction well is being considered.

DOE is also implementing National Laboratory Network recommendations that target improving the aquifer remediation and providing better model predicted cleanup dates (Focus Group 2). In late 2022 to early 2023 DOE completed work using alternative mathematical functions to trend uranium concentration data and using three-dimensional aquifer interpretations over time to improve plume metrics used to assess cleanup progress. Both methods have been successfully added to the Fernald Preserve toolbox for evaluation of the aquifer remedy. More information concerning the National Laboratory Network collaboration and recommendations is provided in Section 3.4 and Appendix A.

The aquifer remedy in the current Operational Design is achieving the uranium discharge limits (i.e., average monthly concentration of less than 30 µg/L and 600 lb annually) established in the

Operable Unit 5 Record of Decision without routine groundwater treatment. Routine groundwater treatment has not been needed since 2010. Occasionally, groundwater is sent to treatment for very short periods of time. The reasons for the short periods of treatment vary, but most are related to times when wells pumping low uranium concentrations are turned off for maintenance and wells pumping higher uranium concentrations continue pumping.

In 2022, 2 billion gallons of groundwater were pumped from the Great Miami Aquifer and 4.5 million gallons (0.22%) of groundwater were treated.

OSDF Monitoring

Engineered features within the OSDF continue to perform as designed, indicating that a leak from the facility is not occurring. Leachate flow continues to diminish as expected, and leak detection system flow volumes indicate that the cell liners are performing as designed.

A few OSDF valve house maintenance issues were addressed in 2022. Over the years, several small, very minor leaks have occurred in the valve house piping that so far have been easily repaired. The liquid was contained within the valve houses and attributed to galvanic corrosion between two different types of metal components of the piping system. Rather than wait for more leaks to develop, with concurrence from EPA and Ohio EPA, DOE began replacing the metal pipes in the valve houses with plastic piping in late 2022. Smaller sampling ports are also being installed in the leachate detection system lines as part of the project.

In late 2021, a small amount of water was observed in OSDF valve house 7 in the area where the leachate collection system piping penetrates the valve house walls and enters the valve house through the east wall of the valve house. The leachate collection system is a double-walled pipe; the secondary containment system contained no liquid indicating that the liquid was not coming from the leachate collection system. The amount of liquid increased after precipitation events. Sampling of the liquid entering the valve house revealed that the uranium concentration matched the very low historical uranium concentrations in the perched groundwater in the area; therefore, the liquid in the valve house is attributed to water leaking into the valve house from immediately outside the valve house wall. DOE repaired the leak in valve house 7 in summer 2022. Unfortunately, additional leaks occurred along the inner surface of the same wall following the repair. It is believed that once the initial leak was fixed, later collection of water on the outside of the valve house wall found other entry points through the wall. Based on the nature of the leaks observed, it is assumed that water is collecting around the base of the east side of the valve house. DOE plans to investigate further when seasonal precipitation is lowest (i.e., late summer and early fall). If deemed appropriate, an engineered fix (e.g., French drain) will be evaluated.

Surface Water and Effluent Pathway

Surface water and effluent are monitored to determine the effects of Fernald Preserve activities on Paddys Run (an intermittent stream), the Great Miami River, and the underlying Great Miami Aquifer, as well as to meet compliance-based surface water and effluent monitoring obligations.

In 2022, 18 surface water locations and 1 effluent location were sampled at various frequencies. The following highlights describe the key findings from the 2022 surface water and effluent monitoring programs:

- Since 1995, the annual uranium mass discharged in Fernald Preserve effluent to the Great Miami River has been less than the Operable Unit 5 Record of Decision limit of 600 lb per year. A total of 335 lb of uranium was discharged in effluent to the Great Miami River in 2022.

- An estimated 32.4 lb of uranium were released to the environment through uncontrolled stormwater runoff from the site. Therefore, the total amount of uranium released through the effluent and uncontrolled surface water pathways during 2022 is estimated to be 367.4 lb.
- Analytical results of 7 of 31 surface water samples collected from location SWD-09 exceeded the surface water final remediation level for total uranium in 2022, the site's primary contaminant. SWD-09 is one of the two locations established to monitor the 2007 maintenance action completed west of the former Waste Pits Area. The second location, SWD-05, did not exceed the surface water final remediation level for uranium in 2022. These locations are in an area of the site that is not accessible to the public.

  Analytical results of surface water samples collected at location SWD-09 have been trending downward since 2010. The surface water from this area remains isolated and does not drain normally to Paddys Run; it either evaporates or infiltrates into the ground. Any infiltration down to the aquifer in this area is within the capture zone of nearby extraction wells operating as part of the groundwater remediation.
- Compliance sampling, consisting of sampling for nonradiological pollutants from uncontrolled runoff in the Storm Sewer Outfall Ditch and effluent discharges from the Fernald Preserve, is regulated under the state-administrated NPDES program. Discharges in 2022 were in compliance with limits identified in the NPDES permit.

In 2021, a review of surface water results at several locations over the past 10 years indicate that reductions in the surface water program are warranted. These reductions were incorporated into the surface water monitoring program for 2023 with approval of the LMICP. The final analytical results for these locations, which are all well within historical ranges, are presented in Appendix B.

Based on the number of years of data collected, DOE is proposing to reduce the weekly sampling at SWD-05 and SWD-09 to a semi-annual frequency to align with the surface water monitoring program outlined in the LMICP. Additional details are provided in Section 4.3.1 and Appendix B.

Natural Resources

The focus of restored area maintenance activities in 2022 involved continued eradication of invasive species, including targeted efforts on teasel species (*Dipsacus* species), giant reed (*Phragmites australis*), lesser celandine (*Ficaria verna*) and callery pear (*Pyrus calleryana*). Fall foliar herbicide application to Amur honeysuckle (*Lonicera maackii*), in conjunction with manual removal, also continued in 2022. Approximately 3 acres of restored prairie, heavy with invasive teasel (*Dipsacus* species), were mowed in the winter, treated with herbicide in the spring, and are planned to be overseeded with prairie seed mix in 2023. In total, approximately 323 acres were addressed for invasive species.

Prescribed burning is a prairie management tool used on the site. In 2022, DOE and the U.S. Forest Service entered into an inter-agency agreement to conduct prescribed burns at the site. On December 2, 2022, the U.S. Forest Service conducted two prescribed burns, burning approximately 20 acres of prairie in the Former Production Area. Additional detail is provided in Section 5.1.

In 2020, the Fernald Natural Resource Trustees conducted a 10-year review of the Restored Area Maintenance Plan, pursuant to the Natural Resource Restoration Plan. That review resulted in the development of the Natural Resource Management Plan (NRMP). This document presents a revised community-based approach for management and evaluation of ecologically restored areas across the Fernald Preserve. DOE implemented the Natural Resource Management Plan in 2021. Functional monitoring in 2022 continued to utilize a community-based approach, pursuant to the NRMP. The NRMP was incorporated as Appendix A of Volume I of the 2023 LMICP (DOE 2023).

Floristic inventories were conducted in prairie and successional areas across the site. Results of this effort indicate the ongoing presence of native vegetation within remediation prairie and remediation successional communities. The prairies appear to have plateaued in their development, as findings in 2022 were consistent with previous years. Early signs of ecological succession were observed in the remediation successional areas. Vegetation monitoring also occurs on the OSDF. These data are reported in the quarterly inspection reporting process. DOE is proposing that beginning in 2023, OSDF vegetation data be reported in the Site Environmental Report rather than the quarterly inspection reporting process. Additional information regarding monitoring activities for evaluation of ecologically restored communities is provided in Appendix C.

Quarterly site and OSDF inspections continued in 2022. Findings were mainly invasive vegetation and damage to deer exclosure fence in the restored areas, and woody vegetation on the cap of the OSDF. Starting in 2022, inspection findings are summarized in the Site Environmental Report and not reported quarterly, unless the finding is related to activity and use limitations of the site. This was the case for one finding in 2022. During the December 2022 inspection, it was discovered that the Main Drainage Corridor culvert was in need of repair. Concrete had degraded, which caused a grate preventing access to the culvert to become dislodged. Plans are being developed to repair the grating in 2023. Additional details on this finding are in Section 5 and Appendix C.

Debris continues to be found, primarily in the Former Production Area and the former Waste Storage Area. Examples of debris include pieces of concrete, rebar, clay tile, and metal. Weather, erosion, and earth-moving activities occasionally reveal small pieces of debris that were not visible during remediation and restoration efforts. A total of 128 pieces of debris were removed in 2022. No debris had fixed radiological contamination above background levels. A summary table of annual debris counts is provided in Appendix C, Table C-6.

With regulatory approval of the LMICP (DOE 2023) in early 2023, annual site inspection photographs will no longer be completed and reported in the Site Environmental Report. The 2022 set of photographs taken are provided in Appendix C along with the earliest photograph at each location. This final set of photographs demonstrates the ecological restoration progress across the site.

1.0 Site Background

Abbreviated Timeline: 1951-2006

1951	Construction of the Feed Materials Production Center began.
1952	Uranium production started.
1986	U.S. Environmental Protection Agency (EPA) and U.S. Department of Energy (DOE) signed the Federal Facility Compliance Agreement, thus initiating the remedial investigation/feasibility study process under the National Contingency Plan.
1989	Uranium production suspended. The Fernald site was placed on the National Priorities List, Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites most in need of cleanup.
1991	As part of the Amended Consent Agreement, the site was divided into operable units for characterization and remedy determination. Uranium production formally ended. The site mission changed from uranium production to environmental remediation and site restoration.
1992	Large-scale groundwater pumping to contain the off-property South Plume began.
1994	Decontamination and dismantling of the first building was completed under the Operable Unit 3 Interim Record of Decision (ROD).
1996	The last operable unit's ROD was signed, signifying the end of the 10-year remedial investigation/feasibility study process. (The Operable Unit 4 ROD was later reopened.) Construction began in support of the Operable Unit 1 selected remedy. Soil remedial excavation began as part of the Operable Unit 5 selected remedy.
1997	Construction of the On-Site Disposal Facility (OSDF) began. First waste placement began in December. Environmental monitoring and reporting were consolidated under the Integrated Environmental Monitoring Plan.
1998	Operable Unit 2 remedial excavations began.
1999	Excavation of the waste pits began (Operable Unit 1 ROD), and the first rail shipment of waste was transported to Envirocare of Utah, Inc.
2000	The ROD Amendment for Operable Unit 4 Silos 1 and 2 Remedial Actions was signed by EPA, thus establishing a new selected remedy for Operable Unit 4.
2001	Cell 1 of the OSDF was capped. Remediation of the Operable Unit 2 Southern Waste Units was completed.
2002	The Silos 1 and 2 Radon Control System began operation and successfully reduced radon levels within the silos. The offsite transfer of nuclear product material was completed. Wastes were placed in OSDF Cells 2 through 5.
2003	All major Operable Unit 2 remedial actions were completed. In addition, approximately 412,000 cubic yards of waste were placed in OSDF Cells 3 through 6.
2004	Removal of Silos 1 and 2 wastes from the silos to the holding tank facility began. Plans to reduce the size of the site's wastewater treatment infrastructure were approved and implemented. The last of Fernald's 10 uranium production complexes, plus an additional 35 structures and 73 trailers, were demolished. All eight cells of the OSDF were capped or received waste. Approximately 513,000 cubic yards of waste were placed in Cells 4 through 8.
2005	Removal of Operable Unit 4, Silo 3 waste began and the first shipment of this waste arrived at Envirocare of Utah. Remedial actions for Operable Unit 1 were completed in June. The first shipment of Silos 1 and 2 waste arrived at Waste Control Specialists in Texas.
2006	With the exception of groundwater remediation, site remediation was completed October 29, 2006. The site was officially transferred to DOE's Office of Legacy Management on November 17, 2006.

In 1951, the U.S. Atomic Energy Commission, a predecessor agency of the U.S. Department of Energy (DOE), began building the Feed Materials Production Center on a 1,050-acre 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, more than 500 million pounds (lb) of uranium metal products were delivered to other sites. These production operations caused releases to the surrounding environment, which resulted in contamination of soil, surface water, sediment, and groundwater on and around the site.

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, also known as Superfund), as amended (Title 42 *United States Code* Section 9601 et seq. [42 USC 9601 et seq.]). The site was renamed the Fernald Environmental Management Project in 1991. In 2003, the site name changed to the Fernald Closure Project to reflect the mission of the site as on a path to closure. In 2007, the site name changed to the Fernald Preserve to reflect the completion of the cleanup (with the exception of groundwater) ushered in by the successful transition to the DOE Office of Legacy Management (LM) in late 2006. In addition to completing groundwater remediation, the LM mission is now to be an asset to the community as an undeveloped park, with an emphasis on wildlife.

Abbreviated Timeline: 2006 - Present	
2008	The old Silos Warehouse was remodeled into the new Fernald Preserve Visitors Center and opened to the public in August 2008. The community was allowed unescorted access to the Fernald Preserve.
2012	The throughput capacity of the Converted Advanced Wastewater Treatment Facility (CAWWT) was reduced from 1,800 gallons per minute (gpm) to 500−600 gpm.
2014	On July 1, 2014, a new groundwater remediation operational design was implemented (DOE 2014). The target system pumping rate was 300 gpm higher than the previous design and accelerated cleanup.
2015	The decision to reduce wastewater treatment capacity to 50 gpm was made.
2017	Completed removal of treatment media, demolition of existing piping and tanks to allow room for the new wastewater treatment system within CAWWT, and design of the new system, which began in 2016. Low-level radioactive waste from the demolition project was disposed of at Waste Control Specialists in Texas. Construction of the new treatment system began.
2018	The new water treatment system became operational in April 2018.
2019	The refurbished CAWWT backwash basin was operational in November 2019.

DOE's Legacy Management Support contractor continues to perform site activities, including the ongoing groundwater remedy. The U.S. Environmental Protection Agency (EPA) Region 5 and the Southwest District Office of the Ohio Environmental Protection Agency (Ohio EPA) provide regulatory oversight.

In the 1980s, the goals of environmental monitoring were 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 (agricultural produce). The goal was to measure the levels of contaminants associated with uranium production operations and report this information to the regulatory agencies and stakeholders.

After the conclusion of the site's uranium production and the completion of the CERCLA remedy selection process, the focus was on the safe and efficient implementation of environmental remediation activities and facility decontamination and dismantling operations. In recognition of this shift in emphasis toward remedy implementation, in 1997 the environmental monitoring program was revised to align with the remediation activities planned for the Fernald site. The site's environmental monitoring program is described in the Integrated Environmental Monitoring Plan (IEMP), which is Attachment D of the *Comprehensive Legacy Management and Institutional Controls Plan* (LMICP) (DOE 2019). Noting that it is expected that fewer changes to the LMICP will be required, DOE proposed to EPA and Ohio EPA that the variance process established in the Fernald Preserve Quality Assurance Project Plan (DOE 2014) be used to communicate LMICP changes instead of updating the entire document each year. This process was approved, and changes required to be implemented for calendar year 2021 were documented and approved by the regulatory agencies in January 2021. This process was again utilized in 2022; a full revision of the LMICP was completed and approved for implementation in calendar year 2023 (DOE 2023).

The environmental monitoring program is designed to ensure the continued protectiveness of the completed remedial actions as well as implementation of the ongoing groundwater remedy and performance of the On-Site Disposal Facility (OSDF). This *Fernald Preserve 2022 Site Environmental Report* summarizes the findings from the monitoring program and provides a status on the progress toward final site restoration. This report consists of the following:

- **Summary Report:** The summary report (Sections 1.0 through 5.0) documents the results of environmental monitoring activities at the Fernald Preserve in 2022. It includes a discussion of ongoing groundwater remediation activities and summaries of environmental data from groundwater, surface water and effluent, and natural resources monitoring programs. It also summarizes the information contained in the appendixes. A glossary is included at the end of the summary report.

- **Appendixes:** The detailed appendixes provide the 2022 environmental monitoring data for the various media, primarily in the form of graphs, figures, and tables. The appendixes are generally distributed only to the regulatory agencies. However, a complete copy of the appendixes is available on the LM public website at https://www.energy.gov/lm/fernald-preserve-ohio-site or by contacting LM at (513) 648-3333; by contacting Interpretive Service at (513) 648-6000; or by sending an email to fernald@lm.doe.gov.

CERCLA Remedial Process

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. Activities include the feasibility study and proposed remedial action plan. After public comments are received and addressed, a remedy is selected and documented in a ROD.

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 CERCLA five-year review process is triggered by the onset of construction for the first operable unit remedial action that will result in hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure. Of all the operable units, the site preparation construction to support the Waste Pits Project under the Operable Unit 1 ROD (DOE 1995b) was the first such action. This construction began on April 1, 1996. To date, DOE has conducted, and the regulatory agencies have approved, five CERCLA five-year reviews (April 2001 [DOE 2001c], April 2006 [DOE 2006b], September 2011 [DOE 2011], September 2016 [DOE 2016b]), and September 2021. These reviews verify that the remedy remains effective and continues to be protective of human health and the environment.

Long-Term Stewardship of CERCLA Remedies: Site closure, relative to the completion of remediation, was defined in the contract between Fluor Fernald Inc. and DOE as the physical completion of the scope of work required by the five RODs with the exception of the groundwater remedy.

LM assumed the long-term surveillance monitoring and maintenance of the Fernald site on November 17, 2006, to ensure continued protection of human health and the environment and continued operation of the groundwater remedy. The *Comprehensive Legacy Management and Institutional Controls Plan* (DOE 2019) defines the activities to be conducted with respect to long-term stewardship at the Fernald Preserve. The CERCLA five-year review process will continue to provide stakeholders information on remedy performance and long-term stewardship.

The remainder of this introductory Section 1.0 provides:

- An overview of the environmental remediation completed as well as ongoing remedy implementation.
- A description of environmental monitoring activities at the Fernald Preserve.
- A description of the physical and ecological characteristics of the Fernald Preserve.

1.1 The Path to Site Closure

In 1986, the Fernald site initiated working through the CERCLA process to characterize the nature and extent of contamination at the site, to establish risk-based cleanup standards, and to select the appropriate remediation technologies to achieve those standards. To facilitate this process, in 1991 the site was organized into five operable units. The purpose of the operable unit concept under CERCLA was to organize site components by geographical location and by the potential for similar technologies to be used for environmental remediation. The remedy selection process culminated in 1996 with the approval of the final Records of Decision (RODs) for all five operable units. However, several of the RODs (including those for Operable Units 1, 4, and 5) have subsequently been modified through issuance of Explanation of Significant Difference documents or ROD Amendment documents. These documents were prepared, submitted for EPA and public review, and issued in accordance with CERCLA regulations. Following approval of the initial RODs, work began on the design and implementation of the operable unit remedies. Table 1 describes each operable unit and gives an overview of its associated remedy.

Table 1. Operable Unit Remedies

Operable Unit	Description	Remedy Overview
1	• Waste Pits 1–6 • Clear well • Burn pit • Berms, liners, caps, and soil within the boundary	ROD approved: March 1995 Explanation of Significant Differences approved: September 2002 ROD Amendment approved: November 2003 Excavation of materials with constituents of concern above final remediation levels (FRLs), waste processing and treatment by thermal drying (as necessary), offsite disposal at a permitted facility, and soil remediation/certification. **Remedial actions completed: June 2005** **Final Remedial Action Report approved: August 2006**
2	• Solid waste landfill • Inactive fly ash pile • Active fly ash pile (now inactive) • North and South Lime Sludge Ponds • Other South Field areas • Berms, liners, and soil within the operable unit boundary	ROD approved: May 1995 Post-ROD fact sheet approved: April 1999 Excavation of all materials with constituents of concern above FRLs, treatment for size reduction and moisture control as required, onsite disposal in the OSDF, and offsite disposal of excavated material that exceeded the waste acceptance criteria for the OSDF. This was the first ROD to specify an onsite disposal in the OSDF. **Remedial actions completed: June 2006** **Final Remedial Action Report approved: September 2006**
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 • Coal pile • Scrap metals piles • Drums, tanks, solid waste, waste product, feedstocks, and thorium	ROD for Interim Remedial Action approved: June 1994 ROD for Final Remedial Action approved: August 1996 Adoption of Operable Unit 3 Interim ROD; alternatives to disposal through the unrestricted or restricted release of materials as economically feasible for recycling, reuse, or disposal; treatment of material for onsite or offsite disposal; required offsite disposal for process residues, product materials, process-related metals, acid brick, concrete from specific locations, and any other material exceeding the OSDF waste acceptance criteria; and onsite disposal for material that meets the OSDF waste acceptance criteria. Post-ROD fact sheet that identifies clean buildings, structures, and materials for beneficial reuse under LM. Approved: December 2006. **Remedial actions completed: October 2006** **Final Remedial Action Report approved: February 2007**

Table 1. Operable Unit Remedies (continued)

Operable Unit	Description	Remedy Overview
4	• Silos 1 and 2 (containing K-65 residues; demolished in 2005) • Silo 3 (containing cold metal oxides; demolished in 2006) • Silo 4 (empty and never used; demolished in 2003) • Decant tank system • Berms and soil within the operable unit boundary	ROD approved: December 1994 Explanation of Significant Differences for Silo 3 approved: March 1998 ROD Amendment for Silos 1 and 2 approved: July 2000 ROD Amendment for Silo 3 approved: September 2003 Explanation of Significant Differences for Silos 1 and 2 approved: November 2003 Explanation of Significant Differences for Operable Unit 4 approved: January 2005 Removal of Silo 3 materials for treatment and Silos 1 and 2 residues and decant sump tank sludges with onsite stabilization of materials, residues, and sludges followed by offsite disposal. Excavation of silos area soils contaminated above the FRLs with onsite disposal for contaminated soils and debris that met the OSDF waste acceptance criteria; and site restoration. Concrete from Silos 1 and 2 and contaminated soil and debris that exceeded the OSDF waste acceptance criteria were disposed of offsite. **Remedial actions for Silo 3 completed: April 2006** **Remedial actions involving the completion of the shipment of stabilized Silos 1 and 2 material to a temporary storage facility in Texas completed: May 2006.** **Final Remedial Action Report approved: September 2006** **Permanent disposal of the 3,776 containers of Silos 1 and 2 material began on October 7, 2009, and the last container was placed on November 2, 2009.**
5	• Groundwater • Surface water and sediments • Soil not included in the definitions of Operable Units 1 through 4 • Flora and fauna	ROD approved: January 1996 Explanation of Significant Differences was approved in November 2001, formally adopting EPA's Safe Drinking Water Act maximum contaminant level for uranium of 30 micrograms per liter as both the FRL for groundwater remediation and the monthly average uranium effluent discharge limit to the Great Miami River. Extraction of contaminated groundwater from the Great Miami Aquifer to meet FRLs at all affected areas of the aquifer. Treatment of contaminated groundwater, storm water, and wastewater to attain concentration and mass-based discharge limits and FRLs in the Great Miami River. Excavation of contaminated soil and sediment to meet FRLs. Excavation of contaminated soil containing perched water that presented an unacceptable threat through contaminant migration to the underlying aquifer. Onsite disposal of contaminated soil and sediment that met the OSDF waste acceptance criteria. Soil and sediment with contaminant concentrations that exceeded the waste acceptance criteria for the OSDF was treated, when possible, to meet the OSDF waste acceptance criteria or was disposed of at an offsite facility. Also includes site restoration, institutional controls, and postremediation maintenance. **Interim Remedial Action Report approved: August 2008**

1.2 Environmental Monitoring Program

In the 1980s, DOE initiated an environmental monitoring program to assess the impact of past operations on the environment and to monitor potential exposure pathways to the local community. Additionally, for nearly 10 years DOE conducted characterization activities at the Fernald site 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—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 removing the contamination that might be released through these exposure pathways and for monitoring these pathways to measure the site's continuing impact on the environment as remediation progressed. The characterization data used to develop the final remedy were also used to focus on and develop the environmental monitoring program documented in the IEMP. The following describes the IEMP's key elements:

- The IEMP defines monitoring activities for environmental media, such as groundwater, surface water and effluent, and natural resources. In general, the primary exposure pathway is monitored, and the program focuses on assessing the effect 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 are continually evaluated. For example, environmental data are routinely evaluated to identify any significant trends that may indicate the potential for an unacceptable future impact to human health or the environment if action is not taken.
- The IEMP is reviewed annually and revised as necessary to ensure that the monitoring program adequately addresses monitoring requirements.
- The IEMP consolidates routine reporting of environmental data into this comprehensive annual report.

1.3 Characteristics of the Site and Surrounding Area

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

1.3.1 Land Use and Demography

Economic activities in the area rely heavily on the physical environment. Land in the area is used primarily for crop farming and gravel pit excavation operations. A private water utility approximately 2 miles east of the Fernald Preserve pumps groundwater primarily for industrial use.

Downtown Cincinnati is approximately 18 miles southeast of the Fernald Preserve (Figure 1). The cities of Fairfield and Hamilton are 6 and 8 miles to the east and northeast, respectively (Figure 2). Scattered residences and several villages, including Fernald, New Baltimore, New Haven, Ross, and Shandon, are also near the site.

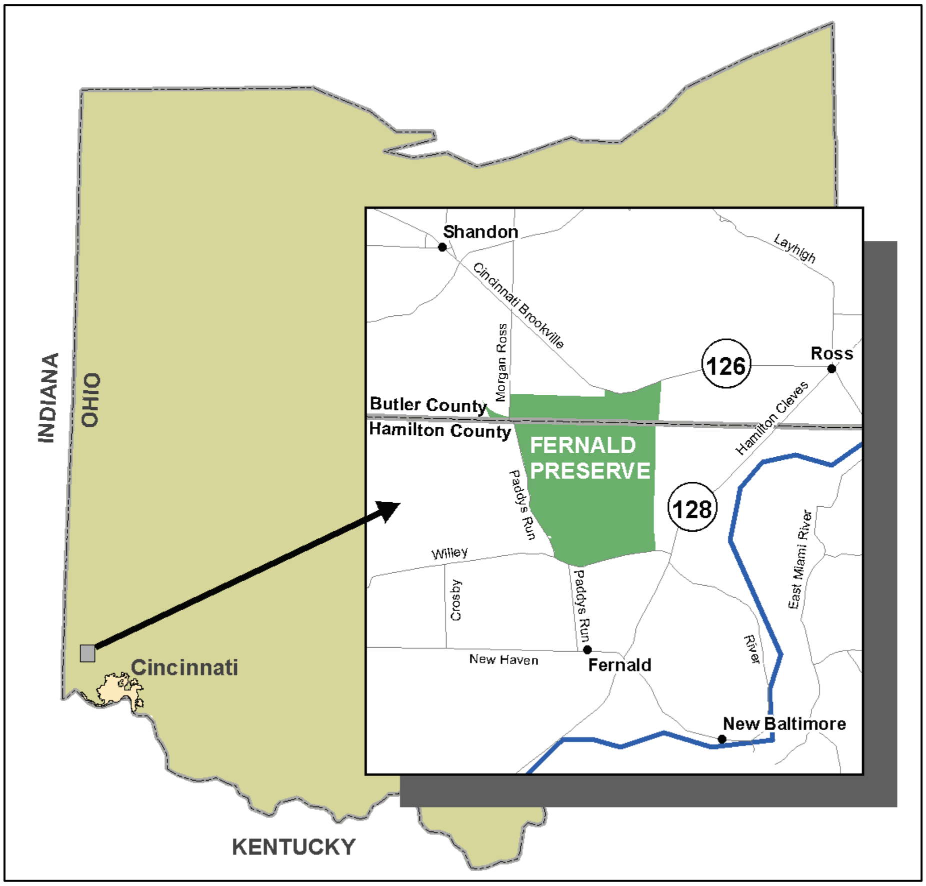


Figure 1. Fernald Preserve and Vicinity

1.3.2 Geography

Figure 3 depicts the location of the major physical features of the site, such as the buildings and supporting infrastructure. The Former Production Area and the OSDF dominate this view. The Former Production Area occupied approximately 136 acres in the center of the site and the OSDF occupies approximately 100 acres. The Great Miami River cuts a terraced valley to the east of the site, and Paddys Run (an intermittent stream) flows from north to south along the site's western boundary. In general, the site lies on a terrace that slopes gently among vegetated bedrock outcrops to the north, southeast, and southwest.

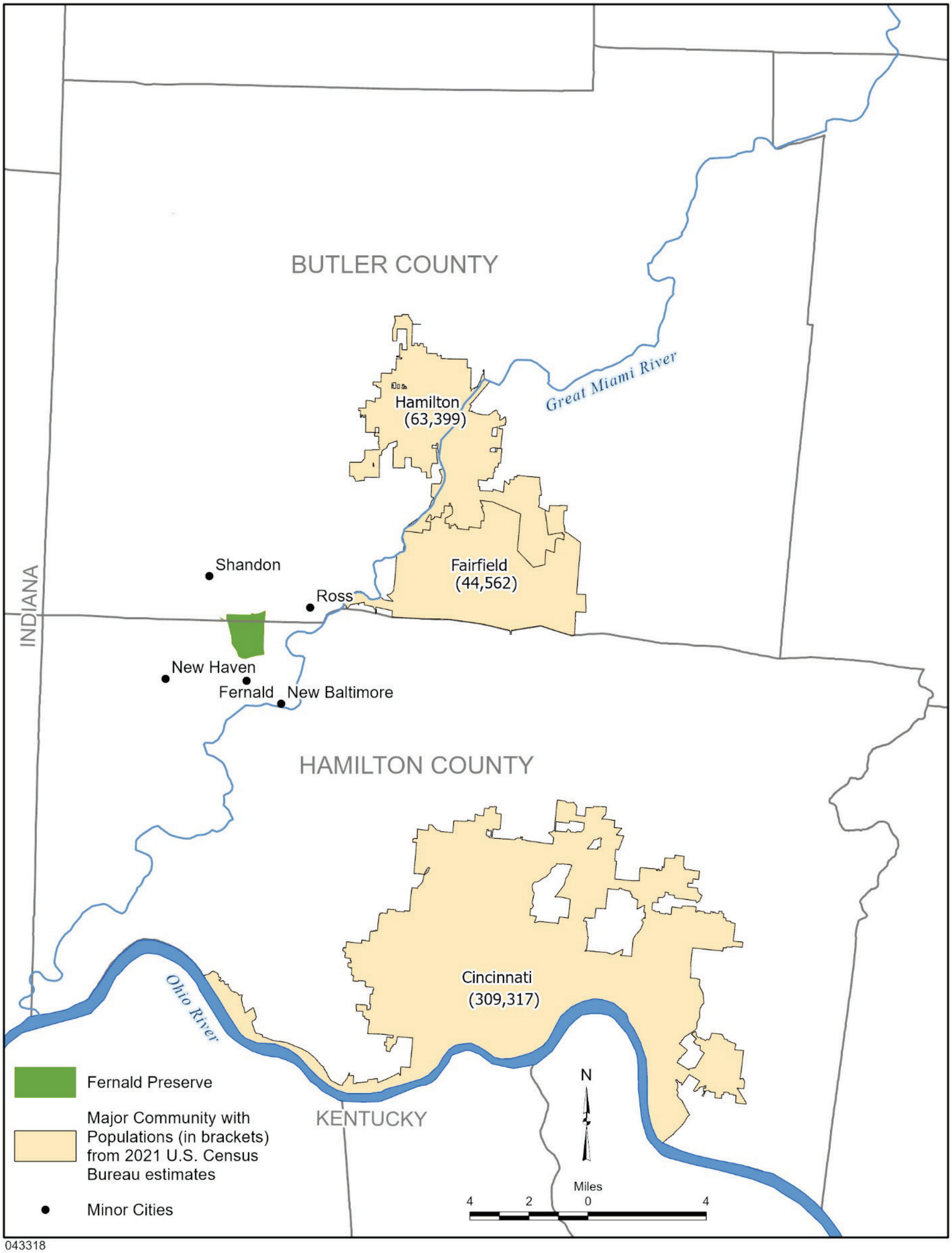


Figure 2. Major Communities in Southwestern Ohio

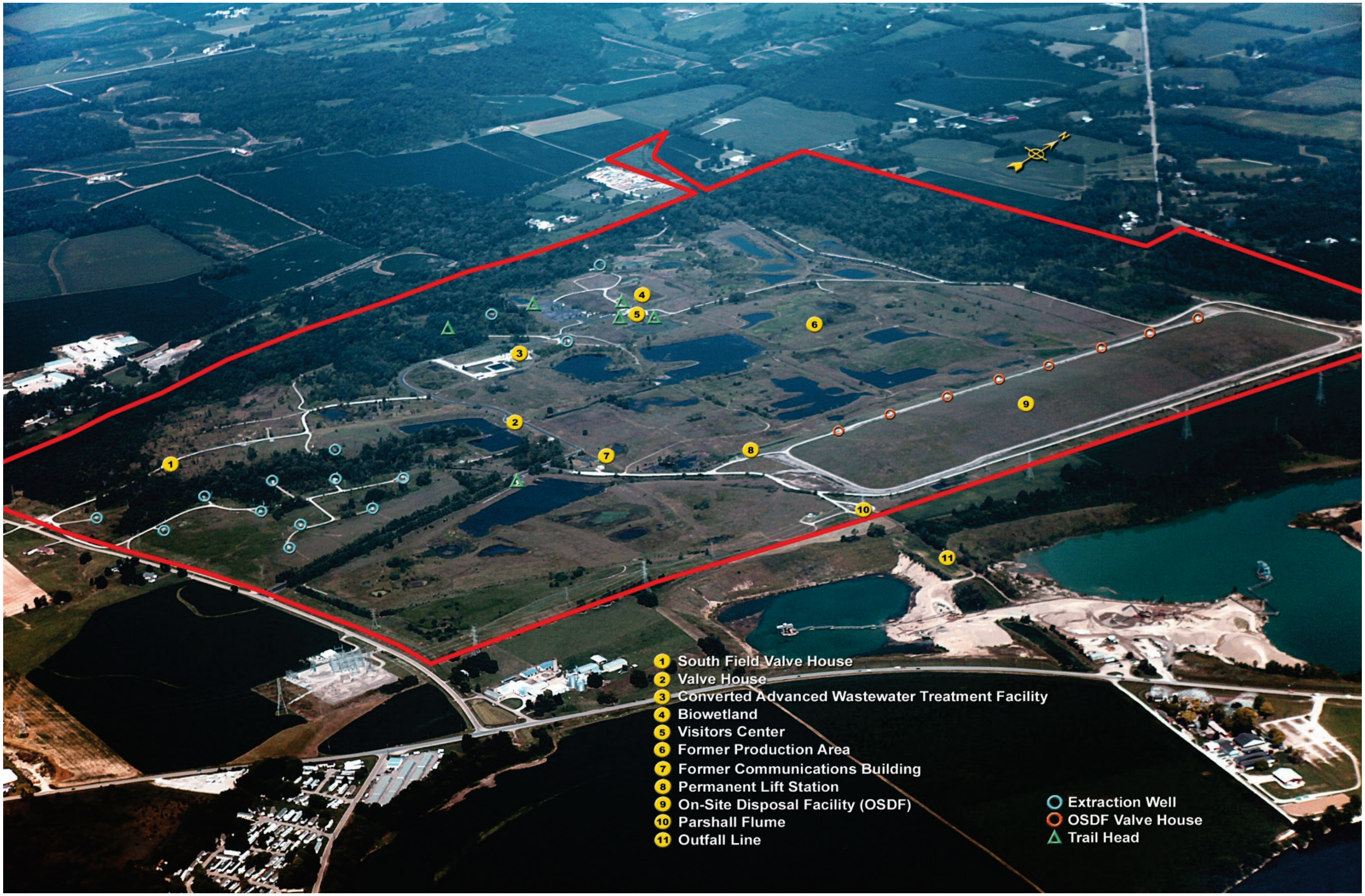


Figure 3. Fernald Preserve Perspective

1.3.3 Geology

Bedrock in the area indicates that approximately 450 million years ago a shallow sea covered the Cincinnati area. Sediments that later became flat-lying shale with interbedded limestone were deposited in the shallow sea, as evidenced by the abundance of marine fossils in the bedrock. In the more recent geologic past, the advance and retreat of three separate glaciers shaped the southwestern Ohio landscape. A large river drainage system south of the glaciers created river valleys up to 200 feet (ft) 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 a glacial overburden—a low-permeability mixture of clay and silt with minor amounts of sand and gravel—deposited across the land surface. The Fernald Preserve is situated on a layer of glacial overburden that overlies portions of a 2- to 3-mile-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 defines the edges and bottom of the New Haven Trough restricts 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 considerable portions of the glacial overburden and exposed the underlying sand and gravel of the Great Miami Aquifer. Thus, in some areas, precipitation and surface water runoff can easily migrate into the underlying Great Miami Aquifer and also transport contaminants to the aquifer. Natural and man-made breaches of the glacial overburden in some areas of the Fernald site were key pathways where contaminated water entered the aquifer, causing the groundwater contamination plumes that are being addressed by aquifer restoration activities. Figure 4 provides a view of the structure of subsurface deposits in the region along an east-west cross section beneath the site and through the New Haven Trough, and Figure 5 presents the regional groundwater flow patterns in the Great Miami Aquifer.

1.3.4 Surface Hydrology

The Fernald Preserve is in the Great Miami River drainage basin (Figure 6). Natural drainage from the site to the Great Miami River occurs primarily via Paddys Run. This intermittent stream begins losing flow to the underlying sand and gravel aquifer south of the former Waste Pits Area. Paddys Run empties into the Great Miami River 1.5 miles south of the site. The Great Miami River, 0.6 mile east of the Fernald Preserve, runs in a southerly direction and flows into the Ohio River about 24 miles downstream of the site. The segment of the Great Miami River between the Fernald Preserve and the Ohio River is not used as a source of public drinking water.

The average flow volume for the Great Miami River in 2022 was 4,629 cubic feet per second. This average is based on daily measurements collected at the U.S. Geological Survey Hamilton stream gauge (USGS 3274000) approximately 10 river miles upstream of the site's effluent discharge.

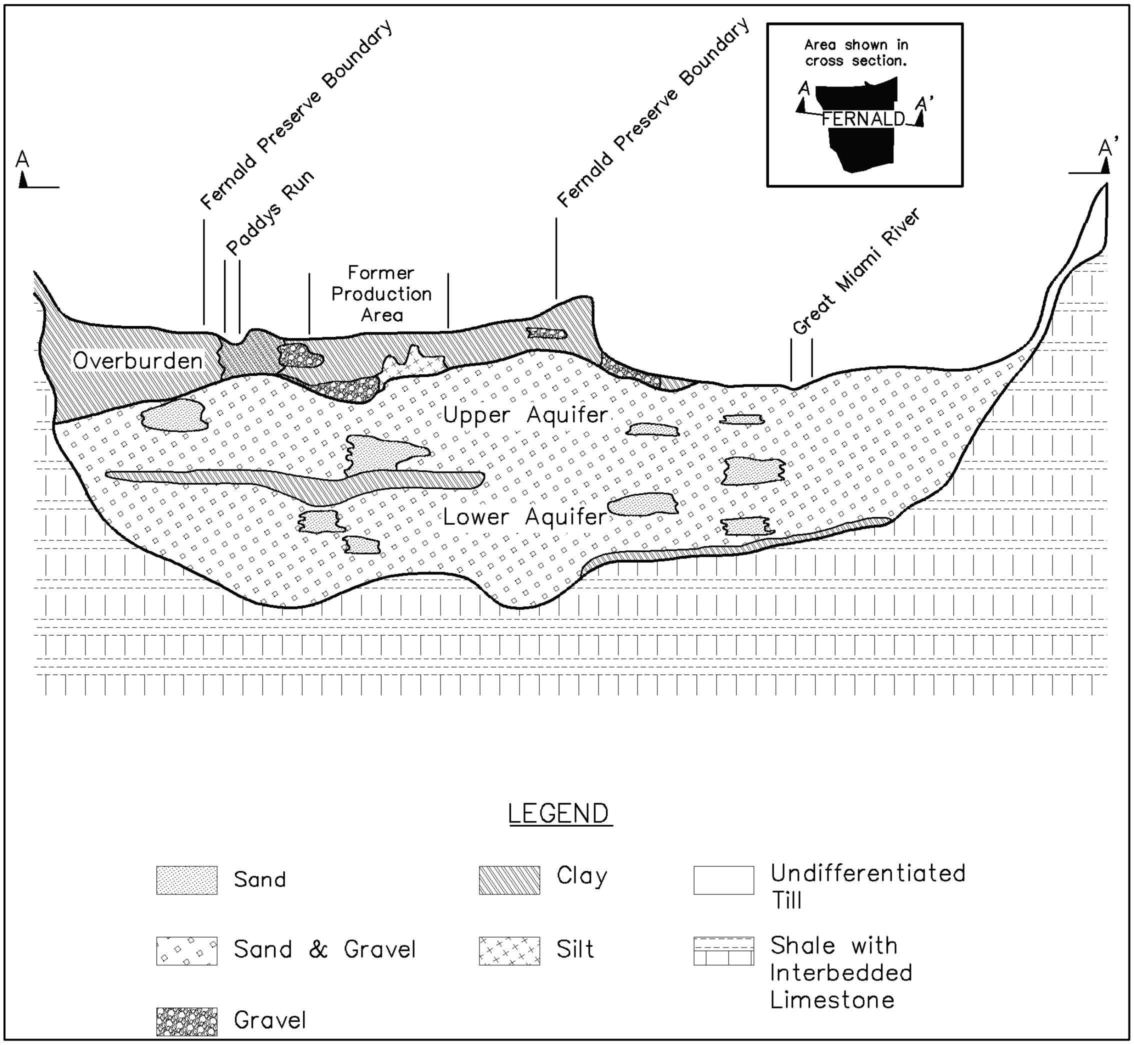
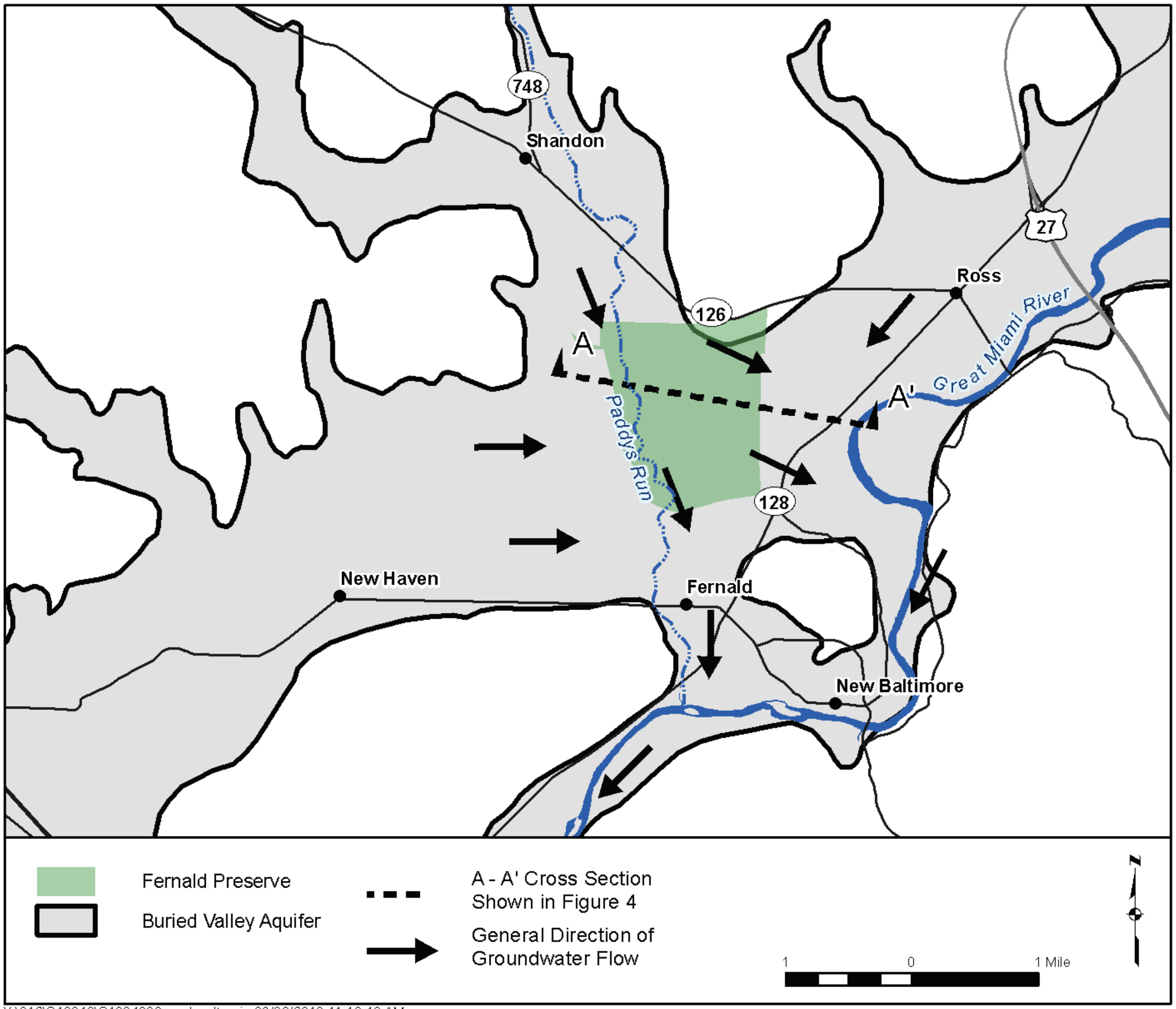


Figure 4. Schematic Cross Section of the New Haven Trough, Looking North



Y:\012\S18046\S1804600.mxd waltersjo 03/06/2018 11:18:19 AM

Figure 5. Regional Groundwater Flow in the Great Miami Aquifer

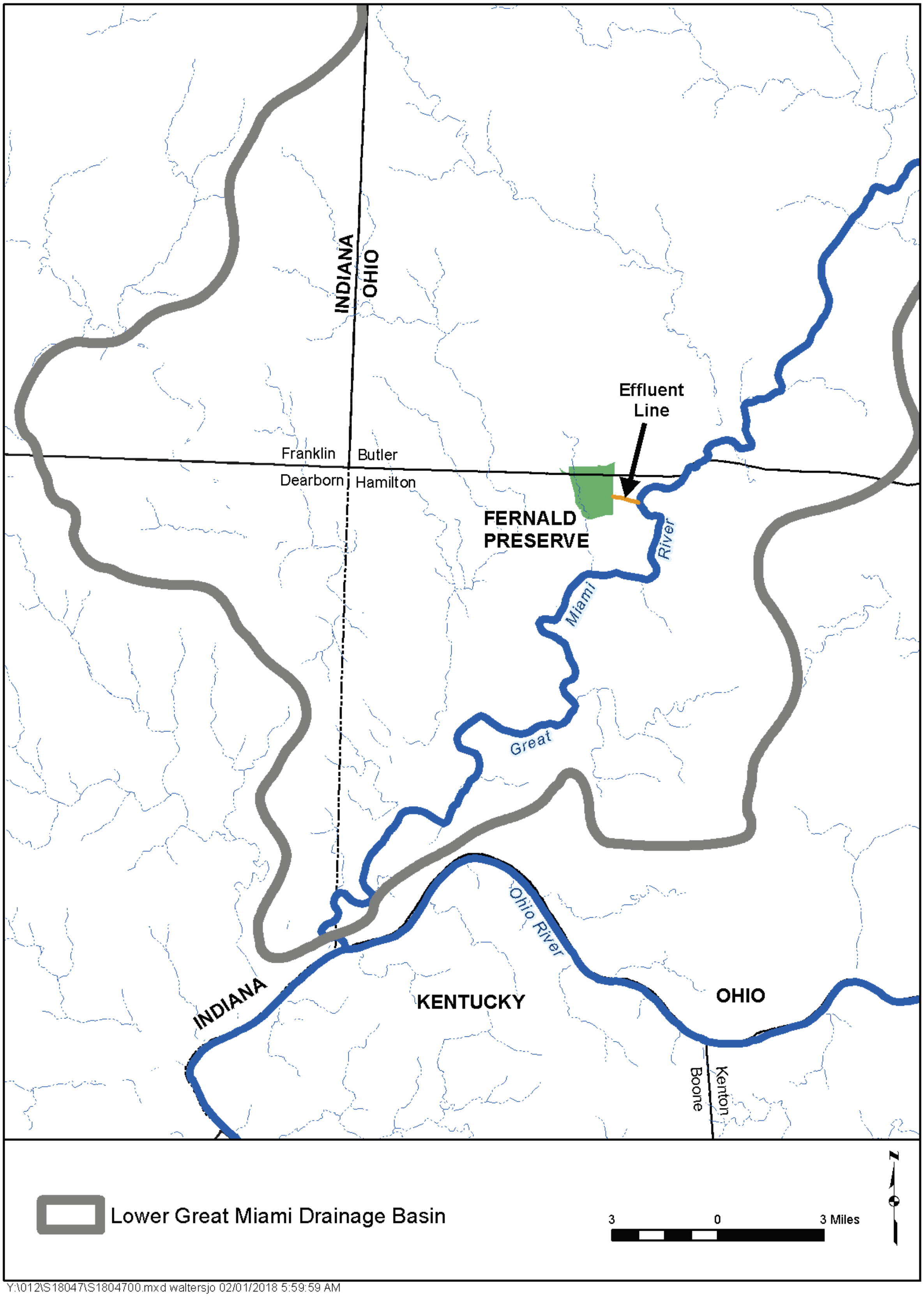


Figure 6. Southern Portion of the Great Miami River Drainage Basin

In 2022, 40.5 inches of precipitation were measured at the Butler County Regional Airport. This measurement, which represents precipitation at the site, is higher than the average annual Cincinnati-area precipitation of 41.4 inches for 1951 through 2022. Figure 7 shows the total annual precipitation recorded at the Fernald Preserve for each year from 1991 through 2022 and the average annual precipitation for the Cincinnati area from 1951 through 2022. Figure 8 shows monthly precipitation at the site for 2022 compared to the Cincinnati-area average monthly precipitation for 1951 through 2022.

1.3.5 Natural Resources

Natural resources have important aesthetic, ecological, economic, educational, historical, recreational, and scientific value to the United States. Their establishment and protection is an ongoing process at the Fernald Preserve. Section 5.0 discusses the site's diverse natural and cultural resources, and summarizes 2022 ecological restoration activities, including results of inspection, monitoring, maintenance, and repair.

The site is located near the transition of the Interior Plateau and Eastern Corn Belt Plains ecoregions. These ecoregions are subsections of the Eastern Deciduous Forest which consists of mosaic of oak-hickory and beech-maple forests. Regional ecology has been greatly altered by past agricultural and land management practices. Large portions of forests have been cleared and converted into agricultural land or pasture. These changes led to a fragmented landscape with a patchwork of cleared land, old fields, and second growth woodlands, with very little mature forest remaining. At the Fernald Preserve, additional changes took place with the planting of several areas of pine plantations in the northern and southern portions of the property. Additional wet forest habitat was recognized in the northern portion of the site as part of sitewide wetland delineation efforts in the 1990s.

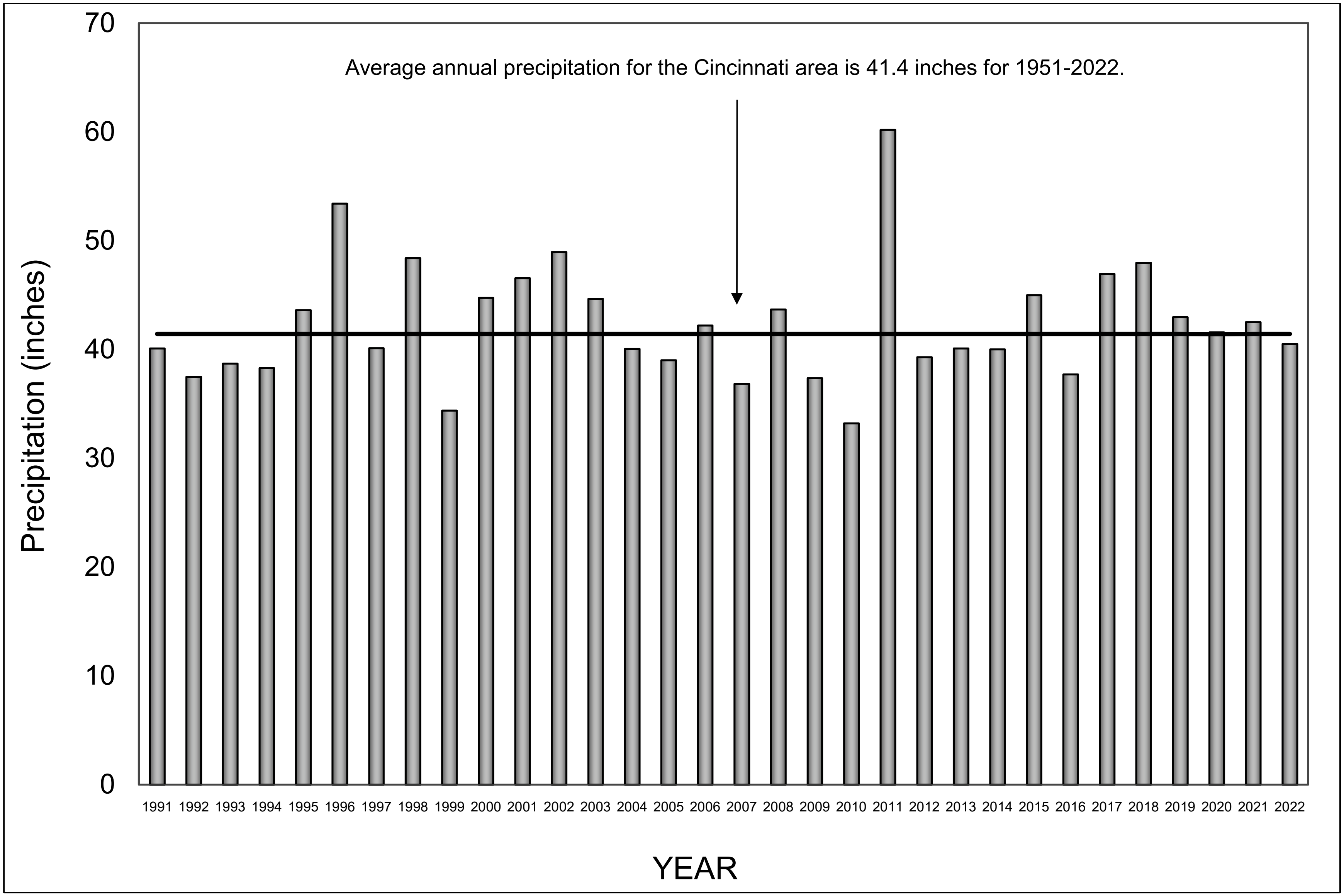


Figure 7. Cincinnati Area Annual Precipitation, 1991–2022

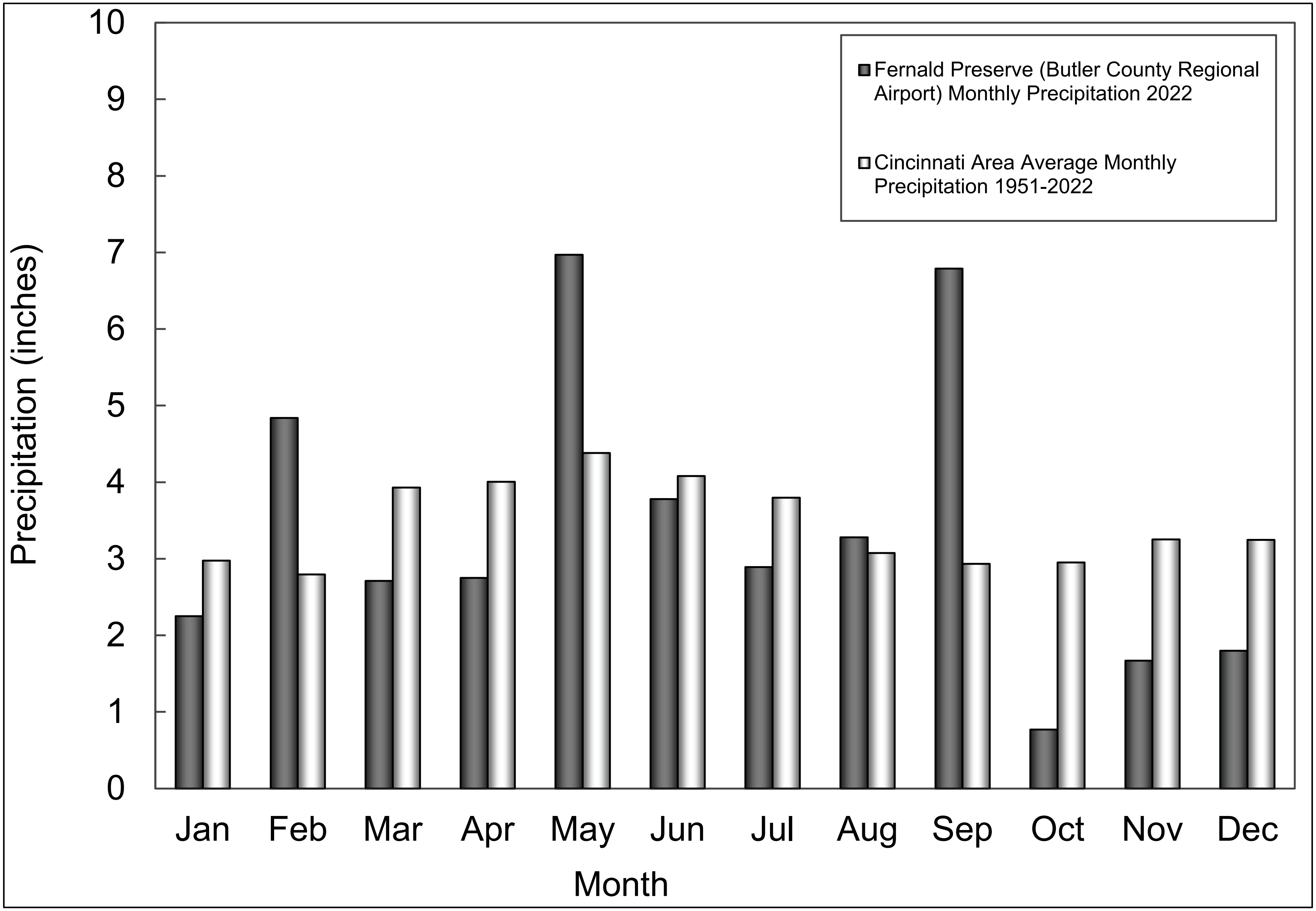


Figure 8. Monthly Precipitation for 2022 Compared to Average Monthly Precipitation for 1951–2022

2.0 Remediation Status and Compliance Summary

This section provides a summary of CERCLA remediation activities in 2022 and summarizes compliance activities with other applicable environmental laws, regulations, and legal agreements. Compliance under CERCLA dictates the environmental remediation of the Fernald Preserve.

EPA and Ohio EPA enforce the environmental laws, regulations, and legal agreements governing work at the Fernald Preserve. EPA develops, promulgates, and enforces environmental protection regulations and technology-based standards. EPA regional offices and state agencies enforce these regulations and standards by review of data collected at the Fernald Preserve. EPA Region 5 has regulatory oversight of the CERCLA process at the Fernald Preserve, with active participation from Ohio EPA.

For some programs—such as those under the Resource Conservation and Recovery Act (RCRA), as amended (42 USC 6901 et seq.); the Clean Air Act, as amended (42 USC 7401 et seq.), excluding National Emissions Standards for Hazardous Air Pollutants compliance; and the Clean Water Act, as amended (33 USC 1251 et seq.)—EPA has authorized the State of Ohio to act as the primary enforcement authority. For these programs, the State of Ohio promulgates state regulations that must be at least as stringent as federal requirements. Several legal agreements between DOE, EPA Region 5, and Ohio EPA identify site-specific requirements for compliance with the regulations. To comply with these regulations, DOE Headquarters issues directives to its field and area offices and conducts audits to ensure compliance with all regulations and compliance agreements.

2.1 CERCLA Remediation Status

By October 2006, remedial actions were completed for four of the five operable units. As of October 29, 2006, the only remaining active remediation involves the ongoing groundwater remedy under Operable Unit 5. Activities under CERCLA during 2022 involved monitoring the performance of the completed remedies and implementing the requirements of the LMICP.

All cleanup-related CERCLA documentation, including a copy of the Administrative Record (AR), is available online at https://www.energy.gov/lm/fernald-preserve-ohio-site. The original and a copy of the AR are in the records warehouse at the LM Business Center in Morgantown, West Virginia. The Fernald Preserve staff can be contacted by phone at (513) 648-3106 for assistance in searching for a document in the CERCLA AR. The CERCLA AR is updated as new documents are created.

The completion and closure of a National Priorities List (NPL) site encompasses several milestones and specific documentation requirements for each milestone completed, as specified in the EPA publication *Close Out Procedures for National Priorities List Sites* (EPA 2011). These milestones begin with remedial action completion and end with deletion from the NPL and include:

- Remedial action completion (Final or Interim Remedial Action Reports).
- Construction completion (Preliminary Closeout Report)—all construction activities are complete, immediate threats are addressed, and long-term threats are under control.

- Site completion (Final Closeout Report)—all site cleanup goals are met, all RODs are complete, institutional controls are in place, and site conditions are protective of human health and the environment.
- Site deletion from the NPL (Notice of Intent to Delete).

DOE has prepared, and both EPA and Ohio EPA have approved, Final Remedial Action Reports for Operable Units 1, 2, 3, and 4. EPA approved the *Interim Remedial Action Report for Operable Unit 5* (DOE 2008) in August 2008. That report detailed the ongoing aquifer restoration activities and provided information indicating that all required groundwater infrastructure had been installed and was functioning as designed. Furthermore, the report provides information that all soils have been remediated (except those associated with the aquifer restoration infrastructure) and that the OSDF is functioning as designed. Operable Unit 5 will remain open until a future final Remedial Action Report for Operable Unit 5 has been prepared. DOE will develop that report once groundwater actions are complete and all soils and infrastructure associated with the groundwater remedy have been adequately addressed (estimated completion date in 2039, based on modeling projections reported in the 2014 Operational Design report [DOE 2014]). EPA issued the *Preliminary Closeout Report, U.S. DOE Feed Materials Production Center, Fernald, Ohio* (EPA 2006) in December 2006. The estimated durations for certifying the last area of the aquifer as being clean and for removing the wellfield infrastructure can be found in the *Fernald Groundwater Certification Plan* (DOE 2006a).

CERCLA Section 121(c) also requires a five-year review process for remedial actions implemented under the signed ROD for each operable unit. The purpose of a five-year review is to determine, through evaluation of performance of the selected remedy, whether the remedy at a site remains protective of human health and the environment. The methods, findings, and conclusions are documented in five-year review reports. In addition, the five-year review reports identify issues found during the review, if any, and document recommendations to address the issues.

EPA approved the first five-year review report for the Fernald Preserve (DOE 2001c) in September 2001. The second five-year review report was submitted in April 2006 (DOE 2006b) and approved by EPA in September 2006. The third five-year review report was submitted to EPA in March 2011 (DOE 2011) and approved by EPA in August 2011. The fourth five-year review began in 2015 and was approved by EPA in September 2016 (DOE 2016b). The fifth five-year review began in fall 2020 and was approved in September 2021 (DOE 2021b).

In the site's fourth CERCLA five-year review report, DOE was required to address the presence of perfluorinated compounds, now called per- and polyfluoroalkyl polyfluorinated alkyl substance (PFAS). PFAS are a large group of emerging potential chemicals of concern, of which perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) are the two most prevalent. PFASs could be present at the Fernald site because very small volumes (i.e., less than 25 gallons) of aqueous foam firefighting agents containing PFOA and PFOS were used for fire training exercises at the former Fire Training Facility from 1976 to 1990. During the extensive site remediation, over 13,000 cubic yards of impacted soil were removed from the Fire Training Facility alone.

In December 2016, DOE submitted the *Draft Perfluorinated Compound Groundwater Screening Sampling and Analysis Plan* (DOE 2016c). In March 2018, DOE submitted the *Draft Polyfluorinated Alkyl Substances (PFASs) Investigation Plan for the Fernald Preserve*

(DOE 2018b). Based on information presented in both documents, PFAS are not a widespread issue at the Fernald Preserve. Interim recommendations were established for PFOA and PFOS by EPA in December 2019 (EPA 2019). To date, no sampling for these emerging contaminants has occurred at the Fernald Preserve.

In the fifth CERCLA five-year review report, DOE reviewed and evaluated the potential for all emerging contaminates currently recognized by the EPA to have been present at the site. An emerging contaminant is a chemical or material that is characterized by a perceived, potential, or real threat to human health or the environmental or by lack of published health standards. This evaluation is presented in the approved *Final Fifth Five-Year Review Report for the Fernald Preserve* (DOE 2021b). With the exception of PFAS, no other emerging contaminant required additional evaluation. The initial evaluation of PFAS at the site focused on aqueous film-forming firefighting foams, but new information has identified additional industrial processes that may have used PFAS. An evaluation of these newly identified general industrial uses of PFAS was conducted to determine if they were historically used at the Fernald site and may have the potential to adversely impact human health and the environment. That evaluation (DOE 2022a) was submitted to the regulators in fall 2022 and indicated that large volumes of PFAS-containing chemicals were not used in any historical processes at the site. Of the approximately 60 general industry PFAS uses evaluated, 5 potential uses of PFAS in historical processes were identified including firefighting foams; laboratory-related supplies; lubricants and greases; pipes, pumps, fittings, and liners; sealants; and water and effluent treatment. Generally, liquid-phase PFAS chemicals would have the most potential to cause environmental concerns if used or disposed directly into the environment. Of the uses identified, firefighting foams and a calibrant used in the laboratory are the only liquid-phase PFAS chemicals identified. No manufacturing of PFAS chemicals or large-scale of PFAS-containing chemicals were identified in this evaluation.

CERCLA remediation highlights during 2022 included the following:

- For 2022, the ongoing groundwater remedy resulted in extraction of 2 billion gallons of groundwater from the Great Miami Aquifer and removal of 354 lb of uranium from the aquifer. Section 3.0 discusses groundwater monitoring and remediation performance.
- The OSDF continues to operate as designed. The OSDF cap underwent four formal inspections. Such inspections are part of the standard operation and maintenance requirements for the facility. Minor maintenance of the cap and associated drainages continues; examples include the removal of small trees and shrubs, spot herbicide application on woody stumps and other invasive plant species and repairing animal burrows. A planned spring prescribed burn of the OSDF cell cap vegetation was postponed while an inter-agency agreement between DOE and the U.S. Forest Service for the conduct of prescribed burns at the Fernald Preserve was finalized. The eight leachate valve houses continued to be inspected daily via operational rounds. Leachate generation has continued to decline as expected, and liner performance is meeting design requirements. Leachate flow and leak detection performance is discussed in Section 3.0. Cap performance is discussed further in Section 5.0.
- Figure 9 indicates soil areas that remain uncertified, pending completion of aquifer restoration and the decontamination and decommissioning of related facilities and associated utilities.
- Elevated uranium concentrations persist in surface water in an area adjacent to former Waste Pit 3. (This issue is further discussed in Section 4.0.) Weekly surface water monitoring in that area continued in 2022. The Paddys Run streambank stabilization project

was completed in 2016 to prevent migration of the Paddys Run streambed into this area. In 2017, DOE replaced several boulders on an in-stream crossvane that were dislodged during 2016 flooding. One additional stone became dislodged in 2018. Site personnel monitored the streambed in 2022 and determined that repairs were not needed. The area will continue to be evaluated in 2023.

- Monitoring and maintenance of ecologically restored areas continued during 2022. Ecological monitoring continued using floristic inventories; remediation prairie and remediation successional areas were evaluated in 2022.
- All required site and OSDF inspections were performed in 2022. Inspection findings in 2022 were similar to those from previous years and consisted mainly of the presence of invasive vegetation and deer enclosure fencing that was damaged by fallen trees and limbs. Debris also continues to be found, primarily in the Former Production Area and the former Waste Storage Area. Minor violations of the institutional controls established in the LMICP included occasional instances of hikers straying off trail. Section 5.0 includes further discussion of the restored area activities and the inspection process.

Construction of on-site modular offices for site field personnel was initiated in 2022. The modular office area is located adjacent to the CAWWT facility. Portions of subsurface infrastructure (buried electric and water lines) have been installed within the uncertified CAWWT footprint. Uncertified soil removed during construction was stockpiled within the CAWWT uncertified area. Sanitary waste from this facility will be treated at the Visitors Center bio-wetland.

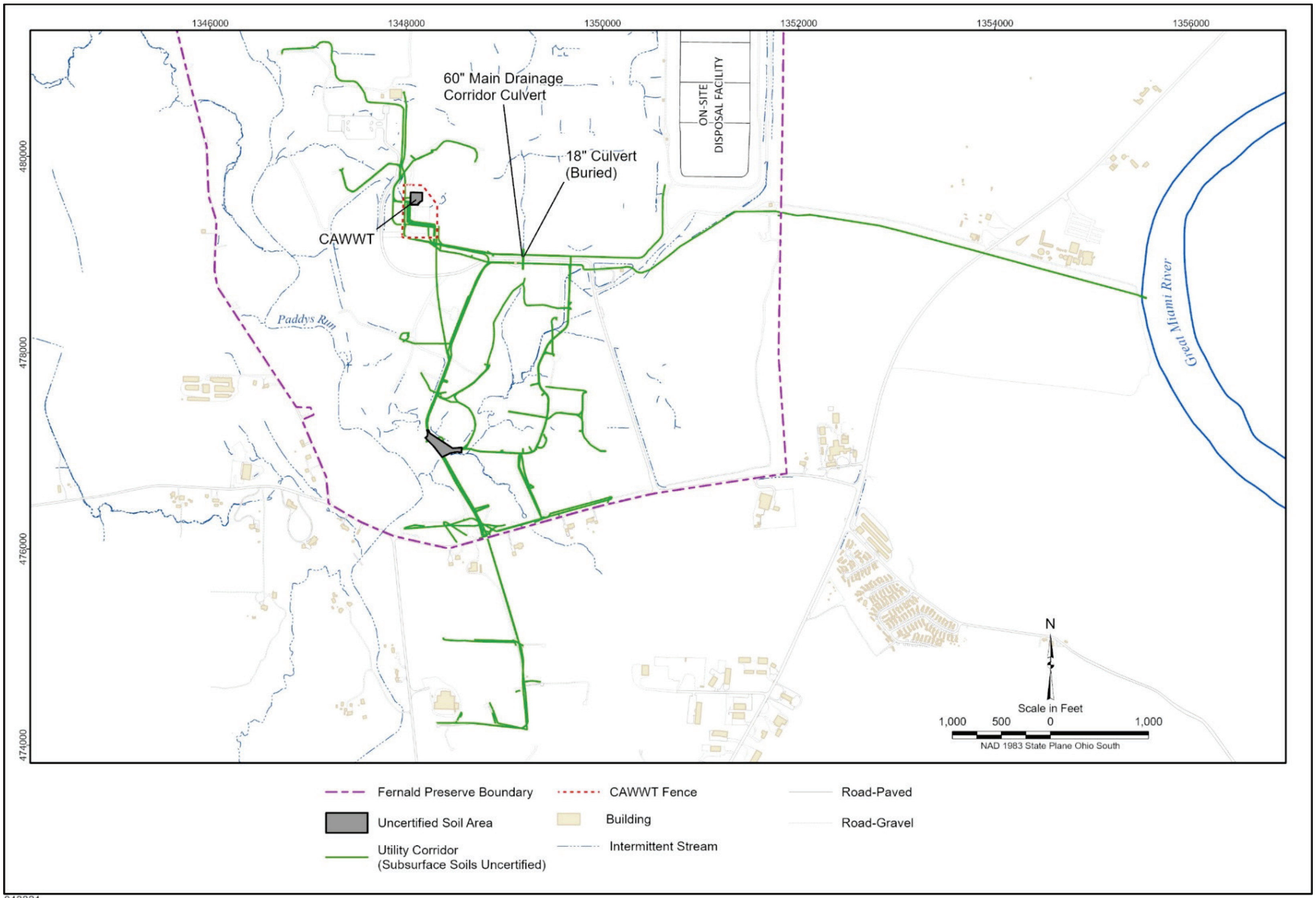


Figure 9. Uncertified Areas and Subgrade Utility Corridors

2.2 Summary of Compliance with Other Requirements

CERCLA requires compliance with other laws and regulations as part of remediation of the Fernald Preserve. These requirements are referred to as applicable or relevant and appropriate requirements (ARARs). ARARs that are pertinent to remediation of the Fernald Preserve are specified in the ROD for each operable unit. This section of the report highlights some of the major requirements related to environmental monitoring and waste management and describes how the Fernald Preserve complied with these requirements in 2022.

The regulations discussed in this section have been identified as ARARs within the RODs. The Fernald Preserve must comply with these regulations while site remediation under CERCLA is underway; compliance is enforced by EPA and Ohio EPA. Some of these requirements include permits for effluent discharges to the Great Miami River, which are also discussed in this section.

2.2.1 RCRA

RCRA regulates the treatment, storage, and disposal of hazardous waste and mixed waste (waste that contains radioactive and hazardous waste components). These wastes are regulated under RCRA and Ohio hazardous waste management regulations; therefore, the Fernald Preserve must comply with legal requirements for managing hazardous and mixed wastes. EPA has authorized Ohio 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 between the State of Ohio and DOE, the 1993 Stipulated Amendment to the Consent Decree between the State of Ohio and DOE, and a series of Director’s Final Findings and Orders issued by Ohio EPA.

2.2.1.1 RCRA Property Boundary Groundwater Monitoring

The Ohio EPA Director’s Findings and Orders for Groundwater, which were signed September 10, 1993, described an alternative monitoring system for RCRA groundwater monitoring. A revision of this document was approved on September 7, 2000, to align with the groundwater monitoring strategy identified in the IEMP. Section 3.3.2 provides a more detailed discussion of the groundwater monitoring program.

2.2.1.2 Waste Management

The Fernald Preserve had one hazardous waste shipment consisting of excess or expired laboratory chemicals on July 26, 2022. No additional treatment, storage, or disposal activities were conducted during 2022. Other wastes managed during 2022 were limited to universal waste (e.g., spent batteries) and uncontaminated solid wastes.

2.2.2 Clean Water Act

Under the Clean Water Act, as amended, the Fernald Preserve is governed by National Pollutant Discharge Elimination System (NPDES) regulations that require the control of discharges of nonradiological pollutants to waters of the State of Ohio. The NPDES permit, issued by the State of Ohio for storm water and wastewater, specifies discharge and sample locations, sampling and reporting schedules, and discharge limitations. Until June 1, 2022, the site operated under an NPDES permit that took effect on March 1, 2015. A new permit was approved and took effect on March 2, 2022. This permit will expire on May 31, 2027. Fernald Preserve submits monthly reports on NPDES activities to Ohio EPA to document compliance with stipulated discharge limits. There were no instances of noncompliance at any of the permitted outfalls in 2022.

A Notice of Intent to use the Ohio General Construction Permit was submitted on May 12, 2022, and approved on May 16, 2022, for construction activities related to the modular office area near CAWWT. Weekly and post-rainfall event inspections were conducted as needed. The annual stormwater evaluation, which is no longer required as part of the new NPDES Permit was conducted on December 19, 2022, as a best management practice, and no issues were identified.

2.2.3 Clean Air Act

Ohio EPA is authorized to enforce the State of Ohio's air standards for particulate matter at the Fernald Preserve. DOE maintains compliance by implementing the Fugitive Dust Control Policy negotiated between DOE and Ohio EPA in 1997. The policy allows for visual observation of fugitive dust and implementation of dust control measures.

2.2.4 Superfund Amendments and Reauthorization Act of 1986

The Superfund Amendments and Reauthorization Act of 1986 (SARA) amended CERCLA and was enacted, in part, to clarify and expand CERCLA requirements. SARA Title III is also known as the Emergency Planning and Community Right-to-Know Act. No chemicals exceeded threshold reporting quantities during 2022, so no report was required.

Another SARA Title III report, the Section 313 Toxic Chemical Release Inventory Report (Form R), is required if quantities of chemicals used or released at the Fernald Preserve exceed an applicable threshold for any SARA 313 chemical. If required, the Toxic Chemical Release Inventory Report lists routine and accidental releases and information about the activities, uses, and waste for each reported toxic chemical. No chemical usage or releases have exceeded the threshold for several years at the Fernald Preserve and, as in past years, no chemical exceeded a reporting threshold during 2022.

Also under SARA Title III, any offsite release meeting or exceeding a reportable quantity as defined by SARA Title III, Section 304, requires that immediate notifications be made to local emergency planning committees and the state emergency response commission. Notifications are also made to the National Response Center and other appropriate federal, state, and local regulatory entities. DOE evaluates and documents all releases that might occur at the Fernald Preserve to ensure that proper notifications are made in accordance with SARA and under CERCLA Section 103, RCRA, the Toxic Substances Control Act, the Clean Air Act, the Clean Water Act, and Ohio environmental laws and regulations. During 2022, there were no releases at the Fernald Preserve that met the reporting criteria.

2.2.5 Other Environmental Regulations

In addition to those described above, the Fernald Preserve is also required to comply with other environmental laws and regulations. Table 2 summarizes compliance with each of these requirements for 2022.

2.2.6 Permits and Licenses

Certain environmental regulations are implemented through permits. The Fernald Preserve's permit for discharging water under NPDES regulations is discussed in Section 2.2.2. In addition, the Fernald Preserve maintains permits administered through the U.S. Fish and Wildlife Service and the Ohio Department of Natural Resources (ODNR) for collection of wildlife specimens. A permit is also obtained to remove Canada goose nests, if necessary. A commercial pesticide applicator license is maintained by site personnel in order to apply herbicide at the Fernald Preserve. As a result of the 2022 interagency agreement between DOE and the U.S. Forest Service for conducting prescribed burns, the U.S. Forest Service secures burn-ban waivers and permits for prescribed burning activities on site. These activities are discussed in Section 5.0.

2.2.7 Federal Facility Compliance Agreement

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

- Maintain a sampling program for the South Plume extraction wells and report the results to EPA, Ohio EPA, and the Ohio Department of Health. The sampling program conducted to address this requirement has been modified over the years and is currently governed by an agreement reached with EPA and Ohio EPA on May 1, 1996 (DOE 1996a). These data are reported in Appendix A.
- Maintain a continuous sample collection program for radiological constituents at the effluent discharge point and report the results to EPA, Ohio EPA, and the Ohio Department of Health. The sampling program was modified several times and was governed by an agreement reached with EPA and Ohio EPA that became effective May 1, 1996 (DOE 1996a). The first IEMP, finalized in 1997, was developed to combine the multiple programs (including the FFCA effluent monitoring) under one reporting structure to facilitate review of the performance of the environmental protection actions for various media under CERCLA remediation of the site. These data are reported in Appendix B.

Table 2. Compliance with Other Environmental Regulations

Regulation and Purpose	Background Compliance Issues	2022 Compliance Activities
Toxic Substances Control Act		
Regulates the manufacturing, use, storage, and disposal of toxic materials, including polychlorinated biphenyls (PCBs) and PCB items.	EPA Region 5 conducted the last routine Toxic Substances Control Act (15 USC 2601 et seq.) inspection of the Fernald Preserve's program on September 21, 1994. No violations of PCB regulations were identified during the inspection.	No PCB liquids or items were used, stored, or shipped in 2022.
Ohio Solid Waste Act		
Regulates infectious waste.	The Fernald Preserve was registered with Ohio EPA as a generator of infectious waste (generating more than 50 lb per month) until December 6, 1999, when Ohio EPA concurred with the Fernald Preserve's qualification as a small quantity generator.	No infectious waste was generated in 2022.
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 (7 USC 136 et seq.) program conducted by EPA Region 5 on September 21, 1994, found the Fernald Preserve to be in full compliance with the requirements of the mandated Act.	Pesticide applications at the Fernald Preserve were conducted according to federal and state regulatory requirements.
National Environmental Policy Act		
Requires the evaluation of environmental, socioeconomic, 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 the National Environmental Policy Act, Title 10 *Code of Federal Regulations* Section 1021. The assessment requires DOE to consult the public before making any decisions on land use; it includes previous DOE commitments.	No National Environmental Policy Act activities were required in 2022.

Table 2. Compliance with Other Environmental Regulations (continued)

Regulation and Purpose	Background Compliance Issues	2022 Compliance Activities
Endangered Species Act		
Requires the protection of any threatened or endangered species found at the site as well as any critical habitat that is essential for the species' existence.	Ecological surveys conducted by Miami University and DOE, in consultation with the Ohio Department of Natural Resources and the U.S. Fish and Wildlife Service, have established the following list of threatened and endangered species and their habitats existing on site: • Cave salamander (*Eurycea lucifluga*), state endangered, marginal habitat—small limestone outcrops and streams—none found. • Sloan's crayfish (*Orconectes sloanii*), state-threatened—found on northern sections of Paddys Run. • Indiana bat (*Myotis sodalis*), federally endangered—found in northern wooded areas along Paddys Run. • Northern long-eared bat (*Myotis septentrionalis*), federally threatened—potential habitat within northern wooded areas along Paddys Run—none found. • Running buffalo clover (*Trifolium stoloniferum*), federally endangered—potential habitat on disturbed areas along Paddys Run—none found. • Spring coralroot (*Corallorhiza wisteriana*), state-threatened—potential habitat within northern wooded areas—none found. • American burying beetle (*Nicrophorus americanus*), federally endangered—potential habitat within a variety of restored areas—released as part of ongoing recovery efforts.	As of 2022, Sloan's crayfish (*Orconectes sloanii*) is no longer listed as threatened by the state of Ohio. Monitoring is no longer required at the site for Sloan's Crayfish. Running buffalo clover (*Trifolium stoloniferum*) was delisted in 2021 and is no longer considered endangered or threatened. Monitoring is no longer required at the site for running buffalo clover. The Cincinnati Zoo requested termination of the 5-year Cooperative Agreement with the U.S. Fish and Wildlife Service and the Cincinnati Zoo to introduce the federally endangered American burying beetle to the Fernald Preserve (DOE 2012a and DOE 2017). The agreement was originally set to expire in 2022, but the Cincinnati Zoo determined the resources were better applied at other release sites across the region (Ray 2021). All parties agreed to terminate the agreement, As of 2021, the American burying beetle has been down listed from endangered to threatened.
Floodplains/Wetlands Review Requirements		
DOE regulations require a floodplain/wetlands assessment for DOE construction and improvement projects. The Clean Water Act also protects jurisdictional wetlands and "Waters of the U.S."	A wetlands delineation of the Fernald Preserve, completed in 1992 and approved by the U.S. Army Corps of Engineers in August 1993, identified 36 acres of freshwater wetlands on the Fernald Preserve property. Wetland mitigation monitoring activities from 2009 to 2011 resulted in the delineation of approximately 31 acres (13 hectares) of mitigated jurisdictional wetlands on the Fernald Preserve property (DOE 2012c).	Monitoring of wetlands will continue in 2024 as part of sitewide ecological restoration monitoring.
National Historic Preservation Act		
Establishes a program for the protection, maintenance, and stewardship of federal prehistoric and historic properties.	The Fernald Preserve is in an area of sensitive historic and prehistoric cultural resources that are eligible for or are listed on the National Register of Historic Places. These cultural resources include historic structures, buildings, and bridges, plus Native American villages and campsites.	No archaeological surveys were required, and no unexpected cultural discoveries were identified in 2022.

Table 2. Compliance with Other Environmental Regulations (continued)

Regulation and Purpose	Background Compliance Issues	2022 Compliance Activities
Native American Graves Protection and Repatriation Act		
Establishes a means for Native Americans to request the return or repatriation of human remains and other cultural items. Federal agencies must return human remains, associated funerary objects, sacred objects, and objects of cultural patrimony to the Native American nations or tribes with cultural affiliation to the remains or material.	Native American remains have been discovered during remediation activities at the Fernald Preserve. Native American remains and artifacts have been removed or left in place with consultation from Native American nations, tribes, and groups.	No Native American remains were discovered or repatriated to Native American nations, tribes, or groups in 2022.
Natural Resource Requirements Under CERCLA and Executive Order 12580		
Requires DOE to act as a trustee (i.e., guardian) for natural resources at its federal facilities.	DOE and the other trustees, which include Ohio EPA and the U.S. Department of the Interior (administered by the U.S. Fish and Wildlife Service), meet regularly to discuss potential impacts to natural resources and to coordinate trustee activities. The trustees also interact with the Fernald Community Alliance, which is a stakeholder organization that works to promote the Fernald Preserve as an asset to the community. In November 2008, the State of Ohio and DOE reached a settlement of the 1986 natural resource injury claim at the Fernald site. While the components of restoration had been established through a 2001 Memorandum of Understanding (DOE 2001d), the State of Ohio and DOE settled outstanding issues such as the payment of monetary penalties, establishment of environmental covenants, and a mutually agreed-upon Natural Resource Restoration Plan (NRRP), which is Appendix B of the *Consent Decree Resolving Ohio's Natural Resource Damage Claim Against DOE* (State of Ohio 2008). In 2009, activities commenced as required in the final NRRP.	In 2020, the Fernald Natural Resource Trustees conducted a 10-year review of the Restored Area Maintenance Plan, pursuant to the NRRP. The review resulted in the development of the Fernald Natural Resource Management Plan. This document presents a revised community-based approach for management and evaluation of ecologically restored areas across the Fernald Preserve. DOE implemented the revised Natural Resource Management Plan in 2021. The Natural Resource Management Plan was incorporated as Appendix A of Volume I of the 2023 LMICP (DOE 2023). The Natural Resource Trustees have drafted a crosswalk that demonstrates completion of all commitments in the Consent Decree and NRRP.

2.3 Split Sampling Program

Since 1987, DOE has participated in a split sampling program with Ohio EPA. 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 close as possible to being identical. The split samples are then submitted to two analytical laboratories; this allows for an independent comparison of data to ascertain quality assurance for laboratory analysis and field sampling methods. Ohio EPA occasionally performs independent sampling in addition to split sampling.

Table 3 provides the analytical results of groundwater samples. Figure 10 shows the split sample location.

Table 3. 2022 DOE and Ohio EPA Groundwater Split Sampling Total Uranium Result Comparison

Sample Location	2022 Sample Date	DOE Result (µg/L)[a]	Ohio EPA Result (µg/L)	FRL[b] (µg/L)
2060	May	22.4	20.25	30
2060	November	25.6	25.72	30

[a] µg/L = micrograms per liter
[b] The groundwater pathway and final remediation levels (FRLs) are discussed in Section 3.0.

Prior to 2022, the three wells sampled in the split sampling program are private homeowner wells and are the longest running groundwater monitoring effort at the site. The program was initiated in 1982 in response to monitoring results indicating above background concentrations of uranium in private wells near the site. By 1984, the site had officially established the program with the monthly sampling of 19 privately-owned wells. In 1996, the private well program had grown to 32 private wells. At a property owner’s request, any drinking water well near the site was sampled for uranium, and the one-time results were reported to the well owner. If any special request sample showed a questionable or significant total uranium concentration, or if the private well was determined to provide critical groundwater information in an area, the property owner had the option to participate in the routine sampling program. These private wells were sampled monthly or quarterly depending upon location, and sampling results were reported annually in the Site Environmental Report. Three private wells (13, 14, and 2060) were included in the monitoring effort (DOE 1997a). These three private wells continued to be sampled through 2022. In 1997, with implementation of the IEMP, the private well program was modified to only include these three private wells and included the private well where off-property contamination was initially reported in 1981 (monitoring well 2060). The other private wells previously monitored were not carried forward into the IEMP program because a public water supply was made available to the surrounding properties that had been affected by the off-property groundwater contamination (DOE 1998). Data from these three remaining private wells have contributed to the delineation of the total uranium plume presented in Section 3.0.

Well 13 has been below the final remediation level (FRL) since 2002 and well 14 has been below the FRL since this well was first sampled in 1988. These wells are located off-site and are outside of the uranium plume boundary identified in Section 3.0 and have been below the FRL for over 20 years. For these reasons, DOE proposed to eliminate monitoring in two of the private wells which are outside the current plume (13 and 14) and to continue monitoring in well 2060. Section 3.3.2 and Appendix A.2 presents additional information concerning these wells.

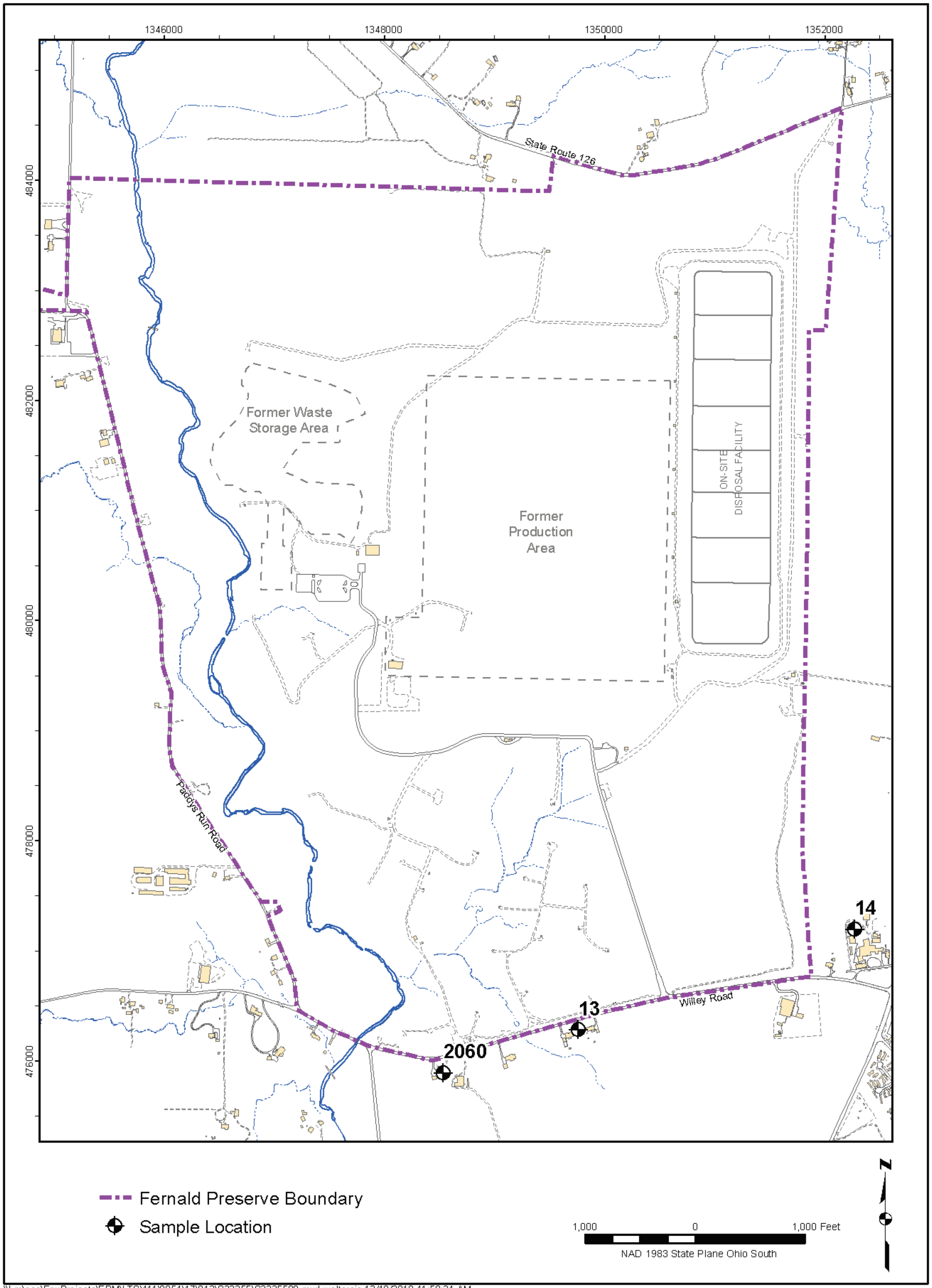


Figure 10. DOE and Ohio EPA Groundwater Split Sample Locations

3.0 Groundwater Pathway

Results in Brief: 2022 Groundwater Pathway

Groundwater Remedy

Since 1993

- 55,123 Mgal of water have been pumped from the Great Miami Aquifer.
- 15,751 net lb of uranium have been removed from the Great Miami Aquifer.

During 2022

- 2,007.52 Mgal of water were pumped from the Great Miami Aquifer.
- 354 lb of uranium were removed from the Great Miami Aquifer.

Groundwater Monitoring Results: Data collected in 2022 show continued progress in reducing the footprint of the maximum uranium plume and that the pumping wells were capturing the uranium plume. Between 2021 and 2022:

- The footprint of the greater than or equal to 30 µg/L total uranium plume was reduced by 1.0 acre (1.3%).
- The footprint of the greater than or equal to 50 µg/L total uranium plume increased by 0.7 acre (1.4%).
- The footprint of the greater than or equal to 100 µg/L total uranium decreased by 0.5 acres (1.8%).

During 2022, the well field underwent an annual planned shutdown that lasted for 43 days (from June 6 through July 18, 2022).

OSDF Monitoring: In 2022, Great Miami Aquifer wells of each of the eight OSDF cells were sampled semiannually for 13 parameters. The leachate collection system, leak detection system, and horizontal till well of each cell were sampled semiannually for uranium, boron, sodium, and sulfate. Flow data from the disposal facility, coupled with the water quality monitoring results and the results of quarterly facility physical inspections, indicate that the OSDF performed as designed in 2021.

This section provides background information on the nature and extent of groundwater contamination in the Great Miami Aquifer due to past operations at the Fernald Preserve, and it summarizes aquifer restoration progress and groundwater monitoring activities and results for 2022.

Restoration of the affected portions of the Great Miami Aquifer and continued protection of the groundwater pathway are primary considerations in the groundwater remediation strategy for the Fernald Preserve. The groundwater pathway will be monitored following remediation according to the *Fernald Groundwater Certification Plan* (DOE 2006a).

3.1 Summary of the Nature and Extent of Groundwater Contamination

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

Groundwater contamination resulted from infiltration of contaminated surface water through the bed of Paddys Run, the storm sewer outfall ditch (SSOD), the Pilot Plant Drainage Ditch (PPDD), and the old drainage ditch from the Plant 1 Pad. In these areas, the glacial overburden is absent (eroded), creating a direct pathway between surface water and the sand and gravel of the aquifer. To a lesser degree, groundwater contamination also resulted where past excavations (such as the waste pits) removed some of the protective clay contained in the glacial overburden and exposed the aquifer to contamination.

Figure 11 shows the 2022 maximum extent (most conservative) footprint of the 30 micrograms per liter (µg/L) uranium plume within the aquifer, as well as the current active restoration modules involved in the groundwater remedy. The current active restoration modules are represented by the cross-hatched areas in the figure, as well as the extraction wells that belong to each module.

3.2 Selection and Design of the Groundwater Remedy

> **Groundwater Modeling at the Fernald Preserve**
> The Fernald Preserve uses a computer model to make predictions about how the concentration and location of contaminants in the aquifer will change over time. Because the model contains simplifying assumptions about the aquifer and the contaminants, the predictions about future behavior must be verified with laboratory analyses of groundwater samples collected during monitoring activities.
>
> If groundwater monitoring data indicate the need for operational changes to the groundwater remedy, the groundwater model is run to predict the effect those changes might have on the aquifer and the contaminants. If the predictions indicate the proposed changes would increase cleanup efficiency and potentially reduce the cleanup time and cost, the operational changes are made once EPA and Ohio EPA concurrence is obtained. Monitoring data are then collected after the changes to verify whether model predictions were correct. If model predictions prove to be incorrect, modifications may be made to the model to improve its predictive capabilities.

While a remedial investigation/feasibility study was in progress and a groundwater remedy was being selected, off-property contaminated groundwater was being pumped from the South Plume area by the South Plume Removal Action System (referred to as the South Plume Module). In 1993, this system was installed south of Willey Road and east of Paddys Run Road to stop the uranium plume in this area from migrating any farther to the south. Figure 11 shows South Plume Module extraction wells 3924, 3925, 3926, and 3927. These extraction wells have successfully stopped further southward migration of the uranium plume beyond the wells and have contributed to significantly reducing total uranium (i.e., sum of all of the isotopes of uranium, measured in µg/L) concentrations in the off-property portion of the plume.

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

The recommended groundwater remedy, which included EPA, Ohio EPA, and community acceptance, was presented in the *Proposed Plan for Operable Unit 5* (DOE 1995c) as the preferred groundwater remedy. Once the proposed plan was approved, the *Record of Decision for Remedial Actions at Operable Unit 5* (OU5 ROD) (DOE 1996b) was issued. The OU5 ROD formally defines the selected groundwater remedy and establishes FRLs for all constituents of concern.

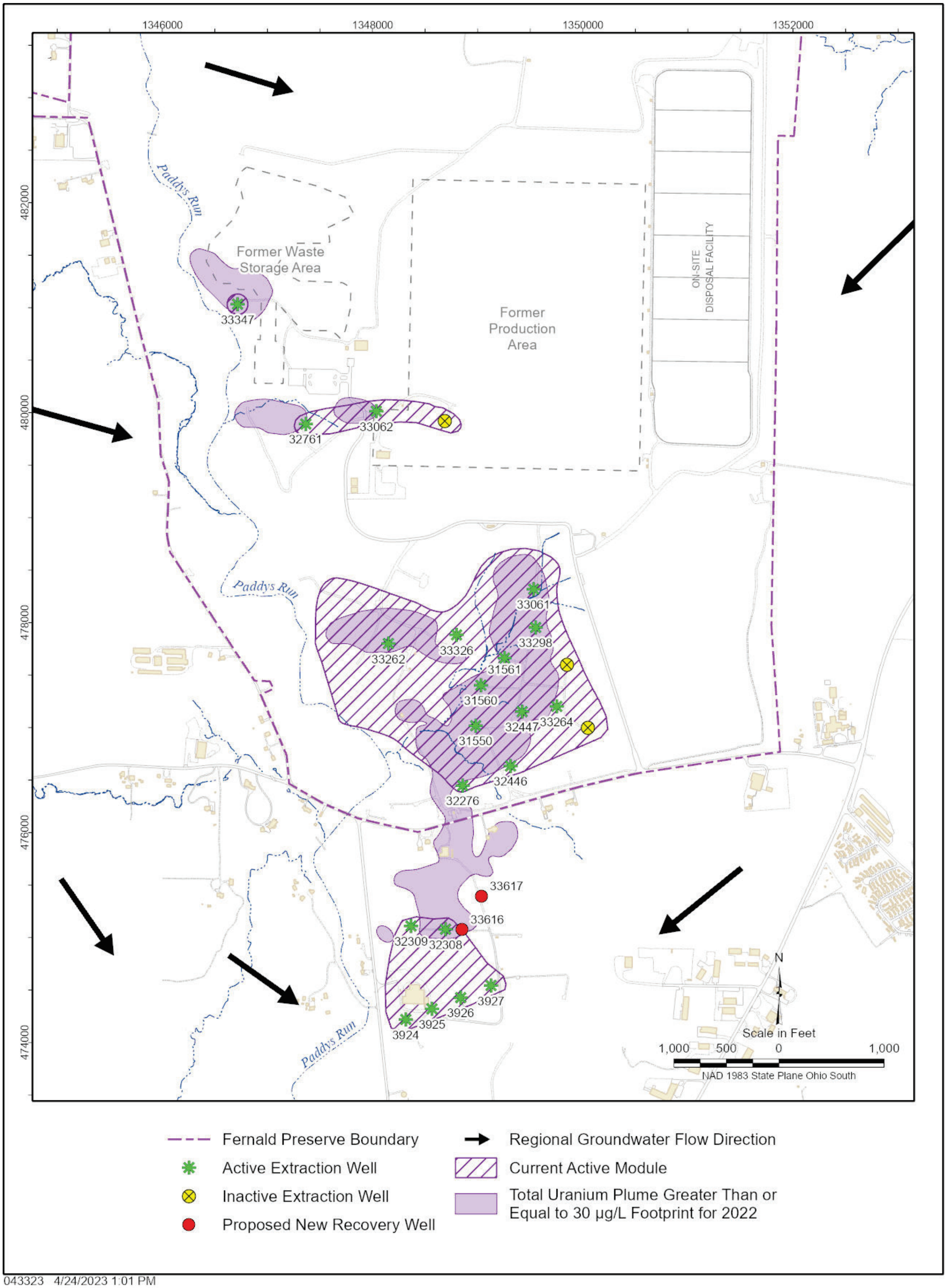


Figure 11. Extraction Wells Active in 2022

Reinjection at the Fernald Site
From 1998 to 2004, reinjection was an enhancement to the groundwater remedy at the Fernald site, supplementing pump-and-treat operations. The term "well-based" refers to the injection of treated groundwater through specially designed reinjection wells. Groundwater pumped from the aquifer was treated via ion exchange to remove contaminants and then reinjected into the aquifer at strategic well locations. Because the treatment process was not 100% efficient, a small amount of uranium was reinjected into the aquifer with the treated water. However, the reinjected groundwater increased the speed at which dissolved contaminants moved through the aquifer and were pulled by extraction wells, thereby decreasing the overall remediation time. Based on updated groundwater modeling and the unfavorable results of a cost–benefit analysis, well-based reinjection was discontinued in 2004.

The OU5 ROD commits to an ongoing evaluation of innovative remediation technologies so that remedy performance can be improved as such technologies become available. As a result of this commitment, an enhanced groundwater remedy was presented in the Operable Unit 5 *Baseline Remedial Strategy Report, Remedial Design for Aquifer Restoration (Task 1)* (DOE 1997b).

Groundwater modeling studies conducted to design the enhanced groundwater remedy suggested that, with the early installation of additional extraction wells and the use of reinjection technology, the remedy could potentially be reduced to 10 years. EPA and Ohio EPA approved the enhanced groundwater remedy that relied on pump-and-treat and reinjection technology. The groundwater remedy included the use of well-based reinjection until September 2004.

Evolution of the enhanced groundwater remedy has been documented through a series of approved designs. These designs are:

- Operable Unit 5 *Baseline Remedial Strategy Report, Remedial Design for Aquifer Restoration (Task 1)* (DOE 1997b).
- *Design for Remediation of the Great Miami Aquifer in the Waste Storage and Plant 6 Areas* (DOE 2001a).
- *Design for Remediation of the Great Miami Aquifer South Field (Phase II) Module* (DOE 2002).
- *Comprehensive Groundwater Strategy Report* (DOE 2003).
- *Groundwater Remedy Evaluation and Field Verification Plan* (DOE 2004).
- *Waste Storage Area Phase II Design Report* and Addendum (DOE 2005b).
- *Operational Design Adjustments-1, WSA Phase-II Groundwater Remediation Design, Fernald Preserve* (DOE 2014).

The enhanced groundwater remedy commenced in 1998 with the startup of the South Field (Phase I), the South Plume Optimization, and the Reinjection Demonstration Modules. It focused primarily on the removal of uranium but was also designed to limit further expansion of the plume, achieve removal of all targeted contaminants to concentrations below designated FRLs, and prevent undesirable groundwater drawdown impacts beyond the site boundary. Startup of the enhanced groundwater remedy included a year-long reinjection demonstration that began in September 1998. Through the years, extraction and reinjection wells had been added and removed from these initial restoration modules.

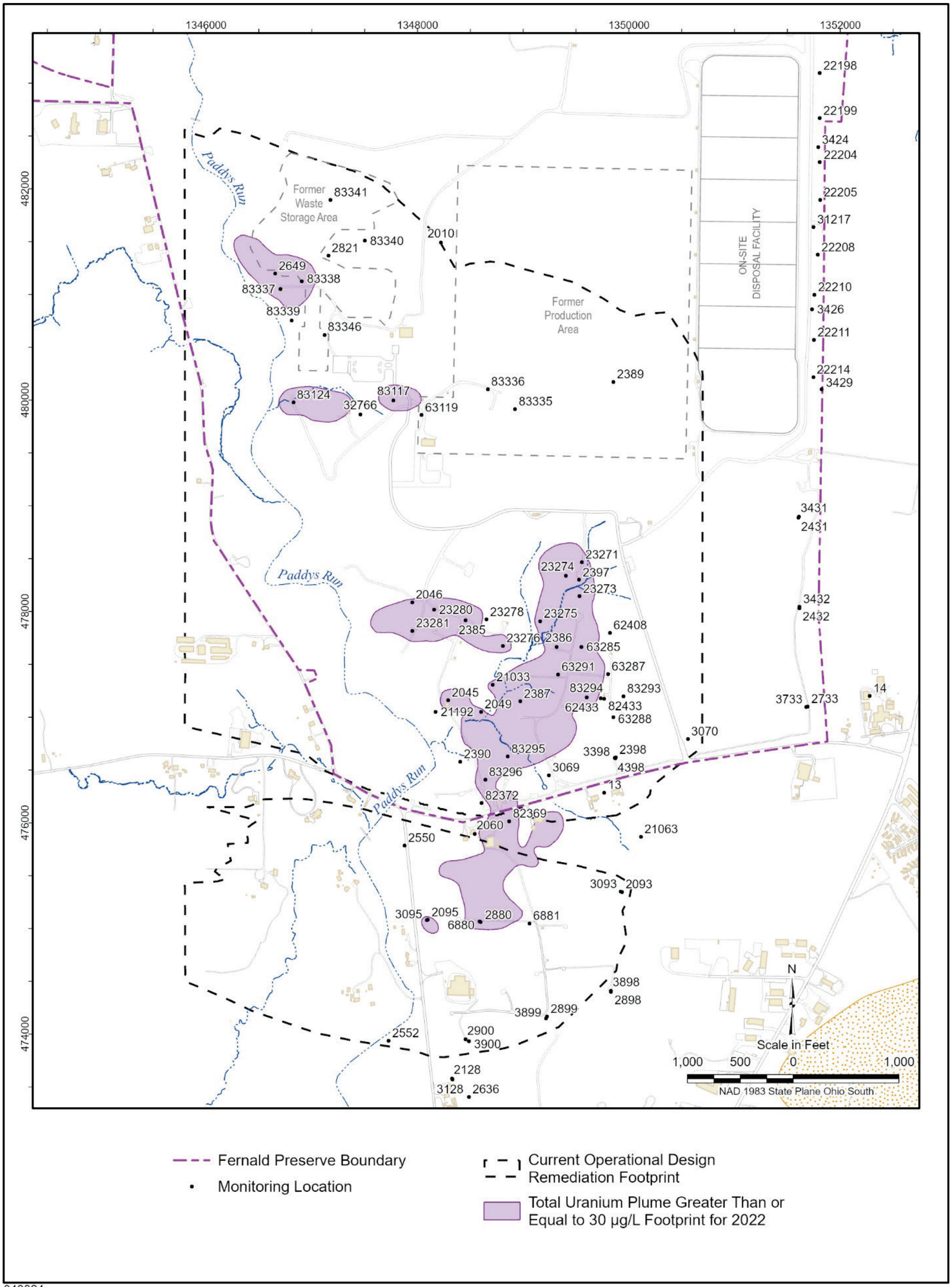
In 2001, EPA and Ohio EPA approved the *Design for Remediation of the Great Miami Aquifer in the Waste Storage and Plant 6 Areas* (DOE 2001a). Approval of this design initiated the installation of the next planned aquifer restoration module. The design specified three extraction wells in the former Waste Storage Area to address contamination in the PPDD plume (Phase I) and two extraction wells to address the remaining contamination after the waste pits excavation was completed (Phase II). One of the three Phase I Waste Storage Area wells (well 32761) was installed in 2000 to support an aquifer pumping test to help determine the restoration well field design. The remaining two Phase I wells (well 33062 and well 33063) were installed in summer 2001 after EPA and Ohio EPA approved the design. All three wells became operational on May 8, 2002. Well 33063 was abandoned in 2004 to facilitate site remediation work. A replacement well (well 33347) was installed and began operating in 2006. Figure 11 shows the existing well locations.

The *Design for Remediation of the Great Miami Aquifer in the Waste Storage and Plant 6 Areas* (DOE 2001a) also provided data indicating that the uranium plume in the former Plant 6 Area was no longer present. It was believed that the uranium concentrations in the plume had decreased to levels below the FRL as a result of plant operations shutting down in the late 1980s and the pumping of highly contaminated perched water as part of the Perched Water Removal Action No. 1 in the early 1990s. Because a uranium plume with concentrations above the groundwater FRL was no longer present in the former Plant 6 Area at the time of the design, a restoration module for the area was determined to be unnecessary. Groundwater monitoring continues in the former Plant 6 Area, with one well (well 2389) in the area identified as having intermittent uranium FRL exceedances. This well is further discussed in Attachment A.2. Figure 12 shows the location of monitoring well 2389.

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

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

In 2004, following regulatory and public input, a decision regarding the future aquifer restoration and wastewater treatment approach was made. In May 2004, EPA and Ohio EPA approved the decision to reduce the size of the advanced wastewater treatment facility and in June 2004 approved the decision to discontinue the use of well-based reinjection. Reducing the size of the advanced wastewater treatment facility provided the opportunity to dismantle and dispose of approximately 90% of the existing facility in the OSDF in time to meet the 2006 closure schedule. This resulted in a protective, more cost-effective, long-term water treatment facility to complete aquifer restoration. Well-based reinjection was discontinued in 2004 on the basis of groundwater modeling cleanup predictions presented in the *Comprehensive Groundwater Strategy Report* (DOE 2003) and the *Groundwater Remedy Evaluation and Field Verification Plan* (DOE 2004). As a result of refined modeling input, updated modeling indicated that the aquifer restoration time frame would likely be extended beyond dates previously predicted.



043324

Figure 12. Locations for Semiannual Total Uranium Monitoring

The updated modeling also indicated that continued use of the groundwater reinjection wells would shorten the aquifer remedy by approximately 3 years. However, the cost of maintaining the reinjection infrastructure was more than operating the extraction well field for this time period. Therefore, well-based reinjection was discontinued in September 2004 to support construction of the CAWWT. All reinjection wells remain in place as potential groundwater remedy performance monitoring locations.

In 2005, the *Waste Storage Area Phase II Design Report* (DOE 2005b) was issued. Comments received from EPA and Ohio EPA resulted in the issuance of an addendum to the report in December 2005. The design consisted of the installation of one more extraction well (well 33347) in the former Waste Storage Area, near the former silos area. Figure 11 shows the location of well 33347.

In 2005, an infiltration test was conducted in the SSOD. The test consisted of gauging the flow into and out of the SSOD with six Parshall flumes to obtain the overall infiltration rate along the SSOD. Findings from the test were included in the *Storm Sewer Outfall Ditch Infiltration Test Report* (DOE 2005a). The decision was made that pumped, clean groundwater would supplement natural storm water flow into the SSOD. This activity continued from 2006 through 2012, when DOE concluded that enough data had been collected to document infiltration rates through the base of the SSOD. Under normal flow conditions, potential infiltration to the aquifer from within the monitored portion of the SSOD (while flowing at or near 500 gpm) is approximately 109–129 gpm. With Ohio EPA and EPA concurrence, supplemental pumping of clean groundwater to the ditch was stopped and the flumes were removed in 2013 to allow water to freely flow down the SSOD. The rapid movement of water through the ditch during storm events will help to scour the ditch channel of fine-grained sediment and is expected to increase the potential for infiltration.

The *Fernald Groundwater Certification Plan* (DOE 2006a) defines a programmatic strategy for certifying completion of the aquifer remedy. It was developed through a series of four technical information exchange meetings held in 2005 among DOE, EPA, and Ohio EPA. Approved by EPA and Ohio EPA, the *Fernald Groundwater Certification Plan* identifies that the IEMP will continue to be the plan that includes remedy performance monitoring requirements.

In 2006, the Waste Storage Area Phase II Module components became operational, marking completion of the groundwater remediation system design. Completion of the Waste Storage Area Phase II Module construction brought the total number of extraction wells in the former Waste Storage Area to four (wells 32761, 33062, 33334, and 33347). These four well locations are shown in Figure 11.

In 2014, with approval from EPA and Ohio EPA, DOE implemented operational changes to optimize the groundwater remedy. Three wells no longer providing benefit to the groundwater remediation were shut down. The freed-up pumping budget was reallocated to the South Plume and South Field to accelerate cleanup of those areas. The operational changes were based on groundwater modeling results reported in 2014 (DOE 2014). The new 2014 design is referred to in this report as the current Operational Design and was implemented on July 1, 2014. Figure 11 shows the extraction well locations. The following subsections present the operational information associated with these modules.

Groundwater modeling conducted in 2012 (in support of the 2014 operational changes) predicted that under the current pumping rates, pumping would continue until 2022 in the South Plume and Southern South Field, 2030 in the northern South Field, and 2035 in the former Waste Storage Area. Annual monitoring results used to track remedy progress indicate that these dates will not be achieved.

In early 2022, the groundwater model was re-run to determine what the new cleanup times would be if uranium concentrations measured in the first half of 2021 were loaded into the model as initial conditions.

As was done for past model runs, modeled predicted cleanup date uncertainty due to changes in the elevation of the water table in the aquifer over time was bracketed by modeling using three different sets of boundary conditions for the elevation of the water table (i.e., wet, nominal, and dry). During wet boundary conditions the water table elevation is at its highest, and during dry boundary conditions the water table elevation is at its lowest. Nominal is the average elevation of the water table. The results were as follows:

Plume Area	Wet Boundary Conditions	Nominal Boundary Conditions	Dry Boundary Conditions
South Plume	2024	2025	2024
South Field	2035	2033	2038
Waste Storage Area	2040	2040	2045

As was done in previous modeling runs, the maximum model predicted cleanup date for each boundary condition was selected as the new targeted cleanup date, resulting in the following new predicted cleanup years.

- South Plume – 2025
- South Field – 2038
- Waste Storage Area – 2045

These new cleanup time predictions assume that the no wellfield pumping changes are made to the current operational design.

Model-predicted cleanup predictions have not been realized in the past, therefore, South Plume wells may need to continue pumping past 2025. Groundwater modeling predicts that capture of the remaining South Plume can be achieved using the existing six South Plume recovery wells pumping at lower rates without impacting the model-predicted cleanup date of 2025. Pumping at lower rates from the existing wells should prolong the operational life of the wells, but continued operation of the existing aging wells comes at an operational risk because their dependability is uncertain. Also, the existing six South Plume wells are no longer situated in good locations to remediate the remaining uranium plume. The leading edge of the South plume is now north of recovery wells 3924, 3925, 3926, and 3927. New wells that are better positioned to remediate the present location of the plume would produce a more efficient cleanup.

To reduce the operational risk of continuing to pump the existing South Plume recovery wells, and to provide for a more efficient cleanup of the remaining South plume, a modeled operational alternative was selected that replaces the six existing South Plume recovery wells with two new recovery wells. The two new recovery wells are better positioned to capture and remediate the remaining South Plume than the current six recovery wells. The modeling further predicts that when the two new wells are operational, the existing South Plume recovery wells (3924, 3925, 3926, and 3927) will no longer be needed to maintain capture of the remaining South plume.

This operational alternative (replacing the six existing South plume wells with two newly positioned recovery wells) is being implemented by DOE. The operational alternative removes the risk involved with the continued operation of the existing aging recovery wells and is not predicted to prolong the remediation of the South Plume. Use of this operational alternative also provides DOE with the option of continuing to operate remaining South Plume recovery wells (3924, 3925, 3926, and 3927) at lower pumping rates to provide additional flushing of the South Plume. The two new wells are scheduled to be operational in early 2024. The locations of the two new wells are shown on Figure 11.

3.3 Groundwater Monitoring Highlights for 2022

Groundwater monitoring results are discussed in terms of restoration and compliance monitoring. The key elements of the Fernald Preserve groundwater monitoring program design are described below. Site personnel completed all groundwater monitoring requirements.

Sampling: Sample locations, frequency, and constituents address operational assessment, restoration assessment, and compliance requirements. Monitoring is conducted to ascertain groundwater quality and groundwater flow direction.

As part of the comprehensive groundwater monitoring program specified in the current IEMP, 93 wells were monitored for water quality in 2022. Figure 12 identifies the location of the current water quality sampling locations for uranium. Figure 13 is a diagram of a typical groundwater monitoring well. Figure 14 illustrates relative monitoring well depths and screen locations. Figure 15 indicates the locations for non-uranium monitoring. In addition to water quality monitoring, 172 wells are used to measure groundwater elevations to verify groundwater flow direction. Figure 16 depicts the routine water-level (groundwater elevation) monitoring wells.

Figure 14 illustrates that there are six different types of monitoring wells (i.e., Type 1, 2, 3, 4, 6, and 8). Monitoring well types 1, 2, 3, 4, and 6 are single-level monitoring wells with a well screen that is 10 or 15 ft in length. Type 8 monitoring wells are multichannel monitoring wells that contain three to six individual 10 ft screens. The Type 8 multichannel monitoring wells provide for sampling a depth profile at a single location. The single-level wells monitor a single 10 ft depth. As summarized below, the location of the monitoring depth is identified by the first digit in the well identification number:

- Type 1: Screen positioned in perched groundwater in the glacial overburden
- Type 2: Screen positioned at the water-table zone of the Great Miami Aquifer
- Type 3: Screen positioned above a clay layer in the Great Miami Aquifer
- Type 4: Screen positioned below a clay layer in the Great Miami Aquifer
- Type 6: Screen positioned at a depth that is between a Type 2 and Type 3

Additionally, 27 locations were sampled using a direct-push (i.e., temporary) sampling tool in 2022. Results are provided in Appendix A, Attachment A.2.

Data Evaluation: The integrated data evaluation process involves review and analysis of the data collected from wells and direct-push sampling locations. The evaluation determines capture and restoration of the total uranium plume, capture and restoration of non-uranium FRL constituents, water quality conditions in the aquifer that indicate a need to modify the design and installation of restoration modules, and the impact of ongoing Fernald Preserve groundwater restoration on the downgradient Paddys Run Road Site plume. The Paddys Run Road Site is a separate contaminant plume, unrelated to the Fernald Preserve, which resulted from industrial activities on privately owned land in the area south of the Fernald Preserve along Paddys Run Road.

Reporting: All data listed for collection in the IEMP are reported in the annual Site Environmental Reports.

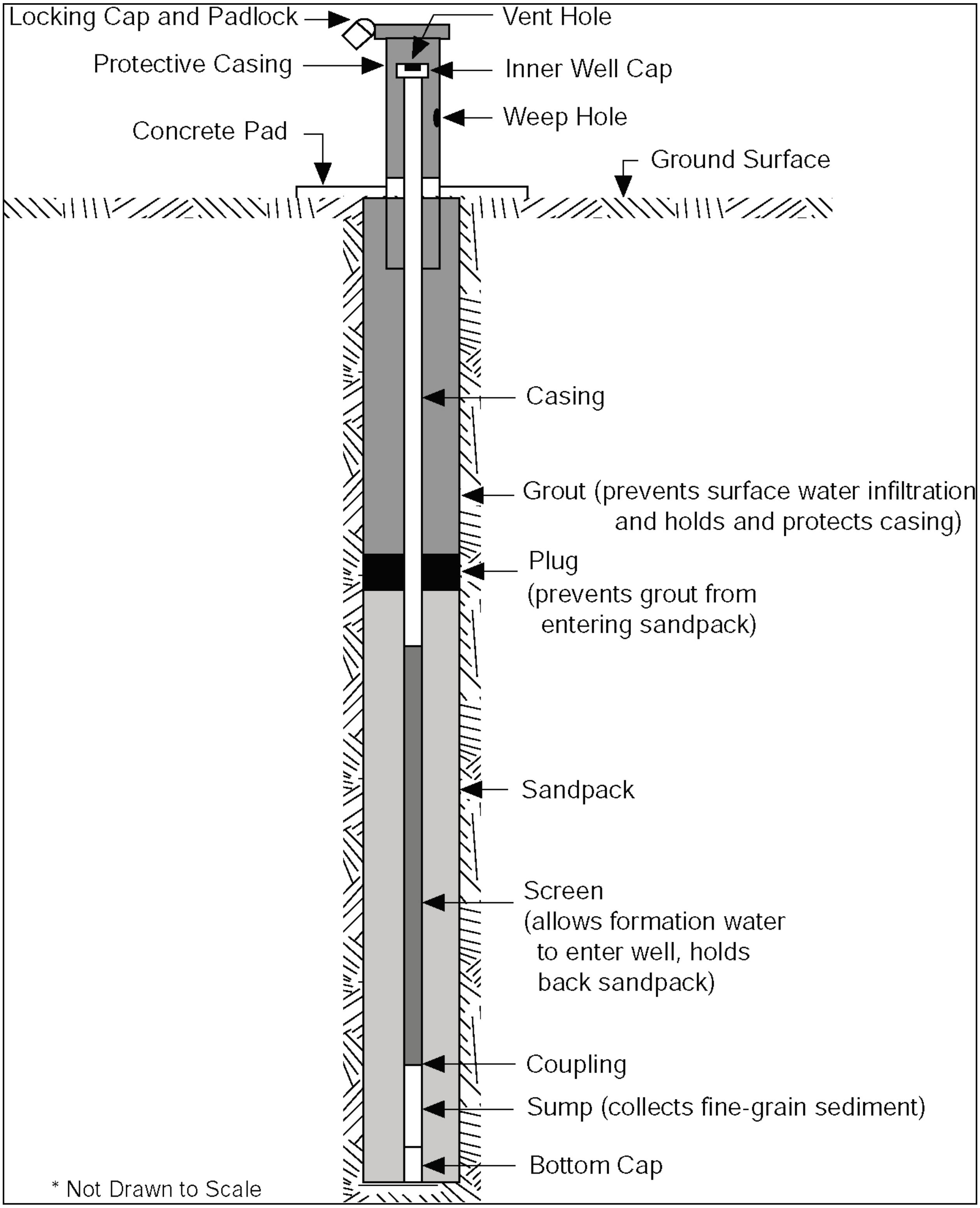


Figure 13. Diagram of a Typical Groundwater Monitoring Well

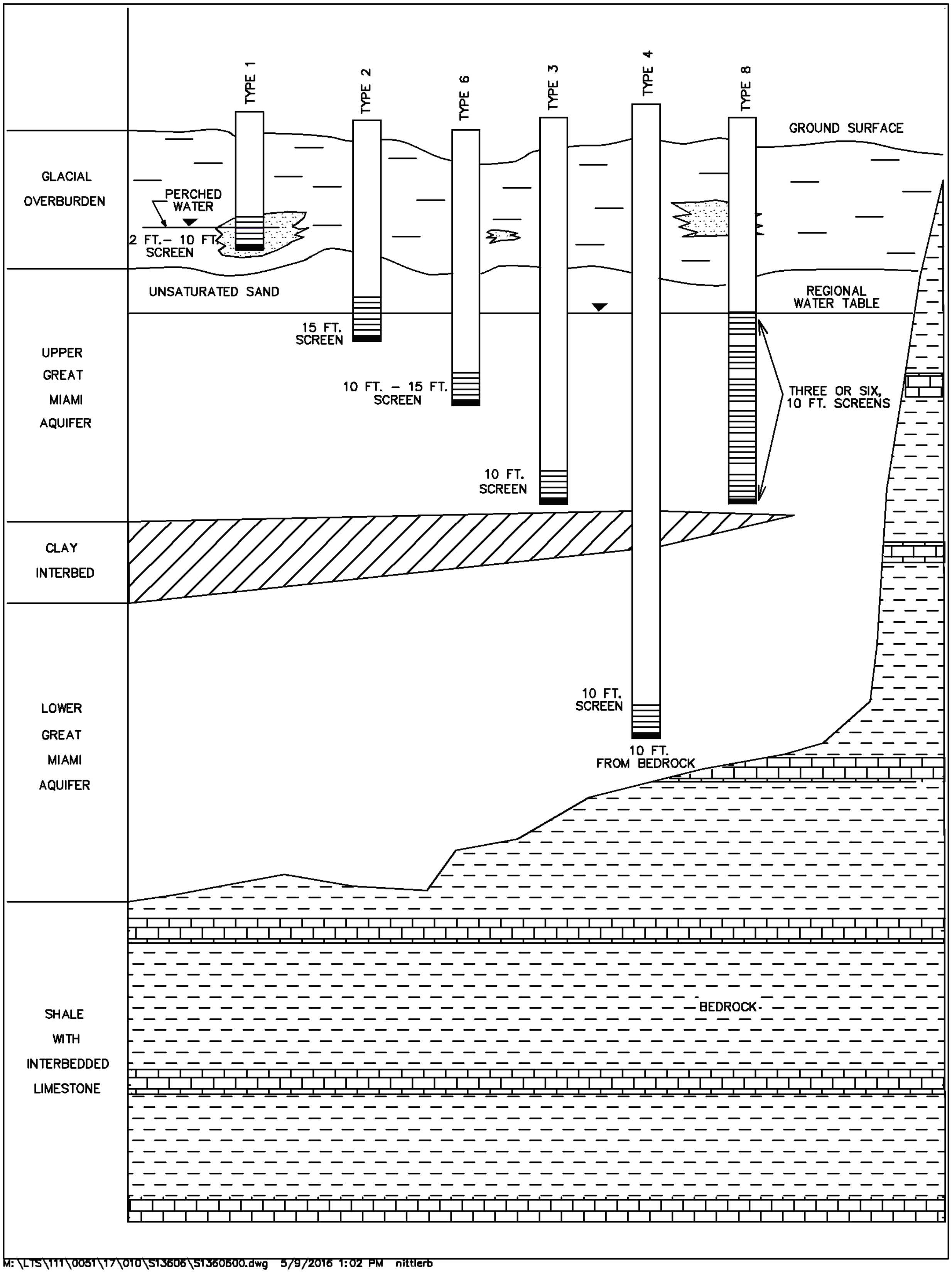


Figure 14. Monitoring Well Screen Locations

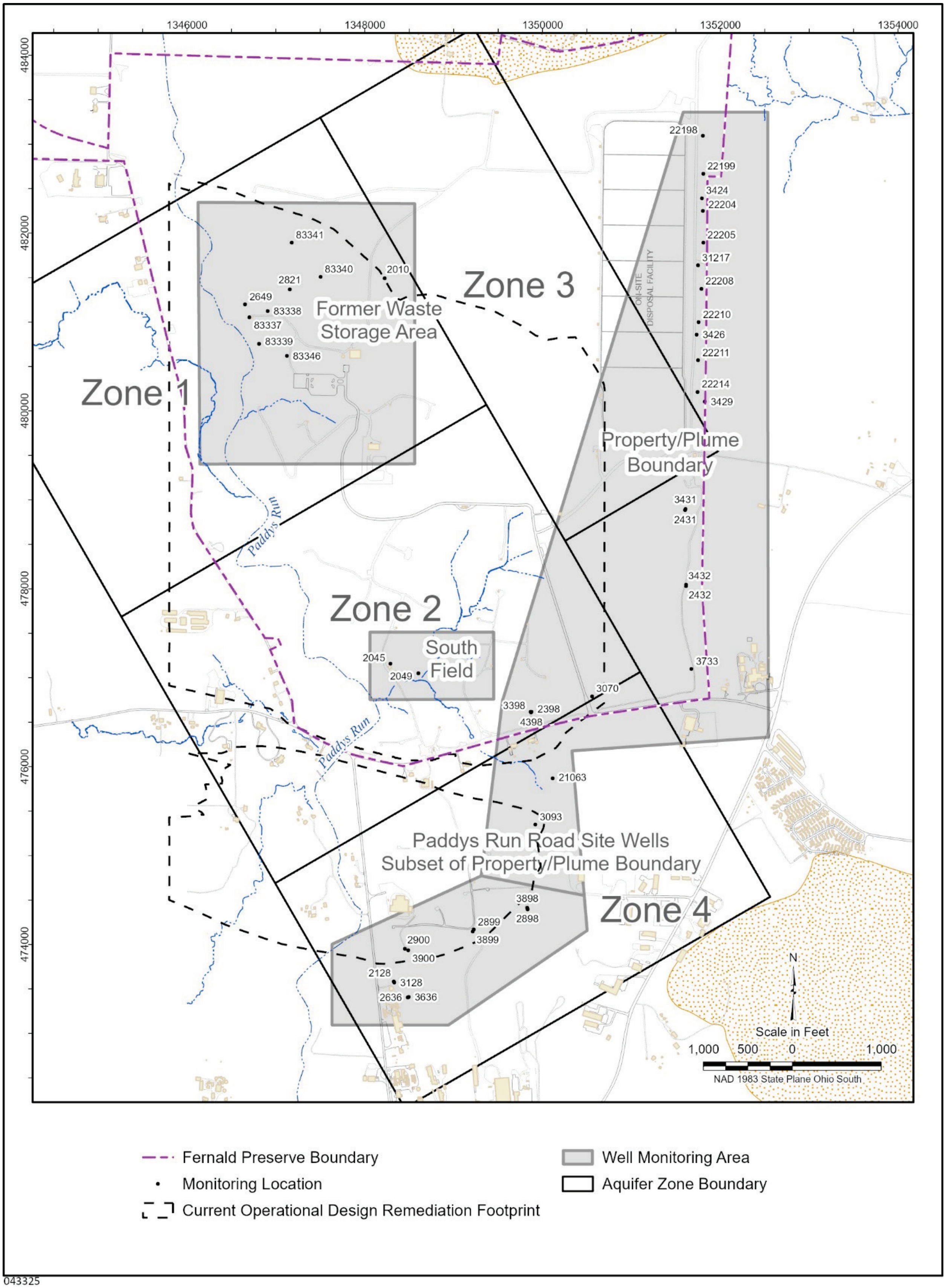


Figure 15. Locations for Non-Uranium Monitoring

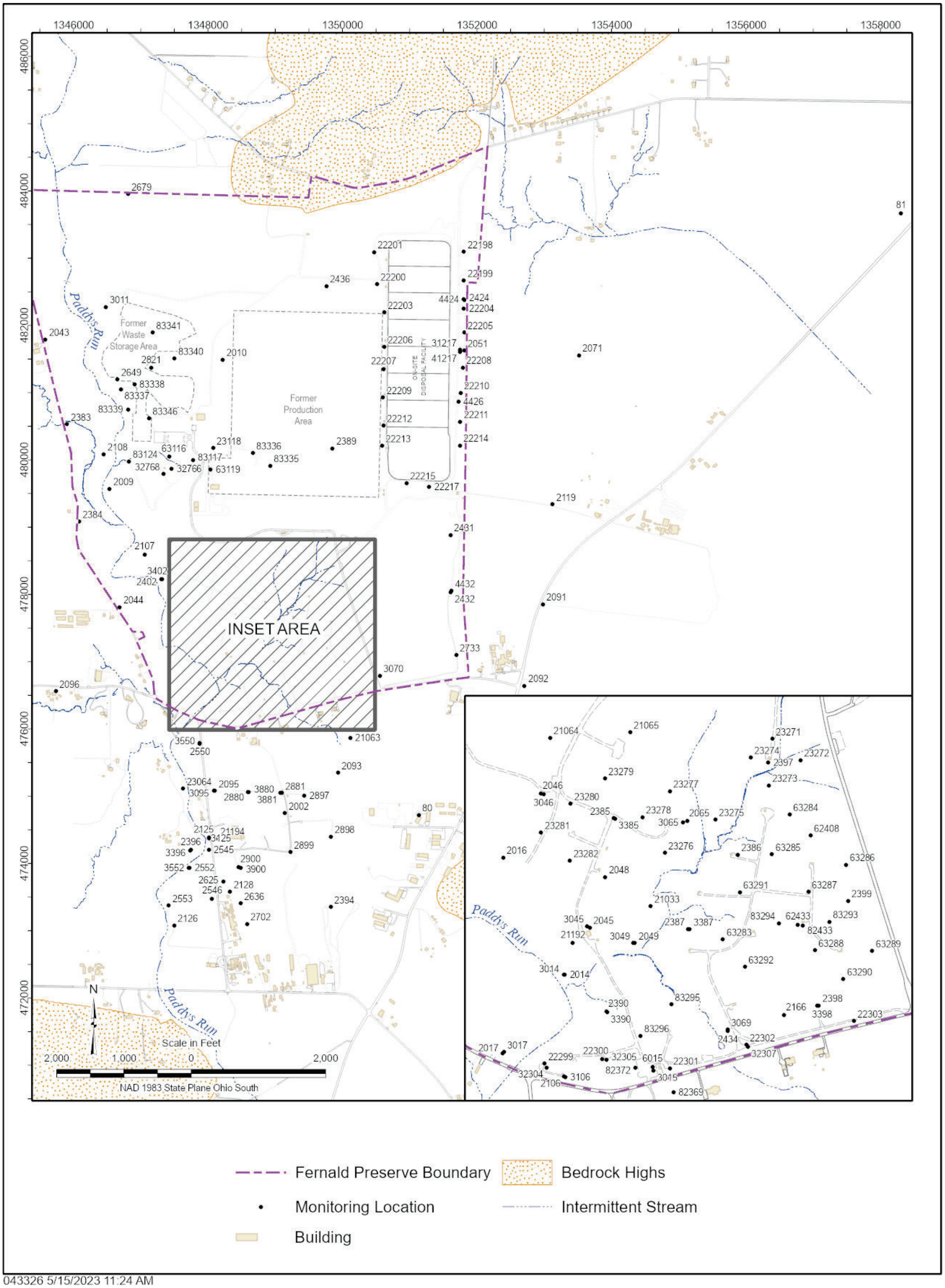


Figure 16. Groundwater Elevation Monitoring Wells

3.3.1 Restoration Monitoring

The Operable Unit 5 ROD (DOE 1996b) states that "areas of the Great Miami Aquifer exceeding final remediation levels will be restored through extraction methods." Uranium is the primary constituent of concern for groundwater. The groundwater FRL for total uranium is 30 µg/L. The background total uranium concentration for unfiltered groundwater samples from the Great Miami Aquifer near the Fernald Preserve is 1.2 µg/L (DOE 1994). Both the area of the aquifer targeted for remediation and the statistical procedures that will be used to verify that the aquifer cleanup objectives have been achieved are presented in the *Fernald Groundwater Certification Plan* (DOE 2006a).

In general, restoration monitoring tracks the progress of the pump-and-treat stage of the groundwater remedy and water quality conditions. Operations are evaluated throughout the year to determine the progress of aquifer remediation. Total uranium concentration maps are developed from analytical data and compared with groundwater elevation maps to show the status of remediation progress and to verify capture of the total uranium plume.

Appendix A provides more-detailed information. Sections that follow identify the specific attachment of Appendix A where the detailed information can be found.

3.3.1.1 Operational Summary

Since 1993:

- 55,123 Mgal of water have been pumped from the Great Miami Aquifer.
- 1,936 Mgal of treated water were reinjected into the Great Miami Aquifer.
- 15,751 net lb of total uranium have been removed from the Great Miami Aquifer.

Appendix A, Attachment A.1, provides detailed operational information on each extraction well. The following sections provide an overview of the individual modules.

Table 4. Groundwater Restoration Module Status for 2022

Modules and Restoration Wells	Target Design Pumping Rate	Volume Pumped	Uranium Removed
	gpm	Mgal	lb
South Plume/ South Plume Optimization Module: 3924, 3925, 3926, 3927, 32308, 32309	1,300[a]	398	56
South Field Module: 31550, 31560, 31561, 32276, 32446, 32447, 33061, 33262, 33264, 33298, 33326	2,875	1,277	237
Waste Storage Area Module: 32761, 33062, 33347	800	332	60
Aquifer Restoration System Total	4,975[a]	2,008	354

[a] In July 2018, the pumping rate of well 3927 was reduced from 200 to 100 gpm.

CAWWT

As presented in the *Fernald Preserve 2015 Site Environmental Report* (DOE 2016a), the CAWWT system had become oversized and reached the end of its useful life. Additionally, equipment corrosion and corrective maintenance had become ongoing issues for facility operations.

In March 2015, a CAWWT Condition Assessment Report was finalized (Whitman, Requardt & Associates 2015) confirming that many of the treatment system components were at or nearing the end of their useful life. A decision was made to replace the CAWWT treatment system with a 50 gpm system inside the CAWWT building. DOE received concurrence on a path forward in July 2015 from EPA and Ohio EPA and in August 2015 from the Fernald Community Alliance. DOE planning for the project began in August 2015.

The project was initiated in 2016 and completed in April 2018. The new system became operational on April 3, 2018.

Refurbishment of the nearby backwash basin occurred in 2019. The backwash basin is used to temporarily store wastewater originating from a variety of sources (i.e., well rehabilitation, CAWWT backwash, OSDF leachate, groundwater sampling, CAWWT laboratory, and CAWWT storm water drainage). Construction began in late summer of 2019 and was completed in December 2019. Accumulated sediment was removed, dried, and packaged for shipment to a licensed low-level radioactive waste disposal facility, Waste Control Specialists, in Texas. The basin liner and wall panels were replaced, and aeration cover systems were installed.

Pulse Pumping

In September 2012, with concurrence from EPA and Ohio EPA, a pulse-pumping exercise began at extraction wells 31550, 31560, 31561, and 33061. These four wells are equipped with pumps and motors that operate most efficiently at rates of approximately 300 gpm. The Waste Storage Area (Phase II) Design called for a target pumping rate of 100 gpm for each of these wells. The 100 gpm rate was being achieved by throttling back on the flow from each of the wells; however, this type of operation was not energy efficient.

To become more energy efficient, beginning in 2012, the wells were being pumped at a higher rate for a shorter period each day to remove the daily volume of water prescribed by the Waste Storage Area (Phase II) Design (DOE 2005b). Specifically, the wells are being pumped for 300 gpm for 8 hours a day (a total of 144,000 gallons per day) rather than 100 gpm for 24 hours a day (a total of 144,000 gallons per day). Flow and particle path monitoring predictions indicate that the new pumping schedule will maintain capture of the total uranium plume. With implementation of the current Operational Design in July 2014, the target pumping rate of extraction well 31561 was increased from 100 to 200 gpm, so pulse pumping was stopped at this well. Pulse pumping continues for the other three wells.

Figure 11 shows the extraction well locations associated with the restoration modules operating in 2022. Also shown in Figure 11 are the three extraction wells that were shut down in April 2014 (33265, 33266, and 33334). Table 4 summarizes the mass of total uranium removed and the volume of groundwater pumped during 2022. Additional details are provided in the module operational summaries in Sections 3.3.1.2 through 3.3.1.4. Figure 17 identifies the yearly and cumulative mass of total uranium removed from the Great Miami Aquifer from 1993 through 2021.

3.3.1.2 South Plume/South Plume Optimization Module Operational Summary

The four extraction wells (3924, 3925, 3926, and 3927) of the South Plume Module began operating in August 1993. The two extraction wells (32308 and 32309) of the South Plume Optimization Module began operating in August 1998. Figure 18 illustrates the southern extent of capture observed for the South Plume/South Plume Optimization Module at the end of 2022.

During 2022, the South Plume/South Plume Optimization Module removed 398 Mgal of groundwater and 56 lb of total uranium from the Great Miami Aquifer. Based on analysis of the data collected in 2022, the module continues to meet its primary objectives as demonstrated by the following:

- Southward movement of the total uranium plume beyond the southernmost extraction wells has not been detected.
- Active remediation of the central portion of the off-property total uranium plume continues to reduce plume concentration. Nearly the entire off-property total uranium plume concentration is now below 100 µg/L. When pumping began in 1993, areas in the off-property total uranium plume had concentrations of over 300 µg/L.
- The Paddys Run Road Site plume (contamination not attributed to Fernald site operations), south of the Fernald Preserve extraction wells, is not being pulled toward the South Plume extraction wells.

In 2022, the South Plume recovery wells continued to experience operational challenges due to their age. Exposure to liquid acid descaler during periodic well treatments and rehabilitations has slowly attacked the metal components of the wells, resulting in leaks. In 2022, South plume recovery wells 3926, 3927, and 32308 experienced operational problems. DOE repaired South Plume recovery well 3926, but, as described below, decisions were made in 2022 to permanently shut down South Plume recovery wells 3927 and 32308.

South Plume recovery well 3927 was able to maintain its design setpoint of 200 gpm from 1993 to 2018. As discussed in Section A.1.9, in 2018 the target pumping rate of South Plume recovery well 3927 was lowered to 100 gpm. In June of 2022, the well was no longer able to maintain 100 gpm and was turned off. DOE attempted several repairs to try to continue operating the well. In July 2022, a new pump and motor were installed, but the pitless adaptor was not able to be seated on the well casing causing the well to leak. In August 2022, the pump and motor were replaced again, but the pitless adaptor would not seat properly a second time. The date of June 6, 2022, is recognized as the official date that this well was permanently turned off. Given that DOE is in the process of installing two new wells that will eliminate the need for recovery wells 3924 through 3927, DOE decided to direct resources toward installing the new wells rather than spending additional resources trying to get recovery well 3927 operating again which would have involved excavations.

In July 2022, an underground leak developed in recovery well 32308 and the well was shut down permanently on July 25, 2022, after 23 years of operation. From 1998 to 2022, the well met its design setpoint of 300 gpm. Groundwater modeling conducted in 2022 demonstrated that the well was no longer located where it needed to be located to efficiently cleanup the remaining South Plume. Given that DOE was already planning a replacement for this well at a more optimal location, DOE decided to direct resources toward installing the new well rather than investigating the cause of the underground leak and implementing costly repairs on a well that was already in the process of being replaced.

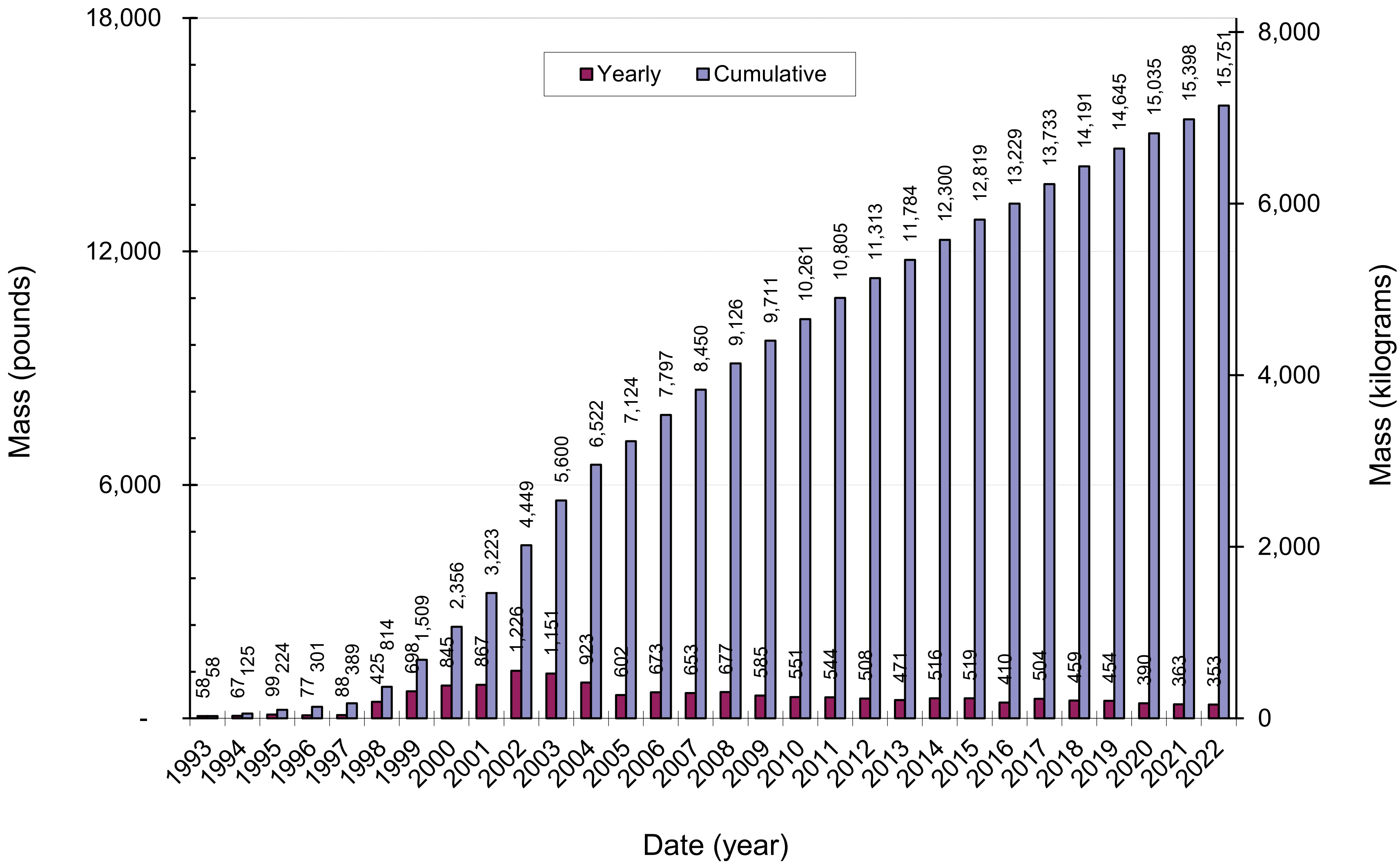


Figure 17. Yearly and Cumulative Mass of Uranium Removed from the Great Miami Aquifer, 1993–2022

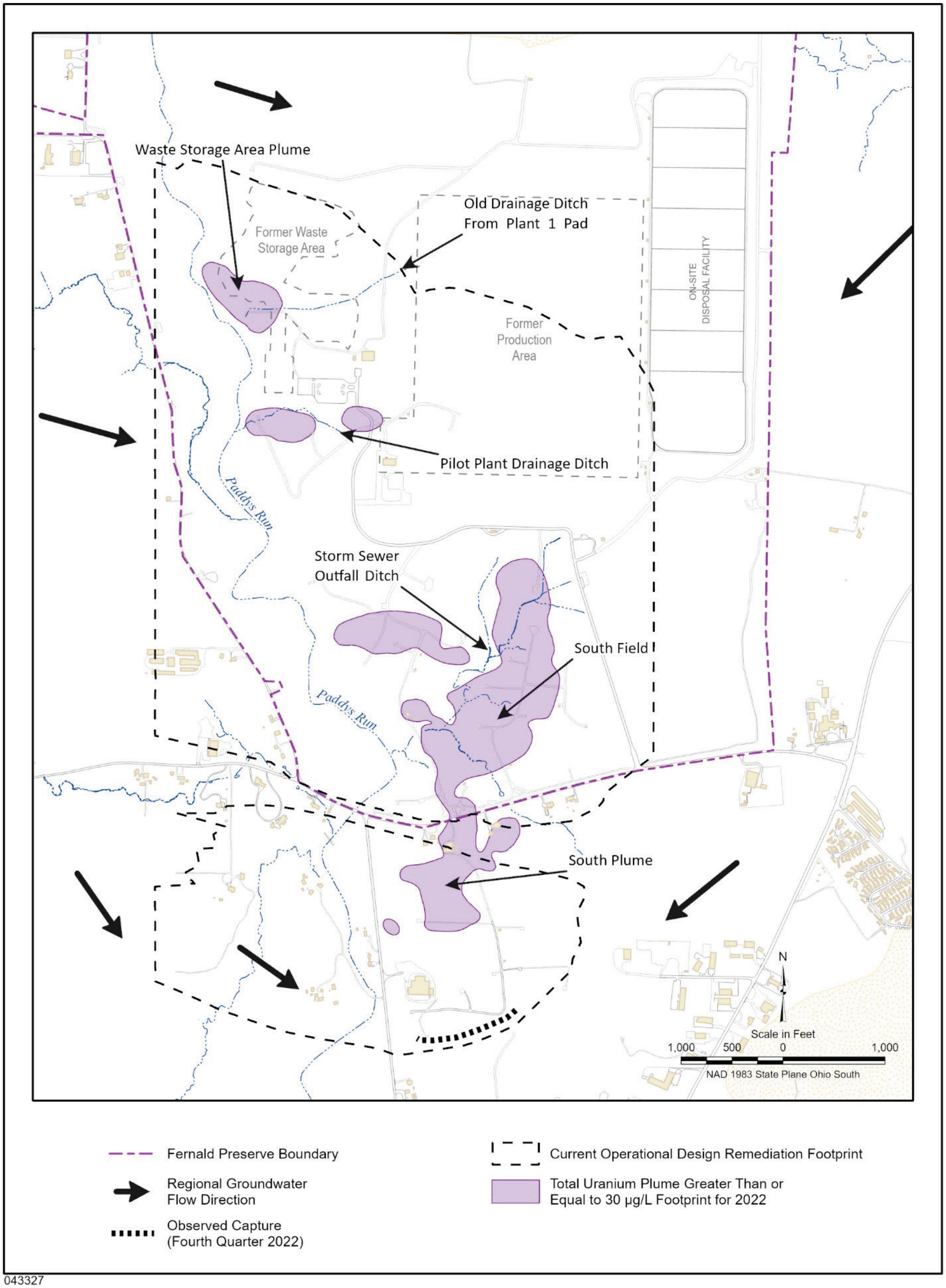


Figure 18. Total Uranium Plume in the Aquifer with Concentrations Greater Than or Equal to 30 µg/L at the End of 2022

3.3.1.3 South Field Module Operational Summary

The South Field Module was constructed in two phases. Phase I began operating in July 1998, and Phase II began operating in July 2003. During 2022, 11 extraction wells were operational.

The 10 original extraction wells installed under Phase I were 31550, 31560, 31561, 31562, 31563, 31564, 31565, 31566, 31567, and 32276. Six of the original 10 wells have been shut down (31562, 31563, 31564, 31565, 31566, and 31567).

- Extraction wells 31564 and 31565 were shut down in December 2001 and May 2001, respectively. Because these wells were located near the upgradient edge of the plume, total uranium concentrations in that region of the aquifer were low. In addition, soil remediation was underway in the area around the wells.
- Extraction well 31566 was shut down in August 1998 and was replaced by extraction well 33262, which was installed as part of South Field (Phase II) Module.
- Extraction well 31563 was shut down in December 2002 and converted to a reinjection well that operated in 2003 and 2004.
- Extraction well 31562 was shut down in March 2003 and replaced by extraction well 33298.
- Extraction well 31567 was shut down in September 2005 and replaced by extraction well 33326.

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

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

- Four additional extraction wells; one in the former Southern Waste Units (extraction well 33262) and three along the eastern edge of the on-property portion of the southern total uranium plume (extraction wells 33264, 33265, and 33266).
- One additional reinjection well in the former Southern Waste Units (reinjection well 33263).
- An extraction well (31563) that was converted into a reinjection well.
- An injection pond that was located in the western portion of the former Southern Waste Units excavations.

In September 2004, the South Field Module reinjection components were shut down. In 2014, operational changes were made to wells in the South Field following recommendations made in a modeling study that was released in 2014 (DOE 2014). On April 14, 2014, extraction wells 33265 and 33266 were shut down because the data indicated that they were no longer providing benefit to the groundwater remedy.

During 2022, the South Field Module removed 1,277 Mgal of groundwater and 237 lb of total uranium from the Great Miami Aquifer.

3.3.1.4 Waste Storage Area Module Operational Summary

The Waste Storage Area Module was constructed in two phases. Phase I became operational on May 8, 2002, nearly 17 months ahead of the October 1, 2003, start date established in the Operable Unit 5 Remedial Action Work Plan. Phase I consisted of three extraction wells (32761, 33062, and 33063). These three wells were installed to remediate a total uranium plume in the PPDD area, according to the *Design for Remediation of the Great Miami Aquifer in the Waste Storage and Plant 6 Areas* (DOE 2001a). In July 2004, extraction well 33063 was plugged and abandoned to make way for surface excavation activities required for site remediation. A replacement well for extraction well 33063 was installed in 2005 (extraction well 33334) and became operational on June 29, 2006. Phase II consisted of one additional extraction well (extraction well 33347), which became operational on October 5, 2006.

In 2014, operational changes were made to wells in the former Waste Storage Area following recommendations made in a modeling study that was released in 2014 (DOE 2014). On April 14, 2014, extraction well 33334 was shut down because the data indicated that it no longer provided a benefit to the groundwater remedy.

During 2022, 332 Mgal of groundwater and 60 lb of uranium were removed from the Great Miami Aquifer through the Waste Storage Area Module.

3.3.1.5 Monitoring Results for Total Uranium

Total uranium is the primary FRL constituent because it is the most prevalent site contaminant and it has affected the largest area of the aquifer. Focusing on remediating the uranium plume also addresses the remaining contaminants. Figure 18 shows the mapped outline of the total uranium plumes in the aquifer through the end of 2022. The total uranium plumes identified in the figure represent the interpreted size of the maximum total uranium plume in which concentrations are at or above the 30 µg/L groundwater FRL for total uranium.

Data collected in 2022 show continued progress in reducing the uranium footprint, as described below:

- The mapped footprint of the total uranium plume decreased in size by 1 acre (1.3%). The area at or above 30 µg/L in 2021 was mapped as being 75.0 acres, and the area above 30 µg/L in 2022 was mapped as being 74.0 acres.
- The area of the total uranium plume above a concentration of 50 µg/L increased in size by 0.7 acre (1.4%). The area at or above 50 µg/L in 2021 was mapped as being 48.7 acres, and the area above 50 µg/L in 2022 was mapped as being 49.4 acres.
- The area of the total uranium plume above a concentration of 100 µg/L decreased in size by 0.5 acres (1.8%). The area at or above 100 µg/L in 2021 was mapped as being 28.3 acres, and the area above 100 µg/L in 2022 was mapped as being 27.8 acres.

Figure 18 identifies hydraulic capture observed during the fourth quarter of 2022 for the active restoration modules and also presents regional groundwater flow directions. The map indicates that the existing extraction system is hydraulically capturing the South Plume and preventing further movement of uranium to the south beyond the extraction wells. Figure 18 also depicts the zone of influence remediation footprint that was predicted by modeling the current Operational Design.

Appendix A, Attachment A.2, provides detailed total uranium plume maps for 2022. Appendix A, Attachment A.3, provides quarterly groundwater elevation maps and capture interpretations, along with graphical displays of groundwater elevation data. Highlights for 2022 for the former Waste Storage Area, former Plant 6 area, and South Field/South Plume area are provided below.

Geoprobe (Direct-Push) Sampling

The Geoprobe, a hydraulically powered, direct-push sampling tool, is used at the Fernald Preserve to obtain groundwater samples at specific depth intervals without installing a permanent monitoring well. Direct-push employs the weight of the vehicle the tool is mounted on and percussive force (hammering) to push the tool into the ground without drilling (or cutting) to displace soil in the tool's path. The Fernald Preserve 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.

Former Waste Storage Area: This area includes the PPDD plume. In 2022, no direct-push samples were collected from the former Waste Storage Area to supplement routine sampling of monitoring wells.

Between 2021 and 2022 the mapped footprint of the 30 µg/L total uranium plume remained the same at 12.5 acres. This is because no direct-push sampling took place in the Former Wase Storage area in 2022. Figure 18 shows the outline of the maximum total uranium plumes in the former Waste Storage Area, as measured in 2022. Data are presented in Appendix A, Attachment A.2.

Former Plant 6 Area: Plans for a restoration module in the former Plant 6 area were abandoned in 2001 based on the outcome of the *Design for Remediation of the Great Miami Aquifer in the Waste Storage and Plant 6 Areas* (DOE 2001a). The design data indicated that the total uranium plume in the former Plant 6 area was no longer present. EPA and Ohio EPA concurred with this decision. Monitoring in the area continues.

Monitoring well 2389 is the only well remaining in the area. Total uranium FRL exceedances were detected at this well again in 2022. As discussed in past Site Environmental Reports, FRL exceedances occur in this area when the water-table elevation exceeds 515 ft above mean sea level. The two samples collected in 2022 at monitoring well 2389 had total uranium concentrations above 30 µg/L. Both samples were collected when the water table had an elevation above 515 ft above mean sea level. The former Plant 6 area will continue to be targeted for additional direct-push sampling when the water table is high to determine whether the total uranium groundwater FRL exceedance is dissipating over time. This location is within the capture zone of the pump-and-treat system.

South Field and South Plume Areas: In 2022, direct-push samples were collected at 27 locations in the South Field and South Plume areas to supplement routine sampling of monitoring wells. Direct-push data for 2022 are presented in Appendix A, Attachment A.2.

In 2022, the mapped footprint of the 30 µg/L total uranium plume in the South Field and South Plume decreased by 1 acre. The area above 30 µg/L in 2021 was mapped as 62.5 acres, and the area above 30 µg/L in 2022 was mapped as 61.5 acres.

In 2022, the area of the total uranium plume in the South Field and South Plume above a concentration of 50 µg/L increased by 0.6 acre. The area above 50 µg/L in 2021 was mapped as 38.9 acres, and the area above 50 µg/L in 2022 was 39.5 acres.

In 2022, the area of the total uranium plume in the South Field and South Plume above a concentration of 100 µg/L decreased by 0.41 acres. The area above 100 µg/L in 2021 was mapped as 20.41 acres, and the area above 100 µg/L in 2022 was 20 acres.

3.3.1.6 Monitoring Results for Non-Uranium Constituents

Although the groundwater remedy is primarily targeting remediation of the total uranium plume, other FRL constituents within the total uranium plume are also being monitored. Figure 19 identifies the locations of the monitoring wells that had non-uranium FRL exceedances. Table 5 shows the number of wells with non-uranium constituents exceeding FRLs in 2022, the number of wells with constituents exceeding FRLs outside the current Operational Design Remediation Footprint, the groundwater FRLs, and the range of 2022 data inside and outside the current Operational Design Remediation Footprint.

Table 5. Non-Uranium Constituents with Results Above FRLs During 2022

Constituent	Number of Wells Exceeding the FRL	Number of Wells Exceeding the FRL Outside the Current Operational Design Remediation Footprint	Groundwater FRL[a]	Range of 2022 Data Inside the Current Operational Design Remediation Footprint[a]	Range of 2022 Data Outside the Current Operational Design Remediation Footprint[a,b]
General Chemistry			(mg/L)	(mg/L)	(mg/L)
Nitrate + Nitrite as Nitrogen	6	0	11[c]	11.6 to 46.8	NA
Inorganics			(mg/L)	(mg/L)	(mg/L)
Molybdenum	1	0	0.10	0.175 to 0.601	NA
Zinc	1	1	0.021	NA	0.0370
Organics			(µg/L)	(µg/L)	(µg/L)
Trichloroethene	1	0	5	8.53	NA
Radionuclides			(pCi/L)	(pCi/L)	(pCi/L)
Technetium-99	2	0	94	322 to 347	NA

[a] mg/L = milligrams per liter, µg/L = micrograms per liter, pCi/L = picocuries per liter.
[b] NA = not applicable.
[c] FRL is based on nitrate from OU5 ROD, Table 9-4; however, the sampling results are for nitrate + nitrite as nitrogen.

During 2022, five non-uranium constituents had FRL exceedances. One location was outside the current uranium-based Operational Design Remediation Footprint (monitoring well 22205, zinc). Additional routine samples will be collected from monitoring well 22205 in 2023 for zinc to determine whether the exceedance is persistent. No plumes were identified for the non-uranium constituents above FRLs at the locations outside the current Operational Design Remediation Footprint in the extensive groundwater characterization efforts evaluated as part of the *Remedial Investigation Report for Operable Unit 5* (DOE 1995d). More details are provided in Appendix A, Attachment A.4.

Non-uranium constituents with FRL exceedances in 2021 at the well locations outside the current Operational Design Remediation Footprint were further evaluated in 2022 to determine if they were random events or if they were persistent according to criteria discussed in Appendix A, Attachment A.4. Additional routine data collected in 2022 were used to determine that the FRL exceedance detected in well 3128 in 2021 was not persistent.

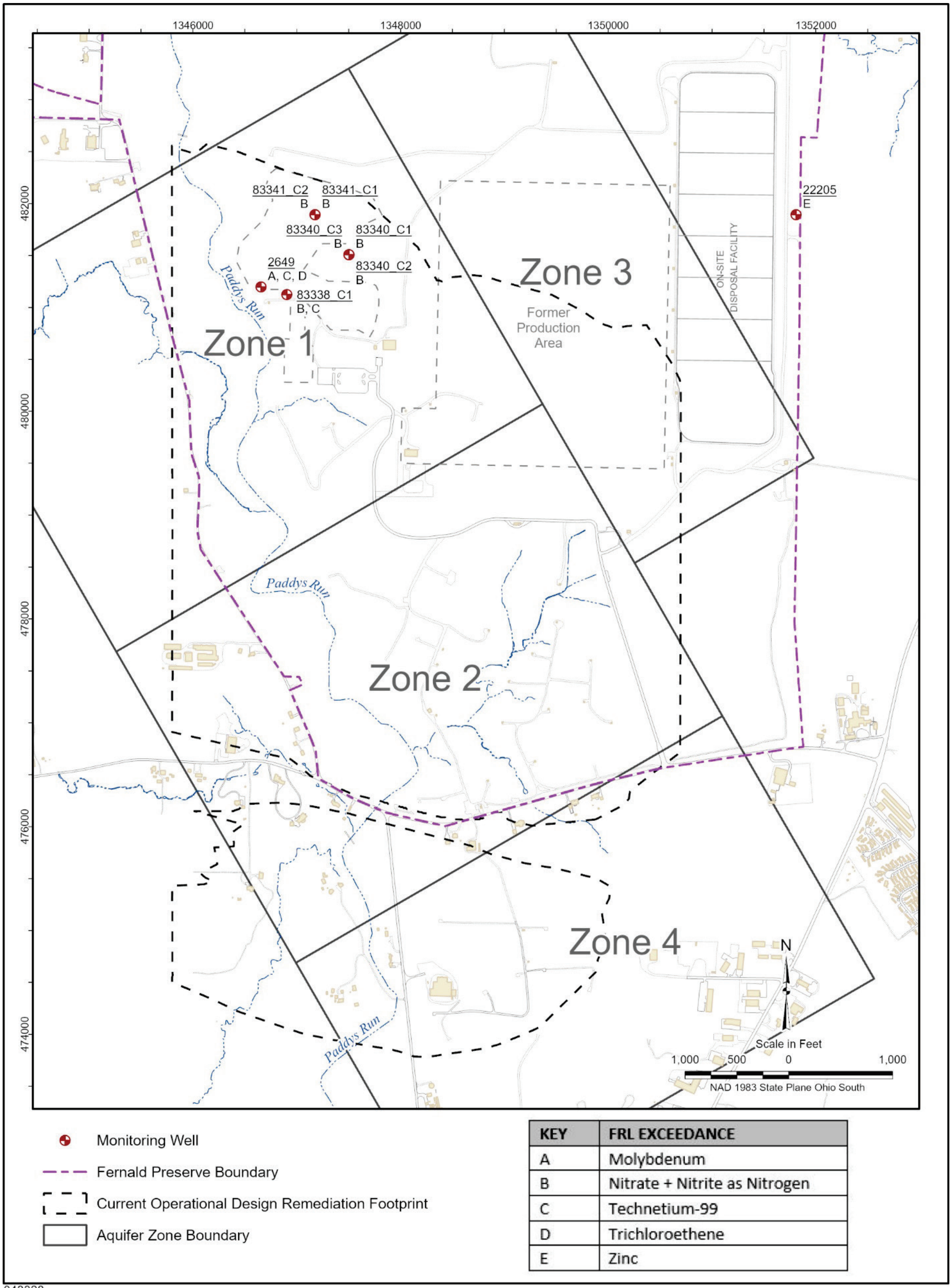
3.3.2 Other Monitoring Commitments

Two other groundwater monitoring activities are included in the IEMP: private well monitoring and property boundary monitoring. As stated earlier, the groundwater data from these activities, along with the data from all other IEMP groundwater monitoring activities, are collectively evaluated for total uranium and, where necessary, non-uranium constituents of concern. This section provides additional details on these two other compliance monitoring activities.

The three private wells (2060, 13, and 14) located along Willey Road were monitored under the IEMP in 2022 to assist in the evaluation of the total uranium plume migration. Off-property groundwater contamination was initially detected at one of these wells (well 2060) in 1981. In 1997, a DOE-sponsored public water supply became available to Fernald site neighbors who were affected by off-property groundwater contamination. When the public water supply became available, DOE discontinued monitoring at many off-property private wells. Data from the three private wells sampled under the IEMP are detailed in Section 2.3 and were incorporated into the total uranium plume maps shown in Figure 18 and Appendix A, Attachment A.2. Non-uranium data from these wells are included in Section 3.3.1.6. Data collected from the 11 wells in the Paddys Run Road area indicate that the Paddys Run Road Site plume (contamination not attributed to Fernald site operations), downgradient of the Fernald Preserve extraction wells, is not being pulled toward the South Plume extraction wells.

With problems associated with the privately-owned pump in well 13 and with an Ohio EPA proposal to reduce split sampling, DOE proposed in the 2021 Site Environmental Report (DOE 2022b) to eliminate monitoring in two of the private wells which are outside the current plume (13 and 14) but continue monitoring in well 2060. Appendix A, Attachment A.2 presents additional information concerning these wells. Following discussions with the homeowners, and with concurrence from EPA and Ohio EPA this change was implemented beginning in 2023.

As indicated in Section 2.0, Ohio EPA issued the Director’s Findings and Orders 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 or variance process (subject to Ohio EPA approval), without issuance of a new Director’s Order. As determined by Ohio EPA, the IEMP will remain in effect following remediation.



KEY	FRL EXCEEDANCE
A	Molybdenum
B	Nitrate + Nitrite as Nitrogen
C	Technetium-99
D	Trichloroethene
E	Zinc

Figure 19. Non-Uranium Constituents with 2022 Results Above FRLs

3.4 Groundwater Remediation Assessment

Data collected in 2022 indicate that the maximum total uranium plume continues to decrease in response to pumping. Table 6 provides a summary.

Table 6. Comparison of 2021 and 2022 Maximum Total Uranium Plume Footprint Areas

Year	Area Greater Than 30 µg/L	Area Greater Than 50 µg/L	Area Greater Than 100 µg/L
2021 (acres)	75	48.7	28.3
2022 (acres)	74	49.4	27.8
Change (acres)	−1.0	−0.7	−0.5
Change (%)	−1.3	+1.4	−1.8

Between 2021 and 2022, the acreage mapped for the area of the maximum uranium plume above 50 µg/L increased by 0.7 acre. Periodic concentration fluctuations within the plume are expected and are attributed to dissolved uranium movement in response to active pumping.

Groundwater elevations measured in 2022 continue to indicate that the pumping wells are maintaining capture of the uranium plume by enhancing and modifying natural groundwater flow directions within the aquifer. Appendix A, Attachment A.3, provides additional information concerning capture of the total uranium plume.

Data collected in 2022 show that the mass of uranium removed from the aquifer was more than what the groundwater model predicted. This indicates that the pumping system remains effective in removing uranium from the aquifer, but that the model is underpredicting how much uranium will need to be removed to achieve cleanup. Appendix A, Attachment A.1, provides additional information concerning the mass of uranium removed from the aquifer.

In 2022, the site groundwater model was updated with uranium concentrations measured in the first half of 2021. Updated modeled cleanup date predictions for the South Plume, South Field and Waste Storage Area were determined to be 2025, 2038, and 2045, respectively. These new cleanup time predictions assume that the no wellfield pumping changes are made to the current operational design.

DOE also modeled in 2022 how best to optimize the South Plume extraction wells moving forward, and how to possibly speed up the cleanup of the South plume. The first model runs focused on utilizing the existing South Plume recovery wells. A big risk factored into these modeling runs though was the assumption that the existing extraction wells would continue to operate dependably until they are no longer needed. DOE was successful in prolonging the operational life of recovery well 3927 by lower its target pumping rate. This approach was therefore modeled for the other extraction wells. The modeling results indicated that predicted cleanup of the South Plume could still be achieved in 2025, even with the existing recovery wells pumping at the lower pumping rates.

Modeling was also conducted in 2022 to provide an alternative approach, should one or more of the existing extraction wells fail. The selected model alternative replaces the six existing South

Plume recovery wells (3924 through 3927) with two new recovery wells that are better positioned for capture and remediation of the remaining South Plume. With operation of the two new proposed recovery wells the existing six South plume extraction wells are no longer needed to capture and remediate the remaining portions of the South Plume. This operational alternative, therefore, removes the risk involved with the continued operation of the existing aging South Plume recovery wells. This alternative also provides DOE with the option of continuing to operate remaining South Plume recovery wells at lower pumping rates to provide additional flushing in the South Plume until it is certified clean.

As discussed in Section 3.3.1.2 recovery wells 3927 and 32308 were permanently shut down in 2022 due to operational problems associated with the old age of the wells. DOE is proceeding with the alternative modeling approach discussed above and is installing two new extraction wells in the South Plume to continue with remediation of the remaining South Plume. The two new extraction wells are scheduled to be operational in 2024.

Bulk plume metrics (i.e., plume acres, average plume concentration, and dissolved uranium mass) are also provided in this year's Site Environmental Report to track groundwater remediation progress. Until 2022, these bulk plume metrics were based on Ricker method calculations (Ricker 2008). Beginning with this year's Site Environmental Report, bulk plume metrics are also provided through the use of Earth Volumetric Studio software. Table 7 provides a summary of the Ricker method bulk plume metrics over time, showing an overall decrease for all three metrics between 2006 and 2022.

Table 7. Bulk Plume Metrics (2006 to 2022)

Year	Plume Area (Acres)	Average Plume Concentration (µg/L)	Remaining Dissolved Uranium Mass (lb)
2006	145.7	92.11	306
2010	132.7	89.96	272
2014	108.0	86.41	213
2016	108.0	79.32	195
2017	97.3	79.12	175
2018	95.9	86.23	190
2019	89.2	81.58	166
2020	85.9	80.77	158
2021[a]	81.6	82.46	153
2022	80.7	88.58	163

[a] Average plume concentration and remaining dissolved uranium mass were corrected from data reported in the 2021 Site Environmental Report (DOE 2022b) from 80.85 µg/L and 150 lb, respectively.

As noted in Table 7, during preparation of these metrics for 2022, it was discovered that errors were noted in the 2021 Site Environmental Report (DOE 2022b). The errors involved the average total uranium concentration and the total mass of dissolved uranium. The errors have been corrected and reported in Appendix A, Attachment A.2; the errors were found to have little effect on the overall interpretation provided in Figure A.2-24. Based on the Ricker method, dissolved mass decreased by approximately 47% between 2006 and 2022, decreasing from 306 lb in 2006 to 163 lb in 2022.

Earth Volumetric Studio software determined bulk plume metric for results for October 1, 2006, October 2, 2021, and October 1, 2022, are as follows.

Metric	October 1, 2006	October 1, 2021	October 1, 2022
Dissolved Mass (lb)	159.64	67.21	54.45
Average Concentration (µg/L)	68.44	67.47	59.21
Area (Acres)	136.50	88.87	85.25
Volume (Cubic Feet)	279.55	119.39	110.21
Average Thickness (feet)	22.45	14.73	14.17

Based on Earth Volumetric Studio software, dissolved plume mass decreased by approximately 66% between 2006 and 2022, decreasing from a maximum 159.64 lb in 2006 to 54.45 lb in 2022. It should be noted that the total mass computed by Earth Volumetric Studio software is significantly lower than the mass calculated by the Ricker method. The 2006 plume mass calculated by the Ricker method is 306 lb compared to 160 lb calculated by the software. The Ricker method is a two-dimensional approach, and conservative assumptions are applied to account for the third vertical dimension. A conservative plume thickness of 30 ft is assumed in the Ricker calculations, and the maximum uranium concentration at each sample location is applied to the full plume thickness. These assumptions are not needed when concentration variations are visualized in three dimensions, so Earth Volumetric Studio software provides a more realistic estimate of plume mass. For example, the average plume thickness calculated by the software for October 2006 is 22.5 ft (25% less than the 30 ft plume thickness assumed for the Ricker method), and the average concentration is 68 µg/L (26% less than the 92 µg/L estimated by the Ricker method). If the mass calculated by the Ricker method is adjusted to account for the overestimates of plume thickness and average concentration, then the 2006 Ricker method calculated mass becomes 170 lb, which is very similar to the 160 lb mass calculate by Earth Volumetric Studio software.

Two calculations, plume center-of-mass and total uranium mass remaining in the aquifer, are presented in Appendix A, Attachment A.2. Plume center-of-mass calculations show that the center of mass of each plume area has remained fairly stationary between 2006 and 2022, indicating that the surrounding pumping wells are capturing the plume and not allowing the center of mass to migrate as it would if no pumping was taking place. Of note is that the center of mass has shifted to the north in the South Field. This provides additional support for the determination that uranium concentrations in the South Plume are decreasing, and that progress is being made in achieving the objective of cleaning up the South Plume first.

The Ricker method calculation for mass remaining in the aquifer estimates the dissolved mass present in the groundwater as total aqueous uranium. The estimate for the mass of aqueous uranium is used to estimate the solid uranium mass adsorbed to aquifer sediments (Deutsch 1997). The dissolved mass and solid mass combined provide an estimate of the total uranium mass remaining in the aquifer. Calculation of the pounds of uranium remaining in the aquifer (dissolved and sorbed) for both the Ricker method and through Earth Volumetric Studio software analysis is 3,395.29 lb and 1,134.19 lb, respectively.

<u>National Laboratory Network Recommendations</u>

In early 2021, a DOE National Laboratory Network Collaboration was conducted concerning the Fernald Preserve groundwater remediation. EPA and Ohio EPA participated in the collaboration, with the understanding that any official input or endorsement for any of the recommendations would be reserved for if, and when DOE decides to pursue implementation of a recommendation at the site. The objective of the collaboration was to present recommendations to improve the ongoing aquifer remediation at the Fernald Preserve.

The collaboration involved two focus groups. Focus Group 1 was challenged with developing recommendations on how to maintain and keep an aging well field system operating efficiently. Focus Group 2 was challenged with developing recommendations to improve the efficiency and success of the existing pumping remedy and to improve the aquifer cleanup predictions for planning purposes while considering the following three site priorities:

1. Focus first on the off-property plume.
2. Focus second on the southern South Field plume.
3. Focus third on the recalcitrant areas of the plume in the South Field and former Waste Storage Area.

Results of Focus Group 1: Aging Well Field System

Focus Group 1 did not identify anything that is currently being done to maintain the aging well field system at the Fernald Preserve that should stop being done. Focus Group 1 acknowledged that operating an aging wellfield system efficiently is somewhat of a “art” rather than a “science” in that there is no one proven method or process that seems to always work. Success involves a degree of trial and error to determine the optimal operational practice for any given well. Given the operational challenges at the Fernald Preserve, the current operation and maintenance program was determined to be sound. When the DOE National Laboratory Network Collaboration personnel contacted area experts for information, those familiar with the site’s well field maintenance program emphasized that they often refer to the Fernald Preserve when they need an example of how to approach the challenge. Focus Group 1 presented the following three consensus recommendations:

1. Test the use of automatic biofilm and scale control in the extraction wells.
2. Test the use of carbon dioxide to rehabilitate extraction wells.
3. Enhance rehabilitation contact (i.e., use of satellite wells to deliver treatments).

DOE began implementing these recommendations in 2022 by conducting a small-scale test of the automatic biofilm and scale control recommendation.

The automatic biofilm and scale control recommendation calls for the routine administration of a biocide like peracetic acid instead of the current practice of doing periodic administration of liquid acid descaler. Routine administration of the peracetic acid will require infrastructure modifications to the wellheads of the extraction wells. Before making these wellhead modifications, DOE conducted a manual test on a select couple of extraction wells. The National Laboratory Network recommendation called for the use of a biocide like peracetic acid on a new extraction well. A new extraction well was not available, so two recently rehabilitated extraction wells were selected for the test. With concurrence from EPA and Ohio EPA, the manual test began in November 2021 and lasted 6 months. Specific capacity data collected during the small-scale test indicate that the routine use of peracetic acid on aged wells that were recently rehabilitated brought no improvement in the efficiency of the wells specific capacity compared to the periodic use of liquid acid descaler on a recently rehabilitated well. However, the scenario of doing routine administration of peracetic acid on a brand-new extraction well remains untested. DOE may attempt the test again when a newly installed extraction well is available.

All three National Laboratory Network recommendations from Focus Group 1 pertain to extending the life of an extraction well. Considering the age of the existing extraction wells, rather than trying to prolong their lives further, the best option may be to strategically replace them. DOE will revisit all three Focus Group 1 National Laboratory Network recommendations as deemed appropriate when replacement of an extraction well is being considered.

Results of Focus Group 2: Improve Efficiency of the Aquifer Cleanup

Focus Group 2 did not identify anything that is currently being done to improve efficiency of the aquifer cleanup at the Fernald Preserve that should be stopped. Six recommendations were presented. Four of the six recommendations involved doing things that are *not* being done at the Fernald Preserve. Two of the six recommendations involved things that the Fernald Preserve are being done but that should be supplemented with something that the Fernald Preserve is *not* doing.

What the Fernald Preserve is not doing, but should be doing:

1. Use alternative mathematical expressions to predict cleanup time frames.
2. Conduct targeted data mining of available site information for enhanced understanding of prior fate and transport behavior and improved predictions of future behavior.
3. Prepare three-dimensional visualizations of key hydrogeologic and geochemical parameter distributions over time.
4. Conduct algorithm-based optimization for future remedy operation and design.

What the Fernald Preserve is doing that should be supplemented with something else:

1. Refine plume metric calculations to reduce uncertainty.
2. Continue to port the site groundwater model to a modern hydrologic software platform.

DOE has implemented two of the Focus Group 2 recommendations in 2022: (1) The use of alternative mathematical expressions (discussed in Appendix A, Attachment A.1) and (2) The three-dimensional visualization of key hydrologic and geochemical parameter distributions over time (discussed in Appendix A, Attachment A.2). It is anticipated that full implementation of all the recommendations will take from 1 to 4 more years. Implementation of any National Laboratory Network recommendation is subject to availability of resources, stakeholder coordination (as appropriate) and regulatory approval.

Both of the completed recommendations mentioned add value to the ongoing aquifer remediation by improving the interpretation capabilities and providing more powerful data analysis techniques. The objective of continuing with the implementation of the remaining recommendations noted above is to improve the predicative capability of the site groundwater model and lead to a more efficient and timely remediation of the remaining contaminant plume.

3.5 OSDF Monitoring

Monitoring of the OSDF is conducted in the leachate collection system (LCS), leak detection system (LDS), glacial till (perched water), and Great Miami Aquifer. Figure 20 identifies the OSDF footprint and monitoring well locations for Cells 1 through 8. Flow is monitored within the facility in the LCS and LDS to determine whether the facility is operating as designed. Water quality is monitored in the LCS, LDS, glacial till, and Great Miami Aquifer to identify any potential water quality changes that could have resulted from leakage from the facility.

LCS and LDS flow data collected in 2022 indicate that engineered features within the OSDF continue to perform as designed. Leachate flow continues to diminish as expected, and LDS flow volumes indicate that the cell liners are performing well as designed.

A comparison of water quality data collected in 2022 from within the facility (LCS and LDS) to water quality data collected beneath the facility (perched groundwater in the glacial till and groundwater in the Great Miami Aquifer) indicates that the facility is operating as designed. Table 8 summarizes the groundwater, LCS, and LDS monitoring information for Cells 1 through 8 of the OSDF by providing the range of total uranium concentrations measured in 2022. The majority of total uranium concentrations measured in 2022 fell within the historical range of concentrations previously measured for each monitoring horizon. New high and new low concentrations measured in 2022 are identified in bold in Table 8.

As shown in Table 8, and summarized below, two new high total uranium concentrations were detected in 2022 within the facility (LDS horizon). As reported in Appendix A, Attachment A.5, the uranium concentrations in the LDS horizons have historically increased as the LDSs dry out. Continued monitoring is the recommended action at this time.

- LDS of Cell 4: A new high of 79.8 µg/L was measured. The previous high was 55.9 µg/L.
- LDS of Cell 6: A new high of 160 µg/L was measured. The previous high was 152 µg/L.

Summary statistics and time versus concentration graphs for each of the monitoring horizons listed in this section are provided in subattachments to Appendix A, Attachment A.5. Also provided in subattachments to Attachment A.5 are bivariate plots for each of the eight cells, which demonstrate that mixing between the LCS, LDS, and horizontal till well at each cell is not occurring. The new high concentrations summarized for 2022 are attributed to decreasing flow rates in the LDS. Continued routine sampling is the recommended action.

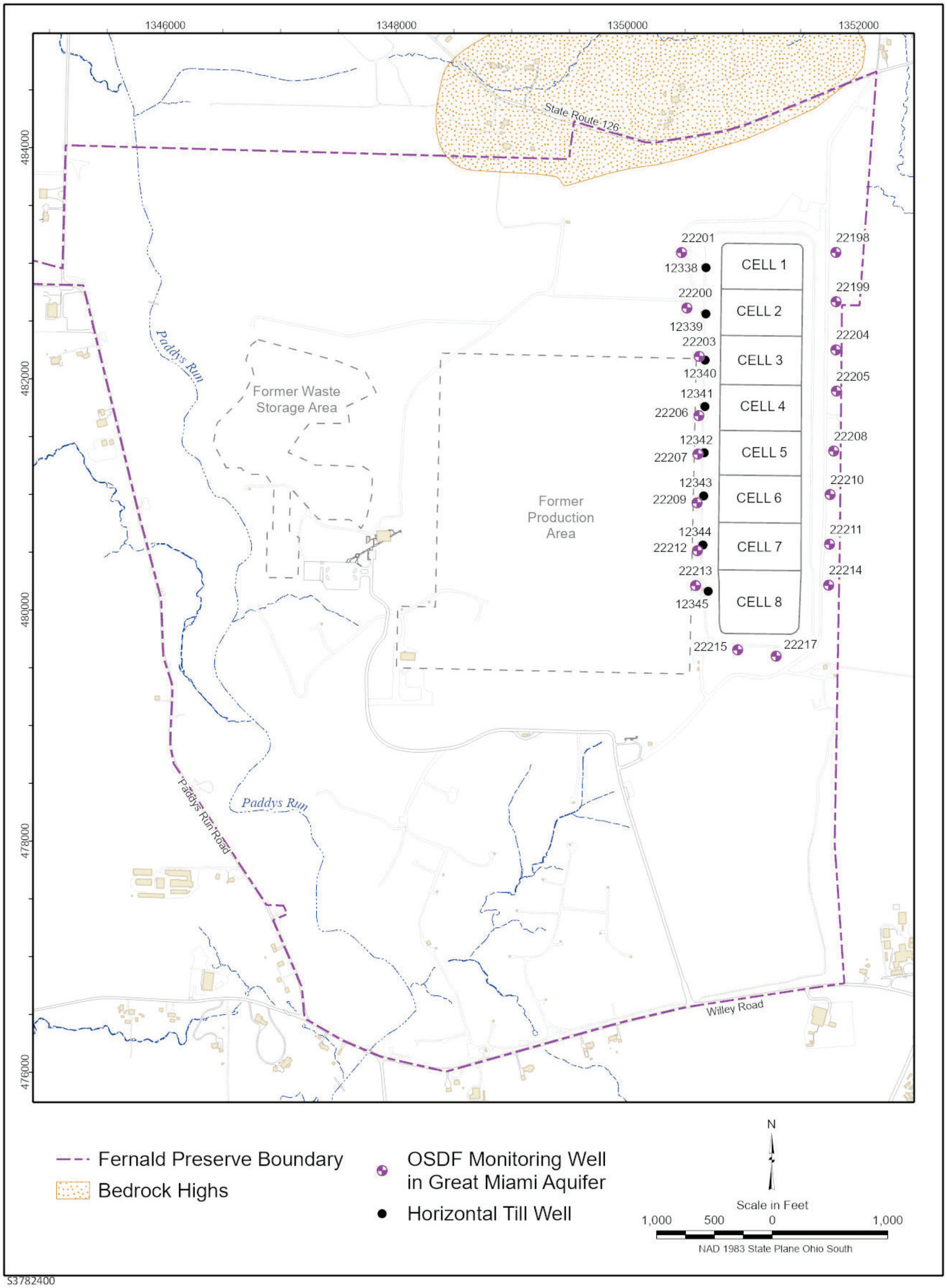


Figure 20. OSDF Footprint and Monitoring Well Locations

Table 8. OSDF Groundwater, Leachate, and LDS Monitoring Summary

Cell (Waste Placement)	Monitoring Location	Monitoring Zone	Date Sampling Started	Total Number of Samples	Range of Total Uranium Concentrations[a,b] (µg/L)	First Half 2022[a,c] (µg/L)	Second Half 2022[a,c] (µg/L)	Historical Trend[d] (Year Last Sampled)
Cell 1 (Dec 1997)	12338C	LCS	Feb 17, 1998	78	ND–206	18.8	10.2	None (2022)
	12338D	LDS	Feb 18, 1998	37	1.50–37.0	DRY	DRY	Up (2011)
	12338	Glacial Till	Oct 30, 1997	87	ND–19	7.12	6.68	Up (2022)
	22201	Great Miami Aquifer	Mar 31, 1997	94	ND–12.4	5.52	6.07	Up (2022)
	22198	Great Miami Aquifer	Mar 31, 1997	143	0.540–15.2	3.08	2.51	Down (2022)
Cell 2 (Nov 1998)	12339C	LCS	Nov 23, 1998	74	4.51–686	45.8	55.9	Up (2022)
	12339D	LDS	Dec 14, 1998	29	4.08–25.8[e]	DRY	DRY	None (2013)
	12339	Glacial Till	Jun 29, 1998	98	ND–36.9	15.8	17.9	Up (2022)
	22200	Great Miami Aquifer	Jun 30, 1997	89	ND–4.69	0.303	1.49	Up (2022)
	22199	Great Miami Aquifer	Jun 25, 1997	120	ND–12.1	0.353	0.513	Down (2022)
Cell 3 (Oct 1999)	12340C	LCS	Oct 13, 1999	72	9.27–206	141	131	Up (2022)
	12340D	LDS	Aug 26, 2002	20	8.90–27.7[e]	DRY	DRY	Down (2007)
	12340	Glacial Till	Jul 28, 1998	91	ND–58.5	16.3	15.2	None (2022)
	22203	Great Miami Aquifer	Aug 24, 1998	84	ND–**23.5**	**23.5**	9.45	Up (2022)
	22204	Great Miami Aquifer	Aug 24, 1998	115	ND–22.9	3.08	1.96	Up (2022)
Cell 4 (Nov 2002)	12341C	LCS	Nov 4, 2002	58	4.41–234	113	86.4	None (2022)
	12341D	LDS	Nov 4, 2002	42	5.74–**79.8**	**79.8**	DRY	Up (2022)
	12341	Glacial Till	Feb 26, 2002	71	3.40–7.91	3.46	3.19	Down (2022)
	22206	Great Miami Aquifer	Nov 6, 2001	75	ND–5.78	0.731	1.14	Up (2022)
	22205	Great Miami Aquifer	Nov 5, 2001	102	0.446–19.7	2.13	2.40	None (2022)
Cell 5 (Nov 2002)	12342C	LCS	Nov 4, 2002	60	3.39–285	131	162	None (2022)
	12342D	LDS	Nov 4, 2002	40	2.93–27.1	DRY	DRY	Down (2013)
	12342	Glacial Till	Feb 26, 2002	72	7.45–21.1	7.64	8.90	Down (2022)
	22207	Great Miami Aquifer	Nov 6, 2001	75	ND–4.48	0.449	0.269	Down (2022)
	22208	Great Miami Aquifer	Nov 5, 2001	101	ND–2.1	0.361	0.254	None (2022)
Cell 6 (Nov 2003)	12343C	LCS	Oct 27, 2003	57	8.03–276	119	103	Down (2022)
	12343D	LDS	Oct 27, 2003	56	3.1–**160**	**160**	133	Up (2022)
	12343	Glacial Till	Mar 14, 2003	64	ND–24.2	8.48	7.80	None (2022)
	22209	Great Miami Aquifer	Dec 16, 2002	70	ND–2.43	0.409	0.447	Down (2022)
	22210	Great Miami Aquifer	Dec 16, 2002	96	ND–1.02	0.638	0.647	None (2022)

Table 8. OSDF Groundwater, Leachate, and LDS Monitoring Summary (continued)

Cell (Waste Placement)	Monitoring Location	Monitoring Zone	Date Sampling Started	Total Number of Samples	Range of Total Uranium Concentrations[a,b] (µg/L)	First Half 2022[a,c] (µg/L)	Second Half 2022[a,c] (µg/L)	Historical Trend[d] (Year Last Sampled)
Cell 7 (Sep 2004)	12344C	LCS	Sep 2, 2004	53	4.72–355	56.2	90.9	Down (2022)
	12344D	LDS	Sep 2, 2004	29	12.2–169[e]	DRY	DRY	Up (2015)
	12344	Glacial Till	Feb 24, 2004	61	0.674–12.1	3.54	3.91	Up (2022)
	22212	Great Miami Aquifer	Jan 21, 2004	63	ND–5.53	0.428	0.385	Down (2022)
	22211	Great Miami Aquifer	Jan 21, 2004	86	ND–4.31	0.369	0.394	None (2022)
Cell 8 (Dec 2004)	12345C	LCS	Oct 18, 2004	50	1.51–335	147	159	None (2022)
	12345D	LDS	Oct 18, 2004	45	9.38–315	DRY	DRY	Up (2021)
	12345	Glacial Till	May 19, 2004	20	3.48–7.3	DRY	DRY	Up (2008)
	22213	Great Miami Aquifer	Mar 31, 2004	62	ND–0.71	0.364	0.354	Up (2022)
	22214	Great Miami Aquifer	Mar 31, 2004	86	ND–2.95	0.469	0.843	Down (2022)
	22215	Great Miami Aquifer	Aug 22, 2005	53	ND–16.4	0.679	0.364	None (2022)
	22217[g]	Great Miami Aquifer	Aug 22, 2005	52	ND–18.3	1.86	5.60	Down (2022)

Note 1: The data on this table represent the raw data from the database; however, data presented in Appendix A, Attachment A.5 have gone through statistical processing and analysis. In regard to the statistical processing, the data were quarterized (normalized to one result per quarter) and outliers removed to arrive at an accurate distribution model. Because of the processing, the total number of samples and range of concentrations on this table may not match the text, tables, and figures in Appendix A, Attachment A.5. The rules used for the statistical processing and analysis in Attachment A.5 are discussed in Appendix A, Attachment A.5, Section A.5.2.1, and summarized in Table A.5-3.

Note 2: Uranium concentration versus time graphs are located in the subattachments to Appendix A, Attachment A.5. See Figures A.5.1-5A and A.5.1-5B for Cell 1; Figures A.5.2-5A and A.5.2-5B for Cell 2; Figures A.5.3-5A and A.5.3-5B for Cell 3; Figures A.5.4-5A and A.5.4-5B for Cell 4; Figures A.5.5-5A and A.5.5-5B for Cell 5; Figures A.5.6-5A and A.5.6-5B for Cell 6; Figures A.5.7-5A and A.5.7-5B for Cell 7; and Figures A.5.8-7A and A.5.8-7B for Cell 8.

[a] **Bold text indicates a new high or low detected in 2022.**
[b] ND = not detected.
[c] Where there are more than two data points for the half year, the higher result is used.
[d] The trends presented here are based on nonparametric Mann-Kendall procedure and come from the tables in Appendix A, Attachment A.5 subattachments for each cell. See Tables A.5.1-1, A.5.2-1, A.5.3-1, A.5.4-1, A.5.5-1, A.5.6-1, A.5.7-1, and A.5.8-1.
[e] Some data are not considered representative of LDS in Cell 2 (December 14, 1998, through May 23, 2000, data set) due to malfunction in Cell 2 leachate pipeline and resulting mixing of individual flows. It is suspected that some November 2004 samples were switched (i.e., 12339C with 12339D, and 12340C with 12340D). If data from these events were included above, maximum total uranium concentrations would be 71 µg/L for 12339D and 72.4 µg/L for 12340D. It is suspected that samples were switched in 2014 (i.e., 12344D with the field duplicate for 12345C). If the data point from this sampling event was not included above, maximum total uranium concentration for 12344D would be 37.6 µg/L.
[f] The Cell 4 LDS was dry, resulting in no data from fourth quarter 2011 through 2016.
[g] Monitoring location 22216 was plugged and abandoned in April 2006. Monitoring location 22217 is its replacement. The results listed for location 22217 also include the results for location 22216.

This page intentionally left blank

4.0 Surface Water and Effluent Pathway

> **Results in Brief: 2022 Surface Water and Effluent Pathway**
>
> **Surveillance Monitoring:** No effluent analytical results from samples collected in 2022 exceeded any surface water FRL.
>
> **Uranium Discharges:** In 2022, 335 lb of uranium were discharged in effluent to the Great Miami River. Approximately 32 lb of uranium were released to the environment through uncontrolled storm water runoff. The estimated total mass of uranium released through the surface water and effluent pathway was approximately 367 lb.
>
> **NPDES Permit Compliance:** There were no instances of noncompliance at any sample location in 2022.

This section presents the 2022 monitoring activities and results for surface water and effluent to determine the effects of site activities on the surface water pathway.

In general, low levels of contaminants enter the surface water pathway at the Fernald Preserve by two primary mechanisms: effluent that is monitored as it is discharged to the Great Miami River and uncontrolled runoff entering the site's drainages from remediated areas that are now certified and restored. Because these discharges have continued through remediation and legacy management, the surface water pathway will continue to be monitored.

4.1 Summary of Surface Water and Effluent Pathway

> To assist in the understanding of this section, the following key definitions are provided:
>
> - **controlled runoff.** Storm water that is collected and, under normal circumstances, treated and discharged to the Great Miami River as effluent. However, currently, the only storm water that is controlled is associated with the footprint of the outdoor processing activities at the wastewater treatment facility.
> - **uncontrolled runoff.** Storm water that is not collected for treatment but enters the site's natural drainages.
> - **effluent.** Primarily untreated groundwater discharged to the Great Miami River via the effluent line. A small amount of groundwater is routed to treatment each month and blended with water from the backwash basin. The small volume of treated water is blended with untreated groundwater and is discharged to the Great Miami River via the outfall line.
> - **surface water.** Water that flows within natural drainage features.

The effluent pathway consists of flows discharged to the Great Miami River via the Parshall Flume, sample location PF 4001. Discharges through this point are considered under the control of wastewater treatment operations. Effluent is currently composed of treated and untreated groundwater, treated leachate from the OSDF, and storm water associated with the footprint of the outdoor processing activities at the wastewater treatment facility. Groundwater is no longer routinely treated to meet discharge limits. A small volume of groundwater is blended with other wastewater stored in the CAWWT backwash basin when basin water is treated. The backwash basin is an above-ground lined impoundment that is used to temporarily store wastewater originating from a variety of sources (i.e., well rehabilitation, CAWWT backwash, OSDF leachate, groundwater sampling, CAWWT laboratory, and CAWWT stormwater drainage).

The volume and flow rate of uncontrolled runoff depend on several tributaries to Paddys Run (e.g., SSOD) as well as the northeast drainage that flows to the Great Miami River. The arrows in Figure 21 indicate the general flow direction of uncontrolled runoff as determined from the topography. Uncontrolled runoff from the Fernald Preserve leaves the property via two drainage pathways: Paddys Run and the northeast drainage ditch.

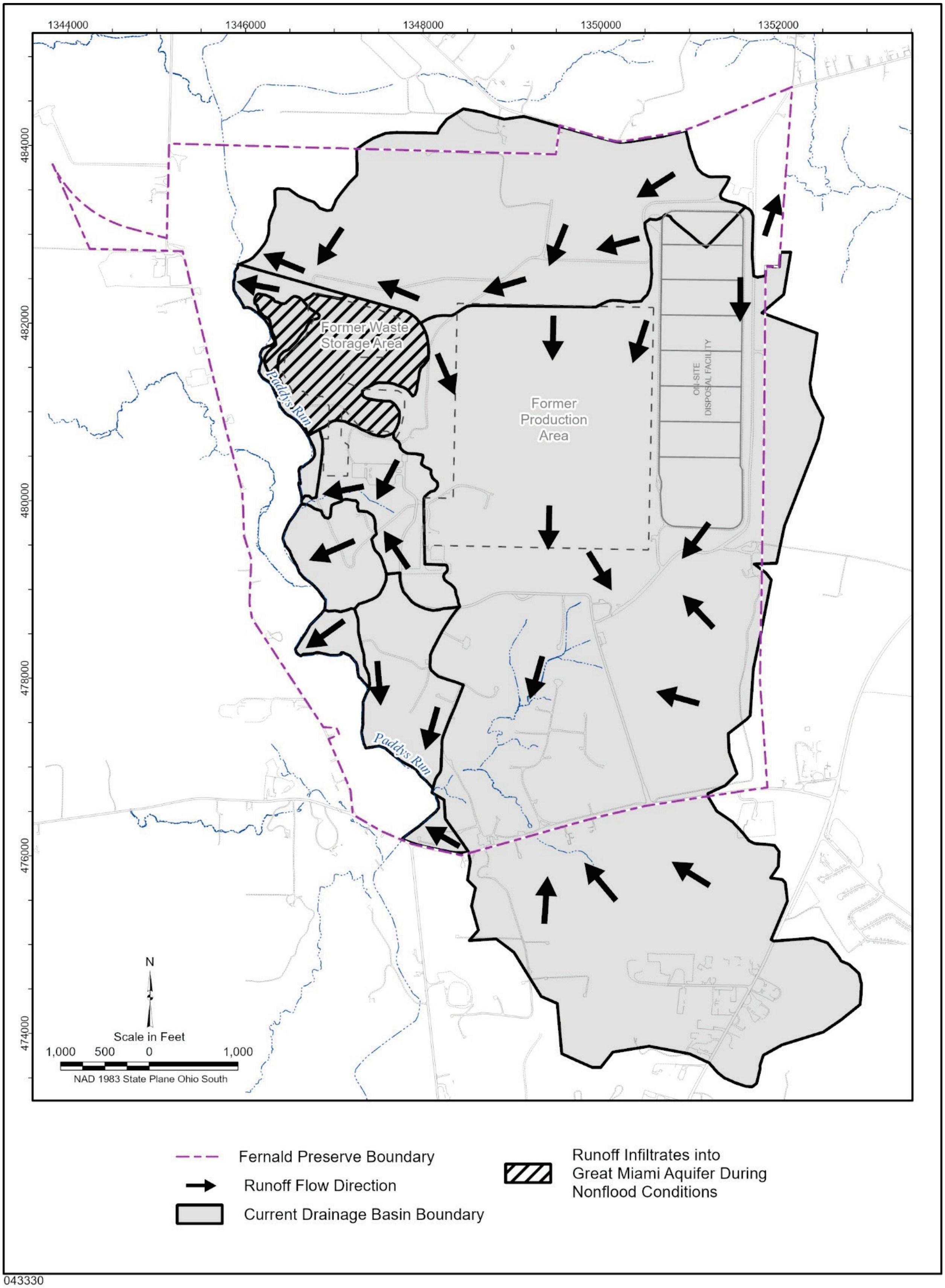


Figure 21. Uncontrolled Surface Water Areas and Runoff Flow Directions

4.2 Remediation Activities Affecting the Surface Water Pathway

Activities that had the potential to affect the surface water pathway included routine operation and maintenance activities of the OSDF and the CAWWT and ecological restoration activities conducted throughout the property, including repairing areas of erosion.

Now that surface remediation has been completed at the Fernald Preserve and the groundwater remedy continues, the restored areas of the site are the primary focus relative to uncontrolled runoff. Controls to mitigate sediment leaving the site are primarily based on the vegetation and stabilization practices (e.g., erosion controls) within the restored areas.

One small area west of the former waste pits, continued to show elevated total uranium concentrations in surface water samples. The location of elevated uranium area is a series of small puddles and drainage ditches due west of the center of former Waste Pit 3, which drain generally south to a depression near the former Waste Storage Area runoff control basin known as the "cement pond." This area does not drain directly to Paddys Run and is not open to the public. A streambank stabilization project was conducted in 2014 and 2015 to ensure that Paddys Run does not erode into this area.

After a limited maintenance activity was completed in the fall of 2007, DOE committed to continue monitoring of the elevated uranium area. Two monitoring points (SWD-05 and SWD-09) were added to the surface water program to fulfill this monitoring commitment (Figure 22). These two locations are sampled weekly when water is present. Surface water volume was sufficient to collect 23 samples at SWD-05 and 31 samples at SWD-09. In 2022, concentrations measured were within the historical range for the area.

4.3 Surface Water and Effluent Monitoring Program

Surface water and effluent are sampled to determine the effect of the Fernald Preserve's activities on the environment. Surface water is sampled at several locations in the site's drainage areas and analyzed for various radiological and nonradiological constituents. Effluent is sampled before discharge into the Great Miami River.

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

- **Sampling:** Sample locations, frequency, and constituents were selected to address requirements of the NPDES permit, the FFCA, and the OU5 ROD and to provide a comprehensive assessment of surface water quality at key locations, including two background (i.e., offsite) locations (Figure 22). Surface water is monitored for six FRL constituents.
- **Data Evaluation:** The integrated data evaluation process focuses on tracking and evaluating data and comparing analytical results with background and historical ranges, FRLs, and NPDES permit limits. This information is used to assess impacts on surface water due to site remediation activities affecting uncontrolled runoff or effluent to the Great Miami River. The assessment also includes identifying the potential for impacts from surface water to groundwater in the Great Miami Aquifer. The ongoing data evaluation is designed to support remedial action decision making.

- **Reporting:** Surface water and effluent data are reported through the annual Site Environmental Report. Monthly discharge monitoring reports required by the NPDES permit are submitted to Ohio EPA.

Data from samples collected under the IEMP are used to fulfill surveillance and compliance monitoring functions. Surveillance monitoring results of the IEMP surface water and effluent program are used to assess the collective effectiveness of site remediation in preventing unacceptable impacts to the surface water and groundwater. Compliance monitoring includes sampling at stormwater and effluent discharge points and is conducted to comply with provisions in the NPDES permit, the FFCA, and the OU5 ROD. 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 22 depicts IEMP and NPDES surface water and effluent sample locations for 2022.

4.3.1 Surveillance Monitoring

> **Effluent** is discharged to the Great Miami River through the effluent line identified in Figure 22. Samples of the 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 mixes with the water in the Great Miami River.

Surveillance monitoring in 2022 was based on an evaluation of analytical results from samples collected during the year. This evaluation indicated that during 2022, there were no exceedances of total uranium in any of the effluent samples analyzed. Seven of the 31 surface water analytical results (23%) from sample location SWD-09 exceeded the surface water FRL for total uranium (530 µg/L) in 2022. The 2022 high result of 918 µg/L is lower than the highest result of 2,087 µg/L collected in 2016. There were no surface water total uranium FRL exceedances in 23 samples collected at SWD-05 in 2022. Analysis of all results from samples collected at SWD-05 and SWD-09 indicates a downward trend for both locations. Residual uranium in the soil appears to be the cause for the elevated uranium concentrations. The contamination appears localized to the area around SWD-09, and the uranium concentrations measured in water collected from locations SWD-05 and SWD-09 appear to be influenced by seasonal changes. Surface water monitoring locations SWD-05 and SWD-09 were established to monitor the area west of the former Waste Pits Area where elevated uranium concentrations have been detected. Based on the number of years of data collected at SWD-05 and SWD-09, DOE is proposing to reduce the weekly sampling frequency at these locations to semi-annual to align with the frequency of sampling as stated in the LMICP. Appendix B provides additional details.

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

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

No total uranium results exceeded the surface water FRL of 530 µg/L during 2022 at these two locations. The total uranium concentration at SWP-03 in the sample collected March 7, 2022, was 2.0 µg/L, well below the surface water total uranium FRL of 530 µg/L. Figure 23 illustrates the decrease of the total uranium concentration in Paddys Run from 1985 through 2022. The large decrease in concentration in 1987 is attributable to the installation of the stormwater retention basin in 1986, which greatly reduced the volume of contaminated runoff flowing into Paddys Run from the Former Production Area.

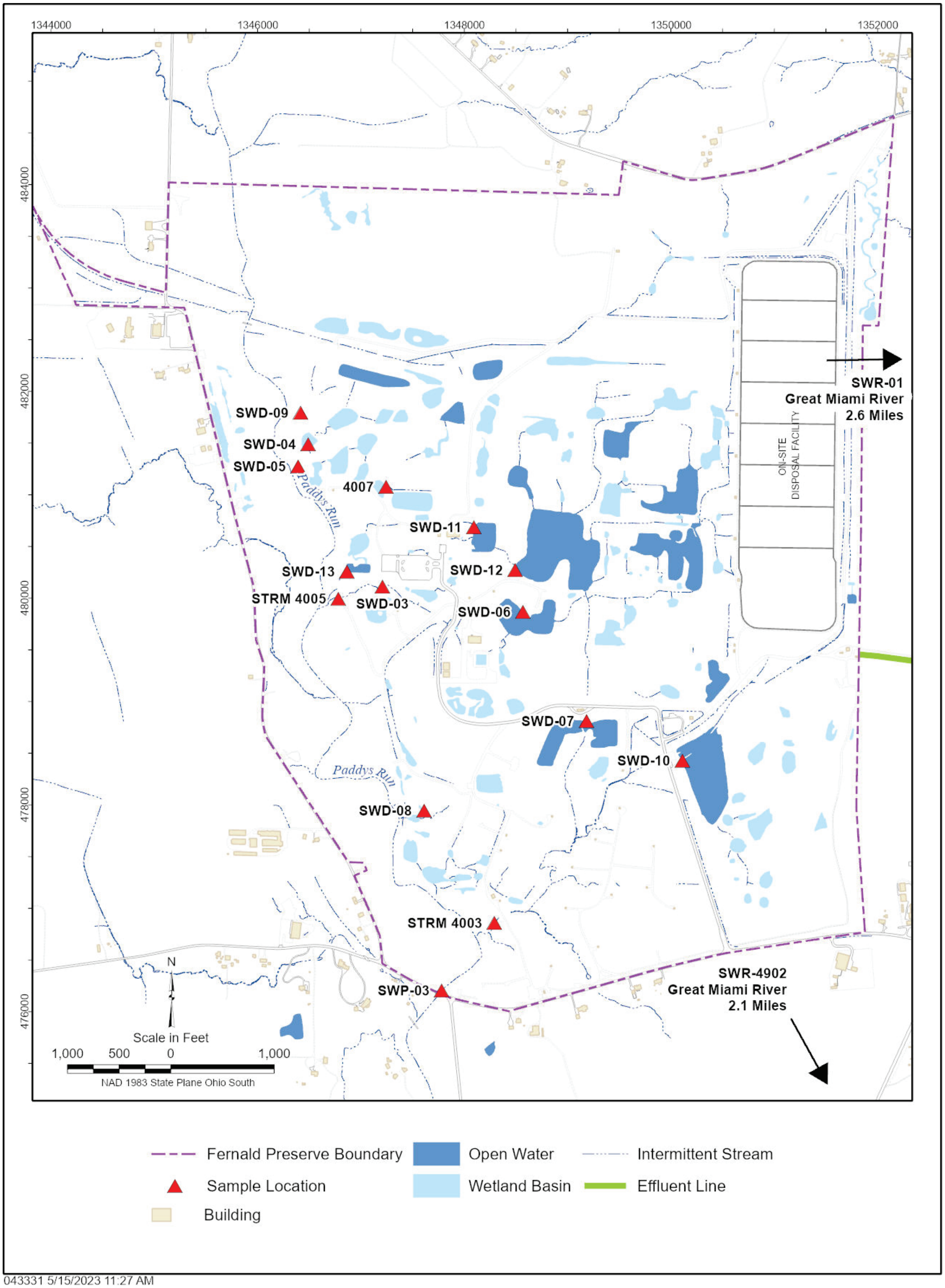


Figure 22. IEMP/NPDES Surface Water and Effluent Sample Locations

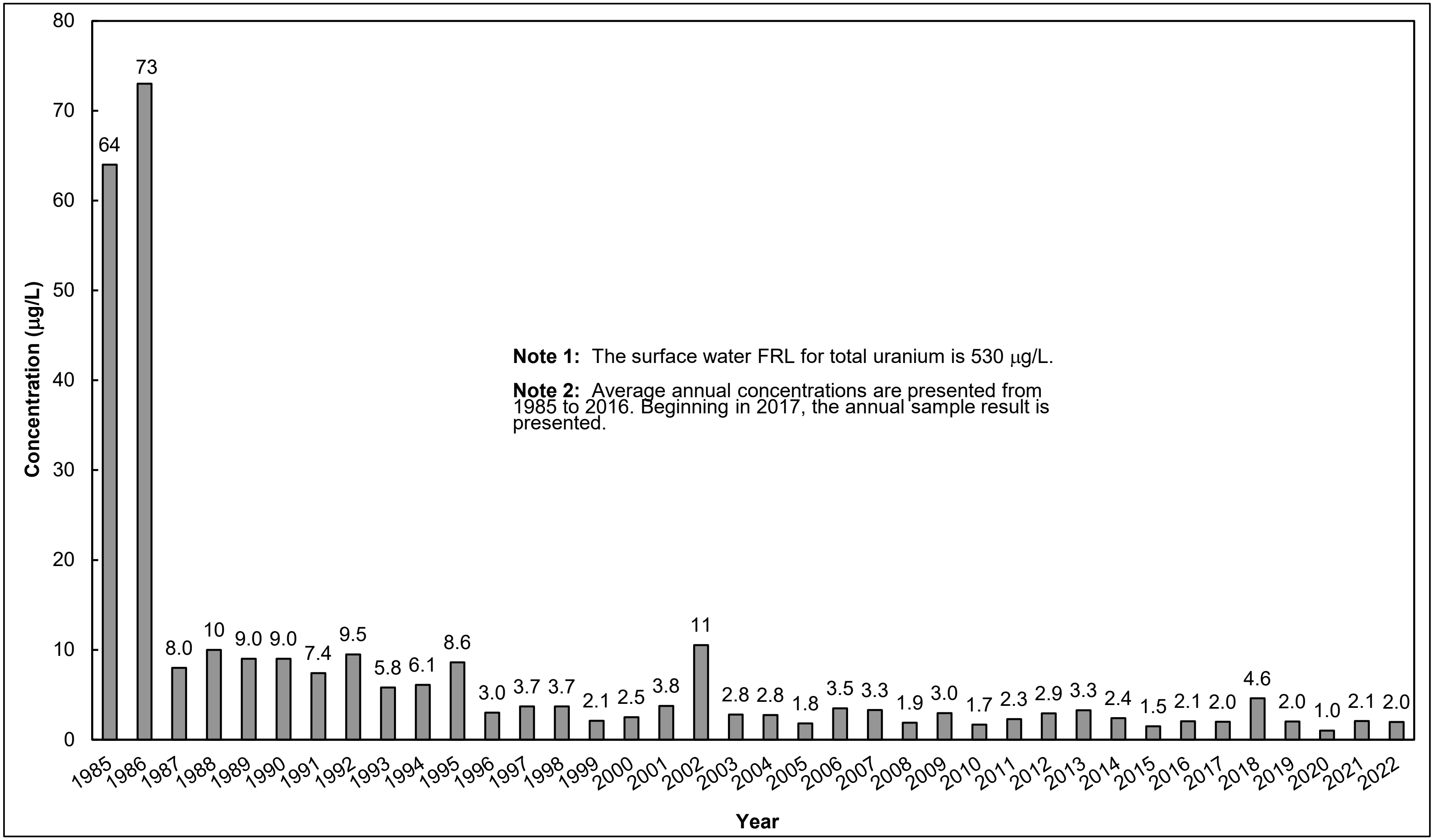


Figure 23. Annual Average Total Uranium Concentrations in Paddys Run at Willey Road (SWP-03 Sample Location)

Samples collected at PF 4001 are used in the surveillance evaluation because this is the last point where effluent is sampled before discharge to the Great Miami River. The maximum daily total uranium concentration at PF 4001 in 2022 was 24.4 µg/L on February 26, 2022. This result is below the drinking water standard (30 µg/L) and far below the surface water total uranium FRL of 530 µg/L. 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. A mixing equation (discussed further in Appendix B) is used to account for the actual flow rate in the Great Miami River and the discharge flow rate at PF 4001 when the maximum uranium concentration was detected. The resulting concentration in the river after mixing was estimated to be 2.30 µg/L for February 26, 2022.

Surface water data are also evaluated to provide an ongoing assessment of the potential for cross-media impacts from surface water to the underlying Great Miami Aquifer. In areas where glacial overburden is absent, a direct pathway exists for contaminants to reach the aquifer. This contaminant pathway to the aquifer was considered in the design of the Fernald Preserve groundwater remedy. The groundwater remedy includes pumping from groundwater extraction wells downgradient of these areas where direct infiltration occurs. This pumping serves to capture and remove contaminated groundwater from the aquifer, mitigating any potential cross-media impacts. To provide this assessment, sample locations were selected to evaluate contaminant concentrations in surface water just upstream or within those areas where site drainages have eroded through the protective glacial overburden. The locations are SWD-03, SWD-04, SWD-05, SWD-07, SWD-08, and STRM 4005.

In 2022, sample results from surface water cross-media impact locations SWD-04 exceeded the total uranium groundwater FRL of 30 µg/L. Location SWD-04 is in the former Waste Storage Area. This location is within the capture zone of the aquifer remediation system. Appendix A, Attachment A.2, provides additional information concerning the impact of surface water infiltrating into the Great Miami Aquifer. Sampling at these locations will continue to provide an assessment of the cross-media impact. Appendix B presents additional details of the FRL exceedances.

In 2015, DOE conducted an assessment of the scope of the surface water quality monitoring program. The assessment concluded that the scope of the program could be reduced. With approval from EPA, Ohio EPA, and local stakeholders, DOE implemented these reductions in 2017. The current surface water program is presented in the IEMP (Attachment D of the LMICP [DOE 2019]). A similar assessment of the surface water quality monitoring program occurred in 2021 and based on this assessment, which was presented in Appendix B of the 2021 Site Environmental Report (DOE 2022b), additional monitoring reductions were warranted. With approval of the 2023 LMICP (DOE 2023), these reductions were incorporated into the surface water program beginning in calendar year 2023.

As stated in Section earlier in this section, based on the number of years of data collected at SWD-05 and SWD-09, DOE is proposing to reduce the frequency of sampling at these locations from weekly to semi-annual to align with the sampling of the remaining surface water locations. With approval from the regulators and stakeholders, this change will be implemented in 2024.

4.3.2 Compliance Monitoring

4.3.2.1 FFCA and OU5 ROD Compliance

The Fernald Preserve is required to monitor effluent discharges at the Parshall Flume (sample location PF 4001) for total uranium mass discharges and total uranium concentrations. This requirement is identified in the July 1986 FFCA and the OU5 ROD (DOE 1996b). The OU5 ROD requires treatment of effluent so that the mass of total uranium discharged to the Great Miami River through PF 4001 does not exceed 600 lb per year. The OU5 ROD and the subsequent *Explanation of Significant Differences for Operable Unit 5* (DOE 2001b) also require that the monthly average total uranium concentration in the effluent not exceed 30 µg/L, the EPA-established drinking water standard.

Figure 24 shows that the cumulative mass of total uranium discharged to the Great Miami River through the Parshall Flume (PF 4001) during 2022 was 335 lb, which is below the annual discharge limit of 600 lb. Figure 25 shows that the monthly average total uranium concentration in water discharged through the Parshall Flume (PF 4001) was below the 30 µg/L discharge limit every month during 2022.

4.3.2.2 NPDES Permit Compliance

Compliance sampling, consisting of sampling for nonradiological pollutants from uncontrolled runoff in the SSOD and effluent discharges from the Fernald Preserve, is regulated under the state-administrated NPDES program. Until June 1, 2022, the site operated under an NPDES permit which took effect on March 1, 2015. A new permit was approved in early 2022 and took effect on June 2, 2022, and will expire on May 31, 2027. There were no instances of noncompliance at any of the permitted outfalls in 2022.

4.3.3 Uranium Discharges in Surface Water and Effluent

As identified in Figure 24, 335 lb of uranium in effluent were discharged to the Great Miami River through the Parshall Flume (PF 4001) in 2022. In addition to the effluent, uncontrolled runoff is also contributing to the amount of uranium entering surface water. Figure 26 presents the mass of uranium from the uncontrolled runoff and controlled discharges from 1993 through 2022.

A loading term is used to estimate the pounds of uranium discharged to Paddys Run via uncontrolled runoff. With the approval of the 2017 Site Environmental Report (DOE 2018a) by EPA and Ohio EPA, the loading term was revised. The revision of the loading term was based on total uranium data from surface water sampling locations, which reflects the decreasing total uranium concentrations measured at points discharging to Paddys Run as a result of significant historical improvements in the capture of contaminated stormwater and remediation of site soil. The current loading term is 0.8 lb of uranium per inch of precipitation. During 2022, 40.5 inches of precipitation fell at the Fernald Preserve; therefore, an estimated 32.4 lb of uranium entered the environment through uncontrolled runoff. The estimated total amount of uranium discharged to the surface water pathway for the year, including controlled effluent discharges and uncontrolled runoff, was approximately 367.4 lb.

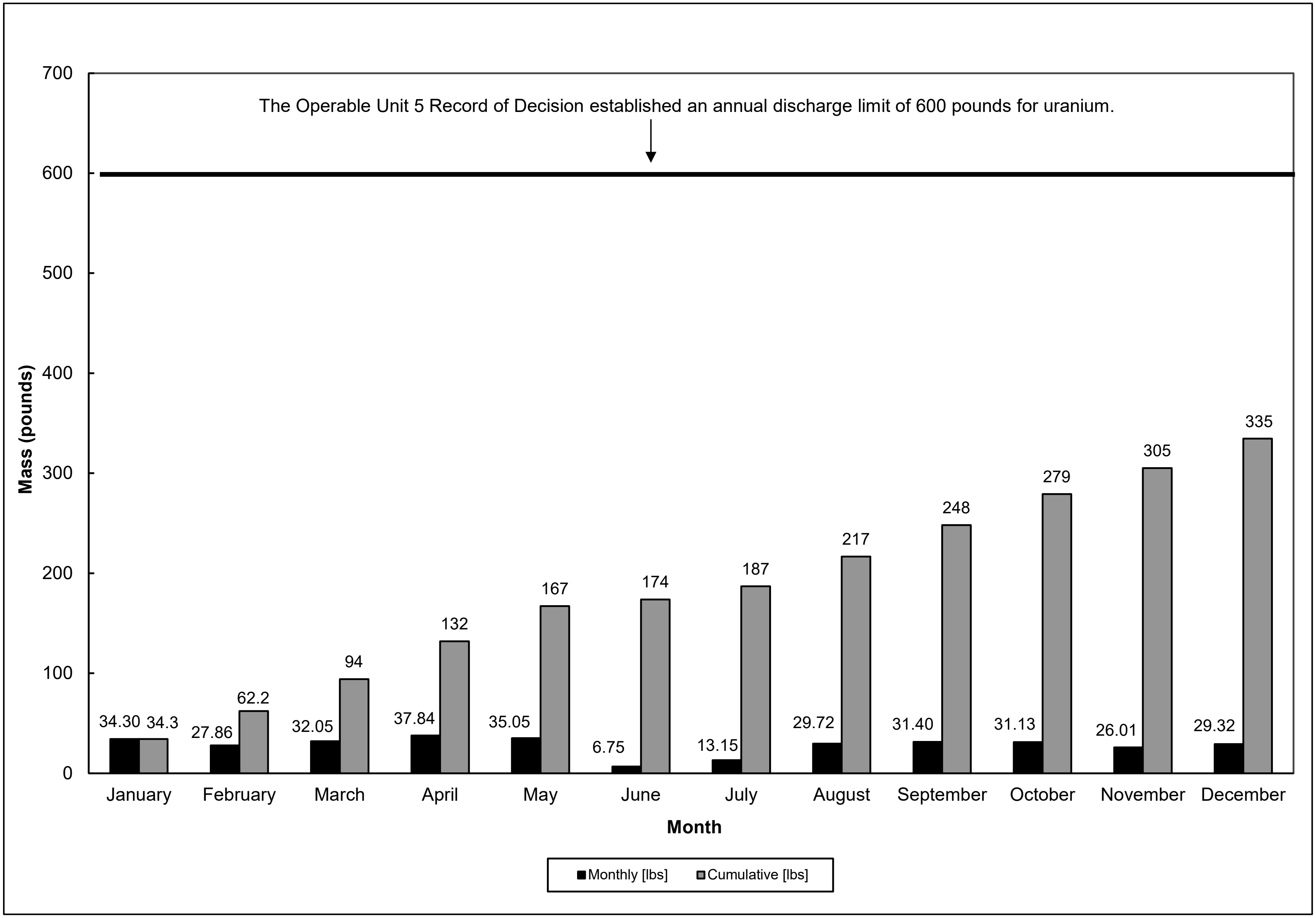


Figure 24. Mass of Uranium Discharged to the Great Miami River Through the Parshall Flume (PF 4001) in 2022

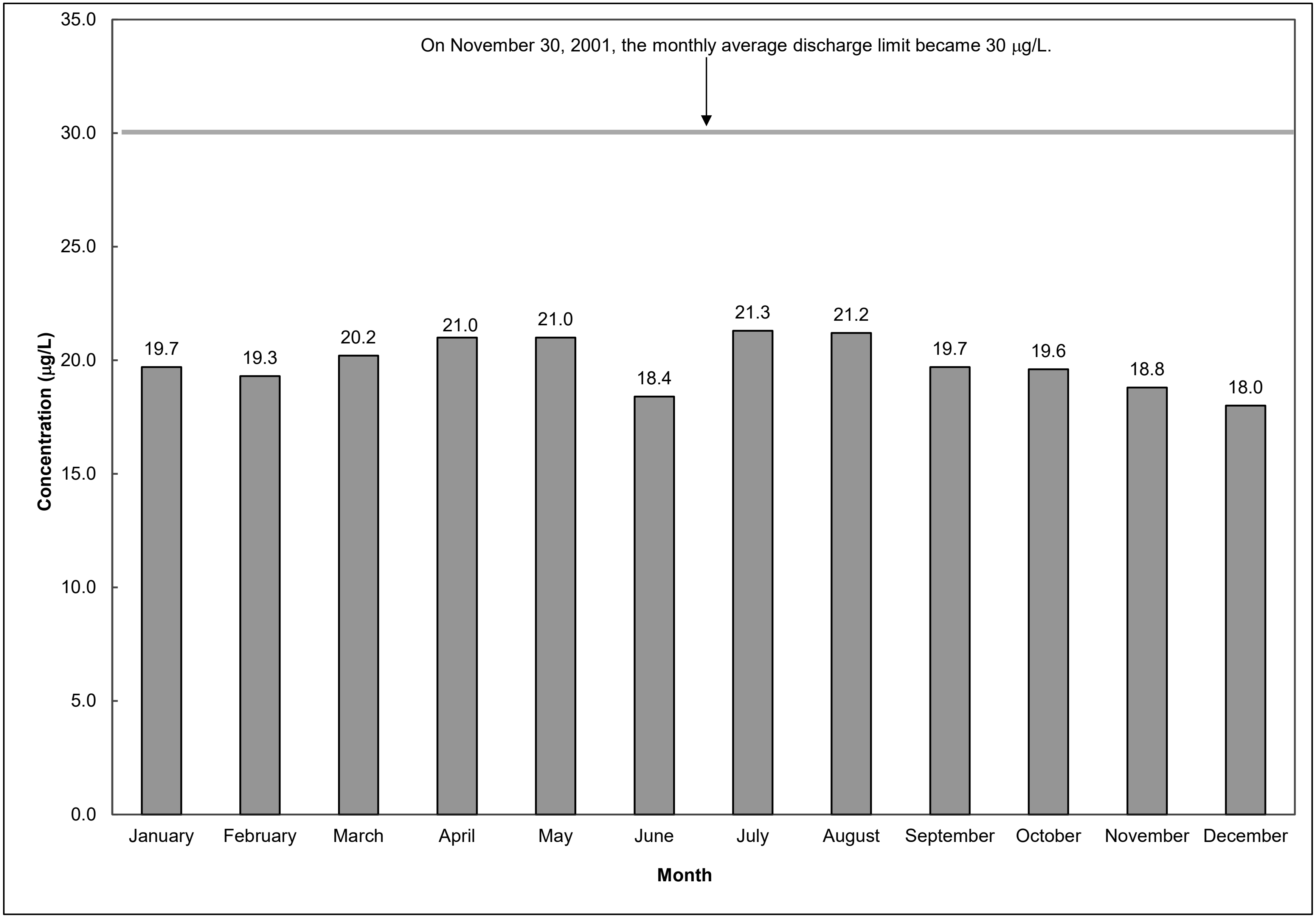


Figure 25. 2022 Monthly Average Total Uranium Concentration in Water Discharged Through the Parshall Flume (PF 4001) to the Great Miami River

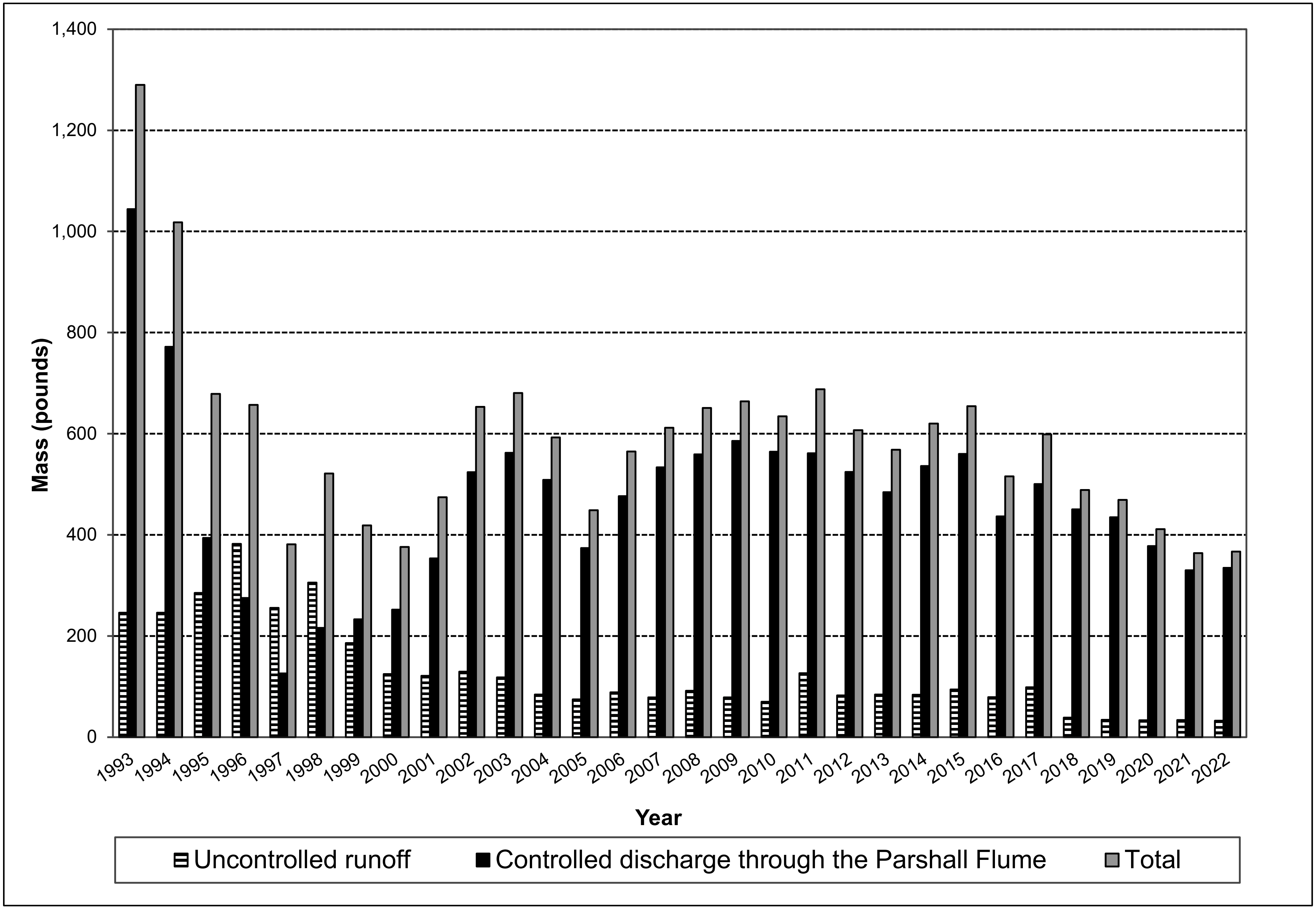


Figure 26. Uranium Discharged via the Surface Water Pathway, 1993−2022

This page intentionally left blank

5.0 Natural Resources

> **Results in Brief: Ecological Monitoring Activities**
>
> In 2022, prairie functional monitoring was conducted using the floristic inventory method implemented in 2021. Restored community-type functional monitoring will continue on a 3-year rotation with the next prairie monitoring event to occur in 2025.
>
> Prescribed burns were completed in two areas in the Former Production Area late in 2022. The post-burn walkdown for the prescribed burn areas was completed in early 2023.
>
> **Functional Monitoring**
>
> - A floristic inventory of remediation prairie communities across the site indicated results were consistent with previous findings. Remediation prairies are stable and are likely plateauing in their development. Monitoring results indicate that remediation successional communities are in the early stages of transitioning to forest communities.
>
> **Implementation Monitoring**
>
> - There was no ecological restoration project implementation monitoring in 2022.
>
> **Site and OSDF Inspections**
>
> - Findings were primarily invasive herbaceous plants and woody vegetation in the restored areas and on the OSDF, as well as the need for repair of deer exclosure fencing. Debris continues to be found, mostly in the Former Production Area and the former Waste Storage Area. During the December 2022 inspection, it was discovered that the Main Drainage Corridor culvert was in need of repair. Concrete had degraded, which caused the grate preventing access to the culvert to become dislodged. Plans are being developed to repair the grating in 2023.
> - No major issues were observed with respect to institutional controls or the integrity of the OSDF cap.

This section provides background information on the natural resources associated with the Fernald Preserve and summarizes the activities in 2022 relating to these resources. Included in this section is a discussion of the following:

- Ecological restoration activities
- Site and OSDF inspections
- Affected habitat areas
- Threatened and endangered species
- Cultural resources

Much of the 1,050 acres of the Fernald Preserve property is undeveloped land that provides habitat for a variety of animals and plants. Wetlands, deciduous and riparian (streamside) woodlands, old fields, grasslands, and aquatic habitats are among the site's natural resources. Over 900 acres of the site have undergone ecological restoration. Figure 27 shows the restoration project areas that have been completed. Some of these areas provide habitat for state and federally endangered species. These endangered species are identified in Section 5.4. Cultural resources, such as prehistoric archaeological sites, have also been surveyed. The Fernald Preserve's mission of long-term stewardship under LM includes establishing, managing, and monitoring ecologically restored areas across the site.

Monitoring of these natural and cultural resources is addressed in the "Natural Resource Monitoring Plan," which is included as Appendix A of Attachment D of the LMICP (DOE 2019). The Natural Resource Monitoring Plan presents an approach for monitoring and reporting the status of several priority natural resources to remain in compliance with pertinent regulations and agreements. The approach for the monitoring and maintenance of ecologically restored areas is also addressed. Restoration monitoring has been ongoing following an expanded approach in 2009, when DOE and Ohio EPA signed a Consent Decree in November 2008 that settled a long-standing natural resource damage claim under Section 107 of CERCLA. As part of the settlement, the Fernald Natural Resource Trustees (DOE, Ohio EPA, and the U.S. Department of the Interior) finalized the Natural Resource Restoration Plan (NRRP), which is Appendix B of the *Consent Decree Resolving Ohio's Natural Resource Damage Claim against DOE* (State of Ohio 2008). The NRRP specifies an ecological monitoring program for restored areas at the site. This includes an enhanced wetland mitigation monitoring program and a functional monitoring program that evaluates restored communities. An implementation monitoring program is also in place and is used to determine whether revegetation efforts are successful following construction activities.

The NRRP also specifies creation of a Restored Area Maintenance Plan (RAMP). This document detailed the approach that was used for managing ecologically restored areas across the site through 2020. The RAMP included provisions for planting and seeding, control of invasive species, management of wetland water levels, erosion control, nuisance animal control, and maintenance of public amenities (DOE 2012b). Field personnel used this plan as a basis for management of restored areas described in the annual Site Environmental Report.

The NRRP required that the RAMP be reviewed after 10 years of implementation. DOE, along with the other Natural Resource Trustees, conducted this review in 2020, which resulted in the development of the Natural Resource Management Plan (NRMP). The NRMP outlines the management and evaluation approach for ecologically restored areas, including revised ecological monitoring methods. A 10-year review of ecological monitoring results showed that restored communities have for the most part been successfully established across the site. The revised approach to functional monitoring outlined in the NRMP shifts the focus from management area evaluations to restored community evaluations. These results will be used to help manage restored areas in future years. Figure 28 shows the breakdown of the communities to be evaluated. Select remediation prairie and remediation successional communities were monitored in 2022 using the revised functional monitoring approach. The NRMP was incorporated as Appendix A of Volume I of the 2023 LMICP (DOE 2023). Additional details are provided in Section 5.1.2 and Appendix C.

5.1 Ecological Restoration Activities

Maintenance in ecologically restored areas included mowing; repairing deer exclosure fence; mitigating potential impacts to high quality wetlands caused by beaver activities; and controlling invasive herbaceous plants, shrubs, and trees. Prescribed burning is a prairie management tool used on the site. In 2022, DOE and the U.S. Forest Service entered into an inter-agency agreement to conduct prescribed burns at the site. On December 2, 2022, the U.S. Forest Service conducted two prescribed burns, burning approximately 20 acres of prairie in the Former Production Area. The post-burn walkdown of this area was completed in early 2023. Figure 29 shows the location of 2022 restoration maintenance activities, which are discussed in the following sections.

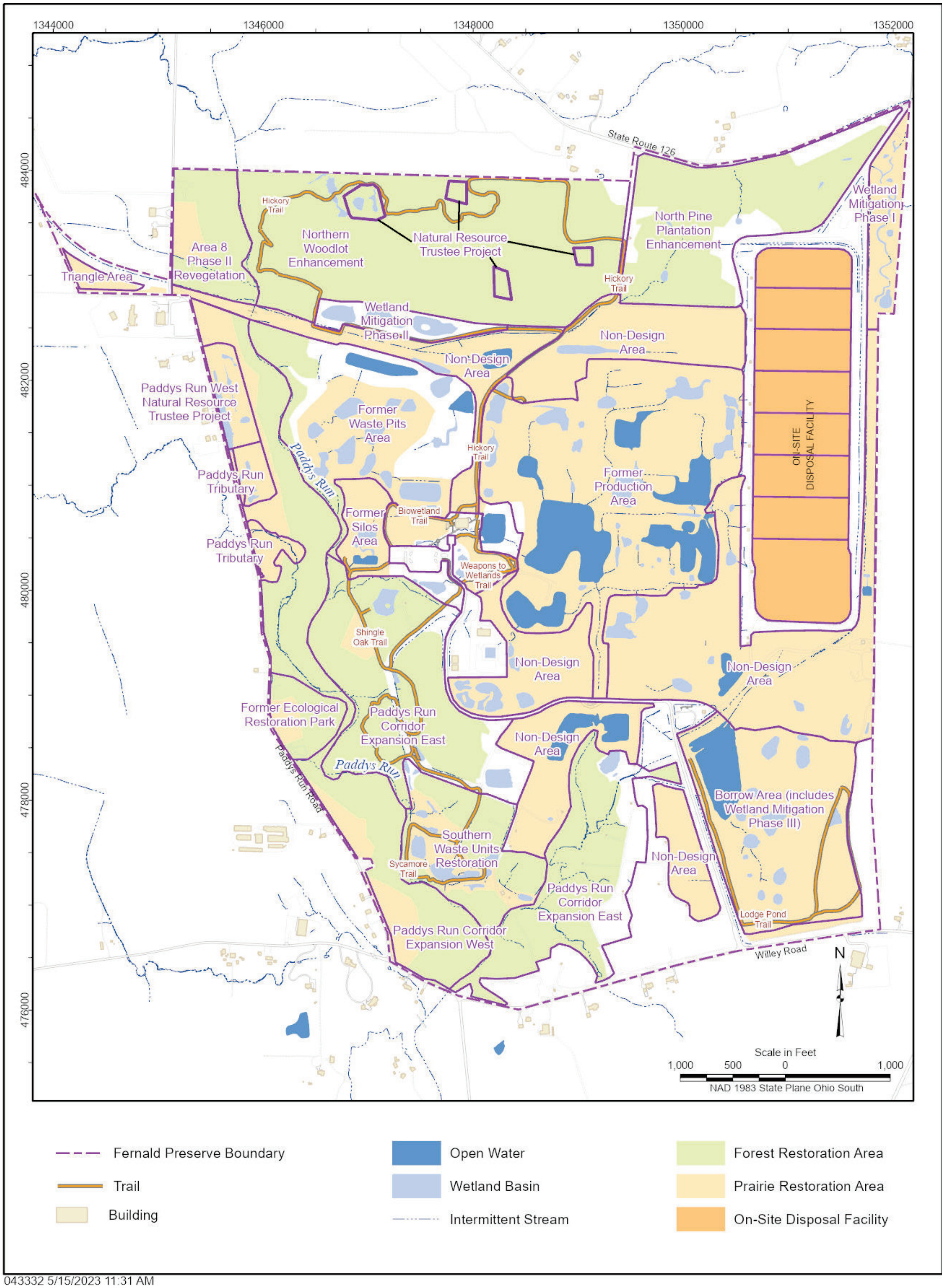


Figure 27. Restoration Project Areas

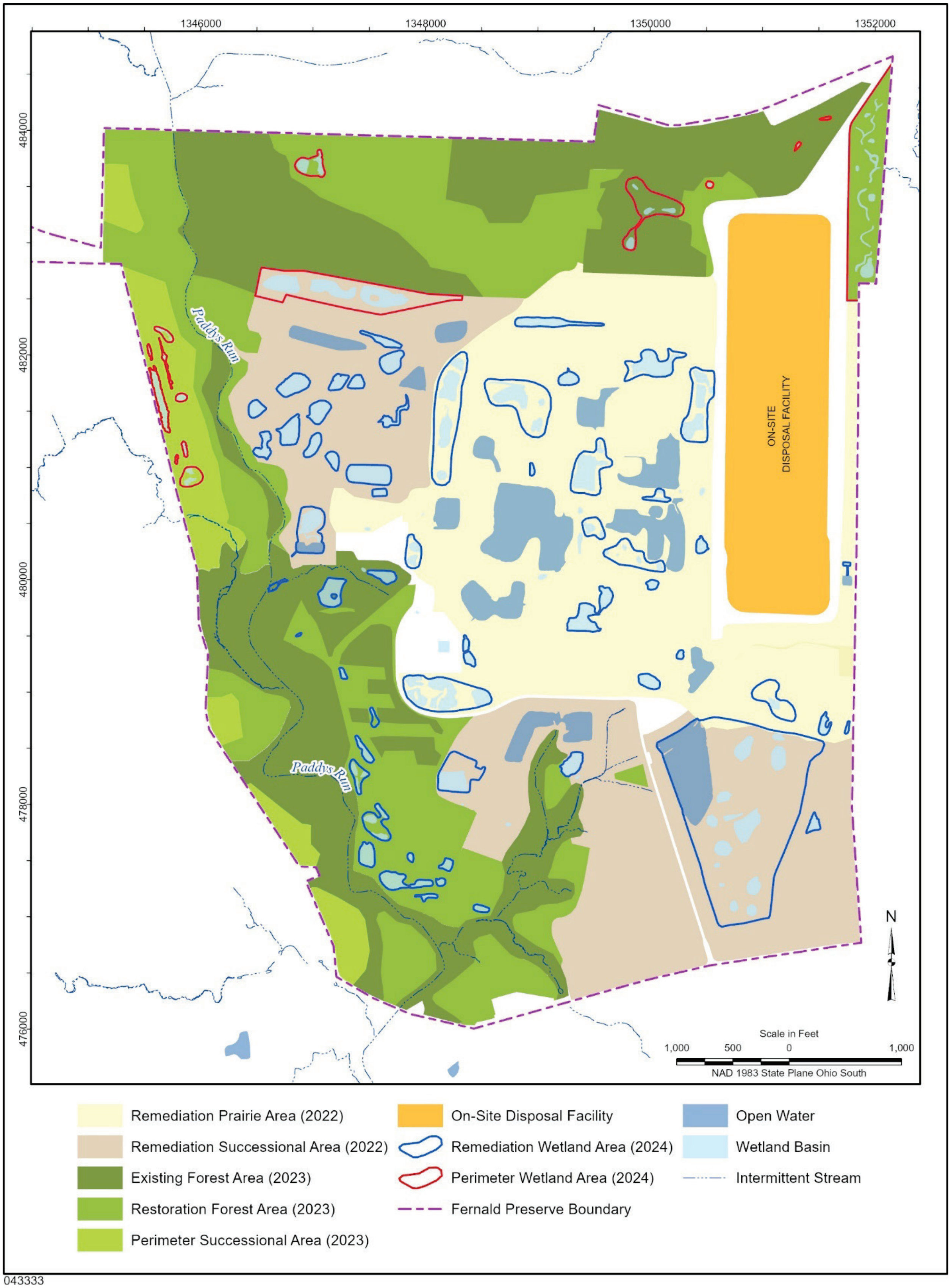


Figure 28. Ecological Community Types

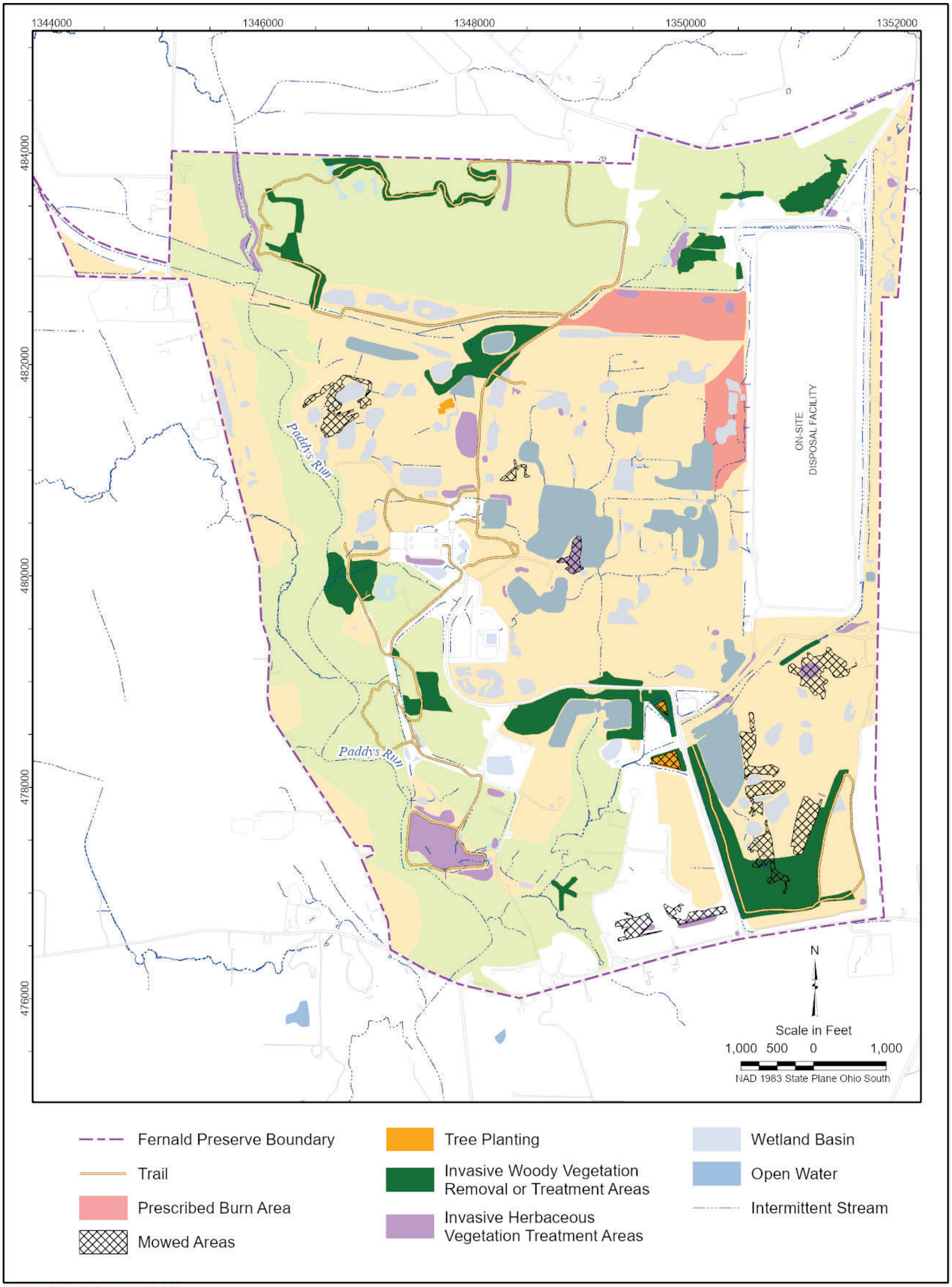


Figure 29. Ecological Restoration Maintenance Activities 2022

5.1.1 Restored Area and OSDF Maintenance and Repair

The primary focus of 2022 restored area maintenance activities (Figure 29) was vegetation management and enhancement, some of which addressed inspection findings identified throughout the year. Appendix C includes summary tables and maps that show the location of specific inspection findings. The goals of restored area maintenance are to combat the invasive species, improve the vegetation quality, and increase species diversity.

Invasive herbaceous species are addressed using a variety of methods including herbicide application, mowing, burning, manual removal, or a combination of these methods. For example, in 2022, several areas with heavy teasel infestations were mowed in late winter then treated with herbicide in the spring. Spot spraying with herbicide to control noxious and invasive herbaceous weeds in restored areas and on the OSDF cap continued in spring 2022. Target herbaceous species are listed on Table 9 and shown on Figure 29. Approximately 272 acres were treated for invasive herbaceous species.

Table 9. Invasive Herbaceous Species Treated in 2022

Common Name	**Scientific Name**
Teasel species	*Dipsacus sp.*
Canada thistle	*Cirsium arvense*
Chinese bush clover	*Lespedez cuneata*
Giant reed	*Phragmites australis*
Lesser celandine	*Ficaria verna*
Mugwort	*Artemisia vulgaris*
Purple loosestrife	*Lythrum salicaria*
Reed canary grass	*Phalaris arundinacea*

Invasive woody vegetation is physically removed or treated with herbicide across the site and on the OSDF cap and perimeter drainages. Trees and shrubs must not become established on the OSDF cap, so they are removed or treated with herbicide once discovered.

Fall foliar herbicide application to control amur honeysuckle (*Lonicera maackii*) continued in 2022. Dense infestations of honeysuckle will crowd out native species, prevent sunlight from reaching the ground, and prevent seedling development of desirable vegetation. A characteristic of honeysuckle is that it does not go dormant until a few weeks after most other vegetation. Timing herbicide application after nearby plants have gone dormant in the fall allows the use of herbicide to treat honeysuckle while avoiding harm to surrounding vegetation. This technique is widely used and has proven to be an effective means of control. In addition to foliar herbicide application, cutting woody vegetation and painting the cut stumps with herbicide was a technique used to aid in the control of several different invasive woody vegetation species, and is a method that can be used throughout the year. Mechanical removal using equipment to remove the woody vegetation from the ground was also employed in 2022. Approximately 51 acres of invasive woody vegetation was managed using this combination of methods across the site (Table 10).

Table 10. Invasive Woody Vegetation Species Treated in 2022

Common Name	Scientific Name
Amur honeysuckle	*Lonicera maackii*
Autumn olive	*Elaeagnus umbellata*
Buckthorn	*Rhamnus cathartica*
Callery pear	*Pyrus calleryana*
Japanese honeysuckle	*Lonicera japonica*
Multiflora rose	*Rosa multiflora*
Tree of heaven	*Ailanthus altissima*

In addition to treatment and removal of invasive vegetation, approximately 120 trees and shrubs were planted in three areas of the site to help increase species diversity, enhance successional development of restored areas, and decrease forest fragmentation

There is a resident population of Canada geese at the Fernald Preserve. Canada geese are considered nuisance animals primarily because of their potential for aggression to humans. However, due to establishment of vegetation and an increase in natural predators, there has not been a population growth, and goose hazing (i.e., scaring and harassing) has not been needed since 2014. Site personnel continue to monitor the Canada goose population each year. The site applies for an ODNR permit to remove nests or addle eggs annually, if necessary.

The mute swan is non-native, invasive, and considered a nuisance species by ODNR; therefore, ODNR grants permission to addle the eggs of the mute swans. No formal permit is required. Reduced site staffing in response to the coronavirus pandemic prevented Fernald Preserve staff from monitoring nesting activities and addling eggs in 2020, which resulted in an increase in the number of mute swans on site. In spring 2021, DOE authorized ODNR to conduct mute swan management activities in support of the ODNR statewide mute swan management program. No mute swan management activities occurred in 2022. Mute swan egg addling by site staff will be employed in 2023, if eggs are present. DOE maintains the agreement with ODNR to allow mute swan management activities on site.

5.1.2 Ecological Restoration Monitoring

> **Ecological Monitoring Parameters**
> There are a number of ways to evaluate the type and quality of habitats within an area. At the Fernald Preserve, ecological monitoring focuses on determining the extent of native plant species composition and calculating a Floristic Quality Assessment Index (FQAI). The FQAI process is described in the *Floristic Quality Assessment Index (FQAI) for Vascular Plants and Mosses for the State of Ohio* (Andreas et al. 2004). The specific parameters used at the Fernald Preserve include the following:
>
> - **Total Species**: The total number of species sampled within a given area.
> - **Native Species**: The total number of species native to Ohio. The updated *Ohio Vascular Plant Database* is used to determine whether a species is native (Gara 2013).
> - **Percent Native Species**: The number of native species divided by the total number of species. Relative frequency of native species is also used. This is calculated by dividing the frequency (or number of times a species is observed) by the total number of observations for a given area.
> - **Average Coefficient of Conservatism (CC)**: The CC is a number between 0 and 10 that has been assigned to virtually every species that may be found in Ohio. The CC value is related to how "tolerant" a species is, as well as its habitat requirements. Nonnative plants have a CC of 0. Common species that can grow in a wide variety of habitats are considered "tolerant" and are scored a CC between 0 and 3. Native plants with very specific habitat requirements are scored high CC values, in the 7–10 range. The updated *Ohio Vascular Plant Database* (Gara 2013) lists the CC for each plant found in Ohio.
> - **Floristic Quality Assessment Index (FQAI)**: The CC values described above are used to calculate the FQAI. The FQAI is the average CC value divided by the square root of the total number of species for a given area.

Before 2021, a two-tier ecological monitoring program was used to assess restoration efforts. Implementation monitoring was used to assess vegetation establishment following seeding and planting projects. Functional monitoring was used to assess the progress of the development of a restored community (prairie, wetland, forest) by comparing floristic quality parameters to those of baseline and reference sites. Reference sites are offsite communities that represent an ideal end-state for site restoration projects. The NRRP states the goals for vegetation establishment were 50% native species and 90% total cover. For woody vegetation, the goal was 80% survival (State of Ohio 2008).

As stated in Section 5.0, the Fernald Preserve Natural Resource Trustees reviewed the ecological monitoring program as part of the 2020 RAMP update. A revised approach to functional monitoring methods and area focus was proposed and subsequently implemented in 2021. This revised method consists of conducting florist inventories and will focus on a specific restored community type each year. Perimeter area and remediation wetland areas were monitored in 2021. Prairie areas and remediation successional areas were monitored in 2022 and existing forest areas, restoration forest areas and perimeter successional areas will be monitored in 2023 (Figure 28).

5.1.2.1 Functional Monitoring

Functional monitoring activities previously conducted compared restored communities to prerestoration "baseline" conditions and high-quality reference sites. Baseline and reference sites were characterized in 2001 and 2002. From 2003 to 2005, restored areas were evaluated. Wetlands were evaluated in 2003, prairie communities in 2004, and forest habitats in 2005. The same 3-year rotation resumed in 2009 and continued through 2014. In 2015, monitoring efforts shifted from sitewide community types to an area-based approach on a 3-year basis. The area-based approach continued through 2020, completing two full cycles of monitoring. In 2021, functional monitoring took place in wetland communities, implementing the new floristic inventory method. In 2022, the floristic inventory method was used to monitor remediation prairie areas and remediation successional areas (Figure 28). For each floristic inventory, the entire monitoring area was examined, and each species observed was recorded. Native and non-native species richness and composition, area mean coefficient of conservatism (CC), and floristic quality assessment index (FQAI) were calculated from the data to assess the condition of the monitoring areas. The latest Ohio FQAI database (Gara 2013) is used to determine nativity status and CC values. Appendix C provides a more detailed discussion regarding ecological monitoring results.

The 2022 functional monitoring results indicate that native vegetation is fully established across all the restored areas monitored. Percent nativity, mean CC and FQAI values are higher in the remediation successional areas than the remediation prairie areas. A historical comparison of these values show results for both remediation prairie areas and remediation successional areas are consistent with previous findings. The remediation prairie areas are stable and have likely plateaued in development, and the remediation successional areas are in the early stages of transitioning to forested areas. Continued vegetation monitoring and management will be required to ensure this successional process continues.

5.2 Fernald Preserve Site, OSDF, and Trail Inspections

The LMICP describes the routine inspection process for both the site and the OSDF. Inspections are conducted quarterly with joint participation from the regulators. Inspections document evidence of unauthorized uses of the site, the effectiveness of institutional controls, and any need for repairs. Inspections are conducted in several phases. Quarterly inspections focus on signs, fencing, gates, site access points, etc. Field walkdowns take place in the winter months when vegetation is dormant, optimizing visibility of site conditions and allowing for easier access to some areas. Ecologically restored areas are evaluated for the presence of noxious weeds, erosion, condition of vegetation, presence of potentially contaminated debris, and signs of damage from nuisance animals. Quarterly inspection reports are posted on the LM public website at https://www.energy.gov/lm/fernald-preserve-ohio-site. The quarterly inspection reports can also be viewed online at the Fernald Preserve Visitors Center or by contacting the site at (513) 648-3330. Appendix C presents inspection findings from all 2022 quarterly site and OSDF inspections. In addition to quarterly inspections, the public trails and overlooks are inspected weekly to ensure that they are safe and usable. Ohio EPA and other regulators are invited to participate in OSDF and site inspections.

5.2.1 Site Inspections

As with recent years, site inspection findings in 2022 consisted mostly of the presence of noxious and invasive weeds and deer exclosure fencing that was damaged by fallen trees and limbs or is deteriorating due to age and weather exposure. Beginning in 2022, inspection findings are detailed in quarterly inspection reports only if the finding is associated with activity and use limitations for the site. As a result, only one inspection finding was reported in the 2022 quarterly inspection reports. The finding was identified during the December 2022 point-specific institutional control inspection and is associated with the Main Drainage Corridor culvert access control grating. The culvert, along with an adjacent 18-inch culvert that is completely buried, was left in place and has fixed radiological contamination. These culverts are located directly below the OSDF leachate conveyance system and the main effluent line running between the CAWWT and the Great Miami River. Because of their location, these culverts could not have been removed without potentially impacting ongoing CAWWT and OSDF operations. Instead, metal grating was installed to prevent access to the 60-inch culvert. Site inspections ensure that the 60-inch culvert grating is in place and is serviceable, and that the 18-inch culvert is not exposed through erosion or other ground disturbance. The last quarterly inspection of 2022 identified that the grate had experienced natural degradation of the concrete which caused the rebar grate to become dislodged. Plans are being developed to repair the grating in 2023. Additional information is provided in Appendix C.

Debris continues to be found, primarily in the Former Production Area and former Waste Storage Area; however, debris finding numbers were lower in 2022 than in previous years. During remediation of the Fernald Preserve, every effort was made to remove and dispose of all debris. However, weather, erosion, and earth-moving activities occasionally reveal small pieces of debris that were not visible during remediation and restoration efforts. Examples of debris include pieces of concrete, rebar, clay tile, asphalt, and metal. Debris is discovered during site inspections and construction activities and by personnel during field activities. In 2022, 128 pieces of debris were discovered. Radiological surveys were conducted of all debris and no debris was observed to have fixed radiological contamination above background levels. All debris was removed from the field and properly disposed. More information regarding debris and other inspection findings is provided in Appendix C.

5.2.2 OSDF Inspections

For inspections of the OSDF, inspectors perform a quarterly walkdown of the perimeter and toe, and an annual walkdown and evaluation of the vegetated cap to verify its integrity. Trees, shrubs, erosion rills, holes from burrowing animals, noxious weeds, settlement cracks, and other indications that there may be an issue with the proper functioning of the cap are flagged and repaired. In 2022, there were no signs that the integrity of the cap had been compromised in any way. Findings consisted mainly of woody vegetation and noxious weeds.

5.2.3 Trail Inspections

Weekly trail inspections continued in 2022 to ensure trails were safe for use. There were no significant findings.

5.3 Affected Habitat Findings

The potential for unanticipated habitat impacts is low, but they can occur during construction or site maintenance activities. The restoration projects described in Section 5.1.1 resulted in minimal impacts. The potential for habitat impacts is considered before site maintenance and construction activities.

Beavers continued to be very active at the site in 2022, resulting in changes to water elevations and vegetation in several wetlands and ponds. An increase in the site beaver population has been observed for the last several years. Beavers are native, and their presence is evidence of continued development of restored plant communities. However, they may alter the landscape by impeding drainages, raising water levels in wetlands, flooding upland areas, and clearing trees. These naturally occurring changes are expected to continue in the future.

5.4 Threatened and Endangered Species and Species Inventories

The Endangered Species Act requires the protection of any federally threatened or endangered species and any habitat critical for the species' existence. Several Ohio laws mandate the protection of state endangered species as well. Since 1993, a number of surveys have been conducted to determine the presence of any threatened or endangered species at the site. As a result of these surveys, the federally endangered Indiana bat and the formerly state threatened Sloan's crayfish (*Orconectes sloanii)* are the only threatened or endangered species observed on the property. As of 2022, Sloan's crayfish was removed from Ohio's threatened or endangered species lists. Suitable habitat exists for the federally endangered Indiana bat, federally threatened northern long-eared bat, the state-threatened spring coral root, and the state-endangered cave salamander. With the exception of an Indiana bat and Sloan's crayfish, none of these species have been found on the site, but their habitat ranges encompass the Fernald Preserve. Figure 30 shows the potential habitats for these species. According to the LMICP (DOE 2019), Section 6.0, "Natural Resource Monitoring Plan," threatened or endangered species habitat will be surveyed as needed before any construction activities. If threatened or endangered species are identified, appropriate avoidance or mitigation efforts will be taken.

Potential Threatened and Endangered Species at the Fernald Preserve

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

Northern Long-Eared Bat: The federally threatened northern long-eared bat (*Myotis septentrionalis*) will roost singly or in colonies in the summer using either live trees with loose bark or dead hollow trees (snags). The Fernald Preserve has been recognized as potential summer roosting habitat for the northern long-eared bat. Although no captures have been recorded at the preserve, a variety of live and dead trees and water sources in the preserve may provide ideal habitat within the known range of this species.

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

Cave Salamander: The state-endangered cave salamander (*Eurycea lucifuga*) is slender and its coloring is red to orange with irregular black dots. It is found in caves, springs, small limestone streams, outcrops, and old springhouses where groundwater is present. It has only been documented in Ohio in Hamilton, Butler, and Adams counties. Suitable habitat within the Fernald Preserve is limited, but populations have been observed just north of the

5.5 Cultural Resources

The Fernald Preserve and surrounding area are in a region of rich soil and many sources of water, such as the Great Miami River. Because of its advantageous location, the area was settled repeatedly throughout prehistoric and historical time, resulting in diverse cultural resources. At a minimum, 148 prehistoric and 40 historic sites have been identified within 1.2 miles of the Fernald Preserve.

Several laws have been established to protect cultural resources. The National Historic Preservation Act requires DOE to consider the effects of its actions on sites that are listed or eligible for listing on the National Register of Historic Places. The Native American Graves Protection and Repatriation Act (Title 43 *Code of Federal Regulations* Section 10 [43 CFR 10]) requires that prehistoric human remains, and associated artifacts, be identified and returned to the appropriate Native American tribe. Compliance with these laws is addressed through a Programmatic Agreement between DOE and the Ohio State Historic Preservation Office (DOE 2012d), which was updated in 2012.

To comply with these laws and the Programmatic Agreement, DOE conducted archaeological surveys before remediation activities in undeveloped areas of the Fernald Preserve. Figure 31 shows the areas of the Fernald Preserve that have been surveyed. These surveys have resulted in the identification of five sites that may be eligible for listing on the National Register of Historic Places. None of these sites were affected by construction activities in 2022.

No archaeological surveys were conducted in 2022, and no unexpected discoveries were encountered during field activities. All ground-disturbing activities took place in previously disturbed or surveyed areas.

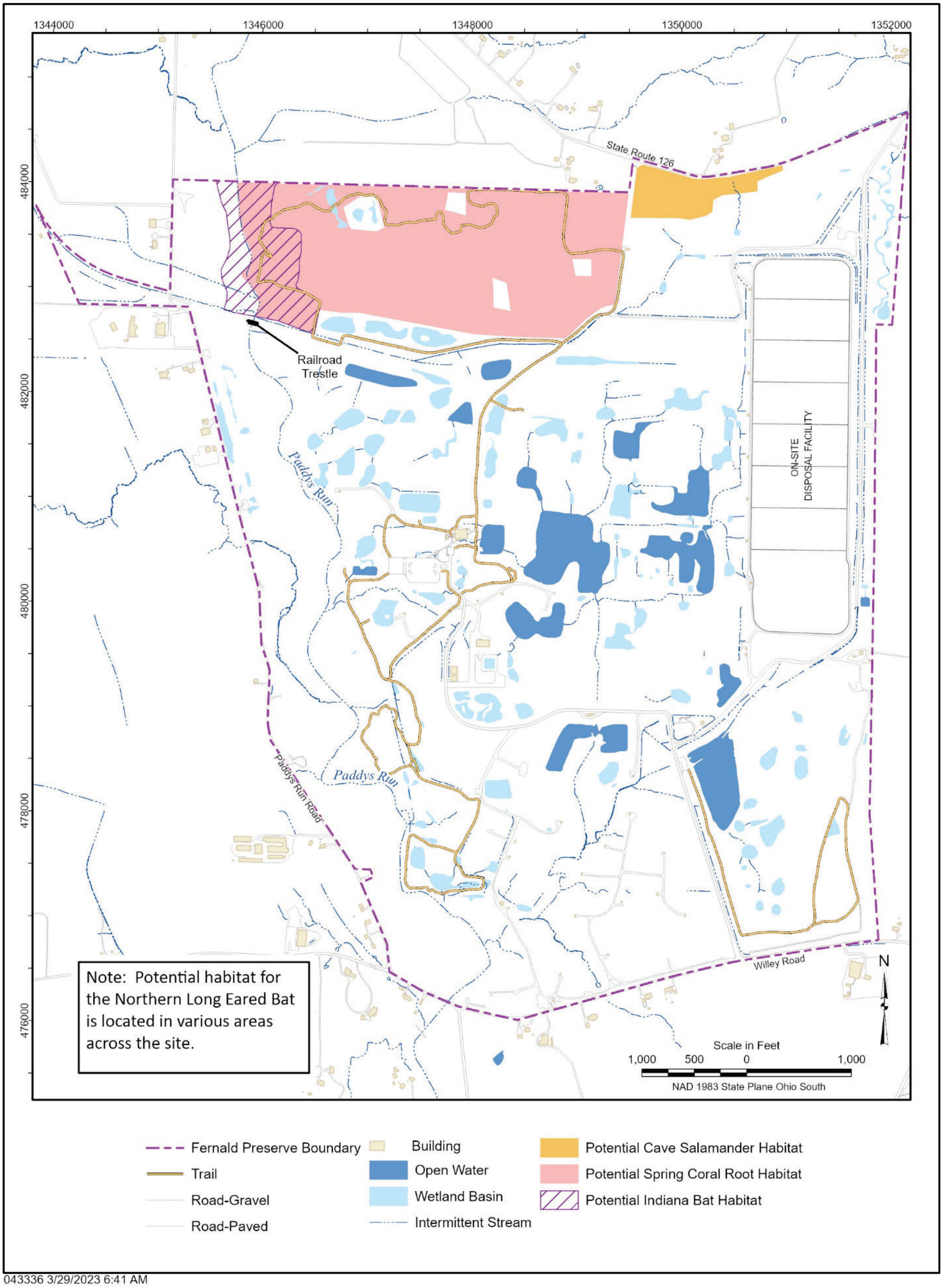
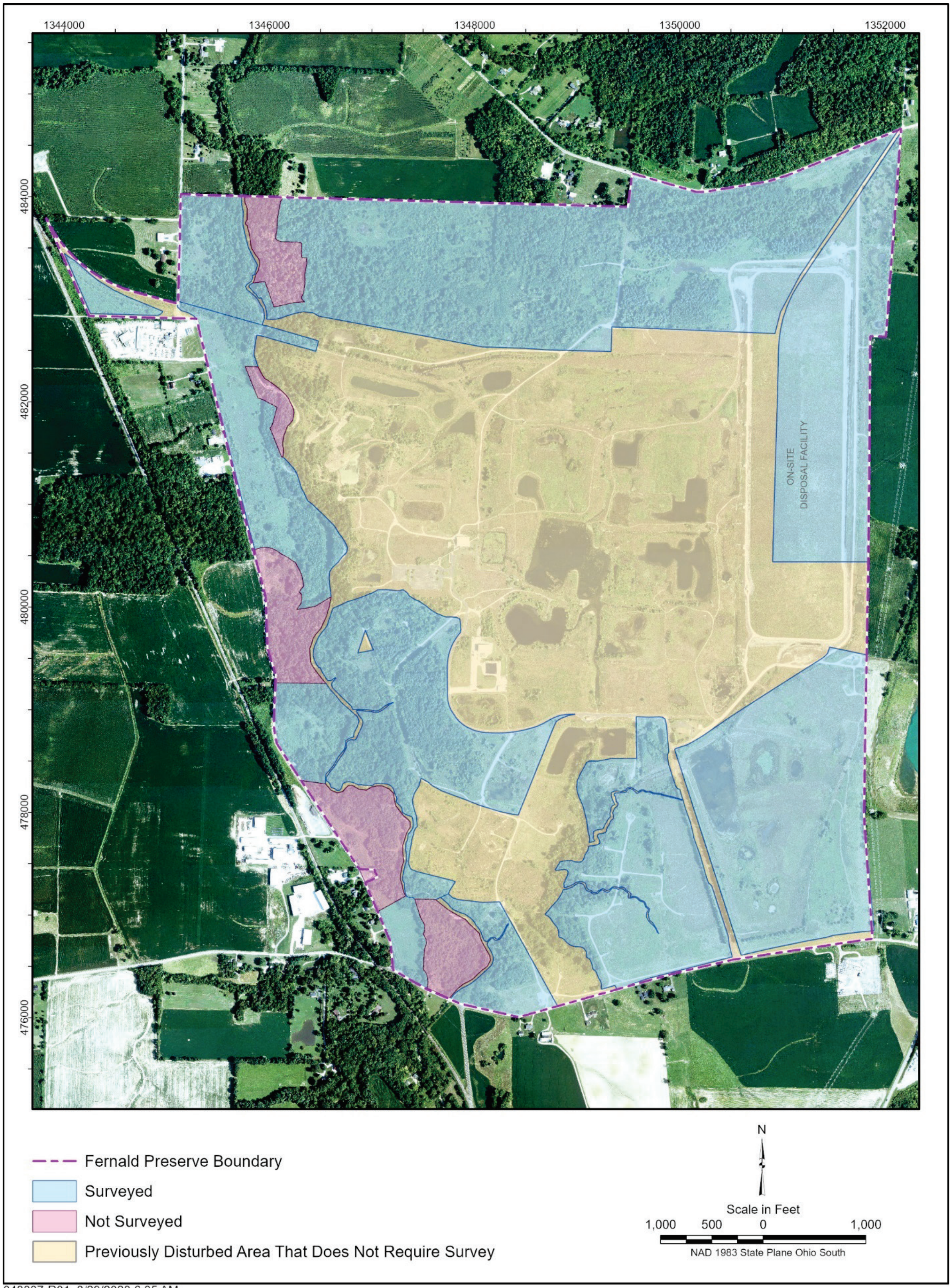


Figure 30. Threatened and Endangered Species Potential Habitat Areas



043337-R01 3/29/2023 6:35 AM

Figure 31. Cultural Resource Survey Areas

6.0 References

7 USC 136 et seq. "Federal Insecticide, Fungicide, and Rodenticide Act", as amended, *United States Code*.

15 USC 2601 et seq. "Toxic Substances Control Act," as amended,

33 USC 1251 et seq. "Clean Water Act" (Federal Water Pollution Control Act), as amended, *United States Code*.

42 USC 6901 et seq. "Resource Conservation and Recovery Act," as amended, *United States Code*.

42 USC 7401 et seq. "Clean Air Act," as amended, *United States Code*.

42 USC 9601 et seq. "Comprehensive Environmental Response, Compensation, and Liability Act of 1980," as amended, *United States Code*.

10 CFR 1021. "National Environmental Policy Act", *Code of Federal Regulations*.

43 CFR 10. "Native American Graves Protection and Repatriation Act," *Code of Federal Regulations.*

Andreas, B.K., J.J. Mack, and J.S. McCormac, 2004. *Floristic Quality Assessment Index (FQAI) for Vascular Plants and Mosses for the State of Ohio,* Ohio EPA, Division of Surface Water, Wetland Ecology Group, Columbus, Ohio.

Deutsch, W.J., 1997. *Groundwater Geochemistry: Fundamentals and Applications to Contamination*, CRC Press, Boca Raton, Florida.

DOE (U.S. Department of Energy), 1994. *Characterization of Background Water Quality for Streams and Groundwater*, Fernald Environmental Management Project, Fernald Area Office, Cincinnati, Ohio, May.

DOE (U.S. Department of Energy), 1995a. *Feasibility Study Report for Operable Unit 5*, Final, Fernald Environmental Management Project, Fernald Area Office, Cincinnati, Ohio, June.

DOE (U.S. Department of Energy), 1995b. *Final Record of Decision for Remedial Actions at Operable Unit 1*, 513 U-003-501.3, Final, Fernald Environmental Management Project, Fernald Area Office, Cincinnati, Ohio, January.

DOE (U.S. Department of Energy), 1995c. *Proposed Plan for Operable Unit 5*, 6865 U-007-405.3, Final, Fernald Environmental Management Project, Fernald Area Office, Cincinnati, Ohio, May.

DOE (U.S. Department of Energy), 1995d. *Remedial Investigation Report for Operable Unit 5*, Final, Fernald Environmental Management Project, Fernald Area Office, Cincinnati, Ohio, March.

DOE (U.S. Department of Energy), 1996a. *Phase VII Removal Actions and Reporting Requirements Under the Fernald Environmental Monitoring Project Legal Agreements,* letter DOE-0395-96 from Johnny Reising, DOE, to James A. Saric, EPA, and Tom Schneider, Ohio EPA, dated January 16, 1996.

DOE (U.S. Department of Energy), 1996b. *Record of Decision for Remedial Actions at Operable Unit 5*, 7478 U-007-501.4, Final, Fluor Fernald, Cincinnati, Ohio, January.

DOE (U.S. Department of Energy), 1997a. *1996 Site Environmental Report*, Fernald Environmental Management Project, Fernald Field Office June.

DOE (U.S. Department of Energy), 1997b. *Baseline Remedial Strategy Report, Remedial Design for Aquifer Restoration (Task 1)*, Final, Fernald Environmental Management Project, Fernald Area Office, Cincinnati, Ohio.

DOE (U.S. Department of Energy), 1998. *1997 Integrated Site Environmental Monitoring Report*, Fluor Daniel Fernald, June.

DOE (U.S. Department of Energy), 2001a. *Design for Remediation of the Great Miami Aquifer in the Waste Storage and Plant 6 Areas*, 52462-RP-0003, Revision A, Draft Final, Fluor Fernald, Fernald Area Office, Cincinnati, Ohio, April.

DOE (U.S. Department of Energy), 2001b. *Explanation of Significant Differences for Operable Unit 5*, Final, Fernald Environmental Management Project, Fernald Area Office, Cincinnati, Ohio, October.

DOE (U.S. Department of Energy), 2001c. *First Five-Year Review Report for the FEMP* (Fernald Environmental Management Project), Fernald Area Office, Cincinnati, Ohio, May.

DOE (U.S. Department of Energy), 2001d. *Memorandum of Understanding for Natural Resource Restoration Plan*, signed by DOE, Ohio EPA, and U.S. Department of Interior, Fluor Fernald, Fernald Area Office, Cincinnati, Ohio, July 12.

DOE (U.S. Department of Energy), 2002. *Design for Remediation of the Great Miami Aquifer South Field (Phase II) Module*, 52462-RP-0001, Revision A, Draft Final, Fluor Fernald, Fernald Area Office, Cincinnati, Ohio, May.

DOE (U.S. Department of Energy), 2003. *Comprehensive Groundwater Strategy Report*, Revision 0, 51900-RP-0001, Cincinnati, Ohio, June.

DOE (U.S. Department of Energy), 2004. *Groundwater Remedy Evaluation and Field Verification Plan*, 52460-PL-0001, Revision 0, Final, Fluor Fernald, Office of Legacy Management, Cincinnati, Ohio, October.

DOE (U.S. Department of Energy), 2005a. *Storm Sewer Outfall Ditch Infiltration Test Report*, 52460-RP-0001, Fernald Area Office, Cincinnati, Ohio.

DOE (U.S. Department of Energy), 2005b. *Waste Storage Area Phase II Design Report*, 52424-RP-0004, Revision A, Draft Final, Fluor Fernald, Fernald Area Office, Cincinnati, Ohio, June.

DOE (U.S. Department of Energy), 2006a. *Fernald Groundwater Certification Plan*, 51900-PL-0002, Revision 1, Final, prepared by Fluor Fernald for the Office of Legacy Management, Cincinnati, Ohio, April.

DOE (U.S. Department of Energy), 2006b. *Second Five-Year Review Report for the FCP* (Fernald Closure Project), 2500-RP-0044, Office of Legacy Management, Cincinnati, Ohio, August.

DOE (U.S. Department of Energy), 2008. *Interim Remedial Action Report for Operable Unit 5*, Office of Legacy Management, Cincinnati, Ohio, August.

DOE (U.S. Department of Energy), 2011. *Third Five-Year Review Report for the Fernald Preserve*, LMS/FER/S07045, Office of Legacy Management, Cincinnati Ohio, September.

DOE (U.S. Department of Energy), 2012a. *Cooperative Agreement to Facilitate Recovery of the American Burying Beetle in Ohio*, signed by M. Knapp, Field Supervisor, U.S. Fish and Wildlife Service; D. Geiser, Director, Office of Legacy Management; and T. Maynard, Executive Director, Cincinnati Zoo & Botanical Garden.

DOE (U.S. Department of Energy), 2012b. *Fernald Preserve, Ohio Restored Area Maintenance Plan,* LMS/FER/S05080, Office of Legacy Management, Cincinnati, Ohio, January.

DOE (U. S Department of Energy), 2012c. *Fernald Preserve Wetland Mitigation Monitoring Report*, LMS/FER/S08266, Final, Office of Legacy Management, Cincinnati, Ohio, May.

DOE (U.S. Department of Energy), 2012d. *Programmatic Agreement Among the U.S. Department of Energy Office of Legacy Management and the Ohio Historic Preservation Office Regarding Archaeological Investigations at the Fernald Preserve*, Office of Legacy Management, Cincinnati, Ohio, April.

DOE (U.S. Department of Energy), 2014. *Operational Design Adjustments-1, WSA Phase-II Groundwater Remediation Design, Fernald Preserve*, LMS/FER/S10798, Office of Legacy Management, Cincinnati, Ohio, March.

DOE (U.S. Department of Energy), 2016a. *Fernald Preserve 2015 Site Environmental Report,* LMS/FER/S13591, Office of Legacy Management, Cincinnati, Ohio, May.

DOE (U.S. Department of Energy), 2016b. *Fourth Five-Year Review Report for the Fernald Preserve*, LMS/FER/S13683, Office of Legacy Management, Cincinnati Ohio, September.

DOE (U.S. Department of Energy), 2016c. *Draft Perfluorinated Compound Groundwater Screening Sampling and Analysis Plan,* LMS/FER/S15292, Office of Legacy Management, Cincinnati, Ohio, December.

DOE (U.S. Department of Energy), 2017. *Memorandum of Agreement to Facilitate Recovery of the American Burying Beetle in Ohio*, signed by Dan Everson, Field Supervisor, U.S. Fish and Wildlife Service; Susan Smiley, Fernald Preserve Site Manager, Office of Legacy Management; and Winton Ray, Curator of Invertebrates, Aquatic Animals and Birds, Cincinnati Zoo & Botanical Garden, October.

DOE (U.S. Department of Energy), 2018a. *Fernald Preserve 2017 Site Environmental Report*, LMS/FER/S13983, Office of Legacy Management, Cincinnati, Ohio, May.

DOE (U.S. Department of Energy), 2018b. *Draft Perfluorinated Alkyl Substances (PFASs) Investigation Plan for the Fernald Preserve,* LMS/FER/S18662, Office of Legacy Management, Cincinnati, Ohio, March.

DOE (U.S. Department of Energy), 2019. *Comprehensive Legacy Management and Institutional Controls Plan*, LMS/FER/S03496, Revision 12, Office of Legacy Management, Cincinnati, Ohio, January.

DOE (U.S. Department of Energy), 2021a. *Fernald Preserve 2020 Site Environmental Report*, LMS/FER/S32359, Office of Legacy Management, Cincinnati, Ohio, May.

DOE (U.S. Department of Energy), 2021b. *Final Fifth Five-Year Review Report for the Fernald Preserve*, LMS/FER/S33442, Office of Legacy Management, September.

DOE (U.S. Department of Energy), 2022a. *Evaluation Report for Uses of Per- and Polyfluoralkyl Substances in Historical Processes at the Feed Materials Production Facility, Fernald, Ohio,* LMS/FER/41372, Office of Legacy Management, Cincinnati, Ohio, August.

DOE (U.S. Department of Energy), 2022b. *Fernald Preserve 2021 Site Environmental Report*, LMS/FER/S37811, Office of Legacy Management, Cincinnati, Ohio, May.

DOE (U.S. Department of Energy), 2023. *Comprehensive Legacy Management and Institutional Controls Plan*, LMS/FER/S03496, Revision 13, Office of Legacy Management, Cincinnati, Ohio, January.

EPA (U.S. Environmental Protection Agency), 2006. *Preliminary Closeout Report, U.S. DOE Feed Materials Production Center, Fernald, Ohio*, EPA Region 5, December.

EPA (U.S. Environmental Protection Agency), 2011. *Close Out Procedures for National Priorities List Sites*, OSWER Directive 9320.2-22-P, Office of Superfund Remediation and Technology Innovation, May.

EPA (U.S. Environmental Protection Agency), 2019. *Interim Recommendations to Address Groundwater Contaminated with Perfluoroctanoic Acid and Perfluorooctanesulfonate*, OLEM Directive 9283.1-47, Office of Land and Emergency Management, December.

Executive Order 12580. *Superfund Implementation,* January 23, 1987.

Ray, 2021. Winton Ray III, curator of Ectotherms, Cincinnati Zoo & Botanical Garden, letter (about Termination of the Current Memorandum of Agreement) to U.S. Fish & Wildlife Service, Ohio Ecological Services Field Office, October 21.

Ricker, J.A., 2008. "A Practical Method to Evaluate Ground Water Contaminant Plume Stability," *Groundwater Monitoring and Remediation* 28(4):85–94.

State of Ohio, 2008. *Consent Decree Resolving Ohio's Natural Resource Damage Claim Against DOE*, State of Ohio *v.* United States Department of Energy et al., Civil Action No. C-1-86-0217, Judge Spiegel.

Whitman, Requardt & Associates LLP, 2015. *Fernald Preserve Site Converted Advanced Wastewater Treatment Current Condition Assessment Report*, Final, March.

This page intentionally left blank

7.0 Glossary

applicable or relevant and appropriate requirements (ARARs). Requirements set forth in regulations that implement environmental and public health laws that a selected remedy must attain unless a waiver is invoked. ARARs are divided into three categories: chemical-specific, location-specific, and action-specific, according to 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 that contains sufficient saturated permeable material to yield economical quantities of water to wells and springs.

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

Certification. The process by which a soil remediation area is certified as clean. Samples from the area are collected and analyzed, and then the contaminant levels are compared to the FRLs established in the OU5 ROD. Not all soil remediation areas at the Fernald Preserve require excavation before certification is done.

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

crossvane. A U-shaped structure of boulders built across a stream channel to reduce water velocity and energy along the streambank.

effluent. Water from numerous areas at the site that is routed through the site's wastewater treatment facility and discharged to the Great Miami River.

Floristic Quality Assessment Index (FQAI). A method of evaluating an ecosystem based on the type and quality of plants present.

glacial overburden/glacial till: Silt, sand, gravel, and clay deposited by glacial action on top of the Great Miami Aquifer and surrounding bedrock highs.

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

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

mixed waste. Hazardous waste (as defined by RCRA) that has been contaminated with low-level radioactive materials.

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

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

remedial investigation/feasibility study. The first major event in the remedial action process that serves to assess site conditions and evaluate alternatives to the extent necessary to select a remedy.

removal action. A short-term cleanup or removal of released hazardous substances from the environment. A removal action is performed in response to a release or the imminent threat of release of hazardous substances into the environment.

surface water. Water that is flowing within natural drainage features.

uncontrolled runoff. Storm water that is not collected by the site for treatment but enters the site's natural drainages.

waste acceptance criteria. A disposal facility's specifications for the types and sizes of materials, the acceptable levels of constituents, and other criteria for all material that can be disposed of in that facility. Offsite disposal facilities such as the Nevada National Security Site (formerly called the Nevada Test Site) that dispose of Fernald Preserve waste have specific waste acceptance criteria. In addition, the OSDF had waste acceptance criteria that were approved by the regulatory agencies.