US Department of Energy
Portsmouth Gaseous
Diffusion Plant

2021

Portsmouth Site
Annual Site Environmental Report

DOE/PPPO/03-1111&D1

Portsmouth Site

Annual Site Environmental Report 2021

DOE/PPPO/03-1111&D1
FBP-ER-RCRA-WD-RPT-0403

Portsmouth Site
Annual Site Environmental Report 2021

December 2022

Prepared for the
U.S. DEPARTMENT OF ENERGY
Office of Environmental Management

Prepared by
FLUOR-BWXT PORTSMOUTH LLC,
managing the
Decontamination and Decommissioning Project at the
Portsmouth Gaseous Diffusion Plant
under Contract DE-AC30-10CC40017

Contents

Figures

Figure *Page*

Tables

Table *Page*

Acronyms and Abbreviations

A	ALARA	as low as reasonably achievable
	ASER	Annual Site Environmental Report
C	CAP-88	Clean Air Act Assessment Package—Version 4.1
	CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
	CFR	*Code of Federal Regulations*
D	DOE	US Department of Energy
	DUF_6	depleted uranium hexafluoride
E	EPCRA	Emergency Planning and Community Right-to-Know Act
M	MEI	maximally exposed individual
N	NEPA	National Environmental Policy Act
	NESHAP	National Emission Standards for Hazardous Air Pollutants
	NPDES	National Pollutant Discharge Elimination System
O	Ohio EPA	Ohio Environmental Protection Agency
	OREIS	Oak Ridge Environmental Information System
P	PEGASIS	PPPO Environmental Geographic Analytical Spatial Information System
	PFAS	per- and polyfluoroalkyl substances
	PK Landfill	X-749B Peter Kiewit Landfill
	PM	particulate matter
	PORTS	Portsmouth Gaseous Diffusion Plant
	PPPO	Portsmouth/Paducah Project Office
R	RCRA	Resource Conservation and Recovery Act
S	SODI	Southern Ohio Diversification Initiative
	STEM	science, technology, engineering, and math
U	US EPA	US Environmental Protection Agency
	USEC	United States Enrichment Corporation

Request for Comments

The US Department of Energy requires an annual site environmental report from each of its sites. This *Portsmouth Site Annual Site Environmental Report 2021* presents the results from the various environmental monitoring programs and activities carried out during the year. This report is a public document that is distributed to government regulators, businesses, special interest groups, and members of the public. Please note that hyperlinks appear throughout this report to take the reader directly to the website or other locations where data, tables, or supporting documents can be found. These links were active at the time of publication, but may become inactive if items have been moved or a website has been renamed.

This report is based on thousands of environmental samples collected at or near the Portsmouth Gaseous Diffusion Plant. Significant efforts were made to provide the data collected and details of DOE's environmental management programs in a clear and concise manner. The editors of this report encourage comments in order to better address the needs of our readers in future environmental reports. You can submit comments by email via the site admin link on the Portsmouth/Paducah Project Office (PPPO) Environmental Geographic Analytical Spatial Information System (PEGASIS) website here.

If you prefer, written comments may be sent to the following address:

U.S. Department of Energy
Portsmouth/Paducah Project Office
1017 Majestic Drive, Suite 200
Lexington, Kentucky 40513

Executive Summary

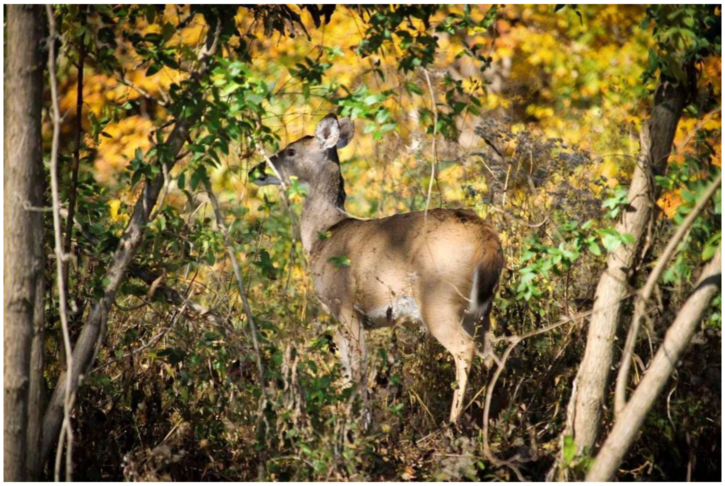


Figure ES.1. A deer in the brush at PORTS

The U.S. Department of Energy (DOE) Portsmouth Gaseous Diffusion Plant (PORTS) is located on a 5.8-square-mile site in a rural area of Pike County, Ohio. The site is 2 miles east of the Scioto River. PORTS, which produced enriched uranium via the gaseous diffusion process from 1954 to 2001, is one of three former uranium enrichment plants used for national security and the commercial sector.

Since 1989 DOE's Office of Environmental Management has been conducting cleanup operations at PORTS even as the site supported the commercial nuclear sector. DOE activities at the site include restoring impacts from past operations to protect human health and the environment; stabilizing infrastructure and removing radioactive and hazardous wastes from facilities; characterizing and disposing of waste stored or generated on site; and decontaminating and decommissioning the gaseous diffusion plant and its support facilities.

Each year, DOE PORTS prepares the Annual Site Environmental Report (ASER) according to the requirements of DOE Order 231.1B, *Environment, Safety, and Health Reporting*. The ASER is a key component of DOE's effort to keep the public informed about environmental conditions at PORTS. This report and previous ASERs can be found here.

DOE conducts environmental monitoring to assess the potential impact of site activities on public health and the environment. In 2021, measurements for external radiation were taken on and around PORTS; more than 5,000 samples of air, water, soil, sediment, vegetation, fish, and wildlife were collected and analyzed for radioactive and nonradioactive contaminants.

The ASER offers a detailed overview of environmental activities at PORTS, which are organized as follows:

Chapter 1: Introduction to PORTS history and mission

Chapter 2: Summary of compliance with laws and regulations

Chapter 3: Details of the PORTS environmental management programs

Chapter 4: Types of radiological environmental monitoring conducted at PORTS and the calculated impacts

Chapter 5: Non-radiological monitoring of air, surface water, sediment, and fish

Chapter 6: Groundwater protection

Chapter 7: Actions to ensure the quality of information from field sampling to analytical data to data management

DOE conducts environmental monitoring to evaluate and assess any unplanned releases. Major sampling efforts of environmental monitoring for 2021 are summarized below.

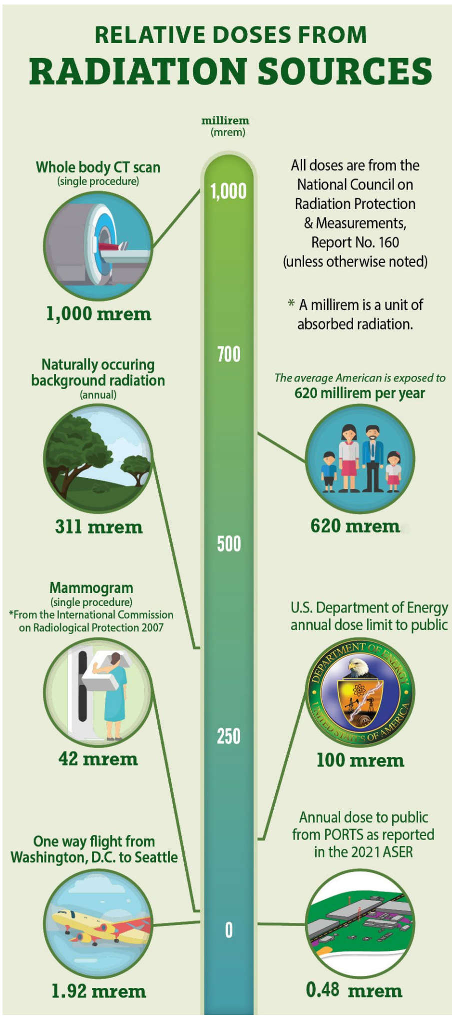


Figure ES.2. Relative doses from radiation sources

- Discharges of radionuclides, chemicals, and other water quality parameters to Little Beaver Creek, the Scioto River, or other water bodies were measured at 11 locations called National Pollutant Discharge Elimination System outfalls.
- External radiation was measured continuously at 29 on-site and off-site locations. The measurements were reported quarterly.
- Ambient air was sampled at 25 on-site and off-site locations and analyzed for radionuclides. Twelve ambient air monitoring stations monitored non-radiological air pollutants that could be released due to decontamination and decommissioning activities: metals, volatile organic compounds, and asbestos. Particulate matter was monitored at seven locations. Fluoride was monitored at 15 on-site and off-site locations.
- Surface water samples were collected from 21 on-site and off-site locations and analyzed for radionuclides. Samples from locations that monitor the On-Site Waste Disposal Facility were also analyzed for chlorinated organic compounds and PCBs.
- Sediment was sampled at 18 locations and analyzed for radionuclides, metals, and PCBs.
- Soil samples were collected at 15 locations, including on-site, fence line, off-site, and background locations and analyzed for radionuclides.
- Biota samples, including vegetation, deer, fish, food crops, milk, and eggs, were analyzed for radionuclides. Fish were also analyzed for PCBs.
- Approximately 340 wells were sampled at varying frequencies to monitor remedial actions, movement of groundwater contaminants, and groundwater quality.

2021 Environmental Performance Summary

DOE’s monitoring performance at PORTS for 2021 is summarized below.

- Environmental monitoring data collected in 2021 are similar to data collected in previous years and indicate radionuclides, metals, and other chemicals released by PORTS would only minimally affect human health and the environment.
- The calculated radiation dose that could be received by a member of the public from all pathways of exposure (see Figure ES.2) was 0.48 millirem (mrem), compared to the DOE annual dose limit of 100 mrem.

- The calculated radiation dose that could be received by a member of the public from all pathways of exposure associated with operation of the On-Site Waste Disposal Facility was 0.0853 mrem, compared to the Ohio Department of Health and DOE annual dose limit of 25 mrem.
- Concentrations of most contaminants detected within the groundwater plumes at PORTS were stable or decreasing in 2021. Concentrations of trichloroethene or metals were increasing in a few monitoring wells in the groundwater plumes. These areas are on site and continue to be closely monitored.
- Operation of the On-Site Waste Disposal Facility began on May 25, 2021. Monitoring results for groundwater, surface water, ambient air, and external radiation did not identify any issues to be addressed in the operation of the On-Site Waste Disposal Facility.
- Results for the residential water supply monitoring program indicated that PORTS has not affected drinking water wells outside the site boundaries.
- Ambient air monitoring contaminant levels for both radionuclides and fluoride continued to be either not detected, detected below DOE Order limits, or within background levels.
- Ambient air monitoring at the stations installed in 2020 and 2021 indicated that levels of particulate matter, metals, volatile organic compounds, and asbestos, if detectable, were within health-based standards.
- Surface water monitoring contaminant levels for radionuclides at on-site and off-site locations upstream and downstream from PORTS continued to be either not detected or below DOE Order limits.
- Sampling of sediment in 2021 for metals indicated that no appreciable differences were evident in the concentrations detected at locations upstream and downstream from PORTS. Contaminant levels for radionuclides were within background levels or below DOE Order limits.
- Concentrations of PCBs in on-site and off-site sediment samples were below the level of concern established by regional screening levels of the US Environmental Protection Agency (EPA) and Ohio EPA.
- Contaminant levels for radionuclides in soil and food crops were within background levels or below DOE Order limits.
- Radionuclides were not detected in samples of fish, deer, milk, and eggs collected in 2021.
- In 2021, PCBs were detected in fish caught in on-site and off-site creeks within the range of concentrations detected in recent years. The detections were within the consumption advisory limits set by the Ohio Department of Health.

DOE received a Notice of Violation from Ohio EPA on June 6, 2022 based on information evaluated during a compliance inspection conducted on August 26, 2021. Ohio EPA determined that DOE had not distributed a Quick Reference Guide for Hazardous Waste Contingency Plan (a type of emergency response plan) to local emergency responders. Local emergency responders had previously received copies of the Hazardous Waste Contingency Plan; the quick reference guide was a new Ohio EPA requirement. The violation was resolved when DOE distributed the Hazardous Waste Contingency Plan Quick Reference Guide to emergency responders and provided proof of distribution to Ohio EPA. No additional activities were required.

DOE and its contractors at PORTS are committed to enhancing environmental stewardship and reducing any impacts that site operations may have on the environment. PORTS implements sound stewardship practices in protecting of land, air, water, and other natural or cultural resources potentially affected by its operations. A report of progress in achieving specified Environmental Management System goals is submitted annually to DOE Headquarters. The environmental stewardship scorecard for PORTS was green for fiscal year 2021, indicating that the site met standards for implementing the Environmental Management System.

The chapters that follow this Executive Summary offer a more complete description of the environmental program at PORTS.

1. Introduction

Construction of the Portsmouth Gaseous Diffusion Plant (PORTS) in a rural area of Pike County, Ohio started in 1952. The US Department of Energy (DOE) chose this location for its third gaseous diffusion plant because of its abundant water resources, reliable electric power, and dependable labor force. PORTS began producing enriched uranium to supply the nation's nuclear defense and nuclear energy systems in 1954, and this mission continued until 2001. In 1993 DOE leased the plant to the United States Energy Corporation (USEC), which managed the uranium enrichment program until 2001. The plant remained in safe standby under USEC management for 10 years, capable of restarting if necessary. In 2011 USEC returned the facilities to DOE for decontamination and decommissioning, and this critical mission is ongoing.

This report aims to fulfill the requirements of DOE Order 231.1B, *Environment, Safety, and Health Reporting*, which requires the development of an annual site environmental report that includes information on regulatory compliance, environmental programs, radiological and non-radiological monitoring programs, groundwater programs, and quality assurance. This Annual Site Environmental Report also demonstrates how DOE complies with the radiation protection requirements of DOE Order 458.1, *Radiation Protection of the Public and the Environment*.

This report is not intended to present all of the monitoring data from PORTS. Data collected for other site purposes such as decontamination and decommissioning, environmental restoration, and waste management are included in other documents that have been prepared according to applicable legal agreements and regulations. These other reports, such as the *2021 Groundwater Monitoring Report* (DOE 2022a) and the *2021 On-Site Waste Disposal Facility Annual Project Status Report* (DOE 2022b) are available at the PORTS Environmental Information Center. These reports and data associated with the reports are also available on the Portsmouth/Paducah Project Office (PPPO) Environmental Geographic Analytical Spatial Information System (PEGASIS) website here.

1.1 Site Location

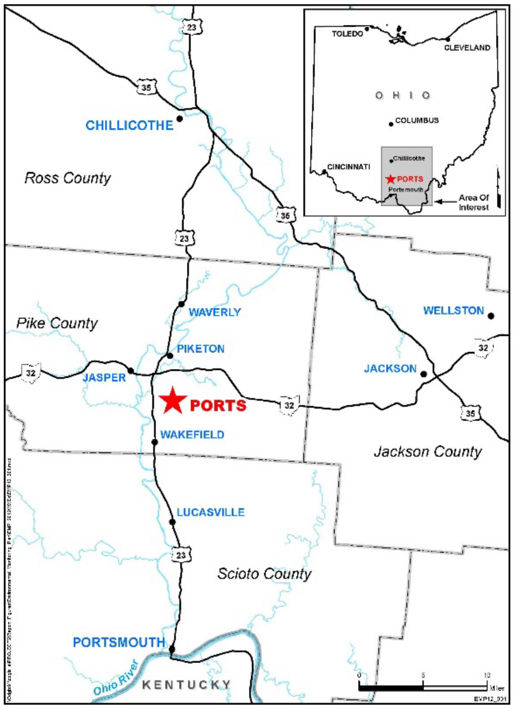


Figure 1.1. Location of PORTS

PORTS is owned by DOE and occupies a 5.8-square-mile site in a rural area of Pike County, Ohio, as shown in Figure 1.1. According to the 2020 US Census (US Census Bureau 2022), Pike County has approximately 27,088 residents. Scattered rural development is typical, but several small villages such as Piketon and Beaver lie within a few miles of the plant. The county's largest community, Waverly, is about 10 miles north of the plant and has a population of about 4,165 residents. The nearest residential center is Piketon, which is 1 to 4 miles north of the plant and has a population of about 2,111. A number of residences are adjacent to the plant boundary.

Other cities within 50 miles of the plant are Portsmouth (population 18,252), 22 miles south; Chillicothe (population 22,059), 27 miles north; and Jackson (population 6,252), 18 miles east (US Census Bureau 2022). The total population within 50 miles of the plant is approximately 662,000, which includes people on the outskirts of Cincinnati and Columbus, Ohio; Ashland, Kentucky; and Huntington, West Virginia.

1.2 Environmental Setting

PORTS occupies an upland area of southern Ohio and has an average land surface elevation of 670 feet above mean sea level. The terrain surrounding the plant site consists of marginal farmland and wooded hills. PORTS is approximately one mile west of the Scioto River.

The climate of the PORTS area is humid-continental and is characterized by warm, humid summers and cold, humid winters. Precipitation is distributed relatively evenly throughout the year and averages approximately 40 inches per year. Prevailing winds are from the south-southwest at approximately 5 miles per hour.

In much of the industrialized area of PORTS, the original topography has been modified and graded for construction of buildings and other infrastructure. Much of the native soil and rock removed from higher elevations of the site was placed as fill in existing drainage valleys and depressions.

The topography at PORTS is dominated by ancient and recent streams. The predominant landform is an undulating, broad, sediment-filled ancient river valley. This valley is oriented north to south and is bounded on the east and west by deeply dissected ridges or low-lying hills. The surface of the ancient river valley is modified by recent streams. Little Beaver Creek, which flows northwest across the middle of the site just north and east of the main industrialized area, forms a small valley. Other small valleys formed by streams have cut into the flat-lying unconsolidated deposits on which PORTS is located. One of these valleys includes a westward-flowing stream, the West Drainage Ditch, near the west-central area of the plant site. Two more streams are located in the southern portion of the industrialized area. In the southeast portion of the site, the southerly flowing stream, Big Run Creek, is situated in a relatively broad, gently sloping valley. A stream in the southwest portion of the site (the Southwestern Drainage

Ditch) that flows to the south and west has formed a narrow, steep-walled valley. All of these streams ultimately discharge to the Scioto River.

1.3 Site Operations

PORTS produced enriched uranium via the gaseous diffusion process from 1954 through 2001. In 1993 DOE leased the uranium production facilities at the site to USEC, which was established by the Energy Policy Act of 1992. USEC produced enriched uranium in the gaseous diffusion process facilities through 2001.

Today DOE, through its managing contractors, is responsible for decontamination and decommissioning of the gaseous diffusion uranium enrichment buildings and associated facilities, environmental restoration, and waste management associated with DOE activities. DOE is also responsible for uranium management, which includes the Depleted Uranium Hexafluoride (DUF_6) Conversion Facility.

Decontamination and decommissioning includes the gaseous diffusion process buildings and associated facilities subject to *The April 13, 2010 Director's Final Findings and Orders for Removal Action and Remedial Investigation and Feasibility Study and Remedial Design and Remedial Action, including the July 16, 2012 Modification thereto*, hereafter referred to as the Decontamination and Decommissioning Director's Final Findings and Orders (Ohio Environmental Protection Agency [Ohio EPA] 2012). Decontamination and decommissioning activities can include deactivating equipment; removing and cleaning process residues from equipment, structures, and piping; and dismantling, demolishing, and removing equipment, structures, piping, and concrete foundations. The Decontamination and Decommissioning Program is also responsible for evaluating alternatives for the disposition of waste generated by decontamination and decommissioning.

The goal of the Environmental Restoration Program is to verify that releases from past operations at PORTS are thoroughly investigated and that, if applicable, remedial actions are taken to protect human health and the environment. Environmental restoration is the investigation and remediation of environmental contamination associated with the past operation of the gaseous diffusion uranium enrichment facilities. Remedial investigations and remedial actions define the nature and extent of environmental contamination, evaluate the potential risk to public health and the environment, remediate areas of environmental contamination, and monitor and evaluate ongoing remedial actions.

Waste management includes managing wastes generated by DOE activities at PORTS, including wastes from decontamination and decommissioning, environmental restoration, the DUF_6 Conversion Facility, and other DOE site activities. Wastes must be identified and stored in accordance with all environmental regulations. The responsible DOE contractor also arranges the transportation and disposal of wastes. The goal of the Waste Management Program is to manage waste from the time it is generated to its ultimate treatment, recycling, or disposal in accordance with all applicable regulations and DOE Orders.

DOE is also responsible for uranium management at PORTS, which includes managing uranium product, coordinating the DUF_6 program, and warehousing other uranium materials such as normal uranium hexafluoride, uranium oxides, and uranium metal.

DOE contractors Fluor-BXWT Portsmouth, Portsmouth Mission Alliance, and Mid-America Conversion Services managed DOE programs at PORTS in 2021. Fluor-BXWT Portsmouth was responsible for the decontamination and decommissioning of the former gaseous diffusion process buildings and associated facilities; environmental restoration of contaminated areas; environmental monitoring and reporting on environmental compliance; disposition of decontamination and decommissioning waste, legacy radioactive waste, and hazardous waste; security forces; uranium management; and operation of the site's waste storage facilities.

Portsmouth Mission Alliance managed facility support services including computer and telecommunications services, security, training, records management, fleet management, non-nuclear facility preventive and corrective maintenance, grounds and road maintenance, snow removal, and janitorial services.

Mid-America Conversion Services managed the DUF_6 Conversion Facility, including surveillance and maintenance of DUF_6 cylinders and environmental compliance and monitoring activities associated with operation of the facility. DUF_6, which is a product of the uranium enrichment process, is stored in cylinders on site. The DUF_6 Conversion Facility converts DUF_6 into uranium oxide and aqueous hydrogen fluoride. The uranium oxide is made available for beneficial reuse, storage, or disposal, and the aqueous hydrogen fluoride is sold for reuse.

Centrus is responsible for environmental compliance, environmental monitoring, and management of wastes generated by current activities at the American Centrifuge Plant. Centrus operates independently of DOE and is regulated by the Nuclear Regulatory Commission. The Centrus data and compliance information included in this report are provided for information only.

2. Compliance Summary

This chapter summarizes PORTS compliance with environmental laws and regulations, DOE orders, and Executive orders. DOE and its contractors are responsible for the Decontamination and Decommissioning Program, Environmental Restoration Program, Waste Management Program, uranium operations, and maintenance of all facilities not leased to Centrus. Centrus is responsible for compliance activities directly associated with the American Centrifuge Plant.

Several federal, state, and local agencies are responsible for enforcing environmental regulations at PORTS. The primary regulatory agencies are Ohio EPA and the US Environmental Protection Agency (US EPA) Region 5. These agencies issue permits, review compliance reports, conduct joint monitoring programs, inspect facilities and operations, and oversee compliance with applicable regulations.

DOE and its contractors conduct self-assessments to identify environmental issues and consult the regulatory agencies to identify the appropriate actions necessary to achieve and maintain compliance.

2.1 Environmental Protection and Waste Management

The following sections discuss environmental protection and waste management activities and compliance with Ohio EPA and US EPA environmental laws, regulations, and permits at PORTS.

2.1.1 Comprehensive Environmental Response, Compensation, and Liability Act

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as Superfund, was passed in 1980. Under CERCLA, a site is investigated and remediated if it poses significant risk to health or the environment. The Superfund Amendments and Reauthorization Act amended CERCLA on October 17, 1986 to reflect US EPA's experience in administering the complex Superfund program. Important changes and additions included increasing the focus on human health problems posed by hazardous waste sites and encouraging greater participation by citizens in deciding how sites should be cleaned up. Section 3.5 of this report describes DOE programs that engage citizens in cleanup decision-making at PORTS.

PORTS is not on the CERCLA National Priorities List. Decontamination and decommissioning of PORTS is proceeding in accordance with the Decontamination and Decommissioning Director's Final Findings and Orders (Ohio EPA 2012) and CERCLA. The former describes the regulatory process for decontamination and decommissioning of the gaseous diffusion process buildings and associated facilities that are no longer in use. Section 3.3 of this report provides additional information about the Decontamination and Decommissioning Program.

Environmental remediation, or the cleanup of soil, groundwater, and other contaminated environmental media at PORTS, has been conducted in accordance with the Consent Decree with the State of Ohio issued on August 29, 1989 and the US EPA Administrative Order by Consent issued on September 29, 1989 (amended in 1994 and 1997 and terminated on February 13, 2017). Ohio EPA oversees environmental remediation activities at PORTS under the Resource Conservation and Recovery Act (RCRA) Corrective Action Program and CERCLA Program. Section 3.4 of this report includes additional information on the Environmental Restoration Program.

Section 103 of CERCLA requires notifying the National Response Center if hazardous substances are released to the environment in amounts greater than or equal to the reportable quantity. Reportable quantities are listed in CERCLA and vary depending on the type of hazardous substance released. During

2021, DOE contractors had no reportable quantity releases of hazardous substances that required notification under Section 103.

2.1.2 Emergency Planning and Community Right-To-Know Act

Also referred to as Title III of the Superfund Amendments and Reauthorization Act, the Emergency Planning and Community Right-to-know Act (EPCRA) requires facilities to report emergency planning information, hazardous chemical inventories, and releases to the environment, including greenhouse gases. PORTS, as a federal facility, is subject to these reporting requirements.

EPCRA's primary purpose is to increase the public's knowledge of and access to information on chemical hazards in their communities. To ensure proper and immediate responses to potential chemical hazards, EPCRA Section 302-304 requires facilities to notify state emergency response commissions and local emergency planning committees of inventories and releases of hazardous substances and extremely hazardous substances when the inventory or release equals or exceeds the established threshold. EPCRA Section 302-303 requires notifying state and local agencies within 60 days when the amount of a substance on the list of extremely hazardous substances first exceeds its established threshold planning quantity. Notifications also are required if a revision to the list results in the facility exceeding the revised threshold planning quantity, or if changes at the facility are relevant to emergency planning. These notifications are required within 60 days and 30 days, respectively, after the facility becomes subject to the requirements. DOE and its contractors make these notifications as needed. EPCRA Section 304 requires reporting emergency or accidental releases above a specified quantity to state and local authorities**.** Fluor-BWXT Portsmouth and Mid-America Conversion Services had no off-site reportable quantity releases subject to Section 304 reporting requirements in 2021.

Sections 311 and 312 of EPCRA require businesses to report the safety data sheets, locations, and quantities of chemicals stored on site (if they exceed specific reporting thresholds) to state and local governments to help communities prepare to respond to chemical spills and similar emergencies. EPCRA Section 311 requires a one-time submittal of safety data sheets of hazardous chemicals present on site at or above the reporting threshold. Section 312 requires an annual Hazardous Chemical Inventory Report of hazardous chemicals present on site above reporting thresholds. Table 2.1 lists the chemicals reported by DOE contractors or lessees (Fluor-BWXT Portsmouth, Mid-America Conversion Services, Portsmouth Mission Alliance, and Centrus) at the PORTS site for 2021:

Table 2.1. Chemicals reported in the Hazardous Chemical Inventory Report for 2021

1,2-propanediol	diesel fuel #2 (ultralow sulfur)	perfluoro-1,3-dimethylcyclohexane
aluminum oxide	ethylene glycol	petroleum distillates
aluminum oxide hydrate	gasoline	potassium hydroxide
argon	hydrogen fluoride	sodium chloride
asbestos	lime, calcium oxide	sodium hydroxide
calcium carbonate	lubricating oils	sulfuric acid
carbon dioxide	methanol	triuranium octaoxide
calcium hydroxide	mineral oils	uranium oxide
calcium magnesium carbonate	nitric acid	uranium hexafluoride
calcium magnesium oxide	nitrogen	uranium metal
citric acid	PCBs	uranium tetrafluoride

EPCRA Section 313 requires US EPA and states to collect data annually on releases and transfers of certain toxic chemicals from industrial facilities, and to make the data available to the public. The site submitted Section 313 Reports to the US EPA and Ohio EPA for the permitted release or off-site treatment or disposal of two chemicals in 2021:

- Hydrogen fluoride: approximately 41 pounds was transported off site for disposal or released to the air from the DUF_6 Conversion Facility.
- Nitrate compounds: approximately 28,000 pounds was released to the Scioto River through permitted National Pollutant Discharge Elimination System (NPDES) outfalls from water treatment.

2.1.3 Resource Conservation and Recovery Act

RCRA established regulatory standards for generating, accumulating, transporting, treating, storing, and disposing of solid and hazardous wastes. Solid wastes as defined by Ohio EPA can be solids, liquids, sludges, or other materials. Hazardous wastes are a subset of solid wastes, and are designated as hazardous by Ohio EPA because of chemical properties including ignitability, corrosivity, reactivity, and toxicity. Owners and operators of hazardous waste treatment, storage, and disposal facilities must obtain operating and post-closure permits.

2.1.3.1 Hazardous Waste

DOE and Fluor-BWXT Portsmouth hold a permit to store hazardous waste at PORTS. The permit, known as a Part B Permit, was issued to DOE and the responsible DOE contractor in 1995 and renewed by Ohio EPA in 2001 and 2011. DOE and Fluor-BWXT Portsmouth submitted a permit renewal application to Ohio EPA in September 2020; however, Ohio EPA had not renewed the permit by the end of 2021. The permit governs the storage of hazardous waste and includes requirements for identifying waste, inspecting storage areas and emergency equipment, developing and implementing emergency procedures, and training, as well as other information required by Ohio EPA. Fluor-BWXT Portsmouth is also regulated as a large quantity hazardous waste generator and manages hazardous waste generated by Fluor-BWXT Portsmouth and Portsmouth Mission Alliance.

Facilities such as PORTS that generate or store hazardous waste must submit a biennial report to Ohio EPA in even-numbered years that covers waste shipped in the previous odd-numbered year (waste shipped in even-numbered years no longer requires reporting). DOE submitted the report for calendar year 2021 to Ohio EPA in February 2022. This biennial report contains the name and address of each facility that waste was shipped to during the previous calendar year, the name and address of the transporter for each waste shipment, the description and quantity of each waste stream shipped off site, and a description of waste minimization efforts.

RCRA also requires groundwater monitoring at certain hazardous waste management units. With the exception of the On-Site Waste Disposal Facility, groundwater monitoring requirements at PORTS have been combined in one document, the *Integrated Groundwater Monitoring Plan* (DOE 2021a). DOE submits to Ohio EPA an annual groundwater report that summarizes the results of monitoring completed in accordance with this plan. Section 6.3 discusses these monitoring results for 2021.

The On-Site Waste Disposal Facility meets requirements for landfills that dispose of RCRA hazardous waste, PCBs, and low-level radioactive waste. The *On-Site Waste Disposal Facility (OSWDF) Performance Standards Verification Plan* (DOE 2021b) includes the environmental monitoring requirements associated with operation of the On-Site Waste Disposal Facility. DOE submits an annual report to Ohio EPA that summarizes the results of the monitoring completed in accordance with this plan.

Mid-America Conversion Services is regulated as a small-quantity hazardous waste generator and, for one period in May, became an episodic large-quantity generator due to waste from neutralizing and inspecting a hydrogen fluoride storage tank. Small-quantity hazardous waste generators are subject to requirements for generation and accumulation of hazardous waste. These requirements include proper waste identification, use of appropriate containers, availability of emergency equipment, and specified shipment information.

2.1.3.2 Solid Waste Disposal Facilities

Groundwater monitoring may be required at closed solid waste disposal facilities such as landfills. Groundwater monitoring requirements for the closed X-734 Landfills, X-735 Industrial Solid Waste Landfill, and X-749A Classified Materials Disposal Facility are included in the *Integrated Groundwater Monitoring Plan* (DOE 2021a). Chapter 6 discusses the groundwater monitoring results for these units in 2021.

2.1.3.3 Underground Storage Tank Regulations

RCRA Subtitle I provides a comprehensive regulatory program for underground tanks that store petroleum or certain hazardous substances. The Underground Storage Tank Program in Ohio is managed in accordance with the Ohio State Fire Marshal’s Bureau of Underground Storage Tank Regulations. Underground storage tanks in the former gaseous diffusion plant buildings and associated facilities are owned by DOE. Portsmouth Mission Alliance and Mid-America Conversion Services have no underground storage tanks. In 2021, Fluor-BWXT Portsmouth was responsible for four tanks and Centrus was responsible for one tank. These include four diesel fuel tanks ranging in size from 2,500 to 20,000 gallons and a 20,000 gallon gasoline tank. The registrations for these tanks are renewed annually.

2.1.4 Federal Facility Compliance Act

The Federal Facility Compliance Act, which was enacted in October 1992, waived federal facilities’ immunity from fines and penalties for violations of hazardous waste management as defined by RCRA. It also provided for the development of site treatment plans for treating DOE mixed waste (low-level hazardous and radioactive waste), and for the approval of such plans. Waste that is a mixture of RCRA hazardous waste and low-level radioactive waste is currently stored at PORTS. On October 4, 1995, Ohio EPA issued a Director’s Final Findings and Orders allowing mixed waste to be stored beyond one year and approving the proposed PORTS site treatment plan. An annual update to the site treatment plan is required by these Director’s Final Findings and Orders. The annual update to the site treatment plan for fiscal year 2021 was submitted to Ohio EPA in December 2021. DOE and FBP are currently shipping RCRA hazardous waste within one year in accordance with RCRA regulations.

2.1.5 National Environmental Policy Act

The National Environmental Policy Act (NEPA) requires federal agencies to evaluate the potential environmental impact of certain proposed activities, and to examine alternatives to proposed actions. DOE has a formal program administered by DOE’s NEPA Implementing Procedures [Title 10 of the *Code of Federal Regulations* (*CFR)* Part 1021] and the Council on Environmental Quality Regulations (40 *CFR* Parts 1500–1508) and pursuant to DOE Order 451.1B, the National Environmental Policy Act Compliance Program. Restoration actions, waste management, enrichment facilities maintenance, and other activities are examined to determine the appropriate level of evaluation and documentation. No environmental assessments or environmental impact statements were completed at PORTS in 2021.

Section II.E of the June 13, 1994 DOE Secretarial Policy Statement on NEPA states that separate NEPA documents are no longer required for environmental restoration activities conducted under CERCLA. Instead, the DOE CERCLA process incorporates NEPA values, which include environmental issues that affect the quality of the human environment. Documenting NEPA values in CERCLA documents allows decision-makers to consider the potential effects of proposed actions on the human environment.

Routine operation and maintenance activities are also evaluated to assess potential environmental impacts. Activities not regulated under CERCLA may be covered under a categorical exclusion or other determination, as defined in NEPA regulations. Such activities are considered routine and have no significant individual or cumulative environmental impacts. DOE policy requires its facilities to post online specific classes of categorical exclusions listed in 10 *CFR* Part 1021, Appendix B to Subpart D. Categorical exclusions for PORTS are posted on the DOE Portsmouth/Paducah Project Office website here.

2.1.6 Toxic Substances Control Act

The Toxic Substances Control Act was enacted in 1976 with two purposes: to ensure US EPA obtains information on the production, use, and environmental and health effects of chemical substances or mixtures, and to provide the means by which US EPA can regulate chemical substances such as PCBs, asbestos, chlorofluorocarbons, and lead.

PORTS complies with PCB regulations (40 *CFR* Part 761) and the Modification to the February 20, 1992 Compliance Agreement between DOE and US EPA for the Toxic Substances Control Act. The compliance agreement was modified on September 25, 1997, then modified again on May 30, 2017. It addresses PCB management issues at PORTS including the use, management, storage, and disposal of PCBs in ventilation duct gaskets and associated collection and containment systems; a negotiated schedule for clean-up, removal, and management of PCB wastes and contaminated items; ongoing air monitoring; and management of PCB spill cleanups.

PCBs are most commonly found in older electrical power system components such as transformers and capacitors. The PCB transformers and capacitors that were present in the gaseous diffusion process buildings have been removed from service.

PORTS prepares an annual document log to meet regulatory requirements in the Toxic Substances Control Act. This log is an inventory of PCB items in use and in storage as waste, as well as shipping and disposal information for PCB items disposed of each year. The *2021 PCB Document Log for the Portsmouth Gaseous Diffusion Plant* (Fluor-BWXT Portsmouth 2022) was prepared in June 2022. Eleven pole-mounted PCB transformers were in service at the PORTS facility at the end of 2021. Approximately 51,250 tons of PCB waste (gross weight) was generated in 2021. Approximately 3.1 tons of PCB waste (gross weight) was shipped off site for disposal in 2021, and 17.5 tons of PCB waste was disposed in the On-Site Waste Disposal Facility. The remaining PCB waste generated in 2021 by decontamination and decommissioning of the X-326 Process Building is in storage for disposal at the On-Site Waste Disposal Facility. Waste contaminated with PCBs was generated during 2021 through decontamination and decommissioning activities in the process buildings and other areas. PORTS also submits annual reports of progress made toward milestones specified in the compliance agreement to US EPA. DOE met the requirements and milestones of this Toxic Substances Control Act Compliance Agreement during 2021.

The DUF_6 Conversion Facility stores and processes cylinders containing DUF_6. Paint on the outside of the cylinders may contain more than 50 parts per million of PCBs. The cylinders are stored in the X-745C, X-745E, and X-745G Cylinder Storage Yards in accordance with an agreement with US EPA, which requires monitoring PCBs in surface water and sediment in drainage basins downstream from the cylinder storage yards. See Sections 5.2.3 and 5.3.2 for the results of this surface water and sediment sampling.

2.1.7 Federal Insecticide, Fungicide, and Rodenticide Act

No restricted-use pesticides were used by DOE contractors in 2021.

2.2 Radiation Protection

PORTS is subject to radiation protection statutes, regulations, and DOE orders designed to protect the health and safety of the public, the workforce, and the environment. The following sections discuss compliance with radiation protection and radioactive waste management requirements. DOE and its contractors maintain and implement programs and procedures to ensure compliance with the relevant laws and regulations described in the following sections. See Chapter 4 for additional information about radiation protection.

2.2.1 Atomic Energy Act of 1954

To ensure proper management of radioactive materials, the Atomic Energy Act of 1954 and its amendments delegate roles and responsibilities for controlling radioactive materials and nuclear energy primarily to DOE, the US Nuclear Regulatory Commission, and US EPA. Through the Atomic Energy Act, DOE regulates the control of radioactive materials under its authority, including the treatment, storage, and disposal of low-level radioactive waste from its operations. Because sections of this Act authorize DOE to establish radiation protection standards for itself and its contractors, DOE published a series of regulations including 10 *CFR* Part 820, *Procedural Rules for DOE Nuclear Activities*; 10 *CFR* Part 830, *Nuclear Safety Management*; and 10 *CFR* Part 835, *Occupational Radiation Protection*. Other DOE directives to protect public health and the environment from potential risks associated with radioactive materials include the current revisions of DOE Order 458.1, *Radiation Protection of the Public and Environment*, and DOE Order 435.1, *Radioactive Waste Management*. DOE PORTS operations are subject to these regulations and directives.

2.2.2 DOE Order 458.1, Radiation Protection of the Public and the Environment

DOE Order 458.1 establishes requirements to protect the public and the environment against undue risk from radiation associated with radiological activities conducted under DOE's control. The objectives of this Order include the following:

- To conduct DOE radiological activities so that exposure to members of the public is maintained within the dose limits established in this Order
- To ensure that potential radiation exposures to members of the public are as low as is reasonably achievable (ALARA)
- To control the radiological clearance of DOE real and personal property
- To ensure that DOE sites have the capabilities, consistent with the types of radiological activities conducted, to monitor routine and non-routine radiological releases and to assess the radiation dose to members of the public
- To protect the environment from the effects of radiation and radioactive material

While the public dose limit of 100 millirem (mrem) per year is the primary dose limit, other regulations control the dose that may be received through specific exposure pathways. Exposure pathways are discussed in Appendix B. The air and water pathways are also regulated by US EPA and Ohio EPA, as discussed in Sections 2.3 and 2.4. DOE Order 458.1 includes dose limits to protect aquatic and terrestrial plants and animals near radiological activities. The Order also regulates the dose that could be received by a member of the public from activities such as the management, storage, disposal, or unrestricted release to the public of radioactive waste, or clearance of real and personal property.

These radiation standards are dose limits, but they do not represent DOE's expected dose to the public and the environment. DOE Order 458.1 requires the "as low as reasonably achievable" (ALARA) process be applied to all routine radiological activities to further reduce radionuclide releases and resulting doses as much as possible.

DOE Order 458.1 includes the following dose limits for members of the general public:

- 100 mrem/year from all radiological releases from a facility and all potential exposure pathways that could contribute significantly to the dose
- 25 mrem/year from radiological releases associated with management, storage, and disposal of radioactive waste (such as operation of the On-Site Waste Disposal Facility) except for transportation, and excluding radon and its decay products
- 25 mrem/year from exposure to real property (land and buildings) released by DOE
- 1 mrem/year from exposure to personal property released by DOE

2.2.2.1 Authorized Limits at PORTS

DOE uses Authorized Limits to establish concentrations or quantities of residual radioactive material that protect human health and the environment. Authorized Limits ensure that doses to the public meet DOE standards and are ALARA, groundwater is protected, no future remediation is needed, and no radiological protection requirements are violated.

In 2021, FBP used the following pre-approved Authorized Limits as documented in the *Environmental Radiation Protection Program* (FBP 2019):

- For radium-226 and radium-228 in soil—5 pCi/gram (0.2 Bq/gram) in excess of background levels, averaged over 100 m^2, in the first 15 cm depth of the surface layer of soil; and 15 pCi/gram (0.56 Bq/gram) in excess of background levels, averaged over any subsequent 15 cm subsurface layer of soil, plus an ALARA assessment. If both thorium-230 and radium-226 or both thorium-232 and radium-228 are present and not in secular equilibrium, the appropriate pre-approved Authorized Limit must be applied to the radionuclide with the higher concentration.
- Previously approved guidelines and limits [such as the surface activity guidelines (DOE Order 5400.5 Chg 2)] may continue to be applied and used as pre-approved Authorized Limits until they are replaced or revised by pre-approved Authorized Limits issued by DOE.

In addition to pre-approved Authorized Limits, the following Authorized Limits were in use in 2021 as documented in the *Environmental Radiation Protection Program* (FBP 2019):

- Authorized Limits for disposition of DOE waste containing low levels of radioactivity in the Waste Control Specialists RCRA landfill
- Authorized Limits for lubricating oil from the process buildings for disposal by incineration
- Authorized Limits for waste disposal at the Carter Valley Landfill in Tennessee

DOE has approved authorized limits for real property release at PORTS. These authorized limits are ALARA and allow DOE to transfer land intended for industrial use. These limits are also approved under CERCLA. Table 2.2 provides the approved authorized limits.

Table 2.2. Approved authorized limits for real property transfer at PORTS

Nuclide	Outdoor Worker[a]
Americium-241	54
Neptunium-237+D[b]	2
Plutonium-238	164
Plutonium-239	143
Plutonium-240	144
Technetium-99	885
Uranium-234	329
Uranium-235	3
Uranium-238+D[b]	16

Notes:
[a]Source: Authorized limits letter (Bradburne May 2, 2018). Limits are shown in picocuries per gram.
[b]"+D" indicates consideration of short-lived decay products of a principal radionuclide down to, but not including, the next principal radionuclide or the final nonradioactive nuclide in the chain.

2.2.3 DOE Order 435.1, Radioactive Waste Management

DOE Order 435.1 establishes requirements for managing high-level waste, transuranic waste, and low-level waste, including the radioactive component of mixed waste (high-level waste, transuranic waste, and low-level waste containing chemically hazardous constituents) in a safe manner that protects the worker, public health, and the environment. Appendix A provides definitions of the waste types. DOE Order 435.1 is a cradle-to-grave approach for managing waste that includes requirements for generating, storing, treating, and disposing of waste and for monitoring facilities after closure.

PORTS manages only low-level radioactive waste and mixed low-level radioactive waste, and operates an On-Site Waste Disposal Facility for waste generated by decontamination and decommissioning that meets criteria for on-site disposal.

The DOE Low-level Waste Disposal Facility Review Group independently reviews the design and operation of the On-Site Waste Disposal Facility to evaluate its compliance with performance objectives in DOE Order 435.1. PORTS received an Operating Disposal Authorization Statement for design, construction, operation, and subsequent closure of the On-Site Waste Disposal Facility in 2019, which was revised in May 2021 to remove or revise conditions that were part of the original Operating Disposal Authorization Statement.

The DOE Low-level Waste Disposal Facility Review Group continues to oversee the operation and ongoing construction of the On-Site Waste Disposal Facility. An annual report documenting the operation of the On-Site Waste Disposal Facility and how the On-Site Waste Disposal Facility meets performance requirements in the Disposal Authorization Statement is provided to the DOE Low-level Waste Disposal Facility Review Group.

2.3 Air Quality and Protection

PORTS is subject to air quality and protection statutes, regulations, and rules designed to protect the health and safety of the public and the environment. The following sections discuss the Site's compliance with US EPA and Ohio EPA requirements. Chapters 4 and 5 include additional information about ambient air monitoring for radionuclides and non-radionuclides, respectively.

2.3.1 Clean Air Act

PORTS complies with the Clean Air Act and its amendments, subsequent federal regulations, and Ohio EPA codes by implementing programs, procedures, and permit requirements. Authority for enforcing compliance with the Clean Air Act and its amendments resides with US EPA Region 5, the Ohio EPA, or both.

Fluor-BWXT Portsmouth is responsible for numerous air emission sources associated with the former gaseous diffusion production and support facilities. These sources, which included the boilers at the X-600 Steam Plant Complex prior to their demolition in 2013, emitted more than 100 tons per year of non-radiological air pollutants specified by Ohio EPA. This caused DOE to become a major source of air pollutants as defined in Title 40 *CFR* Part 70. Ohio EPA issued the final Title V Air Permit to Fluor-BWXT Portsmouth in 2014. Fluor-BWXT Portsmouth submitted a permit renewal application to Ohio EPA in November 2018; however, Ohio EPA had not renewed the permit by the end of 2021. The X-600 Steam Plant Complex has been demolished and is no longer operating.

Fluor-BWXT Portsmouth is required to submit quarterly Title V deviation reports that document any conditions that do not conform to the requirements of the Title V permit. These quarterly reports are summarized in an annual Title V Compliance Certification. Fluor-BWXT Portsmouth had no deviations from the Title V Permit requirements in 2021.

Ohio EPA requires an annual Ohio EPA Fee Emissions Report to document emissions of selected non-radiological air pollutants. US EPA requires an annual report of greenhouse gas emissions. Section 5.1.1 provides more information about these reports and the reported emissions for Fluor-BWXT Portsmouth in 2021.

In 2021, Mid-America Conversion Services was responsible for four permitted sources associated with the DUF_6 Conversion Facility. The annual permit evaluation report for the Mid-America Conversion Services air emission sources did not include any deviations from applicable emission limits or control requirements. Section 5.1.1 provides more information about air emissions from Mid-America Conversion Services in 2021.

2.3.2 National Emission Standards for Hazardous Air Pollutants

Airborne emissions of radionuclides from PORTS are regulated under the National Emission Standards for Hazardous Air Pollutants (NESHAP), Subpart H, National Emission Standards for Emissions of Radionuclides Other Than Radon from DOE Facilities, which requires DOE to submit an annual report of radiological emissions from DOE air emission sources. DOE contractors Fluor-BWXT Portsmouth and Mid-America Conversion Services were both responsible for radiological air emission sources. Section 4.3.2 provides the radiological dose calculations from these emissions.

In 2021, Fluor-BWXT Portsmouth was responsible for numerous air emission sources including continuously monitored vents in the X-330 Process Building and the X-344A Uranium Hexafluoride Sampling Building; room ventilation exhausts and pressure relief vents associated with the X-710 Technical Services Building, X-705 Decontamination Facility, and the XT-847 Glove Box; wastewater treatment facilities that support on-site remedial actions, and the X-622, X-623, X-624, and X-627 Groundwater Treatment Facilities. Radiological emissions from the vents in the X-330 Process Building and the X-344A Uranium Hexafluoride Sampling Building were measured by continuous monitoring if in use. Emissions from the room ventilation exhausts and vents, if in use, were estimated based on operating data and US EPA emission factors. Emissions from the groundwater and wastewater treatment facilities were estimated based on influent and effluent sampling and throughput. Total radiological airborne emissions from Fluor-BWXT Portsmouth sources in 2021 were 0.209 curie (Ci).

In 2021, Mid-America Conversion Services was responsible for emissions from the DUF_6 Conversion Facility. The DUF_6 Conversion Facility did not operate in 2021 due to the COVID-19 pandemic. Emissions from the DUF_6 Conversion Facility were based on continuous monitoring of the conversion building stack. Total radiological airborne emissions from the DUF_6 Conversion Facility in 2021 were 0.0000284 Ci.

Radionuclide emission sources at PORTS also include fugitive and diffuse sources such as demolition of the X-326 Process Building, soil excavation, and operation of the On-Site Waste Disposal Facility. The ambient air monitoring program (Sections 4.3.3 and 4.3.4) assesses non-point source emissions of radionuclides from these activities.

2.3.3 Hydrofluorocarbon Phasedown

Hydrofluorocarbons are greenhouse gases with very high global warming potentials and are used as refrigerants, in fire suppression systems, and certain scientific and electrical equipment. As of October 1, 2021, US EPA began the implementation of hydrofluorocarbons phasedown requirements.

PORTS does not use hydrofluorocarbons for industrial processes. Hydrofluorocarbons are only used for comfort cooling/heating. Hydrofluorocarbon refrigerants used at PORTS are compliant with current regulations in 40 *CFR* Part 82. Hydrofluorocarbons removed as a result of maintenance activities are logged, properly contained, and recycled or disposed. One hundred-fifty pounds (six 25-pound cylinders) of hydrofluorocarbon refrigerants were purchased by PORTS in 2021. Future purchases of refrigerants will consider acceptable alternatives that have lower global warming potentials.

2.4 Water Quality and Protection

PORTS is subject to water quality and protection statutes, regulations, and rules designed to protect the health and safety of the public and the environment. The following sections discuss DOE and its contractors' compliance with US EPA and Ohio EPA requirements.

2.4.1 Clean Water Act

The Clean Water Act was established primarily through passage of the Federal Water Pollution Control Act Amendments of 1972. The Clean Water Act set up four major programs for controlling water pollution: regulating point-source and storm water discharges into waters of the United States, controlling and preventing spills of oil and hazardous substances, regulating discharges of dredge and fill materials into waters of the United States, and providing financial assistance to construct publicly owned sewage treatment works. DOE contractors Fluor-BWXT Portsmouth and Mid-America Conversion Services held NPDES permits during 2021 that allowed discharges of water to surface streams.

Fluor-BWXT Portsmouth was responsible for 18 monitoring locations identified in the Fluor-BWXT Portsmouth NPDES permit. Nine outfalls discharge directly to surface water, six outfalls discharge to another outfall before leaving the site, and three other locations that are not outfalls were also monitored. Section 4.4.1.1 and Section 5.2.1.1 provide additional information on the Fluor-BWXT Portsmouth NPDES outfalls. Figure 4.2 shows the locations of PORTS NPDES outfalls.

The Mid-America Conversion Services NPDES permit allows the discharge of process wastewaters from the DUF_6 Conversion Facility. The Mid-America Conversion Services NPDES permit specifies monitoring requirements for Mid-America Conversion Services Outfall 001 that are only effective when process wastewater is being discharged through the outfall. The permit also includes requirements for Mid-America Conversion Services Outfall 602, which are effective when process wastewater is being discharged to the sanitary sewer system that flows to the X-6619 Sewage Treatment Plant (Fluor-BWXT

Portsmouth NPDES Outfall 003). No process wastewater was discharged through Mid-America Conversion Services Outfall 001 in 2021. Section 4.4.1.1 and Section 5.2.1.2 include additional information on the Mid-America Conversion Services NPDES outfalls.

Fluor-BWXT Portsmouth and Mid-America Conversion Services submit monthly discharge monitoring reports to Ohio EPA that include the data required to demonstrate compliance with the NPDES permits. Table 2.3 summarizes the permit exceedances identified by Fluor-BWXT Portsmouth in 2021. The overall Fluor-BWXT Portsmouth NPDES compliance rate for 2021 was 99 percent. There were no exceedances of Mid-America Conversion Services permit limitations in 2021; therefore, the overall Mid-America Conversion Services NPDES compliance rate for 2021 was 100 percent.

Table 2.3. Fluor-BWXT Portsmouth NPDES exceedances in 2021

Outfall	Parameter	Number of permit exceedances[a]	Number of samples collected	Number of compliant samples	Percent compliance	Month exceeded[b]
002	Oil and grease	1	48	47	98	November
003	E. coli	1	24	23	96	July
003	Mercury	[c]	19	-	-	
004	Copper	1[d]	14	13	93	January
004	Total suspended solids	5[d]	48	43	90	January February June (3)
005	pH	2	48	46	96	April (2)
005	Total suspended solids	3[e]	48	45	94	April December(2)
009	Total suspended solids	1	48	47	98	March

Notes:
[a]Daily exceedances only. Monthly exceedances, if any, are listed in these footnotes.
[b]This column identifies the month that the daily exceedance or exceedances occurred. If there was more than one exceedance during the month, the number of exceedances is provided in parentheses.
[c]The monthly concentration limit for mercury was exceeded in January, February, and August. The monthly loading limit for mercury was exceeded in January, February, May, and August. There were no daily exceedances.
[d]The monthly concentration limit for copper was exceeded in January. The monthly concentration limit for total suspended solids was exceeded in June.
[e]The monthly concentration limit for total suspended solids was exceeded in April and December.

Exceedances of the discharge limitations for total suspended solids, copper, and pH were generally caused by a combination of excessive rainfall and operational issues at the outfall. The exceedance of oil and grease at Outfall 002 may have been caused by a discarded tube of grease, which was immediately removed and secured for proper disposal. Exceedances of the monthly limits for mercury at Outfall 003 are being addressed in accordance with the compliance schedule in the Fluor-BWXT Portsmouth NPDES permit that became effective on July 1, 2020. The overall Fluor-BWXT Portsmouth NPDES compliance rate for 2021 was 99 percent.

Most of the Fluor-BWXT Portsmouth NPDES outfalls are also monitored for radionuclides (see Section 4.4.1.1). The Mid-America Conversion Services outfalls are not monitored for radionuclides. Section 4.4.1.1 and Section 5.2.1.3 provide information about NPDES monitoring completed by Centrus.

Storm water runoff, defined as water from precipitation that flows over land and is not absorbed into the ground, is regulated under the Clean Water Act because it can accumulate debris, chemicals, or other pollutants that affect water quality. Storm water pollution prevention plans are prepared for industrial activities at the PORTS site under the Fluor-BWXT Portsmouth NPDES permit. Construction activities are covered by the NPDES Construction Storm Water General Permit. The storm water pollution prevention plans describe the activities and the controls to be used to minimize impacts to storm water runoff. Storm water management and drainage design will be part of site redevelopment after decontamination, decommissioning, and remediation are completed.

2.4.2 Safe Drinking Water Act

PORTS supplies its facilities with on-site drinking water. Drinking water systems are regulated by the Safe Drinking Water Act, which sets requirements for testing, treating, and disinfecting water as well as maintaining distribution systems and training operators. Fluor-BWXT Portsmouth operated and managed the PORTS drinking water system in accordance with the Safe Drinking Water Act in 2021. The Safe Drinking Water Act also sets health-based standards for naturally-occurring and man-made contaminants that may be found in drinking water. PORTS obtains its drinking water from two water supply well fields west of PORTS in the Scioto River Valley buried aquifer near the Scioto River.

Ohio EPA stipulates the parameters and schedule for sampling drinking water for nitrate, lead, disinfection byproducts, total coliform, chlorine, and other potential contaminants. Sampling results are submitted to Ohio EPA in a monthly report.

Ohio EPA sampled the PORTS drinking water supply in June 2020 for perfluoroalkyl and polyfluoroalkyl substances (PFAS), a group of manmade chemicals used in non-stick products such as Teflon, water- and stain-repellant fabrics, and firefighting foam, among many other uses. No PFAS were detected in PORTS treated drinking water. One type of PFAS, perfluorooctane sulfonate, was detected in the PORTS raw water supply at 5.4 nanograms per liter (ng/L), or parts per trillion. This detection is below the Ohio EPA action limit of 70 ng/L.

DOE is currently planning additional assessment of PFAS at all DOE sites.

2.5 Other Environmental Statutes

This section discusses compliance with other applicable environmental statutes, regulations, and Executive Orders.

2.5.1 Endangered Species Act

The Endangered Species Act of 1973, as amended, provides for the designation and protection of endangered and threatened wildlife and plants and the habitat on which such species depend. When appropriate, formal consultations are made with the US Fish and Wildlife Service and the Ohio Department of Natural Resources.

A 2013 study identified the potential presence of the federally-endangered Indiana bat (*Myotis sodalis*) and the northern long-eared bat (*Myotis septentrionalis*) in the northeastern area of PORTS near the On-Site Waste Disposal Facility (see Section 3.3.2). The study did not detect the Indiana bat in the study area, but did identify both foraging and roosting activities for the northern long-eared bat, which is listed as a threatened species. The US Fish and Wildlife Service issued a biological opinion in 2015 that the On-Site Waste Disposal Facility is not likely to jeopardize the continued existence of the northern long-eared bat.

An additional study in 2019 assessed the potential presence of the Indiana bat and the northern long-eared bat in areas where tree clearing was proposed. No Indiana bats and one northern long-eared bat were identified during the study. Measures to minimize potential impacts to bats continue to be implemented during construction and operation of the On-Site Waste Disposal Facility and other decontamination and decommissioning activities.

2.5.2 Impacts of Invasive Species

Executive Order 13751, Safeguarding the Nation from the Impacts of Invasive Species, calls on government agencies to take steps to prevent the introduction and spread of invasive species, and to support efforts to eradicate and control invasive species that are established. DOE takes steps to minimize the spread of invasive species at PORTS through routine site maintenance such as mowing and spraying for weeds.

2.5.3 Migratory Bird Treaty Act

The 2013 Memorandum of Understanding on Migratory Birds between DOE and the US Fish and Wildlife Service and Executive Order 13186, *Responsibilities of Federal Agencies to Protect Migratory Birds*, direct federal agencies to take certain actions to further implement the Migratory Bird Treaty Act of 1918, which is applicable to PORTS. DOE takes measures to minimize impacts to migratory birds by avoiding disturbance of active nests.

2.5.4 Floodplain Management and Protection of Wetlands

Title 10 *CFR* Part 1022 establishes procedures for complying with Executive Order 11988, *Floodplain Management*, and Executive Order 11990, *Protection of Wetlands*. A site-wide wetland survey report was completed and submitted to the US Army Corps of Engineers in 1996. The 1996 survey identified 41 jurisdictional wetlands and four non-jurisdictional wetlands at PORTS totaling 34.36 acres. A wetland and stream assessment was completed in 2013 for the northeast area of PORTS where the On-Site Waste Disposal Facility is located. DOE has developed mitigation strategies for wetlands and streams impacted by the construction of the On-Site Waste Disposal Facility in accordance with CERCLA requirements.

2.5.5 National Historic Preservation Act

The National Historic Preservation Act of 1966 is the primary law governing a federal agency's responsibility to identify and protect historic properties, defined as cultural resources included in or eligible for inclusion in the National Register of Historic Places. Historic properties include buildings of historic significance and archeological sites. National Historic Preservation Act reviews consider both architectural and archeological properties. Coordination and consultation with the State Historic Preservation Office and other stakeholders occurs as a part of these reviews. The cultural resources of three broad time periods of occupation of the PORTS property have been assessed: the prehistoric era (occupation by Native Americans until approximately 1650), the historic era (occupation by Native Americans and early settlers from 1650 through 1952), and the DOE era (from 1952 to the present).

Fifty-four prehistoric archaeological sites have been identified on PORTS property. Each site was investigated, and four of the sites included sufficient artifacts such as tools, earth ovens, and pottery to be determined eligible for inclusion on the National Register of Historic Places. One of the sites eligible for inclusion on the National Register of Historic Places was in the northeast corner of PORTS in the support area for the On-Site Waste Disposal Facility. DOE worked with the State Historic Preservation Office and Tribal Nations to develop an approach for this approximately one-acre area to recover artifacts and other information prior to the start of construction activities. Field work, including hand excavation of selected areas, was completed in 2015. No significant artifacts were found. A technical report documenting the data recovery process and results was submitted to the State Historic Preservation Office in 2017. A summary report intended for a general audience was submitted to the State Historic Preservation Office in 2019.

Sixty-one historic era sites have been identified on PORTS property. Most of these were farmstead or residential sites, and investigations of the farmstead and residential sites determined they were not eligible for inclusion on the National Register of Historic Places. Two sites, the Holt Cemetery and Mount Gilead Church and Cemetery, are treated as if they are eligible for the National Register.

DOE has worked with the State Historic Preservation Office, Advisory Council on Historic Preservation, Tribal Nations, and individual members of the public interested in historic preservation to determine how best to document the DOE era of site history—that is, the history associated with the buildings and other areas that are part of the decontamination and decommissioning effort. The National Historic Preservation Act review for site decontamination and decommissioning was performed as a part of the CERCLA process. The PORTS Virtual Museum (here) preserves photos, video, oral histories, and other information associated with operation, remediation, and decontamination and decommissioning of PORTS. The records of decision for process buildings and waste disposition (see Section 3.3) list the activities selected to preserve the history associated with the PORTS site. Of these activities, the following have been completed:

- A Comprehensive Summary Report summarizing all investigations related to the National Historic Preservation Act, entitled the *Comprehensive Summary Report of Cultural Resource Investigations Conducted at the Portsmouth Gaseous Diffusion Plant (PORTS Facility), Scioto and Seal Townships, Pike County, Ohio* (Fluor-BWXT Portsmouth 2014)
- A Historic Context Report entitled *The Role of the Portsmouth Gaseous Diffusion Plant in Cold War History* that documents the history of operations and facilities at PORTS from 1952 through the end of the Cold War (DOE 2017a)
- Expansion of the PORTS virtual museum in 2017 to include information on prehistoric activities

Activities selected to preserve the history of the PORTS site and document ongoing activities include collecting and evaluating items recovered from PORTS facilities for potential future display, reaching out to local school districts and others, and taking panoramic and aerial photographs at regular intervals.

2.5.6 Archaeological and Historic Preservation Act and Archaeological Resources Protection Act

The Archaeological and Historic Preservation Act and the Archaeological Resources Protection Act require the Secretary of the Department of Interior to report to Congress on federal archaeological activities. The Archaeological Resources Protection Act requires federal land managers to provide archaeology program information to the Secretary of the Interior for this report; information for PORTS is included in the overall DOE headquarters report.

2.6 Sustainability

DOE and its contractors implement numerous sustainability requirements including Executive Order 13423, *Strengthening Federal Environmental, Energy, and Transportation Management*; Executive Order 13514, *Federal Leadership in Environmental, Energy, and Economic Performance*; the National Energy Conservation Policy Act; the Energy Policy Acts of 1992 and 2005; and the Energy Independence and Security Act of 2007, largely through DOE Order 436.1, *Departmental Sustainability*.

2.6.1 Departmental Sustainability

DOE Order 436.1 requires that sites develop and implement an environmental management system to protect air, water, land, and other natural or cultural resources potentially impacted by DOE operations. Sections 3.1 and 3.2 discuss the DOE PORTS Environmental Management System and Site Sustainability

Program. DOE is committed to reducing potential environmental risks, costs, wastes, and future liability by effectively integrating environmental sustainability principles in DOE activities at PORTS in a cost-effective and environmentally conscious manner.

2.6.2 Federal Leadership in Environmental, Energy, and Economic Performance

On December 8, 2021 the President signed Executive Order 14057, *Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability*, which requires that federal agencies lead by example to achieve a carbon-pollution-free electricity sector by 2035 and net-zero emissions economy-wide by no later than 2050. The *Fiscal Year 2022 Site Sustainability Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2021c) provides goals and progress through fiscal year 2021 for reducing greenhouse gas emissions and water consumption, recycling and diverting wastes, improving electronic stewardship, and other areas. Chapter 3 details the objectives of the Site Sustainability Plan.

2.7 Other Major Environmental Issues and Actions

The following sections summarize environmental release reporting and permits for PORTS.

2.7.1 Enforcement and Compliance History Online

US EPA's Enforcement and Compliance History Online web tool provides environmental regulatory compliance and enforcement information for regulated facilities nationwide. Three facilities in the web tool represent PORTS. The facility names are listed in the web tool as Fluor-BWXT Portsmouth LLC, Mid-America Conversion Services, LLC, and US DOE Portsmouth Gaseous Diffusion Plant – BWCS DUF6. The Facility Registry Service identification numbers are 110046552930, 110030994468, and 110000395260, respectively. The addresses for the facilities are identified as 3930 US Rte 23S, Piketon, Ohio; 3930 US 23, Perimeter Rd, Piketon, Ohio; and 3930 US Route 23 South, Piketon, Ohio; respectively.

2.7.2 Environmental Program Inspections

Federal, state, and local agencies conducted four inspections of DOE activities at PORTS in 2021. Table 2.4 lists these inspections.

Table 2.4. Environmental inspections of DOE activities at PORTS for 2021

Date	DOE contractor	Agency	Type	Notices of Violation
August 26	FBP	Ohio EPA	RCRA compliance (virtual site visit)	Yes
August 26	FBP	Ohio EPA	Closed solid waste management units (virtual site visit)	None
October 19-20	FBP	US EPA	RCRA compliance evaluation	None
November 16	FBP	Pike County Health District	Closed solid waste landfills	None

Acronyms:
FBP = Fluor-BWXT Portsmouth
US EPA = US Environmental Protection Agency

DOE received a Notice of Violation from Ohio EPA on June 6, 2022 based on information evaluated during the RCRA compliance inspection conducted on August 26, 2021. Ohio EPA determined that DOE had not distributed a Quick Reference Guide for Hazardous Waste Contingency Plan (a type of emergency response plan) to local emergency responders. Local emergency responders had previously received copies of the Hazardous Waste Contingency Plan; the quick reference guide was a new Ohio EPA requirement. The violation was resolved when DOE distributed the Hazardous Waste Contingency Plan Quick Reference Guide to emergency responders and provided proof of distribution to Ohio EPA. No additional activities were required.

2.7.3 Unplanned Releases

No unplanned releases from DOE activities at PORTS occurred in 2021.

2.7.4 Summary of Permits

Table 2.5 lists the permits held by DOE and DOE contractors (Fluor-BWXT Portsmouth and Mid-America Conversion Services) in 2021. Portsmouth Mission Alliance does not hold any environmental permits.

Table 2.5. DOE environmental permits and registrations at PORTS

Permit/registered source	Source no.	Issue date	Expiration date	Status
		Fluor-BWXT Portsmouth – Clean Air Act Permits		
Title V Permit	P0109662	4/28/2014	5/19/2019	Active (renewal submitted 11/13/2018)
Permit to Install X-627 Groundwater Treatment Facility (06-07283)	P474, T104, T105	3/15/2005	None	Active
Permit to Install and Operate X-735 Landfill Cap and Venting System (northern portion) (P0104170)	P023	11/12/2008	None	Active
Permit to Install X-670A Cooling Tower (P0106292)	P539	07/29/2010	None	Active
Permit to Install X-333 Low Assay Withdrawal Seal Exhaust System (06-07984)	P117	01/10/2006	None	Inactive
Permit to Install Biodenitrification Vent #1 (06-07928)	P040	11/03/2005	None	Active
Permit to Install Biodenitrification Vent #2 (06-07928)	P041	11/03/2005	None	Active
Permit to Install Biodenitrification Vent #3 (06-07928)	P042	11/03/2005	None	Active
Permit to Install X-700 Radiation Calibration Lab Fume Hood (06-07928)	P045	11/03/2005	None	Active
Permit to Install X-705 Calciners (B Area) (06-07928)	P053	11/03/2005	None	Active
Permit to Install X-344 Pigtail Gulper (06-07760)	P430	05/17/2005	None	Active
Permit to Install X-705 8-inch, 12-inch, and 2.5-ton Uranium Cylinders, Cleaned for Reuse or Disposal (06-06703)	P470	04/11/2002	None	Active
Permit to Install X-344 Toll Transfer Facility (06-06303)	P469	12/12/2000	None	Active
Permit to Install X-343 Feed Vaporization and Sampling (06-06302)	P468	12/12/2000	None	Inactive
Permit to Install 85 Horsepower Trash Pump (06-06170)	P467	05/24/2000	None	Active
Permit to Install X-847 Glove Box (06-5682)	P466	07/21/1999	None	Active
X-624 Groundwater Treatment Facility (now considered a *de minimis* source)	P019	10/28/1992	None	Active
Permit to Install X-623 Groundwater Treatment Facility (06-4613)	P018	01/08/1992	None	Active
Permit to Install X-749 Contaminated Materials Disposal Facility (06-2999)	P027	04/17/1991	None	Active
Permit to Install Gasoline Dispensing Facility (06-02906)	G001	10/31/1990	None	Active

Table 2.5. DOE environmental permits and registrations at PORTS (continued)

Permit/registered source	Source no.	Issue date	Expiration date	Status
Mid-America Conversion Services – Clean Air Act Permits				
Permit No. P0109511 to Install and Operate Process Line 1 (DUF_6 Conversion Facility)	P001	3/23/2012	3/23/2022	Active (renewal submitted September 2021 –all air permits)
Permit No. P0109511 to Install and Operate Process Line 2 (DUF_6 Conversion Facility)	P002	3/23/2012	3/23/2022	
Permit No. P0109511 to Install and Operate Process Line 3 (DUF_6 Conversion Facility)	P003	3/23/2012	3/23/2022	
Permit No. P0109511 to Install and Operate HVAC System (DUF_6 Conversion Facility)	P004	3/23/2012	3/23/2022	
Fluor-BWXT Portsmouth – Clean Water Act/Safe Drinking Water Act Permits				
NPDES Permit	0IO00000*OD	7/1/2020 (effective date)	6/30/2025	Active
Safe Drinking Water Act – License to Operate a Public Water System	OH6632414		Renewed annually	Active
Permit to Install X-622 Groundwater Treatment Facility	06-2951	11/20/1990	None	Active
Permit to Install X-623 Groundwater Treatment Facility	06-3528	1/9/1996	None	Active
Permit to Install X-624 Groundwater Treatment Facility	06-3556	10/28/1992	None	Active
Permit to Install X-627 Groundwater Treatment Facility	06-07283	1/13/2004	None	Active
Mid-America Conversion Services – Clean Water Act Permit				
NPDES Permit	0IS00034*CD	10/1/2019 (effective date)	9/30/2024	Active
Fluor-BWXT Portsmouth – Hazardous Waste Permit				
RCRA Part B Permit (with DOE)	Ohio Permit No. 04-66-0680	3/25/2011	3/25/2021	Active (renewal submitted 9/23/2020)
Fluor-BWXT Portsmouth – Registrations				
Underground Storage Tank Registration	66005107		Renewed annually	Active

3. Environmental Programs and Activities

This chapter summarizes the environmental programs and activities at PORTS including environmental management, site sustainability, decontamination and decommissioning, environmental restoration and remediation, and public awareness.

3.1 Environmental Management System

DOE Order 436.1, *Departmental Sustainability*, requires PORTS to develop and implement an Environmental Management System to protect air, water, land, and other natural or cultural resources that may be impacted by DOE operations.

Fluor-BWXT Portsmouth LLC coordinates the implementation of the Environmental Management System among the DOE site contractors (Fluor-BWXT Portsmouth, Portsmouth Mission Alliance, and Mid-America Conversion Services). A report on progress in achieving Environmental Management System goals is submitted annually to DOE Headquarters. These Environmental Management System goals include objectives related to the following:

- Reducing greenhouse gas emissions
- Reducing energy consumption and intensity in site buildings
- Increasing the use of clean or renewable energy
- Enhancing water use efficiency and management
- Managing fleets to reduce petroleum use and increase alternative fuel and vehicle use
- Promoting sustainable acquisition
- Preventing pollution and reducing waste

The 2021 Environmental Management System environmental stewardship scorecard prepared for PORTS was green, which indicates that standards for Environmental Management System implementation have been met and at least 80 percent of the goal areas for fiscal year 2021 were addressed in the Environmental Management System. Some of the Environmental Management System goal areas do not apply to PORTS because the facility is not operating and is implementing and preparing for decontamination and decommissioning.

Green and sustainable remediation is the abatement, cleanup, or use of methods to contain, remove, or destroy contaminants while seeking to minimize the environmental, economic, and social costs of the remediation. DOE is incorporating green and sustainable remediation in the decontamination and decommissioning activities discussed in this chapter. Actions underway to support green remediation include efficient movement of materials to reduce fuel usage, efforts to minimize water usage and control runoff, and recycling and reuse of materials.

3.2 Site Sustainability Program

In accordance with DOE Order 436.1 and Executive Order 14057, this report provides information on the requirements and responsibilities of managing sustainability at PORTS. DOE is committed to reducing potential environmental risks, costs, wastes, and future liability by effectively integrating environmental sustainability principles in DOE activities at PORTS in a cost-effective and environmentally conscious manner. The DOE Environmental Sustainability Program is a balanced, holistic approach that links planning, budgeting, measuring, and improving PORTS overall environmental performance to specific goals and outcomes. The *Fiscal Year 2022 Site Sustainability Plan* (DOE 2021c) describes the Environmental Sustainability Program and integrates the tenets of the Environmental Management System. The Environmental Sustainability Program includes elements of pollution prevention, waste minimization, sustainable procurement, sustainable design, and energy and water efficiency.

DOE is committed to minimizing or eliminating the amounts and types of wastes it generates and reducing life-cycle costs for managing and dispositioning property and wastes in all DOE projects and activities at PORTS. Effective environmental sustainability management begins with an integrated strategy. To achieve the objectives and targets of the Environmental Sustainability Program, DOE has developed and implemented a well-defined strategy for setting, updating, and achieving objectives and targets in line with the Environmental Management System and DOE pollution prevention goals. The broad objectives are core elements of the Environmental Sustainability Program. The qualitative and quantitative objectives listed below reduce the life-cycle cost and liability of DOE programs and operations at PORTS.

- Eliminating, minimizing, or recycling wastes that would otherwise require storage, treatment, disposal, and long-term monitoring and surveillance
- Eliminating or minimizing use of toxic chemicals and associated environmental releases that would otherwise require control, treatment, monitoring, and reporting
- Maximizing the use and procurement of recycled-content materials and environmentally preferable products and services, thereby minimizing the economic and environmental impacts of managing by-products and wastes generated by mission-related activities
- Reducing the life-cycle cost of managing personal property at PORTS

The *Fiscal Year 2022 Site Sustainability Plan for the Portsmouth Gaseous Diffusion Plant* provides goals and progress through fiscal year 2021 for reducing greenhouse gas emissions and water consumption, recycling and diverting wastes, improving electronic stewardship, and other areas (DOE 2021c). Accomplishments for fiscal year 2021 include the following:

- Greenhouse gas emissions (primarily associated with electricity consumption) have been reduced by 84 percent versus fiscal year 2008 baseline emissions.
- Water use was constant in fiscal year 2021 versus fiscal year 2020. Water use intensity (measured in gallons per gross square footage) has been reduced by 62 percent over the 2007 baseline.
- Approximately 34 percent of nonhazardous waste was recycled and thereby diverted from disposal at an off-site landfill, which is a 22 percent increase from fiscal year 2020.
- Approximately 39 percent of construction and demolition materials were recycled and diverted from off-site disposal, which is a 26 percent increase from fiscal year 2020.

DOE is placing increased emphasis on evaluating materials generated by decontamination and decommissioning for reuse or recycling. An agreement between DOE and the Southern Ohio Diversification Initiative (SODI) allows DOE to transfer excess equipment, clean scrap materials, and other assets to SODI. SODI first attempts to reuse the excess equipment and property in the local community. According to the agreement, if SODI is unable to do so then SODI may sell the property. Proceeds from these sales support economic development in the southern Ohio region. In 2021 SODI received approximately 48 tons of materials from PORTS, primarily recyclable metals and reusable equipment.

Approximately 252 tons of recyclable or reusable materials were sent off site in 2021:

- Aluminum cans: 5,000 pounds
- Aerosol cans: 143 pounds
- Batteries: 172,285 pounds
- Electronic materials such as computer equipment and circuit boards: 56,332 pounds
- Light bulbs: 4385 pounds
- Used oil: 10,073 pounds
- Reusable paint: 2,400 pounds
- Paper and cardboard: 80,000 pounds
- Plastic bottles: 38,500 pounds
- Tires: 31,800 pounds
- Spent toner cartridges: 6,500 pounds
- Recyclable materials to SODI (excess equipment and materials and recyclable metals): 48 tons

The Green Electronics Council recognized PORTS in 2021 with a 5-Star Electronic Product Environmental Assessment Tool Purchasing Award for excellence in sustainable procurement of information technology products. PORTS was recognized as a bronze level recipient of the DOE GreenBuy Award for excellence in sustainable acquisition for fiscal year 2021.

3.3 Environmental Management and Waste Management Activities

Environmental and waste management activities at PORTS include decontamination and decommissioning, and site-wide waste disposition. The following subsections describe these critical efforts.

The Decontamination and Decommissioning Director's Final Findings and Orders (Ohio EPA 2012) is an enforceable agreement between Ohio EPA and DOE that governs the process for decontamination and decommissioning of the gaseous diffusion process buildings and associated facilities that are no longer in use. These Director's Final Findings and Orders, which apply to decontamination and decommissioning of buildings down to and including the building slab and disposal of wastes generated by decontamination and decommissioning, use the CERCLA framework to determine appropriate removal and remedial actions. Documents that describe these proposed activities are submitted to Ohio EPA for either concurrence or approval.

3.3.1 Decontamination and Decommissioning Program: Process Buildings and Other Facilities

Decontamination and decommissioning of the process buildings and other facilities at PORTS is proceeding in accordance with the record of decision for process buildings concurred with by Ohio EPA in 2015 (DOE 2015a). The record of decision includes the following actions:

- Demolition of the buildings or structures
- Characterization and demolition of underground man-made features
- Treatment as needed to meet requirements for either on-site or off-site disposal
- Packaging of generated waste for final disposal, either on-site or off-site

- Transportation and disposal of waste, either on-site or off-site, in accordance with the waste disposition record of decision

The *Remedial Design/Remedial Action Work Plan and Remedial Design for the Process Buildings Deactivation at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio – Deactivation of X-326, X-330, X-333, X-111A, X-111B, X-232C1, X-232C2, X232C3, X-232C4, and X-232C5* (DOE 2016) was developed by DOE and concurred with by Ohio EPA in 2016. The *Comprehensive Deactivation, Demolition, and Disposition Remedial Design/Remedial Action Work Plan for the Process Buildings and Complex Facilities Remedial Action Project and Remedial Design for Deactivation of Complex Facilities at the Portsmouth Gaseous Diffusion Plant* (DOE 2018a) was prepared by DOE and concurred with by Ohio EPA in 2018; it includes deactivation, demolition, and waste disposition activities. These two work plans provide the information to demonstrate that deactivation activities to prepare the three main process buildings, along with their associated support structures and other complex facilities, for demolition meet the requirements of the Decontamination and Decommissioning Director's Final Finding and Orders, the process buildings and waste disposition records of decision, and other applicable requirements.

Demolition of the X-326 Process Building began in 2021. Removal of the transite panels on the outside of the building began on February 24, 2021 and mechanical demolition of the building began on May 17, 2021. At the end of December 2021, 40 percent of the building had been demolished. Figure 3.1 shows the extent of the X-326 Process Building demolition in December 2021.

Figure 3.1. Extent of demolition of the X-326 Process Building in December 2021 (looking northwest)

Waste generated by demolition of the facility is disposed of at the On-Site Waste Disposal Facility if it meets the criteria established for on-site disposal. Waste that does not meet acceptance criteria for on-site waste disposal is shipped off site for disposal in accordance with applicable regulations.

Activities underway at the X-330 and X-333 Process Buildings in 2021 included disassembling and removing equipment, removing wastes including asbestos, PCBs, and RCRA hazardous waste, and deactivating utilities and other systems. Materials that meet the waste acceptance criteria are disposed of at the on-site waste treatment facility; other materials are shipped off site for disposal in accordance with applicable regulations.

3.3.2 Site-Wide Waste Disposition

The record of decision for site-wide waste disposition was concurred with by Ohio EPA in 2015 (DOE 2015b). The record of decision selected a combination of on-site and off-site disposal, including construction of an On-Site Waste Disposal Facility.

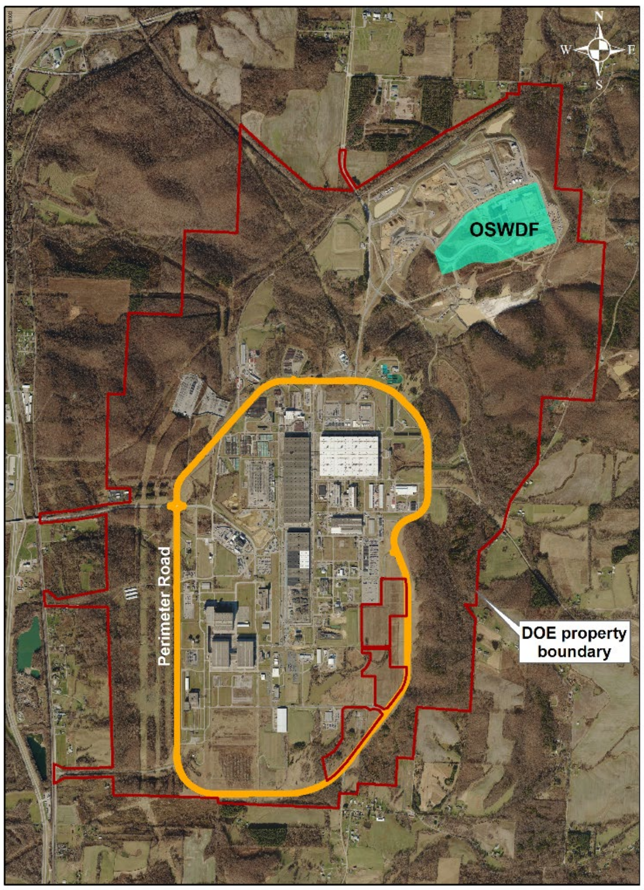


Figure 3.2. Location of the On-Site Waste Disposal Facility (OSWDF) at PORTS

Figure 3.2 shows the location of the On-Site Waste Disposal Facility in the northeast portion of PORTS. Site construction activities began in 2015. The first cell in the On-Site Waste Disposal Facility was completed in 2021 and waste disposal began on May 25, 2021.

Work continued in 2021 on installing the liners and other infrastructure for Cells 4 and 5 in the On-Site Waste Disposal Facility. Installing the leachate transmission piping and valve houses as well as other support areas also continued as planned. Activities were performed in accordance with the On-Site Waste Disposal Facility Final (100%) Design Package and the *Comprehensive On-site Waste Disposal Facility Remedial Design/Remedial Action Work Plan for the Process Buildings and Complex Facilities Remedial Action/Remedial Design Work Plan for the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio, Phase III Balance of the On-site Disposal Remedy* (DOE 2018b).

The *On-site Waste Disposal Facility (OSWDF) Performance Standards Verification Plan* (DOE 2021b) was approved by Ohio EPA as part of the On-site Waste Disposal Facility Final (100%) Design Package. This plan includes groundwater, surface water, air, and external radiation monitoring to verify that waste disposal protects human health and the environment.

DOE prepares an annual status report for the On-Site Waste Disposal Facility project to summarize annual monitoring. The *2021 On-Site Waste Disposal Facility Annual Project Status Report* (DOE 2022b) and data collected in 2021 are available on the PEGASIS website here.

The DOE Low-level Waste Disposal Facility Review Group oversees the operation and ongoing construction of the On-Site Waste Disposal Facility in compliance with DOE Order 435.1, *Radioactive Waste Management* (see Section 2.2.3). The *Fiscal Year 2021 Annual Summary Report for the On-Site Waste Disposal Facility* (DOE 2022c) documents the operation of the On-Site Waste Disposal Facility and how the On-Site Waste Disposal Facility meets performance requirements in the Disposal Authorization Statement. This report is provided to the DOE Low-level Waste Disposal Facility Review Group.

3.4 Environmental Restoration and Remediation

DOE established the Environmental Restoration Program in 1989 to identify, control, and remediate environmental contamination at PORTS. Environmental restoration has been conducted in accordance with the RCRA corrective action process under a Consent Decree with the State of Ohio issued on August 29, 1989, and a US EPA Administrative Order by Consent issued on September 29, 1989, which was amended in 1994 and 1997 and terminated on February 13, 2017. Removal of facilities and structures down to and including the building slab is controlled by the decontamination and decommissioning process (see Section 3.3.1). Investigation and remediation of environmental contamination is completed under the RCRA corrective action process and in accordance with the Consent Decree with the State of Ohio.

In general, the RCRA corrective action process consists of the following:

- A RCRA facility assessment to identify releases of hazardous waste and hazardous constituents and determine the need for further investigation
- A RCRA facility investigation to determine the nature and extent of any contamination
- A corrective measures study to identify and evaluate remedial alternatives to address contamination

Following the approval of the final corrective measures study, Ohio EPA selects remedial alternatives for further review to determine the final remedial actions and documents this decision in the statement of basis, formerly called the preferred plan. After a public review and comment period, Ohio EPA selects the final remedial actions. Ohio EPA issues a decision document to select the final remedial actions and DOE implements the remedial actions. Ohio EPA reviews final remedial actions on a schedule agreed upon by Ohio EPA and DOE (approximately every five years) to ensure that the remedial actions are performing as intended by the decision document and are protecting human health and the environment.

The initial assessment and investigation of PORTS under the RCRA corrective action process was completed in the 1990s. Because PORTS is a large facility, it was divided into quadrants (Quadrant I, II, III, and IV) to facilitate the cleanup process (see Figure 6.1). Remedial actions have been implemented in each quadrant.

Some RCRA corrective action investigations that were deferred to the start of decontamination and decommissioning activities at PORTS are now underway. When the RCRA corrective action process began at PORTS in the 1990s, certain areas in or adjacent to the gaseous diffusion production and operation areas were designated as deferred units. Remedial activities in these areas would have interrupted ongoing operations, or ongoing operations could have recontaminated the areas. Ohio EPA deferred the investigation and remedial action of soil and groundwater associated with these units until decontamination and decommissioning of PORTS began, or until the area no longer met the requirements for deferred unit status. Before the start of decontamination and decommissioning, ongoing environmental monitoring and health and safety programs for on-site workers were used to monitor the contaminants in these areas.

The *Deferred Units Resource Conservation and Recovery Act Facility Investigation/Corrective Measures Study Work Plan* was approved by Ohio EPA in 2015 (DOE 2015c). The soil and groundwater sampling described in the work plan started in 2015 and was completed in 2016. The initial *Deferred Units Resource Conservation and Recovery Act Facility Investigation/Corrective Measures Study Report* was submitted to Ohio EPA in 2017, and Ohio EPA submitted comments to DOE in December 2018. DOE worked to address these comments, which called for additional sampling and installing additional monitoring wells, throughout 2019 and the beginning of 2020. A revised report was submitted to Ohio EPA in August 2020. In 2021, DOE and Ohio EPA worked to resolve additional comments on the report, and a revised report was submitted on August 31, 2021 (DOE 2021d). Ohio EPA approved the report in 2022.

The following sections describe the remedial actions underway in each quadrant as well as ongoing activities at any formerly deferred units. Table 3.1 lists remedial activities for the groundwater monitoring areas at PORTS, which include remedial actions required by decision documents and other actions.

Table 3.1. Remedial actions at PORTS in groundwater monitoring areas

Quadrant and monitoring area	Remedial action and year completed
Quadrant I X-749/X-120 groundwater plume	X-749 multimedia cap – 1992 X-749 barrier wall (north and northwest sides of landfill) – 1992 X-749 subsurface drains and sumps – 1992 South barrier wall – 1994 X-120 horizontal well – 1996 X-625 Groundwater Treatment Facility – 1996 X-749 barrier wall (east and south sides of landfill) – 2002 Phytoremediation (22 acres) – 2002 & 2003 Injection of hydrogen release compounds – 2004 X-749 South Barrier Wall Area extraction wells – 2007 Two additional extraction wells in the groundwater collection trench on the southwest side of the X-749 Landfill – 2008 X-749/X-120 groundwater plume extraction wells – 2010
Quadrant I Peter Kiewit (PK) Landfill (X-749B)	Relocation of Big Run Creek – 1994 Groundwater collection system – 1994 Groundwater collection system expansion – 1997 PK Landfill Subtitle D cap – 1998
Quadrant I Quadrant I Groundwater Investigative (5-Unit) Area	Groundwater extraction wells (3) – 1991 X-622 Groundwater Treatment Facility – 1991 (upgraded in 2001) Interim soil cover at X-231B – 1995 X-231A/X-231B multimedia caps – 2000 Groundwater extraction wells (11) – 2002 Groundwater extraction well (1) – 2009 Removal of contaminated soil at former X-770 Building – 2010
Quadrant I X-749A Classified Materials Disposal Facility	Cap – 1994

Table 3.1. Remedial actions at PORTS in groundwater monitoring areas (continued)

Quadrant and monitoring area	Remedial action and year completed
Quadrant II Quadrant II Groundwater Investigative (7-Unit) Area	Operation of X-700 and X-705 building sumps – 1989 X-622T Groundwater Treatment Facility – 1992 Removal of X-720 Neutralization Pit – 1998 Removal of X-701C Neutralization Pit – 2001 Removal of contaminated soil near X-720 Neutralization Pit – 2001 X-627 Groundwater Treatment Facility – 2004 (replaced the X-622T facility) Enhanced anaerobic bioremediation – 2011
Quadrant II X-701B Former Holding Pond	X-237 Groundwater Collection System – 1991 X-624 Groundwater Treatment Facility – 1991 (upgraded 2006) Extraction wells (3) – 1993 (removed 2009-2011) X-623 Groundwater Treatment Facility – 1993 X-701B sump – 1995 Groundwater remediation by oxidant injection – 2008 Groundwater and soil remediation by oxidant mixing – 2011
Quadrant III X-740 Former Waste Oil Handling Facility Area	Phytoremediation – 1999 Oxidant injections – 2008 Enhanced anaerobic bioremediation – 2011
Quadrant IV X-611A Former Lime Sludge Lagoons	Soil cover – 1996 Prairie vegetation planted – 1997
Quadrant IV X-735 Landfills	Cap on northern portion – 1994 Cap on southern portion – 1998
Quadrant IV X-734 Landfills	Cap on X-734B Landfill (Phase I) – 1999 Cap on X-734 and X-734A Landfills (Phase II) – 2000
Quadrant IV X-533 Former Switchyard Complex	Contaminated soil removal – 2010

3.4.1 Quadrant I

The *Quadrant I Cleanup Alternative Study/Corrective Measures Study* was approved by Ohio EPA in 2000 (DOE 2000). Ohio EPA issued the Decision Document for Quadrant I in 2001, which outlined the required remedial actions for the X-749/X-120 groundwater plume and the Quadrant I Groundwater Investigative (5-Unit) Area (the Five-Unit Groundwater Investigative Area and X-231A/X-231B Oil Biodegradation Plots) (Ohio EPA 2001).

Remedial actions required for the X-749B Peter Kiewit Landfill (PK Landfill) were provided in separate decision documents issued by Ohio EPA in 1996 (Ohio EPA 1996a) and US EPA in 1997 (US EPA 1997). The following sections discuss the remedial actions required for the X-749/X-120 groundwater plume, PK Landfill, and the Quadrant I Groundwater Investigative (5-Unit) Area. Section 6.3.2.1 includes 2021 groundwater monitoring results for the X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility, PK Landfill, and Quadrant I Groundwater Investigative (5-Unit) Area.

3.4.1.1 X-749/X-120 Groundwater Plume

The remedial actions identified for the X-749/X-120 groundwater plume (see Figure 6.2) include phytoremediation of the groundwater plume, installation of a barrier wall around the eastern and southern portion of the X-749 Landfill, and continued operation of the groundwater collection trenches installed at the PK Landfill and X-749 Landfill. Groundwater extraction wells were also installed in 2007, 2008, and 2010 to control migration of the plume and remediate areas of higher trichloroethene concentrations within the plume.

Phytoremediation is a process that uses plants to remove, degrade, or contain contaminants in soil and groundwater. Phytoremediation at the X-749/X-120 groundwater plume was installed in two phases during 2002 and 2003. The barrier wall around the eastern and southern portion of the X-749 Landfill was completed in 2002.

The *First Five-Year Review for the X-749/X-120 Groundwater Plume*, submitted to Ohio EPA in 2011, found that the remedial actions implemented for the X-749/X-120 groundwater plume (both the remedial actions required by the Decision Document and the extraction wells installed in 2007 and 2008) were achieving remedial action objectives by preventing the migration of contaminants from the X-749 Landfill and controlling migration of the X-749/X-120 groundwater plume (DOE 2011). However, Ohio EPA and DOE agreed that the phytoremediation system was not as successful as anticipated in reducing concentrations of trichloroethene in groundwater. The extraction wells that began operating in 2007 and 2008 in the groundwater collection trench on the southwest side of the X-749 Landfill and the X-749 South Barrier Wall Area, as well as the barrier wall on the south and east sides of the landfill (which was completed in 2002), appeared to be primarily responsible for reducing trichloroethene concentrations in the X-749/X-120 groundwater plume. Maintenance of the phytoremediation system was discontinued with the approval of Ohio EPA in 2011.

The most recent five-year review for the X-749/X-120 groundwater plume, entitled *Third Five-Year Review for the X-749/X-120 Groundwater Plume* (DOE 2021e), found that the remedial actions were working effectively to meet the remedial action objectives. The next review of the remedial actions for the X-749/X-120 groundwater plume will be submitted to Ohio EPA in 2026.

Section 6.3.2.1 and Figure 6.2 provide additional information on the 2021 groundwater monitoring results for the X-749/X-120 groundwater plume.

3.4.1.2 PK Landfill

The remedial actions required by the PK Landfill decision documents include continued operation of the eastern groundwater collection system installed in 1994 and construction of an engineered cap that meets the RCRA Subtitle D and related requirements (Ohio EPA 1996a and US EPA 1997). In addition, the southeastern groundwater collection system was constructed in 1997 to contain surface seeps, groundwater from the southern slope of the PK Landfill, and the groundwater plume migrating toward Big Run Creek from the X-749 Landfill.

The most recent five-year review for the PK Landfill (the *Fourth Five-Year Review for the X-749B Peter Kiewit Landfill)* found that the corrective actions implemented at the PK Landfill (the groundwater collection systems, landfill cap, and institutional controls) were continuing to achieve corrective action objectives by eliminating exposure pathways and reducing the potential for transporting contaminants (DOE 2018c). Concentrations of many of the contaminants detected in the PK Landfill wells, sumps, and manholes have decreased. The next review of the remedial actions implemented at the PK Landfill will be submitted to Ohio EPA in 2023.

Section 6.3.2.1 and Figure 6.2 provide 2021 groundwater monitoring results for the PK Landfill area.

3.4.1.3 Quadrant I Groundwater Investigative (5-Unit) Area

Remedial actions identified for the Quadrant I Groundwater Investigative (5-Unit) Area (see Figure 6.3) are installing multimedia caps over the X-231A and X-231B Oil Biodegradation Plots and installing 11 additional groundwater extraction wells to extract contaminated groundwater for treatment in the X-622 Groundwater Treatment Facility (Ohio EPA 2001). The caps were constructed in 2000 and the groundwater extraction wells began operating in 2002. In 2009, an additional extraction well was installed south of the X-326 Process Building to control and remediate a newly identified source of trichloroethene beneath the building. Table 3.1 lists the remedial actions completed for the Quadrant I Groundwater Investigative (5-Unit) Area.

The *Third Five-Year Review for the Five-Unit Groundwater Investigative Area and X-231A/X-231B Oil Biodegradation Plots at the Portsmouth Gaseous Diffusion Plant* (DOE 2018d), which is the most recent five-year review of both the groundwater extraction system for the Quadrant I Groundwater Investigative (5-Unit) Area and the multi-layered caps for the X-231A and X-231B Oil Biodegradation Plots, found that the remedial actions implemented for these areas (the multimedia caps and groundwater extraction system) were continuing to eliminate potential exposure pathways to contaminants, control migration of the groundwater plume, and remove volatile organic compounds from groundwater. The next review of the remedial actions implemented at the Quadrant I Groundwater Investigative (5-Unit) Area and X-231A/B Oil Biodegradation Plots will be submitted to Ohio EPA in 2023.

The X-231B Oil Biodegradation Plot is being excavated in accordance with *The July 30, 2018 Director's Final Findings and Orders for CERCLA Actions to Restore Natural Resources* (Ohio EPA 2018). Ohio EPA and DOE entered into these orders to resolve all impacts to natural resources at PORTS that were identified by the State by implementing specific restoration actions, and to enhance ongoing remediation efforts at PORTS in a manner that helps restore the natural resources damaged by historic operations. Additional areas within the Quadrant I Groundwater Investigative (5-Unit) Area are being excavated in accordance with the Waste Disposition Record of Decision.

Section 6.3.2.1 and Figure 6.3 describe the groundwater monitoring completed in the Quadrant I Groundwater Investigative (5-Unit) Area during 2021.

3.4.2 Quadrant II

Ohio EPA approved the *Quadrant II Cleanup Alternative Study/Corrective Measures Study* in 2001 (DOE 2001). After approving the document, however, Ohio EPA requested an amendment to the approved study to address additional remedial alternatives for the X-701B area. Amendments were submitted in 2001 and 2002. In 2003 Ohio EPA informed DOE that a separate decision document would be prepared for the X-701B area, and the X-701B Decision Document was issued in 2003 (Ohio EPA 2003).

Section 6.3.2.2 includes 2021 groundwater monitoring results for the areas in Quadrant II that require groundwater monitoring: the Quadrant II Groundwater Investigative (7-Unit) Area, X-701B Former Holding Pond, and X-633 Former Recirculating Cooling Water.

3.4.2.1 Quadrant II Groundwater Investigative (7-Unit) Area

The groundwater plume in the Quadrant II Groundwater Investigative (7-Unit) Area includes a number of deferred units, as shown in Figure 6.4. A special investigation in 2009, which sampled soil and groundwater, identified areas where concentrations of trichloroethene were higher. The elevated levels were apparently associated with continuing sources of groundwater contamination in the southeastern portion of the plume. DOE and Ohio EPA agreed that selecting a remedial action for the Quadrant II Groundwater Investigative (7-Unit) Area will be incorporated in the deferred units preferred plan and decision document.

Section 6.3.2.2 and Figure 6.4 describe the groundwater monitoring completed at the Quadrant II Groundwater Investigative (7-Unit) Area in 2021.

3.4.2.2 X-701B Former Holding Pond

Remedial actions required by the Decision Document for X-701B, issued in 2003, include remediating groundwater by injecting a chemical oxidant (Ohio EPA 2003). Oxidant was injected as required by the Decision Document between 2006 and 2008. After injections were completed in 2008, DOE Headquarters conducted an independent review of the X-701B Project to evaluate the remediation results and recommend a path forward. The review found that the method used to inject oxidant into the contaminated area did not address the deepest part of the contaminated soil. Contaminants that remained deep in the soil would continue to be released into the groundwater plume. As an interim remedial measure, DOE proposed to excavate soil in the western part of the X-701B plume area and mix oxidant directly into the contaminated soil. This effort began in December 2009 and was completed in January 2011.

Section 6.3.2.2 and Figure 6.5 describe the groundwater monitoring completed at the X-701B Former Holding Pond in 2021.

3.4.2.3 X-633 Former Recirculating Cooling Water Complex

The X-633 Recirculating Cooling Water Complex was demolished in 2010. In 2011 a RCRA investigation of soil and groundwater in the area identified areas of soil potentially contaminated with metals. However, the higher metal concentrations in these areas, which are 15 to 20 feet below the ground surface, may be due to naturally occurring variations in the area's geology.

Chromium and trichloroethene were detected in groundwater at concentrations above the preliminary remediation goals during the 2011 RCRA investigation for the X-633 area. DOE agreed to sample eight wells around the area each year to continue evaluating chromium and trichloroethene in groundwater. The *2021 Groundwater Monitoring Report for the Portsmouth Gaseous Diffusion Plant* presents the monitoring data for 2021 (DOE 2022a).

3.4.3 Quadrant III

Ohio EPA approved the *Quadrant III Cleanup Alternative Study/Corrective Measures Study* in 1998 (DOE 1998a). The Decision Document for Quadrant III, issued in 1999, required phytoremediation of the groundwater plume near the X-740 Waste Oil Handling Facility (Ohio EPA 1999a). Over 700 hybrid poplar trees were planted on 2.6 acres above the X-740 groundwater plume in 1999 (see Figure 6.8). Evaluation reports for this remedial action in 2003 and 2007 concluded that the phytoremediation had not performed as expected to remove trichloroethene from groundwater in this area (DOE 2003 and DOE 2007).

In response to Ohio EPA concerns about the performance of the phytoremediation system, DOE undertook additional remedial activities for the X-740 area. Three rounds of oxidant injections were completed in 2008. Although this briefly reduced the concentrations of trichloroethene detected in some of the wells, trichloroethene concentrations in groundwater returned to previous levels in 2009.

In 2010 Ohio EPA approved a pilot study of enhanced anaerobic bioremediation for the X-740 area. Emulsified oil, a slow-acting fermentable carbon compound, was injected into parts of the X-740 groundwater plume during December 2010 and January 2011. Trichloroethene decreased in wells in the area of the groundwater plume that was treated during the pilot study. The *Deferred Units RCRA Facility Investigation/ Corrective Measures Study Report* (DOE 2021d) summarizes the results of the pilot study.

In 2021, most of the X-740 groundwater plume was excavated in accordance with *The July 30, 2018 Director's Final Findings and Orders for CERCLA Actions to Restore Natural Resources* (Ohio EPA 2018). All but three of the wells that were part of the X-740 monitoring program were removed to prepare for the excavation. Seven new groundwater monitoring wells were installed in the former plume area in 2022.

Section 6.3.2.3 includes 2021 groundwater monitoring results for the following areas in Quadrant III that require groundwater monitoring: the X-616 Former Chromium Sludge Surface Impoundments and X-740 Former Waste Oil Handling Facility.

3.4.4 Quadrant IV

Ohio EPA approved the *Quadrant IV Cleanup Alternative Study/Corrective Measures Study* in 1998 (DOE 1998b) and DOE received the Decision Document for Quadrant IV in 2000 (Ohio EPA 2000). No new remedial actions were required in Quadrant IV, since earlier remedial actions at the X-344D Hydrogen Fluoride Neutralization Pit, X-735 Landfills, X-611A Former Lime Sludge Lagoons, and X-734 Landfills had been completed.

Section 6.3.2.4 includes 2021 results for the following areas in Quadrant IV that require groundwater monitoring: the X-611A Former Lime Sludge Lagoons, X-735 Landfills, X-734 Landfills, X-533 Former Switchyard Complex, and X-344C Former Hydrogen Fluoride Storage Building.

3.4.4.1 X-611A Former Lime Sludge Lagoons

Ohio EPA and US EPA issued a decision document for the X-611A area in 1996, which required DOE to construct a soil cover over the former lagoons and establish a prairie habitat (Ohio EPA 1996b). The soil cover and prairie planting were completed in 1997. The *Fourth Five-Year Review for the X-611A Prairie* (DOE 2018e), which is the most recent five-year review, found that the soil cover and prairie habitat were meeting the remedial action objectives for this unit by eliminating exposure pathways to the contaminants in the sludge. The next review of the remedial actions implemented at the X-611A area will be submitted to Ohio EPA in 2023.

3.4.4.2 X-734 Landfills

Ohio EPA issued a decision document for the X-734 Landfills in 1999 (Ohio EPA 1999b) that required DOE to construct a multimedia cap over the northern part of the landfills and a soil cap over the southern part. These caps were installed in 1999 and 2000. The *Third Five-Year Review for the X-734 Landfill Area* (DOE 2018f), which is the most recent five-year review, found that the landfill caps have achieved remedial action objectives by isolating contaminants in soil and sediment from people and animals. The caps were also preventing contaminants from migrating from soil to groundwater and from groundwater to surface water. The next review of the remedial actions implemented at the X-734 Landfills will be submitted to Ohio EPA in 2023.

3.4.4.3 X-630 Former Recirculating Cooling Water Complex

The X-630 Recirculating Cooling Water Complex, which was located in Quadrant IV inside Perimeter Road and west of the X-533 Switchyard Complex, was removed in 2011 as part of decontamination and decommissioning. A RCRA investigation of soil and groundwater at the X-630 Recirculating Cooling Water Complex in 2011 identified areas of soil 15 to 20 feet below the ground surface that were potentially contaminated with metals. However, the higher concentrations of metals may result from naturally occurring variations in the geology of the area.

The 2011 RCRA investigation for the X-630 area also detected chromium and trichloroethene in groundwater at concentrations above the preliminary remediation goals. DOE agreed to sample four wells around the area each year to continue evaluating chromium and trichloroethene in groundwater. The *2021 Groundwater Monitoring Report for the Portsmouth Gaseous Diffusion Plant* includes the data for this monitoring (DOE 2022a).

3.5 Public Awareness Program

PORTS has a comprehensive community relations and public participation program. Its purpose is to foster openness and credibility between PORTS officials and local citizens, elected officials, businesses, the media, and the public. The program also offers opportunities for members of the public to be involved in decisions affecting environmental issues at PORTS. Contact information for the organizations that provide PORTS information to the public is listed below.

PORTS Environmental Information Center:

Phone: 740-289-8898
Hours: 9 a.m.–12 noon, Monday and Tuesday; noon–4 p.m. Wednesday and Thursday or by appointment
Email: portseic@ports.pppo.gov
Website: energy.gov/pppo/portsmouth-environmental-information-center
Online documents: eic.ports.pppo.gov

DOE Site Office:

Phone: 740-897-5010
Website: energy.gov/pppo

FBP Public Affairs:

Phone: 740-897-2964
Website: fbportsmouth.com

PORTS Environmental Data (PEGASIS): pegasis.ports.pppo.gov

The PORTS version of PEGASIS allows users to access PORTS environmental monitoring data and display it on a local map that shows where the data were collected. Data from 2010 through the current Annual Site Environmental Report are available on the PEGASIS website here.

3.5.1 Community and Educational Outreach

The PORTS Envoy Program matches employee volunteers with community stakeholders such as families living next to DOE property, community groups, and local government organizations. The envoys share information about decontamination and decommissioning and other site issues with stakeholders and are available to answer stakeholder questions.

DOE holds open houses in neighboring communities or virtual public meetings to keep the public informed and to hear their comments and questions, and periodically publishes fact sheets on major projects. DOE distributes notices of document availability and public comment periods, as well as other communications on its programs, to the local newspaper, the community relations mailing list, neighbors within 2 miles of the plant, and plant employees.

Besides sharing information on environmental programs and activities at PORTS and gathering input from the public, DOE aids the community directly by helping to grow a science, technology, engineering, and math (STEM) environment for rural Appalachian schools. One example is The Ohio University Voinovich School's PORTSfuture Program. Through a grant funded by the Portsmouth/Paducah Project Office, PORTSfuture has been able to reach over 13,000 students in the four-county area in Southern Ohio around PORTS. The PORTSfuture Program engages K-12 and college students in STEM activities focused on technology, energy, environment, entrepreneurship, and water quality. Outreach efforts include in-class activities and curriculum, business pitch competitions, science fairs, summer STEM enrichment programs, and after-school clubs.

In one PORTSfuture program, local high school students produce a summary of the Annual Site Environmental Report for distribution to the public. The PORTS Annual Science Alliance event brings more than 1,500 high school juniors to PORTS for an interactive science fair that includes scientific demonstrations and information on careers in STEM fields. DOE and PORTS contractors also support the annual South Central Ohio Regional Science Bowl, an academic competition for middle school and high school students. Student teams answer questions about biology, chemistry, earth sciences, math, and physics, and the regional winners advance to the National Science Bowl in Washington, D.C. More information about the PORTSfuture Program is provided on the PORTSfuture website here.

3.5.2 Site Specific Advisory Board

The PORTS Site Specific Advisory Board, comprised of citizens from the local area, provides public input and recommendations to DOE on decontamination and decommissioning, environmental remediation, waste management, and related issues. The Board holds regularly scheduled meetings with DOE that are open to the public. Find more information about the PORTS Site Specific Advisory Board on the DOE Portsmouth/Paducah Project Office website here or call 740-289-5249.

3.5.3 Environmental Information Center

The Environmental Information Center provides public access to documents used to make decisions on remedial actions at PORTS. The Information Center is located just north of PORTS at the Ohio State University Endeavor Center, Room 207, 1862 Shyville Road, Piketon, Ohio 45661.

4. Environmental Radiological Protection and Monitoring

Each year DOE and its contractors estimate the potential radiological dose to the public from site operations and effluents. Estimates are calculated to confirm that no individual could have received a dose that exceeded the limits established by DOE, Ohio EPA, or US EPA for protection of the public. This section includes estimates of the maximum potential dose to the public and to plants and animals from PORTS activities.

To help readers understand the information in this section, Appendix B, *Introduction to Radiation*, answers the following questions:

- What is radiation?
- What is a radionuclide?
- What are some radionuclides of concern?
- What is radioactivity and how is it measured?
- What is dose and how is it measured?
- How are radioactivity and dose reported?
- What is an exposure pathway?
- What radiation sources and doses are we exposed to?
- What are the potential health effects of radiation exposure?

2021 Highlights

The paragraphs below summarize the radiological dose a member of the public, known as the maximally exposed individual, or MEI, could have received from PORTS assuming exposure from all relevant pathways. Atmospheric releases, external radiation, and incidental ingestion of surface water, soil, and sediment contribute to the dose that could be received by a member of the public.

As in previous years, the estimated potential dose from PORTS to a member of the public was below applicable US EPA standards and DOE public dose limits, and represents a very small fraction compared to the estimated 620 mrem members of the public receive annually from both natural and man-made sources.

Total dose from all pathways: The calculated dose of radiation a member of the public could receive from all pathways of exposure at PORTS was 0.48 mrem/year, which is 0.48 percent of the DOE annual dose limit of 100 mrem/year, and this dose is considered ALARA.

Dose from the air pathway: US EPA regulates annual radionuclide air emissions and sets a limit of 10 mrem/year at the maximally exposed off-site receptor. The total annual dose from airborne emissions from PORTS was 0.11 mrem/year, or 1.1 percent of the US EPA limit. The total annual dose to a member of the public based on detections of radionuclides in ambient air was 0.227 mrem/year, or 2.27 percent of the US EPA limit. The ambient air dose (0.227 mrem/year) is used to calculate the total dose from all pathways.

Dose from the surface water pathway: Dose from the surface water pathway is evaluated by how much it contributes to the DOE total dose limit of 100 mrem/year from all relevant pathways. The estimated dose from incidental ingestion of surface water was 0 mrem because levels of radionuclides detected at the upstream monitoring location on the Scioto River were higher than the levels of radionuclides detected downstream from PORTS.

Dose from the sediment pathway: Like surface water, dose from the sediment pathway is evaluated by its contribution to the DOE total dose limit of 100 mrem/year from all relevant pathways. The estimated dose from incidental ingestion of sediment from PORTS was 0.040 mrem/year. This level is 0.040 percent of the DOE annual dose limit of 100 mrem/year.

Dose from the soil pathway: Dose from the soil pathway is evaluated by its contribution to the DOE total dose limit of 100 mrem/year from all relevant pathways. The estimated dose from incidental ingestion of soil from PORTS was 0.006 mrem/year. This level is 0.006 percent of the DOE annual dose limit of 100 mrem/year.

Dose associated with the On-Site Waste Disposal Facility: DOE Order 458.1 and Ohio Department of Health regulations limit the dose to a member of the public resulting from management, storage, and disposal of low-level radioactive waste to 25 mrem/year. DOE estimates that the dose attributable to operation of the On-Site Waste Disposal Facility in 2021 was 0.0853 mrem/year. This level is 0.34 percent of the Ohio Department of Health and DOE annual dose limit of 25 mrem/year. The *2021 On-Site Waste Disposal Facility Annual Project Status Report* (DOE 2022b) and data collected in 2021 are available on the PEGASIS website here.

Dose from the direct radiation pathway: Dose from direct radiation is also evaluated by its contribution to the DOE total dose limit of 100 mrem/year from all relevant pathways. The estimated dose from external radiation from PORTS was 0.21 mrem/year, which represents 0.21 percent of the DOE annual dose limit of 100 mrem/year.

Dose to biota: Biota dose modeling indicates that the plants and animals living on or near PORTS are not exposed to doses in excess of the DOE Order limits.

4.1 Environmental Radiological Program

Routine DOE operations at PORTS release radioactive materials to the environment through atmospheric and liquid pathways. These releases may result in a radiation exposure to the public. In accordance with DOE Order 458.1, *Radiation Protection of the Public and the Environment*, DOE has an environmental monitoring program that includes radiological monitoring of pathways that may contribute to the overall dose to the public. Monitoring includes analyses of ambient air, surface water, groundwater, sediment, soil, external radiation, and biota. The goals of the environmental radiological program are as follows:

- To conduct radiological activities so that exposure to members of the public is within the dose limits established by DOE Order 458.1
- To control the radiological clearance of DOE real and personal property
- To ensure that potential radiation exposures to members of the public are ALARA
- To monitor routine and nonroutine radiological releases and to assess the radiation dose to members of the public
- To protect the environment from the effects of radiation and radioactive material

4.2 Radiological Dose

DOE Order 458.1 establishes 100 mrem/year above background levels as the total annual dose limit due to DOE activities to a member of the public. DOE Order 458.1 also limits the dose from management and storage of radioactive waste to 25 mrem/year. DOE operations at PORTS contribute to the yearly public dose through radiological releases and external radiation. DOE controls emissions and effluents to maintain releases at levels that are ALARA. To confirm that doses to the public and biota are below established limits, DOE calculates annual dose estimates using air emissions data, external radiation monitoring data, and environmental monitoring data combined with relevant site-specific data such as meteorological conditions and population characteristics. Background radiation from natural cosmic and terrestrial sources is subtracted from radiological measurements to determine the PORTS dose.

4.2.1 Dose Assessment Methodology

Radiological dose assessments are completed for exposure pathways applicable to PORTS using methods consistent with the requirements of DOE Order 458.1 and other guidance, including the *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Portsmouth Gaseous Diffusion Plant* (DOE 2017b). For air, measurements or estimates of radionuclide concentrations in air released from PORTS are assembled for the calendar year. Models approved by US EPA and DOE (or factors derived from those models) are then used to estimate the total effective dose to a member of the public, known as the MEI, which represents the resident most likely to be affected by a radiological release for that pathway, and the collective total effective dose to the population within a 50-mile radius of PORTS.

To determine compliance with the DOE public dose requirements, PORTS calculates potential off-site doses by collecting samples at off-site locations around PORTS and analyzing the samples for radionuclides that could be present due to past or present activities at PORTS. DOE Order 458.1 states that the pathway and exposure assumptions for the MEI are to be reasonable and should neither underestimate nor substantially overestimate the dose. Radiological dose calculations include the dose to the public from radionuclides released to the air, external radiation, and radionuclides detected by environmental monitoring programs. This summary of the dose calculations assumes that the same MEI, or representative person, routinely drove on Perimeter Road past the cylinder yards when the road was open in 2021 and lives in the immediate vicinity of PORTS.

The MEI is assumed to be exposed to the maximum dose calculated from each pathway. The model assumes the MEI was exposed to radiation at the location where the highest concentration of radionuclides in air has been modeled; consumes milk, meat, and vegetables produced at that location; spends time on or near the Scioto River and local creeks; and hunts or fishes in the local area. The dose is expected to represent an upper limit for exposure because certain activities, such as swimming in the Scioto River, are assumed to occur but are not expected.

4.2.2 Dose Summary

Table 4.1 summarizes the potential dose to the hypothetical MEI, which uses an upper bounding scenario to determine the dose to the MEI from exposure to radionuclides in ambient air. The monitoring results in this table demonstrate the continued effectiveness of radiological control measures practiced at PORTS.

Table 4.1. Summary of potential annual doses to the public from PORTS in 2021

Source of dose	Dose[a]
Airborne radionuclides (ambient air)	0.227[b]
External radiation near cylinder yards (northwest portion of Perimeter Rd)	0.21
Radionuclides detected in the Scioto River	0
Radionuclides detected in off-site sediment	0.040
Radionuclides detected in off-site soil	0.006
Total	0.48[c]

Notes:
[a]Dose is shown in millirem per year.
[b]10 mrem/year is the US EPA limit for airborne radionuclides in the NESHAP (40 *CFR* Part 61, Subpart H).
[c]100 mrem/year is the DOE limit for all potential pathways in DOE Order 458.1.

4.3 Air Monitoring and Estimated Dose

This section discusses airborne discharges of radionuclides from PORTS, ambient air monitoring, and the dose calculations associated with airborne discharges and ambient air.

4.3.1 Air Monitoring

Airborne discharges of radionuclides from PORTS are subject to 40 *CFR* Part 61, Subpart H, NESHAP, which contains the national standards for emissions of radionuclides other than radon from DOE facilities. The applicable standard is a maximum of 10 mrem dose to any member of the public in any year. Releases of radionuclides are used to calculate an annual dose to members of the public, which is reported annually to US EPA and Ohio EPA.

In 2021, Fluor-BWXT Portsmouth was responsible for air emission sources associated with the former gaseous diffusion plant operations, including continuously monitored vents in the X-330 Process Building and the X-344A Uranium Hexafluoride Sampling Building. The vents in the X-330 Process Buildings can be operated to support decontamination and decommissioning activities, but were not in use in 2021. The X-344A vents were in use for ongoing sampling of uranium product. Vents in the X-326 and X-333 Process Buildings have been permanently shut down as part of decontamination and decommissioning activities.

Other radionuclide air emission sources included room ventilation exhausts and pressure relief vents associated with the X-710 Technical Services Building, X-705 Decontamination Facility, and XT-847 Glove Box, which is inactive. These emission sources were not continuously monitored; emissions from these sources, when in use, were estimated based on operating data and US EPA emission factors.

The X-622, X-623, X-624, and X-627 Groundwater Treatment Facilities treated groundwater contaminated with radionuclides or other site water in accordance with the Fluor-BWXT Portsmouth NPDES permit. Wastewater treatment facilities that support decontamination and decommissioning treat water potentially contaminated with radionuclides. Emissions from these treatment facilities were calculated based on influent and effluent sampling at each facility. Total emissions from the Fluor-BWXT Portsmouth airborne sources in 2021 were calculated to be 0.209 Ci (2.09E-01 Ci).

Mid-America Conversion Services was responsible for air emission sources associated with the DUF_6 Conversion Facility, which did not operate in 2021 due to the COVID-19 pandemic. Emissions from the DUF_6 Conversion Facility were based on continuous monitoring of the conversion building stack. Total emissions from the Mid-America Conversion Services airborne sources in 2021 were calculated to be 0.0000284 Ci (2.84E-05 Ci).

The Centrus demonstration cascade was the only source of radionuclide air emissions from Centrus subject to NESHAP reporting. There were no emissions from Centrus in 2021, however, because the demonstration cascade was shut down in 2016.

4.3.2 Air Estimated Dose

An annual dose calculation for atmospheric, or airborne, radionuclides is required by US EPA under NESHAP and is provided to US EPA in an annual report. The effect of radionuclides released to the atmosphere by PORTS during 2021 was determined by calculating the effective annual dose to the MEI, the individual who resides at the most exposed point near the plant, and to the entire population (approximately 662,000 residents) within 50 miles of the plant. Dose was calculated using the CAP-88-PC computer program, Version 4.1, which was developed under the sponsorship of US EPA for use in demonstrating compliance with the radionuclide NESHAP. The program uses models to calculate levels of radionuclides in the air, on the ground, and in food (vegetables, meat, and milk) and subsequent intakes by individuals. The program also uses meteorological data collected at PORTS such as wind direction, wind speed, atmospheric stability, rainfall, and average air temperature.

Radionuclide emissions were modeled for each of the air emission sources discussed in Section 4.2.1. The dose calculations assumed that each person remained unprotected, resided at home (actually outside the house) during the entire year, and obtained food according to the rural pattern defined in the NESHAP background documents. This pattern specifies that 70 percent of the vegetables and produce, 44 percent of the meat, and 40 percent of the milk consumed by each person are produced in the local area, such as in a home garden. The remaining portion of each food is assumed to be produced within 50 miles of PORTS. In reality, the majority of the food consumed locally is purchased at supermarkets that receive food items from all over the world. As a result, these assumptions most likely overestimate the dose received by a member of the public, since it is unlikely that a person spends the entire year outside at home and consumes food from the local area as described above.

The maximum potential annual dose to an off-site individual from radiological releases from PORTS air emission sources in 2021 was 0.11 mrem/year. This annual dose is below the 10 mrem/year limit applicable to PORTS and the approximate 311 mrem/year annual dose that the average individual in the United States receives from natural sources of radiation (National Council on Radiation Protection 2009).

The collective annual dose (or population dose) is the sum of doses to all individual members of the public within 50 miles of PORTS. In 2021, the population dose from PORTS emissions was 1.32 person-rem/year.

4.3.3 Ambient Air Monitoring

Ambient air monitoring measures pollutants in surrounding outdoor air. The ambient air monitoring stations measure radionuclides released from DOE point sources, fugitive air emissions (emissions from PORTS that are not associated with a stack or pipe such as decontamination and decommissioning activities or normal building ventilation), and background levels of radionuclides (radionuclides that occur naturally, such as uranium). The radionuclides measured are isotopic uranium (uranium-233/234, uranium-235/236, and uranium-238), technetium-99, and selected transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240). Thorium isotopes (thorium-228, thorium-230, and thorium-232) were added to the ambient air monitoring program in 2020 because these radionuclides are present in the gaseous diffusion process buildings and could be released during decontamination and decommissioning. These thorium isotopes are also naturally present in the environment.

Ambient air samples were collected from 18 ambient air monitoring stations in accordance with the *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2017c). As shown in Figure 4.1, these ambient air monitoring stations are located within and around PORTS and include a background ambient air monitoring station (A37) approximately 13 miles southwest of the plant. The analytical results from air sampling stations closer to the plant are compared to the background measurements.

The Ohio Department of Health collects air samples at the same 18 air monitoring locations sampled by DOE. The Ohio Department of Health sampling uses separate sampling equipment and analytical laboratories to independently measure airborne radioactivity levels around PORTS. Using separate sampling equipment and analytical laboratories means that analytical results for samples collected at the same location can be different. Data collected by the Ohio Department of Health are available on the state government data portal here. Data collected by DOE are available on the PEGASIS website here.

Ambient air monitoring began at the On-Site Waste Disposal Facility in April 2021. Samples are collected and analyzed for radionuclides at seven monitoring stations around the perimeter of the On-Site Waste Disposal Facility project area, as shown on Figure 4.1. The *2021 On-Site Waste Disposal Facility Annual Project Status Report* (DOE 2022b) and data collected in 2021 are available on the PEGASIS website here.

Ambient concentrations of uranium and uranium isotopes at the monitoring stations are affected by the presence of uranium isotopes in the filters used for sampling. Uranium and uranium isotopes were detected in quality control samples associated with the ambient air samples, and subsequently in unused filters obtained from the manufacturer that are placed at the ambient air stations to collect samples. The presence of uranium and uranium isotopes in the unused filters may have caused slightly elevated analytical results for uranium and uranium isotopes.

To aid in comparing sampling results for air and water to the 100 mrem/year dose limit, DOE converted the 100 mrem/year limit to a derived concentration standard (DOE 2021f). The derived concentration standard is the concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode (ingestion of water or inhalation of air), would result in a dose of 100 mrem/year. Table 4.2 lists the maximum activities of detected radionuclides in ambient air samples in 2021.

Table 4.2. Maximum levels of radionuclides detected in ambient air in 2021

Radionuclide	Maximum activity in picocuries per cubic meter	Location	Derived concentration standard[a]	Percentage of derived concentration standard
Technetium-99	0.0123	A36	2000	0.0006%
Thorium-228	0.0000269	X780-A02[b]	0.10	0.027%
Thorium-230	0.0000432	A36	0.15	0.03%
Thorium-232	0.0000639	X780-A03[b]	0.037	0.17%
Uranium-233/234	0.00106	A52	1.5	0.07%
Uranium-235/236	0.0000545	A52	1.7	0.003%
Uranium-238	0.000125	T7	1.8	0.007%

Notes:
[a]The derived concentration standard (air inhalation) has been converted to picocuries per cubic meter from units of microcuries per milliliter provided in the *Derived Concentration Technical Standard* (DOE 2021f).
[b]On-Site Waste Disposal Facility monitoring locations.

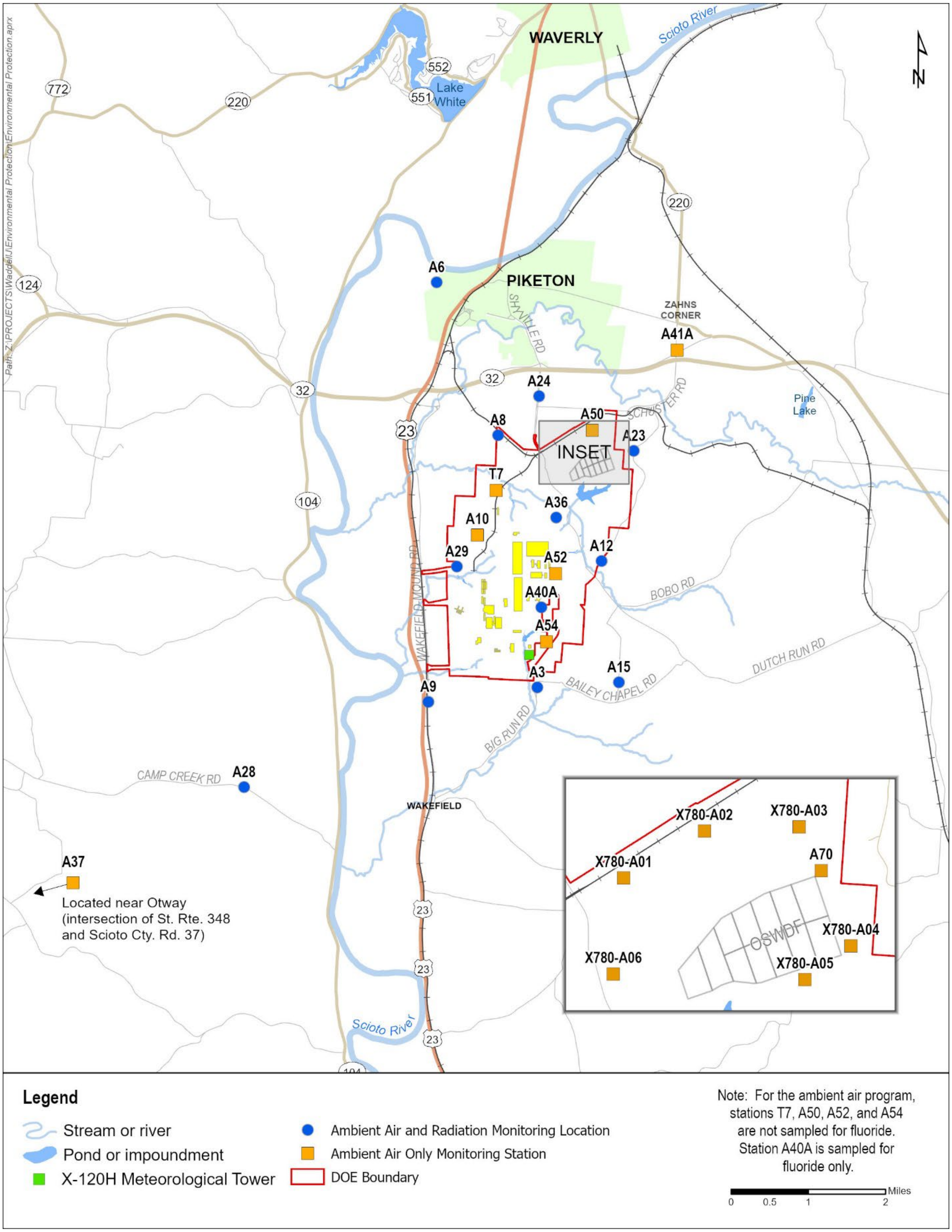


Figure 4.1. Ambient air and radiation monitoring locations

4.3.4 Ambient Air Estimated Dose

The CAP-88 model generates a dose conversion factor that was used to calculate an annual dose for a given level of each radionuclide in air (mrem/pCi/m3). The highest level of each radionuclide detected in 2021 was assumed to be present for the entire year or, if a radionuclide was not detected, the radionuclide was assumed to be present for the entire year at half the highest undetected result. This graded approach is used to calculate an upper bounding dose; the realistic dose to a member of the public (the hypothetical MEI) is less than this upper bounding dose. This approach may overestimate the annual dose because it assumes an individual resides at the location of the monitoring station and breathes the highest levels of radionuclides in air at that location for 24 hours per day, 365 days per year. The dose that a member of the public could receive from radionuclides in ambient air at the background station is subtracted from the dose calculated for the stations closer to PORTS.

The highest annual net dose for ambient air monitoring stations is 0.227 mrem/year at Station A29, which is on the west side of PORTS at the Ohio Valley Electric Corporation (see Figure 4.1). This hypothetical dose of 0.227 mrem/year is below the 10 mrem/year limit applicable to PORTS in NESHAP (40 *CFR* Part 61, Subpart H).

4.4 Liquid Discharge Monitoring and Estimated Dose

PORTS monitors effluent and surface water runoff for radiological constituents to protect human health and the environment.

4.4.1 Surface Water Monitoring

Surface water is monitored for radionuclides in several ways. On-site monitoring includes water discharged through NPDES outfalls and runoff from cylinder storage yards and the On-Site Waste Disposal Facility. The settleable solids monitoring program assesses the concentration of radioactive material present in the sediment suspended in the water sample at selected water discharge locations. The local surface water monitoring program monitors radionuclides in on-site and off-site creeks and the Scioto River. A dose is calculated for a recreational user who swims in the Scioto River.

4.4.1.1 Discharges of Radionuclides from NPDES Outfalls

Fluor-BWXT Portsmouth, Mid-America Conversion Services, and Centrus were responsible for NPDES outfalls at PORTS during 2021 (see Figure 4.2). The Mid-America Conversion Services NPDES outfall is not monitored for radionuclides, so it is not discussed in this section.

Fluor-BWXT Portsmouth monitored NPDES Outfalls 001, 002, 003, 004, 005, 009, 010, 011, 015, 608, and 611 for radiological discharges by collecting water samples and analyzing the samples for uranium, uranium isotopes (uranium-233/234, uranium-235/236, and uranium-238), technetium-99, and transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240). No transuranics (americium-241, neptunium-237, plutonium-238, and plutonium-239/240) were detected in samples collected from the Fluor-BWXT Portsmouth NPDES outfalls during 2021. Activities of technetium-99 and uranium isotopes discharged through the NPDES outfalls were assessed by comparing the activities of the radionuclides to the DOE derived concentration standards (DOE 2021f). Discharges of radionuclides in 2021 were within ALARA goals and were compliant with DOE Order 458.1.

In 2021 Centrus was responsible for three NPDES outfalls through which water is discharged from the site (see Figure 4.2). Outfalls 012 and 013 discharge directly to surface water, and Outfall 613 discharges to the X-6619 Sewage Treatment Plant (Fluor-BWXT Portsmouth NPDES Outfall 003) before leaving the site.

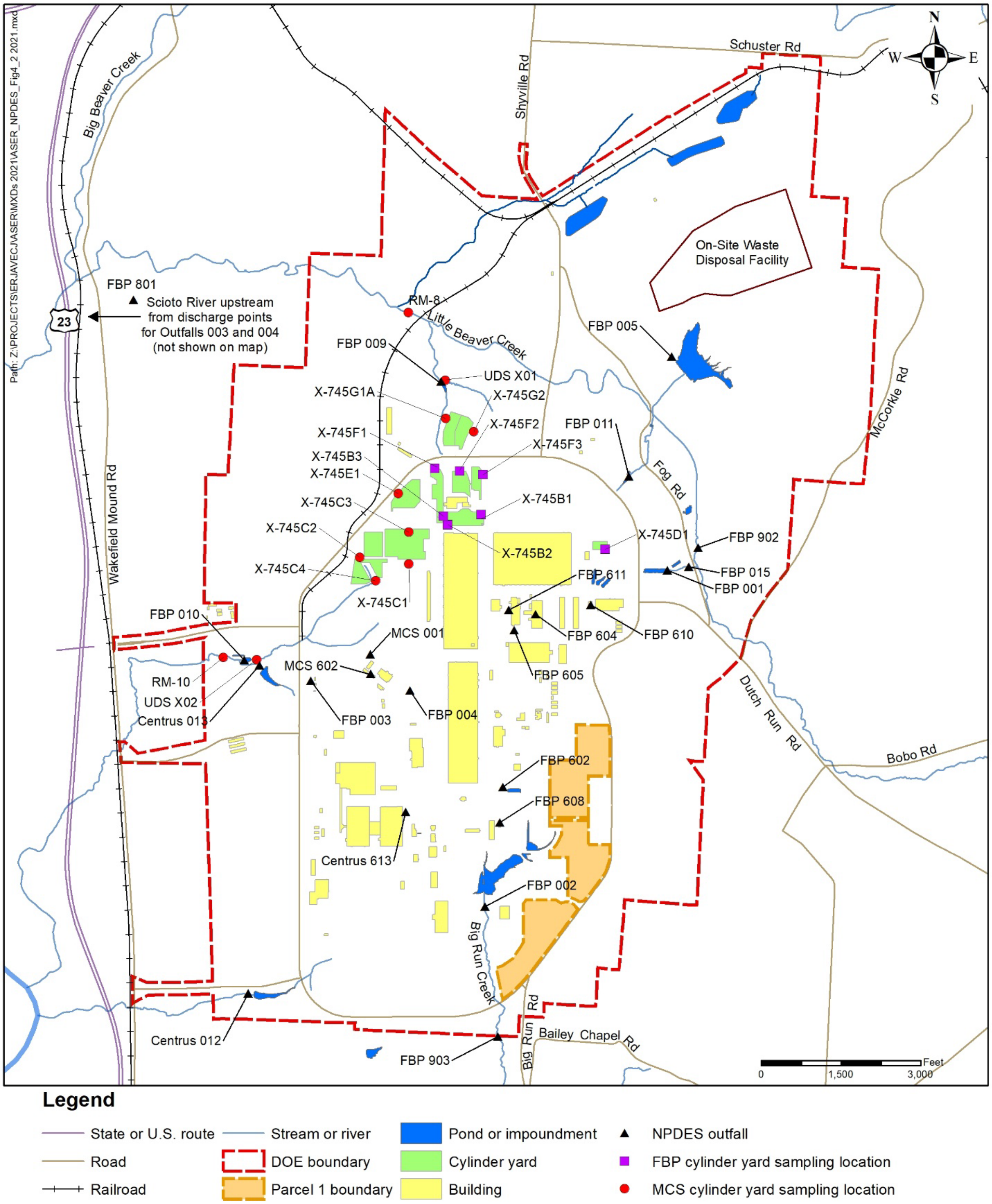


Figure 4.2. PORTS NPDES outfalls/monitoring points and cylinder storage yards sampling locations

Centrus Outfalls 012 and 013 were monitored for radiological discharges by collecting water samples and analyzing the samples for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, and uranium. Transuranic radionuclides and technetium-99 were not detected in any of the samples collected from Centrus NPDES outfalls in 2021. Uranium was detected at low levels, which is typical for these outfalls.

4.4.1.2 Fluor-BWXT Portsmouth Cylinder Storage Yards

Fluor-BWXT Portsmouth collected surface water samples in 2021 from seven locations at the on-site X-745B, X-745D, and X-745F Cylinder Storage Yards. Figure 4.2 shows the sampling locations. Samples were collected monthly if water was available and samples were analyzed for alpha activity, beta activity, and uranium. Table 4.3 shows the maximum levels of alpha activity, beta activity, and uranium detected in 2021.

Table 4.3. Maximum detections of radionuclides at Fluor-BWXT Portsmouth cylinder storage yards in 2021

Radionuclide	Result[a]	Location	Month
Alpha activity	450	X-745B1	March
Beta activity	450	X-745B1	March
Uranium	147	X-745B3	February

Note:
[a]Results are shown in picocuries per liter for alpha activity and beta activity and microgram per liter for uranium.

Surface water from the cylinder storage yards flows to Fluor-BWXT Portsmouth NPDES outfalls prior to discharge from the site; therefore, releases of radionuclides from the cylinder yards are monitored by sampling conducted at the Fluor-BWXT Portsmouth outfalls.

4.4.1.3 Mid-America Conversion Services Cylinder Storage Yards

Ohio EPA requires monthly collection of surface water samples from seven locations at the on-site X-745C, X-745E, and X-745G Cylinder Storage Yards, as shown in Figure 4.2. Samples were analyzed for alpha activity, beta activity, and uranium. Table 4.4 shows the maximum levels of alpha activity, beta activity, and uranium detected in 2021.

Table 4.4. Maximum detections of radionuclides at Mid-America Conversion Services cylinder storage yards in 2021

Radionuclide	Result[a]	Location	Month
Alpha activity	8.77	X-745C1	August
Beta activity	56.7	X-745C3	May
Uranium	7.76	X-745C1	August

Note:
[a]Results are shown in picocuries per liter for alpha activity and beta activity and microgram per liter for uranium.

Surface water from the cylinder storage yards flows to Fluor-BWXT Portsmouth NPDES outfalls prior to discharge from the site; therefore, releases of radionuclides from the cylinder yards are monitored by sampling conducted at the Fluor-BWXT Portsmouth outfalls.

4.4.1.4 On-Site Waste Disposal Facility Surface Water

Environmental surveillance monitoring of surface water is conducted downstream of discharges from sedimentation ponds and at locations downstream from areas where surface water runoff directly enters streams from On-Site Waste Disposal Facility peripheral areas. These locations include tributaries to Little Beaver Creek and Big Beaver Creek that may have continuous or intermittent flow.

Eight locations were monitored for radionuclides in 2021. Low levels of technetium and uranium were detected in the samples. Data collected at the On-Site Waste Disposal Facility surface water sampling locations in 2021 did not identify any issues to be addressed in the operation of the On-Site Waste Disposal Facility. The *2021 On-Site Waste Disposal Facility Annual Project Status Report* (DOE 2022b) and data collected in 2021 are available on the PEGASIS website here.

4.4.1.5 Settleable Solids

DOE collects water samples semiannually from nine effluent locations and three background locations to determine the concentration of radioactive material present in the sediment suspended in the water sample. Figure 4.3 shows these settleable solids monitoring locations. The data are used to determine compliance with DOE Order 458.1, *Radiation Protection of the Public and the Environment*, which states that operators of DOE facilities discharging or releasing liquids containing radionuclides from DOE activities must ensure that the discharges do not exceed an annual average (at the point of discharge) of either 5 pCi/g above background of settleable solids for alpha-emitting radionuclides, or 50 pCi/g above background for beta-gamma-emitting radionuclides.

When a low concentration of settleable solids is detected in a water sample, accurate measurement of the alpha and beta-gamma activity in the settleable solids portion of the sample is not practical due to the small sample size. DOE Handbook *Environmental Radiological Effluent Monitoring and Environmental Surveillance* (DOE 2015d) states that if settleable solids are not detected or the quantity of solids is so small that the radionuclides cannot be detected, the requirements are satisfied. In accordance with the *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2017c) samples with settleable solids less than 40 mg/L are not analyzed for radionuclides. In 2021, settleable solids were not detected at concentrations above 40 mg/L at any of the monitoring locations; therefore, monitoring results for the settleable solids monitoring program are in compliance with DOE Order 458.1.

4.4.1.6 Local Surface Water

Local surface water samples are collected from 14 locations upstream and downstream from PORTS surface water discharges. Figure 4.4 shows the monitoring locations on the Scioto River, Little Beaver Creek, Big Beaver Creek, and Big Run Creek. Samples collected from local streams approximately 10 miles north, south, east, and west of PORTS were used as background measurements.

Samples are collected semiannually and analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, uranium, and uranium isotopes (uranium-233/234, uranium-235/236, and uranium-238) in accordance with the DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2017c). No transuranic radionuclides were detected in the local surface water samples collected during 2021. Table 4.5 lists the maximum detections of technetium-99 and uranium isotopes in local surface water in 2021. These detected concentrations of radionuclides were 0.16 percent or less of the DOE derived concentration standards (DOE 2021f). These derived concentration standards are based on drinking water but the surface water around PORTS is not used as a source of drinking water.

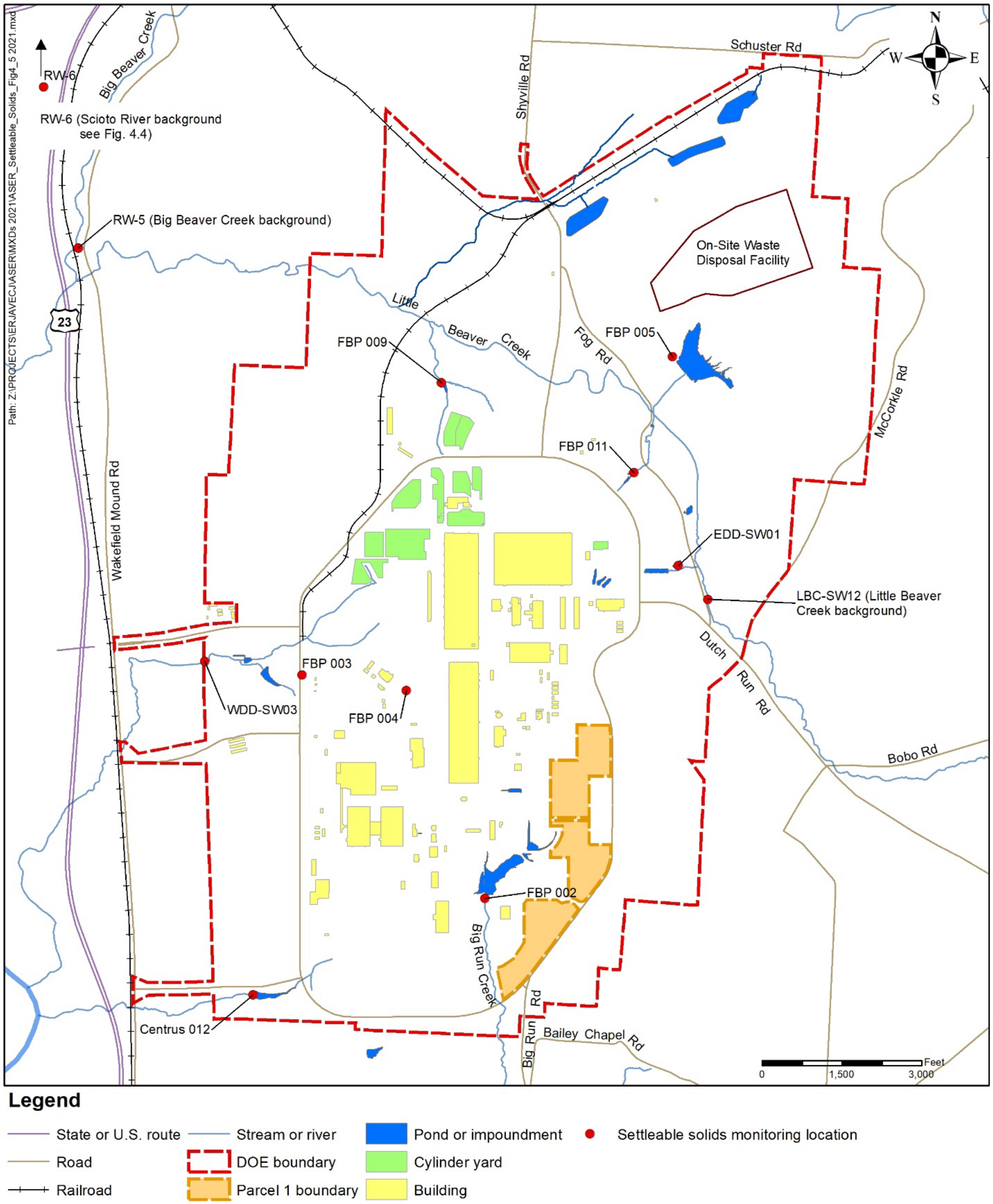


Figure 4.3. Settleable solids monitoring locations

Table 4.5. Maximum levels of radionuclides detected in local surface water in 2021

Radionuclide	Maximum activity[a]	Location	Derived concentration standard[b]	Percentage of derived concentration standard
Technetium-99	14.7	RW-3	390,000	0.0038%
Uranium-233/234	1.94	RW-7	1200	0.16%
Uranium-235/236	0.111	RW-7	1300	0.0085%
Uranium-238	0.504	RW-7	1400	0.036%

Notes:
[a]Results are shown in picocuries per liter.
[b]The derived concentration standard has been converted to picocuries per liter from units of microcurie per milliliter provided in the *Derived Concentration Technical Standard* (DOE 2021f).

4.4.2 Surface Water Estimated Dose

The Scioto River downstream from PORTS and the streams in the area around PORTS are not intentionally used by the public as sources of drinking water. However, a member of the public could be exposed to radionuclides present in surface water through recreational activities such as swimming.

A dose calculation has been developed consistent with the recreational use scenario in the *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Portsmouth Gaseous Diffusion Plant* (DOE 2017b). This dose calculation assumes that a member of the public would swim in the Scioto River for 2 hours per day, 100 days per year. While swimming, a person is assumed to swallow 0.05 liters (less than 2 ounces) of water per hour. This is called incidental ingestion.

Surface water samples are collected semiannually at the Scioto River sampling location in Piketon upstream from PORTS discharges (RW-6) and at the downstream sampling location (RW-1A). Table 4.6 lists the average levels of radionuclides detected in the Scioto River in 2021.

Table 4.6. Average activity of radionuclides detected in the Scioto River in 2021

Radionuclide[a]	Upstream Piketon RW-6	Downstream RW-1A
Uranium-233/234	0.435	0.245
Uranium-238	0.443	0.240

Note:
[a]Average activity is shown in picocuries per liter.

The dose that a member of the public could receive from incidental ingestion of water due to swimming in the Scioto River in Piketon is 0.0014 mrem/year. The dose that a member of the public could receive from incidental ingestion of water due to swimming in the Scioto River downstream from PORTS discharges is 0.00075 mrem/year. Because the dose at the upstream location in Piketon is higher than at the downstream location, the dose to a member of the public from exposure to surface water is considered to be zero.

4.5 Sediment and Soil Monitoring and Estimated Dose

This section discusses the results of sediment and soil monitoring completed in and around PORTS in 2021. The results of this monitoring are used to assess the dose that a member of the public could receive from radionuclides detected in sediment and soil.

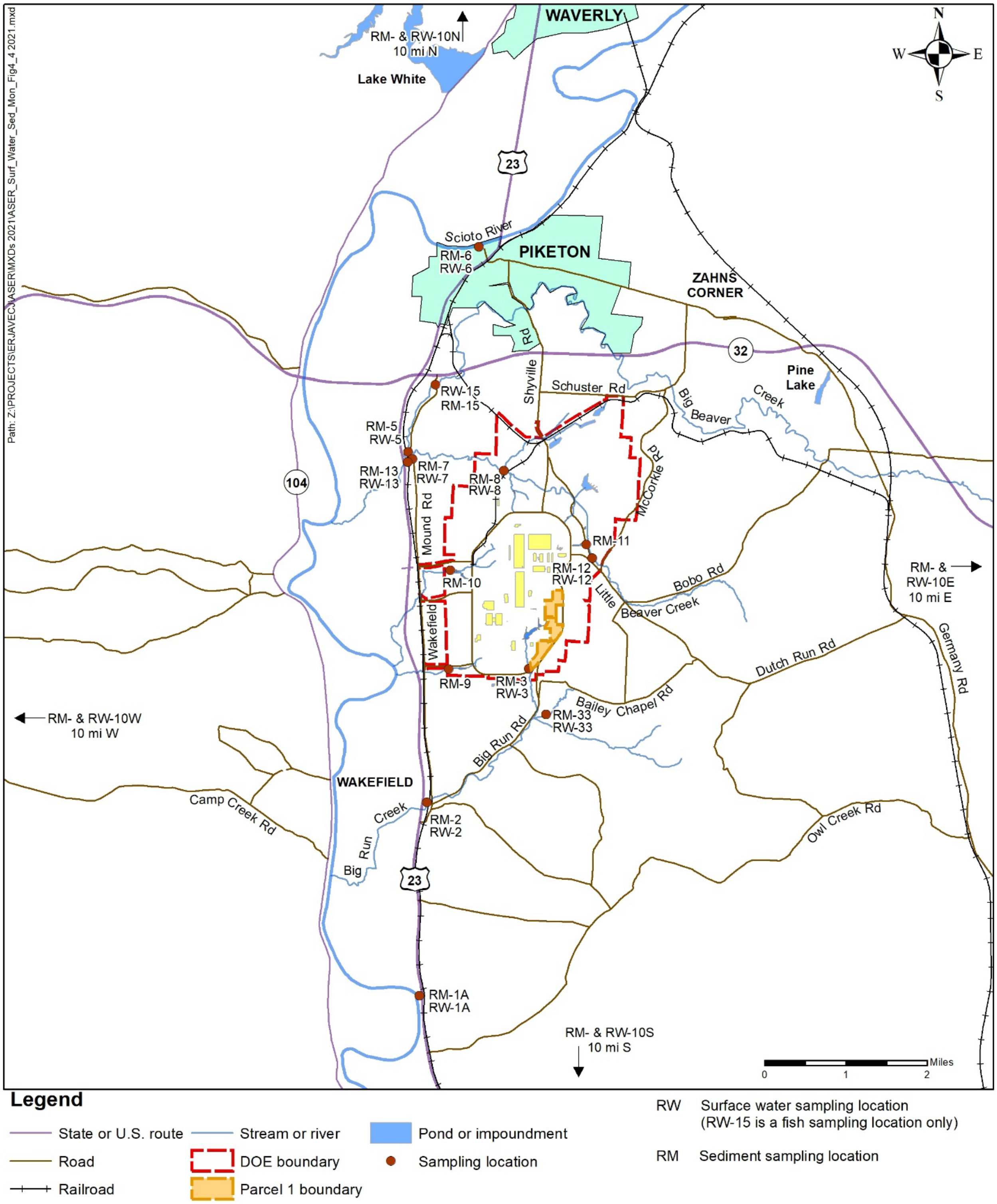


Figure 4.4. Local surface water and sediment monitoring locations

4.5.1 Sediment Monitoring

Sediment samples are collected from the locations upstream and downstream from PORTS where local surface water samples are collected, at the NPDES outfalls on the east and west sides of PORTS, and at a location on Big Beaver Creek upstream from the confluence with Little Beaver Creek (see Figure 4.4). Samples are collected annually and analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, uranium, and uranium isotopes (uranium-233/234, uranium-235/236, and uranium-238) in accordance with the DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2017c).

No transuranics were detected in the sediment samples collected in 2021. Technetium-99 is often detected in sediment samples collected at locations downstream from PORTS surface water discharges. In 2021, technetium-99 was detected at off-site sampling locations on Little Beaver Creek (RM-7) and Big Beaver Creek (RM-13). Technetium-99 was also detected on site at RM-10, RM-11, and RM-8.

Uranium and uranium isotopes occur naturally, but may also be present due to PORTS activities. Maximum detections of uranium and uranium isotopes in sediment samples were identified at RM-8, the on-site sampling location on Little Beaver Creek. Uranium and uranium isotopes detected in the 2021 samples have been detected at similar levels in previous sampling events from 2005 through 2020.

4.5.2 Sediment Estimated Dose

Because members of the public may use streams around PORTS for recreation, a dose calculation has been developed consistent with the recreational use scenario in the *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Portsmouth Gaseous Diffusion Plant* (DOE 2017b). This dose calculation assumes that a member of the public could access off-site streams 100 days per year. While engaging in recreational activities, a person is assumed to swallow 200 milligrams per day (0.007 ounces per day) of sediment.

Sediment samples are collected annually at off-site locations on the Scioto River, Big Beaver Creek, Little Beaver Creek, and Big Run Creek. Samples are also collected from four background creeks approximately 10 miles from PORTS. Table 4.7 lists the radionuclides detected in Big Beaver Creek (RM-13) and the average levels of radionuclides detected at background locations in 2021. The Big Beaver Creek location is shown in Table 4.7 because this location had the highest levels of radionuclides detected at an off-site location in 2021.

Table 4.7. Radionuclides detected in sediment in 2021

Radionuclide[a]	Big Beaver Creek (RM-13)[b]	Average background[c]
Technetium-99	25.9	-0.0401U[d]
Uranium-233/234	6.68	0.438
Uranium-235/236	0.311	0.0199
Uranium-238	0.963	0.424

Notes:
[a]All values are shown in picocuries per gram.
[b]Duplicate sample
[c]Sampling locations RM-10N, RM-10S, RM-10E, and RM-10W
[d]The reported result is undetected (U). Negative results may be reported due to a statistical determination of the counts seen by a detector, minus a background count.

The dose that a member of the public could receive from incidental ingestion of sediment from the Big Beaver Creek at sampling location RM-13 is 0.045 mrem/year. The dose that a member of the public could receive from incidental ingestion of sediment with average levels of radionuclides detected at background locations is 0.0048 mrem/year. When the dose from background levels of radionuclides is subtracted from the dose at sampling location RM-13 on Big Beaver Creek, the dose to a member of the public from exposure to sediment is 0.040 mrem/year.

4.5.3 Soil Monitoring

Soil samples are collected annually from 15 ambient air monitoring locations (see Figure 4.5). Samples are analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, uranium, and uranium isotopes (uranium-233/234, uranium-235/236, and uranium-238) in accordance with the DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2017c).

No transuranic radionuclides or technetium-99 were detected at the soil sampling locations in 2021. Uranium, uranium-233/234, uranium-235/236, or uranium-238 were detected at each of the sampling locations. Uranium and uranium isotopes are usually detected at similar levels at the off-site soil sampling locations, including the background location (A37), which suggests that the uranium detected in these samples occurs naturally.

4.5.4 Soil Estimated Dose

Off-site areas around PORTS could be used for recreation by members of the public, so a dose calculation has been developed consistent with the recreational use scenario in the *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Portsmouth Gaseous Diffusion Plant* (DOE 2017b). This dose calculation assumes that a member of the public could access off-site soil sampling locations 350 days per year. While engaging in recreational activities, a person is assumed to swallow 200 milligrams per day (0.007 ounces per day) of soil.

Soil samples are collected annually at off-site locations and at a background location approximately 10 miles from PORTS in Otway (A37). Table 4.8 lists the radionuclides detected in soil at sampling location A12 (east of PORTS on McCorkle Road) and at the background location A37 in 2021. Location A12 is shown in Table 4.8 because this location had the highest levels of uranium detected at an off-site location in 2021.

Table 4.8. Radionuclides detected in soil in 2021

Radionuclide[a]	A12[b]	A37
Uranium-233/234	0.566	0.366
Uranium-235/236	0.0333	0.0146U[c]
Uranium-238	0.465	0.358

Notes:
[a]All values are shown in picocuries per gram.
[b]Duplicate sample
[c]The reported result is not detected (U).

The dose that a member of the public could receive from incidental ingestion of soil at sampling location A12 is 0.020 mrem/year. The dose that a member of the public could receive from incidental ingestion of soil at background location A37 is 0.014 mrem/year. When the dose from the background level of radionuclides at location A37 is subtracted from the dose at sampling location A12, the dose to a member of the public from exposure to radionuclides in soil is 0.006 mrem/year.

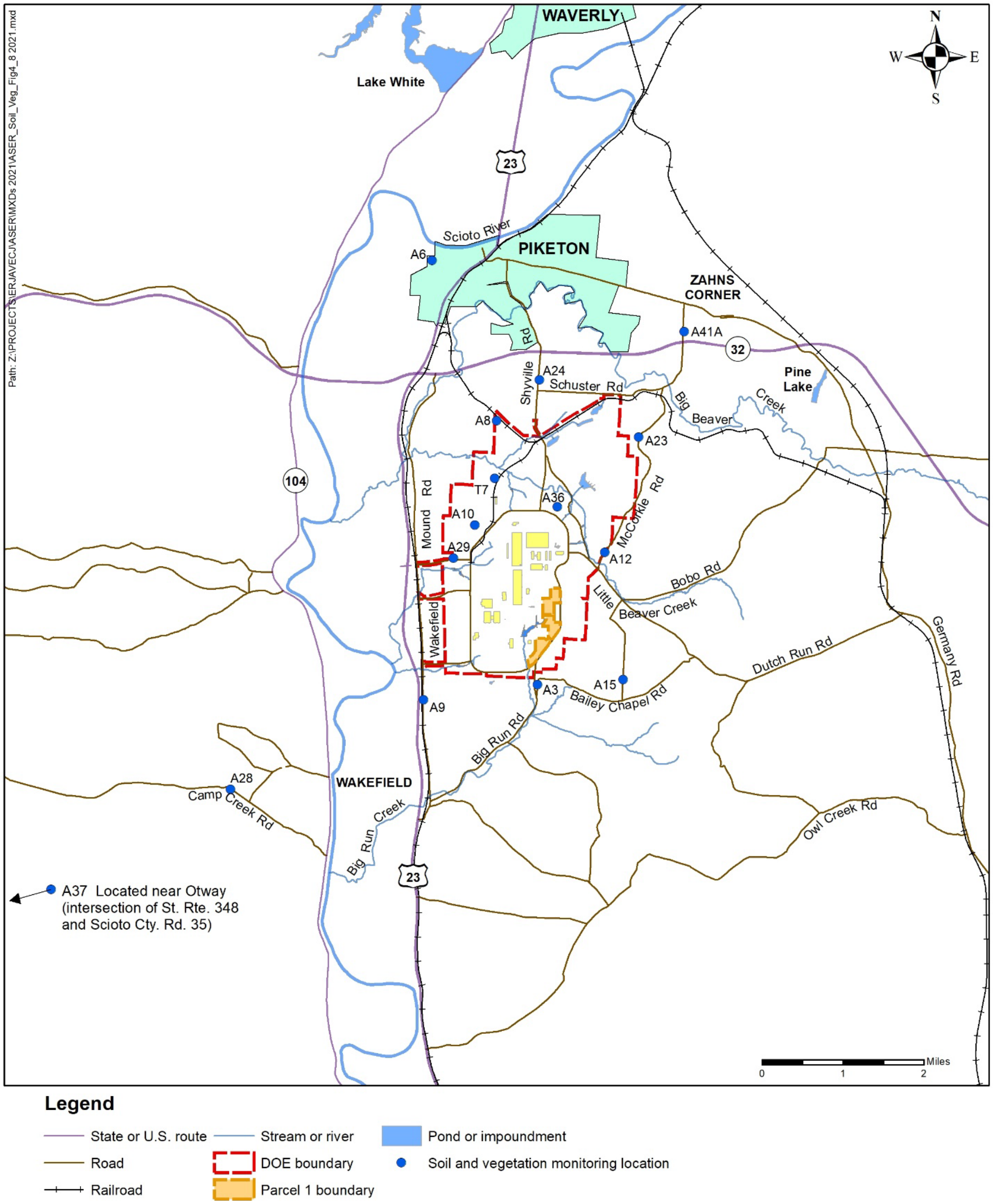


Figure 4.5. Soil and vegetation monitoring locations

4.6 External Radiation Monitoring and Estimated Dose

The external radiation monitoring program at PORTS measures both background radiation and radiation due to radiological sources at PORTS. These data are used to assess the dose that a member of the public could receive from radiation attributable to sources at PORTS.

4.6.1 External Radiation Monitoring

External radiation is measured at on-site and off-site locations in accordance with the DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2017c). External radiation is measured continuously with thermoluminescent dosimeters at five locations near the DUF_6 cylinder storage yards (Figure 4.6), 12 of the ambient air monitoring stations (Figure 4.1), and seven additional on-site locations (Figure 4.6). Five locations around the perimeter of the On-Site Waste Disposal Facility project area are also monitored for external radiation.

Dosimeters are placed at the monitoring locations at the beginning of each quarter. They remain at the monitoring location throughout the quarter, and are removed from the monitoring location at the end of the quarter and sent to the laboratory for processing. A new dosimeter replaces the device that was removed. Radiation is measured in millirems as a whole body dose, which is the dose that a person would receive if they were continuously present at the monitored location.

The dosimeters measure background radiation and any radiation that may be present due to radiological sources at PORTS. Background radiation is primarily cosmic and terrestrial radiation, but also includes global fallout from historic nuclear testing or nuclear accidents such as Chernobyl. Background radiation varies at specific locations based on local geology, nearby structures that could provide shielding or contain naturally-occurring radiation, agricultural use of fertilizer, and many other factors.

Higher concentrations of naturally-occurring radionuclides are present in the shale and sandstone hills at the northern PORTS property line and surrounding PORTS than in the clay and silt present in the center of PORTS where the former gaseous diffusion building are located. Therefore, background radiation measured in areas where the Cuyahoga sandstone is present is expected to be higher than in areas where it is absent.

4.6.2 External Radiation Estimated Dose

Radiation is emitted from DUF_6 cylinders stored on site at PORTS in the cylinder storage yards in the northwest portion of the site near Perimeter Road. External radiation is measured at five locations along Perimeter Road near the boundaries of the cylinder storage yards.

Data from radiation monitoring at the cylinder yards are used to assess potential exposure to a representative on-site member of the public who drives on Perimeter Road. The radiological exposure to an on-site member of the general public is estimated as the time a person drives on Perimeter Road past the cylinder yards (one minute per trip, two trips per day, five workdays per week). Beginning on May 1, 2021, public access to the portion of Perimeter Road next to the cylinder yards was restricted, which means the public had access to Perimeter Road for only 4 months in 2021.

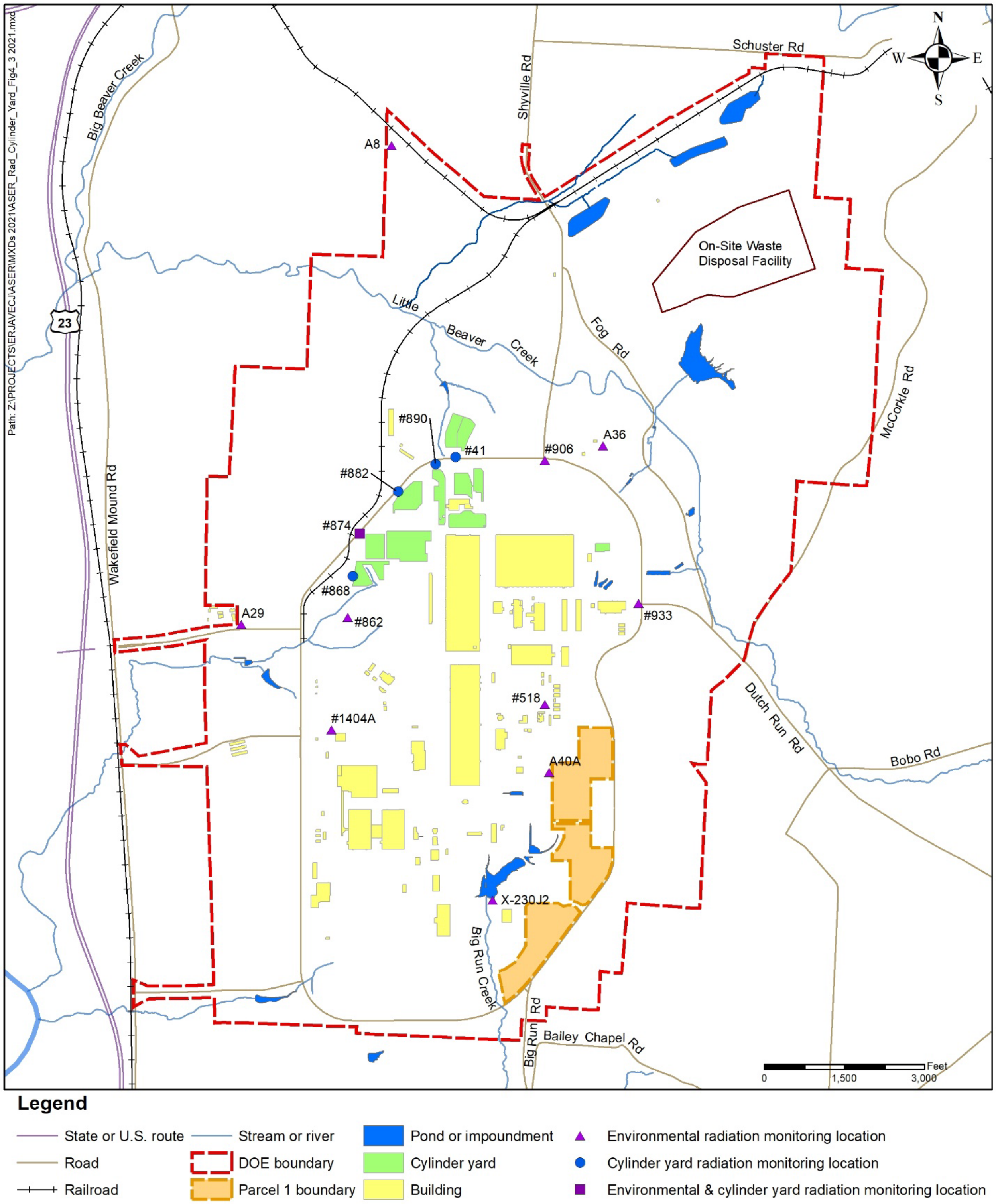


Figure 4.6. External radiation monitoring locations

In 2021, the average annual dose recorded by thermoluminescent dosimeters at the cylinder yards near Perimeter Road was 736 mrem/year, based on dosimeter measurements for an entire year at locations #41, #868, #874, #882, and #890. The average dose measured at off-site external radiation monitoring stations, considered the background dose, was 85 mrem/year. Although the total annual external radiation dose near the cylinder yards is high, a person would receive this dose only if they were present at the cylinder yards for 24 hours per day, 365 days per year. Access to the cylinder yard area is controlled by PORTS security forces, however, so a member of the public could not be continuously exposed to this level of radiation from the cylinder yards. External radiation levels associated with the cylinder yards diminish quickly to background levels with distance from the cylinder yards, as demonstrated by radiation measurements at other on-site and all off-site monitoring locations.

The net dose near the cylinder yards in 2021 was 651 mrem/year (the total dose of 736 mrem/year minus the background dose of 85 mrem/year). Based on the estimated time a person would drive on Perimeter Road near the cylinder yards from January through April of 2021, the dose to an on-site member of the public from radiation from the cylinder yards in 2021 is approximately 0.21 mrem/year.

Data collected in 2021 at the external radiation locations for the On-Site Waste Disposal Facility did not identify any issues to be addressed in the operation of the On-Site Waste Disposal Facility. The *2021 On-Site Waste Disposal Facility Annual Project Status Report* (DOE 2022b) and data collected in 2021 are available on the PEGASIS website here.

4.7 Monitoring of Plants and Animals and Estimated Dose

Wildlife and farm-raised animal products, including meat, eggs, and milk may become contaminated when animals ingest contaminated water, sediment, or other animals, or through direct contact with contaminated areas.

4.7.1 Wildlife, Animal Products, and Crops Monitoring

The *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2017c) requires biological monitoring to assess the uptake of radionuclides in selected local biota (vegetation, deer, fish, crops, milk, and eggs).

4.7.1.1 Vegetation

To assess the uptake of radionuclides in plant material, vegetation samples (primarily grass) are collected in the same areas where soil samples are collected at the ambient air monitoring stations (see Figure 4.5). Samples are collected annually and analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, uranium, and uranium isotopes (uranium-233/234, uranium-235/236, and uranium-238).

Uranium, uranium-233/234, or uranium-238 were detected in the vegetation samples collected at on-site sampling locations A10, A29, A36, A8, and T7. Uranium and uranium-238 were also detected at off-site sampling locations A6 (north of PORTS in Piketon), A9 (southwest of PORTS on old US Route 23), A3 (south of PORTS on Bailey Chapel Road), and A41A (northwest of PORTS at Zahns Corner). Uranium and uranium isotopes are detected occasionally in vegetation samples.

4.7.1.2 Deer

Samples of liver, kidney, and muscle from deer killed on site in motor vehicle collisions are collected annually, if available. Samples are analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, uranium, and uranium isotopes (uranium-233/234, uranium-235/236, and uranium-238). Deer samples were collected in June of 2021. No radionuclides were detected in these deer samples.

4.7.1.3 Fish

Fish samples are collected annually, if available, from locations on Little Beaver Creek (RW-8), Big Beaver Creek (RW-13 and RW-15), and the Scioto River (RW-1A and RW-6), as shown on Figure 4.4. In 2021 fish samples were collected from Little Beaver Creek (RW-8) and Big Beaver Creek (RW-13) and analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, uranium, and uranium isotopes (uranium-233/234, uranium-235/236, and uranium-238). No radionuclides were detected in the fish samples collected during 2021.

4.7.1.4 Crops

In 2021 samples of crops including corn, tomatoes, and grapes were collected from three off-site locations near PORTS. The samples were analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, uranium, and uranium isotopes (uranium-233/234, uranium-235/236, and uranium-238). No radionuclides were detected in these crop samples.

4.7.1.5 Milk and Eggs

Samples were collected from milk and eggs produced near PORTS in 2021. The samples were analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, uranium, and uranium isotopes (uranium-233/234, uranium-235/236, and uranium-238). No radionuclides were detected in these milk and egg samples.

4.7.2 Wildlife, Animal Products, and Crops Estimated Dose

Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Portsmouth Gaseous Diffusion Plant (DOE 2017b) provides exposure scenarios for ingestion of radionuclides detected in deer and fish. If radionuclides are detected in deer or fish, dose is calculated in accordance with the exposure scenarios and assumptions provided in this document. No radionuclides were detected in deer and fish samples collected in 2021.

Exposures to radionuclides that could be present in vegetation (grass) and locally produced crops, milk, and eggs are captured in the food chain models associated with the CAP-88 PC air program discussed in Section 4.3.2.

4.7.3 Biota Monitoring and Estimated Dose

DOE Order 458.1 sets absorbed dose rate limits for aquatic animals, riparian animals (animals that live on the banks of a river or in wetlands adjacent to a body of water), terrestrial plants, and terrestrial animals. Radionuclides from both natural and man-made sources may be found in environmental media such as water, sediments, and soils. Contaminants may accumulate in animals from eating contaminated feed, drinking contaminated water, and breathing contaminated air, and in fish when they eat contaminated food and live in contaminated waters. Because plant and animal populations residing in or near, or taking food or water from these media may be exposed to a greater extent than humans, DOE prepared technical standard DOE-STD-1153-2019, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2019). This standard provides methods and guidance for evaluating doses from ionizing radiation to populations of aquatic animals, riparian animals (those that live along banks of streams or rivers), terrestrial plants, and terrestrial animals. It was used to demonstrate compliance with these limits.

4.7.3.1 Aquatic and Riparian Animals Monitoring

Analytical data for surface water and sediment samples collected during 2021 from Big Run Creek on the south side of the PORTS reservation (surface water sampling location BRC-SW05 and sediment sampling location RM-3) were used to assess the dose limits for aquatic and riparian animals (1 rad/day to aquatic animals and 0.1 rad/day to riparian animals). These locations were selected because levels of radionuclides detected in surface water and sediment from these locations were among the highest detected in samples collected in 2021. Use of maximum detections of radionuclides is required when using the general screening phase to estimate dose as described in the following section. Section 6.3.3 and Section 4.5.1 provide more information about these surface water and sediment sampling programs, respectively. The maximum levels of radionuclides (technetium-99 and uranium isotopes) are shown in Table 4.9.

Table 4.9. Detections of radionuclides used in dose assessment for aquatic and riparian animals

Radionuclide[a]	BRC-SW01	RM-3
Technetium-99	1710	0.118U[b]
Uranium-233/234	86.1	0.535
Uranium-235/236	2.83	0.0263
Uranium-238	2.31	0.326

Note:
[a]Values are shown in picocuries per liter for BRC-SW01 and picocuries per gram for RM-3.
[b]The reported result is undetected (U).

4.7.3.2 Aquatic and Riparian Animals Estimated Dose

DOE used the general screening phase to determine if radiation doses to aquatic and riparian animals were in compliance with the specified dose limits (1 rad/day to aquatic animals and 0.1 rad/day to riparian animals). The maximum levels of radionuclides listed in Table 4.9 were entered in the RESRAD-BIOTA software designed to implement the DOE Technical Standard (DOE 2019). The software compares concentration data from PORTS environmental sampling with biota concentration guide screening values to estimate maximum doses to biota. If the maximum levels of radionuclides detected at the selected PORTS sampling locations result in an output from the software calculations of less than 1, the doses to aquatic and riparian animals are within the dose limits.

In 2021, the RESRAD-BIOTA software output for the maximum levels of radionuclides detected at sampling locations BRC-SW05 in surface water and RM-3 in sediment was 0.453, which is less than 1. Therefore, the assessment indicates that the levels of radionuclides detected in water and sediment at these locations did not result in a dose of more than 1 rad/day to aquatic animals and 0.1 rad/day to riparian animals.

4.7.3.3 Terrestrial Plants and Animals Monitoring

Analytical data for surface water and soil samples collected during 2021 from the northern side of the PORTS reservation (surface water sampling location RW-8 and soil sampling location A8) were used to assess the dose limits for terrestrial plants and animals. These locations were selected because levels of radionuclides detected in surface water and soil from these locations were among the highest detected in samples collected in 2021. Use of maximum detections of radionuclides is required when using the general screening phase to estimate dose as described in the following section. Section 4.4.1.6 and Section 4.5.3 provide additional information about these surface water and soil sampling programs, respectively.

No transuranic radionuclides were detected in 2021 from samples collected at RW-8 in surface water and A8 in soil. Table 4.10 shows the maximum levels of technetium-99 and uranium isotopes.

Table 4.10. Detections of radionuclides used in dose assessment for terrestrial plant and animals

Radionuclide[a]	RW-8	A8
Technetium-99	4.46	-0.134U[b]
Uranium-233/234	1.56	1.12
Uranium-235/236	0.0818	0.0572
Uranium-238	0.486	0.971

Note:
[a]Values are shown in picocuries per liter for RW-8 and picocuries per gram for A8.
[b]The reported result is undetected (U). Negative results may be reported due to a statistical determination of the counts seen by a detector, minus a background count.

4.7.3.4 Terrestrial Plants and Animals Estimated Dose

DOE used the general screening phase to determine if radiation doses to terrestrial plant and animals were in compliance with the specified dose limits (1 rad/day to terrestrial plants and 0.1 rad/day to terrestrial animals). The maximum levels of radionuclides listed in Table 4.10 were entered in the RESRAD-BIOTA software designed to implement the DOE Technical Standard (DOE 2019). The software compares concentration data from PORTS environmental sampling with biota concentration guide screening values to estimate maximum doses to biota. If the maximum levels of radionuclides detected at the selected PORTS sampling locations result in an output from the software calculations of less than 1, the doses to terrestrial plants and animals are within the dose limits.

In 2021, the RESRAD-BIOTA software output for the maximum levels of radionuclides detected at sampling locations RW-8 in surface water and A8 in soil was 0.00086, which is less than 1. Therefore, the assessment indicates that the levels of radionuclides detected in water and soil at these locations did not result in a dose of more than 1 rad/day to terrestrial plants and 0.1 rad/day to terrestrial animals.

4.8 Unplanned Radiological Releases

No unplanned releases of radionuclides took place at PORTS in 2021.

4.9 Release of Property Containing Residual Radioactive Material

Real property is defined as land, anything permanently affixed to the land such as buildings and fences, and things attached to buildings such as light fixtures, plumbing, heating fixtures, or other items that would be personal property if not attached. Personal property is defined as property of any kind, except for real property.

DOE and its contractors use the processes, guidelines, and limits in DOE Order 458.1 and associated guidance for clearance of property with residual radioactive material. Release criteria for surface contamination limits as specified in DOE Order 458.1 are used for clearance of objects with potential surface contamination, while specific authorized limits have been derived to control whether items with potential volumetric contamination are released. Property that may contain residual radioactive material will not be cleared from PORTS unless the level of radiation for the property is demonstrated to be within acceptable limits. Property clearance requirements are governed by procedures established by each DOE contractor. Section 2.2.2.1 provides the authorized limits used by DOE contractors at PORTS. The type and quantity of releases for PORTS contractors are discussed below.

4.9.1 Fluor-BWXT Portsmouth Property Releases

Fluor-BWXT Portsmouth uses pre-approved authorized limits established by DOE orders to evaluate and release materials defined as personal property (see Section 2.2.2.1). Fluor-BWXT Portsmouth also handles releases of personal property for Portsmouth Mission Alliance. In 2021, Fluor-BWXT Portsmouth authorized approximately 1,435 release requests for materials or items of personal property. These include vehicles, equipment, waste and recyclables such as batteries, light bulbs, used oil, and construction debris, and other materials.

DOE has approved authorized limits for real property release at PORTS (see Section 2.2.2.1). DOE did not transfer any real property at PORTS in 2021.

4.9.2 Mid-America Conversion Services Property Releases

In 2021, Mid-America Conversion Services authorized approximately 56 requests for materials to be released off site. These releases included vehicles, equipment, waste and recyclables (batteries, light bulbs, used oil, waste water and debris from the hydrogen fluoride tank relining project, and construction debris), contractor equipment, equipment sent out for calibration, and other items that met the criteria to be released off site.

Mid-America Conversion Services authorized approximately 133 items that met the criteria for exemption in 2021. These items included contractor equipment that was surveyed prior to coming on site, was on site for a short time, and never entered an area controlled for radioactive material; new and unused items sent to Mid-America Conversion Services by mistake; new, unused items that had expired or needed to be returned to the vender for repair or calibration; and other items that met the criteria for exemption. All of these items were thoroughly evaluated before a determination was made.

In 2021, Mid-America Conversion Services did not process any DUF_6. However, Mid-America Conversion Services continued off-site shipment of aqueous hydrogen fluoride produced by the DUF_6 Conversion Facility the previous year. Each shipment met the release limit of less than 3 picocuries per milliliter (0.003 pCi/L) of total uranium activity. Approximately 15,070 gallons of aqueous hydrogen fluoride were shipped off site in 2021.

5. Environmental Non-Radiological Programs

PORTS environmental monitoring activities cover both radiological and non-radiological contaminants. Chapter 4 discusses radiological monitoring, and this chapter describes the site's efforts to monitor potential non-radiological contaminants in air, surface water, sediment, and biota.

The *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2017c) specifies non-radiological monitoring requirements for ambient air, surface water, sediment, and fish, and the *On-Site Waste Disposal Facility (OSWDF) Performance Standards Verification Plan* (DOE 2021b) describes the non-radiological monitoring requirements associated with operation of the On-Site Waste Disposal Facility. Non-radiological data are not collected for all sampling locations or all monitoring programs.

Environmental permits issued by Ohio EPA to Fluor-BWXT Portsmouth, Mid-America Conversion Services, or Centrus specify discharge limitations, monitoring requirements, and reporting requirements for air emissions and water discharges. Centrus data for NPDES water discharges are included in this section to provide a more complete picture of environmental monitoring at PORTS. Centrus data for water discharges are provided for informational purposes only, however, as Centrus operates independently of DOE and is regulated by the Nuclear Regulatory Commission.

This chapter includes data for air, surface water, sediment, and biota (fish). DOE also conducts an extensive groundwater monitoring program at PORTS that includes both radiological and non-radiological constituents. Chapter 6 describes the groundwater monitoring program.

5.1 Air

Permitted air emission sources at PORTS release non-radiological air pollutants, and Section 5.1.1 discusses these airborne discharges. DOE also monitors ambient air for non-radiological air pollutants that could be present due to decontamination and decommissioning activities at PORTS.

5.1.1 Airborne Discharges

Fluor-BWXT Portsmouth is responsible for numerous air emission sources associated with the former gaseous diffusion production and support facilities. These sources included the boilers at the X-600 Steam Plant Complex prior to their demolition in 2013. Based on the X-600 Steam Plant Complex's emission rate, Fluor-BWXT Portsmouth air emission sources were classified as a major source of air pollutants as defined in 40 *CFR* Part 70.

Fluor-BWXT Portsmouth is required to submit the annual Ohio EPA Fee Emissions Report to describe the emissions of selected non-radiological air pollutants. For 2021, Fluor-BWXT Portsmouth emissions of non-radiological air pollutants included 13.62 tons of particulate matter and 1.18 tons of organic compounds. Emissions for 2021 are associated with the X-627 Groundwater Treatment Facility and plant roads and parking areas.

Because the DUF_6 Conversion Facility emits only a small quantity of non-radiological air pollutants, Ohio EPA requires a Fee Emissions Report for this facility only once every two years, in odd-numbered years. The report states increments of emissions: zero, less than 10 tons, 10 to 50 tons, more than 50 tons, and more than 100 tons. Mid-America Conversion Services reported less than 10 tons per year of specified non-radiological air pollutants in 2021.

US EPA also requires annual reporting of greenhouse gas emissions including carbon dioxide, methane, and nitrous oxide. In 2021, Fluor-BWXT Portsmouth reported emissions of 9,155.2 metric tons of carbon dioxide, 0.18 metric ton of methane, and 0.018 metric ton of nitrous oxide. These emissions resulted from burning natural gas at the X-690 Boilers, which provide steam to portions of the plant.

Another potential air pollutant present at PORTS is asbestos released by decontamination and decommissioning of plant facilities. Asbestos emissions are controlled by a system of work practices. The amount of asbestos removed and disposed of is reported to Ohio EPA. In 2021, approximately 202,687 pounds of asbestos-containing materials (net weight) were shipped off site. Asbestos was not detected in ambient air samples collected as part of the ambient air monitoring program in 2021 (see Section 5.1.2.4).

5.1.2 Ambient Air Monitoring

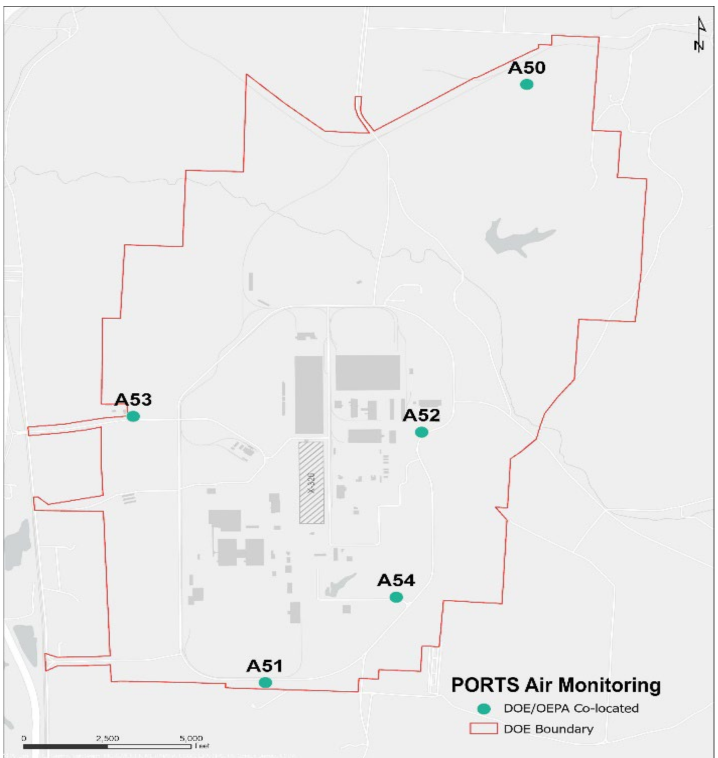


Figure 5.1. DOE/Ohio EPA air monitoring stations

DOE and Ohio EPA run an ambient air monitoring program at PORTS to monitor non-radionuclides that may be released to the environment during decontamination and decommissioning.

Five stations monitor particulate matter, metals, volatile organic compounds, and fibers and asbestos, as shown in Figure 5.1. DOE and Ohio EPA collect samples from each location using separate sampling equipment. Ohio EPA provides air monitoring data to the public on the Ohio EPA website under the heading Special Sampling – Portsmouth GDP here. DOE provides data in PEGASIS here.

Ambient air monitoring also occurs at the On-Site Waste Disposal Facility, and results are discussed separately in Section 5.1.3.

Section 5.1.4 discusses results for 15 ambient air monitoring stations that measure fluoride (see Figure 4.1). Fluoride detected at the ambient air monitoring stations could be present due to background concentrations, since fluoride occurs naturally in the environment; from activities associated with the former gaseous diffusion process; and from operation of the DUF_6 Conversion Facility.

5.1.2.1 Particulate Matter

Particulate matter is a mixture of very small solid particles and liquid droplets in air. Particulate matter includes dust from construction sites, unpaved roads, and fields as well as smoke produced by fires. Numerous industrial processes emit particulate matter, and it is also produced by coal- or gas-burning power plants and gasoline and diesel fuel burned by vehicles.

DOE and Ohio EPA measure two sizes of particulate matter, PM_{10} and $PM_{2.5}$. The numbers refer to the size of the particles: 10 microns or less and 2.5 microns or less. These particles are very small; in comparison, the typical diameter of a human hair is about 70 microns. Air monitors at each of the five sampling locations (see Figure 5.1) continuously measure PM_{10} and $PM_{2.5}$.

The National Ambient Air Quality Standards set a 24-hour average of 150 micrograms per cubic meter (µg/m^3) for PM_{10} in ambient air. This standard applies to geographic areas and not to individual industrial facilities, but the standard is useful in evaluating PORTS monitoring data. Data collected by DOE in 2021 had a maximum 24-hour average for PM_{10} of 61 µg/m^3 at station A50, below the 150 µg/m^3 standard.

The National Ambient Air Quality Standards set a 24-hour average of 35 µg/m^3 for $PM_{2.5}$ in ambient air and a primary annual average standard of 12 µg/m^3. As is the case for the PM_{10} standards, these limits apply to geographic areas and not to individual industrial facilities. However, the standards are useful in evaluating PORTS monitoring data. For data collected by DOE in 2021, the maximum 24-hour average for $PM_{2.5}$ was 25 µg/m^3 at station A52, which is below the 35 µg/m^3 standard. The annual averages measured at the stations were 8 µg/m^3, which are below the 12 µg/m^3 standard.

Hourly measurements for PM_{10} and $PM_{2.5}$ from the Ohio EPA stations are available in real time on the Ohio EPA website here. Summaries of data collected by Ohio EPA are also available on this website.

5.1.2.2 Metals

Metals are a component of particulate matter because metals are naturally present in soil. Metals are also released to the air from burning coal, natural gas, diesel fuel, or gasoline and from numerous industrial processes. DOE and Ohio EPA monitor ambient air for 11 metals designated by Ohio EPA as hazardous air pollutants. These metals could be present in excavated soil and demolition debris at PORTS. One 24-hour sample is collected every six days following the Ohio EPA sampling schedule.

DOE completed an air dispersion modeling evaluation in 2020 to assess potential off-site concentrations of pollutants dispersing from decontamination and decommissioning activities and operation of the On-Site Waste Disposal Facility (DOE 2020). As part of this modeling, DOE developed a screening level for each contaminant called a maximum acceptable ground level concentration. The maximum acceptable ground level concentration is a screening level with a safety factor that Ohio EPA believes will not cause significant adverse human or environmental impacts. Table 5.1 summarizes the metals monitored at PORTS, the maximum detected concentration of each metal in 2021, and the maximum acceptable ground level concentration. All metals detected in ambient air were less than the associated maximum acceptable ground level concentration.

Table 5.1. Metals monitored by DOE in PORTS ambient air

Metal	Maximum detected concentration (µg/m^3)	MAGLC (µg/m^3)	% of MAGLC
Antimony	0.0200	11.9	0.17%
Arsenic	0.00107	0.238	0.45%
Beryllium	0.000257	0.00119	22%
Cadmium	0.00206	0.0476	4.3%
Chromium	0.0833	1.19	6.0%
Cobalt	0.00324	0.476	0.68%
Lead	0.0590	1.19	5.0%
Manganese	0.0936	0.476	20%
Mercury	0.000247	0.595	0.042%
Nickel	0.150	2.38	6.3%
Selenium	0.00823	4.76	0.17%

Acronyms and abbreviations:
µg/m^3 = microgram per cubic meter
MAGLC = maximum acceptable ground level concentration

DOE data for the ambient air monitoring program are available in PEGASIS here. Ohio EPA provides air monitoring data to the public on their website here.

5.1.2.3 Volatile Organic Compounds

Volatile organic compounds are also present in ambient air, primarily due to exhaust from cars and trucks (especially diesel-powered vehicles), but also from power plants that burn coal or natural gas and from other industrial activities. DOE and Ohio EPA monitor ambient air for 20 volatile organic compounds designated by Ohio EPA as hazardous air pollutants. These volatile organic compounds are monitored because they may be present in soil excavated within the X-231A/B Oil Biodegradation Plots and X-740 groundwater plume (see Sections 3.3.1.3 and 3.3.3). These volatile organic compounds could be released to the air during soil excavation, treatment of water collected during the soil excavation, and other decontamination and decommissioning activities. One 24-hour sample is collected every six or 12 days, dependent on site activities, following the Ohio EPA sampling schedule.

Table 5.2 summarizes the volatile organic compounds monitored at PORTS and the maximum detected concentration of each volatile organic compound in 2021.

Table 5.2. Volatile organic compounds monitored by DOE in PORTS ambient air

Volatile organic compound	Maximum detected concentration[a]
1,1,1-Trichloroethane	0.106
1,1,2-Trichloroethane	0.121
1,1-Dichloroethane	0.100
1,1-Dichloroethene	0.114
1,2-Dichloroethane	0.106
1,4-Dioxane	0.313
2-Butanone	8.19
4-Methyl-2-pentanone	0.959
Benzene	0.546
Carbon disulfide	10.6
Carbon tetrachloride	0.192
Chloroethane	0.316
Chloroform	0.383
cis-1,2-Dichloroethene	0.269
Methylene chloride	22.1
Tetrachloroethene	3.9
Toluene	0.519
trans-1,2-Dichloroethene	0.103
Trichloroethene	0.533
Vinyl chloride	0.120

Note:
[a]Maximum detected concentrations are shown in parts per billion by volume.

The air dispersion modeling evaluation assessed potential off-site concentrations of volatile organic compounds dispersing from decontamination and decommissioning activities and operation of the On-Site Waste Disposal Facility (DOE 2020) and developed a screening level for volatile organic compounds known as the maximum acceptable ground level concentration. The maximum acceptable ground level concentration for volatile organic compounds is based on protective values established for trichloroethene, which is the predominant volatile organic compound for the site. The maximum acceptable ground level concentration for total volatile organic compounds is 1334 $\mu g/m^3$. Concentrations of volatile organic compounds detected in ambient air in 2021 are less than this screening level.

5.1.2.4 Fibers and Asbestos

Asbestos fibers could be present in ambient air because decontamination and decommissioning at PORTS includes removing asbestos-containing materials. Asbestos may also be present due to its use in vehicle brakes and clutches, and from demolition or renovation of older homes or other buildings with materials such as siding, insulation, and floor tile that contain asbestos.

Because asbestos fibers are not typically detected in outdoor ambient air, DOE and Ohio EPA monitor ambient air for fibers, which can be asbestos or non-asbestos. If fibers are detected in the sample, the sample is then further analyzed for asbestos fibers. One 24-hour sample is collected every six days following the Ohio EPA sampling schedule. Fibers were detected by DOE at all five air stations in 2021, and each sample with a positive detection of fibers was further analyzed for asbestos fibers. The analysis showed that the fibers detected in samples collected by DOE in 2021 did not include asbestos fibers.

5.1.3 On-Site Waste Disposal Facility

DOE initiated air monitoring at the On-Site Waste Disposal Facility in April 2021, and the On-Site Waste Disposal Facility began operating on May 25, 2021. The ambient air monitoring program for the On-Site Waste Disposal Facility is designed to measure particulate matter and hazardous air pollutants, which include selected metals and volatile organic compounds that are primarily associated with operation of the facility. The ambient air monitoring stations at the On-Site Waste Disposal Facility can also detect pollutants released by decontamination, decommissioning, and other site activities. Air monitoring data are collected to demonstrate compliance with regulatory standards and to verify that pollutants are not present at levels that pose a risk to workers, the public, or the environment. The *On-Site Waste Disposal Facility (OSWDF) Performance Standards Verification Plan* (DOE 2021b) describes the ambient air monitoring program.

Ambient air is monitored at eight locations around the perimeter of the On-Site Waste Disposal Facility project area. Results for ambient air monitoring in 2021 do not indicate any issues to be addressed in operating the On-Site Waste Disposal Facility or implementing decontamination and decommissioning at PORTS. The *2021 On-Site Waste Disposal Facility Annual Project Status Report* (DOE 2022b) and data collected in 2021 are available in PEGASIS here.

5.1.4 Fluoride

In 2021, samples for fluoride were collected weekly from 15 ambient air monitoring stations in and around PORTS (see Figure 4.3), including a background ambient air monitoring station (A37) located approximately 13 miles southwest of the plant.

Fluoride was not detected in 84 percent of the samples collected for the ambient air monitoring program in 2021. Concentrations of fluoride measured in samples collected at the background station (A37) ranged from below the analytical detection limit to 0.052 $\mu g/m^3$. Concentrations of fluoride measured in samples collected at the off-site stations near PORTS ranged from below analytical detection limits to an ambient concentration of 0.058 $\mu g/m^3$ at station A15, which is east-southeast of PORTS on Loop Road. This represents the maximum concentration of fluoride in ambient air in 2021. It is less than the maximum concentration detected in 2020, which was 0.097 $\mu g/m^3$ at station A12, east of PORTS on McCorkle Road.

There is no standard for fluoride in ambient air. Concentrations of fluoride in ambient air around PORTS are within the range of ambient background concentrations measured in the United States (Agency for Toxic Substances and Disease Registry 2003).

5.2 Water

PORTS meets the Clean Water Act regulations through NPDES permits granted by Ohio EPA for effluent discharges. Non-radiological surface water monitoring primarily consists of sampling water discharges associated with the Fluor-BWXT Portsmouth, Mid-America Conversion Services, and Centrus NPDES-permitted outfalls. Surface water is also monitored in the On-Site Waste Disposal Facility project area. PCBs are monitored in on-site surface water downstream from the cylinder storage yards.

Surface water and groundwater are monitored at PORTS. Groundwater monitoring is discussed in Chapter 6, along with additional surface water monitoring conducted as part of the integrated groundwater monitoring program.

5.2.1 Water Discharges via NPDES Outfalls

DOE contractors Fluor-BWXT Portsmouth and Mid-America Conversion Services were responsible for 20 NPDES discharge points (outfalls) or sampling points at PORTS in 2021. Centrus was responsible for three outfalls. This section describes non-radiological discharges from these outfalls during 2021.

5.2.1.1 Fluor-BWXT Portsmouth NPDES Outfalls

In 2021, Fluor-BWXT Portsmouth was responsible for 18 outfalls or sampling points (see Figure 4.2). Nine outfalls discharge directly to surface water, and six outfalls discharge to another outfall before leaving the site. Fluor-BWXT Portsmouth also monitors three additional sampling points that are not discharge locations.

Ohio EPA selects the chemical parameters that must be monitored at each outfall based on the chemical characteristics of the water that flows into the outfall. Ohio EPA also sets discharge limitations for some of these parameters. For example, some of the Fluor-BWXT Portsmouth outfalls discharge water from the groundwater treatment facilities; therefore, the outfalls are monitored for selected volatile organic compounds (*trans*-1,2-dichloroethene and trichloroethene) because the groundwater treatment facilities treat water contaminated with volatile organic compounds. The following chemicals and water quality parameters were monitored at each Fluor-BWXT Portsmouth outfall in 2021:

- Fluor-BWXT Portsmouth NPDES Outfall 001 (X-230J7 East Holding Pond) – cadmium, chlorine, copper, total filterable residue (dissolved solids), fluoride, mercury, oil and grease, pH, silver, total suspended solids, and zinc
- Fluor-BWXT Portsmouth NPDES Outfall 002 (X-230K South Holding Pond) – bis(2-ethylhexyl)phthalate, cadmium, fluoride, mercury, ammonia-nitrogen, oil and grease, pH, selenium, silver, total suspended solids, and thallium
- Fluor-BWXT Portsmouth NPDES Outfall 003 (X-6619 Sewage Treatment Plant) – acute toxicity, ammonia-nitrogen, carbonaceous biochemical oxygen demand, copper, E. coli (May-October only), mercury, nitrite + nitrate, oil and grease, pH, silver, thallium, total suspended solids, and zinc
- Fluor-BWXT Portsmouth NPDES Outfall 004 (Cooling Tower Blowdown) – acute toxicity, beryllium, cadmium, chlorine, chromium, cobalt, copper, total filterable residue (dissolved solids), fluoride, mercury, nickel, oil and grease, total PCBs, pH, selenium, silver, total suspended solids, vanadium, and zinc
- Fluor-BWXT Portsmouth NPDES Outfall 005 (X-611B Lime Sludge Lagoon) – lead, mercury, pH, selenium, and total suspended solids

- Fluor-BWXT Portsmouth NPDES Outfall 009 (X-230L North Holding Pond) – bis(2-ethylhexyl)phthalate, chromium, copper, fluoride, iron, mercury, oil and grease, total PCBs, pH, silver, thallium, trichloroethene, total suspended solids, and zinc
- Fluor-BWXT Portsmouth NPDES Outfall 010 (X-230J5 Northwest Holding Pond) – chromium, copper, iron, lead, mercury, oil and grease, total PCBs, pH, selenium, thallium, total suspended solids, trichloroethene, and zinc
- Fluor-BWXT Portsmouth NPDES Outfall 011 (X-230J6 Northeast Holding Pond) – cadmium, chlorine, chromium, copper, fluoride, oil and grease, total PCBs, pH, selenium, total suspended solids, thallium, trichloroethene, and zinc
- Fluor-BWXT Portsmouth NPDES Outfall 015 (X-624 Groundwater Treatment Facility) – arsenic, barium, total PCBs, pH, silver, and trichloroethene
- Fluor-BWXT Portsmouth NPDES Outfall 602 (X-621 Coal Pile Runoff Treatment Facility) – iron, manganese, pH, and residue (settleable), total suspended solids
- Fluor-BWXT Portsmouth NPDES Outfall 604 (X-700 Biodenitrification Facility) – copper, iron, nickel, nitrate-nitrogen, pH, and zinc
- Fluor-BWXT Portsmouth NPDES Outfall 605 (X-705 Decontamination Microfiltration System) – ammonia-nitrogen, chromium, hexavalent chromium, copper, Kjeldahl nitrogen, nickel, nitrate-nitrogen, nitrite-nitrogen, oil and grease, pH, sulfate, total suspended solids, trichloroethene, and zinc
- Fluor-BWXT Portsmouth NPDES Outfall 608 (X-622 Groundwater Treatment Facility) – trichloroethene, pH, and *trans*-1,2-dichloroethene
- Fluor-BWXT Portsmouth NPDES Outfall 610 (X-623 Groundwater Treatment Facility) – trichloroethene, pH, and *trans*-1,2-dichloroethene
- Fluor-BWXT Portsmouth NPDES Outfall 611 (X-627 Groundwater Treatment Facility) – pH and trichloroethene

As noted above, the Fluor-BWXT Portsmouth NPDES permit also identifies additional monitoring points that are not discharge points. Fluor-BWXT Portsmouth NPDES Station Number 801 is a surface water background monitoring location on the Scioto River upstream from Fluor-BWXT Portsmouth NPDES Outfalls 003 and 004. Samples are collected from this monitoring point to measure toxicity to minnows and another aquatic organism, *Ceriodaphnia*.

Fluor-BWXT Portsmouth NPDES Station Number 902 is a monitoring location on Little Beaver Creek downstream from Outfall 001. Fluor-BWXT Portsmouth NPDES Station Number 903 is a monitoring location on Big Run Creek downstream from Outfall 002. Water temperature is the only parameter measured at these two monitoring points.

The monitoring data detailed in the previous paragraphs are submitted to Ohio EPA in a monthly discharge monitoring report. These monthly discharge monitoring reports are provided to the public on the PEGASIS website here. Discharge limitations at the Fluor-BWXT Portsmouth NPDES monitoring locations were exceeded on 24 occasions in 2021. The overall Fluor-BWXT Portsmouth NPDES compliance rate with the NPDES permit was 99 percent. Section 2.4.1 provides more information about these exceedances.

5.2.1.2 Mid-America Conversion Services NPDES Outfalls

Mid-America Conversion Services is responsible for the NPDES permit for the discharge of process wastewaters from the DUF_6 Conversion Facility. The Mid-America Conversion Services NPDES permit provides monitoring requirements for two outfalls: Mid-America Conversion Services Outfall 001 and Mid-America Conversion Services Outfall 602. Figure 4.2 shows the location of these NPDES outfalls.

Monitoring requirements for Mid-America Conversion Services Outfall 001 are effective only when process wastewater is discharged through the outfall. No process wastewater was discharged through Outfall 001 in 2021; therefore, no monitoring was required.

Mid-America Conversion Services Outfall 602 monitors the discharge of process wastewater to the sanitary sewer, which flows to the X-6619 Sewage Treatment Plant that discharges through Fluor-BWXT Portsmouth NPDES Outfall 003. Process wastewater discharged from Mid-America Conversion Services Outfall 602 was monitored for pH and total flow.

The monitoring data collected in accordance with the Mid-America Conversion Services permit are submitted to Ohio EPA in a monthly discharge monitoring report. No exceedances of permit limitations at Mid-America Conversion Services Outfall 602 occurred during 2021 and there were no discharges through Outfall 001; therefore, the overall Mid-America Conversion Services compliance rate with the NPDES permit was 100 percent.

5.2.1.3 Centrus NPDES Outfalls

Centrus is responsible for three NPDES outfalls through which water is discharged from the site. These are shown in Figure 4.2. Two outfalls discharge directly to surface water, and one outfall discharges to Fluor-BWXT Portsmouth NPDES Outfall 003 before leaving the site. The following chemicals and water quality parameters are monitored at each outfall:

- Centrus NPDES Outfall 012 (X-2230M Southwest Holding Pond) – chlorine, mercury, oil and grease, pH, suspended solids, and total PCBs
- Centrus NPDES Outfall 013 (X-2230N West Holding Pond) – barium, cadmium, chlorine, copper, mercury, oil and grease, pH, suspended solids, total PCBs, and zinc
- Centrus NPDES Outfall 613 (X-6002A Recirculating Hot Water Plant particle separator) – chlorine and suspended solids

The monitoring data are submitted to Ohio EPA in a monthly discharge monitoring report. In May 2021, Centrus exceeded the daily and monthly permit limitations for suspended solids at Outfall 013 due to a culvert failure. Repairs were made and there were no additional exceedances in 2021. The overall Centrus compliance rate with the NPDES permit in 2021 was 99%.

5.2.2 On-Site Waste Disposal Facility Surface Water Monitoring

The On-Site Waste Disposal Facility began operating in May 2021. The *On-Site Waste Disposal Facility (OSWDF) Performance Standards Verification Plan* (DOE 2021b) describes the monitoring program developed to ensure that performance standards for protection of human health and the environment are met during operation of the facility. Surface water monitoring is designed to monitor the impact of waste handling activities associated with the On-Site Waste Disposal Facility on surface water within and flowing from the area. Two types of surface water monitoring are conducted: storm water discharge monitoring and surface water environmental surveillance monitoring.

Storm water discharge monitoring occurs at the discharge point of sedimentation and detention basins and ponds. This monitoring focuses on conventional industrial pollutants associated with activities supporting landfill operations that are conducted in the drainage area such as equipment storage and laydown, vehicle traffic, and maintenance. Four storm water discharge locations were monitored in 2021 for pH, oil and grease, total suspended solids, cadmium, chromium, lead, and mercury. Data collected for the storm water discharges in 2021 did not identify any issues to be addressed in the operation of the On-Site Waste Disposal Facility. The *2021 On-Site Waste Disposal Facility Annual Project Status Report* (DOE 2022b) and data collected in 2021 are available on the PEGASIS website here.

Surface water environmental surveillance monitoring is conducted downstream of discharges from sedimentation ponds and at locations downstream from areas where surface water runoff directly enters streams on the periphery of the On-Site Waste Disposal Facility. These locations include tributaries to Little Beaver Creek and Big Beaver Creek that may have continuous or intermittent flow.

Eight locations were monitored in 2021 for PCBs and chlorinated organics. Data collected at the On-Site Waste Disposal Facility surface water sampling locations in 2021 did not identify any issues to be addressed in the operation of the On-Site Waste Disposal Facility. The *2021 On-Site Waste Disposal Facility Annual Project Status Report* (DOE 2022b) and data collected in 2021 are available on the PEGASIS website here.

5.2.3 Surface Water Monitoring Associated with Cylinder Storage Yards

Both filtered and unfiltered surface water samples are collected quarterly from four locations in the drainage basins downstream from the Mid-America Conversion Services X-745C, X-745E, and X-745G Cylinder Storage Yards (UDS X01, RM-8, UDS X02, and RM-10) shown in Figure 4.2. These locations are on the PORTS site and are not accessible to the public. Samples are analyzed for PCBs. PCBs were not detected in any of the surface water samples (filtered or unfiltered) collected during 2021. Section 5.3.2 presents the results for sediment samples collected as part of this program.

5.3 Sediment

In 2021, sediment monitoring at PORTS included local streams and the Scioto River upstream and downstream from PORTS and drainage basins downstream from the Mid-America Conversion Services cylinder storage yards.

5.3.1 Local Sediment Monitoring

Sediment is sampled annually as specified in the *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2017c). Samples are collected at the same locations upstream and downstream from PORTS where local surface water samples are collected, at the NPDES outfalls on the east and west sides of PORTS, and at a location on Big Beaver Creek upstream from the confluence with Little Beaver Creek (see Figure 4.6). In 2021, samples were analyzed for 20 metals and PCBs, in addition to the radiological parameters discussed in Chapter 4.

PCBs were detected at three on-site and five off-site sampling locations. Samples collected on site from Little Beaver Creek (RM-8), West Drainage Ditch (RM-10), and East Drainage Ditch (RM-11) contained PCBs at concentrations ranging from 23.4 to 76 micrograms per kilogram (µg/kg) or parts per billion (ppb). PCBs were also detected at the off-site sampling locations on Little Beaver Creek (RM-7), Big Beaver Creek (RM-13), Big Run Creek (RM-2), and the Scioto River (RM-6 and RM-1A) at concentrations ranging from 5.75 to 59.7 µg/kg. The concentrations of PCBs detected in the samples are less than the 240 µg/kg risk-based regional screening level for PCB-1254/1260 developed by US EPA and utilized by Ohio EPA (US EPA 2020).

The results of metals sampling conducted in 2021 indicate that no appreciable differences are evident in the concentrations of metals present in sediment samples taken upstream from PORTS and downstream from PORTS. Because metals occur naturally in the environment, the metals detected in the samples most likely did not result from activities at PORTS.

5.3.2 Sediment Monitoring Associated with Cylinder Storage Yards

Sediment samples are collected quarterly from four locations in the drainage basins downstream from the Mid-America Conversion Services X-745C, X-745E, and X-745G Cylinder Storage Yards (UDS X01, RM-8, UDS X02, and RM-10) and analyzed for PCBs. These locations, shown in Figure 4.2, are on the PORTS site and are not accessible to the public.

In 2021, PCBs were detected in at least one of the sediment samples collected at each location. The maximum concentration of PCBs (202.6 µg/kg) was detected in the third quarter sample collected at sampling location UDS X02. The concentrations of PCBs detected in 2021 are below the 1 ppm (1000 µg/kg) reference value set forth in the US EPA Region 5 *TSCA Approval for Storage for Disposal of PCB Bulk Product (Mixed) Waste.* This reference applies to the storage of DUF_6 cylinders at PORTS, which may have paint on the exterior of the cylinders that contains more than 50 ppm PCBs. None of the samples contained PCBs above the 240 µg/kg (ppb) risk-based regional screening level for PCB-1254/1260 developed by US EPA and utilized by Ohio EPA (US EPA 2020). Section 5.2.2 presents the results for surface water samples collected as part of this program.

5.4 Biota

Fish samples are collected annually, if available, from the following locations:

- Little Beaver Creek (RW-8): on site at PORTS
- Big Beaver Creek (RW-15): off site upstream from the confluence with Little Beaver Creek
- Big Beaver Creek (RW-13): off site downstream from the confluence with Little Beaver Creek
- Scioto River (RW-1A): off site downstream from PORTS water discharges
- Scioto River (RW-6): off site upstream from PORTS water discharges at Piketon

In 2021, bass were caught in Big Beaver Creek at RW-13, Little Beaver Creek at RW-8, and the Scioto River at RW-1A at the surface water monitoring locations indicated in Figure 4.4. Fish samples were analyzed for PCBs in addition to the radiological parameters discussed in Chapter 4. Fish samples collected for this program included only the fish fillet—that is, only the portion of the fish that would be eaten by a person. Two samples of fish were analyzed from the bass caught at RW-8.

Table 5.3 summarizes the results of the PCB sampling for 2021 and compares the results to suggested consumption limits from the State of Ohio.

Table 5.3. PCB results in fish and Ohio advisory consumption limits

Ohio advisory consumption limits for PCBs in fish		
Unrestricted Less than 50 µg/kg	**1 meal/week 50-220 µg/kg**	**1 meal/month 220-1000 µg/kg**
RW-1A PCBs: 6.83 µg/kg RW-13 PCBs: 36.1 µg/kg	RW-8 (regular sample) PCBs: 89.6 µg/kg RW-8 (duplicate sample) PCBs: 68.2 µg/kg	

Note:
Source: *State of Ohio Cooperative Fish Tissue Monitoring Program Sport Fish Tissue Consumption Advisory Program* (Ohio EPA 2010).

The Ohio Sport Fish Consumption Advisory (Ohio Department of Health 2021), which advises the public on consumption limits for sport fish caught from all water bodies in Ohio, should be consulted before eating any fish caught in Ohio waters. The advisory recommends a limit of one meal per month for white bass (12 inches and over), common carp, and channel or flathead catfish caught in the Scioto River in Pike and Scioto Counties due to mercury and PCB contamination. The Ohio Department of Health advises limiting consumption of sport fish caught from all waterbodies in Ohio to one meal per week, unless there is a more or less restrictive advisory.

6. Groundwater Protection Programs

Groundwater monitoring at PORTS is required by a combination of state and federal regulations, legal agreements with Ohio EPA, and DOE Orders. Over 300 monitoring wells are used to track the flow of groundwater and to identify and measure groundwater contaminants.

Groundwater monitoring detects the nature and extent of contamination at PORTS, including the types and concentrations of contaminants, and determines the movement of groundwater at the plant. Data obtained from groundwater monitoring support the decision-making process for the ultimate disposition of the contaminants.

This chapter provides an overview of groundwater monitoring at PORTS and presents the results of the groundwater monitoring programs for 2021. Section 3.4 includes additional information about the remedial actions implemented at a number of the areas discussed in this chapter to reduce or eliminate groundwater contamination. This chapter also includes information on the groundwater treatment facilities at PORTS. These facilities receive contaminated groundwater from the groundwater monitoring areas and treat the water prior to discharge through the permitted Fluor-BWXT Portsmouth NPDES outfalls. Visit the PEGASIS website here to view historical data for monitoring wells and groundwater locations at PORTS.

6.1 Geology and Uses of Groundwater

Two water-bearing zones are present beneath the industrialized portion of PORTS that includes the former gaseous diffusion process buildings: the Gallia and Berea formations. The Gallia is the uppermost water-bearing zone and contains most of the groundwater contamination at PORTS. The Berea is deeper than the Gallia and is usually separated from the Gallia by the Sunbury shale, which acts as a barrier to impede groundwater flow between the Gallia and Berea formations. The *2021 Groundwater Monitoring Report* (DOE 2022a) includes additional information about the geology of the industrialized portion of PORTS and is available on the PEGASIS website here.

The On-Site Waste Disposal Facility is in an upland area in the northeast portion of PORTS. The Cuyahoga and Berea formations are the primary water-bearing zones in this area. The Gallia is not present beneath the On-Site Waste Disposal Facility. The Berea is deeper than the Cuyahoga, and the Sunbury shale impedes groundwater flow between the Cuyahoga and Berea formations. The *2021 On-Site Waste Disposal Facility Annual Project Status Report* (DOE 2022b), which includes additional information about the geology of the On-Site Waste Disposal Facility project area, is available on the PEGASIS website here.

Groundwater directly beneath PORTS is not used as a domestic, municipal, or industrial water supply, and contaminants in the groundwater beneath PORTS do not affect the quality of the water in the Scioto River Valley buried aquifer. PORTS is the largest industrial user of water in the vicinity; it obtains water from water supply well fields north and west of PORTS in the Scioto River Valley buried aquifer. DOE has filed a deed notification at the Pike County Auditor's Office that restricts the use of groundwater beneath the PORTS site.

6.2 Groundwater Monitoring Programs

Monitoring wells are used extensively at PORTS to assess the effect of site operations on groundwater quality. Groundwater monitoring at PORTS began in the 1980s and has been conducted in response to state and federal regulations, regulatory documents prepared by DOE, agreements between DOE and Ohio EPA or US EPA, and DOE orders. Groundwater monitoring to meet DOE order requirements includes exit pathway monitoring, which assesses the effect of PORTS on off-site groundwater quality. DOE orders are also the basis for radiological monitoring of groundwater at PORTS. The groundwater monitoring program consists of routine compliance and facility monitoring designed to protect public health and the environment.

Groundwater monitoring at PORTS involves collecting samples of water from groundwater monitoring wells and analyzing them to obtain information about contaminants and naturally-occurring compounds. Monitoring wells also provide other information about groundwater. When the level of water, or groundwater elevation, is measured in a number of wells over a short period of time, the groundwater elevations combined with information about the subsurface soil can be used to estimate the rate and direction of groundwater flow. The rate and direction of groundwater flow can predict the movement of contaminants in the groundwater and this information can be used to develop ways to control or remediate groundwater contamination.

6.2.1 On-Site Waste Disposal Facility

Figure 6.1 shows the On-Site Waste Disposal Facility in the northeast portion of PORTS, which began operating in May 2021. Groundwater monitoring wells have been installed around the On-Site Waste Disposal Facility and are sampled in accordance with the *On-Site Waste Disposal Facility (OSWDF) Performance Standards Verification Plan* (DOE 2021b). This plan describes the monitoring program developed to ensure that operation of the On-Site Waste Disposal Facility meets performance standards for protection of human health and the environment. Ohio EPA concurred with the *On-Site Waste Disposal Facility (OSWDF) Performance Standards Verification Plan*.

6.2.2 Integrated Groundwater Monitoring

The PORTS *Integrated Groundwater Monitoring Plan* was developed during the 1990s to address the regulatory groundwater monitoring requirements applicable to PORTS at that time. The initial plan was approved by Ohio EPA and implemented at PORTS starting in April 1999. The *Integrated Groundwater Monitoring Plan* is periodically revised by DOE and approved by Ohio EPA, and an annual groundwater report is submitted to Ohio EPA in accordance with the plan.

The *Integrated Groundwater Monitoring Plan* (DOE 2021a) requires groundwater monitoring of 14 areas in the quadrants of the site designated by the RCRA Corrective Action Program. Figure 6.1 shows Quadrants I through IV and the groundwater monitoring areas. The *Integrated Groundwater Monitoring Plan* also requires surface water monitoring in creeks and drainage ditches at PORTS that receive groundwater discharge, along with water supply monitoring.

In general, samples are collected from wells or surface water locations and analyzed for metals, volatile organic compounds, and radionuclides. Constituents detected in the groundwater are then compared to standards called preliminary remediation goals to assess the potential for each constituent to affect human health and the environment. Preliminary remediation goals are initial cleanup goals developed early in the decision-making process that are protective of human health and the environment, and they comply with the applicable or relevant and appropriate requirements of state and federal agencies. Preliminary remediation goals are intended to satisfy regulatory cleanup requirements. Preliminary remediation goals for groundwater at PORTS are the maximum contaminant levels in the Ohio EPA drinking water standards.

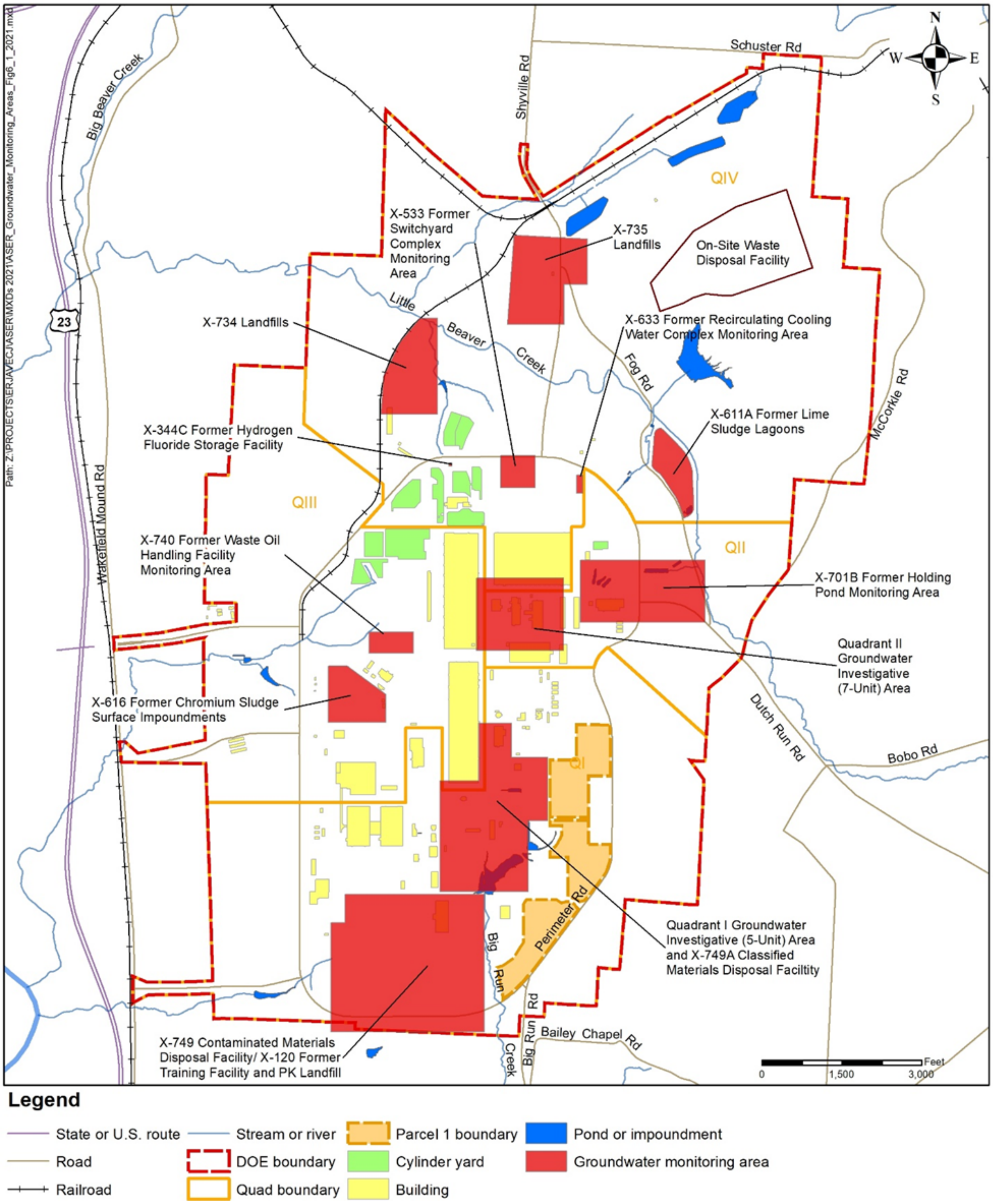


Figure 6.1. Groundwater monitoring areas

Groundwater contamination usually consists of trichloroethene and other volatile organic compounds. Five areas of groundwater contamination, or groundwater plumes, have been identified at PORTS: the X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility, the Quadrant I Groundwater Investigative (5-Unit) Area, the Quadrant II Groundwater Investigative (7-Unit) Area, and the X-701B Former Holding Pond. The fifth groundwater plume at PORTS, the X-740 groundwater plume, was excavated in 2021 in accordance with *The July 30, 2018 Director's Final Findings and Orders for CERCLA Actions to Restore Natural Resources* (Ohio EPA 2018). Other areas are monitored to evaluate groundwater contaminated with metals, to ensure past uses of the area (such as a landfill) have not caused groundwater contamination, or to assess the effectiveness of remediation that has taken place in the area.

6.2.3 Exit Pathway Monitoring

Exit pathway monitoring assesses the effect of the facility on off-site surface water and groundwater quality. The *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2017c) specifies the groundwater monitoring wells and surface water sampling locations near the PORTS boundary that comprise the exit pathway monitoring program. Selected locations on local streams and drainage channels near the PORTS boundary are sampling points of the exit pathway monitoring program because surface water from PORTS NPDES outfalls and groundwater discharge to these surface waters. Monitoring wells near the PORTS boundary are also used in the exit pathway monitoring program. All but one of these sampling locations are also part of the integrated groundwater monitoring program.

6.3 Groundwater Monitoring Results

This section discusses groundwater monitoring results for 2021 for the On-Site Waste Disposal Facility, groundwater monitoring completed in accordance with the *Integrated Groundwater Monitoring Plan* (DOE 2021a), and the exit pathway monitoring program.

6.3.1 On-Site Waste Disposal Facility

Groundwater monitoring at the On-Site Waste Disposal Facility in 2021 was completed in accordance with the *On-Site Waste Disposal Facility (OSWDF) Performance Standards Verification Plan* (DOE 2021b). Twenty-two wells were sampled for organic compounds, statistical indicator parameters, and radionuclides. Data collected in 2021 did not identify any issues that affect the performance or operation of the On-Site Waste Disposal Facility. The *2021 On-Site Waste Disposal Facility Annual Project Status Report* (DOE 2022b) and data collected in 2021 are available on the PEGASIS website here.

6.3.2 Integrated Groundwater Monitoring

Groundwater monitoring in 2021 was completed in accordance with the *Integrated Groundwater Monitoring Plan* dated January 2021 (DOE 2021a). Over 300 wells were sampled for a variety of metals, organic compounds, statistical indicator parameters, water quality parameters, and radionuclides.

The following sections summarize results for the PORTS trichloroethene groundwater plumes, other monitoring areas, surface water monitoring required by the *Integrated Groundwater Monitoring Plan* (DOE 2021a), and water supply monitoring. The *2021 Groundwater Monitoring Report* (DOE 2022a) includes additional information about the monitoring areas and complete data for 2021. The report is available on the PEGASIS website here.

6.3.2.1 Quadrant I Groundwater Monitoring

Quadrant I groundwater monitoring includes investigation and monitoring of the X-749 Contaminated Disposal Facility/X-120 Former Training Facility, PK Landfill, Groundwater Investigative (5-Unit) Area, and X-749A Classified Materials Disposal Facility.

Quadrant I X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility

The most extensive and most concentrated constituents associated with the X-749/X-120 plume are volatile organic compounds, particularly trichloroethene. Figure 6.2 shows the trichloroethene groundwater plume for the X-749/X-120 area for 2021 and the 5-year trends in trichloroethene concentrations for selected wells. In general, the concentrations of trichloroethene in the plume wells and the overall extent of the plume are slowly decreasing.

Extraction wells in the X-749/X-120 groundwater plume continue to control the plume and remove trichloroethene. Volatile organic compounds were not detected in 2021 in any of the off-site monitoring wells at the southern edge of the monitoring area.

The southeastern portion of the plume shrank in 2021 based on the fourth quarter detection of trichloroethene in well X749-13G at 4.04 µg/L. Concentrations of trichloroethene in well X749-13G fluctuated just above and below 5 µg/L (the definition of the plume perimeter) in 2019, 2020, and 2021.

Trichloroethene decreased to less than 100 µg/L in two wells north of the X-749 Landfill: X749-04G and X749-115G. These are the first detections less than 100 µg/L in both of these wells. At the end of 2021, the only well in the area immediately north of the X-749 Landfill with concentrations of trichloroethene greater than 100 µg/L was well PK-09G at 353 µg/L.

On the northwestern perimeter of the plume, trichloroethene continued to increase in well X749-40G as shown on Figure 6.2. The area in the western portion of the plume where trichloroethene concentrations are less than 5 µg/L (the definition of the plume perimeter) changed in 2021. Trichloroethene increased to 10.8 µg/L in well X120-05G, which defines the northern edge of this area. Trichloroethene decreased to 4.79 µg/L in well X749-29G, which defines the eastern edge of the area, and this was the first detection less than 5 µg/L in this well. On the southern edge of the area, trichloroethene increased to 5.12 µg/L in well X749-36G. Concentrations of trichloroethene in well X749-36G have varied above and below 5 µg/L in the last five years.

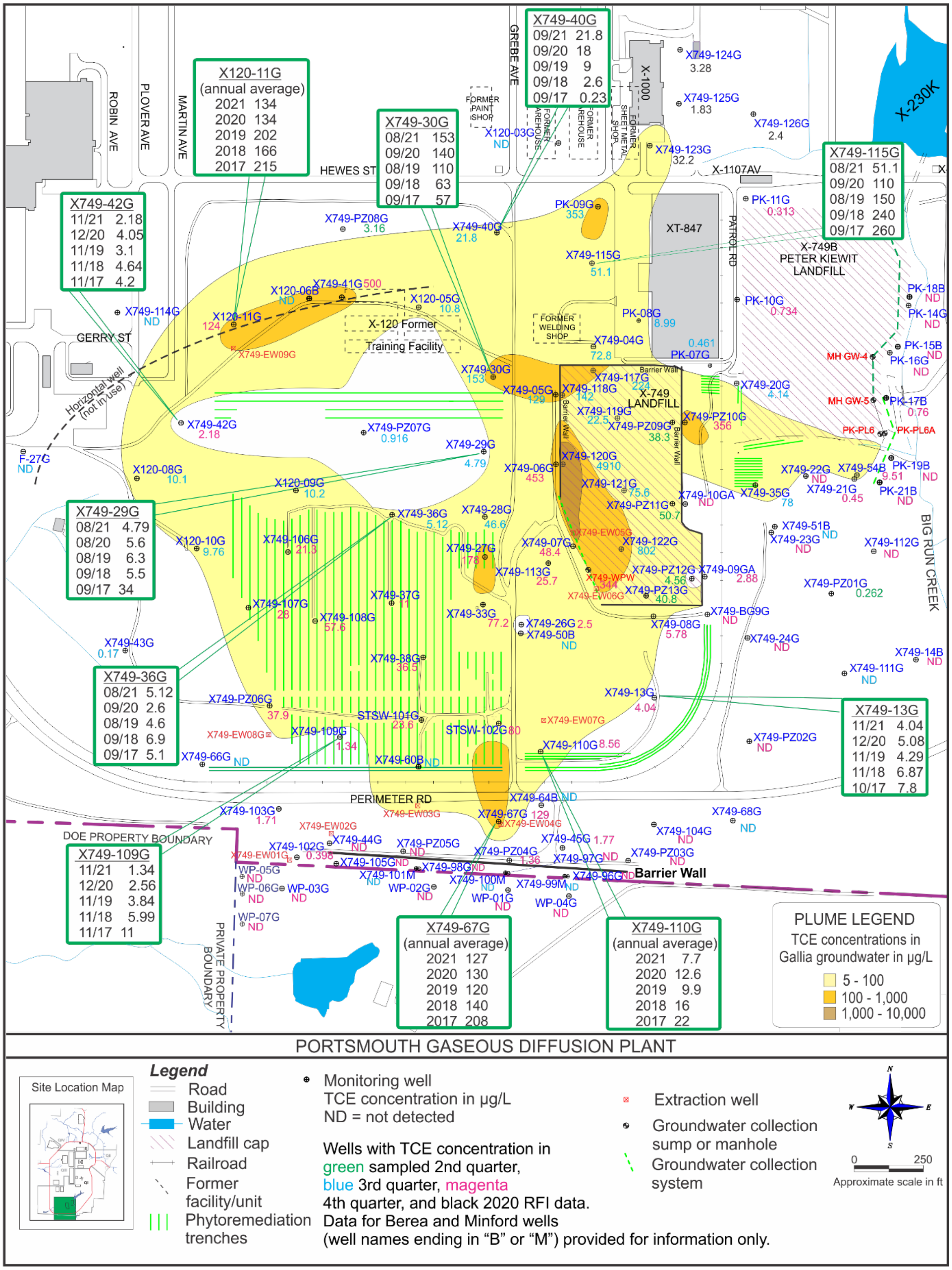


Figure 6.2. Gallia groundwater plume contaminated with trichloroethene at the X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility in 2021

Quadrant I PK Landfill

The PK Landfill is on the east side of the X-749/X-120 groundwater plume, but is not part of the plume (see Figure 6.2). DOE monitors groundwater at the PK Landfill for volatile organic compounds and selected metals. In 2021, vinyl chloride was detected in samples collected from two wells at concentrations that exceeded the preliminary remediation goal of 2 µg/L. These results were consistent with data collected in previous years.

Quadrant I Groundwater Investigative (5-Unit) Area

A contaminated groundwater plume is associated with the Quadrant I Groundwater Investigative (5-Unit) Area. The plume consists primarily of trichloroethene, though other volatile organic compounds are also present. Figure 6.3 shows the trichloroethene groundwater plume for the Quadrant I Groundwater Investigative (5-Unit) Area for 2021 and the 5-year trends in trichloroethene concentrations for selected wells.

Concentrations of trichloroethene continue to vary in wells that monitor the northern portion of the plume near the former X-760 and X-770 Buildings and the X-710 Technical Services Building. Trichloroethene in well X760-03G increased in 2021 to 159 µg/L from 60 µg/L in 2020. However, trichloroethene decreased in well X231B-36G, which monitors the northern portion of the plume on the south side of the X-710 Technical Services Building. Trichloroethene was detected at 643 µg/L in 2021, down from 1,100 µg/L in 2020. Trichloroethene also decreased in well X770-17GA in 2021.

Trichloroethene increased in well X231B-29G, which is located between the X-326 Process Building and the former X-770 Building and is sampled every two years. Trichloroethene was detected at 91.6 µg/L in 2021, an increase from 12 µg/L in 2019 and 4.5 µg/L in 2017.

No other significant changes in trichloroethene concentrations were identified in wells that monitor the Quadrant I Groundwater Investigative (5-Unit) Area in 2021. Groundwater monitoring in the area has been and will continue to be affected by decontamination and decommissioning of the X-326 Process Building and excavation of areas within the groundwater plume. Sections 3.3.1 and 3.4.1.3 provide more information about these activities.

Quadrant I X-749A Classified Materials Disposal Facility

The X-749A Classified Materials Disposal Facility, also known as the X-749A Landfill, is on the east side of the Quadrant I Groundwater Investigative (5-Unit) Area, but is not a part of the groundwater plume in this area (see Figure 6.3). The X-749A Landfill is assessed by a detection monitoring program that uses statistics to determine whether a release has occurred at the landfill. No releases were identified at the X749A Landfill in 2021.

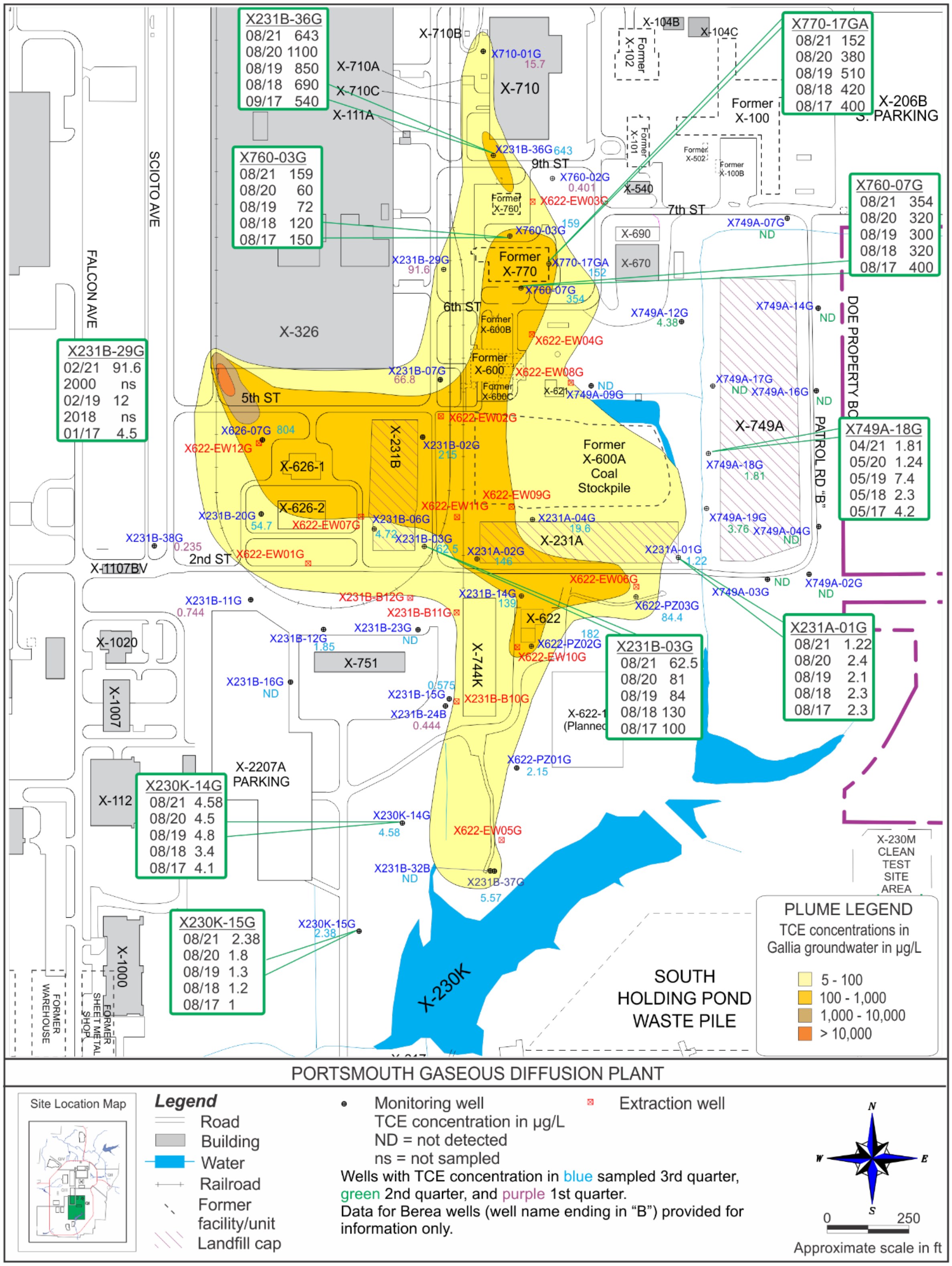


Figure 6.3. Gallia groundwater plume contaminated with trichloroethene at the Quadrant I Groundwater Investigative (5-Unit) Area in 2021

6.3.2.2 Quadrant II Groundwater Monitoring

Quadrant II groundwater monitoring includes investigation and monitoring of the Groundwater Investigative (7-Unit) area, X-701B Former Holding Pond, and X-633 Former Recirculating Cooling Water Complex.

Quadrant II Groundwater Investigative (7-Unit) Area

A contaminated groundwater plume consisting primarily of trichloroethene is associated with the Quadrant II Groundwater Investigative (7-Unit) Area. Figure 6.4 shows the trichloroethene groundwater plume for this area in 2021 and the 5-year trends in trichloroethene concentrations for selected wells. Concentrations of trichloroethene in the plume are stable or decreasing slightly, with one exception. Trichloroethene is increasing in well X701-45G, which monitors the southern perimeter of the plume, with a concentration of 24.9 µg/L in 2021.

Quadrant II X-701B Former Holding Pond

A contaminated groundwater plume of trichloroethene and other volatile organic compounds is located in the X-701B Former Holding Pond area. Figure 6.5 shows the trichloroethene groundwater plume for this area for 2021 and the 5-year trends in trichloroethene concentrations for selected wells.

Concentrations of trichloroethene are increasing on the north edge of the X-701B plume. The concentration of trichloroethene detected in well X701-42G remained high, at 3,990 µg/L, in 2021. Trichloroethene also increased in well X230J7-02GA, located immediately south of the X-230J7 Holding Pond. Typical detections in 2017, 2018, and 2019 were less than 600 µg/L. In 2021, trichloroethene was detected in well X230J7-02GA at 6,140 µg/L. Figure 6.5 shows the 5-year trends in trichloroethene in these two wells.

Trichloroethene is decreasing in many of the wells that monitor the western portion of the X-701B plume. Prior to 2019, trichloroethene was detected at concentrations greater than 100,000 µg/L in three wells: X701-130G, X701-TC28G, and X701-TC61G. Since 2019, trichloroethene decreased to less than 100,000 µg/L in each well, although concentrations have varied above and below 100,000 µg/L in the first and third quarter samples collected from well X701-TC28G.

Trichloroethene is increasing in three wells in the southern portion of the plume: X701-19G, X701-23G, and X701-79G. Trichloroethene was detected at 8.78 µg/L in the sample collected from well X701-19G, which monitors the southern edge of the plume. Trichloroethene was not detected in this well prior to the third quarter of 2018. Trichloroethene has increased in well X701-23G from 5.6 µg/L in 2017 to 15.2 µg/L in 2021. Trichloroethene has increased in well X701-79G from 230 µg/L in 2017 to 419 µg/L in 2021. Figure 6.5 shows the 5-year trends in trichloroethene in these three wells.

Technetium-99 was detected at 1,070 pCi/L in well X701-BW2G, which is immediately south of the former X-701B Holding Pond. This detection is above the Ohio EPA drinking water standard of 900 pCi/L for technetium-99, which is based on a 4 mrem/year dose from beta emitters. Uranium was detected at concentrations ranging from 33.6 to 63.4 µg/L in samples collected from three wells installed in the interim remedial measure treatment area. These detections are above the 30 µg/L Ohio EPA drinking water standard for uranium. These detections of technetium-99 and uranium were consistent with data collected in previous years.

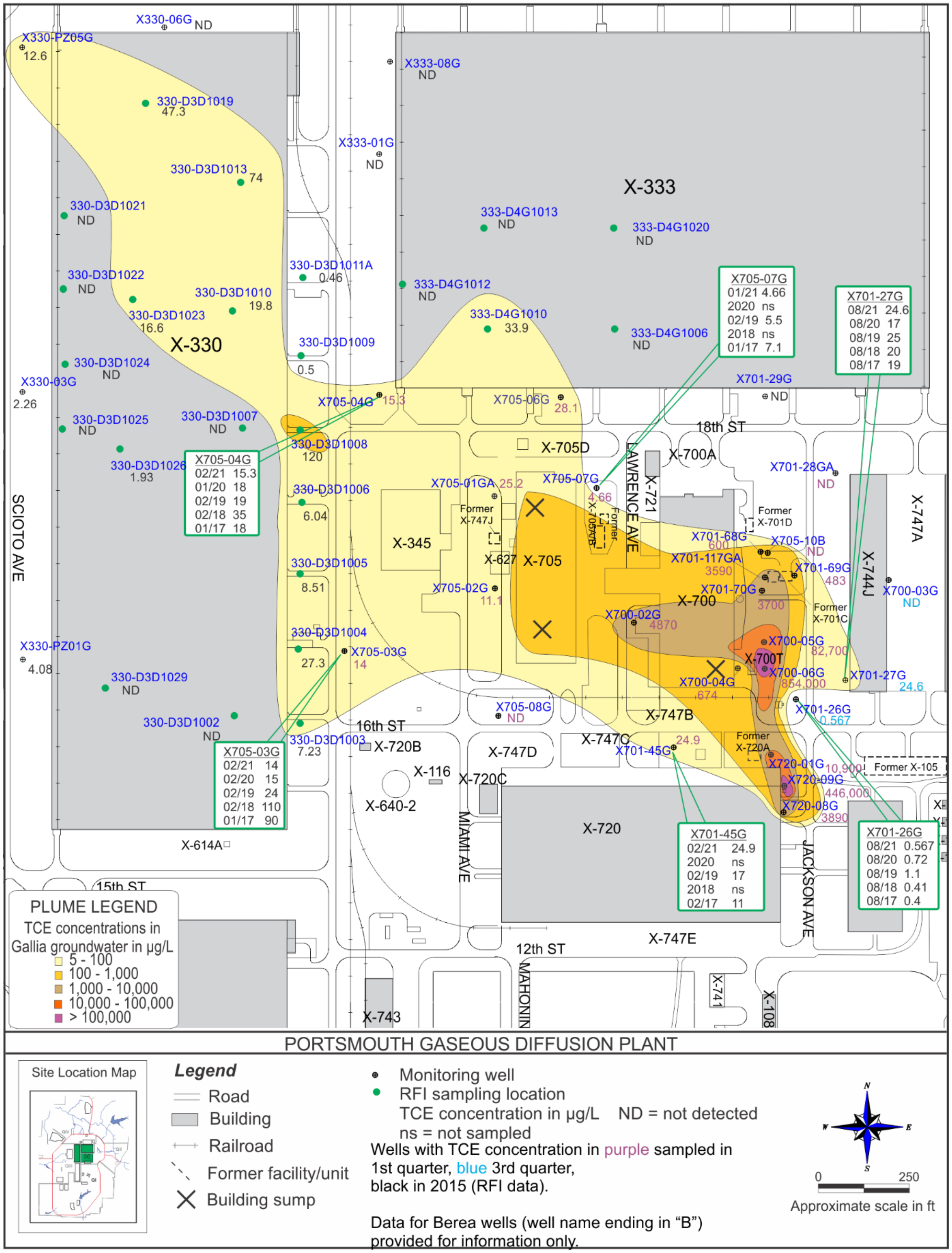


Figure 6.4. Gallia groundwater plume contaminated with trichloroethene at the Quadrant II Groundwater Investigative (7-Unit) Area in 2021

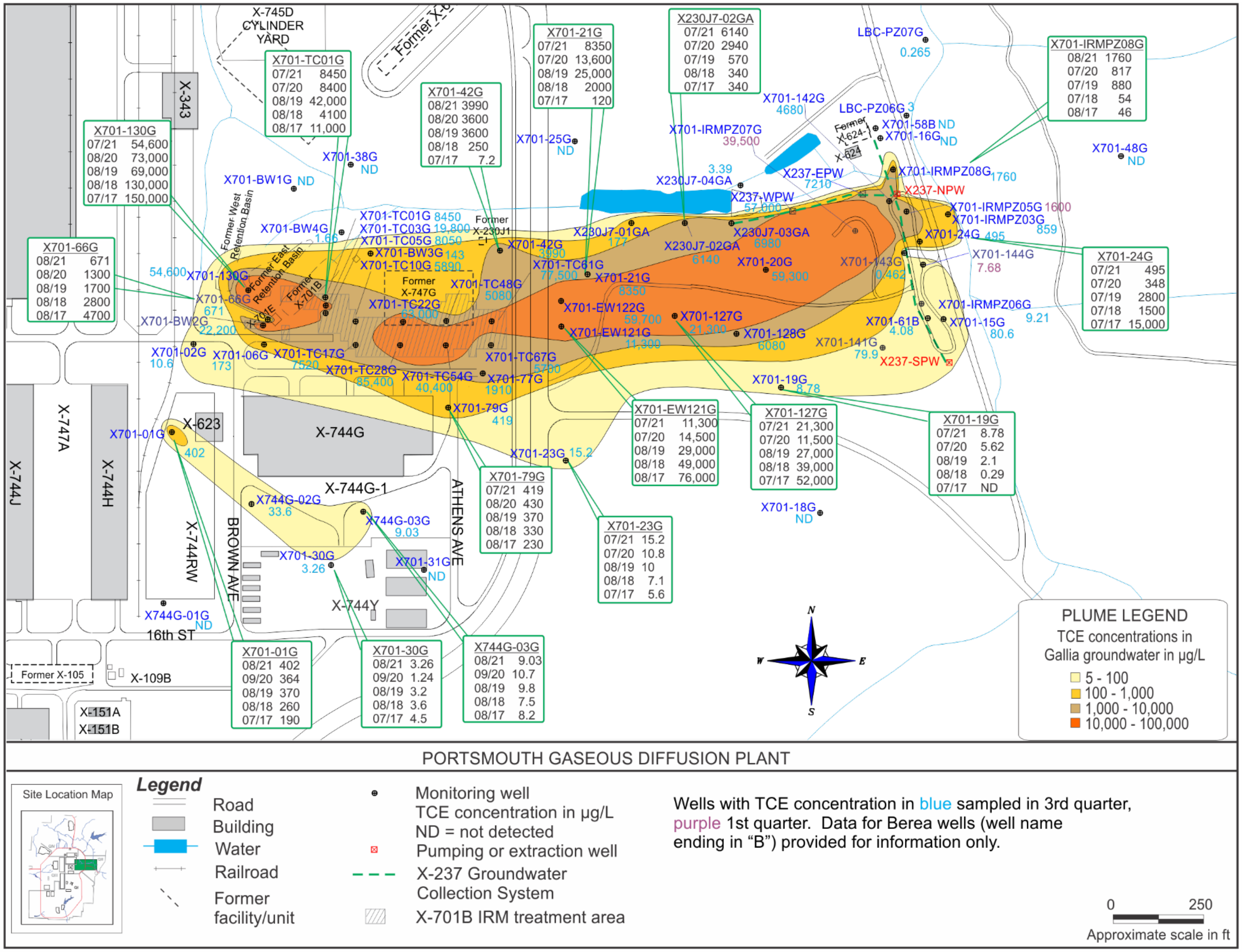


Figure 6.5. Gallia groundwater plume contaminated with trichloroethene at the X-701B Former Holding Pond in 2021

Quadrant II X-633 Former Recirculating Cooling Water Complex

Chromium is monitored in two wells near the X-633 Former Recirculating Cooling Water Complex because chromium was in additives used to treat the cooling water in the 1990s and earlier. Figure 6.1 shows the location of the X-633 Former Recirculating Cooling Water Complex monitoring area. Chromium was detected in both of the X-633 monitoring wells in 2021. These results were consistent with data collected in previous years.

6.3.2.3 Quadrant III Monitoring Areas

Chromium is of special concern at the X-616 Former Chromium Sludge Surface Impoundments because of the previous use of the area. In 2021, chromium was detected above the preliminary remediation goal of 100 µg/L in one well that monitors the X-616 area, well X616-05G on its northeastern boundary. Chromium is typically detected above the preliminary remediation goal in this well. Nickel was detected above the preliminary remediation goal of 100 µg/L for Gallia wells in two wells, X616-05G and X616-25G. Nickel is typically detected above the preliminary remediation goal in these two wells. Figure 6.6 shows the concentrations of chromium and nickel in wells at the X-616 Former Chromium Sludge Surface Impoundments.

Trichloroethene was detected above the preliminary remediation goal of 5 µg/L in four wells west of the former surface impoundments: wells X616-09G, X616-13G, X616-14G, and X616-20B. Figure 6.6 shows the concentrations of trichloroethene detected in the X-616 wells in 2021.

A groundwater plume of trichloroethene was formerly present in the monitoring area for the X-740 Former Waste Oil Handling Facility (see Figure 6.1). The majority of the plume was excavated in 2021 in accordance with *The July 30, 2018 Director's Final Findings and Orders for CERCLA Actions to Restore Natural Resources*. Twenty groundwater monitoring wells were removed in 2020 to prepare for excavation of the groundwater plume. Of the three remaining wells in the X-740 monitoring area, trichloroethene was detected at 22.9 µg/L in one well in 2021. These results were consistent with data collected in previous years.

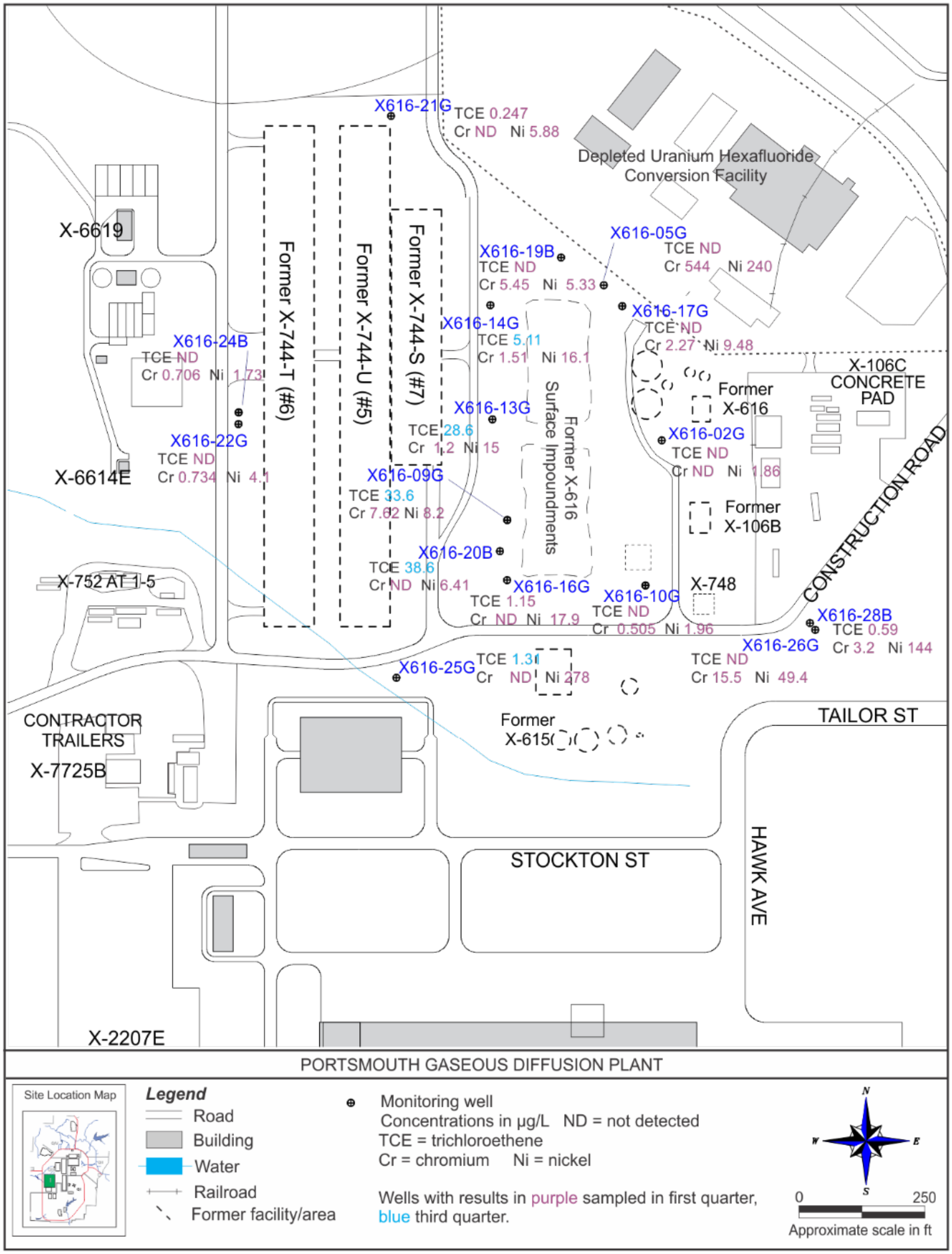


Figure 6.6. Trichloroethene and metal concentrations in groundwater at the X-616 Former Chromium Sludge Surface Impoundments in 2021

6.3.2.4 Quadrant IV Monitoring Areas

DOE monitors groundwater in five areas in Quadrant IV, which is the northern portion of PORTS, as shown in Figure 6.1.

The X-611A Former Lime Sludge Lagoons are in the northeast portion of PORTS next to Little Beaver Creek. As part of the RCRA Corrective Action Program, a prairie habitat has been developed in this area by placing a soil cover over the north, middle, and south lagoons. Beryllium and chromium are monitored at these locations. These metals were detected in the X-611A monitoring wells in 2021 at concentrations below preliminary remediation goals and consistent with data collected in previous years.

The X-735 Landfills, near the northern boundary of PORTS, use a detection monitoring program for Berea wells that applies statistics to determine whether a release has occurred at the landfill. No releases were identified at the X-735 Landfills in 2021. Monitoring data for Gallia wells at the X-735 Landfills are compared to concentration limits set by Ohio EPA. These limits were not exceeded in 2021.

The X-734 Landfills are in the northwest portion of PORTS. Volatile organic compounds, metals, and radionuclides are monitored at the X-734 Landfills. In 2021, no volatile organic compounds, metals, or radionuclides were detected at concentrations above the preliminary remediation goals in the samples collected from the X-734 monitoring wells.

Cadmium and nickel are monitored in three wells north of the X-533 Former Switchyard Complex. Both were detected in the X-533 monitoring wells in 2021. These results were consistent with data collected in previous years.

One well near the X-344C Former Hydrogen Fluoride Storage Building is monitored for volatile organic compounds. Low concentrations of trichloroethene and other volatile organic compounds are typically detected in this well and were detected in 2021 at concentrations below preliminary remediation goals, consistent with data collected in previous years.

6.3.3 Surface Water

Surface water monitoring is conducted in conjunction with groundwater monitoring to determine if contaminants present in groundwater are detected in surface water samples. Surface water is collected quarterly from 14 locations and analyzed for volatile organic compounds and radionuclides. Figure 6.7 shows the surface water monitoring locations.

In 2021, concentrations of trichloroethene detected in East Drainage Ditch and Little Beaver Creek were lower than in 2020. Concentrations of trichloroethene detected in East Drainage Ditch (EDD-SW01) ranged from 1.26 to 47 µg/L. The maximum concentration of trichloroethene detected in Little Beaver Creek was 28.3 µg/L in the second quarter sample collected at LBC-SW01. Trichloroethene was detected in only one of four samples collected from Little Beaver Creek at LBC-SW04, the furthest downstream sampling location on Little Beaver Creek. Trichloroethene was detected in this sample at 1.79 µg/L.

Since the 1990s, trichloroethene and other volatile organic compounds have been detected regularly at low levels in samples collected from the Southwestern Drainage Ditch at UND-SW01, located inside Perimeter Road. The concentrations of volatile organic compounds detected at this monitoring location were typical for this location. Volatile organic compounds were not detected in the samples collected from the Southwestern Drainage Ditch at UND-SW02. The detections of trichloroethene in Little Beaver Creek and the Southwestern Drainage Ditch were below 810 µg/L, which is the Ohio EPA non-drinking water quality criterion for trichloroethene for the protection of human health in the Ohio River drainage basin.

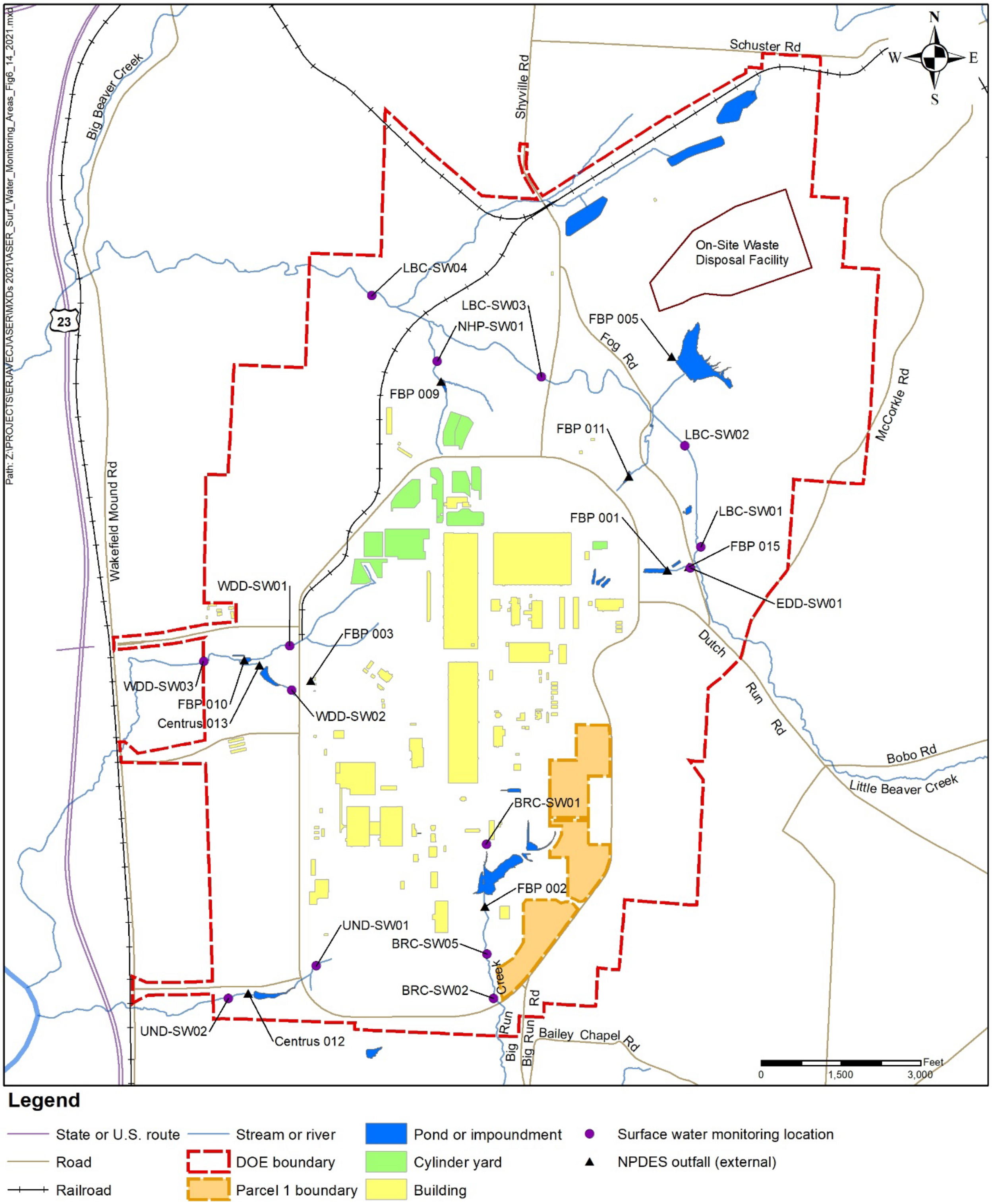


Figure 6.7. Surface water monitoring locations

In 2021, technetium-99 and uranium were detected at measurable levels in the third and fourth quarter samples collected from Big Run Creek. Figure 6.7 shows these monitoring locations. Table 6.1 summarizes sampling results for Big Run Creek and the discharge from the X-230K South Holding Pond (NPDES Outfall 002).

Table 6.1. Technetium-99 and uranium in Big Run Creek and the discharge from the X-230K South Holding Pond

Location	Date	Tc-99	U	U-233/234	U-235/236	U-238
BRC-SW01	7/29/2021	11.7	0.845UJ[a]	0.778UJ[a]	0.00764UJ[a]	0.283UJ[a]
	10/18/2021	199	2.73	9.03	0.361	0.863
NPDES Outfall 002 (X-230K Holding Pond)	Jan-Jun	-0.0966U - 4.04UJ	0.617-1.31	0.43-1.09	0.0113UJ-0.0526UJ	0.203-0.437
	Jul-Dec	7.94-16.1	0.365UJ-0.946	0.462-1.31	0.0114UJ-0.126	0.118UJ-0.313
BRC-SW05	7/29/2021	1710	8.21	86.1	2.83	2.31
	10/18/2021	8.51	0.884	1.21	0.065U[a]	0.287
BRC-SW02	7/29/2021	9.18	0.693	0.666UJ[a]	0.0154UJ[a]	0.23
	10/18/2021	7.71	0.591UJ[a]	0.978	0.0314U[a]	0.194UJ[a]

Note:
Radionuclides measured in picocuries per liter (pCi/L) except uranium in micrograms per liter.
[a]The reported result is undetected (U) or undetected and estimated (UJ). Negative results may be reported due to a statistical determination of the counts seen by a detector, minus a background count.

Acronyms and abbreviations:
NPDES = National Pollutant Discharge Elimination System
Tc-99 = technetium-99
U = uranium

The detection of uranium-233/234 at BRC-SW05 in July 2021 (86.1 pCi/L) is 7 percent of the DOE derived concentration standard of 1,200 pCi/L for uranium-234 (DOE 2021f). Levels of technetium-99, uranium-235/236, and uranium-238 detected in the samples from Big Run Creek and the X-230K South Holding Pond (NPDES Outfall 002) are less than 0.5 percent of the DOE derived concentration standards of 390,000 pCi/L for technetium-99, 1,300 pCi/L for uranium-235, and 1,400 pCi/L for uranium-238 (DOE 2021f).

6.3.4 Water Supply

The water supply monitoring program was developed to determine whether PORTS has had any impact on the quality of private residential drinking water sources. Although this program may indicate whether contaminants were transported off site, it should not be interpreted as an extension of the on-site groundwater monitoring program, which is responsible for detecting contaminants and determining the rate and extent of their movement. Data from the water supply monitoring program are not used in environmental investigations because investigators cannot know how residential wells were constructed, and the types of pumps the wells use may not be ideal for sampling.

Four residential drinking water sources participated in the program in 2021. The PORTS water supply is also sampled as part of this program. Sampling locations may be added or deleted if requested by a resident and as program requirements dictate. Typically, sampling locations are deleted when a resident obtains a public water supply. Wells are sampled semiannually and samples are analyzed for volatile organic compounds and radionuclides.

Chlorination byproducts called trihalomethanes (bromodichloromethane, chloroform, and dibromochloromethane), which are common residuals in treated drinking water, are routinely detected at low concentrations at some of the residential sampling locations. The total concentration of these trihalomethanes was below the Ohio EPA drinking water standard of 80 µg/L.

Each sample was analyzed for transuranics (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, uranium, and uranium isotopes (uranium-233/234, uranium-235/236, and uranium-238). Neither transuranics nor technetium-99 were detected in any of the water supply samples collected in 2021. Low levels of uranium and uranium isotopes detected in some of the wells are consistent with naturally-occurring concentrations found in groundwater in the area.

6.3.5 Exit Pathway Monitoring

Surface water sampling points on Big Run Creek (BRC-SW02), Little Beaver Creek (LBC-SW04), Southwestern Drainage Ditch (UND-SW02), and Western Drainage Ditch (WDD-SW03) are part of the exit pathway monitoring program shown in Figure 6.8. Trichloroethene was detected in one of the samples collected from Little Beaver Creek (LBC-SW04) at 1.79 µg/L. This detection was below the Ohio EPA non-drinking water quality criterion of 810 µg/L for the protection of human health in the Ohio River drainage basin.

No transuranics (americium-241, neptunium-237, plutonium-238, and plutonium-239/240) were detected in samples collected at the surface water exit pathway monitoring locations. Technetium-99 was detected at levels ranging from 7.71 to 25.1 pCi/L in samples collected from Big Run Creek and the Western Drainage Ditch. These detections were 0.006 percent or less of the derived concentration standard of 390,000 pCi/L for technetium-99 in water (DOE 2021f). The derived concentration standard is the concentration of a radionuclide in air or water that under conditions of continuous exposure for one year by one exposure mode (ingestion of water or inhalation of air) would result in a dose of 100 mrem. A concentration of 100 percent of the derived concentration standard would equal a dose at the DOE limit of 100 mrem/year (DOE 2021f).

Volatile organic compounds were also detected in on-site groundwater monitoring wells that are part of the exit pathway monitoring program. Trichloroethene and other volatile organic compounds were detected in two wells that monitor the X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility (see Section 6.3.2.1). Trichloroethene was detected in on-site well X749-45G at concentrations ranging from 1.77 to 11.4 µg/L, with results above the Ohio EPA drinking water standard of 5 µg/L in the first and second quarter samples collected from the well. All other detections of trichloroethene and other volatile organic compounds in the exit pathway monitoring wells were below Ohio EPA drinking water standards.

Exit pathway groundwater monitoring wells were sampled for radionuclides (americium-241, neptunium-237, plutonium-238, plutonium-239/240, technetium-99, uranium, uranium-233/234, uranium-235/236, and uranium-238) in 2021. Only uranium and uranium isotopes were detected in the wells, at levels below the Ohio EPA drinking water standard of 30 µg/L for uranium.

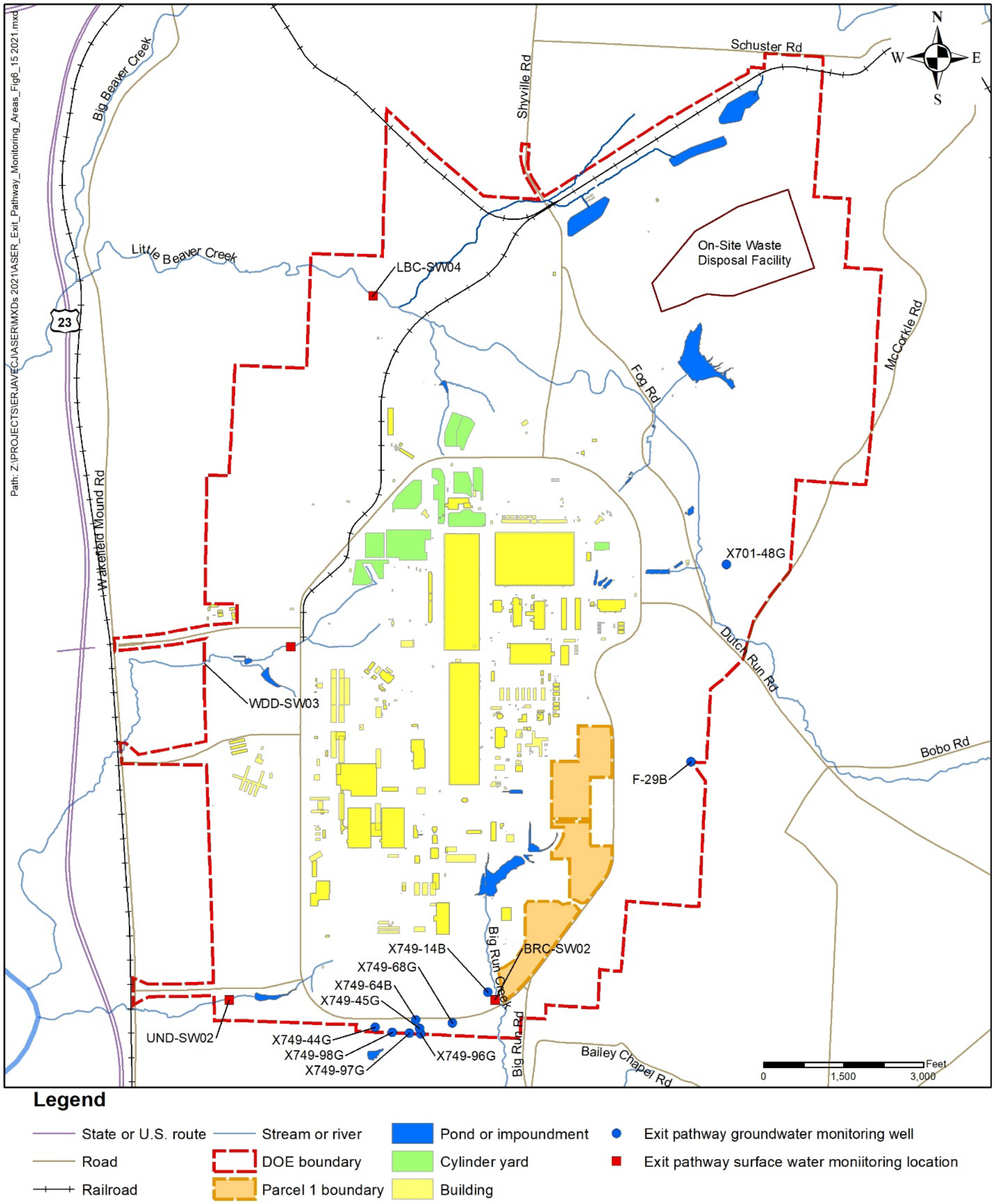


Figure 6.8. Exit pathway monitoring locations

6.4 Emerging Contaminants

Federal and state regulators are interested in emerging contaminants of concern that may be present at DOE sites. These emerging contaminants are chemicals that have been detected in drinking water supplies around the United States, but their risk to human health and the environment may not be fully understood.

PORTS collects samples every two years at selected groundwater monitoring wells for selected emerging contaminants 1,4-dioxane, 1,2,3-trichloropropane, 2,4-dinitrotoluene, and N-nitrosodimethylamine. The most recent sampling conducted in 2021 detected only 1,4-dioxane, though it is routinely detected in the trichloroethene groundwater plumes at PORTS. Concentrations of 1,4-dioxane detected in groundwater in 2021 ranged from 3.62 to 27.8 µg/L. This contaminant is a common component of chlorinated solvents like 1,1,1-trichloroethane and trichloroethene, which were historically used at PORTS.

Perfluoroalkyl substances and polyfluoroalkyl substances, collectively known as PFAS, are another emerging contaminant. The release of PFAS into the environment is a topic of growing public health and environmental concern. PFAS are a class of man-made chemicals that have been manufactured and used in a variety of industries since the 1940s. Since then, thousands of chemical formulations have been developed and widely used in manufacturing and processing facilities due to their resistance to grease, water, oil, and heat. PFAS are often found in commercial products such as stain-resistant carpeting, water-resistant clothing, non-stick and grease-resistant food contact materials such as cookware and food packaging, and aqueous film forming foams used in firefighting. These chemicals are very persistent in the environment and tend to bioaccumulate in food chains.

PORTS groundwater is not currently monitored for these contaminants. Section 2.4.2 discusses sampling for PFAS in the PORTS water supply.

6.5 Groundwater Treatment Facilities

In 2021 the X-622, X-623, X-624, and X-627 Groundwater Treatment Facilities treated a combined total of approximately 26.7 million gallons of water and removed approximately 7 gallons of trichloroethene. All processed water is discharged through NPDES outfalls before exiting PORTS. Table 6.2 summarizes the groundwater treatment facility information for 2021.

Table 6.2. Summary of groundwater treatment facility information for 2021

Facility	Gallons of water treated	Gallons of trichloroethene removed
X-622	18,762,400	2.08
X-623	1100	< 0.0001
X-624	215,800	0.19
X-627	7,725,800	4.71

Note:
Source: *2021 Groundwater Monitoring Report for the Portsmouth Gaseous Diffusion Plant* (DOE 2022a)

6.5.1 X-622 Groundwater Treatment Facility

The X-622 Groundwater Treatment Facility consists of an air stripper with aqueous-phase activated carbon filtration. This facility processes groundwater from the following systems in Quadrant I (see Figures 6.2 and 6.3):

- Groundwater collection system with associated sump (X749-WPW) and extraction wells X749-EW05G and X749-EW06G on the southwest boundary of the X-749 Landfill
- Groundwater extraction wells X749-EW01G, X749-EW02G, X749-EW03G, and X749-EW04G installed in 2007 in the X-749 South Barrier Wall area
- Groundwater extraction wells (X749-EW07G, X749-EW08G, and X749-EW09G) installed in 2010 in the X-749/X-120 groundwater plume
- Groundwater collection system and associated sumps PK-PL6 and PK-PL6A on the eastern boundary of the PK Landfill
- Fifteen extraction wells located in the Quadrant I Groundwater Investigative (5-Unit) Area

In December 2021, three extraction wells in the Quadrant I Groundwater Investigative (5-Unit) Area (X622-EW01, X622-EW03, and X622-EW07) were removed from service in support of the X-231B soil excavation project and the associated utility isolations that were necessary to complete excavation.

The facility processed approximately 18.8 million gallons of groundwater during 2021 and removed approximately 2.08 gallons of trichloroethene from the water. Treated water from the facility discharges through NPDES Outfall 608, which flows to the X-6619 Sewage Treatment Plant (NPDES Outfall 003). No NPDES permit limitations were exceeded at Outfall 608 in 2021.

6.5.2 X-623 Groundwater Treatment Facility

The X-623 Groundwater Treatment Facility consists of an air stripper with offgas activated carbon filtration and aqueous-phase activated carbon filtration. Prior to implementation of the X-701B interim remedial measure in 2009, the X-623 Groundwater Treatment Facility treated groundwater contaminated with trichloroethene from a sump in the bottom of the X-701B Former Holding Pond and three groundwater extraction wells east of the holding pond. The sump and extraction wells were removed in 2009–2011 to facilitate implementation of the interim remedial measure. The X-623 Groundwater Treatment Facility operated only in January 2021 to treat miscellaneous water associated with site activities in accordance with the NPDES permit.

The facility treated 1,100 gallons of water in January 2021, removing less than 0.0001 gallon of trichloroethene from the water. Treated water from the facility discharges through NPDES Outfall 610, which flows to the X-6619 Sewage Treatment Plant (NPDES Outfall 003). No NPDES permit limitations were exceeded at Outfall 610 in 2021.

6.5.3 X-624 Groundwater Treatment Facility

At the X-624 Groundwater Treatment Facility, groundwater is treated via an air stripper with offgas activated carbon filtration and aqueous-phase activated carbon filtration. This facility processes groundwater contaminated with trichloroethene from the X-237 Groundwater Collection System on the east side of the X-701B groundwater plume. The X-237 Groundwater Collection System consists of north-south and east-west collection trenches and two sumps or pumping wells (see Figure 6.5).

The X-624 Groundwater Treatment Facility treated approximately 215,800 gallons of water in 2021, removing approximately 0.19 gallon of trichloroethene from the water. Treated water from the facility discharges through NPDES Outfall 015, which discharges to Little Beaver Creek. No NPDES permit limitations were exceeded at Outfall 015 in 2021.

6.5.4 X-627 Groundwater Treatment Facility

The X-627 Groundwater Treatment Facility consists of an air stripper with offgas activated carbon filtration and aqueous phase activated carbon filtration. The X-700 and X-705 buildings are located above the Quadrant II Groundwater Investigative (7-Unit) Area plume, and contaminated water is collected in the sumps located in the basement of each building (see Figure 6.4).

Approximately 7.7 million gallons of groundwater were processed during 2021, removing approximately 4.71 gallons of trichloroethene from the water. Treated water from the facility discharges through NPDES Outfall 611, which flows to the X-6619 Sewage Treatment Plant (NPDES Outfall 003). No NPDES permit limitations were exceeded at Outfall 611 in 2021.

7. Quality Assurance

Quality assurance, an integral part of environmental monitoring, requires systematic control of the processes involved in sampling the environment and in analyzing the samples. To demonstrate accurate results, DOE uses the following planned and systematic controls:

- Implementing standard operating procedures for collecting and analyzing samples
- Training and qualifying surveyors and analysts
- Implementing sample tracking and chain-of-custody procedures to demonstrate traceability and integrity of samples and data
- Participating in external quality control programs
- Frequently calibrating and routinely maintaining measuring and test equipment
- Maintaining internal quality control programs
- Implementing good measurement techniques and good laboratory practices
- Frequently assessing field sampling, measurement activities, and laboratory processes

DOE contractors conduct environmental sampling at PORTS according to state and federal regulations and DOE Orders. Contractors prepare sampling plans and procedures and choose appropriate sampling instruments or devices as recommended by US EPA, the American Society for Testing and Materials, or other authorities. Chain-of-custody forms are used to document the control of samples from the time they are collected; samples remain in the custody of the sampling group until the samples are received at the laboratory. Samples shipped to an off-site laboratory are sealed inside the shipping container to prevent tampering until they are accepted by the sample custodian at the laboratory.

Analytical data are reviewed to ensure they comply with applicable regulations and permits. Data collected at PORTS identify locations and concentrations of contaminants of concern, evaluate the rate and extent of contamination at the site, and help determine the need for remedial action. Adequate and complete documentation generated as a result of these efforts supports the quality standards established by DOE. In 2021 Fluor-BWXT Portsmouth and Mid-America Conversion Services used quality assurance project plans to ensure a consistent system was used to collect, assess, and document environmental data of known and documented quality.

Fluor-BWXT Portsmouth implements and conducts its Quality Assurance Program in compliance with the following standards and regulations:

- DOE Order 414.1D, *Quality Assurance*
- American Society of Mechanical Engineers Nuclear Quality Assurance Standards NQA-1-2008 with the NQA-1a-2009 Addenda, *QA Requirements for Nuclear Facility Applications*
- Title 10 *CFR* Part 830, Nuclear Safety Management

7.1 Field Sampling

Efforts to ensure the quality of field samples begin with planning for sampling activities and programs and continue in the field as measurements are taken and samples are collected according to the protocols specified for the specific sampling activity. The following sections describe elements crucial to field sample quality.

7.1.1 Data Quality Objectives and Sample Planning

The Fluor-BWXT Portsmouth Quality Assurance Project Plan consists of the *Sample Analysis Data Quality Assurance Project Plan* (DOE 2014), project-specific sampling and analysis plans, and their associated data quality objectives. While the data quality objectives and sampling and analysis plans apply to specific projects, the *Sample Analysis Data Quality Assurance Project Plan* is an overarching framework that ensures standardized and consistent processes are used to obtain samples, collect data, and perform laboratory services.

7.1.2 Training for Sampling Personnel

Training for personnel involved in sampling and monitoring includes a combination of classroom, online, and on-the-job training as required by environmental, health, and safety regulations and DOE contract requirements. Procedures are based on guidelines and regulations created by DOE or other regulatory agencies that have authority over PORTS activities.

7.1.3 Sampling Procedures

Data from sampling can be influenced by the methods used to collect and transport the samples. A quality assurance program includes procedures for collecting samples so that the samples represent the conditions that exist in the environment at the time of sampling. The DOE quality assurance program at PORTS mandates that personnel who collect samples comply with written sampling procedures, use clean sampling devices and containers, use approved sample preservation techniques, and collect field quality control samples. Following strict chain-of-custody procedures ensures the integrity of samples. To maintain sample integrity, samples are delivered to the laboratory as soon as is practical after collection.

7.1.4 Field Quality Control Samples

Field quality control samples that are collected and analyzed include trip blanks, field blanks, field duplicates, and equipment rinseates. Quality control samples for environmental monitoring are collected at a target rate of one per twenty environmental samples or one per analytical batch depending on the samples being collected and the analyses required. Not all types of sampling require all of the field quality control samples. Table 7.1 summarizes the uses and definitions of field quality control samples.

Analytical results for field quality control samples are evaluated to determine if the sampling activities have biased the environmental sample results. This evaluation typically occurs as part of data validation or assessment (see Section 7.3.2). The ambient air monitoring program at PORTS is an example of the successful use of quality control samples to identify bias in sampling (see Section 4.3.3). Field blank samples collected for the ambient air program contain low levels of uranium and uranium isotopes. Further investigation revealed that the filters used to collect air samples contain low levels of uranium due to the materials used to make the filters. As a result, the levels of uranium reported in ambient air may be slightly elevated.

Table 7.1. Definitions and purpose of field quality control samples

Type of sample	Definition and purpose
Trip blank	Used to evaluate contamination from volatile organic compounds during the sampling process. The trip blank is an unopened container of laboratory-grade water that accompanies environmental samples analyzed for volatile organic compounds from sample collection through laboratory analysis.
Field blank	Used to evaluate contamination during the sampling process. The field blank is a container of laboratory-grade water that is carried into the field and opened to expose the field blank to field conditions when the environmental samples are collected. The field blank is analyzed for the same analytes as the environmental samples.
Field duplicate	Used to document the precision of the sampling process and provide information on analytical variability caused by collection methods, laboratory procedures, and sample heterogeneity (the variability within the sample media). A field duplicate, or duplicate sample, is a second environmental sample collected at the same time and from the same place as the first environmental sample. The duplicate sample is analyzed for the same analytes as the first sample.
Equipment rinseate	Used to assess contamination that could be present from reusable sampling equipment, such as a bailer used at a groundwater well to collect water. The sample is collected by rinsing the cleaned equipment with laboratory-grade water. An equipment rinseate is not required when dedicated or disposable sampling equipment is used for sample collection. The equipment rinseate sample is typically analyzed for the same analytes as the associated environmental samples.

7.2 Analytical Quality Assurance

The following sections describe the methods and procedures that ensure the laboratory analysis of samples meets quality standards, as well as the criteria for selecting off-site laboratories to analyze samples from PORTS.

7.2.1 Analytical Procedures

When available and appropriate for the sample matrix, methods approved by US EPA are used to analyze samples. When US EPA-approved methods are not available, PORTS uses other nationally recognized methods such as those developed by DOE and American Society for Testing and Materials. A statement of work for laboratory services identifies the analytical methods to be used for a set of samples. Analytical laboratories follow chain-of-custody procedures and document the steps they use for handling and analyzing samples and reporting results.

7.2.2 Laboratory Quality Control

In 2021, samples collected for DOE environmental monitoring programs at PORTS were sent to analytical laboratories that participated in DOE programs to ensure data quality. DOE contractors at PORTS only use analytical laboratories that demonstrate compliance in the following areas by participating in independent audits and surveillance programs:

- Compliance with federal waste disposal regulations
- Data quality
- Materials management

- Sample control
- Data management
- Electronic data management
- Implementation of a laboratory quality assurance plan
- Review of external and internal performance evaluation program

7.2.3 Independent Quality Control

PORTS is required by DOE, Ohio EPA, and US EPA to participate in independent quality control programs. PORTS also participates in voluntary independent programs to improve analytical quality control. These programs, which are conducted by US EPA, DOE, and commercial laboratories, generate data that are recognized as objective measures and allow participating laboratories and government agencies to review their performance. Data that do not meet acceptable criteria are investigated and documented according to formal procedures. Although participation in certain programs is mandatory, the degree of participation is voluntary, so that each laboratory can select parameters of particular interest to that facility.

7.2.4 Laboratory Audits and Accreditation

The DOE Consolidated Audit Program conducts annual performance qualification audits of environmental laboratories, and the DOE Mixed-Analyte Performance Evaluation Program provides semiannual performance testing and evaluation of analytical laboratories. These programs ensure that the laboratories comply with the appropriate regulations, methods, and procedures.

Analytical laboratories used by Fluor-BWXT Portsmouth, Mid-America Conversion Services, or Centrus in 2021 to analyze the environmental samples discussed in this report include Alloway, ALS, ARS Aleut Analytical, LLC, ETT Environmental, Inc., Eurofins, GEL Laboratories, LLC, and Portsmouth Analytical Laboratory.

The DOE Consolidated Audit Program also audits commercial treatment, storage, and disposal facilities used by PORTS to dispose of RCRA hazardous waste and mixed waste (a combination of RCRA hazardous waste and low-level radioactive waste). Facilities used by PORTS for disposal of RCRA hazardous and mixed waste in 2021 include Perma-Fix (Diversified Scientific Solutions), US Ecology, Energy*Solutions*, and the Nevada National Security Site.

7.3 Data Management

Data must be managed properly so users can retrieve it easily and rely on its integrity. The following sections identify the databases that PORTS relies on to house critical data, and describe the systems and methods used to screen, validate, verify, and assess data from environmental sampling.

7.3.1 Project Environmental Measurements System

The data generated from sampling events are stored in the Project Environmental Measurements System, a consolidated site system for tracking and managing data. This system is used to manage field-generated data, import laboratory-generated data, input data qualifiers identified during data validation, and transfer data to the PORTS Oak Ridge Environmental Information System (OREIS) database.

7.3.2 PORTS OREIS

The PORTS OREIS database consolidates data from the Project Environmental Measurements System for long-term storage. Environmental data from PORTS OREIS is loaded periodically in the PPPO Environmental Geographic Analytical Spatial Information System (PEGASIS).

7.3.3 PEGASIS

PEGASIS provides dynamic mapping and displays of environmental monitoring data. It allows members of the public to access environmental monitoring data and displays the data on a local map to show where the data were collected. Public access to PEGASIS is available here.

7.3.4 Data Verification, Validation, and Assessment

After DOE contractors receive analytical laboratory data, the data are verified for completeness, correctness, consistency, and compliance with written analytical specifications. Selected data are independently evaluated using a systematic process that compares the data to established quality assurance and quality control criteria. An independent data validator checks documentation produced by the analytical laboratory to verify that the laboratory has provided data that meet the established criteria.

Data verification is the systematic process of checking data for completeness, correctness, consistency, and compliance with written analytical specifications. The verification process compares the laboratory data package to requirements associated with the project, and documents requirements that were and were not met. All data collected for environmental monitoring programs are verified.

Data validation for a specific data set is performed by a qualified individual who has not been involved in sampling, laboratory, project management, or other decision making for that project. Data validation evaluates the laboratory’s adherence to the requirements of analytical methods to determine the technical reliability of the reported results. Data are qualified as acceptable, estimated, or rejected. These validation qualifiers are stored in the Project Environmental Measurements System and transferred with the data to the PORTS OREIS. Typically, at least 10 percent of analytical data associated with the environmental sampling programs are validated.

Data assessment is conducted by trained technical personnel in conjunction with other project team members. Data are reviewed for compliance with applicable standards or limits. Current analytical results are also compared to previous results for the sampling location. Data may be analyzed for trends or summary statistics such as average, median, or data range may be calculated.

8. References

Agency for Toxic Substances and Disease Registry 2003. Toxicological Profile for Fluorides, Hydrogen Fluoride, and Fluorine, U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, https://www.atsdr.cdc.gov/ToxProfiles/tp11.pdf, accessed 2/11/2020.

Bradburne, J. May 2, 2018. Department of Energy, Portsmouth/Paducah Project Office, Lexington, Kentucky, letter number PPPO-01-4817418-18B, entitled Contract No. DE-AC30-10CC40017: Authorized Limits Request for the Department of Energy-Owned Project for Industrial Landuse Area Outside the Limited Area at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio, Rev1, DOE/PPPO/03-4362489-18, January 2018 and Implementation Requirements, to Bobby D. Smith, Fluor-BWXT Portsmouth LLC, Piketon, OH.

DOE 1998a. *Quadrant III Cleanup Alternatives Study/Corrective Measures Study Final Report for Portsmouth Gaseous Diffusion Plant, Piketon, Ohio*, DOE/OR/12-1360&D3, POEF-ER-4619&D3, U.S. Department of Energy, Piketon, OH, April.

DOE 1998b. *Quadrant IV Cleanup Alternatives Study/Corrective Measures Study Final Report for Portsmouth Gaseous Diffusion Plant, Piketon, Ohio*, DOE/OR/12-1332&D3, POEF-ER-4609&D3, U.S. Department of Energy, Piketon, OH, August.

DOE 2000. *Quadrant I Cleanup Alternatives Study/Corrective Measures Study Final Report for Portsmouth Gaseous Diffusion Plant*, *Piketon, Ohio*, DOE/OR/12-1248&D6, U.S. Department of Energy, Piketon, OH, May.

DOE 2001. *Quadrant II Cleanup Alternatives Study/Corrective Measures Study Final Report for Portsmouth Gaseous Diffusion Plant, Piketon, Ohio*, DOE/OR/12-1223&D5, U.S. Department of Energy, Piketon, OH, February.

DOE 2003. *Five-Year Evaluation Report for the X-740 Phytoremediation Project at the Portsmouth Gaseous Diffusion Plant*, *Piketon, Ohio,* DOE/OR/11-3135&D1, U.S. Department of Energy, Piketon, OH, October.

DOE 2007. *Supplemental Evaluation to the 2003 Five Year Evaluation Report for the X-740 Phytoremediation Area at the Portsmouth Gaseous Diffusion Plant*, *Piketon, Ohio,* DOE/PPPO/03-0038&D1, U.S. Department of Energy, Piketon, OH, January.

DOE 2011. *First Five-Year Review for the X-749/X-120 Groundwater Plume at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio*, DOE/PPPO/03-0187V1&D1, DOE/PPPO/03-0187V2&D1, U.S. Department of Energy, Piketon, OH, January.

DOE 2014. *Sample Analysis Data Quality Assurance Project Plan (SADQ) at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio,* DOE/PPPO/03-0278&D2, U.S. Department of Energy, Piketon, OH, February.

DOE 2015a. *Record of Decision for Process Buildings and Complex Facilities Decontamination and Decommissioning Evaluation Project at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio,* DOE/PPPO/03-0425&D2, U.S. Department of Energy, Piketon, OH, July.

DOE 2015b. *Record of Decision for the Site-wide Waste Disposition Evaluation Project at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio,* DOE/PPPO/03-0513&D2, U.S. Department of Energy, Piketon, OH, June.

DOE 2015c. *Deferred Units Resource Conservation and Recovery Act Facility Investigation/Corrective Measures Study Work Plan at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio*, DOE/PPPO/03-0252&D3, U.S. Department of Energy, Piketon, OH, March.

DOE 2015d. *Environmental Radiological Effluent Monitoring and Environmental Surveillance*, DOE-HDBK-1216-2015, U.S. Department of Energy, Washington, D.C.

DOE 2016. *Remedial Design/Remedial Action Work Plan and Remedial Design for the Process Buildings Deactivation at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio – Deactivation of X-326, X-330, X-333, X-111A, X-111B, X-232C1, X-232C2, X232C3, X-232C4, and X-232C5,* DOE/PPPO/03-0665&D2, U.S. Department of Energy, Piketon, OH, April.

DOE 2017a. *The Role of the Portsmouth Gaseous Diffusion Plant in Cold War History*, DOE/PPPO/03-0683&D1, U.S. Department of Energy, Piketon, OH February.

DOE 2017b. *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio,* DOE/PPPO/03-0127&D9, U.S. Department of Energy, Piketon, OH, June.

DOE 2017c. *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio,* DOE/PPPO/03-0009&D5, U.S. Department of Energy, Piketon, OH, April.

DOE 2018a. *Comprehensive Deactivation, Demolition, and Disposition Remedial Design/Remedial Action Work Plan for the Process Buildings and Complex Facilities Remedial Action Project and Remedial Design for Deactivation of Complex Facilities at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio,* DOE/PPPO/03-0751&D1, U.S. Department of Energy, Piketon, OH, August.

DOE 2018b. *Comprehensive On-site Waste Disposal Facility Remedial Design/Remedial Action Work Plan for the Process Buildings and Complex Facilities Remedial Action/Remedial Design Work Plan for the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio, Phase III Balance of the On-site Disposal Remedy*, DOE/PPPO/03-0758&D3, U.S. Department of Energy, Piketon, OH, March.

DOE 2018c. *Fourth Five-Year Review for the X-749B Peter Kiewit Landfill at the Portsmouth Gaseous Diffusion Plant*, *Piketon, Ohio,* DOE/PPPO/03-0866&D1, U.S. Department of Energy, Piketon, OH, September.

DOE 2018d. *Third Five-Year Review for the Five-Unit Groundwater Investigative Area and X-231A/ X-231B Oil Biodegradation Plots at the Portsmouth Gaseous Diffusion Plant*, *Piketon, Ohio,* DOE/PPPO/03-0884&D1, U.S. Department of Energy, Piketon, OH, November.

DOE 2018e. *Fourth Five-Year Review for the X-611A Prairie at the Portsmouth Gaseous Diffusion Plant*, *Piketon, Ohio,* DOE/PPPO/03-0856&D1, U.S. Department of Energy, Piketon, OH, May.

DOE 2018f. *Third Five-Year Review for the X-734 Landfill Area at the Portsmouth Gaseous Diffusion Plant*, *Piketon, Ohio,* DOE/PPPO/03-0894&D1, U.S. Department of Energy, Piketon, OH, December.

DOE 2019. *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota,* DOE-STD-1153-2019, U.S. Department of Energy, Washington, D.C., February.

DOE 2020. *Air Emissions Modeling Report for the On-site Waste Disposal Facility (OSWDF), Soil Excavation Projects, and X-326 Process Building Demolition at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio,* DOE/PPPO/03-0924&D1, U.S. Department of Energy, Piketon, OH, March.

DOE 2021a. *Integrated Groundwater Monitoring Plan for the Portsmouth Gaseous Diffusion Plant*, *Piketon, Ohio,* DOE/PPPO/03-0032&D11, U.S. Department of Energy, Piketon, OH, January.

DOE 2021b. *On-Site Waste Disposal Facility (OSWDF) Performance Standards Verification Plan for the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio*, DOE/PPPO/03-0803&D3, Fluor-BWXT Portsmouth LLC, Piketon, OH, July.

DOE 2021c. *Fiscal Year 2022 Site Sustainability Plan for the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio*, DOE/PPPO/03-1003&D1, U.S. Department of Energy, Piketon, OH, December.

DOE 2021d. *Deferred Units Resource Conservation and Recovery Act Facility Investigation/Corrective Measures Study Report at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio,* DOE/PPPO/03-0772&D3, U.S. Department of Energy, Piketon, OH, August.

DOE 2021e. *Third Five-Year Review for the X-749/X-120 Groundwater Plume at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio*, DOE/PPPO/03-1030&D1, Fluor-BWXT Portsmouth LLC, Piketon, OH, June.

DOE 2021f. *Derived Concentration Technical Standard*, DOE-STD-1196-2021, U.S. Department of Energy, Washington, D.C., July

DOE 2022a. *2021 Groundwater Monitoring Report for the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio,* DOE/PPPO/03-1088&D1, U.S. Department of Energy, Piketon, OH, March.

DOE 2022b. *2021 On-Site Waste Disposal Facility Annual Project Status Report for the Portsmouth Gaseous Diffusion Plant*, *Piketon, Ohio,* DOE/PPPO/03-1109&D1, U.S. Department of Energy, Piketon, OH, September.

DOE 2022c. *Fiscal Year 2021 Annual Summary Report for the Report On-Site Waste Disposal Facility at the Portsmouth Gaseous Diffusion Plant*, *Piketon, Ohio,* DOE/PPPO/03-1062&D1, U.S. Department of Energy, Piketon, OH, March.

Fluor-BWXT Portsmouth 2014. *Comprehensive Summary Report of Cultural Resource Investigations Conducted at the Portsmouth Gaseous Diffusion Plant (PORTS Facility), Scioto and Seal Townships, Pike County, Ohio,* FBP-ER-GEN-BG-RPT-0055, Revision 4, Gray & Pape, Inc., Cincinnati, OH, May.

Fluor-BWXT Portsmouth 2019. *Environmental Radiation Protection Program,* FBP-EP-PL-0015, Revision 5, Fluor BWXT Portsmouth, Piketon, OH, April.

Fluor-BWXT Portsmouth 2022. *2021 Polychlorinated Biphenyl (PCB) Document Log for the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio,* FBP-ER-GEN-WD-RPT-0108, Revision 1, Fluor BWXT Portsmouth, Piketon, OH, June.

National Council on Radiation Protection 2009. *Ionizing Radiation Exposure of the Population of the United States*, NCRP Report No. 160, National Council on Radiation Protection and Measurements, Bethesda, MD.

Ohio Department of Health 2021. *Ohio Sport Fish Consumption Advisory,* Ohio Department of Health, Columbus, OH, May.

Ohio EPA 1996a. *Decision Document Peter Kiewit Landfill, U.S. DOE Portsmouth, Pike County, Ohio*, Ohio Environmental Protection Agency, Columbus, OH, May.

Ohio EPA 1996b. *Decision Document X-611A Solid Waste Management Unit U.S. DOE Portsmouth, Pike County, Ohio*, Ohio Environmental Protection Agency, Columbus, OH, June.

Ohio EPA 1999a. *Ohio Environmental Protection Agency's Decision Document for Quadrant III of the Portsmouth Gaseous Diffusion Plant*, Ohio Environmental Protection Agency, Columbus, OH, March.

Ohio EPA 1999b. *The Decision Document for the X-734 Landfill Area in Quadrant IV of the Portsmouth Gaseous Diffusion Plant*, Ohio Environmental Protection Agency, Columbus, OH, September.

Ohio EPA 2000. *U.S. DOE Portsmouth QIV Decision Document*, Ohio Environmental Protection Agency, Columbus, OH, September.

Ohio EPA 2001. *U.S. DOE Portsmouth Quadrant I Decision Document Portsmouth Gaseous Diffusion Plant*, Ohio Environmental Protection Agency, Columbus, OH, March.

Ohio EPA 2003. *Ohio EPA's Decision Document for the X-701B SWMU in Quadrant II of the U.S. DOE Portsmouth Facility, Piketon, Ohio*, Ohio Environmental Protection Agency, Columbus, OH, December.

Ohio EPA 2010. *State of Ohio Cooperative Fish Tissue Monitoring Program Sport Fish Tissue Consumption Advisory Program*, State of Ohio, Columbus, OH, October.

Ohio EPA 2012. *The April 13, 2010 Director's Final Findings and Orders for Removal Action and Remedial Investigation and Feasibility Study and Remedial Design and Remedial Action, including the July 16, 2012 Modification thereto,* Ohio EPA, Columbus, OH, July 16.

Ohio EPA 2018. *The July 30, 2018 Director's Final Findings and Orders for CERCLA Actions to Restore Natural Resources*, Ohio EPA, Columbus, OH, July 30.

U.S. Census Bureau 2022. U.S. Census Bureau, census.gov, population estimates for 2020, (accessed February 1, 2022).

U.S. EPA 1997. *Record of Decision/Statement of Basis Peter Kiewit Landfill United States Department of Energy Portsmouth Gaseous Diffusion Plant Pike County, Ohio,* U.S. Environmental Protection Agency, Washington, D.C. May.

U.S. EPA 2019. Regional Screening Level (RSL) Summary Table (TR=1E-06, HQ=1) May 2020 (corrected), Screening level for PCB-1254/PCB-1260 in residential soil, semspub.epa.gov/work/HQ/200043.pdf (accessed July 6, 2020).

Appendix A: Glossary

Appendix A Glossary

accuracy—The closeness of the result of a measurement to the true value of the quantity.

air stripper—Equipment that bubbles air through water to remove volatile organic compounds from the water.

alpha activity—The rate of emission of alpha particles from a given material.

alpha particle—A positively charged particle emitted from the nucleus of an atom; it has the same charge and mass as that of a helium nucleus (two protons and two neutrons).

ambient air—The surrounding atmosphere as it exists around people, plants, and structures.

analyte—The specific component that is being measured in a chemical analysis.

analytical detection limit—The lowest reasonably accurate concentration of an analyte that can be detected; this value varies depending on the method, instrument, and dilution used.

aquifer—A permeable layer of sand, gravel, or rock below the ground surface that is capable of yielding quantities of groundwater to wells and springs.

atom—Smallest unit of an element capable of entering into a chemical reaction.

average—A measure of the central tendency, or middle, of a group of numbers.

background radiation—Naturally-occurring radiation that includes cosmic radiation, terrestrial radiation, and internal radiation.

beta activity—The rate of emission of beta particles from a given material.

beta particle—A negatively charged particle emitted from the nucleus of an atom during radioactive decay. It has a mass and charge equal to those of an electron.

biota—Animal and plant life.

blank—A control sample that is identical in principle to the sample of interest, except the substance being analyzed is absent. In such cases, the measured value for the substance being analyzed is believed to be a result of artifacts. Under certain circumstances, that value may be subtracted from the measured value to give a net result reflecting the amount of the substance in the sample. US EPA does not permit the subtraction of blank results in US EPA-regulated analyses.

calibration—Determining the variance from a standard of accuracy of a measuring instrument to ascertain what correction factors are necessary.

categorical exclusion—A class of actions that either individually or cumulatively do not have a significant effect on the human environment and therefore do not require preparation of an environmental assessment or environmental impact statement under the National Environmental Policy Act.

CERCLA-reportable release—A release of a substance to the environment that exceeds reportable quantities as defined by the Comprehensive Environmental Response, Compensation, and Liability Act.

chain-of-custody—A process that documents custody and control of a sample through sample collection, transportation, and analysis.

chemical oxygen demand—Indicates the quantity of oxidizable materials present in water, and varies with water composition, concentrations of reagent, temperature, period of contact, and other factors.

closure—Formal shutdown of a hazardous waste management facility under the Resource Conservation and Recovery Act or Comprehensive Environmental Response, Compensation, and Liability Act.

compliance—Fulfillment of the applicable requirements of a plan or schedule ordered or approved by a government authority.

Comprehensive Environmental Response, Compensation, and Liability Act—Legislation that provides for liability, compensation, cleanup, and emergency response for hazardous substances released to the environment and the cleanup of inactive hazardous waste disposal sites.

concentration—The amount of a substance contained in a unit volume or mass of a sample.

confluence—The point at which two or more streams meet; the point where a tributary joins the main stream.

contaminant—Any substance that enters a system such as the environment, food, or the human body, for example, where it is not normally found. Contaminants include substances that spoil food, pollute the environment, or cause other adverse effects.

contamination—Deposition of unwanted material on the surfaces of structures, areas, objects, or personnel.

cosmic radiation—Ionizing radiation with very high energies that originates outside the earth's atmosphere. Cosmic radiation contributes to natural background radiation.

curie—A unit of radioactivity, defined as the quantity of any radioactive nuclide that has 3.7×10^{10} (37 billion) disintegrations per second.

decay, radioactive—The spontaneous transformation of one radionuclide into a different radioactive or nonradioactive nuclide, or into a different energy state of the same radionuclide.

decontamination and decommissioning—Removing equipment, demolishing buildings, disposing of wastes, and investigating potential contamination in areas that are no longer part of current operations.

deferred unit—An area in or adjacent to gaseous diffusion production and operational areas such that remedial activities would have interrupted operations, or an area that could have become recontaminated from ongoing operations. For these reasons, cleanup actions for the area are deferred.

derived concentration standard—A derived concentration value for a radionuclide in a specified environmental medium (e.g., air or water) that would result in a dose in that medium of 100 mrem in a year to a gender- and age-weighted reference person using DOE approved dose coefficients and assuming continuous exposure. Derived concentration standard values represent concentrations at the point of discharge and do not account for attenuation along the pathway before reaching the receptor, therefore, if they are implemented to assist with determining dose to the public from a pathway, then an ALARA analysis is required. While the derived concentration standard values can be used in assessing the magnitude of the dose to the public, they are not recommended for use in public dose estimates as they are likely to produce doses that are overly conservative. For this reason, they are not used to demonstrate compliance with DOE radiation protection dose limits. A detailed pathway analysis is required for calculating public radiation doses resulting from DOE activities.

dose—In this document, "dose" is used exclusively to refer to a radiological dose, defined as the energy imparted to matter by ionizing radiation. Dose can also refer to chemical dose, but chemical dose is not discussed in this report.

> **effective dose—**A measure of the potential biological risk of health effects due to exposure to radiation measured in millirem (1 millirem = 0.01 millisievert). In this document, the term "effective dose" is often shortened to "dose."
>
> **population dose—**The sum of the effective doses to all persons in a specified population measured in units of person-rem (or person-sievert).
>
> **absorbed dose—**The total amount of energy absorbed per unit mass (the amount of energy deposited in body tissue) as a result of exposure to radiation. The unit of absorbed dose is the rad, equal to 0.01 joule per kilogram in any medium (1 rad = 0.01 gray).

duplicate sample—A sample collected from the same location at the same time and using the same sampling device (if possible) as the regular sample.

effluent—A liquid or gaseous discharge to the environment.

effluent monitoring—The collection and analysis of samples or measurement of liquid and gaseous effluents to characterize and quantify the release of contaminants, assess radiation exposures to the public, and demonstrate compliance with applicable standards.

Environmental Restoration—A DOE program that directs the assessment and cleanup of its sites (remediation) and facilities (decontamination and decommissioning) contaminated as a result of nuclear-related activities.

exposure (radiation)—The incidence of radiation on living or inanimate material by accident or intent. Background exposure is the exposure to natural background ionizing radiation. Occupational exposure is exposure to ionizing radiation that takes place at a person's workplace. Population exposure is the exposure to the total number of persons who inhabit an area.

external radiation—Exposure to ionizing radiation when the radiation source is located outside the body.

gamma ray—High-energy, short-wavelength electromagnetic radiation emitted from the nucleus of an excited atom. Gamma rays are identical to X-rays except for the source of the emission.

glove box—An enclosure with built-in sleeves and gloves used by a person to manipulate hazardous materials such as highly enriched uranium without directly exposing the person to the material.

groundwater—Any water found below the land surface.

half-life, radiological—The time required for half of a given number of atoms of a specific radionuclide to decay. Each nuclide has a unique half-life; half-lives can range in duration from less than a second to many millions of years.

industrial solid waste landfill—A type of landfill that exclusively disposes of solid waste generated by manufacturing or industrial operations.

interim remedial measure—Cleanup activities initiated after it has been determined that contamination or waste disposal practices pose an immediate threat to human health or the environment. These measures are implemented until a more permanent solution can be made.

internal radiation—Occurs when radionuclides enter the body, for example, by ingestion of food or liquids, by inhalation, or through an open wound.

irradiation—Exposure to external radiation.

isotopes—Forms of an element having the same number of protons but differing numbers of neutrons in their nuclei.

maximally exposed individual—A hypothetical individual who—because of realistically assumed proximity, activities and habits—would receive the highest radiation dose, taking into account all pathways, from a given event, process, or facility. Defined by DOE Order 458.1.

maximum contaminant level—The maximum permissible level of a contaminant in drinking water provided by a public water system.

migration—The transfer or movement of a material through air, soil, or groundwater.

millirem—The dose that is one-thousandth of a rem.

monitoring—The process of periodically measuring the quantity and quality of factors that can affect the environment or human health to regulate and control potential impacts.

natural radiation—Radiation from cosmic and other naturally occurring radionuclide sources (such as radon) in the environment.

nuclide—An atom specified by atomic weight, atomic number, and energy state.

outfall—The point of conveyance, such as a drain or pipe, of wastewater or other effluents into a ditch, pond, or river.

part per billion—A unit measure of concentration equivalent to the weight to volume ratio expressed as microgram per liter (µg/L) or the weight to weight ratio of microgram per kilogram (µg/kg).

part per million—A unit measure of concentration equivalent to the weight-to-volume ratio expressed as milligrams per liter (mg/L), the weight to weight ratio expressed as milligrams per kilogram (mg/kg), or the weight to weight ratio expressed as micrograms per gram (µg/g).

perfluoroalkyl and polyfluoroalkyl substances—A group of manmade chemicals, collectively abbreviated as PFAS, used in non-stick products such as Teflon, water- and stain-repellant fabrics, and firefighting foam, among others. PFAS are also used in the aerospace, automotive, construction, electronics, and military industries. Certain types of PFAS may have negative health effects for humans and the environment.

person-rem—A unit of measure for the collective dose to a population group. For example, a dose of 1 rem to 10 individuals results in a collective dose of 10 person-rem.

pH—A measure of the hydrogen ion concentration in an aqueous solution. Acidic solutions have a pH from 0 to 7, neutral solutions have a pH equal to 7, and basic solutions have a pH from 7 to 14.

polychlorinated biphenyls—Man-made chemicals, also known as PCBs, that range from oily liquids to waxy solids. PCBs were used in hundreds of industrial and commercial applications due to their chemical properties until production in the United States ceased in 1977. PCBs have been demonstrated to cause a variety of adverse health effects in animals and may cause cancer and other adverse health effects in humans.

preliminary remediation goal—An initial clean-up goal developed early in the decision-making process that is protective of human health and the environment and complies with applicable or relevant and appropriate requirements. Preliminary remediation goals are intended to satisfy regulatory cleanup requirements.

quality assurance—Any action in environmental monitoring to demonstrate the reliability of monitoring and measurement data.

quality control—The routine application of procedures to obtain the required standards of performance in monitoring and measurement processes.

rad—The unit of absorbed dose deposited in a volume of material.

radioactivity—The spontaneous emission of radiation, generally alpha or beta particles or gamma rays, from the nucleus of an unstable isotope.

radionuclide—A radioactive nuclide capable of spontaneously transforming into other nuclides by changing its nuclear configuration or energy level. This transformation is accomplished by emitting photons or particles.

rem—The unit used to measure dose (absorbed dose in rads multiplied by the radiation quality factor). Dose is frequently reported in millirem (mrem), which is one-thousandth of a rem.

remediation—The correction or cleanup of a site contaminated with waste. See Environmental Restoration.

reportable quantity—A release to the environment that exceeds the quantity that must be reported as defined by the Comprehensive Environmental Response, Compensation, and Liability Act.

Resource Conservation and Recovery Act—Federal legislation that regulates the transport, treatment, and disposal of solid and hazardous wastes.

riparian—Related to the banks of a river or wetlands adjacent to rivers and streams.

settleable solids—Material settling out of suspension in a liquid within a defined period of time.

source—A point or object from which radiation or contamination emanates.

Superfund—The program operated under the legislative authority of the Comprehensive Environmental Response, Compensation, and Liability Act and Superfund Amendments and Reauthorization Act that funds and conducts US EPA emergency and long-term removal and remedial actions.

surface water—All water on the surface of the earth, as distinguished from groundwater.

suspended solids—Particles suspended in water, such as silt or clay, that can be trapped by a filter.

terrestrial radiation—Ionizing radiation emitted from radioactive materials in the earth's soils such as potassium-40, radon, thorium, and uranium. Terrestrial radiation contributes to natural background radiation.

transuranics—Elements such as americium, plutonium, and neptunium that have atomic numbers (the number of protons in the nucleus) greater than 92, which is the number of protons in uranium. All transuranics are radioactive.

trichloroethene—A colorless liquid used in many industrial applications as a cleaner or solvent; one of many chemicals that is classified as a volatile organic compound. High levels of trichloroethene may cause health effects such as liver and lung damage and abnormal heartbeat; moderate levels may cause dizziness or headache. The US EPA Integrated Risk Information System characterizes trichloroethene as carcinogenic to humans by all routes of exposure. This conclusion is based on convincing evidence of a causal association between trichloroethene exposure in humans and kidney cancer.

trip blank—A quality control sample of water that accompanies sample containers from the analytical laboratory to the field sampling location where environmental samples are collected, then back to the analytical laboratory to determine whether environmental samples have been contaminated during transport or shipment or by site conditions.

turbidity—A measure of the concentration of sediment or suspended particles in a liquid.

volatile organic compounds—Organic, or carbon-containing, compounds that evaporate readily at room temperature. These compounds are present in solvents, degreasers, paints, thinners, and fuels. Due to factors including widespread industrial use, they are commonly found as contaminants in soil and groundwater. Volatile organic compounds include trichloroethene, vinyl chloride, benzene, and dichloroethenes.

wetland—An area that is inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, floodplains, fens, and similar areas. A jurisdictional wetland is one that falls under state or federal regulatory authority; a non-jurisdictional wetland does not.

Appendix B:
Introduction to Radiation

Appendix B Introduction to Radiation

The information presented in this appendix summarizes concepts pertaining to radiation and radioactivity that the reader may find useful in understanding and interpreting the radiological information presented in this Annual Site Environmental Report.

B.1 What Is Radiation?

Radiation is energy, as shown in Figure B.1. It can come from unstable atoms that undergo radioactive decay, or it can be produced by machines. Radiation travels from its source in the form of energy waves or particles. There are two kinds of radiation: non-ionizing radiation and ionizing radiation.

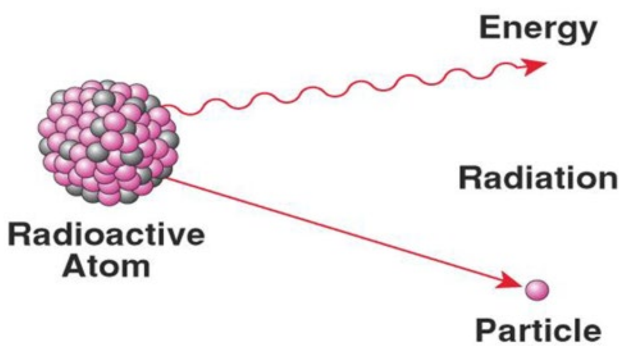


Figure B.1. Radioactive atom showing ionizing radiation

Non-ionizing radiation

Non-ionizing radiation has enough energy to move atoms in a molecule around or cause them to vibrate, but not enough to remove electrons from atoms. Examples of this kind of radiation are radio waves, visible light, and microwaves.

Ionizing radiation

Ionizing radiation has so much energy it can knock electrons out of atoms, a process known as ionization. Examples of ionizing radiation include alpha and beta particles, gamma rays, and x-rays. Ionizing radiation can affect atoms in living things and cause biological damage that is potentially harmful to human health. Ionizing radiation comes from x-ray machines, cosmic particles from outer space, and radioactive elements. Radioactive elements emit ionizing radiation as their atoms undergo radioactive decay. As used in this Annual Site Environmental Report and in the remainder of this appendix, the term “radiation” refers only to ionizing radiation.

Radioactive decay

Radioactive decay is the emission of energy in the form of ionizing radiation. The ionizing radiation that is emitted can include alpha particles, beta particles, and gamma rays.

Types of ionizing radiation

Alpha particles

Alpha particles are positively charged and are made up of two protons and two neutrons emitted from the atom's nucleus during radioactive decay. Alpha particles come from the heaviest radioactive elements such as uranium, radium, and polonium. Although alpha particles are very energetic, they are so heavy that they use up their energy over short distances and are unable to travel very far from the atom. Alpha particles can be stopped by thin layers of materials, such as the outer layer of your skin or a sheet of paper (see Figure B.2).

The health effect from exposure to alpha particles depends on how a person is exposed. Since alpha particles lack the energy to penetrate even the outer layer of skin, exposure to the outside of the body is not a major concern. Inside the body, however, they can be very harmful. If alpha particles are inhaled or swallowed, or get into the body through a cut, they can damage sensitive living tissue. Examples of alpha emitting-radionuclides include radioactive atoms of uranium, plutonium, and americium.

Beta particles

Beta particles are small, fast-moving particles with a negative electrical charge that are emitted from an atom's nucleus during radioactive decay. These particles are emitted by certain unstable atoms such as tritium, carbon-14, and strontium-90. Beta particles travel farther in air than alpha particles but can be stopped by a layer of clothing or by a thin layer of a substance such as aluminum foil, plastic, or wood (see Figure B.2).

The ability of beta particles to penetrate matter increases with energy. Some beta particles are capable of penetrating the skin and causing damage such as skin burns. However, as with alpha particles, beta particles are most hazardous when they are inhaled or swallowed. An example of a beta-emitting radionuclide is technetium.

Gamma rays

Gamma rays are weightless packets of energy called photons. Unlike alpha and beta particles which have both energy and mass, gamma rays are pure energy. Gamma rays are similar to visible light, but have much higher energy. Gamma rays are often emitted along with alpha or beta particles during radioactive decay.

Gamma rays are a radiation hazard for the entire body. They can easily penetrate barriers that can stop alpha and beta particles, such as skin and clothing. Gamma rays have so much penetrating power that several inches of a dense material like lead or even a few feet of concrete may be required to stop them (see Figure B.2). Gamma rays can pass completely through the human body, and they can cause damage to tissue and cells as they pass through. An example of a gamma-emitting radionuclide is cesium.

X-rays

Because of their use in medicine, almost everyone has heard of x-rays. X-rays are similar to gamma rays in that they are photons of pure energy. X-rays and gamma rays have the same basic properties but come from different parts of the atom. X-rays are emitted from the processes outside the nucleus, and gamma rays originate inside the nucleus. X-rays are also generally lower in energy and therefore less penetrating than gamma rays. X-rays can be produced naturally or by machines using electricity.

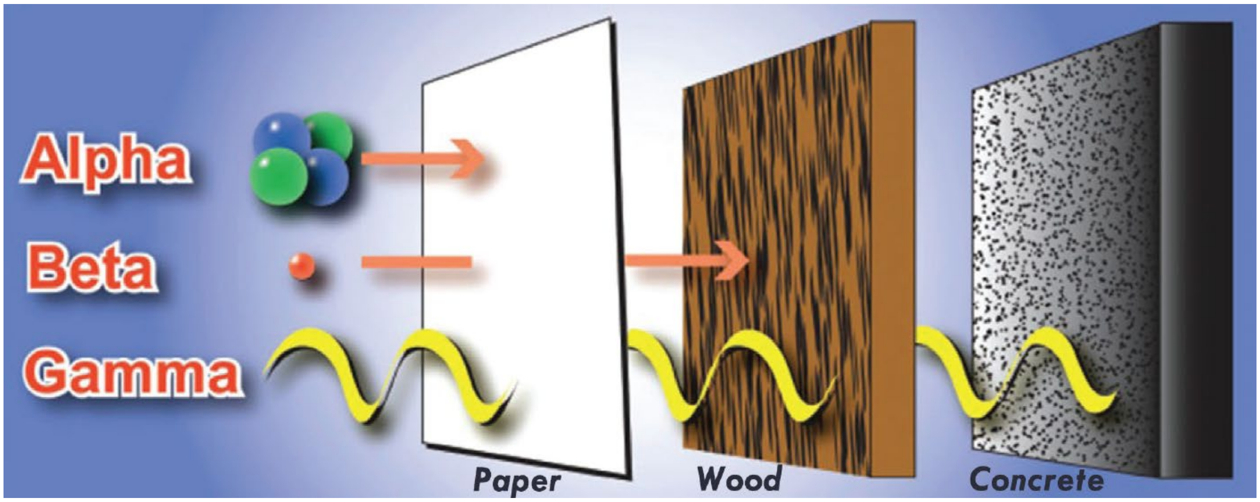


Figure B.2. Comparison of penetrating ability of alpha, beta, and gamma radiation

B.2 What Is a Radionuclide?

Elements in the periodic table can take on several forms. Some of these forms are stable; other forms are unstable. The most stable form of an element is usually the most common in nature. However, all elements have an unstable form. Unstable forms emit ionizing radiation and are radioactive. Some elements have no stable form and are always radioactive, such as uranium. Elements that emit ionizing radiation are called radionuclides.

When a radionuclide decays, it transforms into a different atom called a decay product. These atoms keep transforming into new decay products until they reach a stable state and are no longer radioactive. Radionuclides that decay in more than one step are called series radionuclides. The series of decay products created by these radionuclides is called a decay chain. Each series has its own unique decay chain.

Every radionuclide has a specific decay rate, which is measured in terms of half-life. Radioactive half-life is the time required for half of the radioactive atoms present to decay. Some radionuclides have half-lives of mere seconds, but others have half-lives of hundreds, millions, or billions of years.

Radionuclides in this report are expressed in different ways but each expression identifies the same radionuclide. For example, a common radionuclide of uranium may be expressed as uranium-238, U-238, or ^{238}U.

B.3 What Are Some Radionuclides of Concern?

Radionuclides of concern include uranium-234, uranium-235, uranium-238, thorium-230, technetium-99, plutonium-238, plutonium-239, plutonium-240, neptunium-237, and americium-241. Appendix C lists these radionuclides along with their associated half-lives.

B.4 What Is Radioactivity and How Is It Measured?

As radionuclides decay, they emit one or more types of radiation at characteristic energies that can be measured and used to identify the radionuclide. Detection instruments measure the quantity of radiation emitted over a specified time. The number of decay events (nuclear transformations) over a fixed time can be calculated from this measurement.

Radioactivity is measured in curies (Ci) or becquerels (Bq). One Ci, based on the rate of decay of one gram of radium-226, is defined as the quantity of any radionuclide that undergoes an average transformation rate of 37 billion transformations per second. In the International System of Units (SI), one Bq is equal to one transformation per second. In this Annual Site Environmental Report, radioactivity is usually expressed in Ci.

B.5 What Is Dose and How Is It Measured?

The possible effects of radiation must be measured to determine its potential to cause damage. The amount of energy absorbed by a material that receives radiation is measured in rads. A rad is 100 ergs of radiation energy absorbed per gram of material. Dose is a means of expressing the amount of energy absorbed, taking into account the effects of different kinds of radiation.

Alpha, beta, and gamma radiation affect the body to different degrees. Each type of radiation is given a quality factor that indicates the amount of human cell damage it can cause compared with equal amounts of other ionizing radiation energy. Alpha particles cause 20 times as much damage to internal tissues as x-rays, so alpha radiation has a quality factor of 20 compared to gamma rays, x-rays, and beta particles, each of which has a quality factor of one.

The unit of dose measurement to humans is the roentgen equivalent man (rem). The number of rem is equal to the number of rads multiplied by a quality factor for each type of radiation. For radiation protection purposes, 1 rem of any type of radiation has the same damaging effect.

Exposures to radiation from radionuclides outside the body are called external exposures; exposures to radiation from radionuclides inside the body are called internal exposures. This distinction is important because external exposure occurs only as long as a person is near the radionuclide; simply leaving the area of the source will stop the exposure. Internal exposure continues as long as the radionuclide remains inside the body. Radiation exposures to the human body, whether from external or internal sources, can involve all or a portion of the body. To enable radiation protection specialists to express exposures to portions of the body (and the accompanying doses) in terms of an equal dose to the whole body, scientists developed the concept of effective dose.

Unless otherwise noted, the generic term “dose” used in this report is the total effective dose to a person, which includes both the effective dose that can be attributed to sources outside the body and the committed effective dose from radionuclides deposited inside the body, which is based on a lifetime accumulated dose. For an adult, the lifetime accumulated dose is based on 50 years. Using the total effective dose allows doses from different types of radiation and to different parts of the body to be expressed on the same basis.

B.6 How Are Radioactivity and Dose Reported?

Scientific notation

Concentrations of radionuclides detected in the environment are typically quite small. Scientific notation is used to express numbers that are very small or very large. A very small number may be expressed with a negative exponent, for example 1.5E-03 (or 1.5×10^{-3}). To convert this number to its decimal form, move the decimal point left by the number of places equal to the exponent. In this example, moving the decimal point three places to the left shows that the number 1.5E-03 may also be expressed as 0.0015. For large numbers with a positive exponent, such as 1.5E+06 (or 1.5×10^6), move the decimal point to the right by the number of places equal to the exponent. In this case, 1.5E+06 may also be written as 1,500,000, or 1.5 million. Units for very small and very large numbers are often expressed with a prefix. For example, the prefix kilo (abbreviated as k) means 1,000 of a given unit. One kilometer, therefore equals 1,000 meters. Table B.1 defines the values of radiation-related prefixes used in this Annual Site Environmental Report.

Table B.1. Commonly used numerical prefixes

Multiple	Decimal Equivalent	Prefix	Symbol
10^{-3}	0.001	milli	m
10^{-6}	0.000001	micro	µ
10^{-12}	0.000000000001	pico	p

Concentrations of radioactivity in environmental sample media

Radiological environmental samples identify the concentration of radioactivity using the following units of measure:

- Air samples use the term microcuries per milliliter (µCi/mL).
- Liquid samples use the term picocuries per liter (pCi/L).
- Sediment samples use the term picocuries per gram (pCi/g).
- Radiation exposure measured by environmental dosimeters uses the term millirem (mrem).

Dose

This Annual Site Environmental Report expresses dose in standard units, followed by the equivalent International System of Units, or SI units, in parentheses when applicable. SI is the official system of measurement used internationally to express units of radioactivity and radiation dose. The basic SI unit of radioactivity is the becquerel (Bq), which is equivalent to one nuclear disintegration per second. Multiply the number of curies by 3.7×10^{10} to obtain the equivalent number of becquerels. The concept of dose may also be expressed using the SI units: gray (Gy) for absorbed dose (1 Gy = 100 rad) and sievert (Sv) for effective dose (1 Sv = 100 rem). Table B.2 shows the names and symbols for measurements used to describe radioactivity and dose.

Table B.2. Names and symbols for units of radioactivity and radiological dose

Symbol	Name
Ci	curie (1 Ci = 3.7×10^{10} disintegrations per second)
pCi	picocurie (1 pCi = 1×10^{-12} Ci)
rad	radiation absorbed dose (100 rad = 1 Gy)
mrem	millirem (1 mrem = 1×10^{-3} rem)
Bq	becquerel (1 Bq = 1 disintegration per second)
Sv	sievert (1 Sv = 100 rem)
mSv	millisievert (1×10^{-3} Sv)
Gy	gray (1 Gy = 100 rad)
mGy	milligray (1 mGy = 1×10^{-3} Gy)

B.7 What Is an Exposure Pathway?

An exposure pathway is how a radioactive material is released to the environment, is transported to a receptor (a person, animal, or plant), and comes into contact with a receptor. Figure B.4 illustrates common exposure pathways. Most people come into contact with released radioactive material via one of the following routes:

- Inhaling gases and particulates
- Ingesting vegetables, crops, wild game, milk, and fish
- Ingesting surface water and groundwater
- Absorbing the material through the skin (also called dermal absorption)
- External exposure to ionizing radiation

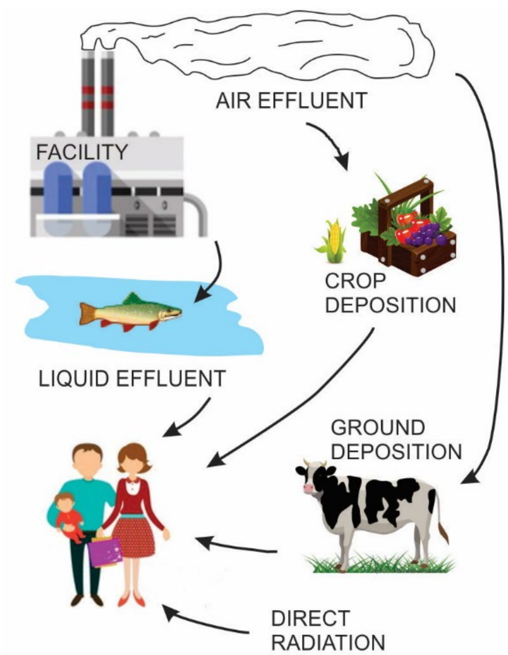


Figure B.3. Potential exposure pathways

B.8 What Radiation Sources and Doses Are We Exposed To?

Sources of radiation surround us at all times. Everyone is routinely exposed to radiation from natural sources such as minerals in the ground and human-made sources such as medical x-rays. Radiation has the same effect on people whether it is natural or human-made. According to the National Council on Radiation Protection and Measurements Report No. 160, *Ionizing Radiation Exposure of the Population of the United States* (NCRP 2009), the average annual radiation dose per person in the US is about 620 mrem (6.2 mSv). Figure B.4 shows the various sources of exposure and the contributions of these sources to the total collective dose for the US population in 2006. Actual doses vary depending on such factors as geographic location, building ventilation, and personal habits.

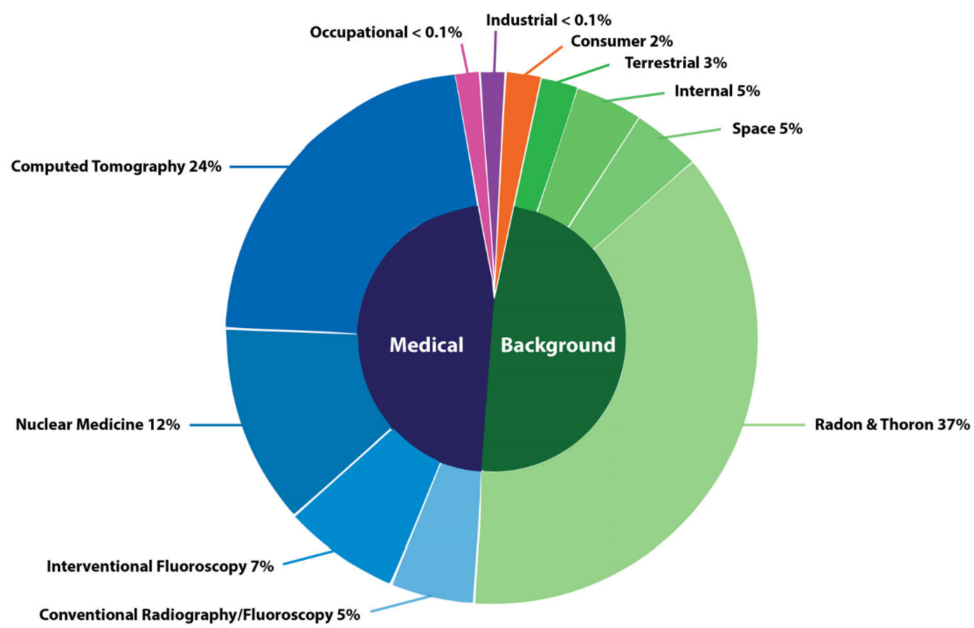
To estimate your average annual yearly dose from the most significant sources of ionizing radiation, use the online calculator on the US EPA website which can be found here.

Natural sources of radiation

Naturally occurring radioactive minerals in the ground, soil, and water produce background radiation, which accounts for 50 percent of the radiation received by the US population. The human body even contains some of these naturally occurring radioactive minerals. Cosmic radiation from space also contributes to the background radiation around us. Natural background radiation levels can vary significantly from place to place, and in the same location over time. The paragraphs below provide more detail on natural sources of background radiation.

External exposure from space (cosmic radiation)

The earth's atmosphere and magnetic shield protect us from cosmic radiation. Earth's magnetic shield is strongest at the equator and weakest near the poles. The magnetic shield diverts most of the cosmic radiation around the earth. Earth's atmosphere shields us from most of the remaining cosmic radiation that travels to earth. People who live at a higher altitude, like Denver, Colorado, are exposed to slightly more cosmic radiation than people who live at a lower altitude.



Average Annual Radiation Dose

Sources	Radon & Thoron	Computed Tomography	Nuclear Medicine	Interventional Fluoroscopy	Space	Conventional Radiography/ Fluoroscopy	Internal	Terrestrial	Consumer	Occupational	Industrial
Units mrem (United States) mSv (International)	228 mrem 2.28 mSv	147 mrem 1.47 mSv	77 mrem 0.77 mSv	43 mrem 0.43 mSv	33 mrem 0.33 mSv	33 mrem 0.33mSv	29 mrem 0.29 mSv	21 mrem 0.21 mSv	13 mrem 0.13 mSv	0.5 mrem 0.005 mSv	0.3 mrem 0.003 mSv

(Source: National Council on Radiation Protection & Measurements, Report No. 160)

Figure B.4. Sources of radiation exposure

Cosmic radiation also produces cosmogenic radionuclides by the interaction of cosmic radiation within the atmosphere or in the earth. The energy from this cosmic radiation blasts apart atoms in the earth's atmosphere and this process continuously produces radionuclides such as tritium, beryllium-7, sodium-22, and carbon-14. Cosmogenic radionuclides, particularly tritium and carbon-14, have been measured in humans, animals, plants, soil, polar ice, surface rocks, sediments, the ocean floor, and the atmosphere. The average annual radiation exposure from cosmic radiation is about 33 mrem.

External exposure from terrestrial radiation (primordial radionuclides)

The primordial radionuclides detected today are billions of years old. The external radiation dose to a person from primordial radionuclides comes from radiation emitted by radioactive materials in the earth's rocks, soils, and minerals. Uranium and thorium, which are naturally found in the earth, are the main sources of terrestrial radiation. Trace amounts of uranium, thorium, and their decay products can be found everywhere. Terrestrial radiation dose levels vary by location, but areas with higher concentrations of uranium and thorium in surface soils generally have higher dose levels. The average annual radiation exposure from terrestrial radiation is about 21 mrem.

Internal exposure from inhalation of radon, thoron, and their decay products

Radon is an inert gas that comes from the natural breakdown of uranium in soil, rock, and water. Radon can accumulate in buildings and get into the air we breathe through cracks, crevices, and openings in the foundation or from bricks and other building materials. Radon gas is not visible and has no odor or taste. It is the second leading cause of lung cancer in the United States after smoking. As shown in Figure B.3, radon, thoron, and their decay products are responsible for most of the annual effective dose (about 228 mrem) from background radiation produced by naturally occurring radionuclides. Radon levels vary widely across the United States. State programs work in partnership with the US EPA to provide education and promote awareness of the health hazards caused by radon.

Internal exposures from radionuclides in the body

Traces of radioactive materials can be found in our bodies; they include potassium-40, the thorium-232 series, and the uranium-238 series. The primary source is potassium-40 which is found in food, primarily fruits and vegetables we ingest. Radionuclides from the thorium-232 and uranium-238 series are found in food and water we ingest. Our bodies contain small amounts of radiation because the body metabolizes the non-radioactive and radioactive forms of potassium and other elements in the same way.

Human-made sources of radiation

In addition to natural sources of radiation, most people are exposed to human-made sources of radiation through medical procedures and consumer products.

Medical

Medical sources are the main source of exposure to the average American from human-made radiation, making up 4 percent of the total dose. This total does not include dose from radiation therapy used to treat cancer, which is typically many times larger. The average annual effective dose from medical sources is roughly 300 mrem and includes medical imaging and nuclear medicine.

Radiation is used in medical imaging, which delivers x-rays to a specific part of the body to create a digital image or film that shows the structures inside like bones, tissues, and organs. Healthcare providers use these images to find out what is causing the health problem (diagnostics) or to guide treatment. Medical imaging does not distribute radionuclides uniformly throughout the body, so the concept of effective dose, which relates the significance of exposure of organs and body parts to the effect on the entire body, is useful in making comparisons. A number of medical imaging tests use ionizing radiation:

- Computed tomography (CT): This medical imaging test uses x-rays to create cross-sectional pictures, like slices, inside selected areas of the body from different angles. The images can show internal organs, blood vessels, soft tissues, and bones. CT scans combine a series of x-ray images in a three-dimensional picture. CT scans check for tumors, infections, blood clots, and internal bleeding. These tests provide an average annual effective dose of 147 mrem.
- Interventional fluoroscopy: This uses x-rays to create a real-time image to guide small instruments such as catheters through blood vessels or other pathways in the body. This process provides an average annual effective dose of 43 mrem.

- Conventional radiography and fluoroscopy: Radiography is the use of x-ray machines by health care providers and dentists to pass x-ray beams through a part of the body and produce images of the tissues, organs, bones, or teeth inside. Fluoroscopy is a medical technique that takes real-time moving images of internal structures in the body by placing a patient between a fluorescent screen and an x-ray source. These processes provide an average annual effective dose of 33 mrem.

Nuclear medicine uses radioactive material inside the body to see how organs or tissues are functioning (diagnostic) or to target and destroy damaged or diseased organs or tissues (treatment). Nuclear medicine does not distribute radionuclides uniformly throughout the body so effective dose, which relates the significance of exposure of organs and body parts to the effect on the entire body, is used to make comparisons. The average annual dose from nuclear medicine is 77 mrem.

For most diagnostic procedures, a tracer containing the radioactive material is injected, swallowed, or inhaled. Then the healthcare provider or radiologist uses a radiation detector to see how much of the tracer is absorbed or how it reacts in the organ or tissue. This gives the healthcare provider information on how well the organ or tissue is functioning. Common diagnostic uses of nuclear medicine include scans of the heart, lung, kidneys, gallbladder, and thyroid.

When nuclear medicine is used in treatment, the tracer targets a harmful organ or tissue and radioactivity damages or stops growth of its cells. Two common uses of nuclear medicine for treatment include radioactive iodine therapy and brachytherapy, a form of radiation treatment where a sealed radiation source is placed inside or next to the area requiring treatment.

Consumer products and activities

The average annual effective dose to an individual from consumer products and activities is about 13 mrem. Cigarette smoke accounts for 35 percent of the dose from consumer products and activities. Building materials account for 27 percent of this dose. Commercial air travel accounts for 26 percent, mining and agriculture account for 6 percent, miscellaneous consumer-oriented products account for 3 percent, combustion of fossil fuels accounts for 2 percent, and highway and road construction materials account for 0.6 percent.

Industrial and occupational

Other sources of radiation include emissions of radioactive materials from nuclear facilities such as uranium mines, fuel processing plants, and nuclear power plants; transportation of radioactive materials; and emissions from mineral extraction facilities. The average annual radiation exposure to the general public from these sources has been estimated at less than 1 mrem/year.

B.9 What Are the Potential Health Effects of Radiation Exposure?

The three primary pathways by which people may be exposed to radiation are direct exposure, inhalation, and ingestion. Exposure from radiation may be from a source outside the body (external exposure) or from radioactive particles that have been taken in by breathing or eating and have become lodged inside the body (internal exposure). Radionuclides that are taken in are not distributed the same way throughout the body. Radionuclides of strontium, plutonium, and americium concentrate in the skeleton, while iodine concentrates in the thyroid. Some radionuclides such as tritium, carbon-14, or cesium-137, however, are distributed throughout the body.

The human body has mechanisms that repair damage from exposure to radiation, but these repair processes are not always successful. Living tissue in the human body can be damaged by ionizing radiation. The severity of the damage depends upon several factors:

- The amount of exposure (low or high)
- The duration of the exposure (long-term, known as chronic, or short-term, known as acute)
- The type of radiation (alpha, beta, and gamma radiations of various energies)
- The sensitivity of the human (or organ) receiving the radiation

The greatest risk from exposure to ionizing radiation is cancer. Much of our knowledge about the risk is based on studies of over 100,000 survivors of the atomic bombs in Hiroshima and Nagasaki, Japan, at the end of World War II. Studies of radiation industry workers and people receiving large doses of medical radiation are also important sources. Scientists have gained important information from these studies:

- The chance of developing cancer (not the seriousness or severity of the cancer) increases as the radiation dose increases.
- Cancers caused by radiation do not appear until years after the radiation exposure.
- Some people are more likely to develop cancer from radiation exposure than others.
- For people who receive low doses of radiation, the risk of cancer from radiation exposure is so small that it is indistinguishable from cancer caused by exposure to chemicals, genetics, smoking, or diet.

Appendix C:
Radionuclide and Chemical Names

Appendix C Radionuclide and Chemical Names

Table C.1. Names and abbreviations for elements and chemical constituents

Constituent	Symbol
Aluminum	Al
Ammonia	NH_3
Antimony	Sb
Arsenic	As
Barium	Ba
Beryllium	Be
Cadmium	Cd
Calcium	Ca
Chromium	Cr
Cobalt	Co
Copper	Cu
Iron	Fe
Lead	Pb
Magnesium	Mg
Manganese	Mn
Mercury	Hg
Nickel	Ni
Nitrogen	N
Nitrate ion	NO_{3-}
Nitrite ion	NO_{2-}
Phosphate ion	PO_4^{2-}
Potassium	K
Selenium	Se
Silver	Ag
Sodium	Na
Sulfate ion	SO_{4-}
Thallium	Tl
Uranium	U
Vanadium	V
Zinc	Zn

Table C.2. Selected names, abbreviations, and half-life for radionuclides

Radionuclide	Symbol	Half-life (years)
Americium-241	Am-241	432.2
Cesium-137	Cs-137	30.1671
Neptunium-237	Np-237	2,144,000
Plutonium-238	Pu-238	87.7
Plutonium-239	Pu-239	24,110
Plutonium-240	Pu-240	6,564
Technetium-99	Tc-99	211,100
Thorium-228	Th-228	1.9116
Thorium-230	Th-230	75,380
Thorium-232	Th-232	14,050,000,000
Uranium-233	U-233	159,200
Uranium-234	U-234	245,500
Uranium-235	U-235	704,000,000
Uranium-236	U-236	23,420,000
Uranium-238	U-238	4,468,000,000

Source: DOE-STD-1196-2021, Derived Concentration Technical Standard, Table 9.

Note: Not all of the radionuclides listed above are found at PORTS.

Appendix D:
Units of Measure

Appendix D Units of Measure

Due to differing permit reporting requirements and instrument capabilities, various units of measurement are used in this report. This list of units of measure and conversion factors is intended to help readers make approximate conversions to other units as needed for specific calculations and comparisons.

Table D.1. Units of measure and their abbreviations

becquerel	Bq	micrometer	µm
British thermal unit	Btu	millicurie	mCi
centimeter	cm	milligram	mg
curie	Ci	milliliter	mL
day	d	millimeter	mm
degrees Celsius	°C	million	M
degrees Fahrenheit	°F	million gallons per day	MGD
disintegrations per minute	dpm	millirad	mrad
foot	ft	millirem	mrem
gallon	gal	milliroentgen	mR
gallons per minute	gal/min	millisievert	mSv
gram	g	minute	min
gray	Gy	nanogram	ng
gross square feet	gsf	parts per billion	ppb
hectare	ha	parts per million	ppm
hour	h	parts per trillion	ppt
inch	in.	picocurie	pCi
joule	J	pound	lb
kilocurie	kCi	pound mass	lbm
kilogram	kg	pounds per square inch	psi
kilometer	km	pounds per square inch gauge	psig
kilowatt	kW	quart	qt
linear feet	LF	radiation absorbed dose	rad
liter	L	roentgen	R
megajoule	MJ	roentgen equivalent man	rem
megawatt	MW	second	S
megawatt-hour	MWh	sievert	Sv
meter	m	standard unit (pH)	SU
metric tons	MT	ton (2,000 lb)	ton
microcurie	µCi	yard	yd
microgram	µg	year	yr

Table D.2. Quantitative prefixes

exa	$\times 10^{18}$	atto	$\times 10^{-18}$
peta	$\times 10^{15}$	femto	$\times 10^{-15}$
tera	$\times 10^{12}$	pico	$\times 10^{-12}$
giga	$\times 10^{9}$	nano	$\times 10^{-9}$
mega	$\times 10^{6}$	micro	$\times 10^{-6}$
kilo	$\times 10^{3}$	milli	$\times 10^{-3}$
hecto	$\times 10^{2}$	center	$\times 10^{-2}$
deka	$\times 10^{1}$	decic	$\times 10^{-1}$

Table D.3. Unit conversions

Unit	Conversion	Equivalent	Unit	Conversion	Equivalent
		Length			
in.	× 2.54	cm	cm	× 0.394	in.
ft	× 0.305	m	m	× 3.28	ft
mile	× 1.61	km	km	× 0.621	mile
		Area			
acre	× 0.405	ha	ha	× 2.47	acre
ft^2	× 0.093	m^2	m^2	× 10.764	ft^2
$mile^2$	× 2.59	km^2	km^2	× 0.386	$mile^2$
		Volume			
ft^3	× 0.028	m^3	m^3	× 35.31	ft^3
qt (US liquid)	× 0.946	L	L	× 1.057	qt (US liquid)
gal	× 3.7854118	L	L	× 0.264172051	gal
		Concentration			
ppb	× 1	µg/kg	µg/kg	× 1	ppb
ppm	× 1	mg/kg	mg/kg	× 1	ppm
ppb	× 1	µg/L	µg/L	× 1	ppb
ppm	× 1	mg/L	mg/L	× 1	ppm
		Weight			
lb	× 0.4536	kg	kg	× 2.205	lb
lbm	× 0.45356	kg	kg	× 2.2046226	lbm
ton, short	× 907.1847	kg	kg	× 0.00110231131	ton, short
		Temperature			
°C	°F = (9/5)°C + 32	°F	°F	°C = (5/9) (F–32)	°C
		Activity			
Bq	$\times 2.7 \times 10^{-11}$	Ci	Ci	$\times 3.7 \times 10^{10}$	Bq
Bq	× 27	pCi	pCi	× 0.037	Bq
mSv	× 100	mrem	mrem	× 0.01	mSv
Sv	× 100	rem	rem	× 0.01	Sv
nCi	× 1,000	pCi	pCi	× 0.001	nCi
mCi/km^2	× 1	nCi/m^2	nCi/m^2	× 1	mCi/km^2
dpm/L	$\times 0.45 \times 10^{9}$	$\mu Ci/cm^3$	$\mu Ci/cm^3$	$\times 2.22 \times 10^{9}$	dpm/L
pCi/L	$\times 10^{-9}$	µCi/mL	µCi/mL	$\times 10^{9}$	pCi/L
pCi/m^3	$\times 10^{12}$	$\mu Ci/cm^3$	$\mu Ci/cm^3$	$\times 10^{12}$	pCi/m^3