Summary of the U.S. Department of Energy Portsmouth Annual Site Environmental Report (ASER) for 2017

Message from the U.S. Department of Energy

The U.S. Department of Energy (DOE) conducts environmental monitoring at the Portsmouth Gaseous Diffusion Plant Site (PORTS) on an ongoing basis. Each year, the information collected is presented in a data volume and a comprehensive publication entitled the Annual Site Environmental Report (ASER). This year, three of Piketon High School's (PHS) Chemistry classes, located in Pike County, Ohio, developed this summary report. Both the ASER and this summary report are important as they allow DOE to clearly and concisely explain our environmental monitoring programs to our many stakeholders. The information presented in this summary shows that the PORTS site near Piketon, Ohio, is operated in an environmentally safe manner. The work at DOE facilities is highly detailed and technically complex, but DOE is committed to performing each of these activities safely. DOE's first priority is to protect the well-being of our workers, the surrounding communities and the environment. DOE would like to offer its sincerest appreciation to the students and faculty leader at PHS who worked on this summary document. DOE congratulates each of you for your effort, enthusiasm and willingness to support this project.

DOE hopes you enjoy reading the PORTS 2017 Annual Site Environmental Report Summary.
https://www.energy.gov/pppo/downloads/2017-portsmouth-annual-site-environmental-report

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Piketon High School Student Recognition 2019

The students of Mrs. Katrina Queen's Chemistry classes at Piketon High School worked in collaboration with Ohio University's Voinovich School of Leadership and Public Affairs to produce this ASER Summary report. The Voinovich School thanks the students for their hard work. Their effort in this public service is much appreciated and worthy of special recognition. The 42 high school students who participated in the preparation of this ASER Summary report are listed below.

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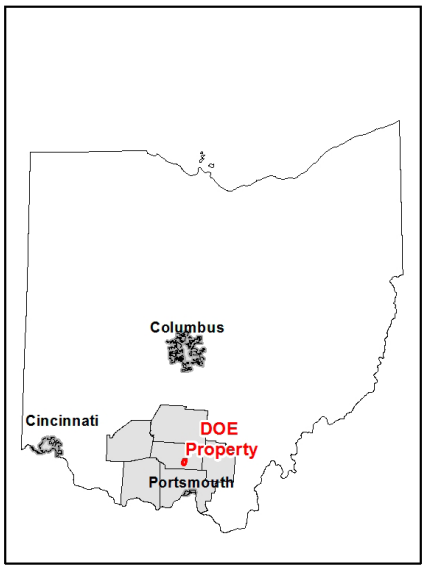
Background For The PORTS Facility

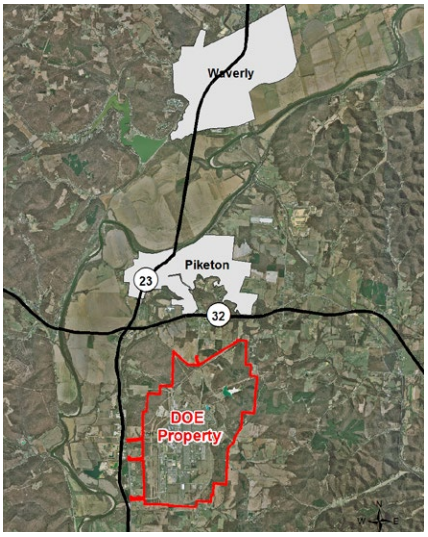
The Portsmouth Gaseous Diffusion Plant is located on a 5.9 square mile site in Pike County, Ohio. The county has a population of 28,227 citizens. Pike county's three incorporated municipalities, the Villages of Piketon, Waverly and Beaver, lie within 8 miles of PORTS. The cities of Portsmouth, Chillicothe, and Jackson lie within a 25 mile radius.



Map: Matt Trainer, Voinovich School of Leadership and Public Affairs

The Portsmouth Gaseous Diffusion Plant enriched uranium from 1954 up until 2001. DOE leased the Portsmouth Gaseous Diffusion Plant to the United States Enrichment Corporation (USEC), who produced enriched uranium from 1993 until 2001. USEC became the Centrus Energy company in 2014.

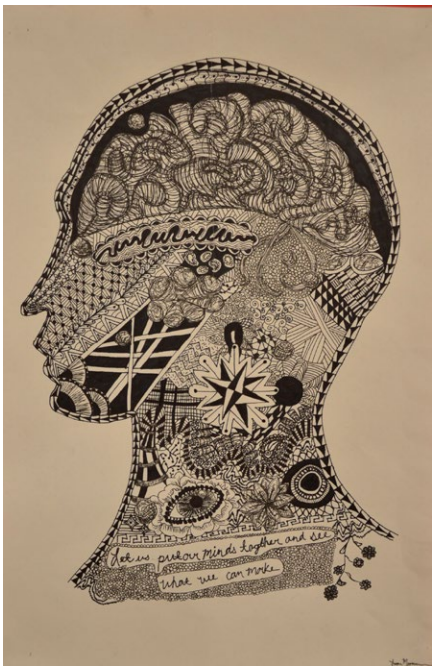
There are many operations at PORTS that DOE manages through contractors. DOE, through its contractors, is responsible for the decontamination and decommissioning (D&D) of the gaseous diffusion process buildings and associated facilities, environmental restoration, waste management, and uranium operations. Fluor-BWXT Portsmouth LLC (FBP) is the DOE contractor responsible for D&D at PORTS which includes the three gaseous diffusion process buildings and other associated facilities. Portsmouth Mission Alliance LLC (PMA) is the contractor responsible for several non-nuclear facility support services. BWXT Conversion Services, LLC (BWCS) was responsible for operations associated with the Depleted Uranium Hexafluoride (DUF_6) conversion facility through January 2017. Mid-America Conversion Services, LLC (MCS) assumed responsibility in February 2017.



Map: Matt Trainer, Voinovich School of Leadership and Public Affairs

D&D at the Portsmouth Gaseous Diffusion Plant is subject to the *April 13th, 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 16th, 2012 Modification thereto (D&D DFF&O)* [Ohio Environmental Protection Agency (Ohio EPA) 2012]. The goal of the Environmental Restoration Program is to verify that releases from past operations at PORTS are investigated and that measures are taken to make sure to protect human health and the environment. The goal for the Waste Management Program is to take care of waste from the time it is produced to its ultimate treatment, recycling, or disposal in accordance with all applicable requirements.

The purpose of the full ASER document is to give details of regulatory compliance and monitoring activities at PORTS. Further, this summary and background report of the full ASER of 2017 is to inform the public about DOE environmental cleanup efforts that are in accordance with local, state, and federal regulations. This report is not intended to provide the public with the data of all the testing performed by DOE and its support contractors at PORTS. The Department of Energy and/or the responsible Department of Energy contractor FBP or MCS held permits for release of water to surface streams, air emission permits and a permit for the storage of hazardous wastes. FBP and MCS are responsible for preparing a number of reports for compliance with various applicable environmental regulations. These reports include an annual groundwater monitoring report.



Artwork by Layne Moorman

Artwork by Mikaila Fremder

Compliance Summary

DOE is responsible for the D&D Program, Environmental Restoration Program, Waste Management Program, uranium operations, and maintenance of all facilities not leased to Centrus. FBP is responsible for air emission permits and National Pollutant Discharge Elimination System (NPDES) outfalls associated with the former gaseous diffusion plant operations. MCS is responsible for all activities that are associated with the DUF_6 Conversion Facility. Centrus is responsible for compliance activities directly associated with the American Centrifuge Plant (ACP) including NPDES outfalls and management of wastes generated by their current operations. Several federal, state, and local agencies are responsible for enforcing the environmental regulations at PORTS. Primary regulatory agencies are the Ohio EPA and the U.S. Environmental Protection Agency (U.S. EPA).

Environmental Laws and Regulations

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) - PORTS is not on the CERCLA National Priorities List of sites, though D&D of Ports has been continuing to proceed in accordance with the D&D DFF&O and CERCLA. The D&D DFF&O describes the regulatory process for D&D of the gaseous diffusion buildings and is associated with the facilities that are no longer in use.

Emergency Planning and Right-to-Know Act - The Emergency Planning and Community Right-To-Know Act requires reporting of emergency planning information, the hazardous chemicals in the inventories, and the releases to the environment. These are submitted to the federal, state, and local authorities. The DOE contractors are required to identify, list and name any hazardous chemicals that are present above the threshold planning quantities set by the U.S. EPA.

Artwork by Delaney Rigsby

In 2017, DOE contractors reported the permitted release of one chemical. The nitrate compounds were released into the Scioto River through permitted NPDES outfalls from water treatment.

Resource Conservation and Recovery Act (RCRA) - RCRA regulates the generation, accumulation, storage, transportation, and disposal of solid and hazardous wastes. The designated areas that store hazardous wastes are inspected and monitored through permits put in place by Ohio EPA. The permits require PORTS to notify if there is any event that mishandles the storage of these hazardous wastes. RCRA also requires groundwater monitoring at certain hazardous waste management units. This will be discussed further in the Groundwater Section.

Federal Facility Compliance Act - The Federal Facility Compliance Act allows the storage of mixed hazardous/low-level waste for longer than one year since the treatment options for these chemicals are not available yet. This act also requires federal facilities to develop and submit the site treatment plans for the treatments of mixed chemicals. Toxic Substances Control Act (TSCA) - TSCA at PORTS regulates the storage, use and disposal of polychlorinated biphenyls (PCBs). An annual log is prepared to meet the TSCA requirements which provides information on PCBs at PORTS.

DOE Order 458.1, Radiation Protection of the Public and the Environment - The purpose of DOE Order 458.1 is to protect the public and the environment against undue risk from radiation. This Order requires that off-site radiation doses do not exceed 100 millirem (mrem)/year.

DOE Order 435.1, Radioactive Waste Management - The objective of DOE Order 431.5 is to ensure all DOE radioactive waste will be managed in a protective way for workers, public health and safety, and the environment.

Clean Air Act - FBP is responsible for numerous air emission sources that are involved with the former gaseous diffusion production and support facilities. The Clean Air Act requires FBP to submit the quarterly Title V Deviation Reports that state any deviations from the requirements to Ohio EPA. FBP did not have any deviations from the permit requirements. In 2017, MCS was responsible for four permitted sources associated with the DUF_6 Conversion Facility. In 2017, the annual Permit Evaluation Reports for the MCS air emissions sources did not report any deviations from applicable emission limits or control requirements.

National Emission Standards for Hazardous Air Pollutants (NESHAP) - NESHAP requires DOE to submit an annual report for radiological emissions from the DOE air emission sources. FBP and MCS are both responsible for many air emission sources at PORTS.

Clean Water Act and Safe Drinking Water Act - The Clean Water Act regulates all the discharge of water from PORTS and requires the reports to be submitted to the Ohio EPA to demonstrate compliance. The Safe Drinking Water Act sets all the requirements for water testing, treatment, and disinfection.

DOE and DOE contractors must also comply with many other regulations. Some of these regulations are the National Environmental Policy Act, the Endangered Species Act, the National Historic Preservation Act, the Archaeological and Historic Preservation Act and the Archaeological Resources Protection Act.

Environmental Program Inspections

During 2017, five inspections of DOE activities at PORTS were conducted by federal, state, or local agencies. FBP received a Notice of Violation in 2017 and FBP implemented procedures to remedy the violation. An unplanned release occurred in 2017 when an oil sheen was discovered after a heavy rainstorm. The area of the oil sheen was located on site and did not impact the public, however improvements were made to the oil capture system.

Artwork by Lauren Carter

Environmental Program Information

Decontamination & Decommissioning Program

On April 13, 2010, Ohio EPA issued the D&D DFF&O, which governs the process for D&D of the gaseous diffusion process buildings and associated facilities that are no longer in use at PORTS. The D&D DFF&O was revised in 2011 and 2012 to add structures that were inadvertently omitted from the original orders. The PORTS Community Relations Plan, also a part of the D&D DFF&O, identifies opportunities to provide information to the public and obtain public input (DOE 2010, DOE 2012), and the Site Specific Advisory Board (SSAB) provides community-based recommendations to DOE surrounding PORTS.

Process Buildings and Other Facilities

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

- Demolition of the buildings or structures;
- Characterization and demolition of underground man-made features;
- Treatment as needed to meet transportation and disposal requirements;
- Packaging of generated waste for final disposal; and
- Transportation and disposal of the waste in accordance with the waste disposition record of decision.

Activities taking place in 2017 regarding D&D included breakdown and removal equipment, removal of waste material (asbestos, PCBs, and RCRA hazardous material), along with deactivation of utilities.

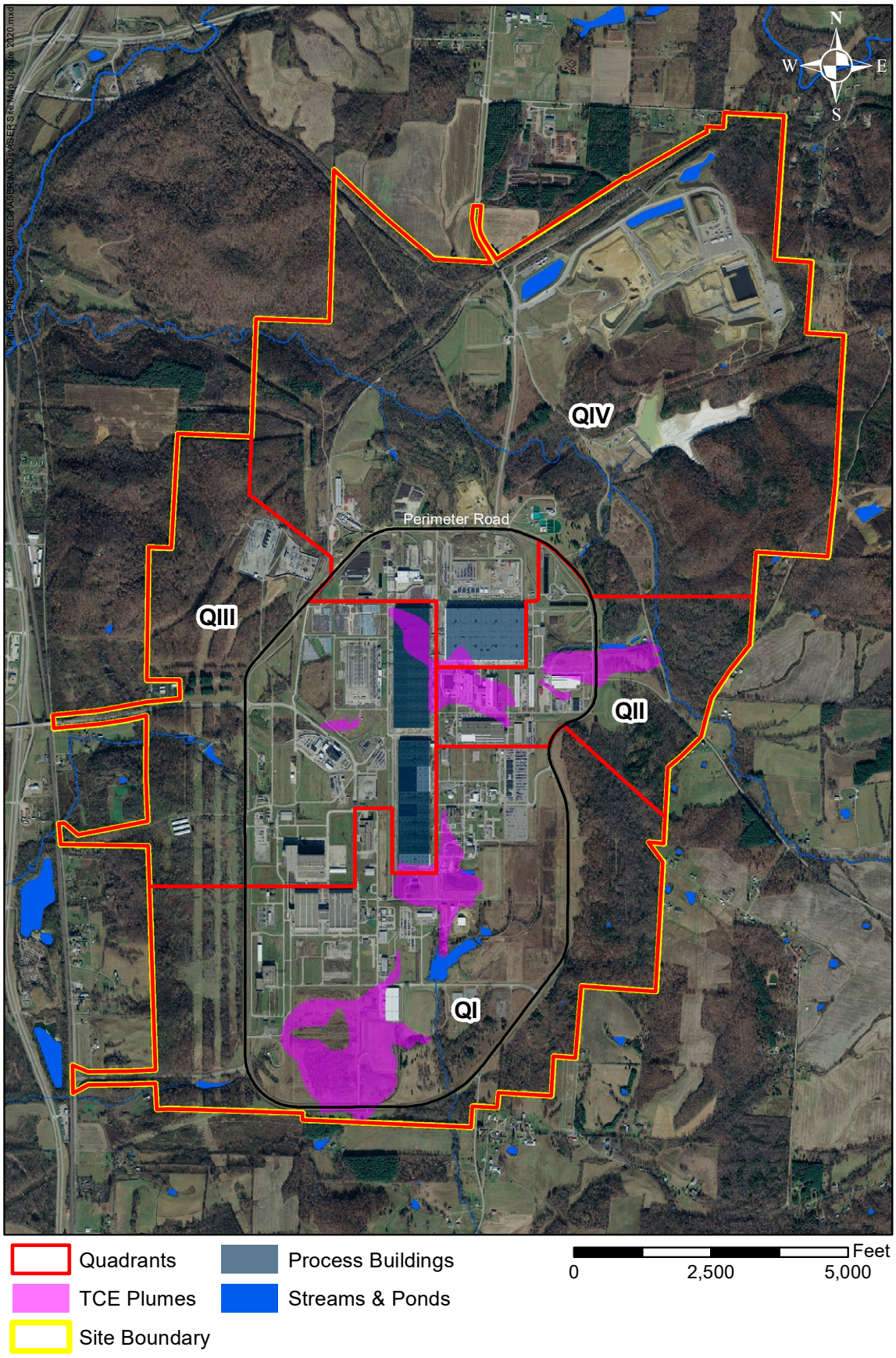
Site Wide Waste Disposition

The record of decision for site-wide waste disposition was concurred with by the 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 (OSWDF).

Environmental Restoration Program

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

1) An assessment to identify releases of hazardous waste and hazardous constituents and determine the need for further investigation,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2) An investigation to determine the nature and extent of any contamination, and
3) A study to identify and evaluate remedial alternatives to address contamination.

The initial assessment and investigation of PORTS under the RCRA corrective action process was completed in the 1990s. Because it is a large facility, it was divided into four quadrants to facilitate the cleanup process. Remedial actions have been started in each of the four quadrants. The following sections discuss the remedial actions taking place in the four quadrants.

Quadrant I

The Quadrant I *the Quadrant I Cleanup Alternative Study/Corrective Measures Study Work Plan* was approved by Ohio EPA in 2000 (DOE 2000). Ohio EPA issued the Decision Document for Quadrant I in 2001, which provided 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).

Artwork by Blake Reader

The remedial actions identified for the X-749/X-120 plume include phytoremediation of the plume, installation of a barrier wall around the eastern and southern portion of that landfill and continued operation of the collection of groundwater from trenches at the landfills. Additionally, groundwater extraction wells were installed in 2007, 2008 and 2010 to control the migration of the plume and remediate areas of higher trichloroethene (TCE) concentrations. The most recent five-year review of the remedial actions occurring for the plume, completed in 2016, examined the effectiveness of these actions. Ohio EPA approved the review and agreed that remedial actions taken were effectively meeting the remedial objectives.

Artwork by Mikaila Fremder

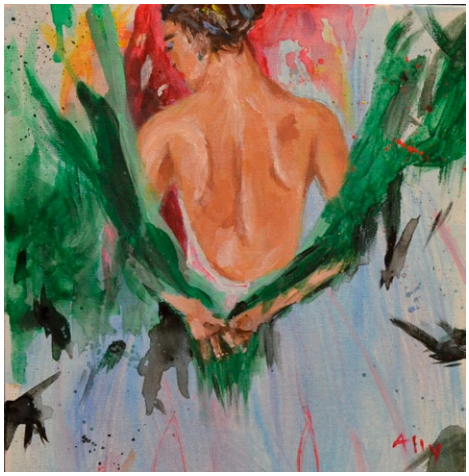
The remedial actions required by the PK Landfill Decision Documents consisted of the continued operation of the eastern groundwater collection system and construction of an engineered cap (Ohio EPA 1996 and U.S. EPA 1997). In addition, the southeastern groundwater collection system was constructed in 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. Five-year reviews for the PK Landfill have 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 contaminant transport.

Quadrant I Groundwater Investigative (5 unit) Area

Remedial actions identified for the Quadrant I Groundwater Investigative (5-Unit) Area are: 1) installation of multimedia caps over the X-231A and X-231B Oil Biodegradation plots; and 2) installation of 11 additional groundwater extraction wells to extract contaminated groundwater for treatment in the X-622 Groundwater Treatment Facility. The caps were constructed in 2000 and operation of the groundwater extraction wells began 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 TCE beneath the building. Five-year reviews found that remedial actions in this area were continuing to be effective at reducing potential exposure pathways, controlling plume migration, and removal of volatile organic compounds (VOCs).

Quadrant II

The *Quadrant II Cleanup Alternative Study/Corrective Measures Study* was approved by the Ohio EPA in 2001 (DOE 2001). In 2009, an investigation was conducted which sampled soil and groundwater. During this investigation, they found areas of higher TCE concentrations that appeared to be associated with continuing sources of groundwater contamination in the southeastern portion of the plume. In 2010, Ohio EPA approved an interim remedial measure (IRM) for this area called enhanced anaerobic bioremediation and was completed in 2013. Overall, there was not a measurable reduction in the average concentration of TCE in groundwater, most likely due to the potential presence of dense non-aqueous phase liquid TCE in the area, and the decision was made to conclude the IRM.



Artwork by Ally Crothers

Also in Quadrant II is the X-701B Former Holding Pond; here, oxidant injections were used to address contaminants. The review of the oxidant injections determined that the method used to inject oxidant into the contaminated area was not able to address contaminants in the deepest portion of the contaminated soil. If contaminants remained in this portion of the soil, they would continue to be released into the groundwater plume. Therefore, DOE proposed an IRM to excavate soil in the western portion of the X-701B plume area and directly mix oxidant into the contaminated soil. Lastly in Quadrant II, is the X-633 Former Recirculating Cooling Water Complex. The X-633 Recirculating Cooling Water Complex was demolished in 2010. TCE and Chromium 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 the evaluation of chromium and TCE in groundwater at this area. The *2017 Groundwater Monitoring Report for the Portsmouth Gaseous Diffusion Plant* provides the data for this monitoring (DOE 2018).

Quadrant III

The *Quadrant III Cleanup Alternative Study/Corrective Measures Study* was approved by Ohio EPA in 1998 (DOE

1998a). The Decision Document for Quadrant III, issued in 1999, required phytoremediation of groundwater plume near the X-740 Waste Oil Handling Facility. Over 700 hybrid poplar trees were planted on a 2.6-acre area above the X-740 groundwater plume. The reports concluded that the phytoremediation system had not performed as expected to remove TCE from the groundwater in this area (DOE 2003 and DOE 2007). In response to Ohio EPA's concerns about the performance of the phytoremediation system, DOE implemented additional remedial activities for the X-740 area. Three rounds of oxidant injections were completed in 2008 to remove TCE from groundwater. Although remedial actions briefly reduced TCE concentrations in some of the wells, TCE concentrations in groundwater returned to typical levels in 2009. In 2010, Ohio EPA approved a pilot study of enhanced anaerobic bioremediation for the X-740 area. TCE has decreased in wells within the area of the groundwater plume that was treated during the pilot study.

Quadrant IV

Artwork by Cheyenne Fout

The *Quadrant IV Cleanup Alternative Study/ Corrective Measure Study* was approved by Ohio EPA in 1998 (DOE 1998b). No new remedial actions were required in Quadrant IV. Five-year reviews completed in 2002, 2008, and 2013 (DOE 2002, DOE 2008a, and DOE 2013a) found that the soil cover and prairie habitat were meeting the remedial action objectives for the X-611A Former Line Sludge Lagoons by eliminating exposure pathways to the contaminants in the sludge at this area. Also in Quadrant IV, the Ohio EPA issued a Decision Document for the X-734 Landfills in 1999 (Ohio EPA 1999). Remedial actions required included the construction of a multimedia cap over the northern portion of the landfills and a soil cap over the southern portion of the area. Five-year reviews completed in 2008 and 2013 found that the landfill caps have achieved remedial action objectives by isolating contaminants in soil and sediment from potential receptors at the X-734 Landfills (DOE 2008b and DOE 2013b). The caps were also preventing contaminants from migrating from soil to groundwater and from groundwater to surface water. The next part of Quadrant IV is the X-630 Recirculating Cooling Water Complex. The Cooling Complex was removed during 2011 as part of D&D. A RCRA investigation of soil and groundwater at the X-630 Recirculating Cooling Water Complex was implemented in 2011. Areas of soil potentially contaminated with metals were identified, but the higher concentrations of metals may have been present in these areas (15 to 20 feet below ground surface) due to naturally-occurring variations in the geology of the area. Chromium and TCE were detected in groundwater at concentrations above the preliminary remediation goals during the 2011 RCRA investigation for the X-630 area. DOE agreed to sample four wells around the area annually to continue the evaluation of chromium and TCE in groundwater in this area.

Waste Management Program

The DOE Waste Management Program directs the safe storage, treatment, and disposal of waste generated by past and present operations and from current D&D and Environmental Restoration projects at PORTS. Waste managed under the program is divided into the following seven categories. These categories are radioactive waste, Hazardous RCRA waste, PCB wastes, RCRA/ low-level radioactive mixed waste, PCB/low-level radioactive mixed waste, PCB/RCRA/low-level radioactive mixed waste, and solid waste. Waste management requirements are varied and are sometimes complex because of the variety of waste streams generated by DOE activities at PORTS. Additional policies have been implemented for management of radioactive, hazardous, and mixed wastes. 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 within the local community. If SODI is unable to place the property for reuse in the local community then they may sell the property. When they sell the property, the proceeds are used to support economic development in the southern Ohio region.

Environmental Sustainability Program

DOE is committed to reducing potential environmental risk, costs, wastes, and future liability by effectively integrating environmental sustainability principles into DOE activities at PORTS in a cost effective and environmentally conscious manner. The *Fiscal Year 2018 Site Sustainability Plan* describes the Environmental Sustainability Program and integrates the tenets of an Emergency Management System (EMS) (DOE 2017a). The Environmental Sustainability Program includes elements of pollution prevention, waste minimization, affirmative procurement, sustainable design, and energy and water efficiency.

Artwork by Mason Goode

These objectives of the sustainability program, presented 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 (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 in the conduct of mission-related activities; and
- reducing the life-cycle cost of managing personal property at PORTS.

The following accomplishments were listed for fiscal year 2017 concerning the reduction in greenhouse gas emissions, water consumption, and recycling:

- a decrease of 60% in greenhouse gas emissions;
- a decrease in water consumption of 13%; and
- replacement of chlorine gas used as a disinfectant in the X-611.

Public Awareness Program

A comprehensive community relations and public participation program is in place at PORTS. The purpose of the program is to foster a spirit of openness and credibility between PORTS officials and local citizens, elected officials, business, media, and various segments of the public. The program also provides the public with opportunities to become involved in the decisions affecting environmental issues at PORTS.

The PORTS Site Specific Advisory Board (SSAB) is a board made up of citizens from the local area. The board members give input to DOE regarding environmental concerns and waste management. There are regularly scheduled public meetings held between DOE and PORTS SSAB. Additional information can found at www.energy.gov/pppo/ports-ssab or by calling 740-289-5249.

Artwork by Tyra Zimmerman

The PORTS Envoy Program matches volunteers with citizens who live around DOE property, community groups and local government organizations. The envoys give information about the plant to stakeholders in the vicinity about issues and are able to answer questions surrounding the plant.

DOE also maintains a public Environmental Information Center to provide public access to documents used to make decisions. Public meetings and workshops on specific topics are also held to keep the public informed and receive their comments and questions.

The following are information sources for the public:

- Environmental Information Center: www.energy.gov/pppo/portsmouth-environmental-center or 740.289.8898
- DOE Portsmouth/Paducah Project Office: www.energy.gov/pppo
- FBP website: www.fbportsmouth.com
- DOE Site Office: 740.897.5010
- FBP Office of Public Affairs: 740.897.2964

An educational outreach program facilitated by a DOE grant administered by Ohio University includes a project in which local high school students produce a summary of the Annual Site Environmental Report for distribution to the public. The DOE Portsmouth/Paducah Project Office website at www.energy.gov/pppo provides additional information about this project.

Environmental Radiological Information

Environmental monitoring at PORTS measures both radiological and chemical parameters in air, water, soil, sediment, and biota. Environmental monitoring programs are required by state and federal regulations, permits, and DOE Orders. These programs may also be developed to address public concerns about plant operations.

Monitoring programs consist of airborne discharges, ambient air, external radiation, discharges to surface water, sediment, soil, vegetation and biota. DOE also conducts an extensive groundwater monitoring program at PORTS, which will be discussed throughout the following sections. A US resident can expect to receive an average dose of 311 mrem/year of radiation from sources of natural occurrences (National Council on Radiation Protection [NCRP] 2009). A dose is a measure of potential biological damage that could be caused by exposure to and subsequent absorption of radiation to the body. Airborne releases from the facility are limited to a dose rate of 10 mrem/year to any member of the public by U.S. EPA. DOE Order 458.1 sets the annual dose limit of 100 mrem/year and as low as reasonably achievable to any member of the public from all releases from a facility. The NESHAP regulations set dose limit of 10 mrem/year from airborne releases. By way of comparison, the maximum dose of radiation a member of the pubic could receive from PORTS in 2017 was 0.90 mrem/year, which is below the DOE limit of 100 mrem/year.

Summary of potential doses to the public from PORTS in 2017

Source of dose	Dose (mrem/year)*
Airborne radionuclides (off-site individual)	0.12
Radionuclides released to the Scioto River	0.0012
External radiation near cylinder yards	0.74
Radionuclides detected by environmental monitoring programs	0.038
Total	**0.90**

**100 mrem/year is the DOE limit in DOE Order 458.1*

Environmental monitoring programs at PORTS are designed to detect the effects (if any) of PORTS operations on human health and the environment. Multiple samples are collected throughout the year and analyzed for radionuclides that could be present from PORTS activities. The results of these monitoring programs are used to gauge the environmental impact of PORTS operations and to set priorities for environmental improvements.

Radiological Emission and Doses

Doses are estimated for exposure to radionuclides from PORTS operations that were detected in 2017 as part of the DOE environmental monitoring programs for sediment, soil, residential drinking water (well water – excluding naturally-occurring detections of uranium isotopes) and selected biota (vegetation, deer, fish, crops, and dairy

products). If radionuclides were detected at locations accessible to the public, a dose assessment is completed based on the monitoring data. Exposure to radionuclides detected in groundwater at PORTS is not included because contaminated groundwater at PORTS is not a source of drinking water. Radionuclides were not detected in 2017 in samples of residential drinking water, deer, fish, crops, and dairy products.

Most consequences associated with radionuclides released to the environment are caused by interactions between human tissue and various types of radiation emitted by the radionuclides. Radiation may come from radionuclides outside the body (external) or from radionuclides inside the body (internal). External exposure happens only as long as a person is near the external radionuclide and internal exposure continues as long as the radionuclide remains inside the body. For uranium isotopes and other radioactive isotopes, a number of specialized measurement units have been defined to describe the amount of ionizing radiation in terms of biological consequences of the absorbed energy. These units are absorbed dose, equivalent dose, effective dose and collective dose.

Airborne Emissions

Artwork by Dakota Cheadle

Airborne discharges of radionuclides from PORTS are regulated under NESHAP. FBP was responsible for air emission sources associated with the former gaseous diffusion plant operations, including continuously monitored vents. Total emissions from FBP sources in 2017 were calculated to be 0.0670 curie (Ci). MCS was responsible for air emissions associated with the DUF_6 Conversion Facility. Total emissions from MCS sources in 2017 were 0.0000442 Ci. The Centrus demonstration cascade was the only source of radionuclide air emissions from Centrus that was subject to NESHAP, and in 2017 Centrus was shut down.

The effect of radionuclides released to the atmosphere by PORTS during 2017 was characterized by calculating the effective dose to the maximally exposed person (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. The maximum potential dose to an off-site individual from radiological releases from DOE air emission sources at PORTS in 2017 was 0.12 millirem per year (mrem/year), which is well below the 10 mrem/year limit. In 2017, the population dose from PORTS emissions was 0.47 person-rem/year. The highest net dose was significantly less than the 10 mrem/year NESHAP limit for airborne radiological releases and 100 mrem/year DOE limit in DOE Order 458.1 for all radiological releases from a facility.

DOE collects samples from 15 ambient air monitoring stations and analyzes them for the radionuclides that could be present in ambient air due to PORTS activities. The net dose for each station ranged from 0 at stations with a lower dose than the background station to 0.072 mrem/year at station A41A. These dose limits are significantly less the 10 mrem/year NESHAP limit and 100 mrem/year DOE limit.

Discharge of Radionuclides from NPDES Outfalls

In 2017, FBP was responsible for 18 monitoring locations identified in the FBP 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 are also monitored. In 2017, Centrus was responsible for three NPDES outfalls through which water is discharged from the site. The dose calculated with these data is significantly less than the 100 mrem/year limit in DOE Order 458.1 for all radiological releases from a facility. The dose released to the Scioto River was also under the dose limit set by DOE.

Dose Calculations for Releases to Surface Water

Radionuclides are measured at the FBP and Centrus NPDES external outfalls. Water from these outfalls is either directly or indirectly discharged into the Scioto River. A hypothetical dose to a member of the public was calculated using the measured radiological discharges and the annual flow rate of the Scioto River. Environmental pathways considered were ingestion of water, ingestion of fish, swimming, boating, and shoreline activities. This exposure scenario is unlikely to underestimate the dose due to the fact that the Scioto River is not used for drinking water. The dose from radionuclides released to the Scioto River in 2017 (0.0012 mrem) is significantly less than the 100 mrem/year DOE limit for all radiological releases from a facility.

Artwork by Layne Moorman

Radiological Dose Calculation for External Radiation

Radiation is emitted from DUF_6 cylinders stored on site at PORTS in the cylinder storage yards. External radiation is measured at five locations along Perimeter Road near the boundaries of the cylinder storage yards in accordance with the DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2017b). The radiological exposure to an on-site member of the general public is estimated as the time that a person drives on Perimeter Road past the cylinder yards which is estimated at 8.7 hours per year (1 min. per trip, 2 trips per day, 5 work days per week, and 52 weeks per year). In 2017, based on these assumptions, exposure to an on-site member of the public from radiation from the cylinder yards is approximately 0.74 mrem/year. There was also a dose calculation completed for a representative off-site member of the public based on the 2 mrem/year difference between the average off-site background dose (86 mrem/year) and the dose at station A29 (88 mrem/year). Assuming that the worker was exposed to this kind of radiation for 250 days/year, one hour being outdoors and 8 hours inside, the dose to this worker is 0.22 mrem. This is significantly less than the 100 mrem/year limit. A person living in the United States receives an average dose of approximately 311 mrem/year from natural sources of radiation (NCRP 2009). The estimated dose for members of the public from the external radiation is approximately 0.2 percent of the average natural radiation a person in the United States receives yearly. Furthermore, more than 2500 DOE employees and contractors were monitored throughout 2017 and received an average dose of 1 mrem.

Radiological Dose Calculations for Off-Site Environmental Monitoring Data

Environmental monitoring at PORTS consists of collecting samples at locations that are off-site and analyzing those samples for radionuclides that could be present due to PORTS. Radiological monitoring programs at PORTS include ambient air, surface water, sediment, soil, residential drinking water, and biota (vegetation, deer, fish, crops, milk, and eggs).

The following table summarizes the results of each dose calculation, which are significantly less than the 100 mrem/year DOE limit.

Summary of potential doses to public from radionuclides detected by DOE environmental monitoring programs 2017

Source of dose	Dose (mrem/year)[a]
Sediment	0.019
Soil	0.018
Vegetation	0.00078
Total	**0.038**

[a] *100 mrem/year is the limit for all potential pathways in DOE Order 458.1*

Protection of Biota

DOE Order 458.1 sets absorbed dose rate limits for aquatic animals, riparian animals, terrestrial plants, and terrestrial animals. The assessments of radionuclides detected in both water and sediment at these locations indicate that they had a dose of less than 1 rad per day to aquatic animals and 0.1 rad per day to riparian animals. The doses to terrestrial plants and animals are also within the dose limits of 1 rad per day. There were no unplanned releases of radionuclides at PORTS in 2017.

Ambient Air Monitoring for Radionuclides

In 2017, samples were collected from 15 ambient air monitoring stations located within and around PORTS. The ambient air monitoring stations measure radionuclides released from 1) DOE point sources, 2) fugitive air emissions, and 3) background levels of radionuclides (radionuclides that occur naturally, such as uranium). To confirm that air emissions from PORTS are within correct regulations and requirements and are not harmful to human health, the ambient are monitoring data were used to calculate a dose to a hypothetical person living at the monitoring station. The highest net dose for the monitoring stations (0.072 mrem/year) was at station A41A. This hypothetical dose is much less than the 10 mrem/year limit applicable to PORTS in NESHAP.

External Radiation

External radiation is measured continuously with thermoluminescent dosimeters (TLDs) at five locations near the DUF_6 cylinder storage yards, 19 locations that include 12 of the ambient air monitoring stations, and seven additional on-site locations. TLDs are placed at the monitoring locations at the beginning of each quarter, 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. 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.

Artwork by Annie McGaughey

External radiation is measured at five locations around the northwest corner of PORTS just inside Perimeter Road near the cylinder storage yards. The average annual dose for these five locations is 739 mrem. For the representative on-site member of the public, such as a delivery person, that is allowed on the portion of Perimeter Road near the cylinder storage yards, the average dose is 0.74 mrem/year, which is less than the DOE limit of 100 mrem/year.

In 2017, the average annual dose measured at eight off-site or background locations was 86 mrem. Two locations within PORTS measured levels of radiation approximately 50% higher or more than the average off-site radiation. The on-site locations with higher doses than the off-site average are not used by the general public, with the exception of location #874 near the cylinder yards and station A29, near the Ohio Valley Electric Corporation (OVEC). The potential estimated dose to this off-site worker is significantly less than the 100 mrem/year dose limit to the public for radionuclides from all potential pathways in DOE. No administrative guidelines or regulatory dose limits were exceeded in 2017.

Surface Water from Cylinder Storage Yards

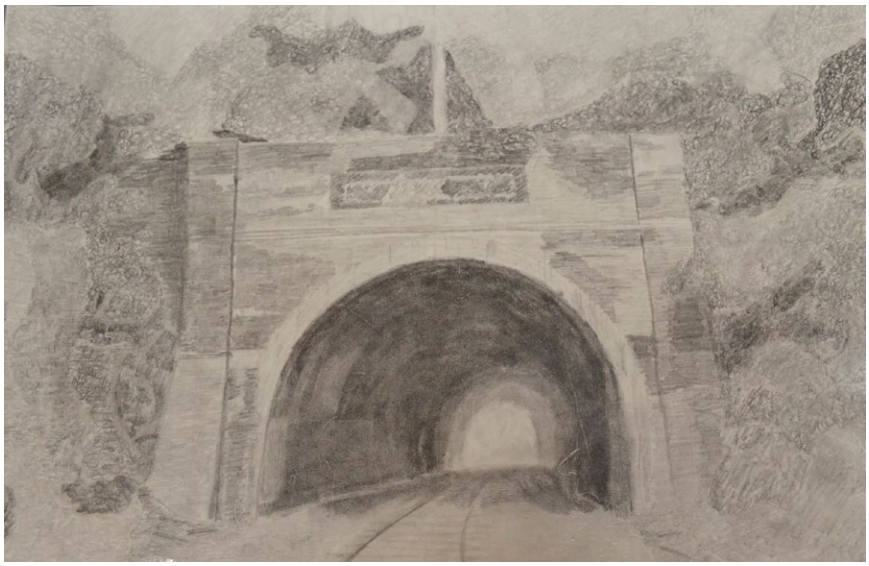
In 2017, FBP collected surface water samples from Cylinder Storage Yards. MCS collected surface water samples at the cylinder yards associated with the DUF_6 Conversion Facility. In 2017, FBP collected surface water samples from seven locations, including the Cylinder Storage Yards. Samples were analyzed for alpha activity, beta activity, and uranium. Samples were collected monthly if water was available. Surface water from the cylinder storage yards flows to FBP NPDES outfalls prior to discharge from the site; therefore, releases of radionuclides from the cylinder yards are monitored by sampling conducted at the FBP outfalls. The dose from radionuclides released to surface water in the Scioto River in 2017 associated with both the FBP and MCS storage yards is significantly less than the 100 mrem/year limit for all radiological releases from a facility in DOE Order 458.1. No transuranic radionuclides were detected in the local surface water samples collected during 2017.

Local Surface Water Monitoring for Radionuclides

In 2017, local surface water samples were collected from 14 locations upstream and downstream from PORTS. Samples were collected semiannually and analyzed for transuranic radionuclides, technetium-99, uranium, and uranium isotopes in accordance with the DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2017b). No transuranic radionuclides, technetium-99, or uranium-235/236 were detected in the local surface water samples collected during 2017.

Sediment

Sediment samples are collected from the same locations upstream and downstream from PORTS where local surface water samples are collected. Samples are collected annually and analyzed for transuranic radionuclides, technetium-99, uranium, and uranium isotopes in accordance with the DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2017b). Uranium and uranium isotopes are naturally occurring but may also be present due to PORTS activities. In 2017, neptunium-237, plutonium-239/240 and technetium-99 were detected in the sediment samples. The total potential dose to a member of the public resulting from PORTS operations is approximately 0.90 mrem/year, which includes the sediment dose calculation of 0.019 mrem, is well below the DOE standard of 100 mrem/year.



Artwork by Bryce Coreno

Settleable Solids

DOE collects semiannual water samples from nine effluent locations and three background locations to determine the concentration of radioactive material that is present in the sediment suspended in the water sample. The data are used to determine compliance with DOE Order 458.1, *Radiation Protection of the Public and the Environment*, which says that operators of DOE facilities releasing liquids containing radionuclides from DOE activities must make sure that the discharges do not exceed an annual average of either of the following:

- 5 pCi/g above background of settleable solids for alpha-emitting radionuclides
- 50 pCi/above background for beta-gamma-emitting radionuclides

In 2017, settleable solids were not detected at concentrations above 40 mg/L at any of the monitoring locations; therefore, monitoring results are in compliance with DOE Order 458.1.

Soil

Soil samples are collected annually from ambient air monitoring locations and analyzed for transuranic radionuclides, technetium-99, uranium, and uranium isotopes in accordance with the DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2017b). Plutonium-239/240 was detected in soil at six of 15 ambient air monitoring stations including the background monitoring station. The detection was much less than the soil screening level for residential soil. Uranium, uranium-233/234, uranium-235/236, and/or uranium-238 were detected at each sampling locations. They are usually detected, so it suggests that they are naturally occurring. The total potential dose to a member of the public resulting from PORTS operations (0.90 mrem/year), which includes the soil dose calculation of 0.018 mrem, is well below the DOE standard of 100 mrem/year.

Artwork by Mason Goode

Biological Monitoring

The DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2017b) requires biological monitoring to assess the uptake of radionuclides into selected local biota. For each selected biota, samples are collected and analyzed for transuranic radionuclides, technetium-99, uranium and uranium isotopes. Vegetation samples were collected in the same areas where soil samples are collected at the ambient air monitoring stations. Deer samples are collected from deer that are killed from vehicle collisions at PORTS, if available. Fish were caught from Big Beaver Creek, Little Beaver Creek, and the Scioto River. Crops were collected from five off-site locations near PORTS. Milk and Eggs were produced near PORTS. No radionuclides were found in the biota except for a small dose in vegetation, which were well under the DOE Oder 458.1 limit.

Releases of Property Containing Residual Radioactive Material

DOE Order 458.1 establishes limits for unconditional release of personal and real property from DOE facilities. Real property is anything attached to property and the property itself. No real property was released from PORTS in 2017. FBP uses pre-approved authorized limits established by DOE Orders to evaluate and release materials defined as personal property. Personal property is any property that isn't real property. In 2017, FBP authorized 1625 release requests for material/items of personal property. In 2017, MCS shipped dilute hydrogen fluoride rinse water produced from cleaning the Conversion facility. Each shipment must meet the release limit of less than 3 picocuries/milliliter (pCi/mL) of total uranium activity. Approximately 9.025 gallons of dilute hydrogen fluoride were shipped off site during 2017. The average total uranium activity of the shipment was 0.016 pCi/mL.

Environmental Non-Radiological Program Information

Non-radiological environmental monitoring on-site at PORTS includes air, surface, water, sediment and fish. The *DOE Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* specifies the non-radiological monitoring requirements for ambient air, surface water, sediment and fish (2017b). Environmental permits are issued by the Ohio EPA to site contractors. These permits specify discharge limitations, monitoring requirements, and/or reporting requirements for air emissions and water discharges.

Airborne Discharges

Permitted air emission sources at PORTS emit non-radiological air pollutants. In addition, the DOE Ambient air monitoring program measures fluoride at monitoring stations within PORTS boundaries and in the surrounding area.

FBP is responsible for numerous air emission sources associated with the former gaseous diffusion production facilities. The sources, which included the boilers from the Steam Plant Complex prior to demolition, emitted more than 100 tons per year of non-radiological air pollutants. MCS reported less than 10 tons/year of specified non-radiological air pollutants in 2017 related to the DUF_6 Conversion Facility.

U.S. EPA also requires annual reporting of greenhouse gas emissions. In 2017, FBP reported emissions of 14,695 metric tons of carbon dioxide, 0.28 metric ton of methane and 0.028 metric ton of nitrous oxide. Also, the amount of asbestos removed and disposed is reported to Ohio EPA. In 2017, 27.2 tons of asbestos-containing materials were shipped from PORTS.

Artwork by Mason Goode

Ambient Air Monitoring for Fluoride

Fluoride detected at the ambient air monitoring stations could be present do to background concentrations naturally in the environment, activities associated with the former gaseous diffusion process and operation of the DUF_6 Conversion Facility. There are 15 different locations around and within PORTS that are monitored weekly for fluoride. There is no standard for fluoride in ambient air and data indicates that ambient concentration of fluoride is not significantly different off-site and background from concentrations at PORTS.

Non-Radiological Water Monitoring

Ground and surface water are monitored at PORTS. Non-radiological surface water monitoring primarily consists

of sampling water discharges associated with the FBP, MCS, and Centrus NPDES-permitted outfalls. PCBs are then monitored in surface water located downstream from the cylinder storage yards. In 2017, DOE contractors FBP and MCS were responsible for 21 NPDES points/fallouts or sampling points at PORTS. Centrus Energy Corps was responsible for three outfalls.

FBP NPDES Outfalls

Ohio EPA selects the chemical parameters that must be monitored at each outfall based on the chemical characteristics. The average monthly concentration preliminary effluent limit for mercury was exceeded in May through August of 2017. FBP has initiated an investigation to identify the source of the mercury detected so that corrective measures can be implemented. The drinking water standard for mercury is 2 µg/L (2000 ng/L). The preliminary effluent limit for mercury (12 nanograms per liter (ng/L)) is lower than the drinking water standard (2000 ng/L) to minimize the accumulation of mercury in biota, such as fish and birds. In September and October of 2017, the maximum daily concentration limit for copper was exceeded in three samples. Discharge limits for pH were also exceeded twice in 2017. Lastly, the maximum daily concentration limit for E. coli was exceeded due to a malfunction in the sewage treatment system. In all three instances, adjustments were made to restore compliance. In 2017, the overall FBP NPDES compliance rate with the NPDES permit was 99%.

Artwork by Ceci Rockwell

MCS NPDES Outfalls

MCS is in charge of the NPDES permit for the discharge of process wastewaters from the DUF_6 Conversion Facility. MCS outfalls had no exceedances of permit limitations, as stated by the Ohio EPA, therefore the overall compliance rate was 100%.

Centrus NPDES Outfalls

Centrus is responsible for three outfalls through which water is discharged from the site. Centrus outfalls had no exceedances of permit limitations, as stated by the Ohio EPA, therefore the overall compliance rate was 100%.

Surface Water & Sediment Monitoring

Surface water samples are collected quarterly from four locations in drainage basins and are then analyzed for PCBs. PCBs were not detected in any of the samples collected during 2017.

Sediment monitoring at PORTS includes sampling from the same locations as surface water which include: local streams; the Scioto River upstream and downstream from PORTS; and, drainage basins downstream from the MCS cylinder storage yards. The results of metals sampling conducted in 2017 indicate that no appreciable differences are evident in the concentrations of metals present in sediment samples taken. However, PCBs were detected in samples upstream and downstream from PORTs and in at least one of the MCS associated sediment samples collected at each location. None of the samples contained PCBs above the risk-based regional screening level for PCB-1254/1260 developed by U.S. EPA and utilized by Ohio EPA.

Artwork by Grace Lightle

Biological Monitoring of Fish

Fish samples were analyzed for PCBs. The 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. PCBs were detected in the bass collected from Little Beaver Creek, upstream and downstream on Big Beaver Creek, as well as from catfish and drum collected from upstream and downstream Scioto River. Consumption limits are set by Ohio EPA which include unrestricted, 1/week, 1/month, 6/year, and do not eat. Consumption limits for sport fish caught from all water bodies in Ohio should be consulted before eating any fish caught in Ohio waters (Ohio EPA 2018). 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/or PCB contamination.

Groundwater Programs

The groundwater monitoring at PORTS is required by a combination of state and federal regulations, legal agreements with Ohio EPA, and DOE Orders. More than four hundred monitoring wells are used to track the flow of groundwater and identify and measure groundwater contaminants. The groundwater programs also include on-site surface water monitoring and water supply monitoring.

Artwork by Luke Nichols

This section provides an overview of groundwater monitoring at PORTS and the results of the groundwater monitoring program for 2017. Groundwater monitoring has been conducted in response to state and/or federal regulations, regulatory documents prepared by DOE, agreements between DOE and Ohio EPA or U.S. EPA and DOE Orders. Due to the many different regulatory programs regarding groundwater, the *Integrated Groundwater Monitoring Plan*, was developed and is used to address all the groundwater monitoring standards (DOE 2015c, DOE 2017c). Groundwater monitoring is also conducted to meet DOE Order requirements.

Groundwater Use and Geology

The Berea and Gallia water bearing zones are both present beneath PORTS. The Gallia is the uppermost zone and contains most of the contamination. Groundwater directly beneath PORTS is not used to supply any local drinking water and does not affect the quality of water in the Scioto River Valley aquifer.

Groundwater Monitoring Activities & Groundwater Monitoring Areas

Samples from the groundwater wells are used to monitor naturally occurring compounds in the groundwater. The rate and direction of groundwater flow can be used to predict the movement of contaminants in groundwater and to develop ways to control the contamination. Samples are collected and compared to preliminary remediation goals, which are initial clean up goals developed early in the decision-making process. The samples are analyzed for metals, VOCs and radionuclides. At PORTS, testing takes place in all four quadrants and is required by the Integrated Groundwater Monitoring Plan (DOE 2017c). Five different areas of contamination in the groundwater, called groundwater plumes, have been identified at PORTS.

X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility/PK Landfill

In the southernmost portion of PORTS in Quadrant I, groundwater concerns focus on three contaminant sources: X-749 Contaminated Materials Disposal Facility (also called the X-749 Landfill), X-120 Former Training Facility, and PK Landfill. A contaminant plume consisting of VOCs, primarily TCE, is associated with the X-749 Contaminated Materials Disposal Facility and X-120 Former Training Facility. The PK Landfill, located northeast of the X-749 Landfill, is not a contaminant source to the X-749 or X-120.

In general, concentrations of TCE were stable or decreasing in the X-749 and X-120 plume. In 1994, a subsurface barrier wall was completed across a portion of this southern boundary of PORTS. The X-749 South Barrier Wall was designed to inhibit migration of the plume off plant property prior to the implementation of a final remedial measure; however, VOCs moved beyond the wall. In 2007, four groundwater extraction wells were installed in the X-749 South Barrier Wall Area, and in 2008, two extraction wells were installed in the groundwater collection system on the southwest side of the landfill. These extraction wells are controlling the migration of the plume off plant property and reducing concentrations of TCE in groundwater. Two additional groundwater extraction wells were installed in 2010 to further control the migration of the X-749/X-120 groundwater plume and remediate areas of higher TCE concentrations within the plume. Another extraction well was also installed in the X-120 area of the plume. Ninety-eight wells and one sump/extraction well were sampled during 2017 to monitor the X-749/X-120 area. Samples from selected groundwater monitoring wells in the X-749/X-120 groundwater plume were analyzed for radionuclides. If detected, radionuclides were present in groundwater at levels below Ohio EPA drinking water standards. Further, no VOCs were detected in any of the off-site monitoring wells.

Artwork by Quincy Harris

The PK Landfill is located west of Big Run Creek just south of the X-230K Holding Pond in Quadrant I and northeast of the X-749 Landfill. PK Landfill, which began operations in 1952, was used as a salvage yard, burn pit, and trash area during the construction of PORTS. After the initial construction, the disposal site was operated as a sanitary landfill until 1968, when soil was graded over the site and the area was seeded with native grasses. The PK Landfill is not part of the X-749/X-120 groundwater plume, although some of the wells associated with the PK Landfill are contaminated with low levels of VOCs, including TCE. Most of the detections of VOCs in the PK Landfill monitoring wells are below remediation goals. No other VOCs were detected that exceeded remediation goals.

Quadrant I Groundwater Investigative (5-Unit) Area/X-749A Classified Materials Disposal Facility

The Quadrant I Groundwater Investigative (5-Unit) Area consists of a groundwater plume resulting from numerous sources of groundwater contamination in the north portion of Quadrant I. Thirty-four wells were sampled in 2017 as part of the monitoring program for the Quadrant I Groundwater Investigative Area. A contaminated groundwater plume consisting primarily of TCE is associated with the Quadrant I Groundwater Investigative Area. Other VOCs are also present in the plume. TCE is increasing in the northern portion of the plume. TCE was detected at 540 µg/L in 2017, which has increased from 220 µg/L in 2016. TCE also increased in the northwestern portion of the plume. TCE was detected at 71,000 µg/L in the third quarter of 2017, which was an increase from 2013-2016. The eastern edge of the groundwater plume changed in 2017 based on detections of TCE. TCE is usually detected in these wells at concentrations just above or below the preliminary remediation goal and was below the preliminary remediation goal in 2017. No other significant changes in TCE concentrations were identified in wells that monitor the Quadrant I Groundwater Investigative Area and none of the control limits requiring Ohio EPA notification were exceeded in the X-749A wells in 2017.

Quadrant II Groundwater Investigative (7-Unit) Area

A contaminated groundwater plume consisting primarily of TCE is associated with the Quadrant II Groundwater Investigative (7-Unit) Area. The Quadrant II Groundwater Investigative (7-Unit) Area consists of an area of groundwater contamination with several potential sources. In 2010, Ohio EPA approved an IRM to remediate contaminant source areas within the southeastern portion of the groundwater plume, which was completed in 2013. The natural groundwater flow direction in this area is to the east toward Little Beaver Creek. The groundwater flow pattern has been changed in this area by use of sump pumps which forces the groundwater plume in this area to flow toward the sumps where it is collected and then treated at the X-627 Groundwater Treatment Facility. Twenty-four wells are part of the routine monitoring program for this area.

Artwork by Riley Williams

Concentrations of TCE detected in the Quadrant II Groundwater Investigative (7-Unit) Area plume were generally stable or decreasing in 2017, with the exception of one well on the southern perimeter of the plume and one well on the eastern side of plume. Additionally, samples were tested for radionuclides, and if detected, they were below Ohio EPA drinking water standards.

X-701B Former Holding Pond

Artwork by Riley Williams

In the eastern portion of Quadrant II, there are three areas with groundwater concerns, including the X-701B Former Holding Pond. A contaminated groundwater plume extends from the X-701B Former Holding Pond towards Little Beaver Creek. Several wells and a sump were installed to intercept contaminated groundwater emanating from the holding pond area before it could join the existing groundwater contaminant plume. The extraction wells and sump were removed between 2009 and 2011 because of the X-701B IRM.

Currently, two groundwater interceptor trenches are used to intercept TCE-contaminated groundwater in the eastern portion of the monitoring area. These interceptor trenches control TCE migration into Little Beaver Creek. Sixty-three wells that monitor the X-701B Former Holding Pond area were sampled in 2017 as part of the *Integrated Groundwater Monitoring Plan* (DOE 2017c).

Concentrations of TCE in 2017 were similar to previous years. TCE is decreasing in a well downgradient of the IRM treatment area. The southern edge of this plume has expanded based on the detection of TCE in two wells. There was also a increase in TCE detected in a well that monitors the eastern portion of the plume.

Samples from 48 wells that monitor the X-701B Holding Pond were analyzed for radionuclides. Technetium-99 or uranium were detected above Ohio EPA drinking water standards in four wells near the former X-701B Pond and east retention basin and in wells installed within the IRM area. Concentrations of radionuclides present in groundwater in the X-701B area can be affected by the oxidant used in the X-701B IRM and the oxidant injections conducted in 2006 through 2008 that were part of the X-701B groundwater remedy. Samples from five wells that monitor the area near the X-744G Bulk Storage Building and X-744Y Storage Yard were analyzed for cadmium and nickel, which were detected above preliminary remediation goals in three of the five wells. Nickel was also detected at concentration above the preliminary remediation goal in samples collected from two wells, which monitor the center of the plume downgradient from the IRM treatment area and the area in which oxidant was injected from 2006 through 2008. This area is likely affected by the oxidant used in the X-701B IRM and the oxidant injections conducted in 2006 through 2008.

Additional Ground Monitoring

X-633 Former Recirculating Cooling Water Complex

The X-633 Former Recirculating Cooling Water Complex in Quadrant II consisted of a recirculating water pumphouse and four cooling towers with associated basins and in 1996 analytical data showed levels of concern for metal contamination. Two of the wells are being sampled semiannually for potential metal contamination as part of the monitoring program. In 2017, chromium was detected in both monitoring wells. Samples from one well showed chromium above the preliminary remediation goal of 100 µg/L. The second well showed below the preliminary remediation goal. These are the typical results for the wells.

X-616 Former Chromium Sludge Surface Impoundments

The X-616 Former Chromium Sludge Surface Impoundments in Quadrant III were two unlined surface impoundments, used for the storage of sludge. In 1990-1991 the sludge was removed and was remediated as an interim action. After testing in 2017, results still showed above the goal level of 100 μ g/L of chromium in the one well. Chromium is usually detected above this goal in the well. Nickel was detected above the preliminary remediation goal of 100 μg/L in two wells like it typically has been found in the past. TCE was also found above the preliminary remediation goal of 5 μg/L in three wells west of the former surface impoundments.

X-740 Former Waste Oil Handling Facility

The X-740 Former Waste Oil Handling Facility, which was demolished in 2006, was located on the western half of PORTS in Quadrant III. The facility was operated from 1983 until 1991 and used as an inventory and staging facility for waste oil and waste solvents. For many years they tried to solve the problem of VOCs above the groundwater area with various methods but failed at each try. A pilot study to enhance the anaerobic bioremediation was conducted from 2010 until 2015. Twenty-three wells that monitor the X-740 Former Waste Oil Handling Facility were sampled during 2017 and found the TCE groundwater plume reduced in size in 2017. The concentrations of TCE decreased to below 5 μg/L in wells that monitor the eastern and northeastern boundaries of the plume. The area of higher TCE concentrations within the plume no longer exists because they are less than 100 μg/L. The TCE concentrations are decreasing because of the bioremediation project.

X-611A Former Sludge Lagoons

The X-611A Former Lime Sludge Lagoons in Quadrant IV were used for the disposal of lime sludge waste from the site water treatment plant from 1954 to 1960. The lagoons covered a surface area of 18 acres and were constructed in a low-lying area that included Little Beaver Creek. As part of the RCRA Corrective Action Program, a prairie habitat in this area was developed by placing a soil cover over the north, middle, and south lagoons to gather the water in this area. Six of the wells are sampled semiannually for beryllium and chromium to monitor as part of the program. The results in 2017 show that chromium was found in four of the six wells and that beryllium was detected in two of the six wells. Both detections of chromium and beryllium were below the preliminary remediation goals.

X-735 & X-734 Landfills

The X-735 Industrial Solid Waste Landfill includes the industrial solid waste cells, asbestos disposal cells, and the chromium sludge mono cells A and B. The landfill began operation in 1981 and initially, a total of 17.9 acres was approved by the Ohio EPA and Pike County Department of Health for landfill disposal of conventional solid wastes. Waste disposal in the northern area ended in 1991, and the Ohio EPA determined that the area required closure as an RCRA hazardous waste landfill. Twenty-one wells were sampled in 2017 as part of the monitoring programs for this area.

The monitoring program at the X-735 Landfills includes corrective measures monitoring for Gallia wells and detection monitoring for Berea wells. As required by the corrective measures monitoring program, concentrations

of three metals (cobalt, mercury, and nickel) and five indicator parameter (alkalinity, chloride, sodium, sulfate, and total dissolved solids) detected in downgradient Gallia wells are compared to concentration limits based on drinking water standards or site background concentrations. None of these concentrations were exceeded in 2017. None of the control limits used to determine a statistically significant change in the indicator parameters requiring Ohio EPA notification was exceeded in the X-735 Berea wells in 2017.

The X-734 Landfills consisted of three landfill units that were used until 1985. The X-734 Landfills were closed in accordance with regulations in effect at the time and now groundwater monitoring is required. However, the RCRA Facility Investigation conducted in the early 1990s identified the presence of VOCs, metals, and radionuclides in soil and/or groundwater in the area. Fifteen wells are sampled semiannually as part of the monitoring program for this area.

VOCs are routinely detected in a number of the wells that monitor the X-734 Landfills, but generally at concentrations below preliminary remediation goals. In 2017, no VOCs were detected at concentrations above the preliminary remediation goals in the samples collected from the X-734 monitoring wells. Samples from the nine of the X-734 monitoring wells were also analyzed for five metals (beryllium, cadmium, chromium, manganese, and nickel). None of the samples contained metals at concentrations above the respective preliminary remediation goal nor transuranics.

X-533 Former Switchyard Complex

The X-533 Former Switchyard Complex in Quadrant IV consisted of a switchyard containing electrical transformers and circuit breakers, associated support buildings, and a transformer cleaning pad. D&D of the facilities began in 2010 and was completed in 2011. Soil contaminated with PCBs or metals was removed from three areas within the complex in 2010; however, none of the soil removal areas were located near the groundwater area of concern. The X-533 Former Switchyard Complex was identified as an area of concern for potential metals contamination in 1996 based on historical analytical data for groundwater wells in this area. The area was added to the PORTS groundwater monitoring program because the sampling identified metals that may have contaminated groundwater in this area. There are three wells are sampled semiannually for cadmium and nickel.

Three wells that monitor the X-533 Former Switchyard Complex were sampled in the second and fourth quarters of 2017 and analyzed for cadmium and nickel. Each of the well samples contained these metals at concentrations above the preliminary remediation goals.

X-344C Former Hydrogen Fluoride Storage Building

The X-344C Former Hydrogen Fluoride Storage Building and associated hydrogen fluoride storage tanks were demolished and removed in 2006. In 2009, an investigation of soils and groundwater near the former building determined that groundwater in one monitoring well south of the former building contained two VOCs at concentrations well below the preliminary remediation goals. One well is sampled annually for VOCs under the monitoring program for this area. Four VOCs, cis-1,2-dichloroethene, trans-1,2-dichloroethene, TCE, and vinyl chloride, were detected in the sample collected in the first quarter of 2017 at concentrations less than the preliminary remediation goals.

Surface Water Monitoring

Surface water monitoring is conducted in conjunction with groundwater assessment monitoring if contaminants present in groundwater are detected in surface water samples. Surface water is collected quarterly from 14 locations including Little Beaver Creek, Big Run Creek, Southwestern Drainage Ditch, North Holding Pond, and Western Drainage Ditch. TCE was detected at several locations, though all detections were below EPA drinking water standards (810 micrograms/liter). No transuranics were detected in 2017. The concentrations of uranium detected in the surface water samples were 0.25% or less of the DOE derived concentration standards for uranium isotopes. The detections during 2017 were within the historical range of uranium detected in surface water at PORTS.

Water Supply Monitoring

Routine monitoring of private residential drinking water sources is completed at PORTS in accordance with the State of Ohio and DOE and the integrated groundwater monitoring plan. The purpose of the program is to determine if PORTS had impacts on the quality of the private residential drinking water sources. Data from this program will not be used in environmental investigations due to the lack of knowledge of how residential wells were constructed and due to the presence of various types of pumps (which may not be ideal equipment for sampling). Four residential drinking areas participated in the program, however, two residential drinking areas were not able to be sampled in 2017 because the well pumps were not operable. In the first and third quarters of 2017, TCE was detected at estimated concentrations ranging from 0.16 to 0.58 ug/L. No other VOCs were detected. Since this residential water supply was added to the monitoring program in 2009, TCE has routinely been detected in the water. These detections are less than the drinking water standard TCE. Chlorination byproducts called trihalomethanes are common residuals in treated drinking water and were detected in the first and third quarter samples collected. The total concentration of these trihalomethanes was less than the Ohio EPA drinking water standard.

DOE Order Monitoring Programs

One of the DOE surveillance monitoring programs at PORTS is exit pathway monitoring. Exit pathway monitoring assesses the effect of the facility on off-site surface water and groundwater quality. Technetium-99 was detected at 16.1 and 7.59 pCi/L at the monitoring location at Little Beaver Creek, these concentrations were 0.037% or less of the standard for Technetium-99 in water. VOCs were also detected in several on-site groundwater monitoring wells and were found to be below Ohio EPA drinking water standards. Samples from exit pathway monitoring wells were also analyzed for radionuclides and if found, the levels were below Ohio EPA drinking water standards.

Groundwater Treatment Facilities

In 2017, a combined total of approximately 35.5 million gallons of water were treated at the X-622, X-623, X-624, and X-627 Groundwater Treatment Facilities. Approximately 21.4 gallons of TCE were removed from the water. No NPDES permit limitations were exceeded that were associated with these groundwater treatment facilities in 2017.

Conclusions

The PORTS facility is a large and complex industrial site that played a role in ensuring our nation's security. The people who worked and continue to work there have provided an invaluable service to our country and its people. It is now tasked to those involved in the D&D of the facility to make sure that the people of this region are safe from any dangers presented by the facility.

The processes of D&D, monitoring and environmental remediation are huge tasks that require the hard work of many people and entities. From the individual worker to the U.S. DOE and from the local environmentalists to the U.S. EPA and Ohio EPA, the students of PHAS thank everyone for their hard work and dedication. This summary has covered environmental monitoring activities at PORTS for calendar year 2017. The following are some of the highlights of 2017:

- D&D of PORTS continues through the disassembly and removal of equipment, removal of wastes including asbestos, PCBs, and hazardous waste, and deactivation of utilities and other systems.
- The Deferred Units RCRA Facility Investigation/Corrective Measures Study Report (DOE 2017d) was submitted to Ohio EPA on September 27, 2017.
- SODI received approximately 596 tons of materials from PORTS, primarily recyclable metals and reusable equipment.
- Environmental monitoring data collected in 2017 are consistent with data collected in previous years and indicated that radionuclides, metals, and other chemicals released by PORTS operations have a minimal effect on human health and the environment.

Potential impacts to human health from PORTS operations are calculated based on environmental monitoring data. The maximum dose that a member of the public could receive from radiation released by PORTS in 2017 is 0.90 mrem. This dose is significantly less than the 100 mrem/year limit set by DOE for the dose to a member of the public from radionuclides from all potential pathways. The dose to a member of the public from airborne radionuclides released by PORTS (0.12 mrem) is also significantly less than the 10 mrem/year standard set by the U.S. EPA. In addition, generally, concentrations of contaminants detected within the groundwater plumes at PORTS were stable or decreasing in 2017.

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Definitions

Alpha activity – the rate of emission of alpha particles from a given material.

Ambient air – the atmosphere around people, plants and structures. Ambient air usually means outdoor air (as opposed to indoor air).

Aquifer – a permeable body of rock below the ground surface that is capable of yielding quantities of groundwater to wells and springs. A subsurface zone that yields economically important amounts of water to wells.

Beta activity – the rate of emission of beta particles from a given source.

Biota – animal and plant life characterizing a given region.

Compliance – fulfillment of applicable regulations or requirements of a plan or schedule ordered or approved by a government authority.

Concentration – the amount of a substance contained in a unit volume or mass of a sample.

Contaminant – any substance that enters a system (the environment, food, the human body, etc.) where it is not normally found. Contaminants include substances that spoil food, pollute the environment, or cause other adverse effects.

Curie (Ci) – a unit of radioactivity, defined as that quantity of any radioactive nuclide which has 3.7×10^{10} (37 billion) disintegrations per second. Several fractions and multiples of the curie are commonly used.

Picocurie (pCi) – 10^{-12} Ci, one-trillionth of a curie; 0.037 disintegration per second.

Decontamination and decommissioning – removing equipment, demolishing buildings, disposing of wastes and investigating potential contamination in areas of PORTS that are no longer part of current operations.

Derived concentration standard – the concentration of a radionuclide in air or water that under conditions of continuous exposure for one year by one exposure mode (i.e., ingestion of water, submersion in air, or inhalation) would result in either a dose of 0.1 rem or a dose of 5 rem to any tissue, including skin and the lens of the eye. The guidelines for radionuclides in air and water are provided in DOE Order 458.1, *Radiation Protection of the Public and the Environment.*

Dose – the energy imparted to matter by ionizing radiation. The unit of absorbed dose is the rad, equal to 0.01 joule per kilogram in any medium.

Absorbed dose – the quantity of ionizing radiation energy absorbed by an organ divided by the organ's mass. Absorbed dose is expressed in units of rad (or gray) (1 rad = 0.01 gray).

Effective dose – the sum of the doses received by all organs or tissues of the body after each one has been multiplied by the appropriate weighting factor.

Collective dose/collective effective dose – the sums of the doses of all individuals in an exposed population expressed in units of person-rem (or person-sievert). The collective effective dose is also frequently called the "population dose."

Downgradient – the direction that groundwater flows; similar to downstream for surface water.

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 waste discharge to the environment.

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 materials 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 – the exposure to ionizing radiation when the radiation source is located outside the body.

Gaseous diffusion – technology used to produce enriched uranium by forcing gases through a porous barrier (United States Nuclear Regulatory Commission, 2017).

Groundwater – any water found below the land surface.

Interim remedial measure (IRM) – cleanup activities initiated after it has been determined that contamination or waste disposal practices pose an immediate threat to human health and/or the environment. These measures are implemented until a more permanent solution can be made.

Ionizing radiation – radiation that has enough energy to remove electrons from substances that it passes through, forming ions (United States Nuclear Regulatory Commission, 2015).

Isotope – form of an element having the same number of protons but differing numbers of neutrons in their nuclei.

Migration – the transfer or movement of a material through air, soil, or groundwater.

picoupi (mrem) – the dose that is one-thousandth of a rem.

Monitoring – process whereby the quantity and quality of factors that can affect the environment or human health are measure periodically to regulate and control potential impacts.

Outfall – the point of conveyance (e.g., drain or pipe) of wastewater or other effluents into a ditch, pond, or river.

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.

Polychlorinated biphenyls (PCBs) – man-made chemicals that range from oily liquids to waxy solids. PCBs were used in hundreds of industrials 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 possibly cause cancer and other adverse effects in humans.

Preliminary Remediation Goal – The maximum concentration of a constituent in environmental media (soil, groundwater, etc.) that is considered protective of human health and the environment.

Quality assurance – any action in environmental monitoring to demonstrate the reliability of monitoring and measurement data.

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 – radioactive nuclide capable of spontaneous transformation into other nuclides by changing its nuclear configuration or energy level. This transformation is accomplished by the emission of photons or particles.

Release – any discharge to the environment. "Environment" is broadly defined as any water, land, or ambient air.

Rem – unit of radiation dose that reflects the ability of different types of radiation to damage human tissues and the susceptibility of different tissues to the damage

Remediate – correction or cleanup of a contaminated site.

Reportable quantity – a release to the environment that exceeds reportable quantities as defined by the Comprehensive Environmental Response, Compensation and Liability Act.

Resource Conservation and Recovery Act (RCRA) – 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 – materials settling out of suspension in a liquid within a defined period of time.

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.

Transuranics – elements such as americium, plutonium and neptunium that have atomic numbers (the number of protons in the nucleus) greater than 92. All transuranics are radioactive.

Trichloroethene (TCE) – a colorless liquid used in many industrial applications as a cleaner and/or solvent. One of many chemicals that is classified as a volatile organic compound. High levels of TCE may cause health effects such as liver and lung damage and abnormal heartbeat; moderate levels may cause dizziness or headache. The International Agency for Research on Cancer considers TCE a probable human carcinogen.

Volatile Organic Compounds (VOCs) – organic (carbon-containing) compounds that evaporate readily at room temperature. These compounds are present in solvents, degreasers, paints, thinners and fuels. Due to a number of factors including widespread industrial use, they are commonly found as contaminants in soil and groundwater. VOCs found at PORTS include TCE, vinyl chloride, benzene and dichloroethenes.

Acronyms and Abbreviations

ACP	American Centrifuge Plant
BWCS	B&W Conversion Services, LLC
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
D&D	decontamination and decommissioning
DFF&O	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
DOE	U.S. Department of Energy
DUF_6	depleted uranium hexafluorids
FBP	Fluor-BWXT Portsmouth LLC
IRM	interim remedial measure
LLC	Limited Liability Company
µg/kg	microgram per kilogram (equivalent to part per billion)
µg/L	microgram per liter (equivalent to part per billion)
$\mu g/m^3$	microgram per cubic meter
ng/L	nanogram per liter
MCS	Mid-American Conversion Services, LLC
mrem	millirem
NESHAP	National Emission Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
Ohio EPA	Ohio Environmental Protection Agency
OVEC	Ohio Valley Electric Corporation

PCB	polychlorinated biphenyl
pCi/g	picocurie per gram
pCi/L	picocurie per liter
pCi/mL	picocurie per milliliter
pCi/m^3	picocurie per cubic meter
PHS	Piketon High School
PK	Peter Kiewit
PMA	Portsmouth Mission Alliance, LLC
PORTS	Portsmouth Gaseous Diffusion Plant
RCRA	Resource Conservation and Recovery Act
RI/FS	remedial investigation/feasibility study
SODI	Southern Ohio Diversification Initiative
TCE	trichloroethene
TLD	thermoluminescent dosimeters
TSCA	Toxic Substances Control Act
USEC	United States Enrichment Corporation
U.S. EPA	U.S. Environmental Protection Agency
VOCs	Volatile Organic Compounds

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