4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

4.1 SUMMARY

Environmental monitoring at PORTS measures both radiological and chemical parameters in air, water, soil, sediment, and biota (animals, vegetation, and crops). This chapter discusses the radiological component of environmental monitoring programs at PORTS; Chapter 5 discusses the non-radiological parameters for the monitoring programs.

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 activities. In 2018, environmental monitoring information was collected by DOE contractors (FBP and MCS) and Centrus. This chapter includes information about water discharges from Centrus to provide a more complete summary of environmental monitoring at PORTS.

Environmental monitoring data collected at PORTS are used to assess potential impacts to human health and the environment from radionuclides released by current and historical activities at PORTS. This impact, called a dose, can be caused by radionuclides released to air and/or water, or radiation emanating directly from buildings or other objects at PORTS. U.S. EPA sets a 10 mrem/year limit for the dose from radionuclides released to the air in the NESHAP (40 CFR Part 61, Subpart H). DOE sets an annual dose limit in DOE Order 458.1 as low as reasonably achievable (ALARA)[1], but no more than 100 mrem/year for the for the total public annual dose from radionuclides from all potential pathways. A person living in the United States receives an average annual dose of approximately 311 mrem/year from natural sources of radiation (National Council on Radiation Protection [NCRP] 2009).

This chapter includes radiological dose calculations for the dose to the public from radionuclides released to the air and the Scioto River, from external radiation, and from radionuclides detected by environmental monitoring programs. The maximum annual dose a member of the public could receive from radiation released by PORTS in 2018 or detected by environmental monitoring programs in 2018 is 0.92 mrem/year and is considered ALARA. This summary of the dose calculations assumes that the same maximally exposed individual, or representative person, routinely drives on Perimeter Road past the cylinder yards and lives in the immediate vicinity of PORTS. The maximally exposed individual, or representative person, is assumed to be exposed to the maximum dose calculated from each pathway. Table 4.1 summarizes this dose information.

Table 4.1. Summary of potential annual doses to the public from PORTS in 2018

Source of dose	Dose (mrem/year)
Airborne radionuclides (off-site individual)	0.10[a]
Radionuclides released to the Scioto River	0.0017
External radiation near cylinder yards (northwest portion of Perimeter Rd)	0.78
Radionuclides detected by environmental monitoring programs	0.037
Total	0.92[b]

[a]10 mrem/year is U.S. EPA limit for airborne radionuclides in the NESHAP (40 CFR Part 61, Subpart H).
[b]100 mrem/year is the DOE limit for all potential pathways in DOE Order 458.1.

[1] "As low as reasonably achievable" is an approach to radiation protection to manage and control releases of radioactive material to the environment, the workforce, and members of the public so that levels are as low as reasonable, taking into account societal, environmental, technical, economic, and public policy considerations. As low as reasonably achievable is not a specific release or dose limit, but a process that has the goal of optimizing control and managing release of radioactive material to the environment and doses so they are as far below the applicable limits as reasonably achievable. This approach optimizes radiation protection.

Figure 4.1 shows the maximum potential annual dose from all exposure pathways to the public from radiation associated with PORTS for the last five years (2014 to 2018). The figure indicates that the typical annual dose from radiation associated with PORTS is consistently approximately 1 mrem/year. This annual dose of approximately 1 mrem/year is significantly less than the total public annual dose limit of 100 mrem/year in DOE Order 458.1 for all radiological releases from a facility and is considered ALARA.

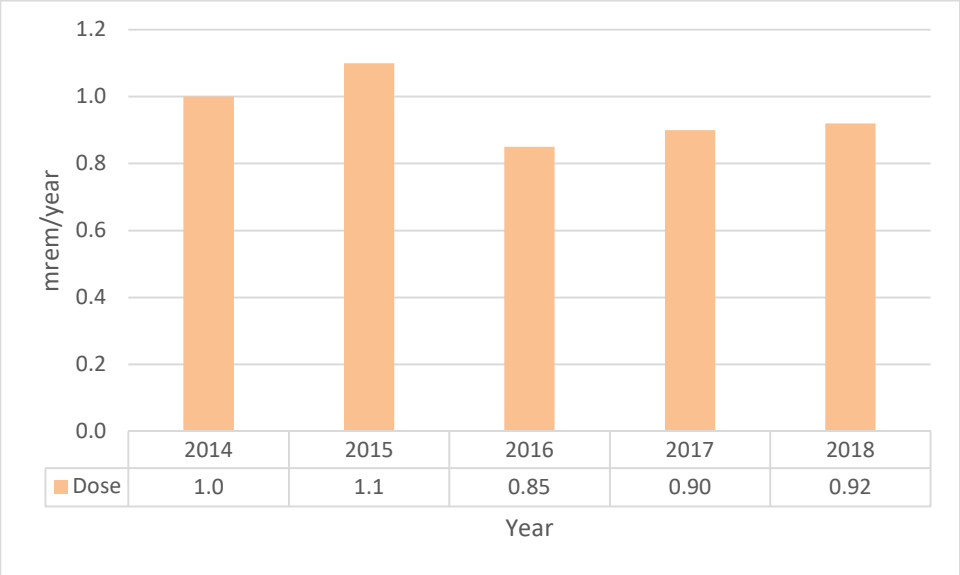

Figure 4.1. Maximum potential annual doses (all pathways) to the public, 2014 – 2018.

4.2 ENVIRONMENTAL RADIOLOGICAL PROGRAM INTRODUCTION

Environmental monitoring programs at PORTS are designed to detect the effects (if any) of activities at PORTS 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 and to set priorities for environmental improvements.

Environmental regulations, permits, DOE Orders, and public concerns are all considered in developing environmental monitoring programs. State and federal regulations drive some of the monitoring conducted at PORTS such as limitations on discharges to air and water. DOE Orders 231.1B, *Environment Safety and Health Reporting*, and 458.1, *Radiation Protection of the Public and the Environment,* also address environmental monitoring requirements.

The DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* describes the environmental monitoring programs for DOE activities at PORTS (DOE 2017b). Specific radionuclides monitored at PORTS are selected based on the materials handled at PORTS and on historic monitoring data. For example, samples are analyzed for uranium and isotopic uranium because of the uranium enrichment process. Samples are analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240) and technetium-99 because these radionuclides are produced during the fission process in nuclear reactors and were introduced to PORTS via the use of recycled uranium beginning in the late 1950s.

In 2018, environmental monitoring data were collected by DOE contractors (FBP and MCS) and Centrus. This chapter provides information on the Centrus NPDES monitoring. Centrus data are provided for informational purposes only; DOE cannot ensure the quality of Centrus data.

Data for the following environmental media are included in this chapter:

- airborne discharges
- ambient air
- external radiation
- discharges to surface water
- surface water
- sediment
- soil
- biota.

DOE also conducts an extensive groundwater monitoring program at PORTS. Chapter 6 provides information on the groundwater monitoring program, associated surface water monitoring, and water supply monitoring.

As discussed in this chapter, dose is a measure of the potential biological damage that could be caused by exposure to and subsequent absorption of radiation to the body. Because there are many natural sources of radiation, a person living in the United States receives an average annual dose of approximately 311 mrem/year from sources of natural radiation (NCRP 2009). The chapter entitled *Introduction to Radiation* at the front of this report provides additional information on radiation and dose.

Releases of radionuclides from PORTS activities can result in a dose to a member of the public in addition to the dose received from natural sources of radiation. PORTS activities that release radionuclides are regulated by U.S. EPA and DOE. Airborne releases of radionuclides from DOE facilities are regulated by U.S. EPA under the NESHAP (40 CFR Part 61, Subpart H). These regulations set an annual dose limit of 10 mrem/year to any member of the public as a result of airborne radiological releases.

DOE regulates radionuclide emissions to all environmental media through DOE Orders 436.1, *Departmental Sustainability,* and 458.1, *Radiation Protection of the Public and the Environment.* DOE Order 458.1 sets a total public annual dose limit as low as reasonably achievable, but no more than 100 mrem/year to any member of the public from all radionuclide releases from a facility. The annual dose limit in NESHAP (10 mrem/year) applies only to airborne radiological releases.

To aid in comparing sampling results for air and water to the 100 mrem/year dose limit, DOE has converted the 100 mrem/year limit into a derived concentration standard (DOE 2011b). 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.

Small quantities of radionuclides were released to the environment from PORTS during 2018. This chapter describes the methods used to estimate the potential doses that could result from radionuclides released from PORTS. In addition, this chapter assesses the potential doses that could result from radionuclides historically released by PORTS and detected in 2018 by environmental monitoring programs.

4.3 RADIOLOGICAL EMISSIONS AND DOSES

Exposure to radioactive materials can occur from releases to the atmosphere, surface water, or groundwater and from exposure to external radiation emanating from buildings or other objects. For 2018, annual doses are estimated for exposure to atmospheric releases, external radiation, and releases to the Scioto River.

Annual doses are also estimated for exposure to radionuclides from PORTS that were detected in 2018 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). Analytical data from the environmental monitoring programs are assessed to determine whether radionuclides were detected at locations accessible to the public. 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.

In 2018, annual doses are estimated for exposure to radionuclides detected by the monitoring programs for sediment, soil, and vegetation. Radionuclides were not detected in 2018 in samples of residential drinking water, deer (muscle), fish, crops, and dairy products.

In addition, DOE Order 458.1 sets absorbed dose rate limits for aquatic animals, riparian animals, terrestrial plants, and terrestrial animals. This chapter discusses the dose calculations completed to demonstrate compliance with these limits.

DOE staff, DOE contractors, and visitors to DOE areas who may be exposed to radiation are also monitored. These results are also provided in this chapter.

4.3.1 Dose Terminology

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. These interactions involve the transfer of energy from radiation to tissue, potentially resulting in tissue damage. Radiation may come from radionuclides outside the body (in or on environmental media or objects) or from radionuclides deposited inside the body (by inhalation, ingestion, and, in a few cases, absorption through the skin). Exposures to radiation from radionuclides outside the body are called external exposures, and 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 external 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 from an x-ray machine is an example of external exposure because the source of radiation is outside the body. An example of an internal exposure is nuclear medicine, which is the use of small amounts of radioactive materials called radiotracers that are typically injected into the bloodstream, inhaled, or swallowed for a medical procedure.

The three naturally-occurring uranium isotopes (uranium-234, uranium-235, and uranium-238) and technetium-99 are the most commonly detected radionuclides in environmental media samples collected around PORTS. Other radioactive isotopes (americium-241, neptunium-237, plutonium-238, plutonium-239/240) are occasionally detected at PORTS and may be included in the calculations to ensure the potential dose from PORTS is not underestimated. Technetium-99 and transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240) are present in the world-wide environment in very small amounts due to radioactive fallout in the atmosphere from nuclear weapons testing by various countries around the world (Argonne National Laboratory 2007).

A number of specialized measurement units have been defined for characterizing exposures to ionizing radiation. Because the damage associated with exposure to radiation results primarily from the exposure of tissue to ionizing radiation, the units are defined in terms of the amount of ionizing radiation absorbed by human (or animal) tissue and in terms of the biological consequences of the absorbed energy. These units include the following:

- *Absorbed dose* – the quantity of ionizing radiation energy absorbed by an organ divided by the organ's mass. The unit of absorbed dose is the rad, equal to 0.01 joule per kilogram in any medium (1 rad = 0.01 gray).

- *Equivalent dose* – the product of the absorbed dose (rad) in tissue and a radiation weighting factor. Equivalent dose is expressed in units of rem or sievert (1 rem = 0.01 sievert).

- *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 tissue weighting factor. It includes the dose from radiation sources internal and/or external to the body. Effective dose is expressed in units of rem (or sievert). In this report, the term "effective dose" is often shortened to "dose."

- *Collective dose* – the sum of the effective doses to all persons in a specified population received in a specified period of time. Collective dose is expressed in units of person-rem or person-sievert. The collective dose is also frequently called the "population dose."

4.3.2 Airborne Emissions

Airborne discharges of radionuclides from PORTS are regulated under the NESHAP (40 CFR Part 61, Subpart H). Releases of radionuclides are used to calculate an annual dose to members of the public, which is reported annually to U.S. EPA and Ohio EPA. Section 4.3.3 discusses the results of this dose calculation.

In 2018, FBP was responsible for air emission sources associated with the former gaseous diffusion plant operations, including continuously monitored vents in the X-330 and X-333 Process Buildings and the X-344A Uranium Hexafluoride Sampling Building. The vents in the X-330 and X-333 Process Buildings were in use to support D&D activities. The X-344A vents were in use for ongoing sampling activities of uranium product. Vents in the X-326 Process Building have been permanently shut down as part of D&D activities.

Other radionuclide air emission sources included room ventilation exhausts and/or pressure relief vents associated with the X-710 Technical Services Building, X-705 Decontamination Facility, X-326 L-cage Glove Box (inactive), and the XT-847 Glove Box (inactive). These emission sources were not continuously monitored; emissions from these sources (when in use) were estimated based on operating data and U.S. 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 FBP NPDES permit). Emissions from the groundwater treatment facilities were calculated based on quarterly influent and effluent sampling at each facility and quarterly throughput. Total emissions from the FBP airborne sources in 2018 were calculated to be 0.0785 Ci (7.85E-02 Ci).

MCS was responsible for air emission sources associated with the DUF_6 Conversion Facility. Emissions from the DUF_6 Conversion Facility were based on continuous monitoring of the conversion building stack. Total emissions from the MCS airborne sources in 2018 were calculated to be 0.0000457 Ci (4.57E-05 Ci).

The Centrus demonstration cascade was the only source of radionuclide air emissions from Centrus that was subject to NESHAP reporting. The demonstration cascade was shut down in 2016; therefore, there were no emissions from Centrus in 2018.

4.3.3 Dose Calculation Based on Airborne Emissions

An annual dose calculation for atmospheric, or airborne, radionuclides is required by U.S. EPA under NESHAP and is provided to U.S. EPA in an annual report. The effect of radionuclides released to the atmosphere by PORTS during 2018 was characterized by calculating the effective annual dose to the maximally exposed individual (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 calculations were made using a computer program called CAP88-PC Version 4.0, which was developed under sponsorship of U.S. 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 (e.g., 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 4.3.2. 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% of the vegetables and produce, 44% of the meat, and 40% of the milk consumed by each person are produced in the local area (e.g., in a home garden). The remaining portion of each food is assumed to be produced within 50 miles of PORTS. These assumptions most likely result in an overestimate of 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 2018 was 0.10 mrem/year. This annual dose is well 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 (NCRP 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 2018, the population dose from PORTS emissions was 2.9 person-rem/year. The population dose based on PORTS emissions was insignificant; for example, the average population dose to all people within 50 miles of PORTS from the ingestion of naturally-occurring radionuclides in water and food was approximately 19,630 person-rem/year based on an average dose of approximately 29 mrem/year to an individual (NCRP 2009).

4.3.4 Dose Calculation Based on Ambient Air Monitoring

DOE collects samples from 15 ambient air monitoring stations (see Figure 4.2) and analyzes them for the radionuclides that could be present in ambient air due to PORTS activities. These radionuclides 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). The ambient air monitoring stations measure radionuclides released from DOE point sources (the sources described in Section 4.3.2), fugitive air emissions (emissions that are not associated with a specific release point such as a stack), and background levels of radiation (radiation that occurs naturally in the environment and is not associated with PORTS).

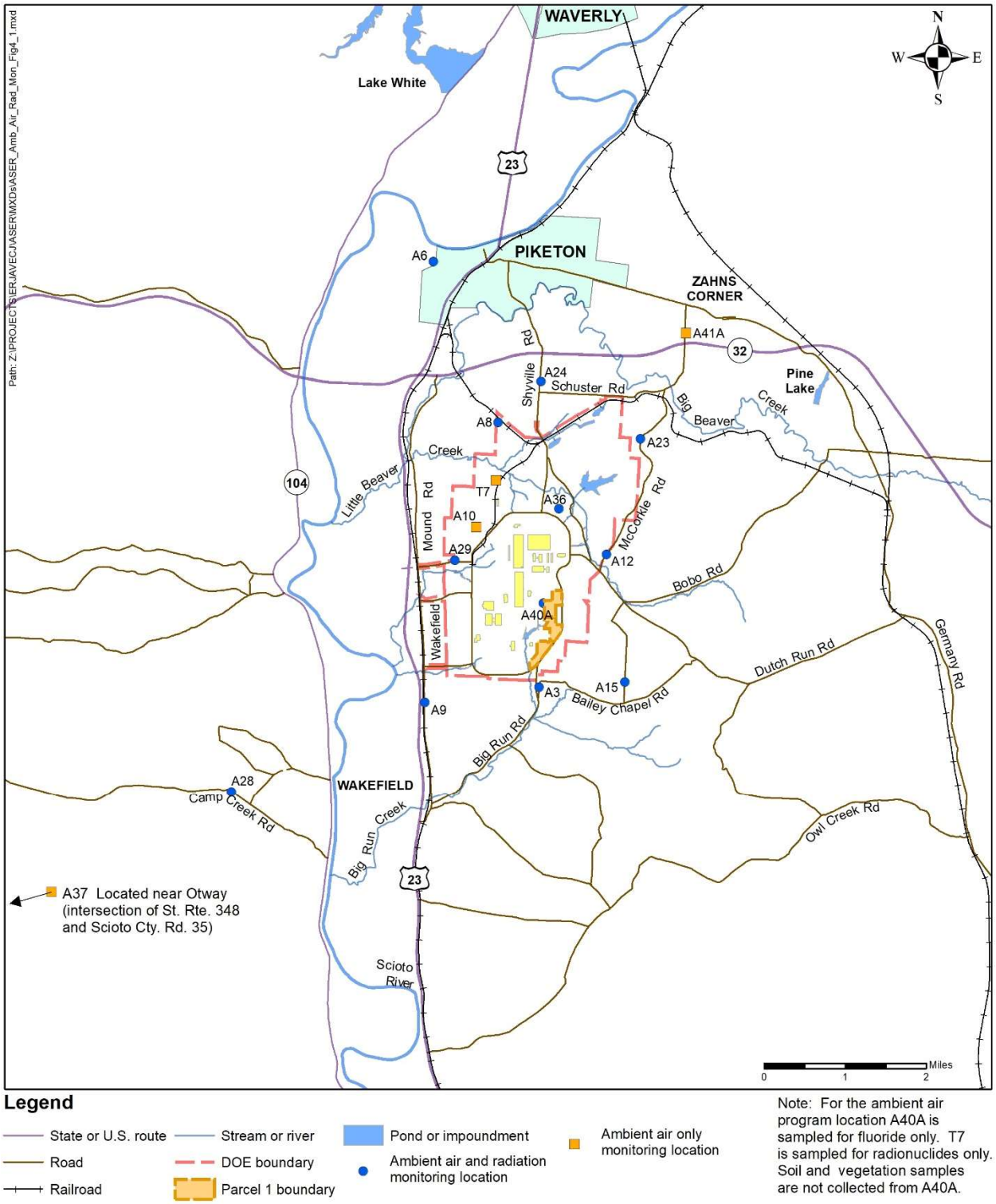

Figure 4.2. DOE ambient air and radiation monitoring locations.

The CAP88 model generates a dose conversion factor that was used to calculate an annual dose for a given level of each radionuclide in air. The following assumptions were made to calculate the annual dose at each station: 1) the highest level of each radionuclide detected in 2018 was assumed to be present for the entire year; or 2) if a radionuclide was not detected, the radionuclide was assumed to be present for the entire year at half the highest undetected result. This approach may overestimate the annual dose because it assumes an individual resides at the location of the monitoring station breathing the highest levels of radionuclides in air at that location for 24 hours/day, 365 days/year. Additionally, the annual dose associated with the background station is not subtracted from the locations near PORTS, which means that the low levels of radionuclides that are naturally-occurring or present due to worldwide fallout are not removed from the dose calculation for stations near PORTS.

The highest annual dose calculation for off-site ambient air monitoring stations near PORTS is 0.06 mrem/year at station A12, which is east of PORTS on McCorkle Road (see Figure 4.2). This hypothetical dose (0.06 mrem/year) is well below the 10 mrem/year limit applicable to PORTS in NESHAP (40 CFR Part 61, Subpart H).

4.3.5 Discharges of Radionuclides from NPDES Outfalls

FBP, MCS, and Centrus were responsible for NPDES outfalls at PORTS during 2018. The MCS NPDES outfall is not monitored for radionuclides; therefore, it is not discussed in this section. A description of the FBP and Centrus outfalls and the discharges of radionuclides from these outfalls during 2018 are included in this section.

4.3.5.1 FBP outfalls

In 2018, 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 (see Figure 4.3). A brief description of each FBP outfall or monitoring location at PORTS follows.

FBP NPDES Outfall 001 (X-230J7 East Holding Pond) – The X-230J7 East Holding Pond receives non-contact cooling water, steam condensate, foundation drainage, storm runoff, hydro-testing water from cylinders, and sanitary water for eyewash/shower station testing and flushing. The pond provides an area where materials suspended in the influent can settle, chlorine can dissipate, oil can be diverted/contained, and pH can be adjusted. Water from this holding pond is discharged to a tributary that flows to Little Beaver Creek.

FBP NPDES Outfall 002 (X-230K South Holding Pond) – The X-230K South Holding Pond receives non-contact cooling water, boiler blowdown, steam condensate, foundation drainage, treated runoff from the former coal pile area, storm runoff, fire-fighting training and fire suppression system water, and sanitary water for eyewash/shower station testing and flushing. The pond provides an area where materials suspended in the influent can settle, chlorine can dissipate, oil can be contained, and pH can be adjusted. Water from this holding pond is discharged to Big Run Creek.

FBP NPDES Outfall 003 (X-6619 Sewage Treatment Plant) – The X-6619 Sewage Treatment Plant treats PORTS sewage, some Pike County sewage, and process wastewater from MCS as well as water discharged from DOE groundwater treatment facilities, the X-700 Biodenitrification Facility, the X-705 Decontamination Microfiltration System, and miscellaneous waste streams. The X-6619 Sewage Treatment Plant uses screening, aeration, clarification, and filtering followed by disinfection to treat wastewater prior to release to the Scioto River.

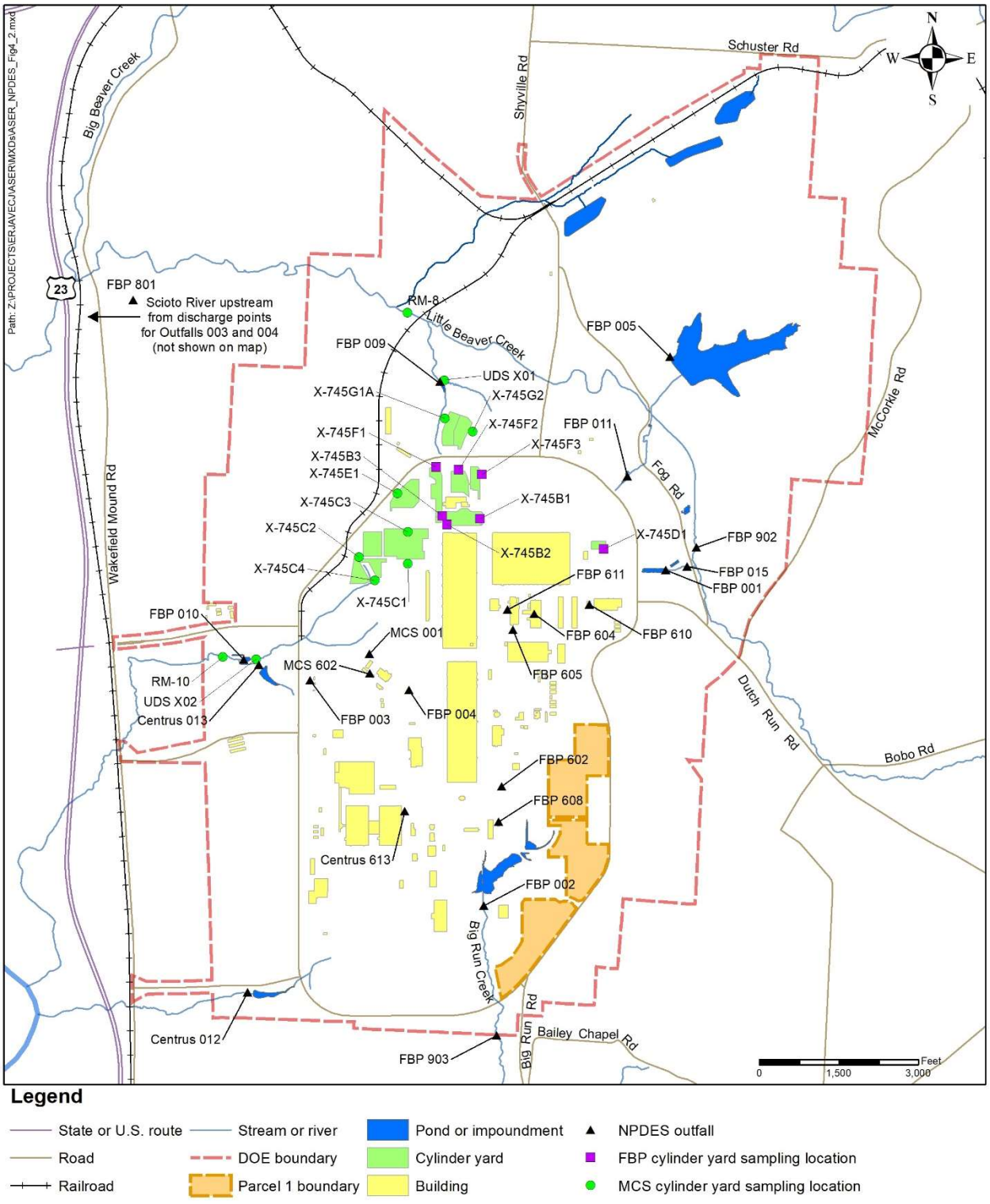

Figure 4.3. PORTS NPDES outfalls/monitoring points and cylinder storage yards sampling locations.

FBP NPDES Outfall 004 (Cooling Tower Blowdown) – Outfall 004 is located within the X-680 Blowdown Sample and Treatment Building at PORTS. It monitors blowdown water from cooling towers on site prior to being discharged to the Scioto River.

FBP NPDES Outfall 005 (X-611B Lime Sludge Lagoon) – The X-611B Lime Sludge Lagoon is used to settle lime sludge used in a water-softening process. The X-611B also receives rainwater runoff. In 2018, the lagoon only discharged during periods of excess precipitation.

FBP NPDES Outfall 009 (X-230L North Holding Pond) – The X-230L North Holding Pond receives non-contact cooling water, steam condensate, storm runoff, fire suppression system water, and sanitary water for eyewash/shower station testing and flushing. The pond provides an area where materials suspended in the influent can settle, chlorine can dissipate, oil can be contained, and pH can be adjusted. Water from this holding pond is discharged to a tributary that flows to Little Beaver Creek.

FBP NPDES Outfall 010 (X-230J5 Northwest Holding Pond) – The X-230J5 Northwest Holding Pond receives non-contact cooling water, steam condensate, storm runoff, fire-fighting training and fire suppression system water, and sanitary water for eyewash/shower station testing and flushing. The pond provides an area where materials suspended in the influent can settle, chlorine can dissipate, oil can be diverted/contained, and pH can be adjusted. Water from this holding pond is discharged to a tributary commonly referred to as the West Ditch, which flows to the Scioto River.

FBP NPDES Outfall 011 (X-230J6 Northeast Holding Pond) – The X-230J6 Northeast Holding Pond receives non-contact cooling water, steam condensate, storm runoff, fire suppression system water, and sanitary water for eyewash/shower station testing and flushing. The pond provides an area where materials suspended in the influent can settle, chlorine can dissipate, oil can be diverted/contained, and pH can be adjusted. Water from this holding pond is discharged to a tributary that flows to Little Beaver Creek.

FBP NPDES Outfall 015 (X-624 Groundwater Treatment Facility) – The X-624 Groundwater Treatment Facility removes VOCs from contaminated groundwater collected in the X-237 Groundwater Collection System in the X-701B Holding Pond area. This collection system was constructed to control the migration of groundwater contaminated with VOCs toward Little Beaver Creek. Treated water is released to a tributary that flows to Little Beaver Creek.

FBP NPDES Outfall 602 (X-621 Coal Pile Runoff Treatment Facility) – Prior to D&D of the X-600 Steam Plant Complex, the X-621 Coal Pile Runoff Treatment Facility treated storm water runoff from the coal pile at the X-600 Steam Plant Complex. The X-600 Steam Plant Complex was removed in 2013. The X-621 Treatment Facility currently operates intermittently to treat precipitation runoff from the area of the former facility. The treated water is discharged to the X-230K South Holding Pond (FBP NPDES Outfall 002).

FBP NPDES Outfall 604 (X-700 Biodenitrification Facility) – The X-700 Biodenitrification Facility receives solutions from plant operations that are high in nitrate. At the X-700, these solutions are diluted and treated biologically using bacteria prior to being discharged to the X-6619 Sewage Treatment Plant (FBP NPDES Outfall 003).

FBP NPDES Outfall 605 (X-705 Decontamination Microfiltration System) – The X-705 Decontamination Microfiltration System treats process wastewater using microfiltration and pressure filtration technology. The treated water is discharged to the X-6619 Sewage Treatment Plant (FBP NPDES Outfall 003).

FBP NPDES Outfall 608 (X-622 Groundwater Treatment Facility) – The X-622 Groundwater Treatment Facility removes VOCs from contaminated groundwater originating from site remediation activities in the southern portion of the site, which is Quadrant I in the RCRA Corrective Action Program (see Chapter 3, Section 3.3.1). Treated water is discharged to the sanitary sewer and then through FBP NPDES Outfall 003.

FBP NPDES Outfall 610 (X-623 Groundwater Treatment Facility) – The X-623 Groundwater Treatment Facility formerly treated contaminated groundwater from extraction wells in the X-701B groundwater plume. The groundwater extraction wells were removed between 2009 and 2011. Currently, the facility removes VOCs from miscellaneous water associated with site activities (in accordance with the FBP NPDES permit). Treated water is discharged to the sanitary sewer and then through FBP NPDES Outfall 003.

FBP NPDES Outfall 611 (X-627 Groundwater Treatment Facility) – The X-627 Groundwater Treatment Facility removes VOCs from groundwater collecting in sumps located in the basements of the X-700 and X-705 buildings, which are part of Quadrant II. Treated water is discharged to the sanitary sewer and then through FBP NPDES Outfall 003.

FBP is also responsible for three additional monitoring points that are not discharge points as described in the previous paragraphs. FBP NPDES Station Number 801 is a surface water background monitoring location on the Scioto River upstream from FBP NPDES Outfalls 003 and 004 that is used for biotoxicity studies. FBP NPDES Station Number 902 is a monitoring location on Little Beaver Creek downstream from FBP NPDES Outfall 001, and FBP NPDES Station Number 903 is a monitoring location on Big Run Creek downstream from FBP NPDES Outfall 002. Water temperature is the only parameter measured at FBP NPDES Station Numbers 902 and 903.

FBP NPDES Outfalls 001, 002, 003, 004, 005, 009, 010, 011, 015, 608, 610, and 611 were monitored 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 external FBP outfalls (Outfalls 001, 002, 003, 004, 005, 009, 010, 011, and 015) during 2018.

Discharges of radionuclides to surface water were calculated using monthly monitoring data from the NPDES outfalls. Analytical results below the detection limit were assigned a value of zero in the calculations to determine the quantities of uranium and technetium-99 discharged through the outfalls. In 2018, uranium discharges from the FBP external outfalls (Outfalls 001, 002, 003, 004, 005, 009, 010, 011, and 015) were estimated at 13.5 kilograms (kg). Total radioactivity (technetium-99 and isotopic uranium) released from the same outfalls was estimated at 0.061 Ci.

Discharges of radionuclides from the outfalls are used in the dose calculation for releases to surface water (Section 4.3.6). The annual dose calculated with these data (0.0017 mrem/year) is significantly less than the 100 mrem/year limit in DOE Order 458.1 for all radiological releases from a facility.

4.3.5.2 Centrus outfalls

In 2018, Centrus was responsible for three NPDES outfalls through which water is discharged from the site (see Figure 4.3). Two outfalls discharge directly to surface water, and one discharges to the X-6619 Sewage Treatment Plant (FBP NPDES Outfall 003) before leaving the site. A brief description of each Centrus NPDES outfall follows.

Centrus NPDES Outfall 012 (X-2230M Southwest Holding Pond) – The X-2230M Southwest Holding Pond accumulates precipitation runoff, non-contact cooling water, and steam condensate from the southwestern portion of PORTS. The pond provides an area where solids can settle, chlorine can dissipate, and oil can be separated from the water prior to its release to an unnamed stream that flows to the Scioto River.

Centrus NPDES Outfall 013 (X-2230N West Holding Pond) – The X-2230N West Holding Pond accumulates precipitation runoff, non-contact cooling water, and steam condensate from the western portion of PORTS. The pond provides an area where solids can settle, chlorine can dissipate, and oil can be separated from the water prior to its release to a tributary commonly referred to as the West Ditch, which flows to the Scioto River.

Centrus NPDES Outfall 613 (X-6002 Particulate Separator) – The X-6002 Particulate Separator removes suspended solids from water used in the X-6002 Recirculating Hot Water Plant, which provides heat to a number of buildings at PORTS. The treated water is discharged to the X-6619 Sewage Treatment Plant (FBP NPDES Outfall 003).

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. Technetium-99 was not detected in any of the samples collected from Centrus NPDES outfalls in 2018.

Neptunium-237 was detected at 0.367 and 0.499 pCi/L in the third quarter samples collected at Outfalls 012 and 013, respectively. Neptunium-237 was not detected in the first, second, and fourth quarter samples collected from Outfalls 012 and 013. No other transuranic radionuclides were detected in any of the samples collected from Centrus NPDES outfalls in 2018.

Uranium discharges in 2018 from external Centrus NPDES outfalls (Outfalls 012 and 013) were estimated at 0.92 kg. These values were calculated using quarterly discharge monitoring reports for the Centrus NPDES outfalls. Analytical results below the detection limit were assigned a value of zero in the calculations to determine the quantities of uranium discharged through the Centrus NPDES outfalls.

Discharges of radionuclides from Centrus Outfalls 012 and 013 are used in the dose calculation for releases to surface water (Section 4.3.6). The annual dose calculated with these data and data from external FBP outfalls (0.0017 mrem/year) is significantly less than the 100 mrem/year limit in DOE Order 458.1 for all radiological releases from a facility.

4.3.6 Dose Calculation for Releases to Surface Water

Radionuclides are measured at the FBP and Centrus NPDES external outfalls (nine FBP outfalls and two Centrus outfalls). Water from these external outfalls is either directly discharged to the Scioto River or eventually flows into the Scioto River from Little Beaver Creek, Big Run Creek, or unnamed tributaries to these water bodies. A hypothetical annual dose to a member of the public was calculated using the measured radiological discharges and the annual flow rate of the Scioto River.

Activity (in picocuries per liter [pCi/L]) for americium-241, neptunium-237, plutonium-238, plutonium-239/240, technetium-99, and isotopic uranium (uranium-233/234, uranium-235/236, and uranium-238) were measured in the water discharged from the FBP outfalls. Uranium mass (in micrograms per liter [µg/L]) and activity (in pCi/L) for americium-241, neptunium-237, plutonium-238, plutonium-239/240, and technetium-99 were measured in the water discharged from the Centrus outfalls. Radionuclides that were not detected were assumed to be present at the detection limit. Uranium measured at the Centrus outfalls was assumed to be 5.2% uranium-235, 94% uranium-238, and 0.8%

uranium-234 based on the highest enrichment of uranium produced by PORTS in the years prior to shutdown of the gaseous diffusion uranium enrichment operations. The maximum individual annual dose was calculated using the above-mentioned measured radionuclide discharges from the plant outfalls and the annual flow rate of the Scioto River.

The dose calculations were derived from the procedures developed for a similar DOE facility: *LADTAP XL: An Improved Electronic Spreadsheet Version of LADTAP II* (Hamby 1991) and *LADTAP-PA: A Spreadsheet for Estimating Dose Resulting from E-Area Groundwater Contamination at the Savannah River Site* (Jannik and Dixon 2006), which updates the 1991 LADTAP XL. Specific exposure scenarios provided in the *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Portsmouth Gaseous Diffusion Plant* (DOE 2017d) were also used when available. Environmental pathways considered were ingestion of water, ingestion of fish, swimming, boating, and shoreline activities. This exposure scenario overestimates the dose to the public because the Scioto River is not used for drinking water downstream of PORTS (98% of the hypothetical dose from liquid effluents is from drinking water). The annual dose from radionuclides released to the Scioto River in 2018 (0.0017 mrem/year) is significantly less than the total public annual dose limit of 100 mrem/year DOE in DOE Order 458.1.

4.3.7 Radiological Dose Calculation for External Radiation

Radiation is emitted from DUF_6 cylinders stored on site at PORTS in the cylinder storage yards located 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 in accordance with the DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2017b). External radiation is measured using thermoluminescent dosimeters (TLDs), which measure both external background radiation and radiation emanating from the DUF_6 cylinders. Section 4.6.2 and Figure 4.4 provide more information about the external radiation monitoring program.

Data from radiation monitoring at the cylinder yards are used to assess potential exposure to a representative on-site member of the public that drives on Perimeter Road. 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 minute per trip, 2 trips per day, 5 work-days per week, and 52 weeks per year). In 2018, the average annual dose recorded by TLDs at the cylinder yards near Perimeter Road was 780 mrem/year, based on TLD measurements for an entire year at locations #41, #868, #874, #882, and #890 (see Section 4.6.2 and Figure 4.4). Although the total annual external radiation dose near the cylinder yards is high, a person would only receive this dose if they were present at the cylinder yards for 24 hours/day, 365 days/year. Access to the cylinder yard area is controlled by PORTS security forces so that 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 typical background levels with distance from the cylinder yards as demonstrated by radiation measurements at other on-site and all off-site monitoring locations. Based on the estimated time that a person would drive on Perimeter Road near the cylinder yards, exposure to an on-site member of the public from radiation from the cylinder yards is approximately 0.78 mrem/year.

External radiation is also measured using TLDs at 19 locations that include 12 of the ambient air monitoring stations and seven additional on-site locations in accordance with the DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2017b). The total annual dose measured in 2018 at station A29, near the Ohio Valley Electric Corporation (OVEC), was 87 mrem/year (see Section 4.6.2 and Figure 4.4). The total annual dose measured at eight of the off-site or background monitoring stations averaged 86 mrem/year. A dose calculation was completed for a representative off-site member of the public, such as a worker at OVEC, based on the 1 mrem/year difference between the average off-site background dose (86 mrem/year) and the dose at station A29 (87 mrem/year). Assuming

that the worker was exposed to this radiation for 250 days/year, one hour outdoors and 8 hours indoors, the dose to this worker is 0.12 mrem/year.

A person living in the United States receives an average annual dose of approximately 311 mrem/year from natural sources of radiation (NCRP 2009). The higher potential estimated dose from external radiation to a member of the public (0.78 mrem/year to a delivery person on Perimeter Road versus 0.12 mrem/year to a worker near station A29) is approximately 0.2 percent of the average yearly natural radiation exposure for a person in the United States and is significantly less than the total public annual dose limit of 100 mrem/year in DOE Order 458.1.

4.3.8 Radiological Dose Results for DOE Workers and Visitors

The DOE Radiological Protection Organization at PORTS monitors external radiation levels in active DOE facilities at PORTS on a continual basis. This radiation monitoring assists in determining the radiation levels that workers are exposed to and in identifying changes in radiation levels. These measurements provide 1) information for worker protection, 2) a means to trend radiological exposure data for specified facilities, and (3) a means to estimate potential public exposure to radiation from DOE activities at PORTS.

The Radiation Exposure Monitoring System report is an electronic file created annually to comply with DOE Order 231.1B. This report contains exposure results for all monitored DOE employees, DOE contractors, and visitors to DOE areas at PORTS with a positive exposure during the previous calendar year. The 2018 Radiation Exposure Monitoring System report indicated that no visitors received a measurable dose (10 mrem/year or more).

More than 2500 DOE employees and DOE contractors were monitored throughout 2018. These workers received an average dose of 1.4 mrem/year. Approximately 2.8% of the monitored workers, primarily workers handling DUF_6 cylinders, received a measurable dose (10 mrem/year total effective dose or more). No administrative guidelines or regulatory dose limits were exceeded in 2018.

4.3.9 Radiological Dose Calculations for Off-site Environmental Monitoring Data

Environmental monitoring at PORTS includes collecting samples at off-site locations around PORTS and analyzing the 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 (well water), and biota (vegetation, deer, fish, crops, milk, and eggs).

Samples are analyzed for uranium, uranium isotopes, technetium-99, and/or selected transuranics (americium-241, neptunium-237, plutonium-238, and plutonium-239/240). Uranium occurs naturally in the environment; therefore, detections of uranium cannot necessarily be attributed to PORTS. Technetium-99 and transuranics could come from PORTS because they were present in recycled uranium processed by PORTS during the Cold War. Technetium-99 and transuranic radionuclides could also come from sources other than PORTS because they are generally present in the world-wide environment in very small amounts due to radioactive fallout in the atmosphere from nuclear weapons testing by various countries around the world (Argonne National Laboratory 2007).

DOE sets a total public annual dose limit as low as reasonably achievable, but no more than 100 mrem/year in DOE Order 458.1 for a potential dose to a member of the public via exposure to all radionuclide releases from a DOE facility. To ensure that PORTS meets this standard, dose calculations may be completed for environmental media.

Dose calculations for ambient air and surface water were presented in Sections 4.3.4 and 4.3.6, respectively. Dose calculations are also completed for detections of radionuclides in sediment, soil,

residential drinking water (well water – excluding naturally-occurring detections of uranium isotopes), and biota (vegetation, deer, fish, crops, and dairy products) at off-site sampling locations. If radionuclides are not detected in the samples, a dose assessment is not completed. Off-site sampling locations are selected based on detections of radionuclides that could cause the highest dose to a member of the public. Detections of radionuclides in sediment and soil on the PORTS facility are not used to assess potential risk because the public does not have access to the sampled areas of the facility.

The summary of these dose calculations assumes that the same individual is exposed to the maximum dose calculated from each pathway. In 2018, dose calculations were completed for public exposure to radionuclides detected in sediment, soil, and vegetation. Radionuclides were not detected in 2018 in samples of residential drinking water, deer (muscle), fish, crops, and dairy products.

The following sections provide brief descriptions of the dose calculations for sediment, soil, and vegetation. Methodologies used to complete each risk calculation are based on information developed and approved by U.S. EPA including the *Exposure Factors Handbook* (U.S. EPA 1997a) and *Federal Guidance Report No. 11 (FGR 11) Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Immersion, and Ingestion* (U.S. EPA 1988).

In addition, specific exposure scenarios provided in the *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Portsmouth Gaseous Diffusion Plant* (DOE 2017d) were used when available. This document integrates the results of technical meetings between Ohio EPA and DOE and provides methods for completing risk analyses at PORTS to promote consistency in the risk approach.

Table 4.2 summarizes the results of each dose calculation. Potential annual doses to the public from radionuclides detected by the PORTS environmental monitoring program in 2018 are significantly less than the 100 mrem/year limit in DOE Order 458.1 and are considered ALARA.

Table 4.2. Summary of potential annual doses to the public from radionuclides detected by DOE environmental monitoring programs in 2018

Source of dose	Dose (mrem/year)[a]
Sediment	0.017
Soil	0.020
Vegetation	0.00041
Total	0.037

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

4.3.9.1 Dose calculation for sediment

The dose calculation for sediment is based on the following detections of radionuclides in the sample collected in 2018 from monitoring location RM-7, an off-site sampling location on Little Beaver Creek (see Section 4.6.5 and Figure 4.5):

- neptunium-237: 0.00789 picocurie per gram (pCi/g)
- technetium-99: 3.23 pCi/g
- uranium-233/234: 2.16 pCi/g
- uranium-235/236: 0.0908 pCi/g
- uranium-238: 0.646 pCi/g.

Based on an incidental ingestion rate of 200 milligrams (mg)/day (0.0007 ounces/day) and an exposure frequency of 100 days/year, which are consistent with the *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Portsmouth Gaseous Diffusion Plant* (DOE 2017d), and exposure factors in U.S. EPA's *Exposure Factors Handbook* (U.S. EPA 1997a), the annual dose that could be received by an individual from sediment contaminated at these levels is 0.017 mrem/year. Section 4.6.5 provides additional information on the sediment monitoring program as well as a map of sediment sampling locations.

4.3.9.2 Dose calculation for soil

The dose calculation for soil is based on the detections of the following uranium isotopes in the soil sample collected at the ambient air monitoring station A9, southwest of PORTS on Old U.S. Route 23 (see Section 4.6.7 and Figure 4.2):

- americium-241: 0.011 pCi/g
- plutonium-239/240: 0.0271 pCi/g
- uranium-233/234: 0.265 pCi/g
- uranium-235/236: 0.0157 pCi/g
- uranium-238: 0.301 pCi/g.

Based on an incidental ingestion rate of 200 mg/day (0.0007 ounces/day) and an exposure frequency of 350 days/year, which are consistent with the *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Portsmouth Gaseous Diffusion Plant* (DOE 2017d), and exposure factors in U.S. EPA's *Exposure Factors Handbook* (U.S. EPA 1997a), the annual dose that could be received by an individual from soil contaminated at these levels is 0.020 mrem/year. Section 4.6.7 provides additional information on the soil monitoring program.

4.3.9.3 Dose calculation for vegetation

The dose calculation for vegetation is based on the following detections of radionuclides in vegetation (primarily grass) and soil at ambient air monitoring station A28 (southwest of PORTS on Camp Creek Road – see Section 4.6.8.1 and Figure 4.2):

<u>Vegetation</u>
- uranium-233/234: 0.0154 pCi/g
- uranium-238: 0.0174 pCi/g

<u>Soil</u>
- plutonium-239/240: 0.0107 pCi/g
- uranium-233/234: 0.277 pCi/g
- uranium-235/236: 0.0142 pCi/g
- uranium-238: 0.238 pCi/g.

The dose calculation is based on human consumption of beef cattle that would eat grass (and soil) containing these radionuclides. Based on an ingestion rate for beef of 2 ounces/day and an exposure frequency of 100 days/year, which are consistent with the *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Portsmouth Gaseous Diffusion Plant* (DOE 2017d) and U.S. EPA's *Exposure Factors Handbook* (U.S. EPA 1997a), the annual dose that could be received by an individual eating beef from cattle that grazed on vegetation and soil contaminated at these levels is 0.00041 mrem/year. Section 4.6.8.1 provides additional information on the vegetation monitoring program.

4.4 PROTECTION OF BIOTA

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. DOE Technical Standard *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2002) was used to demonstrate compliance with these limits.

4.4.1 Aquatic and Riparian Animals

Analytical data for surface water and sediment samples collected during 2018 from the east side of the PORTS reservation [surface water sampling location EDD-SW01 (see Chapter 6, Section 6.4.15 and Figure 6.13) and sediment sampling location RM-11 (see Section 4.6.5 and Figure 4.5)] 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 2018. Section 4.6.5 and Chapter 6, Section 6.4.15 provide more information about these sediment and surface water sampling programs, respectively.

The maximum levels of radionuclides (plutonium-239/240, technetium-99 and uranium isotopes) were as follows. The maximum levels of radionuclides detected at surface water location EDD-SW01 include results for a duplicate sample collected in the first quarter of 2018 (DOE 2019).

Radionuclide	EDD-SW01	RM-11
Plutonium-239/240	not detected	0.0774 pCi/g
Technetium-99	112 pCi/L	3.09 pCi/g
Uranium-233/234	12 pCi/L	4.54 pCi/g
Uranium-235/236	0.606 pCi/L	0.208 pCi/g
Uranium-238	2.08 pCi/L	0.819 pCi/g.

These values were entered into the RESRAD-BIOTA software that is designed to implement the DOE Technical Standard (DOE 2002). The software provides a screening method with generic limiting concentrations of radionuclides in environmental media. If the measured 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 (1 rad/day to aquatic animals and 0.1 rad/day to riparian animals).

In 2018, the RESRAD-BIOTA software output for the maximum levels of radionuclides detected at sampling locations EDD-SW01 (surface water) and RM-11 (sediment) was 0.0731, 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.

4.4.2 Terrestrial Plants and Animals

Analytical data for surface water and soil samples collected during 2018 from the northern side of the PORTS reservation [surface water sampling location LBC-SW04 (see Chapter 6, Section 6.4.15 and Figure 6.13) and soil sampling location A8 (see Figure 4.2)] 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 2018. Section 4.6.7 and Chapter 6, Section 6.4.15 provide additional information about these soil and surface water sampling programs, respectively.

No transuranic radionuclides were detected in 2018 from samples collected LBC-SW04 (surface water) and A8 (soil). The maximum levels of technetium-99 (surface water only) and uranium isotopes were as follows:

Radionuclide	LBC-SW04	A8
Technetium-99	11.9 pCi/L	not detected
Uranium-233/234	1.53 pCi/L	0.483 pCi/g
Uranium-235/236	not detected	0.024 pCi/g
Uranium-238	0.4421 pCi/L	0.438 pCi/g.

These values were entered into the RESRAD-BIOTA software that is designed to implement the DOE Technical Standard (DOE 2002). The software provides a screening method with generic limiting concentrations of radionuclides in environmental media. If the measured 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 (1 rad/day to terrestrial plants and 0.1 rad/day to terrestrial animals).

In 2018, the RESRAD-BIOTA software output for the maximum levels of radionuclides detected at sampling locations LBC-SW04 (surface water) and A8 (soil) was 0.000386, 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.

4.5 UNPLANNED RADIOLOGICAL RELEASES

No unplanned releases of radionuclides took place at PORTS in 2018.

4.6 ENVIRONMENTAL RADIOLOGICAL MONITORING

This section discusses the radiological monitoring programs at PORTS: ambient air monitoring, external radiation, surface water, sediment, settleable solids, soil, vegetation, and biota (deer, fish, crops, milk, and eggs).

4.6.1 Ambient Air Monitoring

The ambient air monitoring stations measure radionuclides released from 1) DOE point sources (the sources discussed in Section 4.3.2), 2) fugitive air emissions (emissions from PORTS that are not associated with a stack or pipe such as remediation sites or normal building ventilation), and 3) background levels of radionuclides (radionuclides that occur naturally, such as uranium). These radionuclides 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).

In 2018, samples were collected from 15 ambient air monitoring stations located within and around PORTS (see Section 4.3.4, Figure 4.2), including a background ambient air monitoring station (A37) located approximately 13 miles southwest of the plant. The analytical results from air sampling stations closer to the plant are compared to the background measurements.

Uranium, uranium isotopes, americium-241, and technetium-99 were detected at the ambient air monitoring stations in 2018. Americium-241 and other transuranic radionuclides can be detected in environmental media due to radioactive fallout from nuclear weapons testing (Argonne National Laboratory 2007). The highest levels of each radionuclide in air were 0.03%, or less, of the DOE derived

concentration standards (DOE 2011b)[1]. Maximum activities of detected radionuclides were located at stations A37 (the background station in Otway) and A10 (on site near the Don Marquis Substation on the west side of PORTS). The following table lists the maximum activities of detected radionuclides (in picocurie per cubic meter [pCi/m^3]):

Radionuclide	Maximum activity (pCi/m^3)	Location	Derived concentration standard (DOE 2011b) (pCi/m^3)[a]	Percentage of derived concentration standard (DOE 2011b)
Americium-241	0.000025	A37	0.097	0.03%
Technetium-99	0.0099	A10	920	0.001%
Uranium-233/234	0.00019	A10	1.1	0.02%
Uranium-238	0.00017	A10	1.3	0.01%

[a]The derived concentration standard has been converted to pCi/m^3 from units of microcurie per milliliter provided in the *Derived Concentration Technical Standard* (DOE 2011b).

To confirm that air emissions from PORTS are within regulatory requirements and are not harmful to human health, the ambient air monitoring data were used to calculate an annual dose to a hypothetical person living at the monitoring station. The highest annual dose calculation for off-site ambient air monitoring stations near PORTS is 0.06 mrem/year at station A12, which is east of PORTS on McCorkle Road (see Figure 4.2). This hypothetical annual dose (0.06 mrem/year) is well below the 10 mrem/year limit applicable to PORTS in NESHAP (40 CFR Part 61, Subpart H). Section 4.3.4 provides additional information about this dose calculation.

4.6.2 External Radiation

External radiation is measured continuously with TLDs at five locations near the DUF_6 cylinder storage yards (see Figure 4.4), 19 locations that include 12 of the ambient air monitoring stations (see Section 4.3.4, Figure 4.2), and seven additional on-site locations (see Figure 4.4). 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. A new TLD replaces the removed device. 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.

External radiation is measured by TLDs at five locations around the northwest corner of PORTS just inside Perimeter Road near the cylinder storage yards (see Figure 4.4). The average annual dose for these five locations (#41, #868, #874, #882, and #890) is 780 mrem/year. Section 4.3.7 provides a dose calculation 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 general public is not allowed on the portion of Perimeter Road near the cylinder storage yards). The potential estimated annual dose from the cylinder yards to a delivery person (0.78 mrem/year) is significantly less than the total public annual dose limit of 100 mrem/year in DOE Order 458.1.

In 2018, the average annual dose measured at eight off-site or background locations (A3, A6, A9, A12, A15, A23, A24, and A28) was 87 mrem/year. Two locations within PORTS measured levels of radiation approximately 50% higher or more than the average off-site radiation (87 mrem/year): location #874 (605 mrem/year) near the X-745C Cylinder Storage Yard and location #862 (120 mrem/year) south of the

[1]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 that is 100% of the derived concentration standard would equate to a dose at the DOE limit of 100 mrem/year (DOE 2011b).

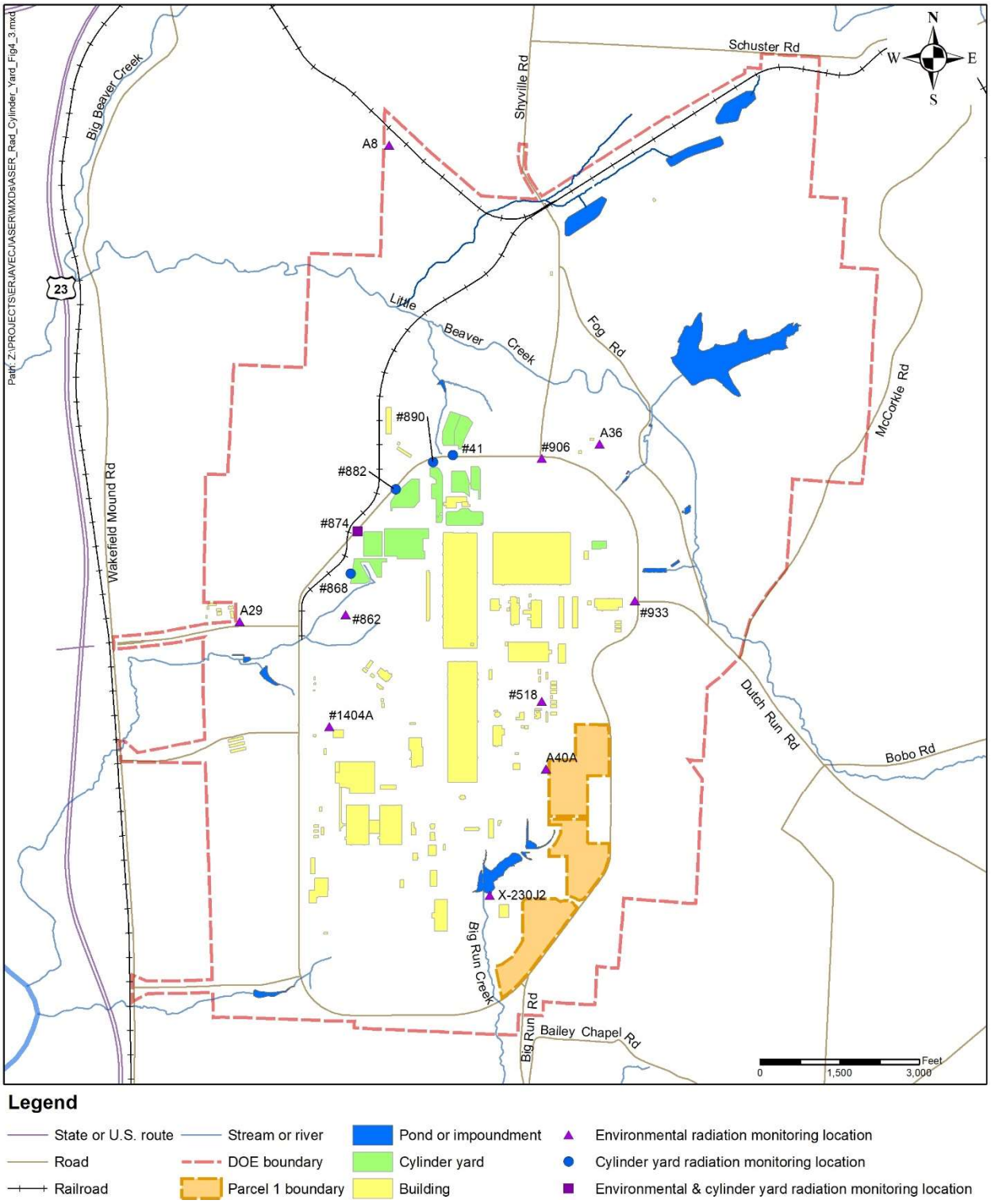

Figure 4.4. On-site radiation and cylinder yard dose monitoring locations.

cylinder yards and west of the X-530A Switchyards. Three other on-site locations (X-230J2, A8, and A29) measured radiation at levels slightly higher than the average background (ranging from 1 mrem/year to 8 mrem/year above average).

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 OVEC. The dose calculation for the representative on-site member of the public exposed to the cylinder yards is discussed above and in Section 4.3.7. Section 4.3.7 also includes a dose calculation for the representative off-site member of the public who works at OVEC near station A29. The potential estimated annual dose to this off-site worker (0.12 mrem/year) is significantly less than the total public annual dose limit of 100 mrem/year in DOE Order 458.1.

Section 4.3.8 provides dose results for DOE workers, including workers in the cylinder yards. No administrative guidelines or regulatory dose limits were exceeded in 2018.

4.6.3 Surface Water from Cylinder Storage Yards

In 2018, FBP collected surface water samples from the X-745B, X-745D, and X-745F Cylinder Storage Yards. MCS collected surface water samples at the cylinder yards associated with the DUF_6 Conversion Facility (X-745C, X-745E, and X-745G Cylinder Storage Yards). Sections 4.6.3.1 and 4.6.3.2 provide the results of sampling completed in 2018 by FBP and MCS, respectively.

4.6.3.1 FBP cylinder storage yards

In 2018, FBP collected surface water samples from seven locations at the X-745B, X-745D, and X-745F Cylinder Storage Yards. Figure 4.3 shows the sampling locations. Samples were analyzed for alpha activity, beta activity, and uranium. Samples were collected monthly if water was available.

Maximum levels of alpha activity, beta activity, and uranium were detected as follows:

Alpha activity: 449 pCi/L (X-745B3, October 2018)
Beta activity: 523 pCi/L (X-745F1, June 2018)
Uranium: 93.1 µg/L (X-745B2, October 2018).

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. Radionuclides detected at FBP outfalls (see Section 4.3.5.1) are used in the dose calculation for releases to surface water (see Section 4.3.6). The annual dose from radionuclides released to the Scioto River in 2018 (0.0017 mrem/year) is significantly less than the total public annual dose limit of 100 mrem/year in DOE Order 458.1.

4.6.3.2 MCS cylinder storage yards

Ohio EPA requires monthly collection of surface water samples from seven locations at the X-745C, X-745E, and X-745G Cylinder Storage Yards. Figure 4.3 shows the sampling locations. Samples were analyzed for alpha activity, beta activity, and uranium.

Maximum levels of alpha activity, beta activity, and uranium were detected as follows:

Alpha activity: 6.25 pCi/L (X-745C1, February 2018)
Beta activity: 7.76 pCi/L (X-745E1, June 2018)
Uranium: 6.2 µg/L (X-745C2, May 2018).

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. Radionuclides detected at FBP outfalls (see Section 4.3.5.1) are used in the dose calculation for releases to surface water (see Section 4.3.6). The annual dose from radionuclides released to surface water (the Scioto River) in 2018 (0.0017 mrem/year) is significantly less than the total public annual dose limit of 100 mrem/year in DOE Order 458.1.

4.6.4 Local Surface Water

Local surface water samples are collected from 14 locations upstream and downstream from PORTS surface water discharges. These samples were taken from the Scioto River, Little Beaver Creek, Big Beaver Creek, and Big Run Creek (see Figure 4.5). As background measurements, samples were also collected from local streams approximately 10 miles north, south, east, and west of PORTS.

Samples were 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 2017b).

Americium-241 was detected at two surface water monitoring locations in 2018: RW-10W (background) and RW-13 (Big Beaver Creek). Americium-241 and other transuranic radionuclides can be detected in environmental media due to radioactive fallout from nuclear weapons testing (Argonne National Laboratory 2007). No other transuranic radionuclides were detected in the local surface water samples collected during 2018. Maximum detections of americium-241, technetium-99, and uranium isotopes in local surface water samples are listed below:

Radionuclide	Maximum activity (pCi/L)	Location	Derived concentration standard (DOE 2011b)[a] (pCi/L)	Percentage of derived concentration standard (DOE 2011b)
Americium-241	1.86	RW-10W	170	1.1%
Technetium-99	7.76	RW-7	44,000	0.02%
Uranium-233/234	2.3	RW-7	680	0.3%
Uranium-235/236	0.217	RW-7	720	0.03%
Uranium-238	0.614	RW-8	750	0.08%

[a]The derived concentration standard has been converted to pCi/L from units of microcurie per milliliter provided in the *Derived Concentration Technical Standard* (DOE 2011b).

These detected concentrations of radionuclides were 1.1%, or less, of the DOE derived concentration standards (DOE 2011b)[1]. This derived concentration standard is based upon direct use of the surface water as drinking water. This comparison is likely to overestimate the dose because surface water around PORTS is not used for drinking water.

4.6.5 Sediment

Sediment samples are collected from 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 4.5). 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

[1]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 that is 100% of the derived concentration standard would equate to a dose at the DOE limit of 100 mrem/year (DOE 2011b).

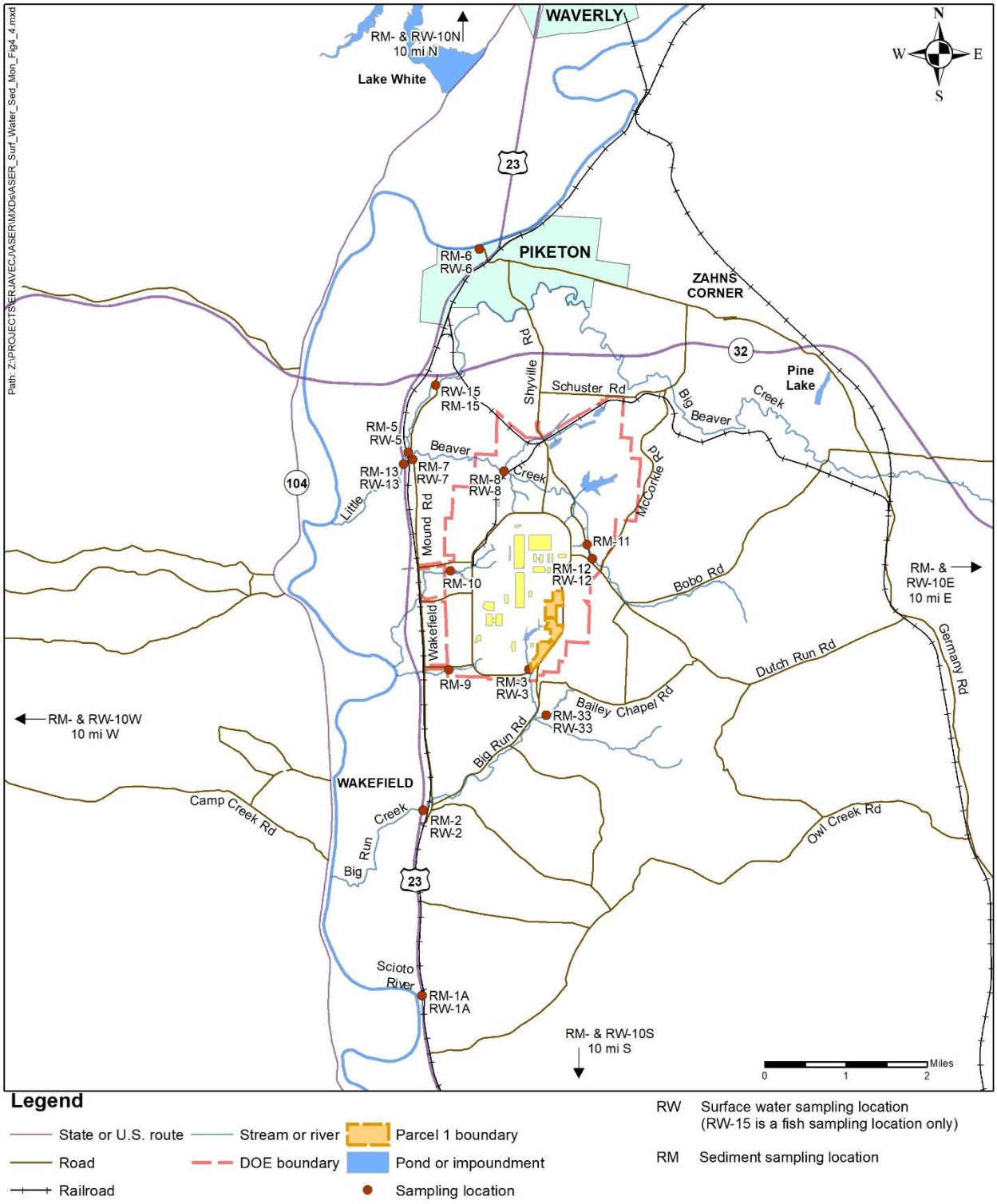

Figure 4.5. Local surface water and sediment monitoring locations.

(uranium-233/234, uranium-235/236, and uranium-238) in accordance with the DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2017b).

Neptunium-237 was detected at estimated levels of 0.00789 and 0.00832 pCi/g in the samples collected from Little Beaver Creek (sampling locations RM-7 and RM-8). Plutonium-239/240 was detected at five sampling locations, including the northern background sampling location, at levels ranging from 0.0093 to 0.0774 pCi/g. Americium-241 was detected at three on-site sampling locations at levels ranging from 0.00775 to 0.0121 pCi/g. No other transuranics were detected in the sediment samples collected in 2018.

Technetium-99 is often detected in sediment samples collected at locations downstream from PORTS surface water discharges. In 2018, technetium-99 was detected in the samples collected from the following locations:

- Big Beaver Creek at RM-13,
- Big Run Creek at RM-3, and
- Little Beaver Creek (RM-11, RM-7 and RM-8).

The highest detection (3.28 pCi/g) was at on-site location RM-8 (Little Beaver Creek near the North Drainage Ditch).

Uranium and uranium isotopes are naturally occurring, but may also be present due to PORTS activities. Maximum detections of uranium and uranium isotopes in sediment samples were detected at on-site sampling locations RM-11 and RM-8 (Little Beaver Creek) as follows.

Uranium: 3.33 micrograms per gram (µg/g) (RM-8)
Uranium-233/234: 4.54 pCi/g (RM-11)
Uranium-235/236: 0.222 pCi/g (RM-8)
Uranium-238: 1.08 pCi/g (RM-8).

Uranium and uranium isotopes detected in the 2018 samples have been detected at similar levels in previous sampling events from 2005 through 2017.

Section 4.3.9.1 provides a dose assessment based on the detections of neptunium-237 (0.00789 pCi/g), technetium-99 (3.23 pCi/g), uranium-233/234 (2.16 pCi/g), uranium-235/236 (0.0908 pCi/g), and uranium-238 (0.646 pCi/g) at the off-site sediment sampling location with the detections of radionuclides that could cause the highest dose to a member of the public (RM-7 on Little Beaver Creek). The total potential annual dose to a member of the public resulting from PORTS (0.92 mrem/year), which includes this dose calculation (0.017 mrem/year), is well below the total public annual dose limit of 100 mrem/year in DOE Order 458.1.

4.6.6 Settleable Solids

DOE collects semiannual water samples from nine effluent locations and three background locations (see Figure 4.6) 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 states that operators of DOE facilities discharging or releasing liquids containing radionuclides from DOE activities must ensure that the

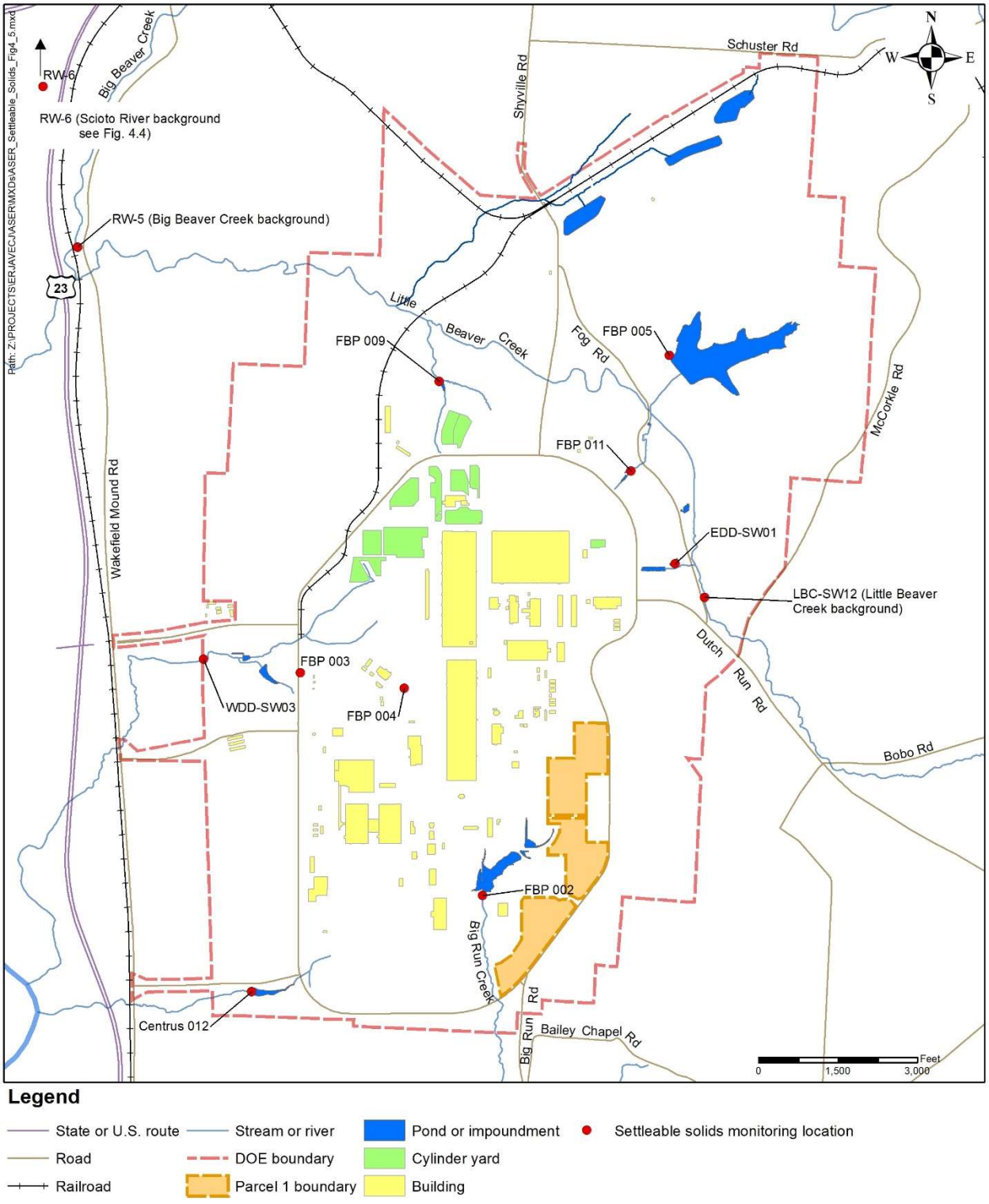

Figure 4.6. DOE settleable solids monitoring locations.

discharges do not exceed an annual average (at the point of discharge) of either of the following:

- 5 pCi/g above background of settleable solids for alpha-emitting radionuclides, and
- 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. A DOE memo (DOE 1995) states that settleable solids of less than 40 milligrams per liter (mg/L) are in *de facto* compliance with the DOE Order 458.1 limits (5 pCi/g above background for alpha activity and 50 pCi/g above background for beta-gamma activity). In 2018, 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. Detections of settleable solids that monitor PORTS effluent and background locations ranged from 4.8 to 38 mg/L.

4.6.7 Soil

Soil samples are collected annually from ambient air monitoring locations (see Figure 4.2) 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 2017b).

Plutonium-239/240 was detected in soil at seven of the 15 ambient air monitoring stations. The highest off-site detection of plutonium-239/240 was 0.0271 pCi/g at station A9 (southwest of the plant on Old U.S. Route 23). Americium-241 was also detected at station A9 at 0.011 pCi/g. These detections are much less than the soil screening levels for americium-241 (2.31 pCi/g) and plutonium-239/240 (3.78 pCi/g) in residential soil calculated using the exposure assumptions in the *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Portsmouth Gaseous Diffusion Plant* (DOE 2017d). These soil screening levels were calculated using a one in a million cancer risk. No other transuranic radionuclides were detected at the soil sampling locations in 2018.

Technetium-99 was not detected in any of the soil samples collected during 2018. Uranium, uranium-233/234, uranium-235/236, and/or uranium-238 were detected at each of the sampling locations. Uranium and uranium isotopes are usually detected at similar levels at all the soil sampling locations, including the background location (A37), which suggests that the uranium detected in these samples is due to naturally-occurring uranium.

Section 4.3.9.2 provides a dose assessment based on the detections of americium-241 (0.011 pCi/g), plutonium-239/240 (0.0271 pCi/g), uranium-233/234 (0.265 pCi/g), uranium-235/236 (0.0157 pCi/g), and uranium-238 (0.301 pCi/g) in soil at the off-site ambient air station with the detections of radionuclides that could cause the highest dose to a member of the public (station A9, southwest of PORTS on Old U.S. Route 23). The total potential annual dose to a member of the public resulting from PORTS (0.92 mrem/year), which includes this dose calculation (0.020 mrem/year), is well below the total public annual dose limit of 100 mrem/year in DOE Order 458.1.

4.6.8 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 (vegetation, deer, fish, crops, milk, and eggs).

4.6.8.1 Vegetation

To assess the uptake of radionuclides into 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 4.2). 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, and/or uranium-238 were detected in the vegetation samples collected at sampling location A12 (east of PORTS on McCorkle Road), A9 (southwest of PORTS on old US Route 23), and A28 (southwest of PORTS on Camp Creek Road). Uranium and uranium isotopes were also detected in vegetation at on-site sampling location A10. Uranium and uranium isotopes are detected occasionally in vegetation samples, and have been detected at similar levels in previous sampling. Section 4.3.9.3 provides a dose assessment for a member of the public based on consumption of beef cattle that would eat grass contaminated with radionuclides at station A28. The total potential annual dose to a member of the public resulting from PORTS (0.92 mrem/year), which includes this dose calculation (0.00041 mrem/year), is well below the total public annual dose limit of 100 mrem/year in DOE Order 458.1.

4.6.8.2 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 February (two deer), May, June, September, and December of 2018.

Technetium-99 was detected at 0.52 and 1.5 pCi/g in liver and kidney samples, respectively, collected from one of the two deer in February 2018. Technetium-99 was not detected in the muscle sample collected from this deer. A dose assessment is only completed when radionuclides are detected in deer muscle samples because people do not typically eat deer liver or kidneys. No other radionuclides were detected in any of the deer samples collected in 2018.

4.6.8.3 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 2018, fish were caught at each of these locations. 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 the fish samples collected during 2018.

4.6.8.4 Crops

In 2018, crop samples, including corn, tomatoes, and beans, were collected from five 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 the crop samples collected during 2018.

4.6.8.5 Milk and eggs

Samples were collected in 2018 of milk and eggs produced 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 the milk and egg samples collected during 2018.

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

Sections 4.7.1 and 4.7.2 provide information about property released from FBP and MCS, respectively.

4.7.1 FBP Property Releases

FBP uses pre-approved authorized limits established by DOE Orders to evaluate and release materials defined as personal property. In 2018, FBP authorized approximately 1640 release requests for materials/items of personal property, which includes vehicles, equipment, waste/recyclables (such as batteries, light bulbs, used oil, and construction debris), and other materials.

In May 2018, DOE approved authorized limits for real property release at PORTS. These authorized limits are as low as reasonably achievable and allow DOE to transfer land intended for industrial use. Table 4.3 provides the approved authorized limits.

Table 4.3. Approved authorized limits for real property transfer at PORTS

Nuclide	Outdoor Worker (pCi/g)[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

[a]Source: Authorized limits letter (Bradburne May 2, 2018).
[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.

On July 20, 2018, DOE transferred real property at PORTS to SODI for economic development. The 80-acre parcel, known as Parcel 1, is located on the eastern side of PORTS within Perimeter Road (see Figure 4.6). The northern portion once held a former air strip used during the early years of plant operation while the southern portion contains a former building slab and parking lot. The parcel was evaluated through radiological surveys and soil sampling and analysis which concluded the parcel was protective of human health and the environment for its intended uses. The transfer required a rigorous review process that included the Ohio Governor or designee (designation was given to Ohio EPA), approval from the Secretary of the DOE, and a 60-day congressional review.

4.7.2 MCS Property Releases

In 2018, MCS resumed off-site shipment of aqueous hydrogen fluoride produced by the DUF_6 Conversion Facility, which converts DUF_6 into uranium oxide and aqueous hydrogen fluoride. Each shipment meets the release limit of less than 3 picocuries/milliliter (pCi/mL), or 0.003 pCi/L, of total uranium activity. Approximately 628,908 gallons of aqueous hydrogen fluoride were shipped off site in 2018.