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Portsmouth Gaseous Diffusion Plant

Annual Site Environmental Report 2016

February 2018

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Portsmouth Gaseous Diffusion Plant
Annual Site Environmental Report – 2016
Piketon, Ohio

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By
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CONTENTS

FIGURES vii

TABLES ix

ACRONYMS AND ABBREVIATIONS xi

DEFINITIONS xiii

EXECUTIVE SUMMARY ES-1

1. INTRODUCTION 1-1
   1.1 SUMMARY 1-1
   1.2 BACKGROUND INFORMATION 1-2
   1.3 DESCRIPTION OF SITE LOCALE 1-3
   1.4 DESCRIPTION OF SITE OPERATIONS 1-3

2. COMPLIANCE SUMMARY 2-1
   2.1 SUMMARY 2-1
   2.2 COMPLIANCE INTRODUCTION 2-1
   2.3 COMPLIANCE STATUS 2-2
      2.3.1 Environmental Restoration and Waste Management 2-2
         2.3.1.1 Comprehensive Environmental Response, Compensation, and Liability Act 2-2
         2.3.1.2 Emergency Planning and Community Right-to-Know Act 2-2
         2.3.1.3 Resource Conservation and Recovery Act 2-3
         2.3.1.4 Federal Facility Compliance Act 2-5
         2.3.1.5 Toxic Substances Control Act 2-5
         2.3.1.6 Federal Insecticide, Fungicide, and Rodenticide Act 2-5
      2.3.2 Radiation Protection 2-6
         2.3.2.1 DOE Order 458.1, *Radiation Protection of the Public and the Environment* 2-6
         2.3.2.2 DOE Order 435.1, *Radioactive Waste Management* 2-6
      2.3.3 Air Quality and Protection 2-6
         2.3.3.1 Clean Air Act 2-6
         2.3.3.2 Clean Air Act, Title VI, Stratospheric Ozone Protection 2-7
         2.3.3.3 National Emission Standards for Hazardous Air Pollutants 2-7
      2.3.4 Water Quality and Protection 2-8
         2.3.4.1 Clean Water Act 2-8
         2.3.4.2 Safe Drinking Water Act 2-8
      2.3.5 Other Environmental Statutes 2-9
         2.3.5.1 Underground storage tank regulations 2-9
         2.3.5.2 National Environmental Policy Act 2-9
         2.3.5.3 Endangered Species Act 2-9
         2.3.5.4 National Historic Preservation Act 2-10
         2.3.5.5 Archaeological and Historic Preservation Act and Archaeological Resources Protection Act 2-10
      2.3.6 DOE Order 436.1, *Departmental Sustainability* 2-10

2.3.7 Executive Orders 2-11
2.3.7.1 Executive Order 11988, *Floodplain Management*, and Executive Order 11990, *Protection of Wetlands* 2-11
2.3.7.2 Executive Order 13693, *Planning for Federal Sustainability in the, Next Decade* 2-11
2.4 OTHER MAJOR ENVIRONMENTAL ISSUES AND ACTIONS 2-12
2.4.1 Environmental Program Inspections 2-12
2.4.2 Notices of Violation 2-12
2.5 UNPLANNED RELEASES 2-13
2.6 SUMMARY OF PERMITS 2-13

3. ENVIRONMENTAL PROGRAM INFORMATION 3-1
3.1 SUMMARY 3-1
3.2 D&D PROGRAM 3-1
3.2.1 Process Buildings and Other Facilities 3-1
3.2.2 Site-wide Waste Disposition 3-2
3.3 ENVIRONMENTAL RESTORATION PROGRAM 3-2
3.3.1 Quadrant I 3-3
3.3.1.1 X-749/X-120 groundwater plume 3-4
3.3.1.2 PK Landfill 3-6
3.3.1.3 Quadrant I Groundwater Investigative (5-Unit) Area 3-6
3.3.2 Quadrant II 3-7
3.3.2.1 Quadrant II Groundwater Investigative (7-Unit) Area 3-7
3.3.2.2 X-701B Former Holding Pond 3-8
3.3.2.3 X-633 Former Recirculating Cooling Water Complex 3-8
3.3.3 Quadrant III 3-8
3.3.4 Quadrant IV 3-9
3.3.4.1 X-611A Former Lime Sludge Lagoons 3-9
3.3.4.2 X-734 Landfills 3-9
3.3.4.3 X-630 Former Recirculating Cooling Water Complex 3-9
3.4 WASTE MANAGEMENT PROGRAM 3-10
3.5 ENVIRONMENTAL SUSTAINABILITY PROGRAM 3-11
3.6 PUBLIC AWARENESS PROGRAM 3-14

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION 4-1
4.1 SUMMARY 4-1
4.2 ENVIRONMENTAL RADIOLOGICAL PROGRAM INTRODUCTION 4-2
4.3 RADIOLOGICAL EMISSIONS AND DOSES 4-3
4.3.1 Dose Terminology 4-3
4.3.2 Airborne Emissions 4-4
4.3.3 Dose Calculation Based on Airborne Emissions 4-5
4.3.4 Dose Calculation Based on Ambient Air Monitoring 4-6
4.3.5 Discharges of Radionuclides from NPDES Outfalls 4-6
4.3.5.1 FBP outfalls 4-6
4.3.5.2 Centrus outfalls 4-11
4.3.6 Dose Calculation for Releases to Surface Water 4-12
4.3.7 Radiological Dose Calculation for External Radiation 4-12
4.3.8 Radiological Dose Results for DOE Workers and Visitors 4-13
4.3.9 Radiological Dose Calculations for Off-site Environmental Monitoring Data 4-13
4.3.9.1 Dose calculation for sediment 4-15
4.3.9.2 Dose calculation for soil 4-15

4.3.9.3 Dose calculation for vegetation 4-15
4.4 PROTECTION OF BIOTA 4-16
4.4.1 Aquatic and Riparian Animals 4-16
4.4.2 Terrestrial Plants and Animals 4-16
4.5 UNPLANNED RADIOLOGICAL RELEASES 4-17
4.6 ENVIRONMENTAL RADIOLOGICAL MONITORING 4-17
4.6.1 Ambient Air Monitoring 4-17
4.6.2 External Radiation 4-18
4.6.3 Surface Water from Cylinder Storage Yards 4-20
4.6.3.1 FBP cylinder storage yards 4-20
4.6.3.2 BWCS cylinder storage yards 4-20
4.6.4 Local Surface Water 4-21
4.6.5 Sediment 4-21
4.6.6 Settleable Solids 4-23
4.6.7 Soil 4-23
4.6.8 Biological Monitoring 4-25
4.6.8.1 Vegetation 4-25
4.6.8.2 Deer 4-25
4.6.8.3 Fish 4-25
4.6.8.4 Crops 4-26
4.6.8.5 Milk and eggs 4-26
4.7 RELEASE OF PROPERTY CONTAINING RESIDUAL RADIOACTIVE MATERIAL 4-26
4.7.1 FBP Releases 4-26
4.7.2 BWCS Releases 4-26

5. ENVIRONMENTAL NON-RADIOLOGICAL PROGRAM INFORMATION 5-1
5.1 SUMMARY 5-1
5.2 ENVIRONMENTAL NON-RADIOLOGICAL PROGRAM INTRODUCTION 5-1
5.3 AIR 5-1
5.3.1 Airborne Discharges 5-1
5.3.2 Ambient Air Monitoring 5-2
5.4 WATER 5-2
5.4.1 Water Discharges (NPDES Outfalls) 5-2
5.4.1.1 FBP NPDES outfalls 5-3
5.4.1.2 BWCS NPDES outfalls 5-5
5.4.1.3 Centrus NPDES outfalls 5-5
5.4.2 Surface Water Monitoring Associated with BWCS Cylinder Storage Yards 5-5
5.5 SEDIMENT 5-5
5.5.1 Local Sediment Monitoring 5-6
5.5.2 Sediment Monitoring Associated with BWCS Cylinder Storage Yards 5-6
5.6 BIOLOGICAL MONITORING - FISH 5-6

6. GROUNDWATER PROGRAMS 6-1
6.1 SUMMARY 6-1
6.2 GROUNDWATER PROGRAMS INTRODUCTION 6-1
6.3 OVERVIEW OF GROUNDWATER MONITORING AT PORTS 6-1
6.3.1 Regulatory Programs 6-1
6.3.2 Groundwater Use and Geology 6-2
6.3.3 Monitoring Activities 6-2
6.4 GROUNDWATER MONITORING AREAS 6-2
6.4.1 X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility 6-4

6.4.1.1 X-749 Contaminated Materials Disposal Facility 6-7
6.4.1.2 X-120 Former Training Facility 6-7
6.4.1.3 Monitoring results for the X-749 Contaminated Materials Disposal Facility/ X-120 Former Training Facility in 2016 6-8
6.4.2 PK Landfill 6-10
6.4.2.1 Monitoring results for the PK Landfill in 2016 6-10
6.4.3 Quadrant I Groundwater Investigative (5-Unit) Area 6-10
6.4.3.1 Monitoring results for the Quadrant I Groundwater Investigative (5-Unit) Area in 2016 6-11
6.4.4 X-749A Classified Materials Disposal Facility 6-11
6.4.4.1 Monitoring results for the X-749A Classified Materials Disposal Facility in 2016 6-11
6.4.5 Quadrant II Groundwater Investigative (7-Unit) Area 6-13
6.4.5.1 Monitoring results for the Quadrant II Groundwater Investigative (7-Unit) Area in 2016 6-13
6.4.6 X-701B Former Holding Pond 6-13
6.4.6.1 Monitoring results for the X-701B Former Holding Pond in 2016 6-15
6.4.7 X-633 Former Recirculating Cooling Water Complex 6-17
6.4.7.1 Monitoring results for the X-633 Former Recirculating Cooling Water Complex in 2016 6-17
6.4.8 X-616 Former Chromium Sludge Surface Impoundments 6-17
6.4.8.1 Monitoring results for the X-616 Former Chromium Sludge Surface Impoundments in 2016 6-17
6.4.9 X-740 Former Waste Oil Handling Facility 6-20
6.4.9.1 Monitoring results for the X-740 Former Waste Oil Handling Facility in 2016 6-20
6.4.10 X-611A Former Lime Sludge Lagoons 6-20
6.4.10.1 Monitoring results for the X-611A Former Lime Sludge Lagoons in 2016 6-22
6.4.11 X-735 Landfills 6-22
6.4.11.1 Monitoring results for the X-735 Landfills in 2016 6-25
6.4.12 X-734 Landfills 6-25
6.4.12.1 Monitoring results for the X-734 Landfills in 2016 6-25
6.4.13 X-533 Former Switchyard Complex 6-25
6.4.13.1 Monitoring results for the X-533 Former Switchyard Complex in 2016 6-27
6.4.14 X-344C Former Hydrogen Fluoride Storage Building 6-27
6.4.14.1 Monitoring results for the X-344C Former Hydrogen Fluoride Storage Building in 2016 6-27
6.4.15 Surface Water Monitoring 6-27
6.4.15.1 Monitoring results for surface water in 2016 6-30
6.4.16 Water Supply Monitoring 6-31
6.5 DOE ORDER MONITORING PROGRAMS 6-33
6.5.1 Exit Pathway Monitoring 6-33
6.6 GROUNDWATER TREATMENT FACILITIES 6-35
6.6.1 X-622 Groundwater Treatment Facility 6-35
6.6.2 X-623 Groundwater Treatment Facility 6-35
6.6.3 X-624 Groundwater Treatment Facility 6-36
6.6.4 X-627 Groundwater Treatment Facility 6-36

7. QUALITY ASSURANCE 7-1
7.1 SUMMARY 7-1
7.2 QUALITY ASSURANCE INTRODUCTION 7-1

7.3 FIELD SAMPLING AND MONITORING 7-2
7.4 ANALYTICAL QUALITY ASSURANCE 7-2

8. REFERENCES 8-1

APPENDIX A: RADIATION A-1
APPENDIX B: ENVIRONMENTAL PERMITS B-1
APPENDIX C: RADIONUCLIDE AND CHEMICAL NOMENCLATURE C-1

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FIGURES

1 Comparison of dose from various common radiation sources ES-7

1.1 The Portsmouth Gaseous Diffusion Plant 1-1

1.2 Location of PORTS 1-3

3.1 Location of the OSWDF at PORTS 3-2

4.1 DOE ambient air and radiation monitoring locations 4-7

4.2 PORTS NPDES outfalls/monitoring points and cylinder storage yards sampling locations 4-8

4.3 On-site radiation and cylinder yard dose monitoring locations 4-19

4.4 Local surface water and sediment monitoring locations 4-22

4.5 DOE settleable solids monitoring locations 4-24

6.1 Groundwater monitoring areas at PORTS 6-3

6.2 TCE-contaminated Gallia groundwater plume at the X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility – 2016 6-9

6.3 TCE-contaminated Gallia groundwater plume at the Quadrant I Groundwater Investigative (5-Unit) Area – 2016 6-12

6.4 TCE-contaminated Gallia groundwater plume at the Quadrant II Groundwater Investigative (7-Unit) Area – 2016 6-14

6.5 TCE-contaminated Gallia groundwater plume at the X-701B Former Holding Pond – 2016 6-16

6.6 Metal concentrations in groundwater at the X-633 Former Recirculating Cooling Water Complex and X-533 Former Switchyard Complex – 2016 6-18

6.7 TCE and metal concentrations in groundwater at the X-616 Former Chromium Sludge Surface Impoundments – 2016 6-19

6.8 TCE-contaminated Gallia groundwater plume near the X-740 Former Waste Oil Handling Facility – 2016 6-21

6.9 Metal concentrations in groundwater at the X-611A Former Lime Sludge Lagoons – 2016 6-23

6.10 Monitoring wells at the X-735 Landfills 6-24

6.11 Monitoring wells at the X-734 Landfills 6-26

6.12 Monitoring well at the X-344C Former Hydrogen Fluoride Storage Building 6-28

6.13 Surface water monitoring locations 6-29

6.14 Water supply monitoring locations 6-32

6.15 Exit pathway monitoring locations 6-34

TABLES

2.1 Chemicals reported in the Hazardous Chemical Inventory Report for 2016 2-3

2.2 Environmental inspections of DOE activities at PORTS for 2016 2-12

3.1 Remedial actions at PORTS in groundwater monitoring areas 3-5

3.2 Waste Management Program off-site treatment, disposal, and recycling accomplishments for 2016 3-12

4.1 Summary of potential doses to the public from PORTS in 2016 4-1

4.2 Summary of potential doses to the public from radionuclides detected by DOE environmental monitoring programs in 2016 4-14

6.1 Analytical parameters for monitoring areas and programs at PORTS in 2016 6-5

6.2 Summary of TCE removed by PORTS groundwater treatment facilities in 2016 6-35

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ACRONYMS AND ABBREVIATIONS

ACP	American Centrifuge Plant
Bq	becquerel
BSFR	bulk survey for release
BWCS	BWXT Conversion Services, LLC
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
Ci	curie
D&D	decontamination and decommissioning
DAS	Disposal Authorization Statement
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* (Ohio EPA 2012)
DOE	U.S. Department of Energy
dps	disintegration per second
DUF_6	depleted uranium hexafluoride
EMS	Environmental Management System
FBP	Fluor-BWXT Portsmouth LLC
Gy	gray
IRM	interim remedial measure
kg	kilogram
lbs	pounds
LFRG	Low-level Waste Disposal Facility Review Group
LLW	low-level radioactive waste
µg/g	microgram per gram (equivalent to part per million)
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
mg	milligram
mg/L	milligram per liter (equivalent to part per million)
mrem	millirem
mSv	millisievert
ng/L	nanogram per liter
NCRP	National Council on Radiation Protection
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
Ohio EPA	Ohio Environmental Protection Agency
OSWDF	on-site waste disposal facility
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
PEGASIS	PORTS Environmental Geographic Analytical Spatial Information System
PK	Peter Kiewit
PMA	Portsmouth Mission Alliance, LLC

PORTS	Portsmouth Gaseous Diffusion Plant
ppb	part per billion
ppm	part per million
rad	radiation absorbed dose
RCRA	Resource Conservation and Recovery Act
rem	roentgen equivalent man
SODI	Southern Ohio Diversification Initiative
Sv	sievert
TCE	trichloroethene
TLD	thermoluminescent dosimeter
TSCA	Toxic Substances Control Act
USEC	United States Enrichment Corporation
U.S. EPA	U.S. Environmental Protection Agency
VOC	volatile organic compound
WEMS	Wastren-EnergX Mission Support, LLC

DEFINITIONS

absorption – In radiological terms, the taking up of energy from radiation by the medium or tissue through which the radiation is passing.

activity – See "radioactivity."

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

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

alpha particle – A positively charged particle consisting of two protons and two neutrons, identical with the nucleus of a helium atom; emitted by several radioactive substances.

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

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

aquifer – A permeable layer of sand, gravel, and/or 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.

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

background radiation – The radiation in humans' natural environment, including cosmic rays and radiation from the naturally-occurring radioactive elements.

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

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

biota – Animal and plant life characterizing a given region.

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

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

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

compliance – Fulfillment of applicable regulations or requirements of a plan or schedule ordered or approved by a government authority.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) – An act to provide for liability, compensation, cleanup, and emergency response for hazardous substances released to the environment and the cleanup of inactive hazardous waste disposal sites.

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

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.

cosmic radiation – Ionizing radiation with very high energies that originates outside the earth's atmosphere. Cosmic radiation is one contributor to natural background radiation.

critical habitat – Specific geographic areas, whether occupied by a species listed under the Endangered Species Act or not, that are essential for conservation of the species and that have been formally designated by a rule published in the Federal Register.

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 of the curie are commonly used:

millicurie (mCi) – 10^{-3} Ci, one-thousandth of a curie; 3.7×10^{7} disintegrations per second.
microcurie (µCi) – 10^{-6} Ci, one-millionth of a curie, 3.7×10^{4} disintegrations per second.
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.

deferred unit – An area at PORTS that was in or adjacent to the gaseous diffusion production and operational areas such that remedial activities would have interrupted operations, or an area that could have become recontaminated from ongoing operations.

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 (100 mrem) or a dose of 5 rem to any tissue, including skin and the lens of the eye. The DOE publication *Derived Concentration Technical Standard* (DOE 2011a) provides the derived concentration standards.

dose – In this document, "dose" is used exclusively to refer to a radiological dose; the energy imparted to matter by ionizing radiation.

- **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).

- **dose** – The product of the absorbed dose (rad) in tissue and a quality factor. 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 weighting factor. In this document, the term "effective dose" is often shortened to "dose."

- **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."

Note that "dose" can also be used to refer to a chemical dose; however, chemical doses are not discussed in this document.

downgradient – The direction that groundwater flows; similar to downstream for surface water.

downgradient well – A well installed downgradient of a site that may be capable of detecting migration of contaminants from a site.

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

effluent – A liquid or gaseous discharge to the environment.

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

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

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

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

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

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

groundwater – Any water found below the land surface.

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

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

in situ – In its original place; field measurements taken without removing the sample from its original location; remediation performed while the contaminated media (e.g., groundwater or soil) remains below the surface or in place.

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.

internal radiation – Occurs when radionuclides enter the body, for example, by ingestion of food or liquids or by inhalation.

irradiation – Exposure to external radiation.

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

maximally exposed individual – A hypothetical individual who remains in an uncontrolled area and would, when all potential routes of exposure from a facility's operations are considered, receive the greatest possible dose.

maximum contaminant level (MCL) – The maximum permissible level of a contaminant in drinking water provided by a public water system.

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

millirem (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 measured periodically to regulate and control potential impacts.

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

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

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

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

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

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

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

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

preliminary remediation goal – An initial clean-up goal developed early in the decision-making process that is 1) protective of human health and the environment, and 2) complies with applicable or relevant and appropriate requirements. Preliminary remediation goals are intended to satisfy regulatory cleanup requirements. For groundwater at PORTS, preliminary remediation goals are the National Pollutant Discharge Elimination System (NPDES) drinking water standards (maximum contaminant levels).

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

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

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

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

radionuclide – A radioactive nuclide capable of 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 – The unit of dose (absorbed dose in rads multiplied by the radiation quality factor). Dose is frequently reported in units of millirem (mrem), which is one-thousandth of a rem.

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

reportable quantity – A release to the environment that exceeds 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 – Material settling out of suspension in a liquid within a defined period of time.

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

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

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

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

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

transuranics – Elements such as americium, plutonium, and neptunium that have atomic numbers (the number of protons in the nucleus) greater than 92 (uranium). 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 U.S. Environmental Protection Agency Integrated Risk Information System characterizes TCE as carcinogenic to humans by all routes of exposure. This conclusion is based on convincing evidence of a causal association between TCE exposure in humans and kidney cancer.

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

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

upgradient – In the opposite direction of groundwater flow; similar to upstream for surface water.

upgradient well – A well installed hydraulically upgradient of a site to provide data to compare to a downgradient well to determine whether the site is affecting groundwater quality.

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.

weighting factor (radiation) – The factor by which an absorbed dose (rad) is multiplied to obtain a quantity that expresses, on a common scale for all ionizing radiation, the biological damage to an exposed person. The weighting factor is used because some types of radiation, such as alpha particles, are more biologically damaging than others.

weighting factor (tissue) – A tissue specific number that represents the fraction of the total potential health risk resulting from uniform, whole body irradiation to the specific organ or tissue (bone marrow, lungs, thyroid, etc.).

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

EXECUTIVE SUMMARY

PURPOSE

This Annual Site Environmental Report is prepared to summarize environmental monitoring and compliance activities conducted at the U.S. Department of Energy (DOE) Portsmouth Gaseous Diffusion Plant (PORTS) for calendar year 2016. Environmental monitoring is conducted to assess the impact, if any, that site operations may have on public health and the environment. The report fulfills a requirement of DOE Order 231.1B, *Environment, Safety and Health Reporting*, for preparation of an annual summary of environmental data to characterize environmental management performance. The Annual Site Environmental Report also provides the means by which DOE demonstrates compliance with the radiation protection requirements of DOE Order 458.1, *Radiation Protection of the Public and the Environment*.

SITE AND OPERATIONS OVERVIEW

PORTS, which produced enriched uranium via the gaseous diffusion process from 1954 to 2001, is one of three uranium enrichment facilities originally built in the United States; the other two were constructed in Oak Ridge, Tennessee and Paducah, Kentucky, respectively. PORTS is located on 5.9 square miles in Pike County, Ohio. The county has approximately 28,160 residents (U.S. Census Bureau 2017).

DOE is responsible for decontamination and decommissioning (D&D) of the gaseous diffusion process buildings and associated facilities, environmental restoration, waste management, depleted uranium hexafluoride (DUF_6) conversion, and management of other non-leased facilities at PORTS. DOE contractors Fluor-BWXT Portsmouth LLC (FBP), Wastren-EnergX Mission Support, LLC (WEMS), Portsmouth Mission Alliance, LLC (PMA), and BWXT Conversion Services, LLC (BWCS) managed DOE programs at PORTS in 2016.

FBP was responsible for the following activities:

- D&D of the former gaseous diffusion process building and associated facilities;
- environmental restoration of contaminated areas;
- monitoring and reporting on environmental compliance;
- disposition of legacy radioactive waste;
- uranium management; and
- operation of the site's waste storage facilities.

WEMS provided facility support services until April 24, 2016. PMA began a contract to provide facility support services on April 25, 2016. These services include the following:

- computer and telecommunications services;
- security;
- training;
- records management;
- fleet management;
- non-nuclear facility preventive and corrective maintenance;
- grounds and road maintenance;
- snow removal; and
- janitorial services.

BWCS was responsible for operations associated with the DUF_6 Conversion Facility, including surveillance and maintenance of DUF_6 cylinders, and environmental compliance and monitoring activities

associated with operation of the DUF_6 Conversion Facility. DUF_6, which is a product of the uranium enrichment process, is stored in cylinders on site. The DUF_6 Conversion Facility converts DUF_6 into uranium oxide and aqueous hydrogen fluoride. The uranium oxide is made available for beneficial reuse, storage, or disposal, and the aqueous hydrogen fluoride is sold for reuse.

Centrus Energy Corp. (Centrus), formerly USEC, Inc., leases facilities at PORTS for the development of a gaseous centrifuge uranium enrichment facility – the American Centrifuge Plant (ACP); however, this project is currently shutdown due to lack of funding.

With the exception of Chapter 2, Compliance Summary; Chapter 4, Environmental Radiological Program Information; and Chapter 5, Environmental Non-Radiological Program Information, this report does not cover Centrus operations at PORTS because their operations are not subject to DOE Orders. Centrus data are included in these chapters to provide a more complete picture of the operations in place at PORTS to detect and assess potential impacts to human health and the environment resulting from PORTS activities.

ENVIRONMENTAL MONITORING AND RADIOLOGICAL DOSE SUMMARY

Extensive environmental monitoring is completed at PORTS to comply with environmental regulations, permit requirements, and DOE Orders, and assess the impact, if any, that site operations may have on public health and the environment. The *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2013a) describes the DOE environmental monitoring programs at PORTS, with the exception of groundwater monitoring. Groundwater monitoring, which also includes related surface water monitoring and residential water supply monitoring, is described in the *Integrated Groundwater Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2015b).

Environmental monitoring includes the collection of samples of air, water, soil, sediment, and biota (vegetation, deer, fish, crops, milk, and eggs). Samples are collected at varying frequencies (weekly, monthly, quarterly, annually, or biennially). In 2016, environmental monitoring information was collected for the following programs:

- ambient air
- external radiation
- discharges to surface water
- local surface water
- sediment
- soil
- biota (vegetation, deer, fish, crops, milk, and eggs)
- groundwater.

Samples are analyzed for radionuclides, metals, and/or other chemicals that could be present in the environment due to PORTS activities, although many of these analytes also occur naturally or can be present due to human activities not related to PORTS. Over 3000 samples from these programs are collected on an annual basis.

Potential impacts on human health from radionuclides released by PORTS operations are calculated based on environmental monitoring data. This impact, if any, is calculated in terms of a dose. A dose can be caused by radionuclides released into the air and/or water, or radiation emanating directly from buildings or other objects at PORTS. PORTS complies with the following dose limits:

- The U.S. Environmental Protection Agency (U.S. EPA) has established a dose limit of 10 millirem (mrem)/year from radionuclides released to the air in Title 40 of the *Code of Federal Regulations* (CFR), Part 61, National Emission Standards for Hazardous Air Pollutants (NESHAP), Subpart H,

National Emission Standards for Emissions of Radionuclides Other Than Radon from DOE Facilities (40 CFR Part 61, Subpart H).

- The DOE has established a dose limit for members of the general public in DOE Order 458.1, which is as low as reasonably achievable[1], but no more than 100 mrem/year for the dose from radionuclides from all potential pathways of exposure including inhalation, ingestion of water and soil/sediments, consumption of food, and direct external radiation.

To aid in comparing sampling results for air and water to the 100 mrem/year dose limit, the 100 mrem/year limit is converted into a derived concentration standard (DOE 2011a). The derived concentration standard is the concentration of a radionuclide in air or water that under conditions of continuous exposure for one year by one exposure mode (ingestion of water or inhalation of air) would result in a dose of 100 mrem. A concentration of 100% of the derived concentration standard would equate to a dose at the DOE limit of 100 mrem/year.

Environmental monitoring data collected in 2016 are consistent with data collected in previous years and indicate that radionuclides, metals, and other chemicals released by PORTS operations have a minimal effect on human health and the environment. The following sections summarize the results of environmental monitoring conducted at PORTS in 2016:

Ambient air. Radionuclides in ambient air are monitored at 15 monitoring stations that are located on site, at the site perimeter, within the local area, and west of PORTS in an area not potentially impacted by PORTS operations (the background location). Samples are analyzed monthly or quarterly for radionuclides that can be associated with PORTS operations. These radionuclides are transuranics (manmade elements greater than atomic number 92 [americium-241, neptunium-237, plutonium-238, plutonium-239/240]), a fission product (technetium-99), uranium, and uranium isotopes (uranium-233/234, uranium-235/236, and uranium-238).

Uranium, uranium isotopes, and technetium-99 were detected at the ambient air monitoring stations in 2016. The highest levels of each radionuclide in air were 0.02% or less of the DOE derived concentration standards (DOE 2011a).

The ambient air monitoring data were used to calculate the potential worst case dose from the air pathway to a hypothetical person living at the monitoring station. This approach is unlikely to underestimate the dose because it assumes an individual resides at the location of the monitoring station breathing the air at that location for 24 hours/day, 365 days/year. The highest net dose calculation for the off-site ambient air stations (0.0013 mrem/year) was at station A6 in Piketon. This net dose was calculated by subtracting the dose at the background station from the dose at the monitoring stations closer to PORTS. This hypothetical dose is well below the 10 mrem/year limit applicable to PORTS in NESHAP (40 CFR Part 61, Subpart H).

Discharges to surface water. Discharges of chemicals and other parameters that measure water quality are regulated by the National Pollutant Discharge Elimination System (NPDES) under the Clean Water Act. Water from PORTS is discharged to off-site water bodies through 11 locations called NPDES outfalls. The Ohio Environmental Protection Agency (Ohio EPA) selects the chemicals monitored at the

[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.

outfalls based on the chemical characteristics of the water discharged from the outfall. Outfalls are also monitored for radionuclides. Sampling frequencies vary from weekly to quarterly.

Transuranic radionuclides were not detected in any of the samples collected from FBP and Centrus NPDES external outfalls in 2016. Uranium discharges from the FBP and Centrus external outfalls were estimated at 8.3 kilograms (kg). Total radioactivity (technetium-99 and isotopic uranium) released from the FBP outfalls was estimated at 0.055 curie (Ci).

Water from the NPDES outfalls is discharged to or eventually flows to the Scioto River. Data for radionuclide discharges is used to calculate a potential worst case dose to a hypothetical member of the public who is exposed to water from the Scioto River. Exposure pathways considered were ingestion of water, ingestion of fish, swimming, boating, and shoreline activities. This exposure scenario is unlikely to underestimate the dose because the Scioto River is not used for drinking water downstream of PORTS (97% of the hypothetical dose from liquid effluents is from drinking water). The dose from radionuclides released to the Scioto River in 2016 (0.0015 mrem) is significantly less than the 100 mrem/year DOE limit in DOE Order 458.1 for all radiological releases from a facility.

Discharges of chemicals and other non-radiological parameters that affect water quality are regulated by Ohio EPA in NPDES permits issued to FBP, BWCS, and Centrus. In 2016, the overall FBP NPDES compliance rate with the NPDES permit was 99%. Discharge limitations at the FBP NPDES monitoring locations were exceeded on nine occasions. One exceedance was due to the chlorine concentration in the sanitary sewage discharge. Five exceedances were due to maximum water temperatures during hot and dry weather during July and August 2016.

Three exceedances of a preliminary effluent limit were due to concentrations of mercury in holding pond discharges. In May, June, and September of 2016, the average monthly concentration preliminary effluent limit for mercury was exceeded at Outfall 001 (the X-230J7 East Holding Pond). The average monthly concentration preliminary effluent limit is 12 nanograms/liter (ng/L). Average monthly concentrations at Outfall 001 were 22.7 ng/L in May, 20.5 ng/L in June, and 15.35 ng/L in September. FBP has initiated an investigation to identify the source of the mercury detected at Outfall 001 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 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.

Ohio EPA did not issue a Notice of Violation for any of these exceedances. The overall Centrus and BWCS compliance rates were 100%.

External radiation. External radiation is measured continuously with thermoluminescent dosimeters (TLDs) at five locations near the DUF_6 cylinder storage yards and 19 on-site and off-site locations (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. A new TLD replaces the removed device. Radiation is measured as a whole body dose (in mrem), which is the dose that a person would receive if they were continuously present at the monitored location.

The external radiation measured for the PORTS environmental monitoring program includes both external background radiation and radiation emanating PORTS activities such as storage of DUF_6 cylinders. 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 2016, the average annual dose (8736 hours) recorded at the cylinder yards near Perimeter Road was 764 mrem/year. Based on these assumptions, exposure to an on-site member of the public from radiation from the cylinder yards is approximately 0.76 mrem/year.

A person living in the United States receives an average dose of approximately 311 mrem/year from natural sources of radiation (National Council on Radiation Protection [NCRP] 2009). The potential estimated dose from external radiation to a member of the public (0.76 mrem/year to a member of the public allowed to drive on Perimeter Road past the cylinder yards) is approximately 0.2% of the average yearly natural radiation exposure for a person in the United States and is significantly less than the 100 mrem/year limit to a member of the public in DOE Order 458.1 for all radiological releases from a facility.

Local surface water. Samples of surface water are collected semiannually from 14 locations upstream and downstream from PORTS at locations on the Scioto River, Little Beaver Creek, Big Beaver Creek, and Big Run Creek and background locations on local streams approximately 10 miles north, south, east, and west of PORTS. Samples are analyzed for radionuclides.

Uranium and uranium isotopes were detected at most of the surface water sampling locations. These detected concentrations of radionuclides were less than 0.5% of the DOE derived concentration standards (DOE 2011a). This derived concentration standard is based upon direct use of the surface water as drinking water. This comparison is unlikely to underestimate the dose because surface water around PORTS is not used for drinking water.

Sediment. Samples of sediment are collected annually at 17 monitoring locations, which include the 14 locations sampled for the local surface water monitoring program (Scioto River, Little Beaver Creek, Big Beaver Creek, Big Run Creek, and background locations on local streams) and three on-site NPDES outfalls on the east and west sides of PORTS. Samples are analyzed for radionuclides and polychlorinated biphenyls (PCBs).

Neptunium-237 was detected at Little Beaver Creek sampling locations RM-7 and RM-8, and Big Beaver Creek sampling location RM-13. Technetium-99 was detected in samples collected from Big Beaver Creek at RM-13, Big Run Creek at RM-3, on-site near NPDES outfalls 010 and 013 (RM-10), and downstream locations on Little Beaver Creek (RM-7 and RM-8). Uranium and uranium isotopes were also detected at each of the sampling locations, including upstream and background sampling locations.

The dose assessment based on the detections of radionuclides in sediment 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) calculated a dose of 0.034 mrem/year, which is well below the DOE standard of 100 mrem/year in DOE Order 458.1.

PCBs were detected in samples collected from Little Beaver Creek (RM-7, RM-8, and RM-11), Big Beaver Creek (RM-13), Big Run Creek (RM-2 and RM-3), and on-site in the West Drainage (RM-10). None of the detections of PCBs in sediment around PORTS were above the risk-based regional screening level developed by U.S. EPA and utilized by Ohio EPA of 240 micrograms per kilogram (µg/kg) or parts per billion (ppb) (U.S. EPA 2017).

Soil. Soil samples are collected annually at 15 ambient air monitoring locations (on-site, fence line, off-site and background locations) and analyzed for radionuclides.

Plutonium-239/240 was detected in soil at nine of the 15 ambient air monitoring stations including the background monitoring station (A37). Americium-241 and neptunium-237 were also detected at stations southwest and east of PORTS. These detections were much less than 0.1 picocurie per gram (pCi/g) and most likely present due to atmospheric fallout from nuclear weapons testing. The detections are much less than the soil screening levels for these radionuclides in residential soil: plutonium-239/240 – 3.78 pCi/g, americium-241 – 2.31 pCi/g, and neptunium-237 – 1.73 pCi/g. These screening levels were calculated using the exposure assumptions in the *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Portsmouth Gaseous Diffusion Plant* (DOE 2015c).

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.

The dose assessment based on the detections of radionuclides in soil at the off-site ambient air station with the concentrations of radionuclides that could cause the highest dose to a member of the public (station A12, east of PORTS on McCorkle Road) calculated a dose of 0.022 mrem/year, which is well below the DOE limit of 100 mrem/year in DOE Order 458.1.

Biota (vegetation, deer, fish, crops, milk, and eggs). Vegetation samples are collected annually at 15 ambient air monitoring locations (on-site, fence line, off-site and background locations). Deer samples are collected annually or as available from deer killed on site in motor vehicle collisions. Fish are collected annually from on-site and off-site streams (Little Beaver Creek, Big Beaver Creek and the Scioto River, as available). Crops, milk, and eggs are collected annually (as available) from the local community. All samples are analyzed for radionuclides. Fish are also analyzed for PCBs.

Radionuclides were not detected in samples of deer (muscle), fish, crops, milk, and eggs collected in 2016. Uranium, uranium-233/234, and uranium-238 were detected in one of the vegetation samples collected in 2016. The dose assessment for a member of the public based on consumption of beef cattle that would eat grass contaminated with radionuclides calculated a dose of 0.00033 mrem/year, which is well below the DOE Order 458.1 limit of 100 mrem/year.

PCBs were detected in the fish sample collected from Little Beaver Creek at 307 µg/kg. PCBs were also detected in upstream and downstream Big Beaver Creek fish samples at 12.1 to 33.8 µg/kg. PCBs were detected in catfish collected from upstream and downstream Scioto River sampling locations at 37.5 and 50.7 µg/kg, respectively. These detections were compared to the Ohio Fish Consumption Advisory Chemical Limits provided in the *State of Ohio Cooperative Fish Tissue Monitoring Program Sport Fish Tissue Consumption Advisory Program* (Ohio EPA 2010). These limits are set for the following consumption rates: unrestricted, 1/week, 1/month, 6/year, and do not eat. The concentration of PCBs detected in the fish caught on site in Little Beaver Creek (RW-8) is above the 1/week maximum limit (220 µg/kg) and below the 1/month maximum limit (1000 µg/kg). The concentrations of PCBs detected in fish collected from Big Beaver Creek (20.8 and 21.8 µg/kg) and the Scioto River (37.5 and 50.7 µg/kg) are less than or just above the unrestricted limit (50 µg/kg). The Ohio Department of Health advises that everyone limit consumption of sport fish caught from all waterbodies in Ohio to one meal per week, unless there is a more or less restrictive advisory (Ohio EPA 2017).

Groundwater. Groundwater contamination at PORTS is contained on site. More than 300 wells are sampled at varying frequencies to monitor corrective actions, movement of groundwater contaminants, and groundwater quality. Samples are analyzed for volatile organic compounds (VOCs), radionuclides, metals, and other parameters, specific to the contaminants present at the monitoring area. In general, concentrations of contaminants detected within the groundwater plumes at PORTS were stable or

decreasing in 2016. No VOCs were detected in any of the seven off-site monitoring wells that monitor the X-749/X-120 groundwater plume near the southern boundary of PORTS. Residential water supplies near PORTS were monitored to verify that site contaminants have not migrated into off-site drinking water wells. Results of this program indicate that PORTS has not affected drinking water wells outside the site boundaries.

Dose. To demonstrate compliance with DOE Order 458.1, this Annual Site Environmental Report includes radiological dose calculations for the dose to the public from radionuclides released to the environment based on environmental monitoring data collected by DOE contractors and Centrus (discussed in the previous paragraphs). Figure 1 provides a comparison of the doses from various common radiation sources.

The maximum dose that a member of the public could receive from radiation released by PORTS in 2016 is 0.83 mrem. This maximum dose assumes that the same individual, or representative person, routinely drives on Perimeter Road past the cylinder yards, and lives in the immediate vicinity of PORTS.

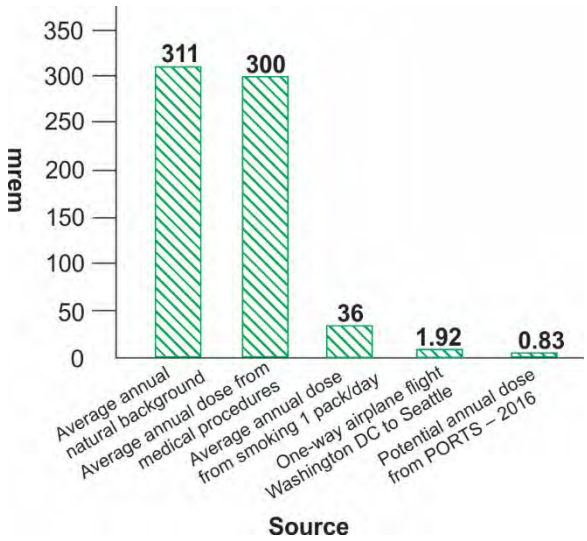

Figure 1. Comparison of dose from various common radiation sources.

The representative person is assumed to be exposed to the maximum dose calculated from each pathway. The dose is based on:

- 0.0015 mrem from radionuclides released to the Scioto River,
- 0.76 mrem from external radiation near the cylinder yards on the northwest portion of Perimeter Road (the dose to a person who works at the Ohio Valley Electric Corporation in 2016 was lower [0.64 mrem]),
- 0.056 mrem based on exposure to radionuclides detected at off-site monitoring locations in 2016 (sediment [0.034 mrem], soil [0.022 mrem], and biota [0.00033 mrem]), and
- 0.016 mrem from radionuclides released to the air (the dose calculated by the U.S. EPA model required to demonstrate compliance with the NESHAP 10 mrem/year standard [40 CFR Part 61 Subpart H]).

This dose (0.83 mrem) is significantly less than the 100 mrem/year limit set in DOE Order 458.1 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 (0.016 mrem) is also significantly less than the 10 mrem/year standard set by U.S. EPA in NESHAP (40 CFR Part 61 Subpart H). A person living in the United States receives an average dose of approximately 311 mrem/year from natural sources of radiation (National Council on Radiation Protection [NCRP] 2009).

ENVIRONMENTAL COMPLIANCE

DOE and/or the responsible DOE contractor (FBP or BWCS) have been issued permits for discharge of water to surface streams, air emission permits, and a permit for the storage of hazardous waste.

FBP and BWCS are responsible for preparing a number of reports for compliance with environmental regulations. These reports include: an annual groundwater monitoring report; a biennial hazardous waste report; an annual PCB document log; an annual summary of radionuclide air emissions and the associated dose to the public from these emissions; annual or biennial reports of specified non-radiological air emissions; a monthly report of National Pollutant Discharge Elimination System (NPDES) monitoring data; an annual hazardous chemical inventory; and an annual toxic chemical release inventory.

Centrus is responsible for compliance activities directly associated with the ACP and Lead Cascade including air emission permits associated with the gaseous centrifuge uranium enrichment operations (the proposed ACP and Lead Cascade), NPDES outfalls, and management of wastes generated by their current operations.

DOE/FBP received two Notices of Violation in 2016 as described in the following paragraphs.

FBP received a Notice of Violation dated April 28, 2016 from Ohio EPA due to a failure to provide sufficient disinfection treatment for the PORTS water supply. In order to ensure proper disinfection, water in the treatment plant must be in contact with chlorine for a minimum amount of time, which depends upon the amount of disinfectant in the water and other characteristics of the water. This minimum contact time was not met for approximately 10 hours on March 15, 2016. Notices of this violation were posted throughout the plant as required by Ohio EPA. No further actions were required.

FBP received a Notice of Violation dated August 9, 2016 from Ohio EPA based on a self-reported occurrence in which 11 containers of hazardous waste were stored in an unpermitted area and were not inspected or labeled properly. The waste consisted of used personal protective equipment, plastics, and soil. The materials were regulated as hazardous waste because they were used during a sampling project in an area where soil and groundwater are potentially contaminated with trichloroethene (TCE), which is a hazardous waste. FBP immediately transferred the waste to a permitted storage location in the X-326 Process Building, properly labeled the waste, and began inspections. No waste was released to the environment and no threats to human health were identified. No further actions were required.

ENVIRONMENTAL PROGRAMS

D&D, Environmental Restoration, Waste Management, and Public Awareness Programs are conducted at PORTS to protect and inform the local population, improve the quality of the environment, and comply with federal and state regulations.

D&D Program

D&D of the PORTS gaseous diffusion process buildings and associated facilities is proceeding in accordance with 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 (which includes the July 16, 2012 Modification thereto)* (D&D DFF&O) (Ohio EPA 2012). The D&D DFF&O is a legal agreement between Ohio EPA and DOE that governs the process for D&D of the buildings/structures that are no longer in use at PORTS.

Ohio EPA concurred with the records of decision for the process buildings and waste disposition in 2015. The record of decision for the process buildings and other facilities selected controlled removal of stored waste and materials, demolition of the buildings or structures, and characterization of materials for disposal or disposition (DOE 2015d). The record of decision for waste disposition selected a combination of on-site and off-site disposal (DOE 2015e), which includes construction of an on-site waste disposal facility (OSWDF).

Implementation of the selected remedial actions began after completion of the records of decision. Activities underway in 2016 in the process buildings included disassembly and removal of equipment, removal of wastes including asbestos, PCBs, and hazardous waste, and deactivation of utilities and other systems. Initial site construction activities for the OSWDF included tree clearing, fencing, and utility installation, as well as construction of erosion and sediment controls, retention ponds for surface water runoff, and installation of office trailers.

Environmental Restoration Program

The Environmental Restoration Program was established by DOE in 1989 to identify, control, and remediate environmental contamination at PORTS. The initial assessment and investigation of PORTS under the Resource Conservation and Recovery Act (RCRA) corrective action process was completed in the 1990s. Corrective actions, also called remedial actions, are underway in each quadrant. The Environmental Restoration Program monitors and maintains five closed landfills in accordance with Ohio EPA regulations and operates four groundwater treatment facilities to treat contaminated groundwater from the on-site groundwater plumes that are contaminated with industrial solvents, including TCE.

With the beginning of D&D, investigation of areas known as "deferred units" is beginning to occur. Deferred units are areas that were in or adjacent to the gaseous diffusion production and operational areas such that remedial activities would have interrupted operations, or were areas that could have become recontaminated from ongoing operations. Ohio EPA deferred investigation/remedial action of soil and groundwater associated with these units until D&D of PORTS (or until the area no longer met the requirements for deferred unit status). Chemical and/or radionuclide contaminants present in the deferred units were contained on site and were not a threat to the public. Ongoing environmental monitoring and on-site worker health and safety programs monitor the contaminants in these areas prior to D&D.

The *Deferred Units RCRA Facility Investigation/Corrective Measures Study Work Plan* was approved by Ohio EPA in 2015 (DOE 2015a). Soil and groundwater sampling in the work plan started in 2015 and was completed in 2016. DOE was evaluating data collected in accordance with the work plan and developing the Deferred Units RCRA Facility Investigation/Corrective Measures Study Report throughout 2016.

Waste Management Program

The DOE Waste Management Program at PORTS directs the safe storage, treatment, and disposal of waste generated from D&D of facilities that are no longer in use, past plant operations, ongoing plant maintenance, and ongoing environmental restoration projects. In 2016, FBP shipped approximately 3650 tons of waste or other materials to off-site facilities for treatment, disposal, recycling, or reuse.

With the beginning of D&D at PORTS, DOE is placing increased emphasis on the evaluation of materials generated by D&D for reuse or recycling. An agreement between DOE and the Southern Ohio Diversification Initiative (SODI) allows DOE to transfer excess equipment, clean scrap materials, and other assets to SODI. SODI first attempts to reuse the excess equipment and property within the local community. Pursuant to the agreement, if SODI is unable to place the property for reuse in the local community, SODI may sell the property. When SODI sells the property, the proceeds are used to support economic development in the southern Ohio region. In 2016, SODI received approximately 243 tons of materials from PORTS, primarily recyclable metals and reusable equipment.

Public Awareness Program

DOE provides a public Environmental Information Center to allow access to all documents used to make decisions on remedial actions being taken at PORTS. The information center is located just north of PORTS at the Ohio State University Endeavor Center (Room 207), 1862 Shyville Road, Piketon, Ohio 45661. The Information Center is open 9 a.m. to noon Monday and Tuesday, noon to 4 p.m. Wednesday

and Thursday, or by appointment (call 740-289-8898). The email address is portseic@pma-iss.com and web site is portsmoutheic.com. Additional information is provided by the DOE Site Office (740-897-5010) and the Office of Public Affairs (740-897-3933). This Annual Site Environmental Report and other information can also be obtained from the DOE web site for PORTS at www.energy.gov/pppo or the FBP web site at www.fbportsmouth.com. PORTS Environmental Geographic Analytical Spatial Information System (PEGASIS) is designed to provide a dynamic mapping and environmental monitoring data display. The web site is https://gisviewer.fbports.com/default.aspx. Public update meetings and public workshops on specific topics are also held to keep the public informed and to receive their comments and questions. Periodically, fact sheets about major projects are written for the public. Additionally, notices of document availability and public comment periods, as well as other communications on the program, are regularly distributed to the local newspaper and those on the community relations mailing list, neighbors within 2 miles of the plant, and plant employees.

The PORTS Site Specific Advisory Board, comprised of citizens from the local area, provides public input and recommendations to DOE on environmental remediation, waste management, and related issues at PORTS. Regularly scheduled meetings that are open to the public are held between DOE and the PORTS Site Specific Advisory Board. Additional information about the board can be obtained at www.ports-ssab.energy.gov or by calling 740-289-5249.

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

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 web site at www.energy.gov/pppo provides additional information about this project.

DOE has worked with the State Historic Preservation Office, Advisory Council on Historic Preservation, Tribal Nations, and individual members of the public interested in historic preservation to determine how best to document the history associated with the gaseous diffusion process buildings and other areas that are part of D&D. The PORTS Virtual Museum (www.portsvirtualmuseum.org) preserves photos, video, oral histories, and other information associated with operation, remediation, and D&D of PORTS.

1. INTRODUCTION

1.1 SUMMARY

The Portsmouth Gaseous Diffusion Plant (PORTS) is located on a 5.9-square-mile site in a rural area of Pike County, Ohio (see Figure 1.1). U.S. Department of Energy (DOE) activities at PORTS include decontamination and decommissioning (D&D) of the process buildings and associated facilities formerly used for the gaseous diffusion process of uranium enrichment, environmental restoration, waste management, and uranium operations. Fluor-BWXT Portsmouth LLC (FBP) is the DOE contractor responsible for D&D of PORTS, which includes the three gaseous diffusion process buildings and other associated facilities. BWXT Conversion Services, LLC (BWCS) was responsible for operations associated with the Depleted Uranium Hexafluoride (DUF_6) Conversion Facility throughout 2016.

The United States Enrichment Corporation (USEC) operated the gaseous diffusion uranium enrichment facilities at PORTS until 2001. USEC, Inc. (the parent company of USEC) became Centrus Energy Corp. (Centrus) in 2014 after a financial restructuring. Centrus leases facilities at PORTS for the development of a gaseous centrifuge uranium enrichment facility – the American Centrifuge Plant (ACP); however, this project is currently shutdown due to lack of funding.

In general, activities conducted by Centrus are not covered by this document because their operations are not subject to DOE Orders. However, some Centrus environmental compliance information is provided in Chapter 2 and radiological and non-radiological environmental monitoring program information is discussed in Chapters 4 and 5, respectively. Centrus data are included in these chapters to provide a more complete picture of the programs in place at PORTS to detect and assess potential impacts to human health and the environment resulting from PORTS activities.

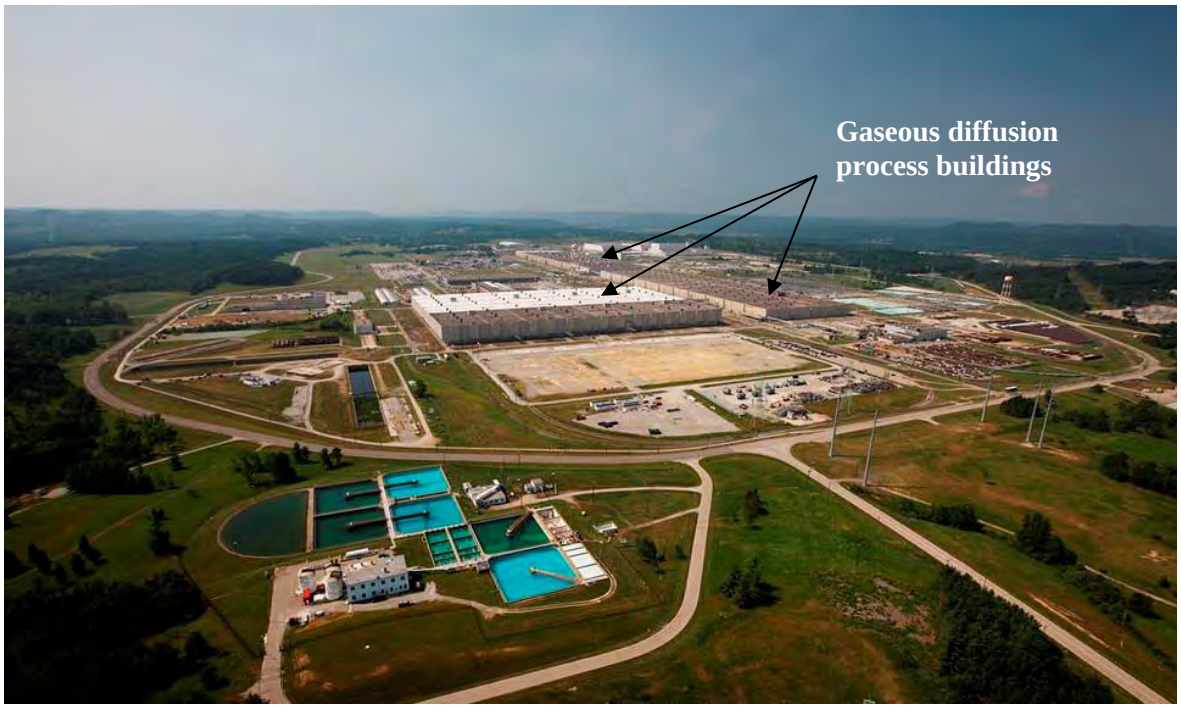

Figure 1.1 The Portsmouth Gaseous Diffusion Plant.

1.2 BACKGROUND INFORMATION

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

DOE is responsible for D&D of the gaseous diffusion process buildings and associated facilities, environmental restoration, waste management, and uranium operations. DOE contractors FBP, Wastren-EnergX Mission Support, LLC (WEMS), Portsmouth Mission Alliance LLC (PMA), and BWCS managed DOE programs at PORTS in 2016.

FBP was responsible for the following activities:

- D&D of the former gaseous diffusion process building and associated facilities;
- environmental restoration of contaminated areas;
- monitoring and reporting on environmental compliance;
- disposition of legacy radioactive waste;
- uranium management; and
- operation of the site's waste storage facilities.

WEMS provided facility support services until April 24, 2016. PMA began a contract to provide facility support services on April 25, 2016. These services include the following:

- computer and telecommunications services;
- security;
- training;
- records management;
- fleet management;
- non-nuclear facility preventive and corrective maintenance;
- grounds and road maintenance;
- snow removal; and
- janitorial services.

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

Centrus was developing gaseous centrifuge uranium enrichment technology at PORTS including a small scale demonstration facility (the Lead Cascade) and a commercial scale uranium enrichment facility (the ACP). The Lead Cascade operated from 2006 until June 2016. The commercial scale ACP was under development. Operation or development of both of these facilities is currently shutdown due to lack of funding. Both of these facilities (the Lead Cascade and the ACP) were housed in existing buildings at PORTS.

This report is intended to fulfill the requirements of DOE Order 231.1B, *Environment, Safety and Health Reporting*. This DOE Order requires development of an annual site environmental report that includes information on regulatory compliance, environmental programs, radiological and non-radiological monitoring programs, groundwater programs, and quality assurance. The Annual Site Environmental

Report also provides the means by which DOE demonstrates compliance with the radiation protection requirements of DOE Order 458.1 *Radiation Protection of the Public and the Environment*.

This report is not intended to present all of the monitoring data at PORTS. Additional data collected for other site purposes, such as environmental restoration and waste management, are presented in other documents that have been prepared in accordance with applicable laws and regulations. These data are presented in other reports, such as the *2016 Groundwater Monitoring Report* (DOE 2017a), which are available at the PORTS Environmental Information Center.

1.3 DESCRIPTION OF SITE LOCALE

PORTS is located in a rural area of Pike County, Ohio, on a 5.9-square-mile site. The site is 2 miles east of the Scioto River in a small valley running parallel to and approximately 120 feet above the Scioto River floodplain. Figure 1.2 depicts the plant site within the State of Ohio and its immediate environs.

Pike County has approximately 28,160 residents (U.S. Census Bureau 2017). Scattered rural development is typical; however, the county contains a number of small villages such as Piketon and Beaver that lie within a few miles of the plant. The county's largest community, Waverly, is about 10 miles north of the plant and has a population of about 4,365 residents (U.S. Census Bureau 2017). The nearest residential center in this area is Piketon, which is 1 to 4 miles north of the plant and has a population of about 2,189 (U.S. Census Bureau 2017). A number of residences are located adjacent to the plant boundary.

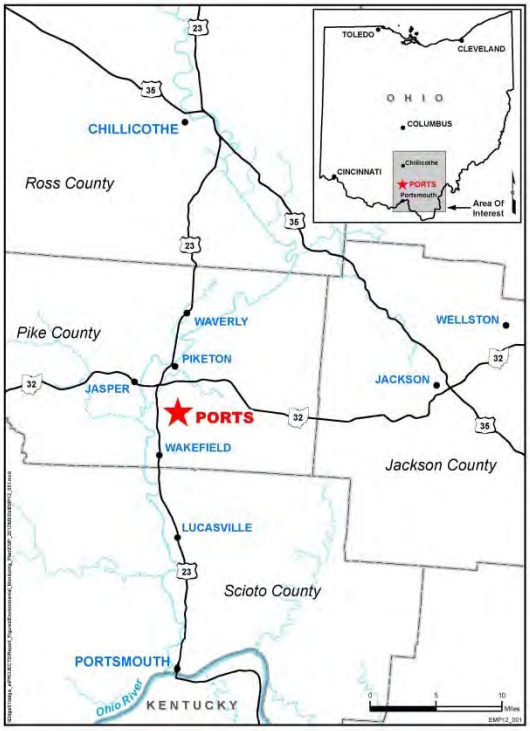

Figure 1.2. Location of PORTS.

Additional cities within 50 miles of the plant are Portsmouth (population 20,422), 22 miles south; Chillicothe (population 21,725), 27 miles north; and Jackson (population 6,320), 18 miles east (U.S. Census Bureau 2017). The total population within 50 miles of the plant is approximately 662,000 persons.

1.4 DESCRIPTION OF SITE OPERATIONS

DOE, through its managing contractors, is responsible for D&D of the gaseous diffusion uranium enrichment buildings and associated facilities, environmental restoration, and waste management associated with DOE activities. DOE is also responsible for uranium management, which includes the DUF_6 Conversion Facility.

D&D includes the gaseous diffusion process buildings and associated facilities subject to *The April 13, 2010 Director's Final Findings and Orders for Removal Action and Remedial Investigation and Feasibility Study and Remedial Design and Remedial Action, including the July 16, 2012 Modification thereto* (D&D DFF&O) [Ohio Environmental Protection Agency (Ohio EPA) 2012]. D&D activities can consist of deactivation of equipment; removal and cleaning of process residues from equipment, structures, and piping; and dismantlement, demolition, and removal of equipment, structures, piping, and

concrete foundations. The D&D Program is also responsible for conducting an evaluation of alternatives for disposition of waste generated by D&D.

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

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

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

2. COMPLIANCE SUMMARY

2.1 SUMMARY

In 2016, DOE and/or the responsible DOE contractor (FBP or BWCS) held permits for discharge of water to surface streams, air emission permits, and a permit for the storage of hazardous wastes. FBP is responsible for the National Pollutant Discharge Elimination System (NPDES) outfalls and air emission permits that were associated with the gaseous diffusion plant. BWCS is responsible for activities associated with the DUF_6 Conversion Facility.

FBP and BWCS are responsible for preparing a number of reports for compliance with various applicable environmental regulations. These reports include an annual groundwater monitoring report, a biennial hazardous waste report, an annual polychlorinated biphenyl (PCB) document log, an annual summary of radionuclide air emissions and the associated dose to the public from these emissions, annual or biennial reports of specified non-radiological air emissions, a monthly report of NPDES monitoring data, an annual hazardous chemical inventory, and an annual toxic chemical release inventory. Additional information on each of these reports is provided within this chapter.

DOE activities at PORTS are inspected regularly by the federal, state, and local agencies responsible for enforcing environmental regulations at PORTS. DOE/FBP received two Notices of Violation in 2016 as described in the following paragraphs.

FBP received a Notice of Violation dated April 28, 2016 from Ohio EPA due to a failure to provide sufficient disinfection treatment for the PORTS water supply. In order to ensure proper disinfection, water in the treatment plant must be in contact with chlorine for a minimum amount of time, which depends upon the amount of disinfectant in the water and other characteristics of the water. This minimum contact time was not met for approximately 10 hours on March 15, 2016. Notices of this violation were posted throughout the plant as required by Ohio EPA. No further actions were required.

FBP received a Notice of Violation dated August 9, 2016 from Ohio EPA based on a self-reported occurrence in which 11 containers of hazardous waste were stored in an unpermitted area and were not inspected or labeled properly. The waste consisted of used personal protective equipment, plastics, and soil. The materials were regulated as hazardous waste because they were used during a sampling project in an area where soil and groundwater are potentially contaminated with trichloroethene (TCE), which is a hazardous waste. FBP immediately transferred the waste to a permitted storage location in the X-326 Process Building, properly labeled the waste, and began inspections. No waste was released to the environment and no threats to human health were identified. No further actions were required.

2.2 COMPLIANCE INTRODUCTION

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 NPDES outfalls associated with the former gaseous diffusion plant operations. BWCS is responsible for activities associated with the DUF_6 Conversion Facility.

Centrus is responsible for compliance activities directly associated with the ACP and Lead Cascade including air emission permits associated with the gaseous centrifuge uranium enrichment operations (the proposed ACP and the Lead Cascade), NPDES outfalls, and management of wastes generated by their current operations.

DOE and/or DOE contractors (FBP or BWCS) held two NPDES permits for discharge of water to surface streams, numerous air emission permits, and a Resource Conservation and Recovery Act (RCRA) Part B

permit for the storage of hazardous wastes. Appendix B lists the active environmental permits and registrations held by DOE and/or DOE contractors (FBP and BWCS) at the end of 2016.

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

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

2.3 COMPLIANCE STATUS

This section discusses the DOE compliance status at PORTS with respect to environmental laws and regulations, DOE Orders, and Executive Orders.

2.3.1 Environmental Restoration and Waste Management

This section discusses the DOE compliance status at PORTS with U.S. EPA and Ohio EPA regulations pertaining to environmental restoration and waste management.

2.3.1.1 Comprehensive Environmental Response, Compensation, and Liability Act

PORTS is not on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priorities List of sites. However, D&D of PORTS is proceeding 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 process buildings and associated facilities that are no longer in use. Chapter 3, Section 3.2, provides additional information about the D&D Program.

Environmental remediation, or the cleanup of soil, groundwater and other environmental media contaminated by PORTS operations, has been conducted in accordance with the Consent Decree with the State of Ohio, issued on August 29, 1989 and the U.S. EPA Administrative Order by Consent, issued on September 29, 1989 (amended in 1994 and 1997 and terminated on February 13, 2017). Ohio EPA oversees environmental remediation activities at PORTS under the RCRA Corrective Action Program and CERCLA Program. Chapter 3, Section 3.3, provides additional information on the Environmental Restoration Program.

Section 103 of CERCLA requires notification to the National Response Center if hazardous substances are released to the environment in amounts greater than or equal to the reportable quantity. Reportable quantities are listed in CERCLA and vary depending on the type of hazardous substance released. During 2016, DOE contractors had no reportable quantity releases of hazardous substances subject to Section 103 notification requirements.

2.3.1.2 Emergency Planning and Community Right-To-Know Act

The Emergency Planning and Community Right-To-Know Act of 1986, also referred to as the Superfund Amendments and Reauthorization Act Title III, requires reporting of emergency planning information, hazardous chemical inventories, and releases to the environment. Emergency Planning and Community Right-To-Know Act reports are submitted to federal, state, and local authorities.

For emergency planning purposes, facilities must submit information on chemicals present on site above specified quantities (called the threshold planning quantity) to state and local authorities. When a new chemical is brought on site or increased to exceed the threshold planning quantity, information about the new chemical must be submitted to state and local authorities within three months.

Section 304 of the Emergency Planning and Community Right-To-Know Act requires reporting of off-site reportable quantity releases to state and local authorities**.** During 2016, FBP and BWCS had no off-site reportable quantity releases subject to Section 304 reporting requirements.

The Hazardous Chemical Inventory Report includes the identity, location, storage information, and hazards of the chemicals present on site in amounts above the threshold planning quantities specified by U.S. EPA. This report is submitted annually to state and local authorities. Table 2.1 lists the chemicals reported by the PORTS site, which included DOE contractors or lessees (FBP, PMA, BWCS, and Centrus) for 2016:

Table 2.1. Chemicals reported in the Hazardous Chemical Inventory Report for 2016

1,2-propanediol	full range straight run middle distillate	petroleum distillates
aluminum oxide	gasoline	potassium hydroxide
aluminum oxide hydrate	hydrogen fluoride	sodium chloride
argon	kerosene	sodium hydroxide
asbestos	lime calcium oxide	sodium polyacrylate
calcium chloride	limestone	sulfuric acid
carbon dioxide	lubricating oils	sulfur dioxide
chlorine	methanol	triuranium octaoxide
citric acid	mineral oils	uranium oxide
dichlorotetrafluoroethane (CFC-114)	nitric acid	uranium hexafluoride
diesel fuel #2 (ultralow sulfur)	nitrogen	uranium metal
ethylene glycol	PCBs	uranium tetrafluoride
fluorotrichloromethane (CFC-11)	perfluoro-1,3-dimethylcyclohexane	

The Toxic Chemical Release Inventory is sent annually to U.S. EPA and Ohio EPA. This report details releases to the environment of specified chemicals when they are manufactured, processed, or otherwise used by the entire site in amounts that exceed threshold quantities specified by U.S. EPA. For this report, U.S. EPA defines a release to include on-site treatment, off-site disposal, and recycling conducted in accordance with regulations.

For 2016, DOE contractors reported the permitted release and/or off-site treatment of three chemicals:

- chlorine: used for water treatment;
- hydrogen fluoride: approximately 1 lb (pound) released to the air from the DUF_6 Conversion Facility; and
- nitrate compounds: approximately 46,000 lbs released to the Scioto River through permitted NPDES outfalls (from water treatment).

2.3.1.3 Resource Conservation and Recovery Act

RCRA regulates the generation, accumulation, storage, transportation, and disposal of solid and hazardous wastes. "Solid wastes," as defined by Ohio EPA, can be solids, liquids, sludges, or other materials. Hazardous wastes are a subset of solid wastes, and are designated as hazardous by Ohio EPA because of various chemical properties, including ignitability, corrosivity, reactivity, and toxicity.

Hazardous waste. DOE and FBP hold a permit to store hazardous waste at PORTS. The permit, often called a Part B Permit, was issued to DOE and the responsible DOE contractor in 1995, and renewed by Ohio EPA in 2001 and 2011. The permit governs the storage of hazardous waste and includes

requirements for waste identification, inspections of storage areas and emergency equipment, emergency procedures, training requirements, and other information required by Ohio EPA.

In accordance with the terms and conditions of the RCRA Part B Permit, DOE and FBP are required to report to Ohio EPA any self-identified activities that are not in compliance with the Part B permit. In July 2016, DOE and FBP notified Ohio EPA of a permit non-compliance. FBP had discovered that waste consisting of used personal protective equipment, plastics, and soil, had been accumulated in an area not specifically permitted for storage of hazardous waste. These materials (the soil, personal protective equipment, etc.) were regulated as hazardous waste because they were used during a sampling project in an area where soil and groundwater are potentially contaminated with TCE, which is a hazardous waste. The waste, which was in 11 containers, was properly labeled and transferred to a permitted storage location in the X-326 Process Building. No waste was released to the environment and no threats to human health were identified. Ohio EPA issued a Notice of Violation to DOE and FBP for this permit non-compliance (see Section 2.4.2).

Facilities such as PORTS that generate or store hazardous waste are required to submit a biennial report to Ohio EPA (in even-numbered years) that covers waste shipped in the previous odd-numbered year (i.e., waste shipped in even-numbered years no longer requires reporting). DOE submitted the report for calendar year 2015 to Ohio EPA in February 2016. This biennial report contains the name and address of each facility that waste was shipped to during the previous calendar year, the name and address of the transporter for each waste shipment, the description and quantity of each waste stream shipped off site, and a description of waste minimization efforts. Chapter 3, Section 3.4, Waste Management Program, provides additional information on wastes from DOE activities at PORTS that were recycled, treated, or disposed in 2016.

RCRA also requires groundwater monitoring at certain hazardous waste management units. As discussed in Chapter 6, groundwater monitoring requirements at PORTS have been integrated into one document, the *Integrated Groundwater Monitoring Plan* (DOE 2015b). Hazardous waste management units monitored in accordance with the *Integrated Groundwater Monitoring Plan* include the X-749 Contaminated Materials Disposal Facility (northern portion), X-231B Southwest Oil Biodegradation Plot (Quadrant I Groundwater Investigative [5-Unit] Area), X-701C Neutralization Pit (Quadrant II Groundwater Investigative [7-Unit] Area), X-701B Former Holding Pond, X-701B retention basins, X-744Y Waste Storage Yard (X-701B area), X-230J7 Holding Pond (X-701B area), X-616 Former Chromium Sludge Surface Impoundments, and X-735 RCRA Landfill (northern portion). Chapter 6 discusses the groundwater monitoring requirements for these units.

A groundwater report that summarizes the results of monitoring completed in accordance with the *Integrated Groundwater Monitoring Plan* is submitted annually to Ohio EPA (DOE 2017a). Chapter 6 discusses these monitoring results for 2016.

BWCS is regulated as a small quantity hazardous waste generator, and for one period in July, became an episodic large quantity generator due to waste generated from hydrogen fluoride storage tank cleanout and inspection. Small quantity hazardous waste generators are subject to requirements for generation and accumulation of hazardous waste. These requirements include proper waste identification, use of appropriate containers, availability of emergency equipment, and specified shipment information.

Solid waste. Groundwater monitoring may be required at closed solid waste disposal facilities, such as landfills. Groundwater monitoring requirements for the closed X-734 Landfills, X-735 Industrial Solid Waste Landfill, and X-749A Classified Materials Disposal Facility are included in the *Integrated Groundwater Monitoring Plan* (DOE 2015b). Chapter 6 discusses the groundwater monitoring results for these units in 2016. There are no solid waste landfills currently operating at PORTS.

2.3.1.4 Federal Facility Compliance Act

Waste that is a mixture of RCRA hazardous waste and low-level radioactive waste (LLW) is currently stored at PORTS. RCRA hazardous waste is subject to Land Disposal Restrictions, which with limited exceptions do not allow the storage of hazardous waste for longer than one year. The Federal Facility Compliance Act, enacted by Congress in 1992, allows for the storage of mixed hazardous/LLW for longer than one year because treatment for this type of waste is not readily available. The Act also requires federal facilities to develop and submit site treatment plans for treatment of mixed wastes. On October 4, 1995, Ohio EPA issued a Director's Final Findings and Orders allowing the storage of mixed waste beyond one year and approving the proposed Site Treatment Plan. An annual update to the Site Treatment Plan is required by these Director's Final Findings and Orders. The annual update to the Site Treatment Plan for fiscal year 2016 was submitted to Ohio EPA in December 2016.

2.3.1.5 Toxic Substances Control Act

The Toxic Substances Control Act (TSCA) regulates the use, storage, and disposal of PCBs, which are most commonly found in older electrical power system components, such as transformers and capacitors. The PCB transformers and capacitors that were present in the gaseous diffusion process buildings have been removed from service. Four PCB transformers were in service at PORTS at the end of 2016: one in the X-530 Switchyard and three pole-mounted transformers within the PORTS facility. One pole-mounted transformer was removed during 2016.

An annual document log is prepared to meet TSCA regulatory requirements. The document log provides an inventory of PCB items in use, in storage as waste, and shipping/disposal information for PCB items disposed in 2016. The *2016 PCB Document Log for the Portsmouth Gaseous Diffusion Plant* was prepared in June 2017 and revised in 2018. Approximately 28.9 tons of PCB waste (gross weight) was generated in 2016. Approximately 4 tons of PCB waste (gross weight), which includes 2.4 tons of bulk product, was shipped for disposal in 2016. Waste contaminated with PCBs was generated during 2016 through D&D activities in the process buildings and other areas.

A TSCA Federal Facilities Compliance Agreement between DOE and U.S. EPA became effective in 1992 to resolve several PCB compliance issues. These issues included the use of PCBs in systems that are not totally enclosed, storage of wastes containing both PCBs and radionuclides in accordance with nuclear criticality safety requirements, and storage of wastes containing both PCBs and radionuclides for longer than one year. The agreement required installation of troughs under motor exhaust duct gaskets located in the former gaseous diffusion facilities to collect PCB oil leaks. When leaks or spills of PCBs occur, they are managed in accordance with the Federal Facilities Compliance Agreement.

Annual reports of progress made toward milestones specified in the Federal Facilities Compliance Agreement are submitted to U.S. EPA. DOE was in compliance with the requirements and milestones of this Federal Facilities Compliance Agreement during 2016.

The DUF_6 Conversion Facility stores and processes cylinders containing DUF_6 that may have paint containing greater than 50 parts per million (ppm) of PCBs present on the outside of the cylinders. The cylinders are stored in the X-745C, X-745E and X-745G Cylinder Storage Yards. The cylinders are stored in accordance with an agreement with U.S. EPA that includes monitoring of PCBs in surface water and sediment in drainage basins downstream from the cylinder storage yards. Chapter 5, Sections 5.4.2 and 5.5.2 provide the results of this surface water and sediment sampling, respectively.

2.3.1.6 Federal Insecticide, Fungicide, and Rodenticide Act

No restricted-use pesticides were used by DOE contractors in 2016.

2.3.2 Radiation Protection

This section discusses the DOE compliance status with DOE Orders pertaining to radiation protection and management of radioactive waste.

2.3.2.1 DOE Order 458.1, *Radiation Protection of the Public and the Environment*

The purpose of DOE Order 458.1 is to establish requirements to protect the public and the environment against undue risk from radiation associated with radiological activities conducted under the control of the DOE pursuant to the Atomic Energy Act of 1954, as amended. The objectives of DOE Order 458.1 are:

- to conduct DOE radiological activities so that exposure to members of the public is maintained within the dose limits established in the Order and are as low as reasonably achievable, and

- ensure that DOE sites have the capabilities, consistent with the types of radiological activities conducted, to monitor routine and non-routine radiological releases and assess the radiation dose to members of the public.

DOE Order 458.1 requires that off-site radiation doses do not exceed 100 millirem (mrem)/year above background for all exposure pathways. Chapter 4 provides the dose calculations or monitoring results that demonstrate compliance with this DOE Order.

2.3.2.2 DOE Order 435.1, *Radioactive Waste Management*

The objective of DOE Order 435.1 is to ensure that all DOE radioactive waste is managed in a manner that is protective of worker and public health and safety, and the environment. DOE Order 435.1 applies to all high-level waste, transuranic waste, and LLW, including the radioactive component of mixed waste for which DOE is responsible. Only LLW and mixed LLW are found at PORTS. Chapter 3, Section 3.4 provides additional information about the DOE Waste Management Program at PORTS.

An on-site waste disposal facility (OSWDF) has been selected per the record of decision for waste disposal for disposal of waste generated by D&D that meets criteria for on-site disposal (see Chapter 3, Section 3.2.2). The DOE Low-level Waste Disposal Facility Review Group (LFRG) has completed an independent review of the design and planned operation of the OSWDF as presented in a Performance Assessment and Composite Analysis and determined compliance with performance objectives in DOE Order 435.1. PORTS received a Disposal Authorization Statement (DAS) for design and construction of the OSWDF from the DOE Office of Site Restoration in 2015. This DAS requires completion of the construction, along with a comparison of the as-built facility to that reviewed, and satisfaction of the conditions in the DAS, as verified by the LFRG, prior to issuance of the DAS for Operations.

2.3.3 Air Quality and Protection

This section discusses the DOE compliance status with U.S. EPA and Ohio EPA regulations pertaining to air emissions (both radionuclides and non-radiological pollutants) and stratospheric ozone protection. Chapter 4, Figure 4.1 is a map of the PORTS ambient air monitoring locations.

2.3.3.1 Clean Air Act

FBP is responsible for numerous air emission sources associated with the former gaseous diffusion production facilities and support facilities. These sources, which included the boilers at the X-600 Steam Plant Complex (prior to demolition in 2013), emitted more than 100 tons per year of non-radiological air pollutants specified by Ohio EPA, which caused DOE to become a major source of air pollutants as defined in Title 40 of the *Code of Federal Regulations* (CFR) Part 70. Ohio EPA issued the final Title V Air Permit to FBP in 2014.

FBP is required to submit quarterly Title V Deviation Reports that document any deviations from requirements of the Title V permit. These quarterly reports are summarized in an annual Title V Compliance Certification. In 2016, FBP did not have any deviations from the Title V Permit requirements.

Ohio EPA requires an annual report called the Ohio EPA Fee Emissions Report to report emissions of selected non-radiological air pollutants. U.S. EPA requires an annual report of greenhouse gas emissions. Chapter 5, Section 5.3.1 provides more information about these reports and the reported emissions for 2016.

In 2016, BWCS was responsible for four permitted sources associated with the DUF_6 Conversion Facility. The Annual Permit Evaluation Report for the BWCS air emission sources did not report any deviations from applicable emission limits or control requirements. Chapter 5, Section 5.3.1, provides more information about air emissions from BWCS in 2016.

Appendix B lists the FBP and BWCS air emission sources at PORTS. Radiological air emissions from the DOE air emission sources are discussed in Chapter 4 and non-radiological air emissions are discussed in Chapter 5.

2.3.3.2 Clean Air Act, Title VI, Stratospheric Ozone Protection

DOE has instituted a record-keeping system consisting of forms and labels to comply with the Title VI record-keeping and labeling requirements. These requirements affect all areas that use ozone-depleting substances. The service record and retrofit or retirement plan forms apply to units with a capacity of more than 50 pounds. The refrigeration equipment disposal log and associated appliance disposal label are used by all units regardless of capacity. The technicians who service equipment under DOE control are trained in accordance with U.S. EPA requirements.

An ozone-depleting substance, specifically dichlorotetrafluoroethane (CFC-114), was used as a coolant in the gaseous diffusion cascade system formerly used to produce enriched uranium**.** The CFC-114 was removed from the cascade system in 2012 and was stored in tanks within the X-333 Process Building in 2016.

2.3.3.3 National Emission Standards for Hazardous Air Pollutants

The National Emission Standards for Hazardous Air Pollutants (NESHAP), Subpart H, National Emission Standards for Emissions of Radionuclides Other Than Radon from DOE Facilities (40 CFR Part 61, Subpart H) requires DOE to submit an annual report for radiological emissions from DOE air emission sources. DOE contractors FBP and BWCS were both responsible for radiological air emission sources. Chapter 4, Section 4.3.3, provides the radiological dose calculations from these emissions.

FBP sources. In 2016, FBP was responsible for numerous air emission sources including 1) continuously monitored vents in the X-326 and X-330 Process Buildings and the X-344A Uranium Hexafluoride Sampling Building; 2) room ventilation exhausts and/or pressure relief vents associated with the X-700 Chemical Cleaning Facility, X-710 Technical Services Building, X-705 Decontamination Facility, the X-326 L-Cage Glove Box, and the XT-847 Glove Box; and 3) the X-622, X-623, X-624, X-627 Groundwater Treatment Facilities.

Radiological emissions from the vents in the X-326 and X-330 Process Buildings and the X-344A Uranium Hexafluoride Sampling Building were measured by continuous monitoring. Emissions from the room ventilation exhausts and vents (if in use) were estimated based on operating data and U.S. EPA emission factors. Emissions from the groundwater treatment facilities were estimated based on quarterly

influent/effluent sampling and quarterly throughput. Total radiological airborne emissions from FBP sources in 2016 were 0.007101 curie (Ci) (7.101E-03 Ci).

BWCS sources. In 2016, BWCS was responsible for emissions from the DUF_6 Conversion Facility. Emissions from the DUF_6 Conversion Facility were based on continuous monitoring of the conversion building stack. Total radiological airborne emissions from the DUF_6 Conversion Facility in 2016 were 0.0000416 Ci (4.16E-05 Ci).

2.3.4 Water Quality and Protection

This section discusses the DOE compliance status with U.S. EPA and Ohio EPA regulations pertaining to water quality and protection.

2.3.4.1 Clean Water Act

DOE contractors FBP and BWCS held NPDES permits during 2016 that allowed discharges of water to surface streams. 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 were also monitored. Chapter 4, Section 4.3.5.1, and Chapter 5, Section 5.4.1.1, provide additional information on the FBP NPDES outfalls. Chapter 4, Figure 4.2 is a map of the PORTS NPDES outfalls.

The BWCS NPDES permit allows the discharge of process wastewaters from the DUF_6 Conversion Facility. The BWCS NPDES permit provides monitoring requirements for BWCS Outfall 001 that are only effective when process wastewater is being discharged through the outfall. The permit also includes requirements for BWCS Outfall 602, which are effective when process wastewater is being discharged to the sanitary sewer system that flows to the X-6619 Sewage Treatment Plant (FBP NPDES Outfall 003). No process wastewater was discharged through BWCS Outfall 001 in 2016. Chapter 4, Section 4.3.5, and Chapter 5, Section 5.4.1.2, provide additional information on the BWCS NPDES outfalls.

Data required to demonstrate compliance with the NPDES permits are submitted to Ohio EPA in monthly discharge monitoring reports (see Chapter 5, Section 5.4.1.1). Nine permit limitations associated with the FBP NPDES permit were exceeded during 2016 (see Chapter 5, Section 5.4.1.1). The overall FBP NPDES compliance rate for 2016 was 99%. There were no exceedances of BWCS permit limitations in 2016; therefore, the overall BWCS NPDES compliance rate for 2016 was 100%.

Most of the FBP NPDES outfalls are also monitored for radionuclides (see Chapter 4, Section 4.3.5). The BWCS outfalls are not monitored for radionuclides.

Stormwater runoff, water from precipitation that flows over land and is not absorbed into the ground, is regulated under the Clean Water Act because it can accumulate debris, chemicals, or other pollutants that affect water quality. Stormwater Pollution Prevention Plans are prepared for the site industrial activities under the FBP NPDES permit. Construction activities are covered by the NPDES Construction Stormwater General Permit. The Stormwater Pollution Prevention Plans include descriptions of the activities and the controls to be used to minimize impacts to stormwater runoff.

Stormwater management and drainage design will be part of site redevelopment after D&D and remediation are completed.

2.3.4.2 Safe Drinking Water Act

In 2016, FBP was responsible for operation of the PORTS drinking water system. Drinking water systems are regulated by the Safe Drinking Water Act, which sets requirements for water testing, treatment, and disinfection, as well as distribution system maintenance and operator training. The Safe

Drinking Water Act also sets health-based standards for naturally-occurring and man-made contaminants that may be found in drinking water.

PORTS obtains its drinking water from two water supply well fields west of PORTS in the Scioto River Valley buried aquifer near the Scioto River. Ohio EPA provides the parameters and schedule for sampling the drinking water for various parameters, including nitrate, lead, disinfection byproducts, total coliform, and chlorine. Sampling results are submitted to Ohio EPA in a monthly report. Section 2.4.2 provides information about a Notice of Violation received by FBP in 2016 related to operation of the PORTS drinking water system.

2.3.5 Other Environmental Statutes

This section discusses the DOE compliance status with other applicable environmental statutes and regulations including underground storage tank regulations and the Endangered Species Act.

2.3.5.1 Underground storage tank regulations

The Underground Storage Tank Program is managed in accordance with the Ohio State Fire Marshal's Bureau of Underground Storage Tank Regulations. Seven underground storage tanks in the former gaseous diffusion plant buildings and associated facilities are owned by DOE (FBP is responsible for five tanks and Centrus is responsible for two tanks). These tanks include six diesel fuel tanks ranging in size from 550 to 20,000 gallons and a 20,000 gallon gasoline tank. The registrations for these tanks are renewed annually.

2.3.5.2 National Environmental Policy Act

The National Environmental Policy Act (NEPA) requires evaluation of the environmental impacts of activities at federal facilities and of activities funded with federal dollars.

DOE has a formal program dedicated to compliance pursuant to DOE Order 451.1B, *National Environmental Policy Act Compliance Program*. Restoration actions, waste management, enrichment facilities maintenance, and other activities are evaluated to determine the appropriate level of evaluation and documentation. No environmental impact statements or environmental assessments were completed during 2016.

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

2.3.5.3 Endangered Species Act

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

A study was conducted in 2013 to identify the potential presence of the federally-endangered Indiana bat (*Myotis sodalis*) and the northern long-eared bat (*Myotis septentrionalis*), in the northeastern area of PORTS that is the planned location for the OSWDF (see Chapter 3, Section 3.2.2). The study did not identify the presence of the federally-endangered Indiana bat in the study area. Both foraging and roosting activities were identified for the northern long-eared bat, which is listed as a threatened species.

In 2015, the U.S. Fish and Wildlife Service issued a Biological Opinion that the OSWDF is not likely to jeopardize the continued existence of the northern long-eared bat. Measures will be taken during construction and operation of the OSWDF to minimize potential impacts to bats.

2.3.5.4 National Historic Preservation Act

The National Historic Preservation Act of 1966 is the primary law governing the protection of cultural resources (archaeological and historical properties). Cultural resource reviews are conducted on a case-by-case basis, and consultations with the State Historic Preservation Office and other stakeholders are made as required by Sections 106 and 110 of the Act. The cultural resources of three broad periods of occupation of the PORTS property have been assessed: the prehistoric era (occupation by Native Americans until approximately 1650), the historic era (occupation by Native Americans and early settlers from 1650 through 1952) and the DOE era (the period of occupation by DOE – 1952 to the present).

Fifty-four prehistoric archaeological sites have been identified on PORTS property. Each of these sites was investigated, and four of the sites included sufficient artifacts such as tools, earth ovens, and pottery to be determined eligible for inclusion on the National Register of Historic Places. One of the sites eligible for inclusion on the National Register of Historic Places was located in the northeast corner of PORTS in the support area for the OSWDF. DOE worked with the State Historic Preservation Office and Tribal Nations to develop a data recovery approach for this area so that artifacts and other information could be recovered from the area (approximately 1 acre) prior to construction activities. Field work, including hand excavation of selected areas, was completed in 2015. No significant artifacts were found.

Sixty-one historic era sites have been identified on PORTS property. Most of these sites were farmstead/residential sites, and investigations of the farmstead/residential sites determined that the sites were not eligible for inclusion on the National Register of Historic Places. Two sites, the Holt Cemetery and Mount Gilead Church and Cemetery, were determined to be eligible for inclusion on the National Register of Historic Places.

DOE has worked with the State Historic Preservation Office, Advisory Council on Historic Preservation, Tribal Nations, and individual members of the public interested in historic preservation to determine how best to document the DOE era of site history, that is, the history associated with the buildings and other areas that are part of D&D. Requirements of the National Historic Preservation Act have been included in the CERCLA process. The PORTS Virtual Museum (www.portsvirtualmuseum.org) preserves photos, video, oral histories, and other information associated with operation, remediation, and D&D of PORTS. The records of decision for process buildings and waste disposition (see Chapter 3, Section 3.2) list the activities selected to preserve the history and cultural resources associated with the PORTS site.

2.3.5.5 Archaeological and Historic Preservation Act and Archaeological Resources Protection Act

The Archaeological and Historic Preservation Act and the Archaeological Resources Protection Act require the Secretary of the Department of Interior to report to Congress on various federal archaeological activities. The Archaeological Resources Protection Act requires federal land managers to provide archaeology program information to the Secretary of the Interior for this report; a questionnaire that provides information for PORTS is completed annually by DOE.

2.3.6 DOE Order 436.1 *Departmental Sustainability*

DOE Order 436.1, *Departmental Sustainability*, requires development and implementation of an Environmental Management System (EMS) in order to protect air, water, land, and other natural or cultural resources potentially impacted by DOE operations.

FBP, PMA, and BWCS have developed the following EMS criteria, as applicable: site EMS policy statement, EMS implementation training, identification of significant environmental aspects of site

operations, establishment of measurable environmental objectives and targets, EMS awareness training (initial and ongoing), and establishment of EMS procedures.

FBP serves as the coordinating contractor for EMS implementation among the DOE site contractors (FBP, PMA, and BWCS). FBP identified the following significant environmental aspects for fiscal year 2016: chemical use, electric use, water use, and waste management (waste generation and recycle/reuse of materials, property and equipment). FBP reported that at least 80% of the established EMS objectives for fiscal year 2016 were accomplished or on schedule to be met.

The highest priority aspects identified in the PMA EMS report were air emissions, release of liquid effluents, and generation of solid waste. The PMA report stated that at least 80% of the established EMS objectives and targets were on schedule to be met.

An independent audit of the BWCS EMS program was conducted by DOE in February 2016. The audit found that the BWCS EMS plan and implementing procedures have the required content to conform to DOE 436.1. BWCS identified the following significant environmental aspects for fiscal year 2016: discharges to air, discharges to surface water, and hazardous and radioactive waste management. BWCS reported that at least 80% of the established EMS objectives, targets, and programs were on schedule to be met.

Chapter 3, Section 3.5, provides information about the DOE Environmental Sustainability Program at PORTS.

2.3.7 Executive Orders

Executive Orders are issued by the President to various federal agencies, including DOE. This section discusses the DOE compliance status at PORTS with Executive Orders pertaining to the environment.

2.3.7.1 Executive Order 11988, *Floodplain Management,* and Executive Order 11990, *Protection of Wetlands*

Title 10 of the CFR Part 1022 establishes policy and procedures for compliance with Executive Order 11988, *Floodplain Management*, and Executive Order 11990, *Protection of Wetlands*.

A site-wide wetland survey report was completed and submitted to the Corps of Engineers in 1996. The 1996 survey identified 41 jurisdictional wetlands and four non-jurisdictional wetlands totaling 34.361 acres at PORTS.

A wetland and stream assessment was completed in 2013 for the northeast area of PORTS where the OSWDF will be constructed. DOE is developing mitigation strategies for wetlands and streams that will be impacted by the construction of the OSWDF in accordance with CERCLA applicable or relevant and appropriate requirements.

2.3.7.2 Executive Order 13693, *Planning for Federal Sustainability in the Next Decade*

Executive Order 13693 establishes a framework to maintain federal leadership in sustainability and greenhouse gas emission reductions. Executive Order 13693 revoked both Executive Order 13423 and Executive Order 13514. Existing activities included in the DOE Environmental Sustainability Program at PORTS (see Chapter 3, Section 3.5) support this executive order. These existing activities include improving energy and water use efficiency; encouraging site-wide recycling and material reuse; and increasing the use of alternative fuel and alternative fuel vehicles.

Green and sustainable remediation is the abatement, cleanup, or use of methods to contain, remove, or destroy contaminants while seeking to minimize the environmental, economic, and social costs of the

remediation. FBP is incorporating green and sustainable remediation into the D&D activities discussed in Chapter 3. Actions being taken to support green remediation include efficient movement of materials to reduce fuel usage, efforts to minimize water usage and control runoff, and recycling/reuse of materials.

2.4 OTHER MAJOR ENVIRONMENTAL ISSUES AND ACTIONS

This section summarizes environmental inspections of DOE activities at PORTS during 2016 and the results of these inspections.

2.4.1 Environmental Program Inspections

During 2016, five inspections of DOE activities at PORTS were conducted by federal, state, or local agencies. Table 2.2 lists these inspections.

Table 2.2. Environmental inspections of DOE activities at PORTS for 2016

Date	DOE contractor	Agency	Type	Notices of Violation
April 12-13	FBP	U.S. EPA & Ohio EPA	RCRA compliance	None
July 13	FBP	Ohio EPA/Pike County Health District	Closed solid waste landfills (X-735, X-749, X-749A)	None
August 31	FBP	Ohio EPA	Clean Air Act – Title V permit	None
December 12	FBP	Ohio EPA	RCRA Corrective Action surveillance and maintenance closed units	None
December 14	FBP	Ohio EPA	RCRA Corrective Action surveillance and maintenance groundwater treatment facilities	None

2.4.2 Notices of Violation

DOE/FBP received two Notices of Violation in 2016 as described in the following paragraphs.

FBP received a Notice of Violation dated April 28, 2016 from Ohio EPA due to a failure to provide sufficient disinfection treatment for the PORTS water supply. In order to ensure proper disinfection, water in the treatment plant must be in contact with chlorine for a minimum amount of time, which depends upon the amount of disinfectant in the water and other characteristics of the water. This minimum contact time was not met for approximately 10 hours on March 15, 2016. Notices of this violation were posted throughout the plant as required by Ohio EPA. No further actions were required.

DOE/FBP received a Notice of Violation dated August 9, 2016 from Ohio EPA based on a self-reported occurrence in which 11 containers of hazardous waste were stored in an unpermitted area and were not inspected or labeled properly. The waste consisted of used personal protective equipment, plastics, and soil. The materials were regulated as hazardous waste because they were used during a sampling project in an area where soil and groundwater are potentially contaminated with TCE, which is a hazardous waste. FBP immediately transferred the waste to a permitted storage location in the X-326 Process Building, properly labeled the waste, and began inspections. No waste was released to the environment and no threats to human health were identified. No further actions were required.

2.5 UNPLANNED RELEASES

No unplanned releases from DOE activities at PORTS occurred in 2016.

2.6 SUMMARY OF PERMITS

Appendix B lists the permits held by DOE and/or DOE contractors in 2016.

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3. ENVIRONMENTAL PROGRAM INFORMATION

3.1 SUMMARY

Ohio EPA concurred with the records of decision for the process buildings and waste disposition in 2015. The record of decision for the process buildings and other facilities selected controlled removal of stored waste and materials, demolition of the buildings or structures, and characterization of materials for disposal or disposition (DOE 2015d). The record of decision for waste disposition selected a combination of on-site and off-site disposal (DOE 2015e), which includes construction of an OSWDF.

Soil and groundwater is being investigated and remediated, if necessary, as part of the Environmental Restoration Program at PORTS. Ohio EPA approved the *Deferred Units RCRA Facility Investigation/Corrective Measures Study Work Plan for Solid Waste Management Units* in 2015 (DOE 2015a). This work plan was developed to investigate "deferred units" at PORTS, which are areas of potential soil and/or groundwater contamination that were in or adjacent to the gaseous diffusion production and operational areas such that remedial activities prior to D&D would have interrupted operations, or were areas that could have become recontaminated from ongoing operations. Soil and groundwater sampling in the work plan started in 2015 and was completed in 2016. DOE was evaluating data collected in accordance with the work plan and developing the RCRA Facility Investigation/Corrective Measures Study Report throughout 2016.

In 2016, FBP shipped 3650 tons of waste or other materials to off-site facilities for treatment, disposal, recycling, or reuse. Activities undertaken by the Environmental Sustainability and Public Awareness programs are also discussed in this chapter.

Chapter 2, Section 2.3.6, provides information on implementation of the DOE EMS at PORTS.

3.2 D&D PROGRAM

On April 13, 2010, Ohio EPA issued the D&D DFF&O, which is an enforceable agreement between Ohio EPA and DOE that 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 D&D DFF&O, which applies to the D&D of buildings down to and including the building slab and disposal of wastes generated by D&D, uses the CERCLA framework for determining appropriate removal and remedial actions. Documents are submitted to Ohio EPA for either concurrence or approval. Chapter 2, Section 2.3.1.1, provides additional information about the D&D DFF&O.

Community involvement is an important part of the CERCLA process and the D&D DFF&O. Opportunities for public comment are built into the D&D process as described in Sections 3.2.1 and 3.2.2. The PORTS Community Relations Plan (DOE 2010, DOE 2012) identifies opportunities to provide information to the public and obtain public input. Additionally, the PORTS Site Specific Advisory Board provides recommendations to DOE based on the concerns of the communities surrounding PORTS. Section 3.6 provides additional information on the PORTS Public Awareness Program.

3.2.1 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 by Ohio EPA in 2015 (DOE 2015d). 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.

The Process Buildings Deactivation Remedial Design/Remedial Action Work Plan (DOE 2016d) was developed by DOE and concurred with by Ohio EPA in 2016. The Work Plan provides the information to demonstrate that deactivation activities to prepare the three main process buildings and associated support structures for demolition meet the requirements of the D&D DFF&O, the Process Buildings and Waste Disposition records of decision, and other applicable requirements. Activities underway in 2016 included disassembly and removal of equipment, removal of wastes including asbestos, PCBs, and RCRA hazardous waste, and deactivation of utilities and other systems.

3.2.2 Site-wide Waste Disposition

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

Figure 3.1 shows the location of the planned OSWDF in the northeast portion of PORTS. Ohio EPA concurred with Phase I and Phase II of the remedial design/remedial action work plan for the OSWDF (DOE 2015f) in 2015, which allowed initial site construction activities such as tree clearing, fencing, utility installation, and installation of erosion and sediment controls. These activities began after approval of the work plan and continued in 2016. An addendum to the Phase II work plan was completed and concurred with by Ohio EPA in 2016, which allowed additional construction to support the OSWDF (DOE 2016a). These activities included construction of retention ponds for surface water runoff and installation of office trailers and utilities. The activities authorized by the addendum continued in 2017.

Figure 3.1. Location of the OSWDF at PORTS.

3.3 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, under a Consent Decree with the State of Ohio, issued on August 29, 1989 and a U.S. EPA Administrative Order by Consent, issued on September 29, 1989 (amended in 1994 and 1997 and terminated on February 13, 2017). With implementation of D&D, removal of facilities and structures down to and including the building slab is controlled by the D&D process (see Section 3.2). Investigation and remediation of environmental contamination is completed under the RCRA corrective action process and in accordance with the Consent Decree with the State of Ohio.

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

1) an assessment to identify releases of hazardous waste and hazardous constituents and determine the need for further investigation (the RCRA facility assessment),

2) an investigation to determine the nature and extent of any contamination (the RCRA facility investigation), and

3) a study to identify and evaluate remedial alternatives to address contamination (the corrective measures study).

Following the approval of the final corrective measures study, Ohio EPA selects the remedial alternatives that will undergo further review to determine the final remedial actions (the preferred plan). Upon completion of the public review and comment period, Ohio EPA selects the final remedial actions. Ohio EPA issues a decision document to select the final remedial actions and the remedial actions are implemented by DOE. Final remedial actions are reviewed by Ohio EPA on a schedule agreed upon by Ohio EPA and DOE (approximately every five years) to ensure that the remedial actions are performing as intended by the decision document and are protective of human health and the environment.

The initial assessment and investigation of PORTS under the RCRA corrective action process was completed in the 1990s. Because PORTS is a large facility, it was divided into quadrants (Quadrant I, II, III, and IV) to facilitate the cleanup process (see Chapter 6, Figure 6.1). Remedial actions have been implemented in each of the PORTS quadrants.

With the beginning of D&D, investigation of areas known as "deferred units" has begun. Deferred units are areas that were in or adjacent to the gaseous diffusion production and operational areas such that remedial activities prior to D&D would have interrupted operations, or were areas that could have become recontaminated from ongoing operations. Ohio EPA deferred investigation/remedial action of soil and groundwater associated with these units until D&D of PORTS (or until the area no longer met the requirements for deferred unit status). Ongoing environmental monitoring and on-site worker health and safety programs monitor the contaminants in these areas prior to D&D.

The *Deferred Units RCRA Facility Investigation/Corrective Measures Study Work Plan* was approved by Ohio EPA in 2015 (DOE 2015a). Soil and groundwater sampling in the work plan started in 2015 and was completed in 2016. DOE was evaluating data collected in accordance with the work plan and developing the Deferred Units RCRA Facility Investigation/Corrective Measures Study Report throughout 2016.

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

3.3.1 Quadrant I

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

Remedial actions required for the X-749B Peter Kiewit Landfill (PK Landfill) were provided in separate Decision Documents issued by Ohio EPA in 1996 (Ohio EPA 1996a) and U.S. EPA in 1997 (U.S. EPA 1997). The following sections discuss the remedial actions required for the X-749/X-120 groundwater plume, PK Landfill, and the Quadrant I Groundwater Investigative (5-Unit) Area. Chapter 6 provides 2016 groundwater monitoring results for the X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility, (Section 6.4.1.3 and Figure 6.2), PK Landfill (Section 6.4.2.1 and Figure 6.2) and Quadrant I Groundwater Investigative (5-Unit) Area (Section 6.4.3.1 and Figure 6.3).

3.3.1.1 X-749/X-120 groundwater plume

The remedial actions identified for X-749/X-120 groundwater plume (see Chapter 6, Figure 6.2) include phytoremediation of the groundwater plume, installation of a barrier wall around the eastern and southern portion of the X-749 Landfill, and continued operation of the groundwater collection trenches installed at the PK Landfill and X-749 Landfill. In addition, groundwater extraction wells were installed in 2007, 2008, and 2010 to control migration of the plume and remediate areas of higher TCE concentrations within the plume.

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

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

The *Second Five-Year Review for the X-749/X-120 Groundwater Plume at the Portsmouth Gaseous Diffusion Plant* (DOE 2016e) was submitted to Ohio EPA in June 2016. The five-year review presented an evaluation of the effectiveness of the remedial actions implemented for the X-749/X-120 groundwater plume. Ohio EPA approved the report in July 2016 and agreed that the remedial actions are working effectively to meet the remedial action objectives for the X-749/X-120 groundwater plume.

A potential source area to the X-749/X-120 groundwater plume was identified recently north of the X-749 Landfill. This area has been investigated as part of the *Deferred Units RCRA Facility Investigation/ Corrective Measures Study Work Plan for Solid Waste Management Units* (DOE 2015a).

Chapter 6, Section 6.4.1.3 and Figure 6.2, provide additional information about the 2016 groundwater monitoring results for the X-749/X-120 groundwater plume.

Table 3.1. Remedial actions at PORTS in groundwater monitoring areas

Quadrant/monitoring area	Remedial action/year completed
Quadrant I X-749/X-120 groundwater plume	X-749 multimedia cap – 1992 X-749 barrier wall (north and northwest sides of landfill) – 1992 X-749 subsurface drains and sumps – 1992 South barrier wall – 1994 X-120 horizontal well – 1996 X-625 Groundwater Treatment Facility – 1996 X-749 barrier wall (east and south sides of landfill) – 2002 Phytoremediation (22 acres) – 2002 & 2003 Injection of hydrogen release compounds – 2004 X-749 South Barrier Wall Area extraction wells – 2007 Two additional extraction wells in the groundwater collection trench on the southwest side of the X-749 Landfill – 2008 X-749/X-120 groundwater plume extraction wells – 2010
Quadrant I Peter Kiewit (PK) Landfill (X-749B)	Relocation of Big Run Creek – 1994 Groundwater collection system – 1994 Groundwater collection system expansion – 1997 PK Landfill Subtitle D cap – 1998
Quadrant I Quadrant I Groundwater Investigative (5-Unit) Area	Groundwater extraction wells (3) – 1991 X-622 Groundwater Treatment Facility – 1991 (upgraded in 2001) Interim soil cover at X-231B – 1995 X-231A/X-231B multimedia caps – 2000 Groundwater extraction wells (11) – 2002 Groundwater extraction well (1) – 2009 Removal of contaminated soil at former X-770 Building – 2010
Quadrant I X-749A Classified Materials Disposal Facility	Cap – 1994
Quadrant II Quadrant II Groundwater Investigative (7-Unit) Area	Operation of X-700 and X-705 building sumps – 1989 X-622T Groundwater Treatment Facility – 1992 Removal of X-720 Neutralization Pit – 1998 Removal of X-701C Neutralization Pit – 2001 Removal of contaminated soil near X-720 Neutralization Pit – 2001 X-627 Groundwater Treatment Facility – 2004 (replaced the X-622T facility) Enhanced anaerobic bioremediation – 2011
Quadrant II X-701B Former Holding Pond	X-237 Groundwater Collection System – 1991 X-624 Groundwater Treatment Facility – 1991 (upgraded 2006) Extraction wells (3) – 1993 (removed 2009-2011) X-623 Groundwater Treatment Facility – 1993 X-701B sump – 1995 Groundwater remediation by oxidant injection – 2008 Groundwater and soil remediation by oxidant mixing – 2011

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

Quadrant/monitoring area	Remedial action/year completed
Quadrant III X-740 Former Waste Oil Handling Facility Area	Phytoremediation – 1999 Oxidant injections – 2008 Enhanced anaerobic bioremediation – 2011
Quadrant IV X-611A Former Lime Sludge Lagoons	Soil cover – 1996 Prairie vegetation planted – 1997
Quadrant IV X-735 Landfills	Cap on northern portion – 1994 Cap on southern portion – 1998
Quadrant IV X-734 Landfills	Cap on X-734B Landfill (Phase I) – 1999 Cap on X-734 and X-734A Landfills (Phase II) – 2000
Quadrant IV X-533 Former Switchyard Complex	Contaminated soil removal – 2010

3.3.1.2 PK Landfill

The remedial actions required by the PK Landfill Decision Documents consisted of the continued operation of the eastern groundwater collection system installed in 1994 and construction of an engineered cap that meets the RCRA Subtitle D and related requirements (Ohio EPA 1996a and 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 (DOE 2008d, DOE 2013e) 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 for contaminant transport. Concentrations of many of the contaminants detected in the PK Landfill wells, sumps, and manholes have decreased. The next review of the remedial actions implemented at the PK Landfill will be submitted to Ohio EPA in 2018.

Chapter 6, Section 6.4.2.1 and Figure 6.2, provide 2016 groundwater monitoring results for the PK Landfill area.

3.3.1.3 Quadrant I Groundwater Investigative (5-Unit) Area

Remedial actions identified for the Quadrant I Groundwater Investigative (5-Unit) Area (Chapter 6, Figure 6.3) 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 (Ohio EPA 2001). 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. Table 3.1 lists the remedial actions completed for the Quadrant I Groundwater Investigative (5-Unit) Area.

Five-year reviews of both the groundwater extraction system for the Quadrant I Groundwater Investigative (5-Unit) Area and the multi-layered caps for the X-231A and X-231B Oil Biodegradation Plots was completed in 2008 (DOE 2008a) and 2013 (DOE 2013b). The reports found that the remedial

actions implemented for the X-231A and X-231B Oil Biodegradation Plots and the Five-Unit Groundwater Investigative Area (the multimedia caps and groundwater extraction system) were continuing to eliminate potential exposure pathways to contaminants, control migration of the groundwater plume, and remove volatile organic compounds (VOCs) from groundwater. The next review of the remedial actions implemented at the Quadrant I Groundwater Investigative (5-Unit) Area and X-231A/B Oil Biodegradation Plots will be submitted to Ohio EPA in 2018.

Chapter 6, Section 6.4.3.1 and Figure 6.3, provide information on the groundwater monitoring completed in the Quadrant I Groundwater Investigative (5-Unit) Area during 2016.

3.3.2 Quadrant II

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

Chapter 6 provides 2016 groundwater monitoring results for the following areas in Quadrant II that require groundwater monitoring: Quadrant II Groundwater Investigative (7-Unit) Area (Section 6.4.5.1 and Figure 6.4), X-701B Former Holding Pond (Section 6.4.6.1 and Figure 6.5), and X-633 Former Recirculating Cooling Water Complex (Section 6.4.7.1 and Figure 6.6).

3.3.2.1 Quadrant II Groundwater Investigative (7-Unit) Area

A number of deferred units are in the groundwater plume in the Quadrant II Groundwater Investigative (7-Unit) Area (Chapter 6, Figure 6.4). A special investigation conducted in 2009, which sampled soil and groundwater, identified 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. Enhanced anaerobic bioremediation utilizes injections of fermentable carbon compounds such as sodium lactate (a common ingredient in soaps and face creams) to provide additional food for naturally-occurring microorganisms in soil that degrade TCE to harmless substances. The project began in 2010 and was completed in 2013.

The *Final Report for the 7-Unit Interim Remedial Measure* was submitted to Ohio EPA in 2014 (DOE 2014). Overall, the results indicated that appropriate conditions could be established at the site to degrade TCE despite the high TCE concentrations in soil and groundwater. Enhanced anaerobic bioremediation successfully reduced TCE to *cis*-1,2-dichloroethene, and with bioaugmentation, some of the *cis*-1,2-dichloroethene was converted to ethane. The report concluded that after the six injection events plus a bioaugmentation event (injection of additional microorganisms that degrade VOCs), overall there was not a measureable 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.

DOE and Ohio EPA have agreed that selection of a remedial action for the Quadrant II Groundwater Investigative (7-Unit) Area will be incorporated into the deferred units preferred plan and decision document.

Chapter 6, Section 6.4.5.1 and Figure 6.4, provide information about the groundwater monitoring completed at the Quadrant II Groundwater Investigative (7-Unit) Area during 2016.

3.3.2.2 X-701B Former Holding Pond

Remedial actions required by the Decision Document for X-701B, issued in 2003, include groundwater remediation by injection of a chemical oxidant (Ohio EPA 2003). The oxidant injections required by the Decision Document took place between 2006 and 2008. Following the end of the injections in 2008, an independent review of the X-701B project was completed by DOE Headquarters to evaluate remediation results and provide recommendations for a path forward.

The review of the X-701B 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. The IRM began in December 2009 and was completed in January 2011. Chapter 6, Section 6.4.6.1 and Figure 6.5, provide information about the groundwater monitoring completed at the X-701B Former Holding Pond during 2016.

3.3.2.3 X-633 Former Recirculating Cooling Water Complex

The X-633 Recirculating Cooling Water Complex was demolished in 2010. A RCRA investigation of soil and groundwater in the area 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 ft 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-633 area. DOE agreed to sample eight wells around the area annually to continue evaluation of chromium and TCE in groundwater at this area. The *2016 Groundwater Monitoring Report for the Portsmouth Gaseous Diffusion Plant* provides the data for this monitoring (DOE 2017a).

3.3.3 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 the groundwater plume near the X-740 Waste Oil Handling Facility (Ohio EPA 1999a).

Over 700 hybrid poplar trees were planted on a 2.6-acre area above the X-740 groundwater plume (Chapter 6, Figure 6.8) in 1999. Evaluation reports for this remedial action were completed in 2003 and 2007. The reports concluded that the phytoremediation system had not performed as expected to remove TCE from groundwater in this area (DOE 2003 and DOE 2007b).

In response to Ohio EPA 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 the groundwater. Although the oxidant briefly reduced TCE concentrations detected 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. Section 3.3.2.1 provides additional information about enhanced anaerobic bioremediation. Emulsified oil, a slow-acting fermentable carbon compound, was injected into the selected portions of the X-740 groundwater plume during December 2010 and January 2011. Collection of groundwater samples to monitor the pilot study continued through 2015. TCE has decreased in wells within the area of the groundwater plume that was treated during the pilot study (see Chapter 6, Section 6.4.9.1 and Figure 6.8).

The *Final Report for the X-740 Pilot Study* (DOE 2016b) was approved by Ohio EPA in June 2016. A summary of the results of the pilot study is included in the Deferred Units RCRA Facility Investigation/Corrective Measures Study Report (DOE 2017b).

Chapter 6 provides 2016 groundwater monitoring results for the following areas in Quadrant III that require groundwater monitoring: X-616 Former Chromium Sludge Surface Impoundments (Section 6.4.8.1 and Figure 6.7) and X-740 Former Waste Oil Handling Facility (Section 6.4.9.1 and Figure 6.8).

3.3.4 Quadrant IV

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

Chapter 6 provides 2016 groundwater monitoring results for the following areas in Quadrant IV that require groundwater monitoring: X-611A Former Lime Sludge Lagoons (Section 6.4.10.1 and Figure 6.9), X-735 Landfills (Section 6.4.11.1 and Figure 6.10), X-734 Landfills (Section 6.4.12.1 and Figure 6.11), X-533 Former Switchyard Complex (Section 6.4.13.1 and Figure 6.6), and X-344C Former Hydrogen Fluoride Storage Building (Section 6.4.14.1 and Figure 6.12).

3.3.4.1 X-611A Former Lime Sludge Lagoons

Ohio EPA and U.S. EPA issued a Decision Document for the X-611A area (Chapter 6, Figure 6.9) in 1996, which required a soil cover over the former lagoons and establishment of a prairie habitat (Ohio EPA 1996b). The soil cover and planting of the prairie were completed in 1997. Five-year reviews completed in 2002, 2008, and 2013 (DOE 2002b, DOE 2008c, and DOE 2013d) found that the soil cover and prairie habitat were meeting the remedial action objectives for this unit by eliminating exposure pathways to the contaminants in the sludge at this area. The next review of the remedial actions implemented at the X-611A area will be submitted to Ohio EPA in 2018.

3.3.4.2 X-734 Landfills

Ohio EPA issued a Decision Document for the X-734 Landfills (Chapter 6, Figure 6.11) in 1999 (Ohio EPA 1999b). Remedial actions required by the Decision Document included construction of a multimedia cap over the northern portion of the landfills and a soil cap over the southern portion of the area. These caps were installed in 1999 and 2000.

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 (DOE 2008b and DOE 2013c). The caps were also preventing contaminants from migrating from soil to groundwater and from groundwater to surface water. The next review of the remedial actions implemented at the X-734 Landfills will be submitted to Ohio EPA in 2018.

3.3.4.3 X-630 Former Recirculating Cooling Water Complex

The X-630 Recirculating Cooling Water Complex, located in Quadrant IV within Perimeter Road and west of the X-533 Switchyard 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 ft 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 evaluation of chromium and TCE in groundwater at this area. The *2016 Groundwater Monitoring Report for the Portsmouth Gaseous Diffusion Plant* provides the data for this monitoring (DOE 2017a).

3.4 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, which are defined below:

- *LLW* – radioactive waste not classified as high level or transuranic waste. Some LLW is also classified as bulk survey for release (BSFR) waste. BSFR waste consists of solid materials such as building rubble, soil, paper, or plastics that have extremely low levels of radioactivity. BSFR waste is evaluated by an intermediate facility to ensure it meets criteria for radioactivity and other parameters, and then it is disposed at one of four authorized landfills in Tennessee.

- *Hazardous (RCRA) waste* – waste listed under RCRA or waste that exhibits one or more of the four RCRA hazardous characteristics: ignitability, corrosivity, reactivity, and toxicity. Universal waste, which includes common items such as batteries and light bulbs, is a subset of RCRA waste that is subject to reduced requirements for storage, transportation, and disposal or recycling.

- *PCB wastes* – waste containing PCBs, a class of synthetic organic chemicals. Disposal of PCB-contaminated materials is regulated under TSCA.

- *RCRA/low-level radioactive mixed waste* – waste containing both hazardous and radioactive components. The waste is subject to RCRA, which governs the hazardous components, and to the Atomic Energy Act that governs the radioactive components.

- *PCB/low-level radioactive mixed waste* – waste containing both PCB and radioactive components. The waste is subject to TSCA regulations that govern PCB components, and to the Atomic Energy Act that governs radioactive components.

- *PCB/RCRA/low-level radioactive mixed waste* – waste containing PCB and radioactive components that is also a RCRA hazardous waste. The waste is subject to RCRA regulations, TSCA regulations that govern PCBs, and to the Atomic Energy Act that governs radioactive components.

- *Solid waste* – Waste that includes construction and demolition debris, industrial waste, and sanitary waste, as defined by Ohio regulations. These wastes can include waste from construction or demolition activity and office waste. Waste contaminated with asbestos may also be included in this category if it is not included in any of the categories listed above (PCB, RCRA, and/or LLW).

Waste management requirements are varied and are sometimes complex because of the variety of waste streams generated by DOE activities at PORTS. DOE Orders, Ohio EPA regulations, and U.S. EPA regulations must be satisfied to demonstrate compliance with waste management activities. Additional policies have been implemented for management of radioactive, hazardous, and mixed wastes. These policies include the following:

- minimizing waste generation;

- characterizing and certifying wastes before they are stored, processed, treated, or disposed;

- pursuing volume reduction (such as blending and bulking) as well as on-site storage in preparation for safe and compliant final treatment and/or disposal; and

- recycling.

With the beginning of D&D at PORTS, DOE is placing increased emphasis on the evaluation of materials generated by D&D for reuse or recycling. An agreement between DOE and the Southern Ohio Diversification Initiative (SODI) allows DOE to transfer excess equipment, clean scrap materials and other assets to SODI. SODI first attempts to reuse the excess equipment and property within the local community. Pursuant to the agreement, if SODI is unable to place the property for reuse in the local community, SODI may sell the property. When SODI sells the property, the proceeds are used to support economic development in the southern Ohio region. In 2016, SODI received approximately 243 tons of materials from PORTS, primarily recyclable metals and reusable equipment.

In 2016, FBP shipped 3650 tons of materials to off-site facilities for treatment, disposal, recycling, or reuse (see Table 3.2).

The following materials from FBP were sent off-site for recycling in 2016:

- aluminum cans: 1700 lbs
- batteries: 35,398 lbs
- electronic materials (computer equipment, etc.): 8913 lbs
- light bulbs: 16,443 lbs
- paper/cardboard: 119,479 lbs
- plastic bottles: 13,300 lbs
- used oil: 51,341 lbs
- recyclable metals: 188 lbs
- toner cartridges: 5116 lbs
- recyclable materials to SODI (excess equipment, recyclable metals, etc.): 243 tons.

3.5 ENVIRONMENTAL SUSTAINABILITY PROGRAM

DOE is committed to reducing potential environmental risks, 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 DOE Environmental Sustainability Program is a balanced, holistic approach that links planning, budgeting, measuring, and improving PORTS overall environmental performance to specific goals and outcomes. The *Fiscal Year 2017 Site Sustainability Plan* describes the Environmental Sustainability Program and integrates the tenets of an EMS (see Chapter 2, Section 2.3.6) (DOE 2016c). The Environmental Sustainability Program includes elements of pollution prevention, waste minimization, affirmative procurement, sustainable design, and energy and water efficiency.

DOE is committed to minimizing and/or eliminating the amounts and types of wastes generated and to achieving reduced life cycle costs for managing and dispositioning property and wastes during all of DOE projects and activities at PORTS.

Table 3.2. Waste Management Program off-site treatment, disposal, and recycling accomplishments for 2016

Waste type	Waste stream	Quantity (lbs[a])	Treatment or disposal, facility
RCRA	Aerosol cans and other liquids classified as hazardous waste	1332	Environmental Quality Co.
RCRA	Lead pipe and air filters contaminated with metals	18,841	Michigan Disposal Waste Treatment Plant/Wayne Disposal Inc.
LLW	Used oils	25,388	Diversified Scientific Solutions
LLW	Sludges, scrap metal, and other debris.	271,167	EnergySolutions Clive, UT
LLW	D&D waste, uranium materials, scrap metal, and other solids	3,302,789	Nevada National Security Site
LLW/BSFR	Assorted solids (wood, metal, plastic, etc.)	375,170	EnergySolutions Gallaher Rd, TN
RCRA/LLW	Lab wastes and other liquids or solids	17,367	Diversified Scientific Solutions
RCRA/LLW	D&D waste, soil, lab wastes, and other materials	56,707	EnergySolutions Clive, UT
RCRA/LLW	Alumina trap waste, lab wastes, and other materials	1778	Materials & Energy Corp.
RCRA/LLW	Solids contaminated with RCRA metals	356	EnergySolutions Bear Creek, TN
RCRA/LLW	Solids contaminated with RCRA metals	135	Waste Control Specialists
LLW/PCB	D&D waste from X-326 and lab wastes	2111	Nevada National Security Site
RCRA/LLW/ PCB	Transformer oil	6	Diversified Scientific Solutions
RCRA/LLW/ PCB	Solid samples	6	EnergySolutions Clive, UT
PCB	Solid materials contaminated with PCBs	384	Environmental Quality Co.
Solid waste	D&D waste, concrete, asphalt, metal, office waste, and other solid materials	2,463,540	Rumpke/Pike Sanitation Landfill
Solid waste	Non-hazardous liquids (antifreeze, floor sealer)	3439	Environmental Quality Co.
Solid waste	Non-hazardous liquids (non-recyclable oil)	19,965	Clean Harbors
Solid waste	Waste cardboard, plastic, metal	2441	EnergySolutions Bear Creek, TN

Table 3.2. Waste Management Program off-site treatment, disposal, and recycling accomplishments for 2016 (continued)

Waste type	Waste stream	Quantity (lbs[a])	Treatment or disposal, facility
-	Recyclable aluminum cans, batteries, electronic materials, plastic, batteries, metal, light bulbs, etc. (see Section 3.4)	251,878	Various (not including SODI)
-	Recyclable materials transferred to SODI (see Section 3.4)	485,436	-

[a]lbs in net weight (waste only).

Effective environmental sustainability management begins with an integrated strategy. In order to achieve the objectives and targets of the Environmental Sustainability Program, DOE has developed and implemented a well-defined strategy for setting, updating, and achieving objectives and targets in line with the EMS and in conjunction with DOE pollution prevention goals. The broad objectives are core elements of the Environmental Sustainability Program. These objectives, presented below, are both qualitative and quantitative and 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.

DOE continued energy reduction programs at PORTS that focused on accomplishing the goals of Executive Order 13693, *Planning for Federal Sustainability in the Next Decade*. Executive Order 13693 provides goals for greenhouse gas emission reductions and environmental sustainability (including energy and water efficiency; waste and pollution prevention; and electronics stewardship).

In support of this Executive Order, the *Fiscal Year 2017 Site Sustainability Plan for the Portsmouth Gaseous Diffusion Plant* provides goals and progress through fiscal year 2016 for reductions in greenhouse gas emissions, water consumption, recycling/waste diversion, electronic stewardship, and other areas (DOE 2016c). The following accomplishments were listed for fiscal year 2016:

- a decrease of 56% in greenhouse gas emissions (primarily associated for electricity consumption) versus the fiscal year 2008 baseline emissions.
- a decrease in water consumption of 6% in fiscal year 2016 versus fiscal year 2015.
- 16.2% of electricity consumption from renewable energy sources, which exceeds the goal of 10%.

- an increase in alternative fuel vehicles (either flex-fuel or hybrid vehicles) to 81% of the total vehicle fleet. All new vehicles are alternate fuel vehicles.

PORTS received a 2-Star EPEAT Purchasing Award from the Green Electronics Council for its policies and procedures for the purchase of EPEAT-certified products in 2016.

3.6 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, comprised of citizens from the local area, provides public input and recommendations to DOE on D&D, environmental remediation, waste management, and related issues at PORTS. Regularly scheduled meetings that are open to the public are held between DOE and the PORTS Site Specific Advisory Board. Additional information about the PORTS Site Specific Advisory Board can be obtained at www.ports-ssab.energy.gov or by calling 740-289-5249.

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

DOE also maintains a public Environmental Information Center to provide public access to documents used to make decisions on remedial actions being taken at PORTS. The Information Center is located just north of PORTS at the Ohio State University Endeavor Center (Room 207), 1862 Shyville Road, Piketon, Ohio 45661. The email address is portseic@pma-iss.com and web site is portsmoutheic.com. Hours for the Information Center are 9 a.m. to noon Monday and Tuesday, noon to 4 p.m. Wednesday and Thursday, or by appointment (call 740-289-8898). Other information, including this Annual Site Environmental Report, can also be obtained from the DOE Portsmouth/Paducah Project Office web site at www.energy.gov/pppo or the FBP web site at www.fbportsmouth.com. PORTS Environmental Geographic Analytical Spatial Information System (PEGASIS) is designed to provide a dynamic mapping and environmental monitoring data display. The web site is https://gisviewer.fbports.com/default.aspx.

Public update meetings and public workshops on specific topics are also held to keep the public informed and to receive their comments and questions. Periodically, fact sheets about major projects are written for the public. Additionally, notices of document availability and public comment periods, as well as other communications on the program, are regularly distributed to the local newspaper and those on the community relations mailing list, neighbors within 2 miles of the plant, and plant employees.

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 web site at www.energy.gov/pppo provides additional information about this project.

Points of contact have been established for the public to obtain information or direct questions regarding the Environmental Management Program. The DOE Site Office may be contacted at 740-897-5010. The Office of Public Affairs (740-897-3933) also provides information on the program.

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 operations. In 2016, environmental monitoring information was collected by DOE contractors (FBP and BWCS) and Centrus. This chapter includes information on air emissions and 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 PORTS operations. 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 a dose limit as low as reasonably achievable[1], but no more than 100 mrem/year for the dose from radionuclides from all potential pathways in DOE Order 458.1. A person living in the United States receives an average 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 surface water (the Scioto River), from external radiation, and from radionuclides detected by environmental monitoring programs. The maximum dose a member of the public could receive from radiation released by PORTS in 2016 or detected by environmental monitoring programs in 2016 is 0.83 mrem/year. This summary of the dose calculations assumes that the same individual, or representative person, routinely drives on Perimeter Road past the cylinder yards and lives in the immediate vicinity of PORTS. The 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 doses to the public from PORTS in 2016

Source of dose	Dose (mrem/year)
Airborne radionuclides (off-site individual)	0.016[a]
Radionuclides released to the Scioto River	0.0015
External radiation near cylinder yards (northwest portion of Perimeter Rd)	0.76
Radionuclides detected by environmental monitoring programs	0.056
Total	0.83[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.

4.2 ENVIRONMENTAL RADIOLOGICAL PROGRAM INTRODUCTION

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.

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 2013a). 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 2016, environmental monitoring data were collected by DOE contractors (FBP and BWCS) and Centrus. This chapter provides information on the Centrus NPDES monitoring program and air emissions of radionuclides from Centrus sources. Centrus data are provided for informational purposes only; DOE cannot ensure the quality of Centrus data.

Data from the following environmental monitoring programs 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 dose of approximately 311 mrem/year from sources of natural radiation (NCRP 2009). Appendix A 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 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, the 100 mrem/year limit is converted into a derived concentration standard (DOE 2011a). 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.

Small quantities of radionuclides were released to the environment from PORTS operations during 2016. This chapter describes the methods used to estimate the potential doses that could result from radionuclides released from PORTS operations. In addition, this chapter assesses the potential doses that could result from radionuclides historically released by PORTS and detected in 2016 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 2016, doses are estimated for exposure to atmospheric releases, external radiation, and releases to surface water (the Scioto River).

Doses are also estimated for exposure to radionuclides from PORTS operations that were detected in 2016 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 2016, doses are estimated for exposure to radionuclides detected by the monitoring programs for sediment, soil, and vegetation. Radionuclides were not detected in 2016 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.

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, and uranium-236) are occasionally detected at PORTS and may be included in the calculations to ensure the potential dose from PORTS operations 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.

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 a 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 2016, FBP was responsible for air emission sources associated with the former gaseous diffusion plant operations, including continuously monitored vents in the X-326 Process Building and the X-344A Uranium Hexafluoride Sampling Building. The vents in the X-326 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-330 and X-333 Process Buildings that were continuously monitored when the gaseous diffusion plant was operating were inactive during 2016.

Other radionuclide air emission sources included room ventilation exhausts and/or pressure relief vents associated with the X-700 Chemical Cleaning Facility (inactive), 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 DOE/FBP airborne sources in 2016 were calculated to be 0.007101 Ci (7.101E-03 Ci).

BWCS 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 DOE/BWCS airborne sources in 2016 were calculated to be 0.0000416 Ci (4.16E-05 Ci).

Total emissions from all DOE airborne sources in 2016 were calculated to be 0.007143 Ci (7.143E-03 Ci). Centrus reported total emissions of 0.00000615 Ci (6.15E-06 Ci) from airborne sources that are part of the Lead Cascade.

4.3.3 Dose Calculation Based on Airborne Emissions

A 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 2016 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. 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 dose to an off-site individual from radiological releases from PORTS air emission sources in 2016 was 0.016 mrem/year. The dose from the Centrus sources is negligible compared to DOE sources. This dose is well below the 10-mrem/year limit applicable to PORTS and the approximate 311-mrem/year dose that the average individual in the United States receives from natural sources of radiation (NCRP 2009).

The collective dose (or population dose) is the sum of the individual doses to the entire population within 50 miles of PORTS. In 2016, the population dose from PORTS emissions was 0.06 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 4.1) 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 and Centrus 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 operations).

The CAP88 model generates a dose conversion factor that was used to calculate a dose for a given level of each radionuclide in air. The following assumptions were made to calculate the dose at each station: 1) the highest level of each radionuclide detected in 2016 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.

The dose associated with each radionuclide at each ambient air monitoring station was added to obtain the gross dose for each station. The net dose for each station was obtained by subtracting the dose measured at the background station (A37). The net dose for each station ranged from 0 at stations with a lower dose than the background station to 0.0013 mrem/year at station A6 in Piketon (see Figure 4.1).

The highest net dose measured at the ambient air monitoring stations (0.0013 mrem/year at station A6) is 8% of the dose calculated from the combined DOE and Centrus point source emissions (0.016 mrem/year). This dose is significantly less than the 10 mrem/year NESHAP limit for airborne radiological releases (40 CFR Part 61, Subpart H) and 100 mrem/year DOE limit in DOE Order 458.1 for all radiological releases from a facility.

4.3.5 Discharges of Radionuclides from NPDES Outfalls

FBP, BWCS, and Centrus were responsible for NPDES outfalls at PORTS during 2016. The BWCS 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 2016 are included in this section.

4.3.5.1 FBP outfalls

In 2016, 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 4.2). 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.

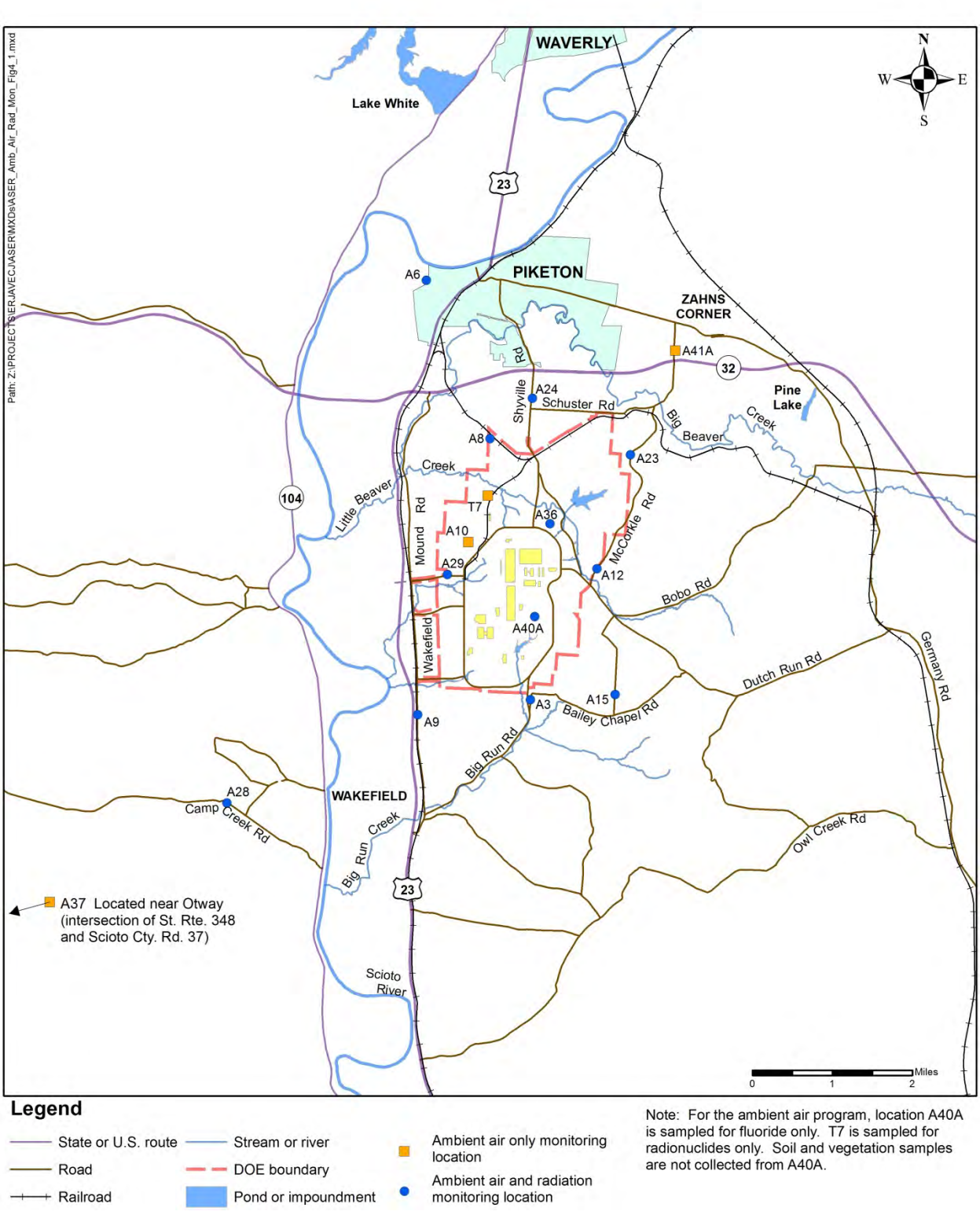

Figure 4.1. DOE ambient air and radiation monitoring locations.

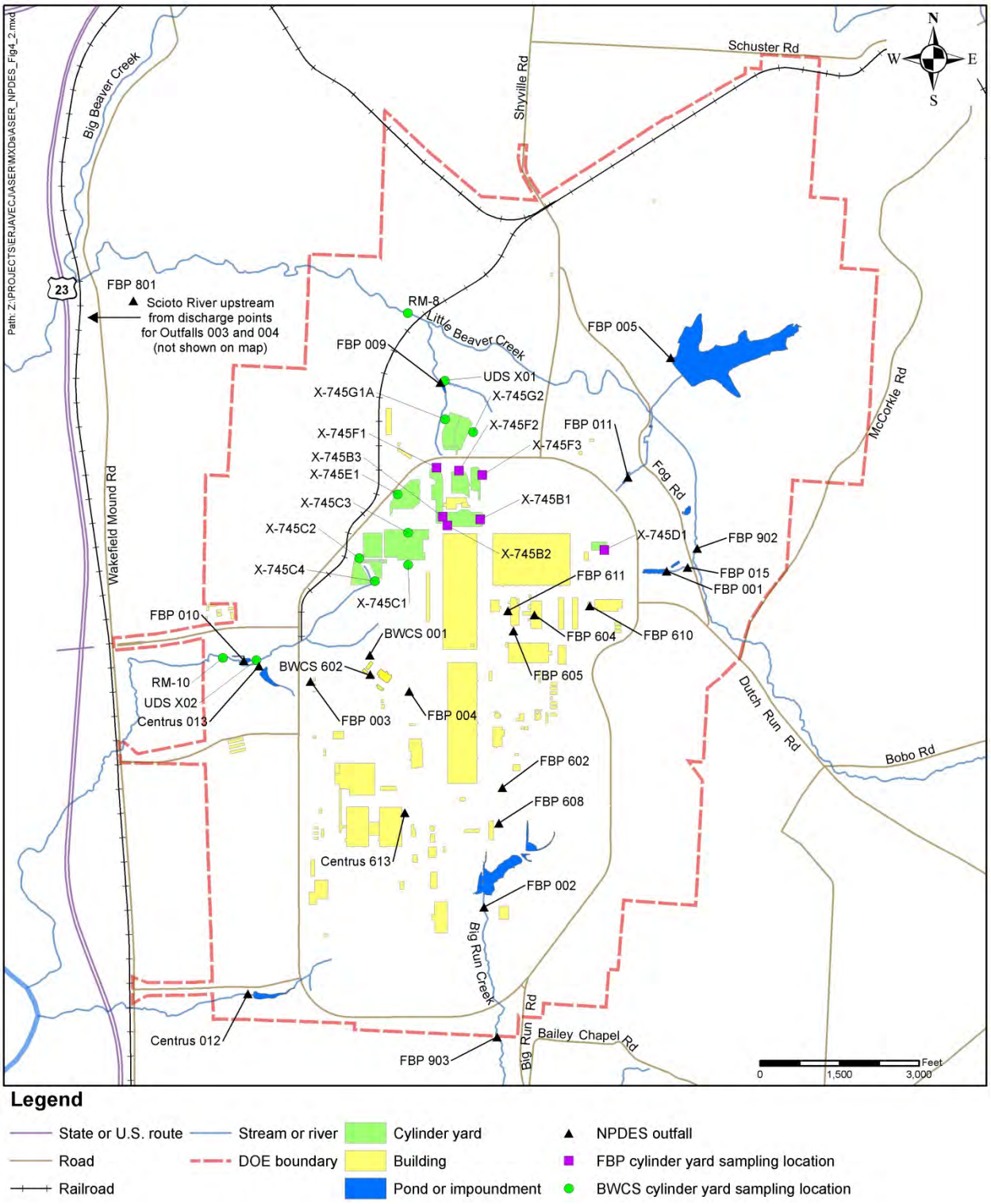

Figure 4.2. PORTS NPDES outfalls/monitoring points and cylinder storage yards sampling locations.

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 BWCS 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.

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. Currently the lagoon only discharges 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).

Discharges of radionuclides in liquids through FBP NPDES outfalls have no significant impact on public health and the environment. In 2016, uranium discharges from the FBP external outfalls (Outfalls 001, 002, 003, 004, 005, 009, 010, 011, and 015) were estimated at 7.8 kg. Total radioactivity (technetium-99 and isotopic uranium) released from the same outfalls was estimated at 0.055 Ci.

Discharges of radionuclides 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. Discharges of radionuclides from the outfalls are used in the dose calculation for releases to surface water (Section 4.3.6). 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.

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 2016.

4.3.5.2 Centrus outfalls

In 2016, Centrus was responsible for three NPDES outfalls through which water is discharged from the site (see Figure 4.2). 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.

Transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240) and technetium-99 were not detected in any of the samples collected from Centrus NPDES outfalls in 2016.

Uranium discharges in 2016 from external Centrus NPDES outfalls (Outfalls 012 and 013) were estimated at 0.505 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 dose calculated with these data and data from external FBP outfalls 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 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 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 2013b) were also used when available. Environmental pathways considered were ingestion of water, ingestion of fish, swimming, boating, and shoreline activities. This exposure scenario is unlikely to underestimate the dose because the Scioto River is not used for drinking water downstream of PORTS (97% of the hypothetical dose from liquid effluents is from drinking water). The dose from radionuclides released to the Scioto River in 2016 (0.0015 mrem) is significantly less than the 100 mrem/year DOE limit in DOE Order 458.1 for all radiological releases from a facility.

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 2013a). 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 4.3 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 2016, the average annual dose (8736 hours) recorded at the cylinder yards near Perimeter Road was 764 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 4.3). Based on these assumptions, exposure to an on-site member of the public from radiation from the cylinder yards is approximately 0.76 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 2013a). The total annual dose measured in 2016 at station A29, near the Ohio Valley Electric Corporation (OVEC), was 93 mrem/year (see Section 4.6.2 and Figure 4.3). The total dose measured at eight of the off-site or background monitoring stations averaged 88 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 5 mrem/year difference between the average off-site background dose (88 mrem/year) and the dose at station A29 (93 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 0.64 mrem.

A person living in the United States receives an average dose of approximately 311 mrem/year from natural sources of radiation (National Council on Radiation Protection [NCRP] 2009). The higher potential estimated dose from external radiation to a member of the public (0.76 mrem/year to a delivery person on Perimeter Road versus 0.64 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 100 mrem/year limit in DOE Order 458.1 for all radiological releases from a facility.

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 2016 Radiation Exposure Monitoring System report indicated that no visitors received a measurable dose (10 mrem or more).

More than 2500 DOE employees and DOE contractors were monitored throughout 2016. These workers received an average dose of 1.0 mrem. Less than 2% of the monitored workers, primarily workers handling DUF_6 cylinders, received a measurable dose (10 mrem total effective dose or more). No administrative guidelines or regulatory dose limits were exceeded in 2016.

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 operations. 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 operations. Technetium-99 and transuranics could come from PORTS operations 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.

DOE sets a 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 2016, dose calculations were completed for public exposure to radionuclides detected in sediment, soil, and vegetation. Radionuclides were not detected in 2016 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 1997) 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 2015c) 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 doses to the public from radionuclides detected by the PORTS environmental monitoring program in 2016 are significantly less than the 100 mrem/year limit in DOE Order 458.1.

Table 4.2. Summary of potential doses to the public from radionuclides detected by DOE environmental monitoring programs in 2016

Source of dose	Dose (mrem/year)[a]
Sediment	0.034
Soil	0.022
Vegetation	0.00033
Total	0.056

[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 2016 from monitoring location RM-7, an off-site sampling location on Little Beaver Creek (see Section 4.6.5 and Figure 4.4):

- neptunium-237: 0.0171 picocuries per gram (pCi/g)
- technetium-99: 7.22 pCi/g
- uranium-233/234: 4.49 pCi/g
- uranium-235/236: 0.227 pCi/g
- uranium-238: 1.06 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 2015c), and exposure factors in U.S. EPA's *Exposure Factors Handbook* (U.S. EPA 1997), the dose that could be received by an individual from sediment contaminated at these levels is 0.034 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 A12, east of PORTS on McCorkle Road (see Section 4.6.7 and Figure 4.1):

- neptunium-237: 0.0197 pCi/g
- plutonium-239/240: 0.0116 pCi/g
- uranium-233/234: 0.343 pCi/g
- uranium-235/236: 0.0147 pCi/g
- uranium-238: 0.337 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 2015c), and exposure factors in U.S. EPA's *Exposure Factors Handbook* (U.S. EPA 1997), the dose that could be received by an individual from soil contaminated at these levels is 0.022 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 A23 (northeast of PORTS at Taylor and McCorkle Road – see Section 4.6.8.1 and Figure 4.1):

<u>Vegetation</u>
- uranium-233/234: 0.0102 pCi/g
- uranium-238: 0.00728 pCi/g

<u>Soil</u>
- plutonium-239/240: 0.0129 pCi/g
- uranium-233/234: 0.288 pCi/g
- uranium-235/236: 0.0137 pCi/g
- uranium-238: 0.259 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 2015c) and U.S. EPA's *Exposure Factors Handbook* (U.S. EPA 1997), the dose that could be received by an individual eating beef from cattle that grazed on vegetation and soil contaminated at these levels is 0.00033 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 2002a) 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 2016 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 the duplicate sample from sediment sampling location RM-11 (see Section 4.6.5 and Figure 4.4)] 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 2016. 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 (technetium-99 and uranium isotopes) were as follows:

Radionuclide	EDD-SW01	RM-11
Technetium-99	36 pCi/L	not detected
Uranium-233/234	5.3 pCi/L	3.65 pCi/g
Uranium-235/236	0.305 pCi/L	0.149 pCi/g
Uranium-238	1.01 pCi/L	0.731 pCi/g.

These values were entered into the RESRAD-BIOTA software that is designed to implement the DOE Technical Standard (DOE 2002a). 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 2016, the RESRAD-BIOTA software output for the maximum levels of radionuclides detected at sampling locations EDD-SW01 (surface water) and RM-11 (sediment) was 0.0333, 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 2016 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 4.1)] 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 2016. 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 2016 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	12 pCi/L	not detected
Uranium-233/234	1.94 pCi/L	0.785 pCi/g
Uranium-235/236	not detected	0.0328 pCi/g
Uranium-238	0.608 pCi/L	0.708 pCi/g.

These values were entered into the RESRAD-BIOTA software that is designed to implement the DOE Technical Standard (DOE 2002a). 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 2016, the RESRAD-BIOTA software output for the maximum levels of radionuclides detected at sampling locations LBC-SW04 (surface water) and A8 (soil) was 0.000621, 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 2016.

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 and Centrus 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 2016, samples were collected from 15 ambient air monitoring stations located within and around PORTS (see Section 4.3.4, Figure 4.1), 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.

No transuranic radionuclides were detected at the ambient air monitoring stations in 2016. Maximum activities of detected radionuclides are listed below (in picocurie per cubic meter [pCi/m^3]):

Radionuclide	Maximum activity (pCi/m^3)	Location	Derived Concentration Standard (DCS) (DOE 2011a)	Percentage of DCS
Technetium-99	0.042	A6	920	0.005%
Uranium-233/234	0.00018	A10	1.1	0.02%
Uranium-235/236	0.000027	A36	1.2	0.002%
Uranium-238	0.000097	A10	1.3	0.007%

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 a dose to a hypothetical person living at the monitoring station. The highest net dose calculation for the off-site ambient air stations (0.0013 mrem/year) was at station A6 in Piketon. This hypothetical dose 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 4.3), 19 locations that include 12 of the ambient air monitoring stations (see Section 4.3.4, Figure 4.1), and seven additional on-site locations (see Figure 4.3). 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 at five locations around the northwest corner of PORTS just inside Perimeter Road near the cylinder storage yards (see Figure 4.3). The average annual dose for these five locations (#41, #868, #874, #882, and #890) is 764 mrem. 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 dose from the cylinder yards to a delivery person (0.76 mrem/year) is significantly less than DOE's 100 mrem/year dose limit to the public for radionuclides from all potential pathways.

In 2016, the average annual dose measured at eight off-site or background locations (A3, A6, A9, A12, A15, A23, A24, and A28) was 88 mrem. Two locations within PORTS measured levels of radiation approximately 50% higher or more than the average off-site radiation (88 mrem): location #874 (593 mrem) near the X-745C Cylinder Storage Yard and location #862 (123 mrem) south of the cylinder yards and west of the X-530A Switchyards. Four other on-site locations (X-230J2, A8, A29, and A40A) measured radiation at levels slightly higher than the average background (ranging from 1 mrem to 10 mrem 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

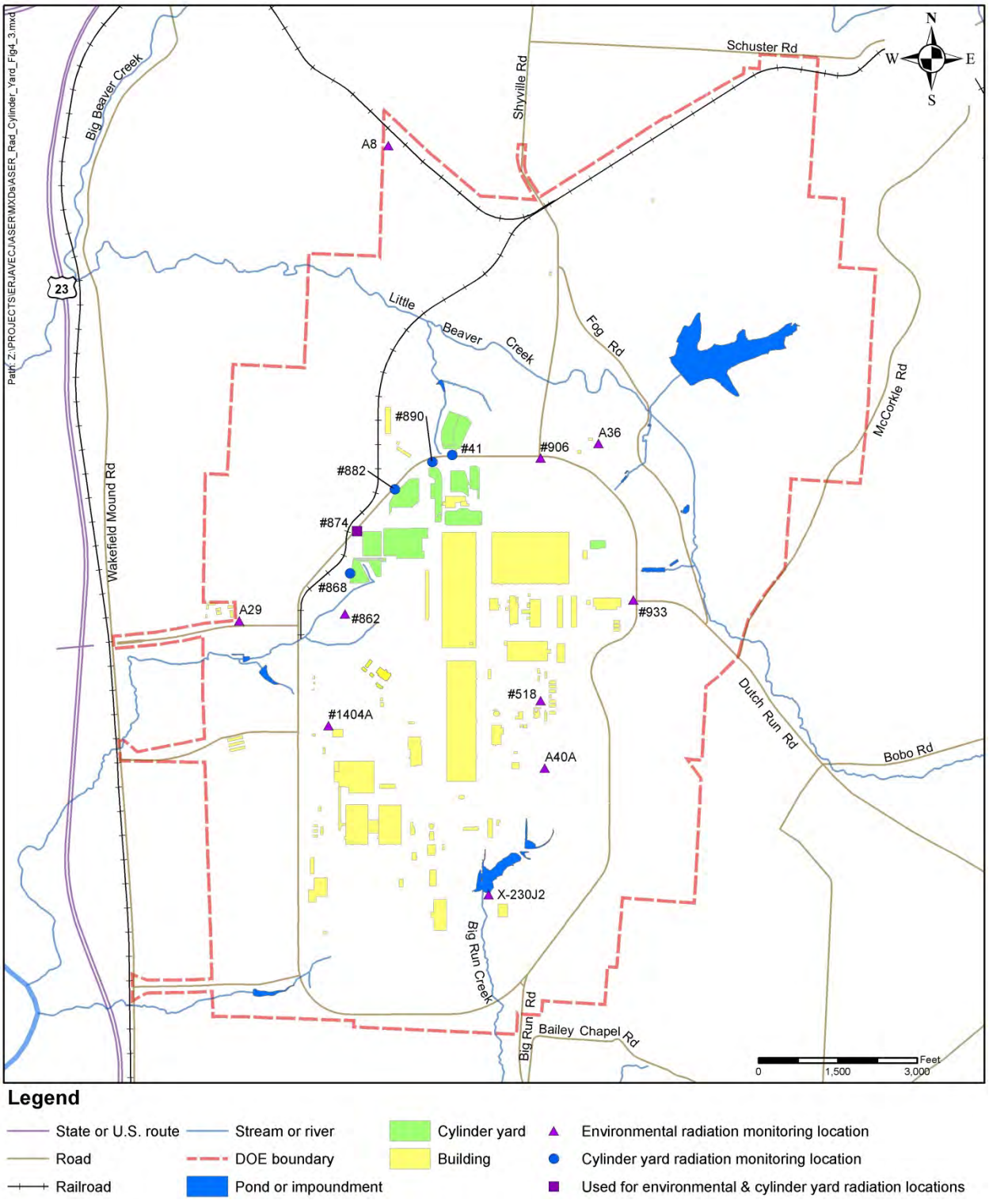

Figure 4.3. On-site radiation and cylinder yard dose monitoring locations.

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 dose to this off-site worker (0.64 mrem/year) is significantly less than the 100 mrem/year dose limit to the public for radionuclides from all potential pathways 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 2016.

4.6.3 Surface Water from Cylinder Storage Yards

In 2016, FBP collected surface water samples from the X-745B, X-745D, and X-745F Cylinder Storage Yards. BWCS 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 2016 by FBP and BWCS, respectively.

4.6.3.1 FBP cylinder storage yards

In 2016, FBP collected surface water samples from seven locations at the X-745B, X-745D, and X-745F Cylinder Storage Yards. Figure 4.2 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: 308 pCi/L (X-745D1, December 2016)
Beta activity: 414 pCi/L (X-745D1, December 2016)
Uranium: 43.9 µg/L (X-745B2, February 2016).

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 dose from radionuclides released to surface water (the Scioto River) in 2016 (0.0015 mrem) is significantly less than the 100 mrem/year limit for all radiological releases from a facility in DOE Order 458.1.

4.6.3.2 BWCS 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 4.2 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: 18.1 pCi/L (X-745C1, November 2016)
Beta activity: 12.3 pCi/L (X-745C1, November 2016)
Uranium: 14 µg/L (X-745C4, January 2016).

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 dose from radionuclides released to surface water (the Scioto River) in 2016 (0.0015 mrem) is significantly less than the 100 mrem/year limit for all radiological releases from a facility in DOE Order 458.1.

4.6.4 Local Surface Water

In 2016, local surface water samples were collected from 14 locations upstream and downstream from PORTS. These samples were taken from the Scioto River, Little Beaver Creek, Big Beaver Creek, and Big Run Creek (see Figure 4.4). 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 2013a).

No transuranic radionuclides, technetium-99, or uranium-235/236 were detected in the local surface water samples collected during 2016. Maximum detections of uranium isotopes in local surface water samples are listed below:

Radionuclide	Maximum activity (pCi/L)	Location	Derived Concentration Standard (DCS) (DOE 2011a)	Percentage of DCS
Uranium-233/234	1.8	RW-7	680	0.3%
Uranium-238	0.655	RW-1A	750	0.1%

4.6.5 Sediment

Sediment samples are collected from the same locations upstream and downstream from PORTS where local surface water samples are collected and at the NPDES outfalls on the east and west sides of PORTS (see Figure 4.4). Samples are collected annually and analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, uranium, and uranium isotopes (uranium-233/234, uranium-235/236, and uranium-238) in accordance with the DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2013a).

Americium-241, plutonium-238, and plutonium-239/240 were not detected in any of the sediment samples collected in 2016. Neptunium-237 was detected at levels from 0.017 to 0.0172 at Little Beaver Creek sampling locations (RM-7 and RM-8) and Big Beaver Creek (RM-13).

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 background sampling location RM-10W and off-site sampling location RM-7 (Little Beaver Creek). Uranium was detected at 3.42 micrograms per gram (µg/g) (RM-10W), uranium-233/234 was detected at 4.49 pCi/g (RM-7), uranium-235/236 was detected at 0.227 pCi/g (RM-7), and uranium-238 was detected at 1.14 pCi/g (RM-10W). Uranium and uranium isotopes detected in the 2016 samples have been detected at similar levels in previous sampling events from 2002 through 2015.

Technetium-99 is often detected in sediment samples collected at locations downstream from PORTS. In 2016, technetium-99 was detected in the sample collected from Big Beaver Creek at RM-13, downstream location on Big Run Creek at RM-3, the location downstream from NPDES outfalls 010 and 013 (RM-10), and downstream locations on Little Beaver Creek (RM-7 and RM-8). The highest detection (7.22 pCi/g) was at location RM-7 (Little Beaver Creek). These detections of technetium-99 are consistent with or less than data from previous sampling events (2002 through 2015).

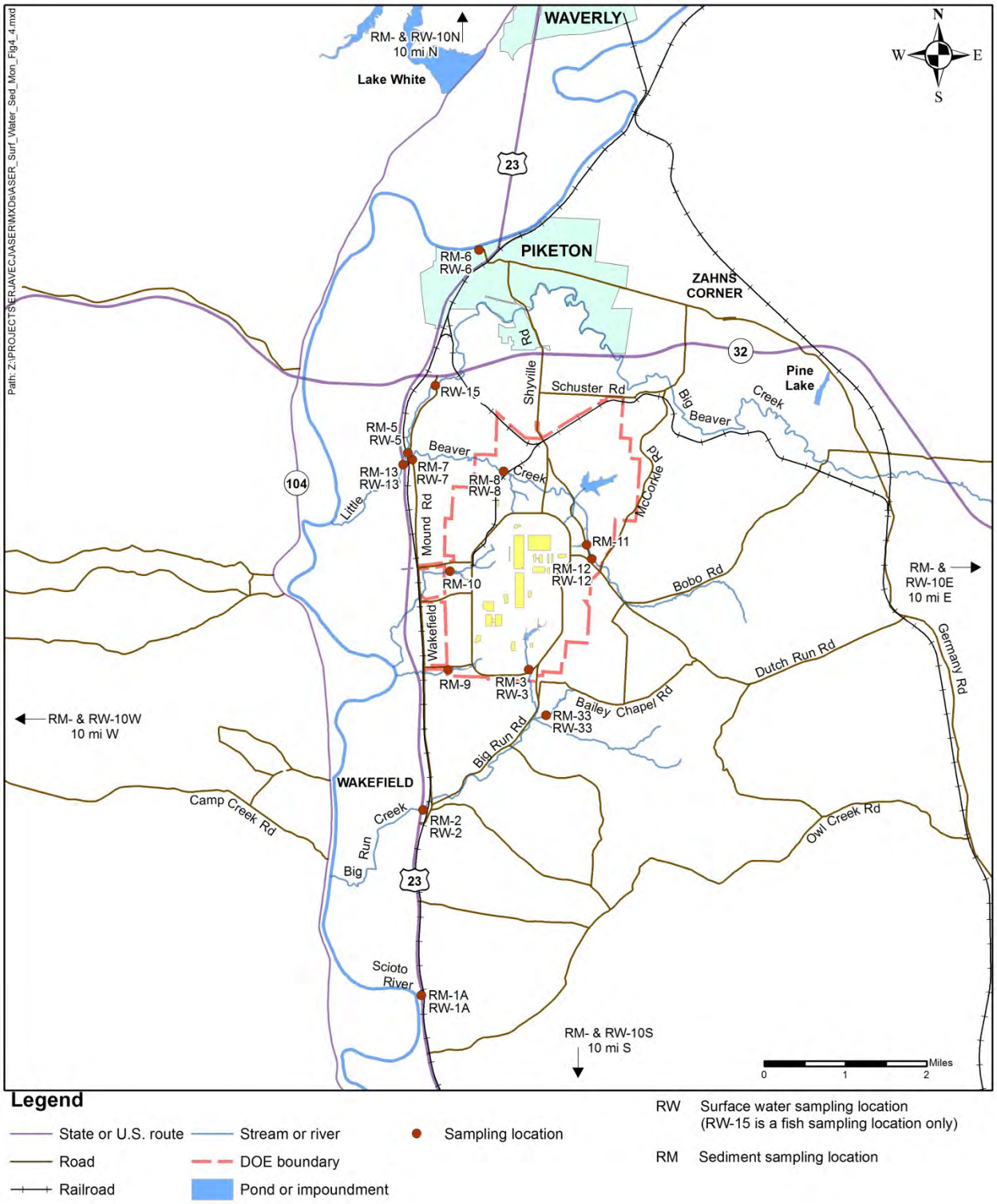

Figure 4.4. Local surface water and sediment monitoring locations.

Section 4.3.9.1 provides a dose assessment to a member of the public based on detections of radionuclides at sampling location RM-7 on Little Beaver Creek. This off-site sampling location had the following levels of radionuclides detected in 2016 that would cause the highest dose to a member of the public: 0.0171 pCi/g of neptunium-237, 7.22 pCi/g of technetium-99, 4.49 pCi/g of uranium-233/234, 0.227 pCi/g of uranium-235/236, and 1.06 pCi/g of uranium-238. The total potential dose to a member of the public resulting from PORTS operations (0.83 mrem/year), which includes this dose calculation (0.034 mrem/year), is well below the DOE standard 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 4.5) 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 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 2016, 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 4.4 to 14 mg/L.

4.6.7 Soil

Soil samples are collected annually from ambient air monitoring locations (see Figure 4.1) 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 2013a).

Plutonium-239/240 was detected in soil at nine of the 15 ambient air monitoring stations including the background monitoring station (A37). The highest detection was 0.0226 pCi/g at station A9 (southwest of the plant on Old U.S. Route 23). These detections are much less than the soil screening level for plutonium-239/240 in residential soil (3.78 pCi/g) calculated using the exposure assumptions in the *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Portsmouth Gaseous Diffusion Plant* (DOE 2015c).

Americium-241 was detected at station A9 at 0.013 pCi/g. Neptunium-237 was detected at station A12 (east of PORTS on McCorkle Road) at 0.0197 pCi/g. These detections are much less than the soil screening levels for americium-241 and neptunium-237 in residential soil, 2.31 and 1.73 pCi/g respectively. These soil screening levels were calculated using the exposure assumptions in the *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Portsmouth Gaseous Diffusion Plant* (DOE 2015c). No other transuranics were detected in any of the soil samples collected during 2016.

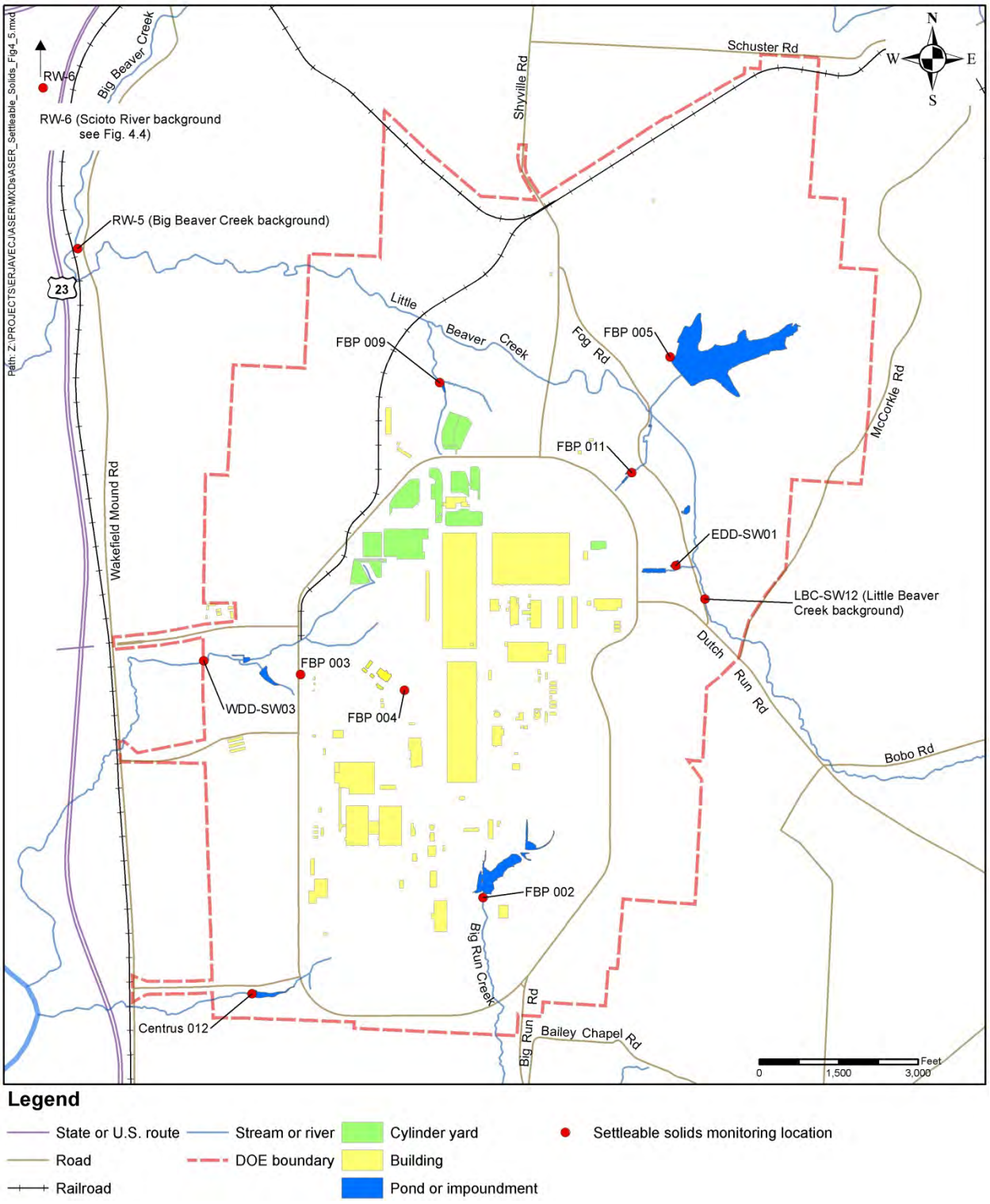

Figure 4.5. DOE settleable solids monitoring locations.

Technetium-99 was not detected in any of the soil samples collected during 2016. 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 neptunium-237 (0.0197 pCi/g), plutonium-239/240 (0.0116 pCi/g), uranium-233/234 (0.343 pCi/g), uranium-235/236 (0.0147 pCi/g), and uranium-238 (0.337 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 A12, east of PORTS on McCorkle Road). The total potential dose to a member of the public resulting from PORTS operations (0.83 mrem/year), which includes this dose calculation (0.022 mrem/year), is well below the DOE 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 2013a) 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 4.1). Samples are collected annually and analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, uranium, and uranium isotopes (uranium-233/234, uranium-235/236, and uranium-238) in accordance with the DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2013a).

Uranium, uranium-233/234, and uranium-238 were detected in the vegetation sample collected at Station A23 (northeast of PORTS at Taylor and McCorkle Road). 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. The total potential dose to a member of the public resulting from PORTS operations (0.83 mrem/year), which includes this dose calculation (0.00033 mrem/year), is well below the DOE Order 458.1 limit of 100 mrem/year.

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 and November of 2016. Technetium-99 was detected at 0.212 pCi/g in the deer kidney collected in February 2016. No other radionuclides were detected in any of the deer samples collected in 2016. A dose assessment is only completed when radionuclides are detected in deer muscle samples because people do not typically eat deer liver or kidneys.

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 2016, 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 2016.

4.6.8.4 Crops

In 2016, 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 2016.

4.6.8.5 Milk and eggs

Samples were collected in 2016 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 2016.

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.

No real property was released from PORTS in 2016. Sections 4.7.1 and 4.7.2 provide information about personal property released from FBP and BWCS, respectively.

4.7.1 FBP releases

FBP uses pre-approved authorized limits established by DOE Orders to evaluate and release materials defined as personal property. In 2016, FBP authorized 1893 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.

4.7.2 BWCS releases

In 2016, BWCS continued 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 must meet the release limit of less than 3 picocuries/milliliter (pCi/mL) of total uranium activity. Approximately 12,220 gallons of aqueous hydrogen fluoride were shipped off site during 2016. The average total uranium activity of the shipment was 0.009 pCi/mL.

5. ENVIRONMENTAL NON-RADIOLOGICAL PROGRAM INFORMATION

5.1 SUMMARY

Non-radiological environmental monitoring at PORTS includes air, water, sediment, and fish. Monitoring of non-radiological parameters is required by state and federal regulations and/or permits, but is also performed to reduce public concerns about plant operations.

Non-radiological data collected in 2016 are similar to data collected in previous years.

5.2 ENVIRONMENTAL NON-RADIOLOGICAL PROGRAM INTRODUCTION

Environmental monitoring programs at PORTS usually monitor both radiological and non-radiological constituents that could be released to the environment as a result of PORTS activities. The radiological components of each monitoring program were discussed in the previous chapter. The DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2013a) specifies non-radiological monitoring requirements for ambient air, surface water, sediment, and fish. Non-radiological data are not collected for all sampling locations or all monitoring programs.

Environmental permits issued by Ohio EPA to FBP, BWCS, or Centrus specify discharge limitations, monitoring requirements, and/or reporting requirements for air emissions and water discharges. Centrus data for NPDES water discharges are included in this section to provide a more complete picture of environmental monitoring at PORTS. Centrus information for discharges to water is provided for informational purposes only; DOE is not certifying the accuracy of the Centrus data.

Data from the following environmental monitoring programs are included in this chapter:

- air
- surface water
- sediment
- biota (fish).

DOE also conducts an extensive groundwater monitoring program at PORTS that includes both radiological and non-radiological constituents. Chapter 6 provides information on the groundwater monitoring program, associated surface water monitoring, and water supply monitoring.

5.3 AIR

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. Chapter 4, Figure 4.1 is a map of the PORTS ambient air monitoring locations.

5.3.1 Airborne Discharges

FBP is responsible for numerous air emission sources associated with the former gaseous diffusion production facilities and support facilities. These sources, which included the boilers at the X-600 Steam Plant Complex (prior to demolition in 2013), emitted more than 100 tons per year of non-radiological air pollutants specified by Ohio EPA, which caused DOE to become a major source of air pollutants as defined in 40 CFR Part 70.

FBP is required to submit an annual report called the Ohio EPA Fee Emissions Report to report emissions of selected non-radiological air pollutants. FBP reported the following emissions of non-radiological air pollutants for 2016: 14.6 tons of particulate matter and 2.29 tons of organic compounds. Emissions for

2016 are associated with the X-627 Groundwater Treatment Facility, the X-670A Cooling Tower, X-333 Coolant System, and plant roads/parking areas.

The DUF_6 Conversion Facility emits only a small quantity of non-radiological air pollutants. Because of these small emissions, Ohio EPA requires a Fee Emissions Report only once every two years (in odd-numbered years). BWCS reported less than 10 tons/year of specified non-radiological air pollutants in 2015 (the report requires reporting in increments of emissions: zero, less than 10 tons, 10-50 tons, more than 50 tons, and more than 100 tons). BWCS reported 1 lb of hydrogen fluoride emitted to the air in the Toxic Chemical Release Inventory for 2016 (see Chapter 2, Section 2.3.1.2).

U.S. EPA also requires annual reporting of greenhouse gas emissions (carbon dioxide, methane, and nitrous oxide). In 2016, FBP reported emissions of 13,817 metric tons of carbon dioxide, 0.26 metric ton of methane, and 0.026 metric ton of nitrous oxide. These emissions result from combustion of natural gas used at the X-690 Boilers.

Another potential air pollutant present at PORTS is asbestos released by D&D of plant facilities. Asbestos emissions are controlled by a system of work practices. The amount of asbestos removed and disposed is reported to Ohio EPA. In 2016, 1.05 tons of asbestos-containing materials (net weight) were shipped from PORTS.

5.3.2 Ambient Air Monitoring

In addition to the radionuclides discussed in Chapter 4, DOE ambient air monitoring stations also measure fluoride. Fluoride detected at the ambient air monitoring stations could be present due to background concentrations (fluoride occurs naturally in the environment), activities associated with the former gaseous diffusion process, and operation of the DUF_6 Conversion Facility.

In 2016, samples for fluoride were collected weekly from 15 ambient air monitoring stations in and around PORTS (see Chapter 4, Figure 4.1), including a background ambient air monitoring station (A37) located approximately 13 miles southwest of the plant.

In 2016, fluoride was not detected in 88 percent of the samples collected for the ambient air monitoring program. If fluoride is not detected in a sample, the ambient concentration of fluoride is calculated assuming that fluoride is present at the detection limit. The average ambient concentration of fluoride measured in samples collected at background station A37 was 0.015 microgram per cubic meter ($\mu g/m^3$). Average ambient concentrations of fluoride measured at the stations around PORTS ranged from 0.015 $\mu g/m^3$ at station A23 (northeast of PORTS at Taylor and McCorkle Road) to 0.021 $\mu g/m^3$ at station A36 (on site at the X-611 Water Filtration Plant). There is no standard for fluoride in ambient air. The data indicate that ambient concentrations of fluoride at off-site and background locations are not appreciably different from concentrations at PORTS.

5.4 WATER

Surface water and groundwater are monitored at PORTS. Groundwater monitoring is discussed in Chapter 6, along with surface water monitoring conducted as part of the groundwater monitoring program. Non-radiological surface water monitoring primarily consists of sampling water discharges associated with the FBP, BWCS, and Centrus NPDES-permitted outfalls. PCBs are monitored in surface water downstream from the cylinder storage yards.

5.4.1 Water Discharges (NPDES Outfalls)

In 2016, DOE contractors (FBP and BWCS) were responsible for 21 NPDES discharge points (outfalls) or sampling points at PORTS. Centrus was responsible for three outfalls. This section describes non-radiological discharges from these outfalls during 2016.

5.4.1.1 FBP NPDES outfalls

In 2016, FBP was responsible for 18 outfalls or sampling points. Nine outfalls discharge directly to surface water, and six outfalls discharge to another outfall before leaving the site. FBP also monitors three additional sampling points that are not discharge locations. Chapter 4, Section 4.3.5.1, provides a brief description of each FBP outfall or sampling point and provides a site diagram showing each FBP NPDES outfall/sampling point (see Chapter 4, Figure 4.2).

Ohio EPA selects the chemical parameters that must be monitored at each outfall based on the chemical characteristics of the water that flows into the outfall and sets discharge limitations for some of these parameters. For example, some of the FBP outfalls discharge water from the groundwater treatment facilities; therefore, the outfalls are monitored for selected VOCs (*trans*-1,2-dichloroethene and/or TCE) because the groundwater treatment facilities treat water contaminated with VOCs. Chemicals and water quality parameters monitored at each FBP outfall in 2016 are as follows:

- FBP NPDES Outfall 001 (X-230J7 East Holding Pond) – cadmium, chlorine, copper, dissolved solids, fluoride, mercury, oil and grease, pH, silver, suspended solids, and zinc.
- FBP NPDES Outfall 002 (X-230K South Holding Pond) – cadmium, fluoride, mercury, ammonia-nitrogen, oil and grease, pH, selenium, silver, suspended solids, and thallium.
- FBP NPDES Outfall 003 (X-6619 Sewage Treatment Plant) – acute toxicity, ammonia-nitrogen, carbonaceous biochemical oxygen demand, chlorine (May-October only), copper, E. coli (May-October only), fecal coliform (May-October only), mercury, nitrite + nitrate, oil and grease, pH, silver, thallium, suspended solids, and zinc.
- FBP NPDES Outfall 004 (Cooling Tower Blowdown) – acute toxicity, chlorine, copper, dissolved solids, mercury, oil and grease, pH, suspended solids, and zinc.
- FBP NPDES Outfall 005 (X-611B Lime Sludge Lagoon) – lead, mercury, pH, selenium, and suspended solids.
- FBP NPDES Outfall 009 (X-230L North Holding Pond) – bis(2-ethylhexyl)phthalate, copper, fluoride, mercury, oil and grease, pH, silver, suspended solids, and zinc.
- FBP NPDES Outfall 010 (X-230J5 Northwest Holding Pond) –lead, mercury, oil and grease, pH, selenium, suspended solids, and zinc.
- FBP NPDES Outfall 011 (X-230J6 Northeast Holding Pond) – cadmium, chlorine, copper, fluoride, oil and grease, pH, suspended solids, thallium, and zinc.
- FBP NPDES Outfall 015 (X-624 Groundwater Treatment Facility) – arsenic, barium, total PCBs, pH, silver, and TCE.
- FBP NPDES Outfall 602 (X-621 Coal Pile Runoff Treatment Facility) – iron, manganese, pH, and suspended solids.
- FBP NPDES Outfall 604 (X-700 Biodenitrification Facility) – copper, iron, nickel, nitrate-nitrogen, pH, and zinc.

- FBP NPDES Outfall 605 (X-705 Decontamination Microfiltration System) – ammonia-nitrogen, chromium, hexavalent chromium, copper, Kjeldahl nitrogen, nickel, nitrate-nitrogen, nitrite-nitrogen, oil and grease, pH, sulfate, suspended solids, TCE, and zinc.

- FBP NPDES Outfall 608 (X-622 Groundwater Treatment Facility) – TCE, pH, and *trans*-1,2-dichloroethene.

- FBP NPDES Outfall 610 (X-623 Groundwater Treatment Facility) – TCE, pH, and *trans*-1,2-dichloroethene.

- FBP NPDES Outfall 611 (X-627 Groundwater Treatment Facility) – pH and TCE.

The FBP NPDES Permit also identifies 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. Samples are collected from this monitoring point to measure toxicity to minnows and another aquatic organism, *Ceriodaphnia*.

FBP NPDES Station Number 902 is a monitoring location on Little Beaver Creek downstream from FBP NPDES Outfall 001. 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 each of these monitoring points.

The monitoring data detailed in the previous paragraphs are submitted to Ohio EPA in a monthly discharge monitoring report.

In 2016, discharge limitations at the FBP NPDES monitoring locations were exceeded on nine occasions.

In May, June, and September of 2016, the average monthly concentration preliminary effluent limit for mercury was exceeded at Outfall 001 (the X-230J7 East Holding Pond). The average monthly concentration preliminary effluent limit is 12 nanograms/liter (ng/L). Average monthly concentrations at Outfall 001 were 22.7 ng/L in May, 20.5 ng/L in June, and 15.35 ng/L in September. FBP has initiated an investigation to identify the source of the mercury detected at Outfall 001 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 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.

The maximum 24-hour temperature limit at Station 902 (a monitoring location on Little Beaver Creek downstream from Outfall 001) was exceeded on three occasions in July and August of 2016. The maximum 24-hour temperature limit is 29.4 ºC and a maximum temperature of 30 ºC was measured on July 19, July 27, and August 3, 2016. These exceedances were due to the hot and dry weather conditions when the samples were collected.

The maximum average monthly temperature limit at Station 902 was also exceeded in July and August. The average temperatures for July and August were 28.8 and 28.0 ºC, respectively, which exceeded the average monthly limit of 27.8 ºC. These exceedances were due to the hot and dry weather conditions during July and August.

The maximum daily concentration limit for chlorine (0.05 mg/L) was exceeded once at Outfall 003 (X-6619 Sewage Treatment Plant) in 2016. Chlorine was detected at 0.06 mg/L in the sample collected on June 15, 2016. Operations at the outfall appeared to be normal, but adjustments were made to

chlorination additives and the concentration of chlorine at the outfall decreased to less than the limit within four hours.

In 2016, the overall FBP NPDES compliance rate with the NPDES permit was 99%.

5.4.1.2 BWCS NPDES outfalls

BWCS is responsible for the NPDES permit for the discharge of process wastewaters from the DUF_6 Conversion Facility. The BWCS NPDES permit provides monitoring requirements for two outfalls: BWCS Outfall 001 and BWCS Outfall 602. Chapter 4, Figure 4.2 shows the location of the BWCS NPDES outfalls. Monitoring requirements for BWCS Outfall 001 are only effective when process wastewater is being discharged through the outfall. No process waste water was discharged through Outfall 001 in 2016; therefore, no monitoring was required.

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

The monitoring data collected in accordance with the BWCS permit are submitted to Ohio EPA in a monthly discharge monitoring report. No exceedances of permit limitations at BWCS Outfall 602 occurred during 2016; therefore, the overall BWCS compliance rate with the NPDES permit was 100%.

5.4.1.3 Centrus NPDES outfalls

Centrus is responsible for three NPDES outfalls through which water is discharged from the site (see Chapter 4, Figure 4.2). Two outfalls discharge directly to surface water, and one outfall discharges to FBP NPDES Outfall 003 before leaving the site. Chapter 4, Section 4.3.5.2, provides a brief description of each Centrus NPDES outfall. Chemicals and water quality parameters monitored at each Centrus outfall are as follows:

- Centrus NPDES Outfall 012 (X-2230M Southwest Holding Pond) – chlorine, iron, oil and grease, pH, suspended solids, total PCBs, and TCE.

- Centrus NPDES Outfall 013 (X-2230N West Holding Pond) – chlorine, oil and grease, pH, suspended solids, and total PCBs.

- Centrus NPDES Outfall 613 (X-6002A Recirculating Hot Water Plant particle separator) – chlorine, pH, and suspended solids.

The monitoring data are submitted to Ohio EPA in a monthly discharge monitoring report. No exceedances of permit limitations at Centrus Outfalls 012, 013, and 613 occurred during 2016; therefore, the overall Centrus compliance rate with the NPDES permit was 100%.

5.4.2 Surface Water Monitoring Associated with BWCS Cylinder Storage Yards

Surface water samples (filtered and unfiltered) are collected quarterly from four locations in the drainage basins downstream from the BWCS X-745C, X-745E, and X-745G Cylinder Storage Yards (UDS X01, RM-8, UDS X02, and RM-10 – see Chapter 4, Figure 4.2) and analyzed for PCBs. PCBs were not detected in any of the surface water samples (filtered or unfiltered) collected during 2016. Section 5.5.2 presents the results for sediment samples collected as part of this program.

5.5 SEDIMENT

In 2016, sediment monitoring at PORTS included local streams and the Scioto River upstream and downstream from PORTS and drainage basins downstream from the BWCS cylinder storage yards.

5.5.1 Local Sediment Monitoring

Sediment samples are collected annually at the same locations upstream and downstream from PORTS where local surface water samples are collected and at the NPDES outfalls on the east and west sides of PORTS (see Chapter 4, Figure 4.4). In 2016, samples were analyzed for 20 metals and PCBs, in addition to the radiological parameters discussed in Chapter 4.

PCBs were detected in sediment samples collected downstream from PORTS. PCBs were detected in samples collected from Little Beaver Creek (RM-7, RM-8, and RM-11), Big Beaver Creek (RM-13), Big Run Creek (RM-2 and RM-3), and the West Drainage Ditch near FBP NPDES Outfall 010 and Centrus NPDES Outfall 013 (RM-10).

None of the detections of PCBs in sediment around PORTS were above the risk-based regional screening level for PCB-1254/1260 developed by U.S. EPA and utilized by Ohio EPA: 240 micrograms per kilogram (µg/kg) or parts per billion (ppb) (U.S. EPA 2017). The highest detection of PCBs (105 µg/kg) was on site in Little Beaver Creek at the discharge from the X-230J7 Holding Pond (RM-11). Investigation and remediation of PCBs in soil and sediment at PORTS will be addressed as part of the environmental remediation of PORTS.

The results of metals sampling conducted in 2016 indicate that no appreciable differences are evident in the concentrations of metals present in sediment samples taken upstream from PORTS, at background sampling locations, and downstream from PORTS. Metals occur naturally in the environment. Accordingly, the metals detected in the samples most likely did not result from activities at PORTS.

5.5.2 Sediment Monitoring Associated with BWCS Cylinder Storage Yards

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

In 2016, PCBs were detected in at least one of the sediment samples collected at each location. The maximum concentration of PCBs (150 µg/kg) was detected at sampling location UDS X02. The concentrations of PCBs detected in 2016 are below the 1 ppm (1000 ppb) reference value set forth in the U.S. EPA Region 5 *TSCA Approval for Storage for Disposal of PCB Bulk Product (Mixed) Waste*, which applies to the storage of DUF_6 cylinders at PORTS that may have paint on the exterior of the cylinders that contains more than 50 ppm PCBs. 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: 240 µg/kg (ppb) (U.S. EPA 2017).

Section 5.4.2 presents the results for surface water samples collected as part of this program.

5.6 BIOLOGICAL MONITORING - 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). In 2016, fish were caught at each of these locations. Chapter 4, Figure 4.4, shows the surface water monitoring locations where the fish were caught.

Fish samples were analyzed for PCBs, in addition to the radiological parameters discussed in Chapter 4. Fish samples collected for this program included only the fish fillet, that is, only the portion of the fish that would be eaten by a person. The fish samples collected at Little Beaver Creek (RW-8) and Big Beaver Creek (RW-13 and RW-15) were bass. The fish samples collected from the Scioto River (RW-1A and RW-6) were catfish.

PCBs were detected in the bass collected from Little Beaver Creek at 307 µg/kg. PCBs were also detected in upstream and downstream Big Beaver Creek bass samples at 12.1 to 33.8 µg/kg. PCBs were detected in catfish collected from upstream and downstream Scioto River sampling locations at 37.5 and 50.7 µg/kg, respectively. These detections were compared to the Ohio Fish Consumption Advisory Chemical Limits provided in the *State of Ohio Cooperative Fish Tissue Monitoring Program Sport Fish Tissue Consumption Advisory Program* (Ohio EPA 2010). These limits are set for the following consumption rates: unrestricted, 1/week, 1/month, 6/year, and do not eat. The concentration of PCBs detected in the fish caught on site in Little Beaver Creek (RW-8) is above the 1/week maximum limit (220 µg/kg) and below the 1/month maximum limit (1000 µg/kg). The concentrations of PCBs detected in fish collected from Big Beaver Creek (20.8 and 21.8 µg/kg) and the Scioto River (37.5 and 50.7 µg/kg) are less than or just above the unrestricted limit (50 µg/kg).

The Ohio Sport Fish Consumption Advisory, available from Ohio EPA, Division of Surface Water, advises the public on consumption limits for sport fish caught from all water bodies in Ohio and should be consulted before eating any fish caught in Ohio waters (Ohio EPA 2017). The advisory recommends a 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. The Ohio Department of Health advises that everyone limit consumption of sport fish caught from all waterbodies in Ohio to one meal per week, unless there is a more or less restrictive advisory.

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6. GROUNDWATER PROGRAMS

6.1 SUMMARY

Groundwater monitoring at PORTS is required by a combination of state and federal regulations, legal agreements with Ohio EPA, and DOE Orders. More than 400 monitoring wells are used to track the flow of groundwater and to identify and measure groundwater contaminants. Groundwater programs also include on-site surface water monitoring and water supply monitoring.

Groundwater plumes that consist of VOCs, primarily TCE, are found at five of the PORTS monitoring areas: X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility, Quadrant I Groundwater Investigative (5-Unit) Area, Quadrant II Groundwater Investigative (7-Unit) Area, X-701B Former Holding Pond, and X-740 Former Waste Oil Handling Facility. In general, concentrations of contaminants detected within these plumes were stable or decreasing during 2016.

The groundwater plume at the X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility is near the southern boundary of PORTS. In 2016, no VOCs were detected in any of the seven off-site monitoring wells. TCE has not been detected in groundwater beyond the DOE property boundary at concentrations that exceed the Ohio EPA drinking water standard of 5 µg/L. Data collected in 2016 indicate that the groundwater extraction wells installed in the X-749/X-120 groundwater plume are succeeding in reducing TCE concentrations within the plume.

The *2016 Groundwater Monitoring Report for the Portsmouth Gaseous Diffusion Plant* provides further details on the groundwater plumes at PORTS, specific monitoring well identifications, and analytical results for monitoring wells (DOE 2017a). This document and other documents referenced in this chapter are available in the PORTS Environmental Information Center.

6.2 GROUNDWATER PROGRAMS INTRODUCTION

This chapter provides an overview of groundwater monitoring at PORTS and the results of the groundwater monitoring program for 2016. The following sections provide an overview of the PORTS groundwater monitoring program followed by a review of the history and 2016 monitoring data for each area. Chapter 3, Section 3.3, provides additional information about the remedial actions implemented at a number of the areas discussed in this chapter to reduce or eliminate groundwater contamination.

This chapter also includes information on the groundwater treatment facilities at PORTS. These facilities receive contaminated groundwater from the groundwater monitoring areas and treat the water prior to discharge through the permitted FBP NPDES outfalls.

6.3 OVERVIEW OF GROUNDWATER MONITORING AT PORTS

This section provides an overview of the regulatory basis for groundwater monitoring at PORTS, groundwater use and geology, and monitoring activities and issues.

6.3.1 Regulatory Programs

Groundwater monitoring at PORTS was initiated in the 1980s. 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.

Because of the numerous regulatory programs applicable to groundwater monitoring at PORTS, an *Integrated Groundwater Monitoring Plan* was developed to address all groundwater monitoring requirements for PORTS. The initial plan was approved by Ohio EPA and implemented at PORTS starting in April 1999. The *Integrated Groundwater Monitoring Plan* is periodically revised by DOE and

approved by Ohio EPA. An annual groundwater report is submitted to Ohio EPA in accordance with the *Integrated Groundwater Monitoring Plan*.

Groundwater monitoring in 2016 was completed in accordance with the *Integrated Groundwater Monitoring Plan* dated July 2015 (DOE 2015b). The 2015 *Integrated Groundwater Monitoring Plan* incorporated minor revisions to the groundwater monitoring program, such as adding wells to the monitoring programs for the Quadrant I Groundwater Investigative (5-Unit) Area and X-701B Former Holding Pond.

Groundwater monitoring is also conducted to meet DOE Order requirements. Exit pathway monitoring assesses the effect of PORTS on off-site groundwater quality. DOE Orders are the basis for radiological monitoring of groundwater at PORTS.

6.3.2 Groundwater Use and Geology

Two water-bearing zones are present beneath the industrialized portion of PORTS: the Gallia and Berea formations. The Gallia is the uppermost water-bearing zone and contains most of the groundwater contamination at PORTS. The Berea is deeper than the Gallia and is usually separated from the Gallia by the Sunbury shale, which acts as a barrier to impede groundwater flow between the Gallia and Berea formations. Additional information about site hydrogeology is available in the PORTS Environmental Information Center.

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

6.3.3 Monitoring Activities

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

6.4 GROUNDWATER MONITORING AREAS

The *Integrated Groundwater Monitoring Plan* requires groundwater monitoring of the following areas within the quadrants of the site designated by the RCRA Corrective Action Program (DOE 2015b). These areas (see Figure 6.1) are:

- Quadrant I
  - X-749 Contaminated Materials Disposal Facility /X-120 Former Training Facility,
  - PK Landfill,
  - Quadrant I Groundwater Investigative (5-Unit) Area,
  - X-749A Classified Materials Disposal Facility,

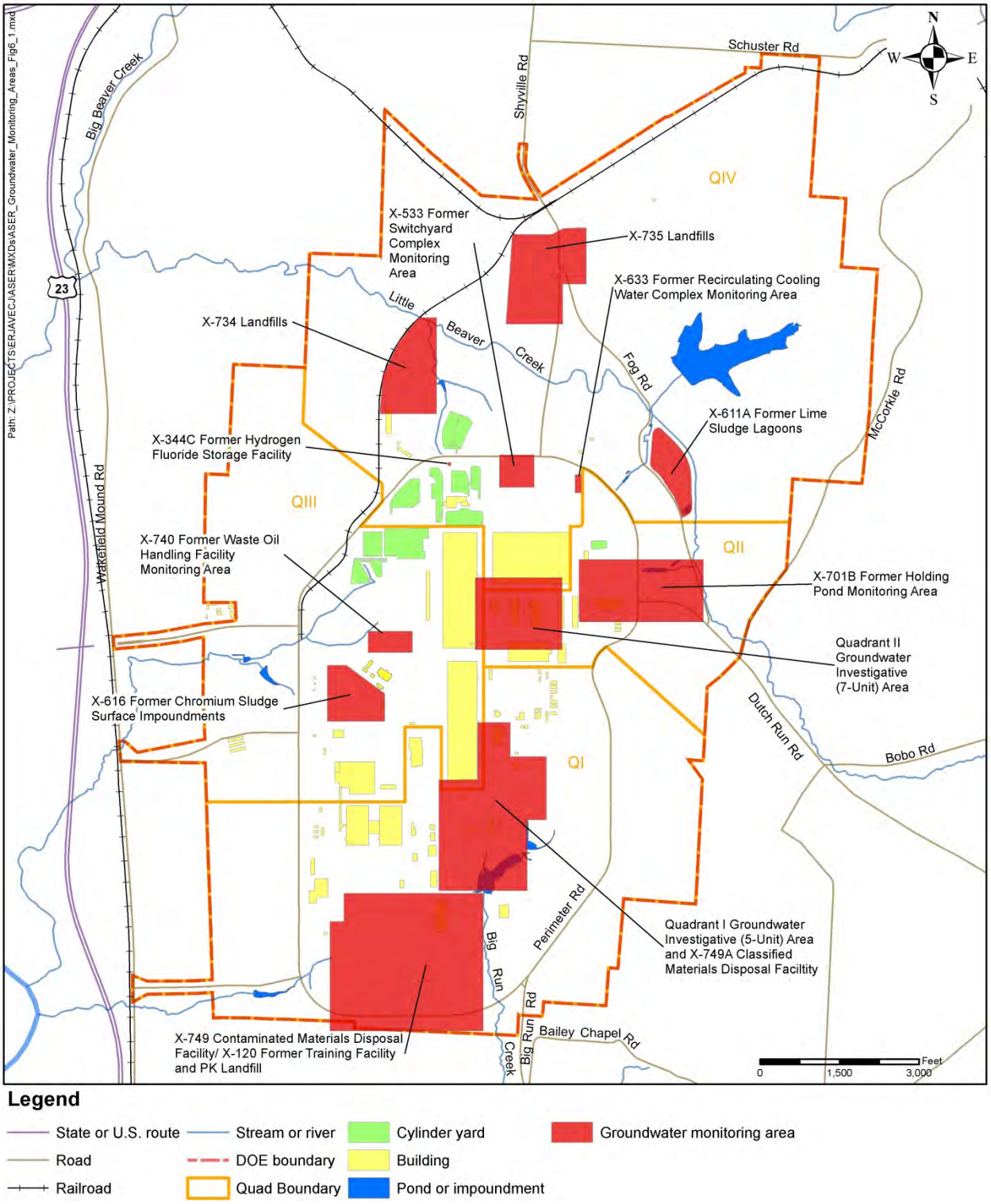

Figure 6.1. Groundwater monitoring areas at PORTS.

- Quadrant II
  - Quadrant II Groundwater Investigative (7-Unit) Area,
  - X-701B Former Holding Pond,
  - X-633 Former Recirculating Cooling Water Complex,
- Quadrant III
  - X-616 Former Chromium Sludge Surface Impoundments,
  - X-740 Former Waste Oil Handling Facility,
- Quadrant IV
  - X-611A Former Lime Sludge Lagoons,
  - X-735 Landfills,
  - X-734 Landfills,
  - X-533 Former Switchyard Complex, and
  - X-344C Former Hydrogen Fluoride Storage Building.

The *Integrated Groundwater Monitoring Plan* also contains requirements for 1) surface water monitoring in creeks and drainage ditches at PORTS that receive groundwater discharge; and 2) water supply monitoring (DOE 2015b).

In general, samples are collected from wells (or surface water locations) at each area listed above and are analyzed for metals, VOCs, and/or radionuclides. Table 6.1 lists the analytical requirements for each groundwater monitoring area and other monitoring programs described in this chapter. Constituents detected in the groundwater are then compared to standards called preliminary remediation goals to assess the potential for each constituent to affect human health and the environment. Preliminary remediation goals are initial clean-up goals developed early in the decision-making process that are 1) protective of human health and the environment, and 2) comply with applicable or relevant and appropriate requirements. Preliminary remediation goals are intended to satisfy regulatory cleanup requirements. For groundwater at PORTS, preliminary remediation goals are the NPDES drinking water standards (maximum contaminant levels).

Five areas of groundwater contamination, commonly called groundwater plumes, have been identified at PORTS. Groundwater contamination consists of VOCs (primarily TCE) and radionuclides such as technetium-99. The areas that contain groundwater plumes are X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility, Quadrant I Groundwater Investigative (5-Unit) Area, Quadrant II Groundwater Investigative (7-Unit) Area, X-701B Former Holding Pond, and X-740 Former Waste Oil Handling Facility. Other areas are monitored to evaluate groundwater contaminated with metals, to ensure past uses of the area (such as a landfill) have not caused groundwater contamination, or to monitor remediation that has taken place in the area.

The following sections describe the history of each groundwater monitoring area and groundwater monitoring results for each area in 2016.

6.4.1 X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility

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 immediately northeast of the X-749 Landfill, is not a contaminant source to the X-749/X-120 groundwater plume.

Table 6.1. Analytical parameters for monitoring areas and programs at PORTS in 2016

Monitoring Area or Program	Analytes
X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility[a,b]	VOCs transuranics: ^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}$Pu technetium-99 U, $^{233/234}$U, $^{235/236}$U, ^{238}U total metals: Be, Cd, Cr, Mn, Ni
PK Landfill[b]	VOCs total metals: Be, Cd, Cr, Mn, Ni
Quadrant I Groundwater Investigative (5-Unit) Area[a,b]	VOCs transuranics: ^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}$Pu technetium-99 U, $^{233/234}$U, $^{235/236}$U, ^{238}U total metals: Be, Cd, Cr, Mn, Ni
X-749A Classified Materials Disposal Facility	VOCs–2 technetium-99 U, $^{233/234}$U, $^{235/236}$U, ^{238}U alkalinity chloride sulfate chemical oxygen demand total dissolved solids total metals Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Ni, K, Se, Ag, Na, Tl, V, Zn nitrate/nitrite ammonia
Quadrant II Groundwater Investigative (7-Unit) Area[a,b]	VOCs transuranics: ^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}$Pu technetium-99 U, $^{233/234}$U, $^{235/236}$U, ^{238}U total metals: Be, Cd, Cr, Mn, Ni
X-701B Former Holding Pond[a,b]	VOCs transuranics: ^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}$Pu technetium-99 U, $^{233/234}$U, $^{235/236}$U, ^{238}U alkalinity chloride sulfate total dissolved solids total metals: Be, Cd, Cr, Mn, Ni
X-633 Former Recirculating Cooling Water Complex	total metals: Cr
X-616 Former Chromium Sludge Surface Impoundments	VOCs total metals: Be, Cd, Cr, Mn, Ni
X-740 Former Waste Oil Handling Facility[a]	VOCs
X-611A Former Lime Sludge Lagoons	total metals: Be, Cr
X-735 Landfills	VOCs–2 technetium-99 U, $^{233/234}$U, $^{235/236}$U, ^{238}U alkalinity chloride sulfate chemical oxygen demand total dissolved solids total metals: Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Hg, Pb, Mg, Mn, Ni, K, Se, Ag, Na, Tl, V, Zn nitrate/nitrite ammonia

Table 6.1. Analytical parameters for monitoring areas and programs at PORTS in 2016 (continued)

Monitoring Area or Program	Analytes	
X-734 Landfills	VOCs transuranics: ^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}$Pu technetium-99 U, $^{233/234}$U, $^{235/236}$U, ^{238}U alkalinity chloride	total metals: Be, Cd, Cr, Mn, Ni, Na ammonia chemical oxygen demand nitrate/nitrite sulfate total dissolved solids
X-533 Former Switchyard Complex	total metals: Cd, Ni	
X-344C Former Hydrogen Fluoride Storage Building	VOCs	
Surface Water	VOCs transuranics: ^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}$Pu	technetium-99 U, $^{233/234}$U, $^{235/236}$U, ^{238}U
Water Supply	VOCs transuranics: ^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}$Pu	technetium-99 U, $^{233/234}$U, $^{235/236}$U, ^{238}U alpha activity
Exit Pathway	VOCs transuranics: ^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}$Pu	technetium-99 U, $^{233/234}$U, $^{235/236}$U, ^{238}U

[a]Selected well(s) in this area are sampled once every two years for a comprehensive list of more than 200 potential contaminants (40 CFR Part 264 Appendix IX – Appendix to Ohio Administrative Code Rule 3745-54-98).
[b]Not all wells in this area are analyzed for all listed analytes.

Notes:
VOCs: Acetone, benzene, bromodichloromethane, bromoform, carbon disulfide, carbon tetrachloride, chlorobenzene, chloroethane, chloroform, dibromochloromethane, 1,2-dichlorobenzene, 1,4-dichlorobenzene, 1,1-dichloroethane, 1,2-dichloroethane, 1,1-dichloroethene, cis-1,2-dichloroethene, trans-1,2-dichloroethene, ethylbenzene, bromomethane, chloromethane, methylene chloride, 2-butanone (methyl ethyl ketone), 4-methyl-2-pentanone (methyl isobutyl ketone), 1,1,2,2-tetrachloroethane, tetrachloroethene, toluene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, TCE, trichlorofluoromethane (CFC-11), vinyl chloride, xylenes (m,p-xylenes).

VOCs–2: VOCs listed above plus: acrylonitrile, bromochloromethane, 1,2-dibromo-3-chloropropane, 1,2-dibromoethane, trans-1,4-dichloro-2-butene, 1,2-dichloropropane, cis-1,3-dichloropropene, trans-1,3-dichloropropene, 2-hexanone (methyl butyl ketone), dibromomethane, iodomethane, styrene, 1,1,1,2-tetrachloroethane, 1,2,3-trichloropropane, and vinyl acetate.

Appendix C lists the symbols for metals and transuranic radionuclides.

6.4.1.1 X-749 Contaminated Materials Disposal Facility

The X-749 Contaminated Materials Disposal Facility is a landfill located in the south-central section of the facility in Quadrant I. The landfill covers approximately 11.5 acres and was built in an area of highest elevation within the southern half of PORTS. The landfill operated from 1955 to 1990, during which time buried wastes were generally contained in metal drums or other containers compatible with the waste.

The northern portion of the X-749 Landfill contains waste contaminated with industrial solvents, waste oils from plant compressors and pumps, sludges classified as hazardous, and low-level radioactive materials. The southern portion of the X-749 Landfill contains non-hazardous, low-level radioactive scrap materials.

The initial closure of the X-749 Landfill in 1992 included installation of 1) a multimedia cap; 2) a barrier wall along the north side and northwest corner of X-749 Landfill; and 3) subsurface groundwater drains on the northern half of the east side and the southwest corner of the landfill, including one sump within each of the groundwater drains. The barrier wall and subsurface drains extended down to bedrock. An additional barrier wall on the south and east sides of the X-749 Landfill was constructed in 2002. The groundwater drain and sump on the east side of the landfill were removed for construction of this barrier wall. Groundwater from the remaining subsurface drain is treated at the X-622 Groundwater Treatment Facility and discharged through FBP NPDES Outfall 608, which flows to the X-6619 Sewage Treatment Plant (FBP NPDES Outfall 003).

The leading edge of the contaminated groundwater plume emanating from the X-749 Landfill is near the southern boundary of PORTS. 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 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 migration of the X-749/X-120 groundwater plume and remediate areas of higher TCE concentrations within the plume. A third extraction well was installed in the X-120 area of the plume (see Section 6.4.1.2). Chapter 3, Section 3.3.1.1, provides additional information about the remedial actions implemented to address the X-749/X-120 groundwater plume.

Eighty-four wells and one sump/extraction well were sampled during 2016 to monitor the X-749/X-120 area. Table 6.1 lists the analytical parameters for the wells and sump in this area.

6.4.1.2 X-120 Former Training Facility

The X-120 Former Training Facility (originally called the Goodyear Training Facility and also called the X-120 Old Training Facility), which is west and north of the X-749 Contaminated Materials Disposal Facility, covered an area of approximately 11.5 acres west of the present-day XT-847 building. The X-120 Former Training Facility included a machine shop, metal shop, paint shop, and several warehouses used during the construction of PORTS in the 1950s.

Groundwater in the vicinity of this facility is contaminated with VOCs, primarily TCE. In 1996, a horizontal well was installed along the approximate axis of the X-120 plume. Contaminated groundwater flowed from this well to the X-625 Groundwater Treatment Facility. In 2003, operation of the X-625 Groundwater Treatment Facility and horizontal well ceased with the approval of Ohio EPA due to the limited amount of groundwater collected by the well. A groundwater extraction well was installed in 2010 in the area west of the X-120 Former Training Facility to remediate the higher concentrations of

TCE in groundwater in this area. Chapter 3, Section 3.3.1.1, provides additional information about the remedial actions implemented to address the X-749/X-120 groundwater plume.

Eighty-four wells and one sump/extraction well were sampled during 2016 to monitor the X-749/X-120 area. Table 6.1 lists the analytical parameters for the wells and sump in this area.

6.4.1.3 Monitoring results for the X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility in 2016

The most extensive and most concentrated constituents associated with the X-749/X-120 plume (see Figure 6.2) are VOCs, particularly TCE.

In general, concentrations of TCE were stable or decreasing within the X-749/X-120 groundwater plume. The area within the plume where TCE concentrations are less than 5 µg/L changed and became larger in 2016 compared to 2015 based on concentrations of TCE detected in wells X749-29G and X749-42G (see Figure 6.2). TCE was detected at 4 µg/L in the fourth quarter sample collected from well X749-42G. Concentrations of TCE detected in X749-42G have fluctuated above and below the preliminary remediation goal (5 µg/L) since 2013. The decreased concentration of TCE in well X749-42G has enlarged the area within the plume where TCE concentrations are less than 5 µg/L. The concentration of TCE detected in well X749-29G, which defines the eastern side of the area, increased to 31 µg/L in 2016. The concentration of TCE detected in well X749-29G in the last six years has fluctuated above and below the preliminary remediation goal. Concentrations of TCE remained less than 5 µg/L in 2016 in the other three wells that define the area (X120-05G, X749-PZ07G, and X749-36G).

The boundary of the eastern portion of X-749 groundwater plume that emanates from the east side of the X-749 Landfill remained similar to previous years. Within the eastern portion of the plume, concentrations of TCE remained stable (X749-21G and X749-20G) or continued to decrease (X749-35G and X749-PZ10G).

Extraction well X749-EW09G was installed in 2010 to remediate higher concentrations of TCE associated with the former X-120 facility in the northern portion of the X-749/X-120 groundwater plume. The average concentration of TCE detected in 2016 in well X120-11G (200 µg/L) has decreased from average concentrations in 2012–2015 (see Figure 6.2). These results indicate that extraction well X749-EW09G is functioning as intended to reduce concentrations of TCE in this area.

Extraction well X749-EW08G is intended to control migration of the southwestern portion of the X-749/X-120 groundwater plume. TCE was not detected in the downgradient well X749-66G in 2016. TCE, 1,1-dichloroethane, and 1,1-dichloroethene were detected at estimated concentrations of 0.38 µg/L or less in the fourth quarter sample collected from well X749-103G.

Groundwater extraction well X749-EW07G was installed in 2010 to remediate areas of higher TCE concentrations south of the X-749 Landfill. Wells X749-67G and X749-110G monitor the performance of extraction well X749-EW07G. The average concentration of TCE detected in 2016 in well X749-67G (220 µg/L) has decreased from the average annual concentrations detected in 2012–2015 (see Figure 6.2). The average concentration of TCE detected in 2016 in well X749-110G (27 µg/L) is similar to 2015 (28 µg/L) and has decreased from the average annual concentrations detected in 2012–2014 (see Figure 6.2). These results indicate that extraction well X749-EW07G is functioning as intended to reduce concentrations of TCE south of the X-749 Landfill.

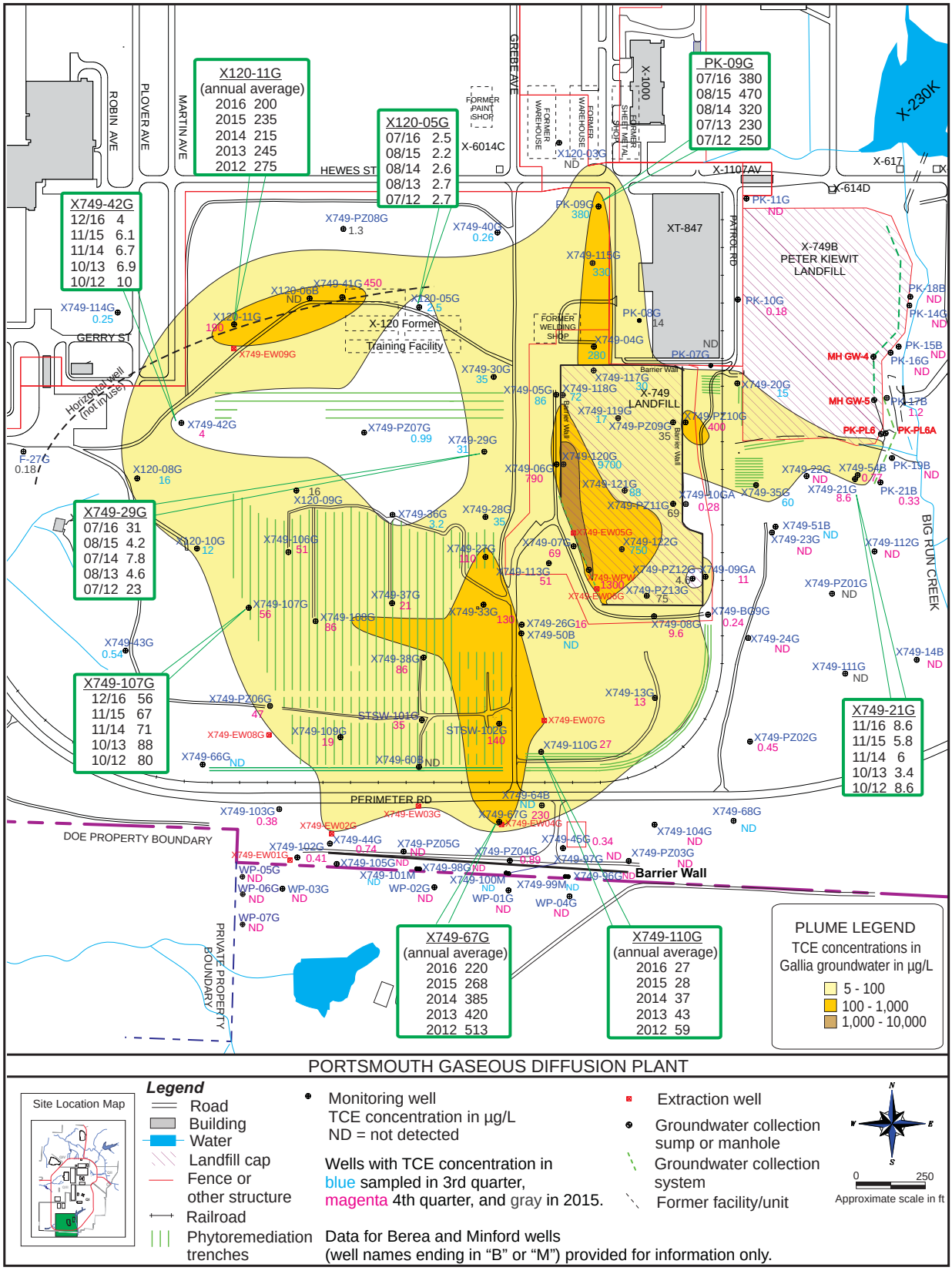

Figure 6.2. TCE-contaminated Gallia groundwater plume at the X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility – 2016.

The concentrations of TCE detected in on-site monitoring wells downgradient of the X-749 South Barrier Wall area groundwater extraction wells (wells X749-EW01G, EW02G, EW03G, and EW04G) have decreased to below 5 µg/L in most sampling events since 2011, with the exception of well X749-67G (discussed in the previous paragraph). No VOCs were detected in any of the seven off-site monitoring wells.

6.4.2 PK Landfill

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.

During site investigations, intermittent seeps were observed emanating from the PK Landfill into Big Run Creek. In 1994, a portion of Big Run Creek was relocated approximately 50 feet to the east. A groundwater collection system was installed in the old creek channel to capture the seeps emanating from the landfill. A second collection system was constructed in 1997 on the southeastern landfill boundary to contain the groundwater plume migrating toward Big Run Creek from the southern portion of the PK Landfill. Although the PK Landfill is adjacent to the X-749 Landfill and X-749/X-120 groundwater plume, it is not a source of contaminants detected in the X-749/X-120 groundwater plume. A cap was constructed over the landfill in 1998. Chapter 3, Section 3.3.1.2, provides additional information about the remedial actions implemented at PK Landfill.

In 2016, nine wells and two sumps were sampled to monitor the PK Landfill area. Table 6.1 lists the analytical parameters for the wells, sumps, and manholes in this area.

6.4.2.1 Monitoring results for the PK Landfill in 2016

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 (see Figure 6.2). Most of the detections of VOCs in the PK Landfill monitoring wells are below preliminary remediation goals. In 2016, vinyl chloride was detected in samples collected from wells PK-17B and PK-21B at concentrations ranging from 13 to 20 µg/L, which exceed the preliminary remediation goal of 2 µg/L. Vinyl chloride is typically detected in these wells at concentrations above the preliminary remediation goal. No other VOCs were detected in the PK Landfill monitoring wells at concentrations that exceeded the preliminary remediation goals.

6.4.3. Quadrant I Groundwater Investigative (5-Unit) Area

The Quadrant I Groundwater Investigative (5-Unit) Area consists of a groundwater plume resulting from a number of potential sources of groundwater contamination in the northern portion of Quadrant I: the X-231A and X-231B Oil Biodegradation Plots, X-600 Former Steam Plant Complex, X-600A Former Coal Pile Yard, X-621 Coal Pile Runoff Treatment Facility, X-710 Technical Services Building, the X-760 Former Pilot Investigation Building, and the X-770 Former Mechanical Testing Facility. The X-231B Southwest Oil Biodegradation Plot was monitored prior to implementation of the *Integrated Groundwater Monitoring Plan*.

Three groundwater extraction wells were installed in 1991 as part of an IRM for the X-231B Southwest Oil Biodegradation Plot. Eleven additional groundwater extraction wells were installed in 2001-2002 as part of the remedial actions required by the Quadrant I Decision Document. These wells began operation in 2002. An additional extraction well south of the X-326 Process Building began operating in 2009. The extracted groundwater is treated at the X-622 Groundwater Treatment Facility and discharged through FBP NPDES Outfall 608, which flows into the X-6619 Sewage Treatment Plant (FBP NPDES

Outfall 003). Multimedia landfill caps were installed over the X-231B area and a similar area, X-231A, in 2000 to minimize water infiltration and control the spread of contamination. Chapter 3, Section 3.3.1.3, provides additional information about the remedial actions implemented in the Quadrant I Groundwater Investigative (5-Unit) Area.

Twenty-four wells were sampled in 2016 as part of the monitoring program for the Quadrant I Groundwater Investigative (5-Unit) Area. Table 6.1 lists the analytical parameters for the wells in this area.

6.4.3.1 Monitoring results for the Quadrant I Groundwater Investigative (5-Unit) Area in 2016

A contaminated groundwater plume consisting primarily of TCE is associated with the Quadrant I Groundwater Investigative (5-Unit) Area (see Figure 6.3). Other VOCs are also present in the plume.

The eastern edge of the groundwater plume changed slightly in 2016 based on the detection of TCE at 7.4 µg/L in X231A-01G. TCE is usually detected in well X231A-01G at concentrations just above the preliminary remediation goal (5 µg/L), but was detected at 3.8 µg/L in 2015 (see Figure 6.3). No other significant changes in TCE concentrations were identified in wells that monitor the Quadrant I Groundwater Investigative (5-Unit) Area in 2016.

6.4.4 X-749A Classified Materials Disposal Facility

The 6-acre X-749A Classified Materials Disposal Facility (also called the X-749A Landfill) is a landfill that operated from 1953 through 1988 for the disposal of wastes classified under the Atomic Energy Act (see Figure 6.3). Potential contaminants include PCBs, asbestos, radionuclides, and industrial waste. Closure of the landfill, completed in 1994, included the construction of a multilayer cap and the installation of a drainage system to collect surface water runoff. The drainage system discharges via the X-230K South Holding Pond (FBP NPDES Outfall 002). Although the X-749A Classified Materials Disposal Facility is located at the eastern edge of the Quadrant I Groundwater Investigative (5-Unit) Area groundwater plume, the X-749A Landfill is not the source of the VOCs detected in some of the X-749A monitoring wells at the eastern edge of the Quadrant I Groundwater Investigative (5-Unit) Area groundwater plume.

Ten wells associated with the landfill were sampled in 2016. Table 6.1 lists the analytical parameters for the wells in this area.

6.4.4.1 Monitoring results for the X-749A Classified Materials Disposal Facility in 2016

Under the detection monitoring program for the X-749A Landfill, concentrations of alkalinity, ammonia, calcium, chloride, iron, nitrate/nitrite, sodium, and sulfate in downgradient Gallia wells were evaluated using two statistical procedures to monitor potential impacts to groundwater and trends in concentrations of these parameters. Ohio EPA is notified when the statistical control limit for any of the indicator parameters using the first statistical procedure is exceeded at any of the downgradient Gallia wells in two consecutive semiannual sampling events. The second statistical procedure monitors long-term trends in concentrations of the indicator parameters and does not require Ohio EPA notification.

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-749A wells in 2016.

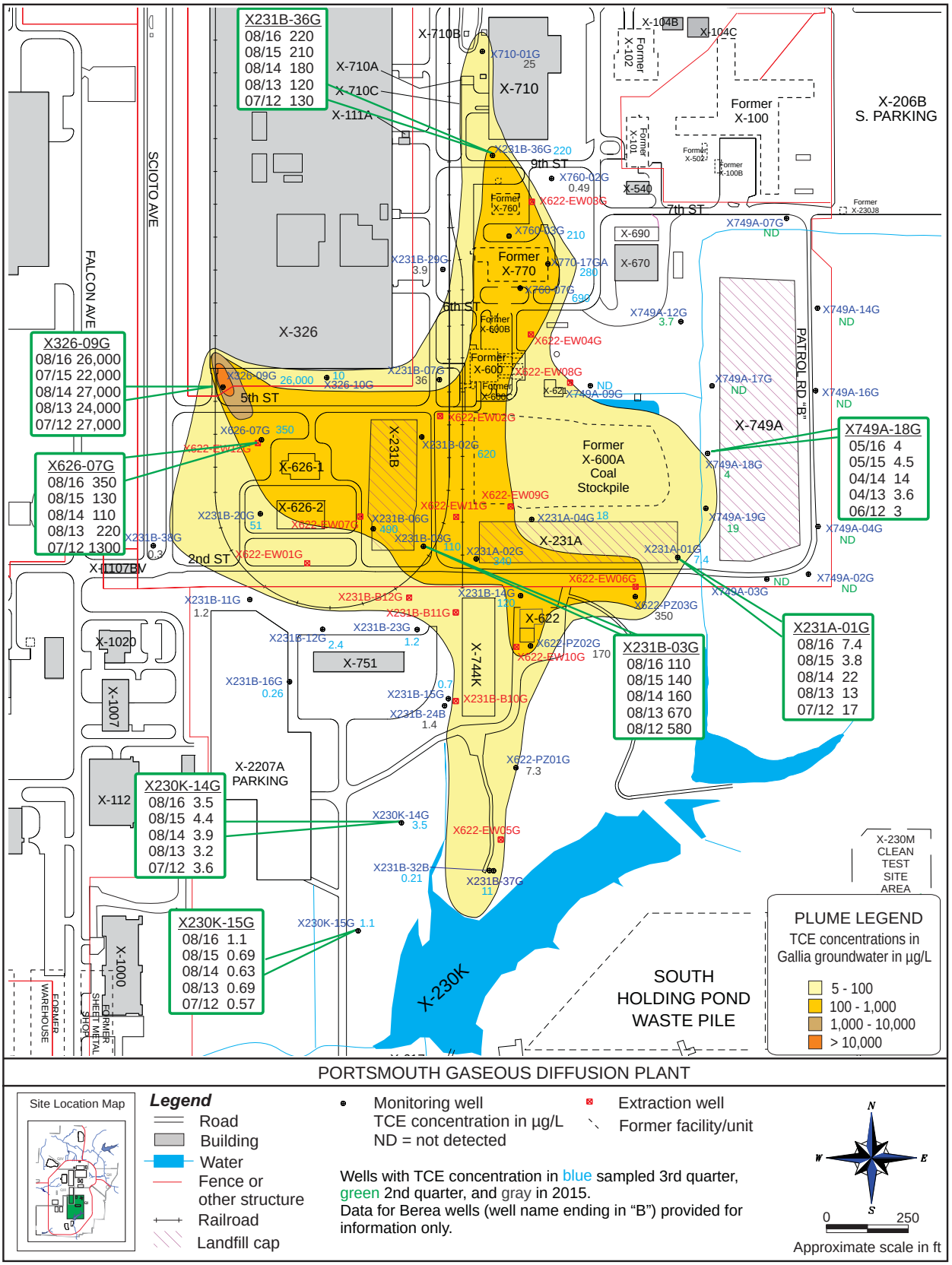

Figure 6.3. TCE-contaminated Gallia groundwater plume at the Quadrant I Groundwater Investigative (5-Unit) Area – 2016.

6.4.5 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. One of these sources, the X-701C Neutralization Pit, was monitored prior to implementation of the *Integrated Groundwater Monitoring Plan*. The X-701C Neutralization Pit was an open-topped neutralization pit that received process effluents and basement sump wastewater such as acid and alkali solutions and rinse water contaminated with TCE and other VOCs from metal-cleaning operations. The X-701C Neutralization Pit was located within a TCE plume centered around the X-700 and X-705 buildings. The pit was removed in 2001. 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. Chapter 3, Section 3.3.2.1 provides additional information about the Quadrant II Groundwater Investigative (7-Unit) Area.

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 in the basements of the X-700 and X-705 buildings. Thus, the groundwater plume in this area does not spread but instead flows toward the sumps where it is collected and then treated at the X-627 Groundwater Treatment Facility. This facility discharges through FBP NPDES Outfall 611, which flows to the X-6619 Sewage Treatment Plant (FBP NPDES Outfall 003). Twenty-four wells are part of the routine monitoring program for this area. Table 6.1 lists the analytical parameters for the wells in this area.

6.4.5.1 Monitoring results for the Quadrant II Groundwater Investigative (7-Unit) Area in 2016

A contaminated groundwater plume consisting primarily of TCE is associated with the Quadrant II Groundwater Investigative (7-Unit) Area (see Figure 6.4).

Concentrations of TCE detected in the Quadrant II Groundwater Investigative (7-Unit) Area plume were generally stable or decreasing in 2016, with the exception of X705-03G in the southwest portion of the plume. TCE has increased to 88 µg/L in 2016 in well X705-03G (see Figure 6.4).

Wells at the eastern or southeastern boundary of the monitoring area, X700-03G, X701-26G, and X701-27G, were sampled semiannually to monitor movement of the east side of the Quadrant II Groundwater Investigative (7-Unit) Area plume towards the X-701B Former Holding Pond Area. TCE was not detected in any of the samples collected from well X700-03G. Concentrations of TCE detected in wells X701-26G and X701-27G were similar to or less than TCE concentrations detected in 2015 (see Figure 6.4).

6.4.6 X-701B Former Holding Pond

In the eastern portion of Quadrant II, groundwater concerns focus on three areas: the X-701B Former Holding Pond, the X-230J7 Holding Pond, and the X-744Y Waste Storage Yard.

The X-701B Former Holding Pond was used from the beginning of plant operations in 1954 until 1988. The pond was designed for neutralization and settlement of acid waste from several sources. TCE and other VOCs were also discharged to the pond. Two surface impoundments (sludge retention basins) were located west of the holding pond. The X-230J7 Holding Pond received wastewater from the X-701B Former Holding Pond. The X-744Y Waste Storage Yard is south of the X-701B Former Holding Pond. The yard was approximately 15 acres and surrounded the X-744G Bulk Storage Building. RCRA hazardous waste was managed in this area.

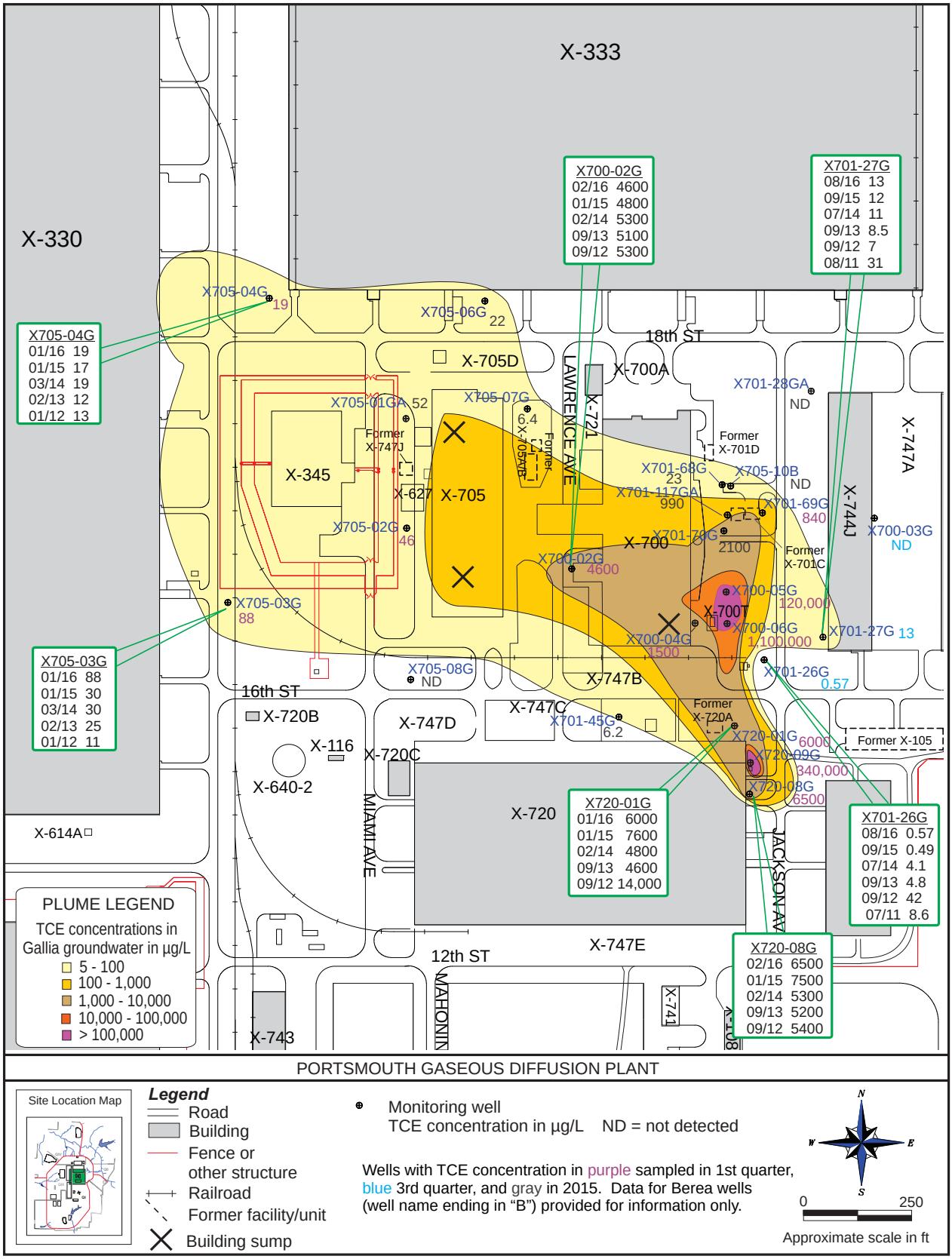

Figure 6.4. TCE-contaminated Gallia groundwater plume at the Quadrant II Groundwater Investigative (7-Unit) Area – 2016.

A contaminated groundwater plume extends from the X-701B Former Holding Pond towards Little Beaver Creek. Three groundwater extraction wells were installed in 1993 southeast of the X-701B Former Holding Pond and a sump was installed in 1995 in the bottom of the pond as part of the RCRA closure of the unit. These wells and sump were designed 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 (see Chapter 3, Section 3.3.2.2).

Two groundwater interceptor trenches (French drains) are used to intercept TCE-contaminated groundwater in the eastern portion of the monitoring area. These interceptor trenches, called the X-237 Groundwater Collection System, control TCE migration into Little Beaver Creek. The 660-foot-long primary trench has two sumps in the backfill and a 440-foot-long secondary trench intersects the primary trench. The extracted groundwater is treated at the X-624 Groundwater Treatment Facility and discharges through FBP NPDES Outfall 015, which flows to Little Beaver Creek.

Groundwater remediation in the X-701B Former Holding Pond Area was initiated in 2006 (see Chapter 3, Section 3.3.2.2). Oxidant was injected into the subsurface in the western portion of the area from 2006 through 2008 to remediate VOCs in soil and groundwater. The X-701B IRM was initiated in December 2009 and completed in 2011 to further address contaminants remaining in soil and groundwater following the oxidant injections. Contaminated soil in the X-701B IRM area was removed and mixed with oxidant, with additional oxidant mixed into soil remaining at the bottom of the excavation.

Sixty-two wells that monitor the X-701B Former Holding Pond area were sampled in 2016. Table 6.1 lists the analytical parameters for the wells that are part of the *Integrated Groundwater Monitoring Plan* (DOE 2015b).

6.4.6.1 Monitoring results for the X-701B Former Holding Pond in 2016

In general, concentrations of TCE detected in wells within the X-701B plume in 2016 were similar to previous years. Concentrations of TCE remain elevated in wells X701-BW2G and X701-130G that monitor the western portion of the plume, west of the IRM treatment area (see Figure 6.5). TCE is decreasing in well X701-EW121G, which is downgradient (east) of the IRM treatment area (see Figure 6.5).

In the third quarter, TCE was detected at 210 µg/L in well X701-01G in the southwestern portion of the monitoring area. TCE increased to above 5 µg/L in wells X701-30G and X744G-03G in 2016. The TCE concentrations in the wells that define this area of the plume have rebounded since the completion of the IRM in 2011, which ended the dewatering of the IRM area (see Figure 6.5).

Samples from 48 wells that monitor the X-701B Holding Pond were analyzed for radionuclides (americium-241, neptunium-237, plutonium-238, plutonium-239/240, technetium-99, uranium, uranium-233/234, uranium-235/236, and/or uranium-238). Technetium-99 or uranium were detected above Ohio EPA drinking water standards (900 pCi/L for technetium-99 based on a 4 mrem/year dose from beta emitters, and 30 µg/L for uranium) in seven 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. The oxidant, which affects the oxidation/reduction potential and pH of the soil and/or groundwater, temporarily causes metals in soil to be mobilized into the groundwater. It is expected that the metals will move downgradient with groundwater flow for a short distance and then be re-adsorbed into the soil matrix as the geochemistry of the soil and groundwater returns to ambient conditions.

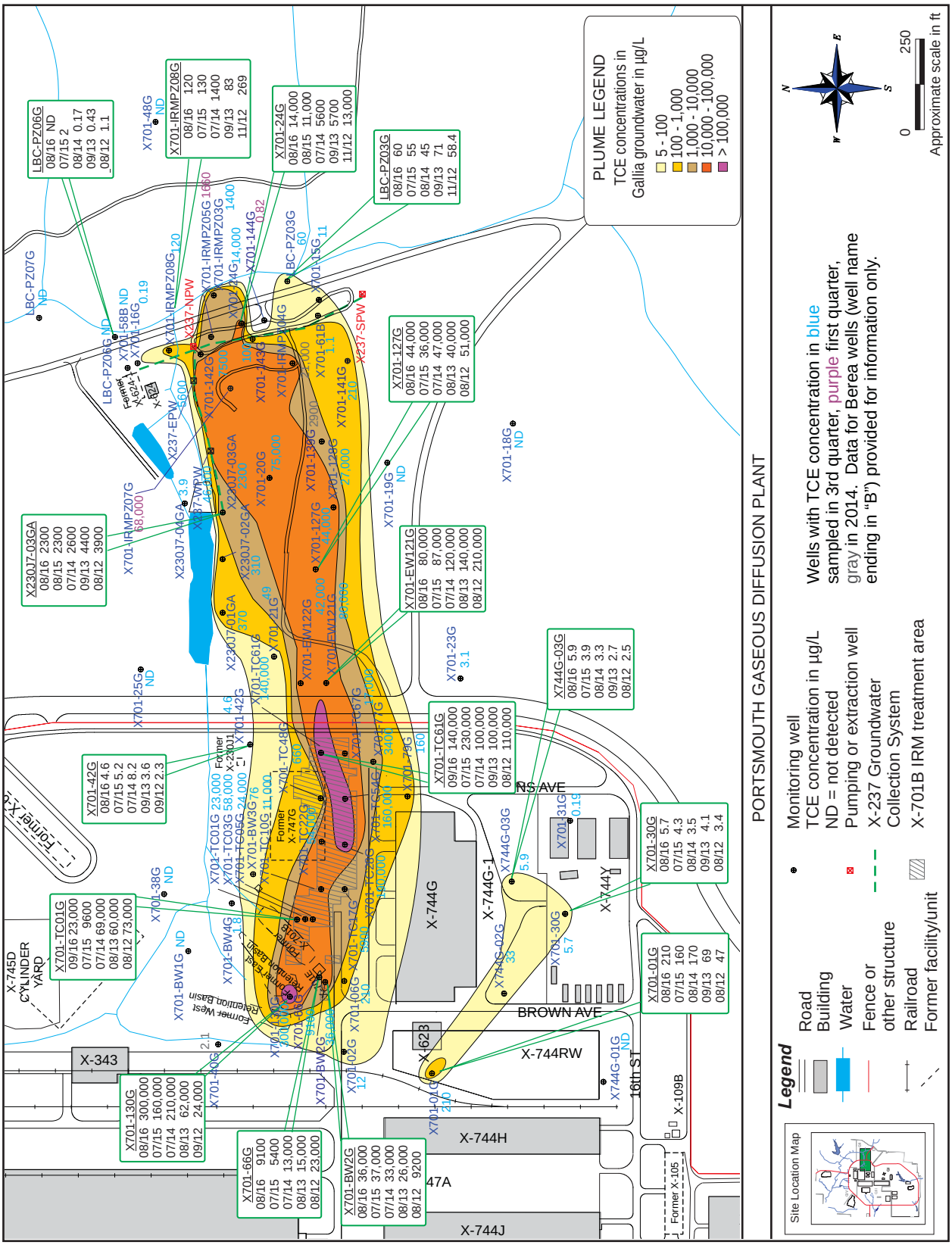

Figure 6.5. TCE-contaminated Gallia groundwater plume at the X-701B Former Holding Pond – 2016.

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 (X701-01G, X744G-01G, and X744G-02G). These results are typical for the X-744 area wells. Nickel was also detected at concentrations above the preliminary remediation goal in samples collected from wells X701-20G and X701-127G, 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.

6.4.7 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. Chromium-based corrosion inhibitors were added to the cooling water until the early 1990s, when the system was converted to a phosphate-based inhibitor. D&D of the facilities was completed in 2010. Chapter 3, Section 3.3.2.3 provides additional information about the RCRA investigation of soils and groundwater in this area.

The X-633 Former Recirculating Cooling Water 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. Samples from wells in this area were collected in 1998 and 1999 to assess the area for metals contamination. Based on detections of chromium above the preliminary remediation goal, this area was added to the PORTS groundwater monitoring program. Two wells are sampled semiannually for chromium as part of the monitoring program for this area.

6.4.7.1 Monitoring results for the X-633 Former Recirculating Cooling Water Complex in 2016

Chromium was detected in both of the X-633 monitoring wells in 2016. Samples collected from well X633-07G contained chromium at concentrations above the preliminary remediation goal of 100 µg/L: 370 µg/L (second quarter) and 510 µg/L (fourth quarter). Samples collected from well X633-PZ04G also contained chromium but at concentrations well below the preliminary remediation goal. These results are typical for these wells. Figure 6.6 shows the chromium concentrations detected in the X-633 Former Recirculating Cooling Water Complex wells.

6.4.8 X-616 Former Chromium Sludge Surface Impoundments

The X-616 Former Chromium Sludge Surface Impoundments in Quadrant III were two unlined surface impoundments used from 1976 to 1985 for storage of sludge generated by the treatment of water from the PORTS process cooling system. A corrosion inhibitor containing chromium was used in the cooling water system. Sludge containing chromium was produced by the water treatment system and was pumped into and stored in the X-616 impoundments. The sludge was removed from the impoundments and remediated as an interim action in 1990 and 1991. The unit was certified closed in 1993. Sixteen wells are sampled as part of the monitoring program for this area. Table 6.1 lists the analytical parameters for the wells in this area.

6.4.8.1 Monitoring results for the X-616 Former Chromium Sludge Surface Impoundments in 2016

Chromium is of special concern at X-616 because of the previous use of the area. In 2016, chromium was detected above the preliminary remediation goal of 100 µg/L in one well that monitors the X-616 area: well X616-05G (on the northeastern boundary of the area). Chromium is typically detected above the preliminary remediation goal in this well. Nickel was detected above the preliminary remediation goal (100 µg/L for Gallia wells) in two wells (X616-05G and X616-25G). Nickel is typically detected above the preliminary remediation goal in these two wells. Figure 6.7 shows the concentrations of chromium and nickel in wells at the X-616 Former Chromium Sludge Surface Impoundments.

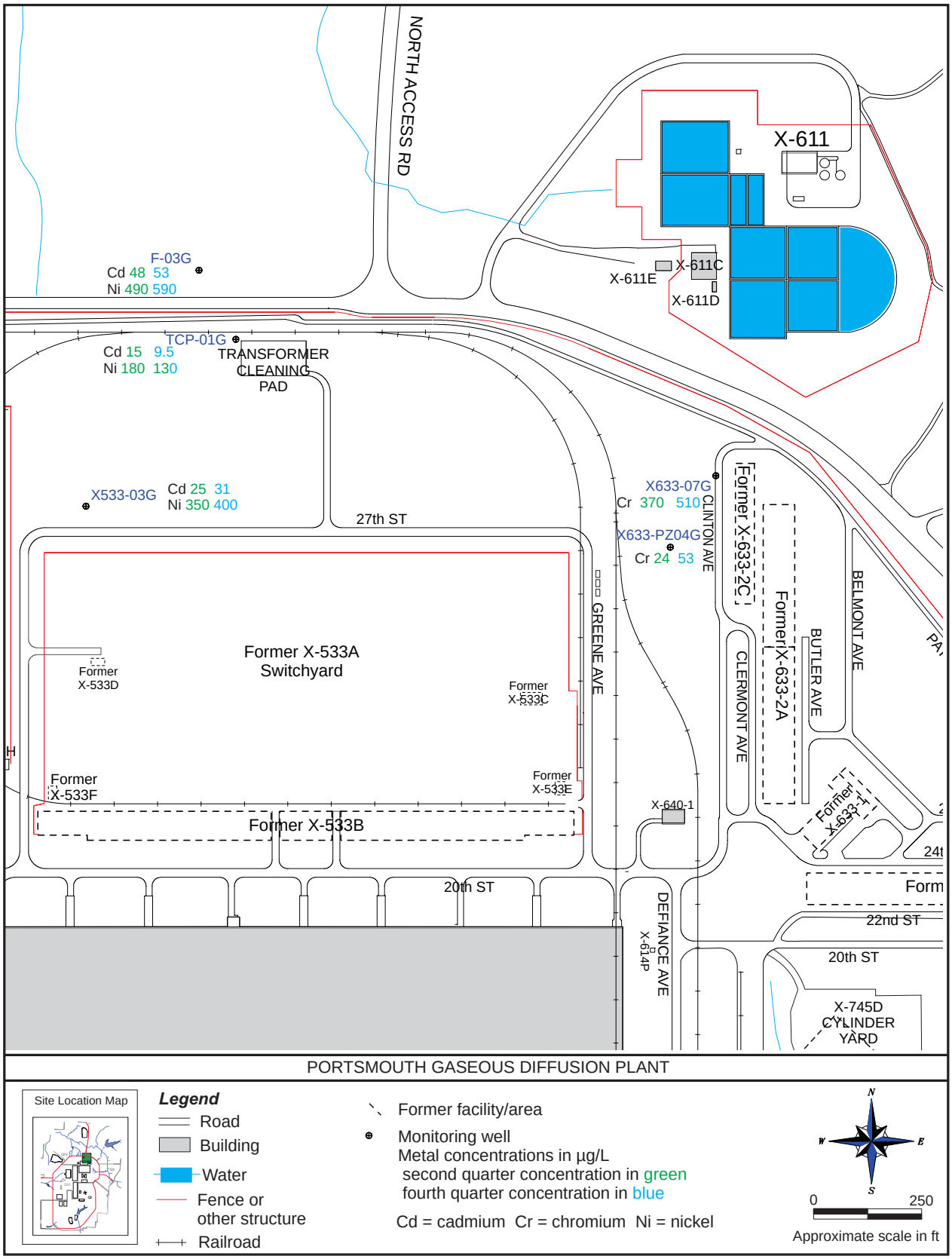

Figure 6.6. Metal concentrations in groundwater at the X-633 Former Recirculating Cooling Water Water Complex and X-533 Former Switchyard Complex – 2016.

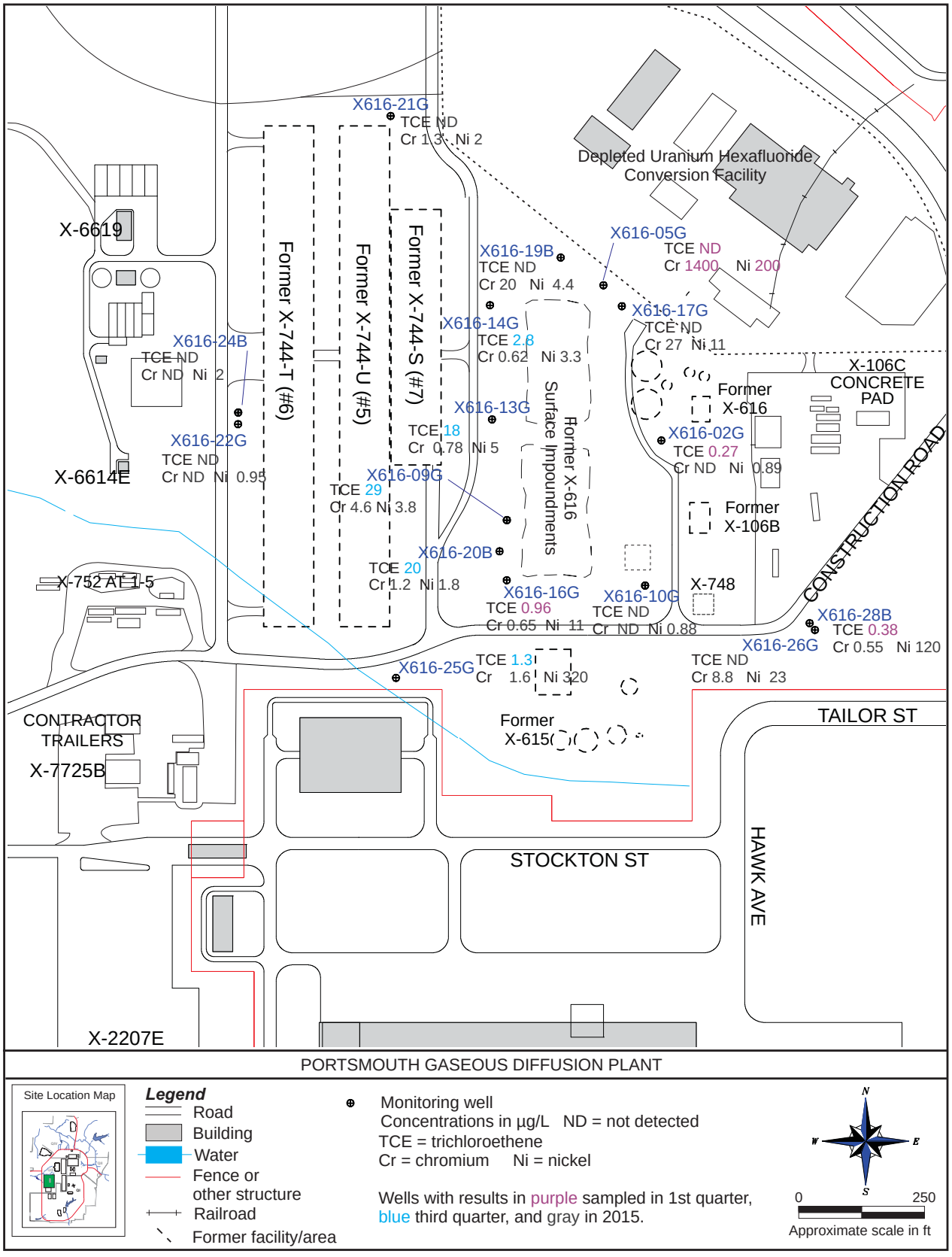

Figure 6.7. TCE and metal concentrations in groundwater at the X-616 Former Chromium Sludge Surface Impoundments – 2016.

TCE was detected above the preliminary remediation goal of 5 µg/L in three wells west of the former surface impoundments: wells X616-09G, X616-13G, and X616-20B. TCE has been detected above 5 µg/L in wells X616-09G and X616-20B since 2004 or earlier. Concentrations of TCE increased to above 5 µg/L in well X616-13G in 2013. Figure 6.7 shows the concentrations of TCE detected in the X-616 wells in 2016.

6.4.9 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 south of the X-530A Switchyard in Quadrant III. The X-740 facility, which operated from 1983 until 1991, was used as an inventory and staging facility for waste oil and waste solvents that were generated from various plant operational and maintenance activities. A sump within the building was used between 1986 and 1990 to collect residual waste oil and waste solvents from containers crushed in a hydraulic drum crusher at the facility. The facility and sump were initially identified as hazardous waste management units in 1991. The X-740 Former Waste Oil Handling Facility (both the facility and sump identified as hazardous waste management units) underwent closure, and closure certification was approved by Ohio EPA in 1998.

In 1999, poplar trees were planted in a 2.6-acre phytoremediation area above the groundwater plume near the X-740 Former Waste Oil Handling Facility. Because phytoremediation did not work as anticipated to reduce the concentrations of VOCs in groundwater in this area, three rounds of oxidant injections were completed during 2008. Additional alternatives for groundwater remediation in this area were evaluated in 2009, and a pilot study of enhanced anaerobic bioremediation took place from 2010 through 2015. Chapter 3, Section 3.3.3, provides additional information about the remedial activities for the X-740 area.

Nineteen wells that monitor the X-740 Former Waste Oil Handling Facility were sampled during 2016.

6.4.9.1 Monitoring results for the X-740 Former Waste Oil Handling Facility in 2016

A contaminated groundwater plume consisting primarily of TCE is located near the X-740 Former Waste Oil Handling Facility in Quadrant III. Figure 6.8 shows the TCE groundwater plume in 2016 for the X-740 area. The perimeter of the X-740 groundwater plume did not change in 2016. However, concentrations of TCE are decreasing in Gallia wells that monitor the pilot study (X740-18G, X740-19G, X740-20G, X740-21G, X740-22G and X740-PZ14G – see Figure 6.8). TCE has also decreased in wells X740-03G and X740-09B, which had the highest concentrations of TCE in the X-740 groundwater plume prior to the pilot study.

6.4.10 X-611A Former Lime Sludge Lagoons

The X-611A Former Lime Sludge Lagoons in Quadrant IV were comprised of three adjacent unlined sludge retention lagoons constructed in 1954 and used for disposal of lime sludge waste from the site water treatment plant from 1954 to 1960. The lagoons covered a surface area of approximately 18 acres and were constructed in a low-lying area that included Little Beaver Creek. As a result, approximately 1500 feet of Little Beaver Creek were relocated to a channel just east of the lagoons.

As part of the RCRA Corrective Action Program, a prairie habitat has been developed in this area by placing a soil cover over the north, middle, and south lagoons. A soil berm was also constructed outside the northern boundary of the north lagoon to facilitate shallow accumulation of water in this low-lying area. Chapter 3, Section 3.3.4.1, provides more information about this remediation. Six wells are sampled semiannually as part of the monitoring program for this area. Table 6.1 lists the analytical parameters for the wells in this area.

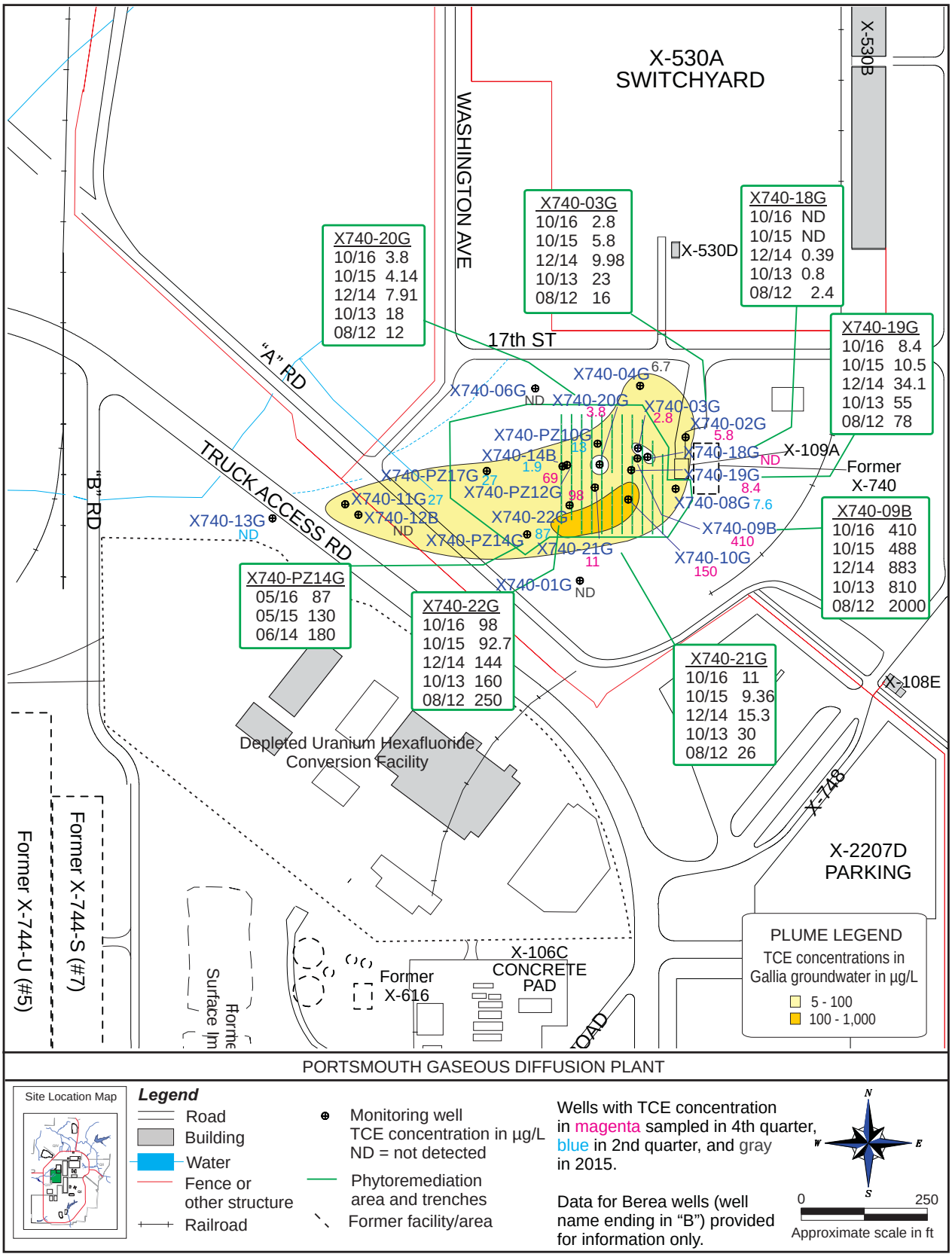

Figure 6.8. TCE-contaminated Gallia groundwater plume near the X-740 Former Waste Oil Handling Facility – 2016.

6.4.10.1 Monitoring results for the X-611A Former Lime Sludge Lagoons in 2016

The six monitoring wells at X-611A are sampled and analyzed for beryllium and chromium. In 2016, chromium was detected in the samples collected from three of the six wells in this area at concentrations between 0.9 and 42 µg/L, which are below the preliminary remediation goal (100 µg/L).

In 2016, beryllium was detected in five of the six wells in this area at concentrations of 1 µg/L or less, which are less than the preliminary remediation goals (6.5 µg/L for Gallia wells and 7 µg/L for Berea wells). Figure 6.9 shows the concentrations of beryllium and chromium detected in the X-611A wells in 2016.

6.4.11 X-735 Landfills

Several distinct waste management units are contained within the X-735 Landfills area in Quadrant IV. The main units consist of the hazardous waste landfill, referred to as the X-735 RCRA Landfill, and the X-735 Industrial Solid Waste Landfill. The X-735 Industrial Solid Waste Landfill includes the industrial solid waste cells, asbestos disposal cells, and the chromium sludge monocells A and B. The chromium sludge monocells contain a portion of the chromium sludge generated during the closure of the X-616 Chromium Sludge Surface Impoundments.

Initially, a total of 17.9 acres was approved by Ohio EPA and Pike County Department of Health for landfill disposal of conventional solid wastes. The landfill began operation in 1981. During operation of the landfill, PORTS investigations indicated that wipe rags contaminated with solvents had inadvertently been disposed in the northern portion of the landfill. The contaminated rags were considered a hazardous waste. Waste disposal in the northern area ended in 1991, and Ohio EPA determined that the area required closure as a RCRA hazardous waste landfill. Consequently, this unit of the sanitary landfill was identified as the X-735 RCRA Landfill.

A buffer zone was left unexcavated to provide space for groundwater monitoring wells and a space between the RCRA landfill unit and the remaining southern portion, the X-735 Industrial Solid Waste Landfill. Routine groundwater monitoring has been conducted at the X-735 Landfills since 1991.

The industrial solid waste portion of the X-735 Landfills included a solid waste section and an asbestos waste section. The X-735 Industrial Solid Waste Landfill, not including the chromium sludge monocells, encompasses a total area of approximately 4.1 acres. Operation of the X-735 Industrial Solid Waste Landfill ceased in 1997; this portion of the landfill was capped in 1998.

The *Integrated Groundwater Monitoring Plan* incorporates monitoring requirements for the hazardous and solid waste portions of the X-735 Landfills (DOE 2015b). In addition, the *Corrective Measures Plan for the X-735 Landfill* was approved by Ohio EPA in 2008 (DOE 2007a). This plan provides the monitoring requirements for Gallia wells that monitor the X-735 Landfill. Corrective measures monitoring was implemented because Ohio EPA determined that assessment monitoring of the landfill, completed between 2005 and 2007, identified that a small release of leachate constituents is occurring or has occurred from the X-735 Landfills. Seventeen wells were sampled in 2016 as part of the monitoring programs for this area. Table 6.1 lists the analytical parameters and Figure 6.10 shows the monitoring wells in this area.

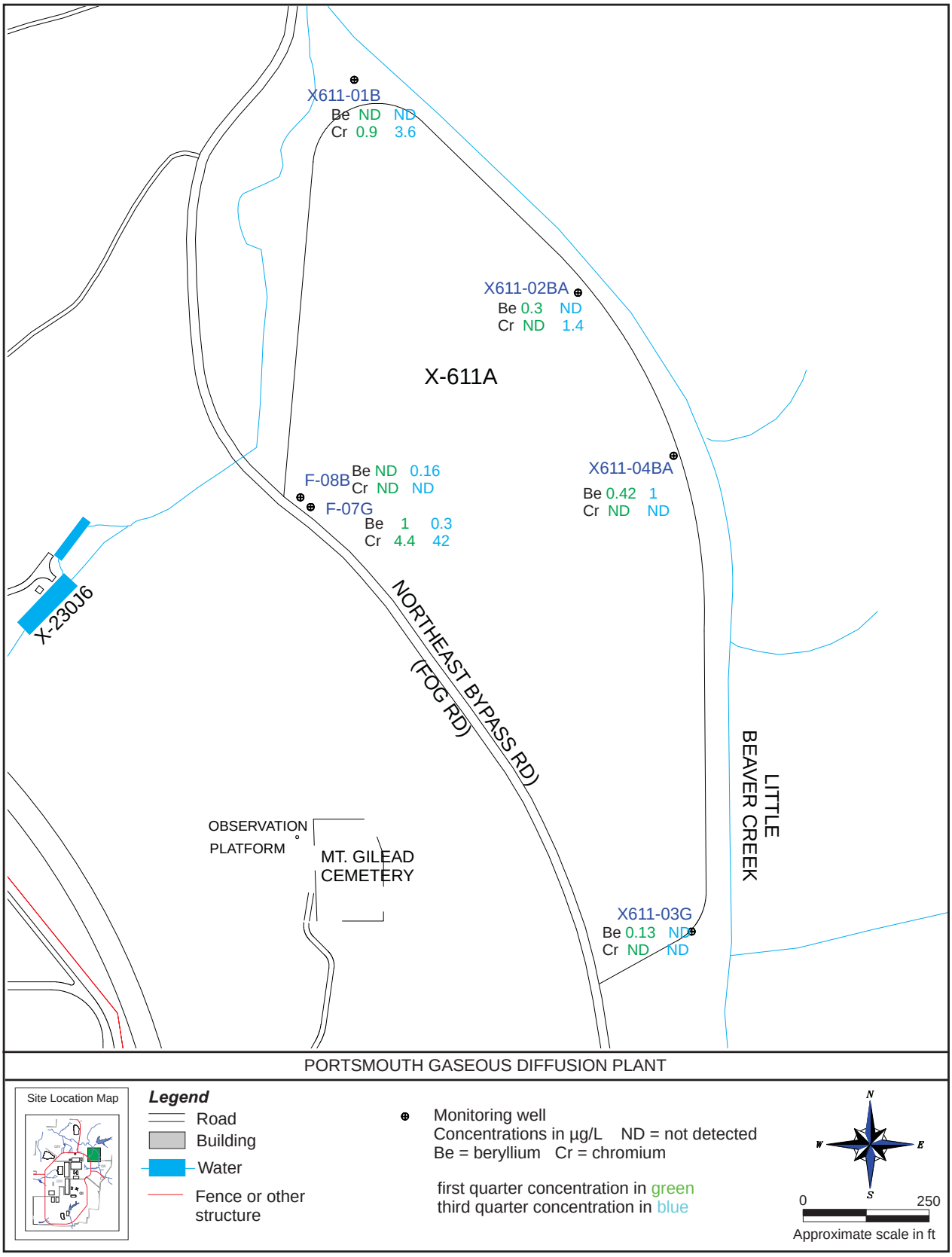

Figure 6.9. Metal concentrations in groundwater at the X-611A Former Lime Sludge Lagoons – 2016.

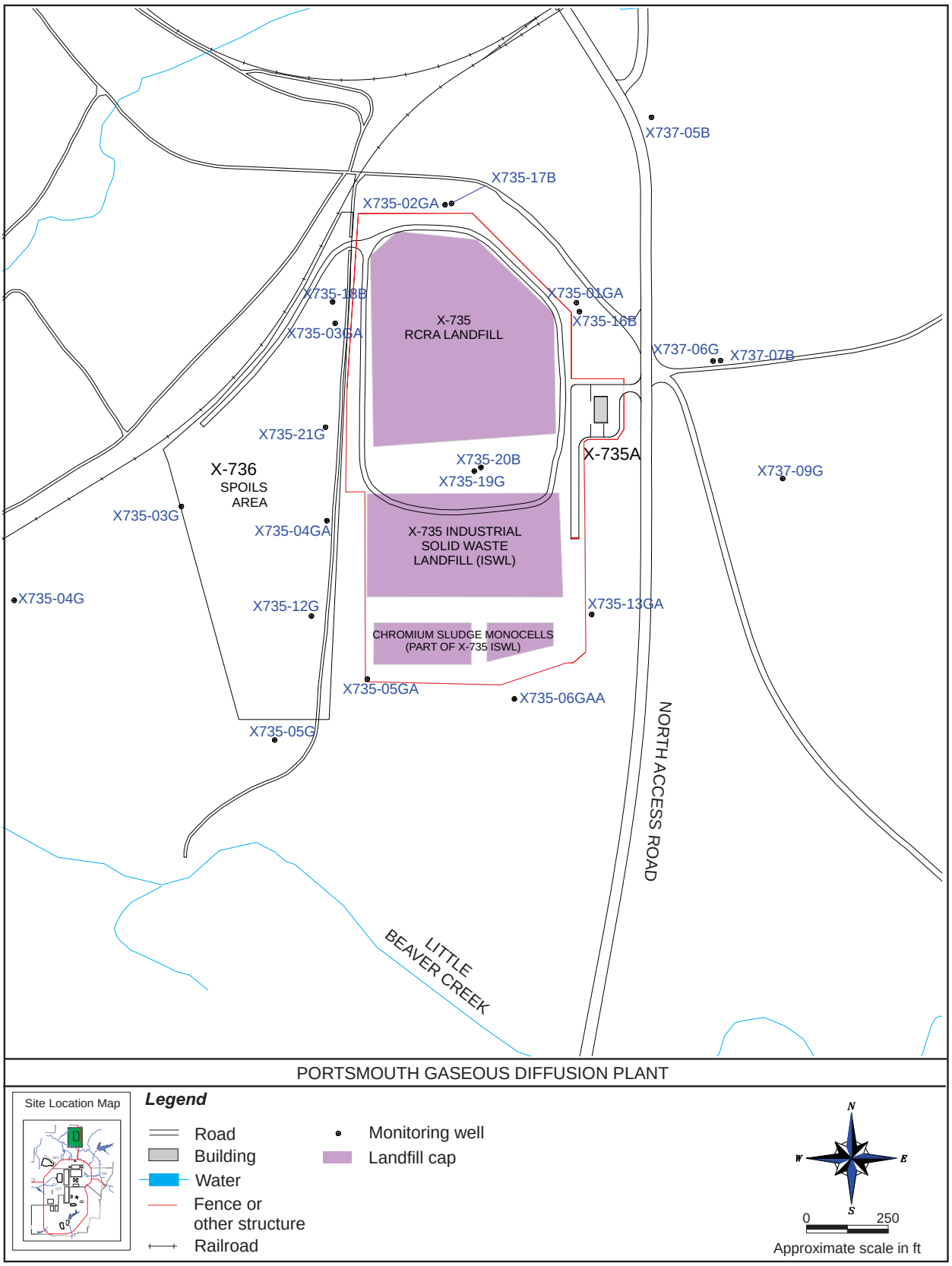

Figure 6.10. Monitoring wells at the X-735 Landfills.

6.4.11.1 Monitoring results for the X-735 Landfills in 2016

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 parameters (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 concentration limits were exceeded in 2016.

The detection monitoring program for X-735 Berea wells continued in 2016. Concentrations of alkalinity, ammonia, calcium, chloride, iron, nitrate/nitrite, potassium, sodium, and sulfate in downgradient Berea wells were evaluated to monitor potential impacts to groundwater and trends in concentrations of these parameters. 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 2016.

6.4.12 X-734 Landfills

The X-734 Landfills in Quadrant IV consisted of three landfill units that were used until 1985. Detailed records of materials disposed in the landfills were not kept. However, wastes known to be disposed at the landfills included trash and garbage, construction spoils, wood and other waste from clearing and grubbing, and empty drums. Other materials reportedly disposed in the landfills may have included waste contaminated with metals, empty paint cans, and uranium-contaminated soil from the X-342 area.

The X-734 Landfills were closed in accordance with regulations in effect at that time, and no groundwater monitoring of the area was 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. The X-734 Landfills were capped in 1999-2000 as part of the remedial actions required for Quadrant IV. Chapter 3, Section 3.3.4.2, provides more information about the remedial actions for this area.

Fifteen wells (see Figure 6.11) are sampled semiannually as part of the monitoring program for this area. Table 6.1 lists the monitoring parameters for the wells in this area.

6.4.12.1 Monitoring results for the X-734 Landfills in 2016

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 2016, 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.

6.4.13 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. The groundwater area of concern is located north of the switchyard and associated support buildings near the 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 north side of the area near the transformer cleaning pad).

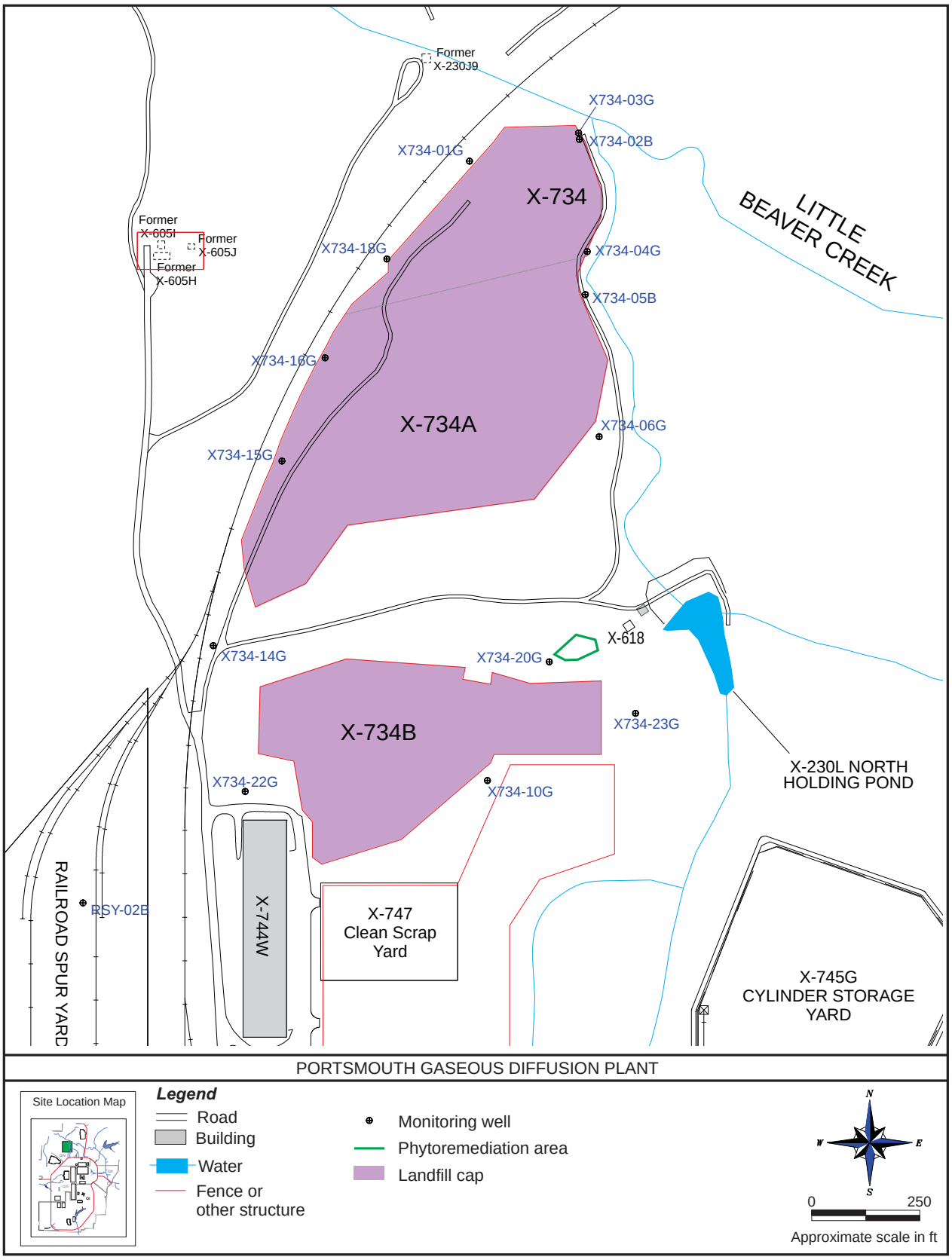

Figure 6.11. Monitoring wells at the X-734 Landfills.

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. Samples from wells in this area were collected in 1998 and 1999 to assess the area for metals contamination. The area was added to the PORTS groundwater monitoring program because the sampling identified metals that may have contaminated groundwater in this area. Three wells are sampled semiannually for cadmium and nickel.

6.4.13.1 Monitoring results for the X-533 Former Switchyard Complex in 2016

Three wells that monitor the X-533 Former Switchyard Complex (F-03G, TCP-01G, and X533-03G) were sampled in the second and fourth quarters of 2016 and analyzed for cadmium and nickel. Each of the well samples contained these metals at concentrations above the preliminary remediation goals (6.5 µg/L for cadmium and 100 µg/L for nickel). Concentrations of cadmium detected in the wells ranged from 9.5 to 53 µg/L, and concentrations of nickel detected in the wells ranged from 130 to 590 µg/L. Figure 6.6 shows the concentrations of metals detected in the X-533 wells in 2016.

6.4.14 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 (*cis*-1,2-dichloroethene and *trans*-1,2-dichloroethene) at concentrations well below the preliminary remediation goals.

This area was added to the PORTS groundwater monitoring program in 2010. One well is sampled annually for VOCs under the monitoring program for this area (see Figure 6.12).

6.4.14.1 Monitoring results for the X-344C Former Hydrogen Fluoride Storage Building in 2016

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 2016 at low concentrations of 2 µg/L or less, which are below the preliminary remediation goals. These detections are consistent with the data collected at this well in 2009 through 2015.

6.4.15 Surface Water Monitoring

Surface water monitoring is conducted in conjunction with groundwater assessment monitoring to determine if contaminants present in groundwater are detected in surface water samples. Surface water is collected quarterly from 14 locations (see Figure 6.13). Surface water samples are analyzed for the parameters listed in Table 6.1. The purpose for each surface water monitoring location is described as follows:

- Little Beaver Creek and East Drainage Ditch sample locations LBC-SW01, LBC-SW02, and EDD-SW01 assess possible X-701B area groundwater discharges.

- Little Beaver Creek sample locations LBC-SW02 and LBC-SW03 assess potential contamination from the X-611A Former Lime Sludge Lagoons.

- Big Run Creek sample location BRC-SW01 assesses potential groundwater discharges from the Quadrant I Groundwater Investigative (5-Unit) Area.

- Big Run Creek sample location BRC-SW05 monitors potential discharges from the X-749/PK Landfill groundwater collection system on the east side of the landfills, as well as the Quadrant I Groundwater Investigative (5-Unit) Area.

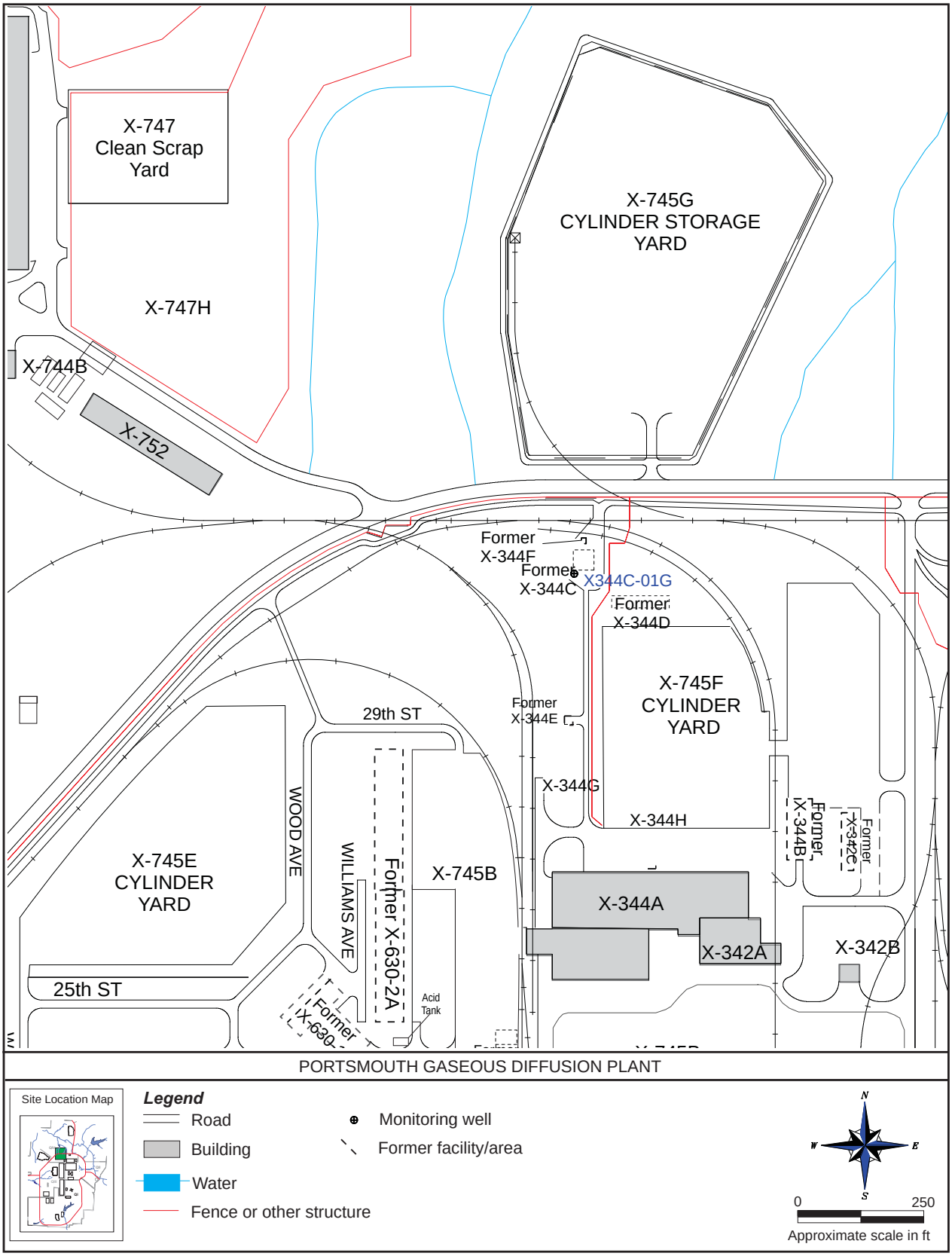

Figure 6.12. Monitoring well at the X-344C Former Hydrogen Fluoride Storage Building.

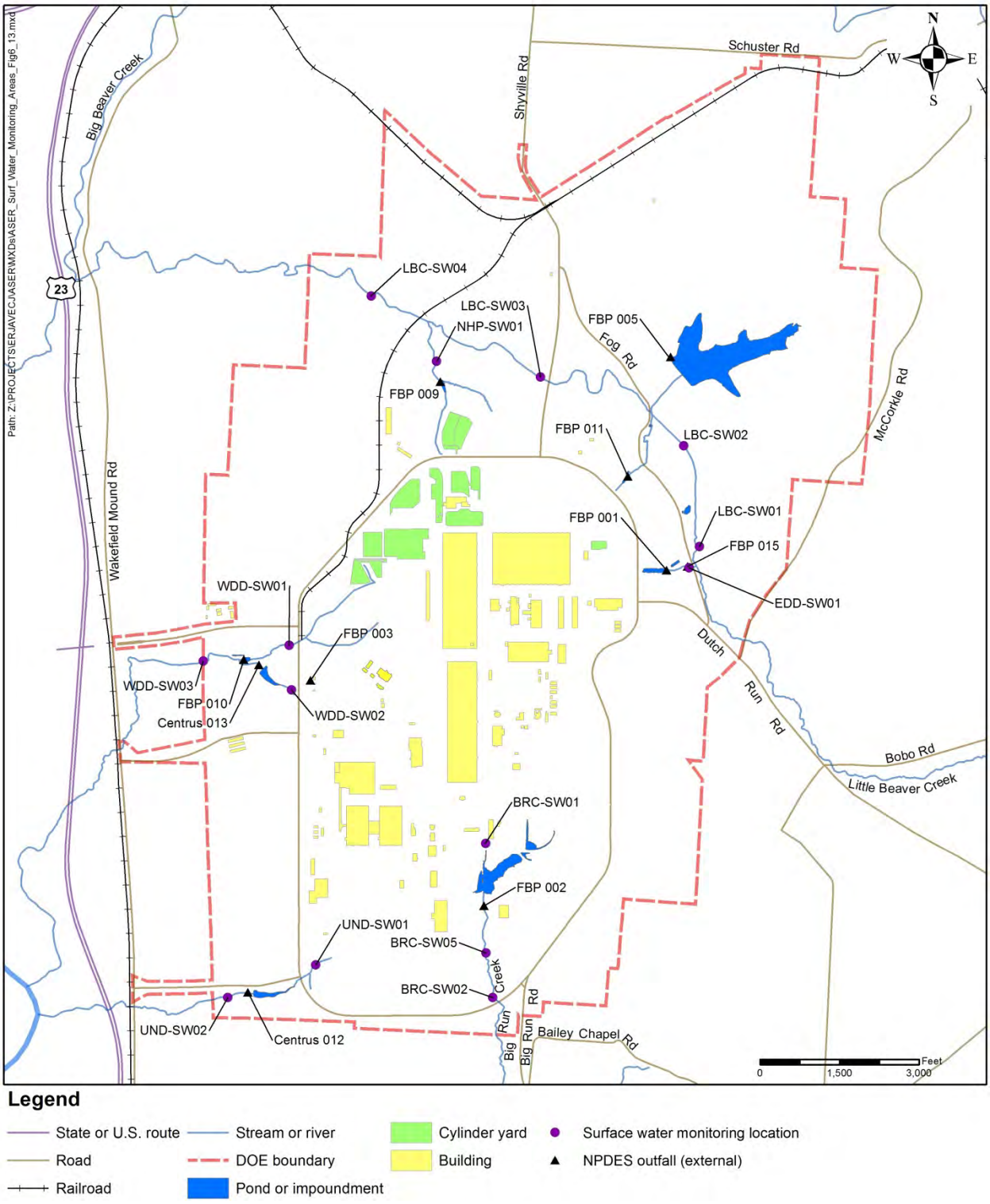

Figure 6.13. Surface water monitoring locations.

- Big Run Creek sample location BRC-SW02 (downstream from BRC-SW01 and BRC-SW05) monitors potential discharges from the Quadrant I Groundwater Investigative (5-Unit) Area, X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility, and PK Landfill.

- Southwestern Drainage Ditch sample locations UND-SW01 and UND-SW02 assess potential groundwater releases to this creek and the X-2230M Southwest Holding Pond from the western portion of the X-749/X-120 groundwater plume.

- North Holding Pond sample location NHP-SW01 and Little Beaver Creek sample location LBC-SW04 assess potential groundwater discharges from the X-734 Landfill and other Quadrant IV sources.

- Western Drainage Ditch sample locations WDD-SW01, WDD-SW02, and WDD-SW03 assess potential groundwater discharges from the X-616 and X-740 areas to the Western Drainage Ditch and the X-2230N West Holding Pond.

6.4.15.1 Monitoring results for surface water in 2016

Trihalomethanes are a category of VOCs that are byproducts of water chlorination and include bromodichloromethane, bromoform, chloroform, and dibromochloromethane. These compounds are detected at most of the surface water sampling locations because the streams receive discharges that contain chlorinated water from the PORTS NPDES outfalls. These detections were well below the Ohio EPA non-drinking water quality criteria for the protection of human health in the Ohio River drainage basin (bromodichloromethane – 460 µg/L; bromoform – 3600 µg/L; chloroform – 4700 µg/L; and dibromochloromethane – 340 µg/L).

Since the 1990s, TCE has been detected regularly at low levels in samples collected from the Southwestern Drainage Ditch (UND-SW01, located inside Perimeter Road). In 2016, TCE was detected at 1.9 to 4.4 µg/L in each of the four samples collected from the Southwestern Drainage Ditch at UND-SW01. *Cis*-1,2-dichloroethene and 1,1-dichloroethene were also detected at estimated concentrations less than 0.65 µg/L in samples collected at UND-SW01. VOCs were not detected in the samples collected from the Southwestern Drainage Ditch at UND-SW02. The detections of TCE were well below the Ohio EPA non-drinking water quality criterion for TCE (810 µg/L) for the protection of human health in the Ohio River drainage basin.

TCE and *cis*-1,2-dichloroethene were detected in samples collected from the East Drainage Ditch and Little Beaver Creek at a maximum concentration of 4.7 µg/L. TCE and other VOCs are routinely detected in East Drainage Ditch and Little Beaver Creek at low concentrations. All detections of TCE were well below the Ohio EPA non-drinking water quality criterion for TCE (810 µg/L) for the protection of human health in the Ohio River drainage basin.

Samples collected in the second and fourth quarters of 2016 were analyzed for selected transuranics (americium-241, neptunium-237, plutonium-238, and plutonium-239/240). No transuranics were detected in the surface water samples collected during 2016.

Technetium-99 was detected at levels up to 36 pCi/L in samples collected from the East Drainage Ditch (EDD-SW01) and Little Beaver Creek (LBC-SW01, LBC-SW02, LBC-SW03, and LBC-SW04). These detections are within the historical range of technetium-99 detected in surface water at PORTS, and are 0.08% or less of derived concentration standard for technetium-99 in water (44,000 pCi/L – DOE 2011a).

The concentrations of uranium detected in the surface water samples were less than 1% of the DOE derived concentration standards for uranium isotopes (680 pCi/L for uranium-233/234, 720 pCi/L for

uranium-235, and 750 pCi/L for uranium-238) (DOE 2011a). The detections of uranium and uranium isotopes in surface water during 2016 were within the historical range of uranium detected in surface water at PORTS.

6.4.16 Water Supply Monitoring

Routine monitoring of private residential drinking water sources is completed at PORTS in accordance with the requirements of Section VIII of the September 1989 Consent Decree between the State of Ohio and DOE and the *Integrated Groundwater Monitoring Plan* (DOE 2015b).

The purpose of the program is to determine whether PORTS has had any impact on the quality of the private residential drinking water sources. Although this program may provide an indication of contaminant transport off site, it should not be interpreted as an extension of the on-site groundwater monitoring program, which bears the responsibility for detection of contaminants and determining the rate and extent of contaminant movement. 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 water sources participated in the program in 2016. Two residential drinking water sources that are included in the water supply monitoring program (RES-004 and RES-005) were not able to be sampled in 2016 because the well pumps were not operable. The PORTS water supply is also sampled as part of this program. Figure 6.14 shows the drinking water sources that were part of the monitoring program in 2016. Sampling locations may be added or deleted if requested by a resident and as program requirements dictate. Typically, sampling locations are deleted when a resident obtains a public water supply. Wells are sampled semiannually with samples analyzed for the parameters listed in Table 6.1.

In the first and third quarters of 2016, TCE was detected at estimated concentrations ranging from 0.19 to 0.38 µg/L in the samples collected from RES-017, which is south of PORTS on Big Run Road. No other VOCs were detected in the samples at this location. Since this residential water supply was added to the monitoring program in 2009, TCE has routinely been detected in the water supply samples at concentrations up to 1 µg/L. These detections are less than the drinking water standard for TCE (5 µg/L). Big Run Creek is located between RES-017 and the affected water-bearing formation (i.e., Gallia groundwater) located in the southern portion of the plant site west of Big Run Creek. The Gallia groundwater drains into Big Run Creek.

Chlorination byproducts called trihalomethanes (bromodichloromethane, bromoform, chloroform, and dibromochloromethane), which are common residuals in treated drinking water, were detected in the first and third quarter samples collected from residential sampling location RES-015. The total concentration of these trihalomethanes was less than the Ohio EPA drinking water standard (80 µg/L for total trihalomethanes).

Each sample was analyzed for transuranics (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, uranium, and uranium isotopes (uranium-233/234, uranium-235/236, and uranium-238). No transuranics or technetium-99 were detected in any of the water supply samples collected in 2016. Low levels of uranium and uranium isotopes detected in some of the wells are consistent with naturally-occurring concentrations found in groundwater in the area.

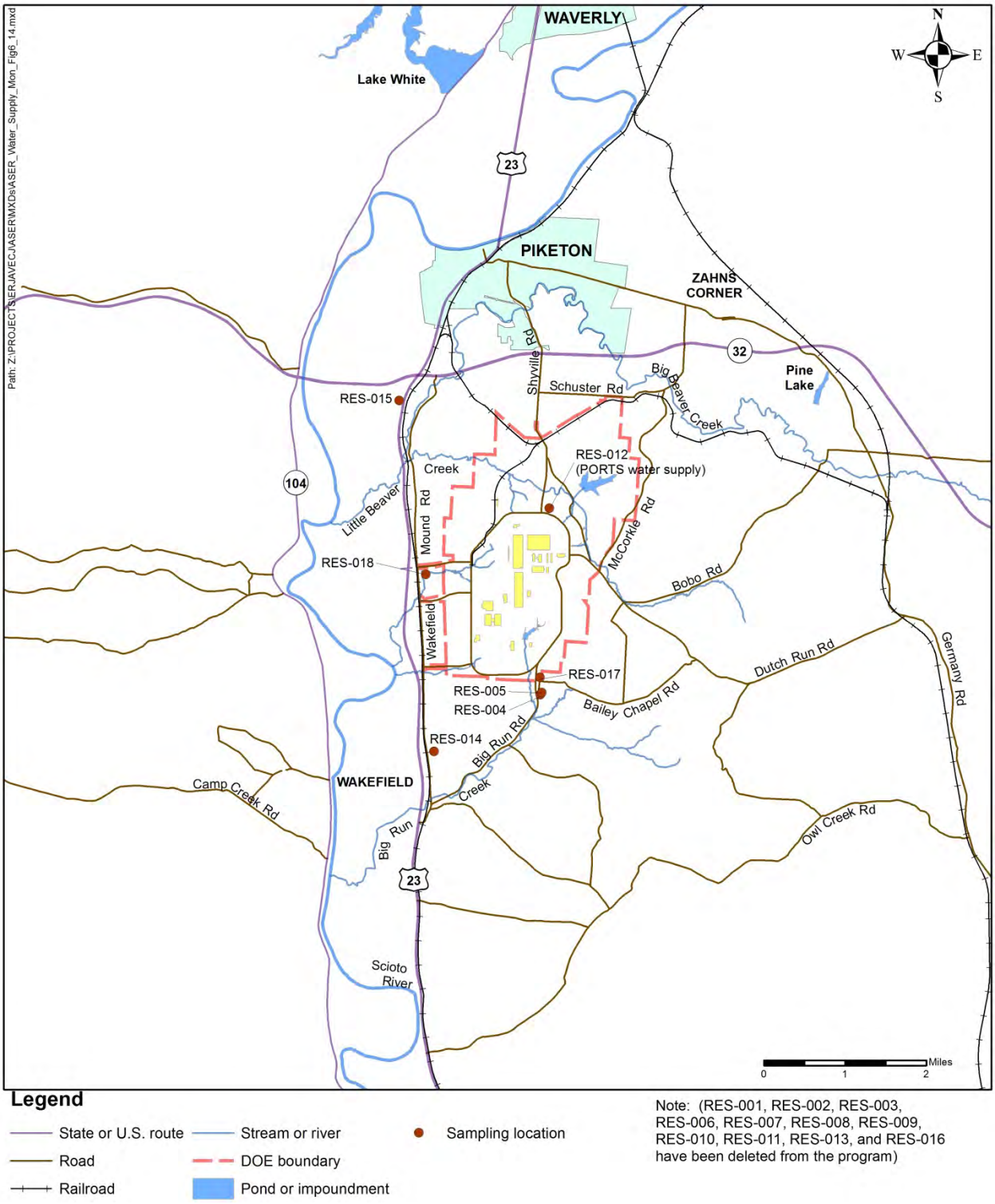

Figure 6.14. Water supply monitoring locations.

6.5 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.

6.5.1 Exit Pathway Monitoring

Selected locations on local streams and drainage channels near the PORTS boundary are sampling points of the exit pathway monitoring program because surface water from PORTS NPDES outfalls and groundwater discharge to these surface waters. Monitoring wells near the PORTS boundary are also used in the exit pathway monitoring program. Figure 6.15 shows the sampling locations for exit pathway monitoring and Table 6.1 lists the analytical parameters.

Surface water sampling points on Big Run Creek (BRC-SW02), Little Beaver Creek (LBC-SW04), Southwestern Drainage Ditch (UND-SW02), and Western Drainage Ditch (WDD-SW03) are part of the exit pathway monitoring program (see Figure 6.13). Trihalomethanes (bromodichloromethane, bromoform, chloroform, and dibromochloromethane), which are common residuals in chlorinated drinking water, were detected in samples collected from the Western Drainage Ditch at concentrations well below Ohio EPA non-drinking water quality criteria for trihalomethanes for the protection of human health in the Ohio River drainage basin (see Section 6.4.15.1).

Technetium-99 was detected at 12 pCi/L in the first quarter sample collected at the surface water exit pathway monitoring location on Little Beaver Creek (LBC-SW04). This detection was 0.03% of the derived concentration standard for technetium-99 in water (44,000 pCi/L – DOE 2011a).

VOCs were also detected in several on-site groundwater monitoring wells that are part of the exit pathway monitoring program. TCE and other VOCs were detected in several wells that monitor the X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility (see Section 6.4.1.3). Detections of TCE and other VOCs in the exit pathway monitoring wells were below Ohio EPA drinking water standards.

Only groundwater monitoring well X701-48G was sampled for radionuclides in 2016 (most exit pathway monitoring wells are sampled for radionuclides every two years in odd-numbered years). No radionuclides (americium-241, neptunium-237, plutonium-238, plutonium-239/240, technetium-99, uranium, uranium-233/234, uranium-235/236, and uranium-238) were detected in well X701-48G in 2016.

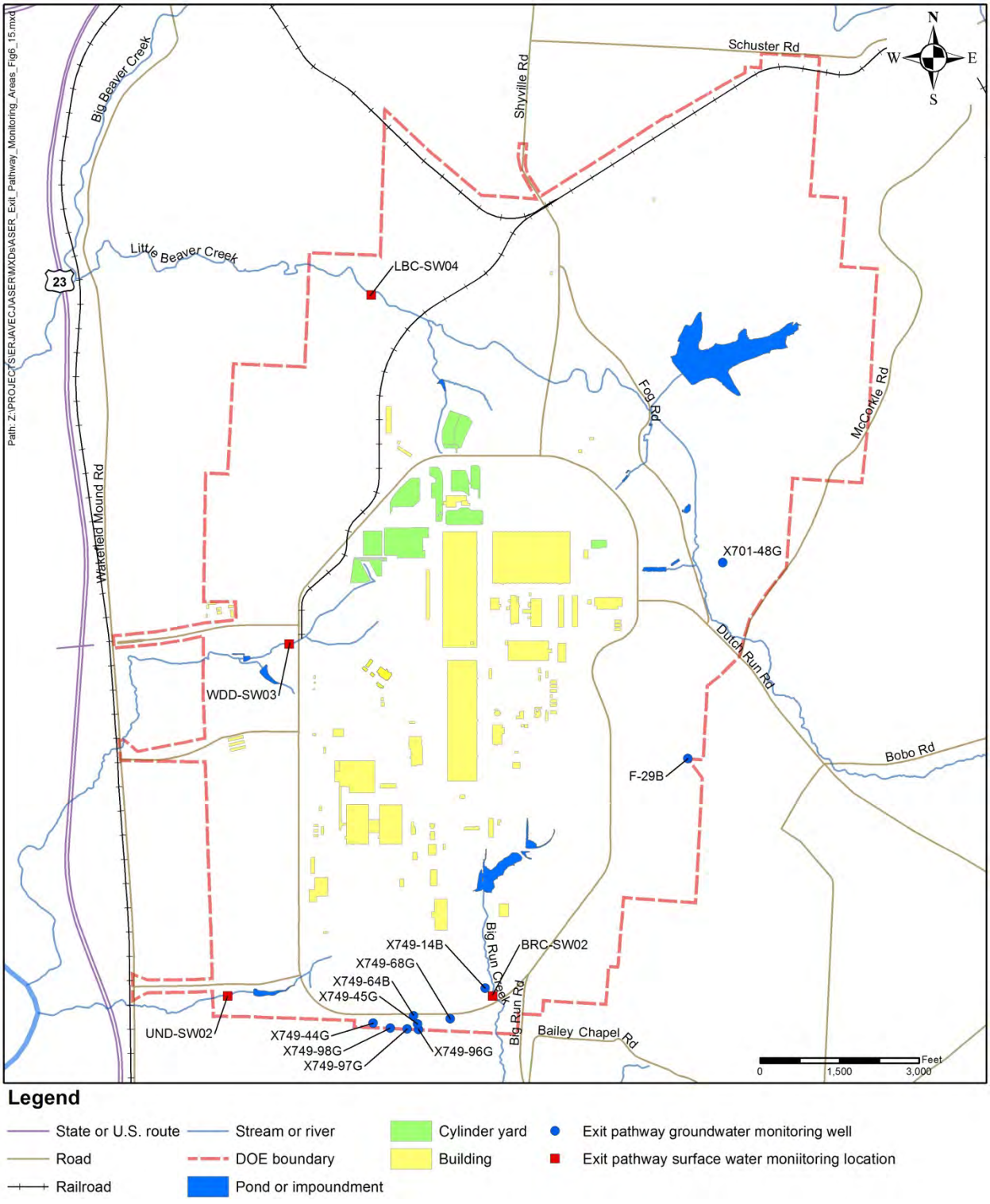

Figure 6.15. Exit pathway monitoring locations.

6.6 GROUNDWATER TREATMENT FACILITIES

In 2016, a combined total of approximately 32.7 million gallons of water were treated at the X-622, X-623, X-624, and X-627 Groundwater Treatment Facilities. Approximately 20 gallons of TCE were removed from the water. All processed water is discharged through NPDES outfalls before exiting PORTS. Facility information is summarized in Table 6.2.

Table 6.2. Summary of TCE removed by PORTS groundwater treatment facilities in 2016[a]

Facility	Gallons of water treated	Gallons of TCE removed
X-622	18,876,900	1.7
X-623	28,140	< 0.001
X-624	2,805,800	8.6
X-627	10,938,485	9.5

[a]Source: *2016 Groundwater Monitoring Report for the Portsmouth Gaseous Diffusion Plant* (DOE 2017a)

6.6.1 X-622 Groundwater Treatment Facility

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

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

The facility processed approximately 18.9 million gallons of groundwater during 2016, thereby removing approximately 1.7 gallons of TCE from the water. Treated water from the facility discharges through FBP NPDES Outfall 608, which flows to the X-6619 Sewage Treatment Plant (FBP NPDES Outfall 003). No NPDES permit limitations were exceeded at Outfall 608 in 2016.

6.6.2 X-623 Groundwater Treatment Facility

The X-623 Groundwater Treatment Facility consists of an air stripper with offgas activated carbon filtration and aqueous-phase activated carbon filtration. Prior to implementation of the X-701B IRM in 2009, the X-623 Groundwater Treatment Facility treated TCE-contaminated groundwater from a sump in the bottom of the X-701B Former Holding Pond and three groundwater extraction wells (X623-EW01G, X623-EW02G, and X623-EW03G) east of the holding pond. The sump and extraction wells were removed in 2009-2011 to facilitate implementation of the IRM.

During 2016, the X-623 Groundwater Treatment Facility operated intermittently to treat miscellaneous water associated with site activities in accordance with the NPDES permit. The X-623 Groundwater Treatment Facility did not operate in February, April, May, July, October, and November of 2016.

The facility treated 28,140 gallons of water during 2016, thereby removing less than 0.001 gallon of TCE from the water. Treated water from the facility discharges through FBP NPDES Outfall 610, which flows to the X-6619 Sewage Treatment Plant (FBP NPDES Outfall 003). No NPDES permit limitations were exceeded at Outfall 610 in 2016.

6.6.3 X-624 Groundwater Treatment Facility

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

The X-624 Groundwater Treatment Facility treated approximately 2.8 million gallons of water in 2016, thereby removing approximately 8.6 gallons of TCE from the water. Treated water from the facility discharges through FBP NPDES Outfall 015, which discharges to Little Beaver Creek. No NPDES permit limitations were exceeded at Outfall 015 in 2016.

6.6.4 X-627 Groundwater Treatment Facility

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

Almost 11 million gallons of groundwater were processed during 2016, thereby removing approximately 9.5 gallons of TCE from the water. Treated water from the facility discharges through FBP NPDES Outfall 611, which flows to the X-6619 Sewage Treatment Plant (FBP NPDES Outfall 003). No NPDES permit limitations were exceeded at Outfall 611 in 2016.

7. QUALITY ASSURANCE

7.1 SUMMARY

Quality assurance and quality control are essential components of DOE environmental monitoring programs at PORTS. Quality is integrated into sample preservation, field data and sample collection, sample transportation, and sample analysis. Numerous program assessment activities in the field and within the facilities are conducted at regular intervals to demonstrate that quality is built into and maintained in all DOE programs. Analytical laboratories used by DOE contractors during 2016 participated in the DOE Consolidated Audit Program and Mixed-Analyte Performance Evaluation Program.

7.2 QUALITY ASSURANCE INTRODUCTION

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

- implementation of standard operating procedures for sample collection and analysis;
- training and qualification of surveyors and analysts;
- implementation of sample tracking and chain-of-custody procedures to demonstrate traceability and integrity of samples and data;
- participation in external quality control programs;
- frequent calibration and routine maintenance of measuring and test equipment;
- maintenance of internal quality control programs;
- implementation of good measurement techniques and good laboratory practices; and
- frequent assessments of field sampling, measurement activities, and laboratory processes.

Environmental sampling is conducted by DOE contractors at PORTS in accordance with state and federal regulations and DOE Orders. Sampling plans and procedures are prepared, and appropriate sampling instruments or devices are selected in accordance with practices recommended by U.S. EPA, the American Society for Testing and Materials, or other authorities. Chain-of-custody forms document sample custody from sample collection through receipt by the analytical laboratory. The samples remain in the custody of the sampling group until the samples are received at the laboratory. Samples shipped to an off-site laboratory are sealed within the shipping container to prevent tampering until they are received by the sample custodian at the off-site laboratory.

The analytical data are reviewed to determine compliance with applicable regulations and permits. The data are used to identify locations and concentrations of contaminants of concern, to evaluate the rate and extent of contamination at the site, and to help determine the need for remedial action. Adequate and complete documentation generated as a result of these efforts supports the quality standards established by DOE. Quality Assurance Project Plans were used by FBP and BWCS during 2016 to ensure a consistent system for collecting, assessing, and documenting environmental data of known and documented quality.

7.3 FIELD SAMPLING AND MONITORING

Personnel involved in field sampling and monitoring are properly trained through a combination of classroom, on-line, and/or on-the-job training as required by environmental, health, and safety regulations and DOE contract requirements. Procedures are developed from guidelines and regulations created by DOE or other regulatory agencies that have authority over PORTS activities. These procedures specify sampling protocol, sampling devices, containers, and preservatives to be used. Chain-of-custody procedures (used with all samples) are documented, and samples are controlled and protected from the point of collection to the generation of analytical results.

Data generated from field sampling can be greatly influenced by the methods used to collect and transport the samples. A quality assurance program provides the procedures for proper sample collection so that the samples represent the conditions that exist in the environment at the time of sampling. The DOE quality assurance program at PORTS mandates compliance with written sampling procedures, use of clean sampling devices and containers, use of approved sample preservation techniques, and collection of field blanks, trip blanks, and duplicate samples. Chain-of-custody procedures are strictly followed to maintain sample integrity. In order to maintain sample integrity, samples are delivered to the laboratory as soon as practicable after collection.

7.4 ANALYTICAL QUALITY ASSURANCE

DOE contractors at PORTS only use analytical laboratories that demonstrate compliance in the following areas through participation in independent audits and surveillance programs:

- compliance with federal waste disposal regulations,
- data quality,
- materials management,
- sample control,
- data management,
- electronic data management,
- implementation of a laboratory quality assurance plan, and
- review of external and internal performance evaluation program.

After analytical laboratory data are received by DOE contractors, they are independently evaluated using a systematic process that compares the data to established quality assurance/quality control criteria. An independent data validator checks documentation produced by the analytical laboratory to verify that the laboratory has provided data that meet established criteria.

In 2016, samples collected for DOE environmental monitoring programs at PORTS such as NPDES monitoring, groundwater monitoring required by the *Integrated Groundwater Monitoring Plan* (DOE 2015b), and environmental monitoring required by the *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (DOE 2013a), were sent to analytical laboratories that participated in DOE programs to ensure data quality. The DOE Consolidated Audit Program implements annual performance qualification audits of environmental laboratories. The DOE Mixed-Analyte Performance Evaluation Program provides semiannual performance testing and evaluation of analytical laboratories.

8. REFERENCES

American Nuclear Society 1986. *Glossary of Terms in Nuclear Science and Technology*, LaGrange Park, IL.

Biological Effects of Ionizing Radiations 1990. *Health Effects of Exposure to Low Levels of Ionizing Radiation*, Committee on the Biological Effects of Ionizing Radiations (BEIR V), National Research Council, National Academy of Sciences, National Academy Press, Washington, D.C.

DOE 1995. Memorandum, Pelletier to Pearson: *Requirements for Control of Settleable Solids*, Air, Water and Radiation Division: EH-412, Washington D.C., December 6.

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

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

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

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

DOE 2002a. *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*, DOE-STD-1153-2002, U.S. Department of Energy, Washington, D.C., July.

DOE 2002b. *X-611A Prairie and X-749B Peter Kiewit Landfill Five-Year Evaluation Report for the Portsmouth Gaseous Diffusion Plant*, DOE/OR/11-3110&D1, U.S. Department of Energy, Piketon, OH, August.

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

DOE 2007a. *Corrective Measures Plan for the X-735 Landfill at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio*, DOE/PPPO/03-0019&D4, U.S. Department of Energy, Piketon, OH, October.

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

DOE 2008a. *First Five-Year Review for the Five-Unit Groundwater Investigative Area and X-231A/ X-231B Oil Biodegradation Plots at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio*, DOE/PPPO/03-0054&D2, U.S. Department of Energy, Piketon, OH, April.

DOE 2008b. *First Five-Year Review for the X-734 Landfill Area at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio,* DOE/PPPO/03-0073&D2, U.S. Department of Energy, Piketon, OH, December.

DOE 2008c. *Second Five-Year Review for the X-611A Prairie at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio,* DOE/PPPO/03-0072&D2, U.S. Department of Energy, Piketon, OH, December.

DOE 2008d. *Second Five-Year Review for the X-749B Peter Kiewit Landfill at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio,* DOE/PPPO/03-0053&D2, U.S. Department of Energy, Piketon, OH, March.

DOE 2010. *Community Relations Plan for the U.S. Department of Energy's Decontamination and Decommissioning Project at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio,* DOE/PPPO/03-0128&D1, U.S. Department of Energy, Piketon, OH, June.

DOE 2011a. *Derived Concentration Technical Standard,* DOE-STD-1196-2011, U.S. Department of Energy, Washington, D.C., April.

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

DOE 2012. *Addendum to the Community Relations Plan for the U.S. Department of Energy's Decontamination and Decommissioning Project at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio,* DOE/PPPO/03-0128&D2/A1, U.S. Department of Energy, Piketon, OH, September.

DOE 2013a. *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio,* DOE/PPPO/03-0009&D4, U.S. Department of Energy, Piketon, OH, February.

DOE 2013b. *Second Five-Year Review for the Five-Unit Groundwater Investigative Area and X-231A/ X-231B Oil Biodegradation Plots at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio,* DOE/PPPO/03-0490&D1, U.S. Department of Energy, Piketon, OH, September.

DOE 2013c. *Second Five-Year Review for the X-734 Landfill Area at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio,* DOE/PPPO/03-0559&D1, U.S. Department of Energy, Piketon, OH, December.

DOE 2013d. *Third Five-Year Review for the X-611A Prairie at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio,* DOE/PPPO/03-0482&D2, U.S. Department of Energy, Piketon, OH, July.

DOE 2013e. *Third Five-Year Review for the X-749B Peter Kiewit Landfill at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio,* DOE/PPPO/03-0489&D1, U.S. Department of Energy, Piketon, OH, September.

DOE 2014. *Final Report for the 7-Unit Interim Remedial Measure at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio,* DOE/PPPO/03-0606&D1, U.S. Department of Energy, Piketon, OH, October.

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

DOE 2015b. *Integrated Groundwater Monitoring Plan for the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio,* DOE/PPPO/03-0032&D8, U.S. Department of Energy, Piketon, OH, July.

DOE 2015c. *Methods for Conducting Human Health Risk Assessments and Risk Evaluations at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio,* DOE/PPPO/03-0127&D8, U.S. Department of Energy, Piketon, OH, October.

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

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

DOE 2015f. *Remedial Design/Remedial Action Work Plan for the On-site Waste Disposal Facility Initial Site Preparation and Construction Activities at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio,* DOE/PPPO/03-0691&D1, U.S. Department of Energy, Piketon, OH, September.

DOE 2016a. *Addendum to Remedial Design/ Remedial Action Work Plan for On-site Waste Disposal Facility Initial Site Preparation and Construction Activities at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio, Phase II Initial Site Construction – Addendum,* DOE/PPPO/03-0691&D1/A1, U.S. Department of Energy, Piketon, OH, September.

DOE 2016b. *Final Report for the X-740 Pilot Study at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio,* DOE/PPO/03-0748&D1, U.S. Department of Energy, Piketon, OH, May.

DOE 2016c. *Fiscal Year 2017 Site Sustainability Plan for the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio,* DOE/PPPO/03-0742&D1, U.S. Department of Energy, Piketon, OH, December.

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

DOE 2016e. *Second Five-Year Review for the X-749/X-120 Groundwater Plume at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio,* DOE/PPPO/03-0756&D1, U.S. Department of Energy, Piketon, OH, June.

DOE 2017a. *2016 Groundwater Monitoring Report for the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio,* DOE/PPPO/03-0786&D1, U.S. Department of Energy, Piketon, OH, March.

DOE 2017b. *Deferred Units Resource Conservation and Recovery Act Facility Investigation/Corrective Measures Study Report at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio,* DOE/PPPO/03-0772&D1, U.S. Department of Energy, Piketon, OH, September.

Hamby, D. M. 1991. *LADTAP XL: An Improved Electronic Spreadsheet Version of LADTAP II,* DE93003179, Westinghouse Savannah River Company, Aiken, SC.

Health Physics Society 2010. *Environmental Radiation* (Fact Sheet – Adopted January 2010), available at www.hps.org (accessed March 2, 2016).

Jannik and Dixon 2006. *LADTAP-PA: A Spreadsheet for Estimating Dose Resulting from E-Area Groundwater Contamination at the Savannah River Site*, Savannah River National Laboratory, Aiken, SC.

McGraw-Hill 1989. *McGraw-Hill Dictionary of Scientific and Technical Terms*, 4th ed., McGraw-Hill, Inc., NY.

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

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

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

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

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

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

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

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

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

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

Ohio EPA 2017. *Ohio Sport Fish Consumption Advisory*, Ohio EPA Division of Surface Water, Columbus, OH, April.

U.S. Census Bureau 2017. U.S. Census Bureau, www.census.gov, population estimates for 2016, (accessed June 15, 2017).

U.S. EPA 1988. *Federal Guidance Report No. 11 (FGR 11) Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Immersion, and Ingestion*, EPA-520/1-88-020, U.S. Environmental Protection Agency, Washington, D.C.

U.S. EPA 1997. *Exposure Factors Handbook*, EPA/600/P-95/002Fa, U.S. Environmental Protection Agency, Washington, D.C.

U.S. EPA 2017. Regional Screening Level (RSL) Summary Table (TR=1E-06, HQ=1) June 2017, Screening level for PCB-1254/PCB-1260 in residential soil, www.epa.gov/risk/risk-based-screening-table-generic-tables (accessed November 3, 2017).

Westinghouse Savannah River Company 1994. *Savannah River Site Environmental Report for 1993, Summary Pamphlet*, Savannah River, GA.

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APPENDIX A

RADIATION

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This appendix presents basic facts concerning radiation. The information is intended as a basis for understanding the dose associated with releases from PORTS, not as a comprehensive discussion of radiation and its effects on the environment and biological systems. *The McGraw-Hill Dictionary of Scientific and Technical Terms* defines radiation and radioactivity as follows:

> *radiation*—1) The emission and propagation of waves transmitting energy through space or through some medium; for example, the emission and propagation of electromagnetic, sound, or elastic waves. 2) The energy transmitted through space or some medium; when unqualified, usually refers to electromagnetic radiation. Also known as radiant energy. 3) A stream of particles, such as electrons, neutrons, protons, alpha particles, or high-energy photons, or a mixture of these (McGraw-Hill 1989).
>
> *radioactivity*—A particular type of radiation emitted by a radioactive substance, such as alpha radioactivity (McGraw-Hill 1989).

Radiation occurs naturally; it was not invented but discovered. People are constantly exposed to radiation. For example, radon in air, potassium in food and water, and uranium, thorium, and radium in the earth's crust are all sources of radiation. The following discussion describes important aspects of radiation, including atoms and isotopes; types, sources, and pathways of radiation; radiation measurement; and dose information.

A.1 ATOMS AND ISOTOPES

All matter is made up of atoms. An atom is "a unit of measure consisting of a single nucleus surrounded by a number of electrons equal to the number of protons in the nucleus" (American Nuclear Society 1986). The number of protons in the nucleus determines an element's atomic number, or chemical identity. With the exception of hydrogen, the nucleus of each type of atom also contains at least one neutron. Unlike protons, the number of neutrons may vary among atoms of the same element. The number of neutrons and protons determines the atomic weight. Atoms of the same element with a different number of neutrons are called isotopes. In other words, isotopes have the same chemical properties but different atomic weights. Figure A.1 depicts isotopes of the element hydrogen.

Another example is the element uranium, which has 92 protons; all isotopes of uranium, therefore, have 92 protons. However, each uranium isotope has a different number of neutrons. Uranium-238 (also denoted ^{238}U) has 92 protons and 146 neutrons; uranium-235 has 92 protons and 143 neutrons; uranium-234 has 92 protons and 142 neutrons.

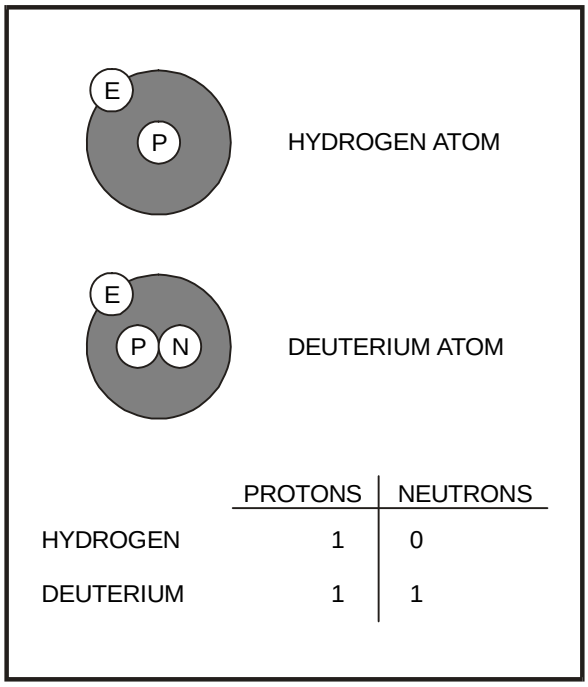

Figure A.1. Isotopes of the element hydrogen

Some isotopes are stable, or nonradioactive; some are radioactive. Radioactive isotopes are called radioisotopes, or radionuclides. In an attempt to become stable, radionuclides "throw away," or emit, rays or particles. This emission of rays and particles is known as radioactive decay. Each radionuclide has a "radioactive half-life," which is the average time that it takes for half of a specified number of atoms to decay. Half-lives can be very short (less than a second) or very long (millions of years), depending on the radionuclide. Appendix C presents the half-lives of radionuclides of interest at PORTS.

A.2 RADIATION

Radiation, or radiant energy, is energy in the form of waves or particles moving through space. Visible light, heat, radio waves, and alpha particles are examples of radiation. When people feel warmth from the sunlight, they are actually absorbing the radiant energy emitted by the sun.

Electromagnetic radiation is radiation in the form of electromagnetic waves; examples include gamma rays, ultraviolet light, and radio waves. Particulate radiation is radiation in the form of particles; examples include alpha and beta particles. Radiation also is characterized as ionizing or nonionizing radiation by the way in which it interacts with matter.

A.2.1 Ionizing Radiation

Normally, an atom has an equal number of protons and electrons; however, atoms can lose or gain electrons in a process known as ionization. Some forms of radiation can ionize atoms by "knocking" electrons off atoms. Examples of ionizing radiation include alpha, beta, and gamma radiation.

Ionizing radiation is capable of changing the chemical state of matter and subsequently causing biological damage and thus is potentially harmful to human health. Figure A.2 shows the penetrating potential of different types of ionizing radiation.

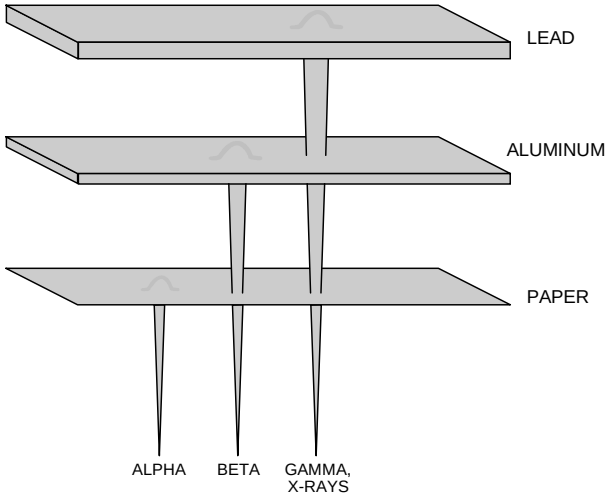

Figure A.2. Penetrating power of radiation.

A.2.2 Nonionizing Radiation

Nonionizing radiation bounces off or passes through matter without displacing electrons. Examples include visible light and radio waves. Currently, it is unclear whether nonionizing radiation is harmful to human health. In the discussion that follows, the term radiation is used to describe ionizing radiation.

A.3 SOURCES OF RADIATION

Radiation is everywhere. Most occurs naturally, but a small percentage is human-made. Naturally occurring radiation is known as background radiation.

A.3.1 Background Radiation

Many materials are naturally radioactive. In fact, this naturally occurring radiation is the major source of radiation in the environment. Although people have little control over the amount of background radiation to which they are exposed, this exposure must be put into perspective. Background radiation remains relatively constant over time; background radiation present in the environment today is much the same as it was hundreds of years ago.

Sources of background radiation include uranium in the earth, radon in the air, and potassium in food. Background radiation is categorized as space, terrestrial, or internal, depending on its origin.

A.3.1.1 Space radiation

Energetically charged particles from outer space continuously hit the earth's atmosphere. These particles and the secondary particles and photons they create are called space or cosmic radiation. Because the atmosphere provides some shielding against space radiation, the intensity of this radiation increases with altitude above sea level. For example, a person in Denver, Colorado, is exposed to more space radiation than a person in Death Valley, California.

A.3.1.2 Terrestrial radiation

Terrestrial radiation refers to radiation emitted from radioactive materials in the earth's rocks, soils, and minerals. Radon (Rn); radon progeny, the relatively short-lived decay products of radium-226 (^{226}Ra); potassium (^{40}K); isotopes of thorium (Th); and isotopes of uranium (U) are the elements responsible for most terrestrial radiation.

A.3.1.3 Internal radiation

Radioactive material in the environment can enter the body through the air people breathe and the food they eat; it also can enter through an open wound. Natural radionuclides that can be inhaled and ingested include isotopes of uranium, thorium, radium, radon, polonium, bismuth, and lead in the ^{238}U and ^{232}Th decay series. In addition, the body contains isotopes of potassium (^{40}K), rubidium (^{87}Rb), and carbon (^{14}C).

A.3.2 Human-made Radiation

Most people are exposed to human-made sources of radiation. Examples include consumer products, medical sources, and industrial or occupational sources. About one-half of 1% of the U.S. population performs work in which radiation in some form is present. Atmospheric testing of atomic weapons was a source of human-made radiation, but testing has been suspended in the United States and most parts of the world. Fallout from atmospheric weapons testing is not currently a significant contributor to background radiation (Health Physics Society 2010).

A.3.2.1 Consumer products and activities

Some consumer products are sources of radiation. In some consumer products, such as smoke detectors, watches, or clocks, radiation is essential to the performance of the device. In other products or activities, such as smoking tobacco products or building materials, the radiation occurs incidentally to the product function. Commercial air travel is another consumer activity that results in exposure to radiation (from space radiation).

A.3.2.2 Medical sources

Radiation is an important tool of diagnostic medicine and treatment, and, in this use, is the main source of exposure to human-made radiation. Exposure is deliberate and directly beneficial to the patients exposed. Generally, medical exposures result from beams directed to specific areas of the body. Thus, all body organs generally are not irradiated uniformly. Radiation and radioactive materials are also used in a wide variety of pharmaceuticals and in the preparation of medical instruments, including the sterilization of heat-sensitive products such as plastic heart valves. Nuclear medicine examinations and treatment involve the internal administration of radioactive compounds, or radiopharmaceuticals, by injection, inhalation, consumption, or insertion. Even then, radionuclides are not distributed uniformly throughout the body.

A.3.2.3 Industrial and occupational sources

Other sources of radiation include emissions of radioactive materials from nuclear facilities such as uranium mines, fuel processing plants, and nuclear power plants; emissions from mineral extraction facilities; and the transportation of radioactive materials. Workers in certain occupations may also be

exposed to radiation due to their jobs. These occupations include positions in medicine, aviation, research, education, and government.

A.4 PATHWAYS OF RADIATION

Radiation and radioactive materials in the environment can reach people through many routes (see Figure A.3). Potential routes for radiation are referred to as pathways. For example, radioactive material in the air could fall on a pasture. The grass could then be eaten by cows, and the radioactive material on the grass would be present in the cow's milk. People drinking the milk would thus be exposed to this radiation. Or people could simply inhale the radioactive material in the air. The same events could occur with radioactive material in water. Fish living in the water would be exposed; people eating the fish would then be exposed to the radiation in the fish. Or people swimming in the water would be exposed.

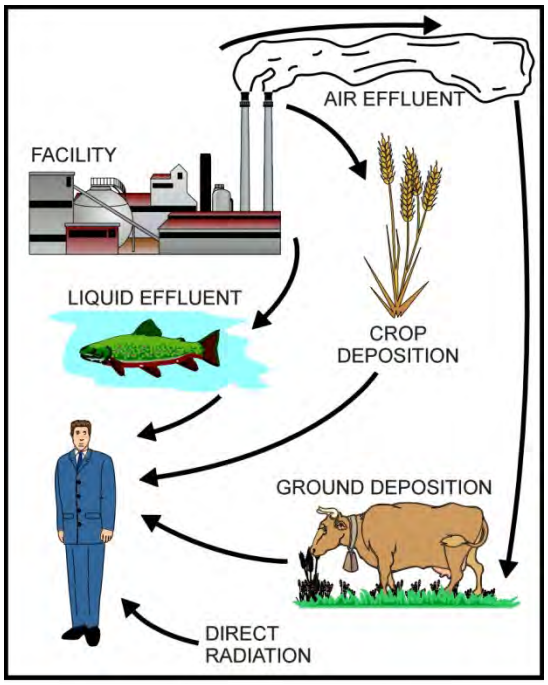

Figure A.3. Possible radiation pathways.

A.5 MEASURING RADIATION

To determine the possible effects of radiation on the environment and the health of people, the radiation must be measured. More precisely, its potential to cause damage must be determined.

A.5.1 Activity

When measuring the amount of radiation in the environment, what is actually being measured is the rate of radioactive decay, or activity. The rate of decay varies widely among the various radionuclides. For that reason, 1 gram of a radioactive substance may contain the same amount of activity as several tons of another material. This activity is expressed in a unit of measure known as a curie (Ci). More specifically, 1 Ci = 3.7E+10 (37,000,000,000) atom disintegrations per second (dps). In the international system of units, 1 dps = 1 becquerel (Bq). Table A.1 provides units of radiation measure and applicable conversions.

Table A.1. Units of radiation measures

Current System	International System	Conversion
curie (Ci)	Becquerel (Bq)	1 Ci = 3.7 x 10^{10} Bq
rad (radiation absorbed dose)	Gray (Gy)	1 rad = 0.01 Gy
rem (roentgen equivalent man)	Sievert (Sv)	1 rem = 0.01 Sv

A.5.2 Absorbed Dose

The total amount of energy absorbed per unit mass as a result of exposure to radiation is expressed in a unit of measure known as a rad. In the international system of units, 100 rad equals 1 gray (Gy). In terms of human health, however, it is the effect of the absorbed energy that is important, not the actual amount.

A.5.3 Dose

The measure of potential biological damage caused by exposure to and subsequent absorption of radiation is expressed in a unit of measure known as a rem. One rem of any type of radiation has the same total damaging effect. Because a rem represents a fairly large dose, dose is expressed as a millirem (mrem) or 1/1000 of a rem. In the international system of units, 100 rem equals 1 sievert (Sv); 100 mrem equals 1 millisievert (mSv). Specific types of dose are defined as follows:

- **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).

- **committed equivalent dose** – The calculated equivalent dose to a tissue or organ over a 50-year period after known intake of a radionuclide into the body. Contributions from external dose are not included. Committed equivalent dose is expressed in units of rem (or sievert).

- **committed effective dose** – The sum of the committed equivalent doses to various tissues in the body, each multiplied by the appropriate tissue weighting factor. Committed effective dose is expressed in units of rem (or 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). This dose is also called the population dose.

A.6 DOSE

Determining dose is an involved process using complex mathematical equations based on several factors, including the type of radiation, the rate of exposure, weather conditions, and typical diet. Basically, ionizing radiation is generated from radioactive decay, or activity. People absorb some of the energy to which they are exposed. This absorbed energy is calculated as part of an individual's dose. Whether radiation is natural or human-made, its effects on people are the same.

A.6.1 Comparison of Dose Levels

Table A.2 presents a scale of dose levels. Included is an example of the type of exposure that may cause such a dose or the special significance of such a dose. This information is intended to familiarize the reader with the type of doses individuals may receive.

A.6.1.1 Dose from space radiation

The average annual dose received by residents of the United States from space radiation is about 33 mrem (0.33 mSv) (NCRP 2009). The average dose to a person living in Honolulu, Hawaii (at sea level and near the equator) is about 20 mrem (0.2 mSv), while the average dose to a person living in Colorado Springs, Colorado (high altitude and latitude) is about 70 mrem (0.7 mSv) (Health Physics Society 2010).

Table A.2. Comparison and description of various dose levels[a]

Dose level	Description
0.85 mrem (0.0085 mSv)	Approximate daily dose from natural background radiation, including radon
1.92 mrem (0.0192 mSv)	Cosmic dose to a person on a one-way airplane flight from Washington D.C. to Seattle
10 mrem (0.10 mSv)	Annual exposure limit, set by U.S. EPA, for exposures from airborne emissions from operations of nuclear fuel cycle facilities, including power plants and uranium mines and mills
36 mrem (0.36 mSv)	Average annual dose to a person who smokes one pack of cigarettes per day
36 mrem (0.36 mSv)	Mammogram (two views)
46 mrem (0.46 mSv)	Estimate of the largest dose any off-site person could have received from the March 28, 1979, Three Mile Island nuclear power plant accident
60 mrem (0.60 mSv)	X-ray (single exposure) of abdomen or hip
100 mrem (1.00 mSv)	Annual limit of dose from all DOE facilities to a member of the public who is not a radiation worker
244 mrem (2.44 mSv)	Average dose from an upper gastrointestinal diagnostic X-ray series
300 mrem (3.00 mSv)	Average annual dose to a person in the United States from all sources of medical radiation
311 mrem (3.11 mSv)	Average annual dose to a person in the United States from all sources of natural background radiation
700 mrem (7.0 mSv)	Computed tomography – chest
1-5 rem (0.01-0.05 Sv)	U.S. EPA protective action guideline calling for public officials to take emergency action when the dose to a member of the public from a nuclear accident will likely reach this range
5 rem (0.05 Sv)	Annual limit for occupational exposure of radiation workers set by the Nuclear Regulatory Commission and DOE
10 rem (0.10 Sv)	The Biological Effects of Ionizing Radiation V report estimated that an acute dose at this level would result in a lifetime excess risk of death from cancer of 0.8% (Biological Effects of Ionizing Radiation 1990)
25 rem (0.25 Sv)	U.S. EPA guideline for voluntary maximum dose to emergency workers for non-lifesaving work during an emergency
75 rem (0.75 Sv)	U.S. EPA guideline for maximum dose to emergency workers volunteering for lifesaving work
50-600 rem (0.50-6.00 Sv)	Doses in this range received over a short period of time will produce radiation sickness in varying degrees. At the lower end of this range, people are expected to recover completely, given proper medical attention. At the top of this range, most people would die within 60 days

[a]Adapted from Savannah River Site Environmental Report for 1993, Summary Pamphlet, WSRC-TR-94-076, Westinghouse Savannah River Company, 1994 and NCRP Report No. 160, *Ionizing Radiation Exposure of the Population of the United States* (NCRP 2009).

A.6.1.2 Dose from terrestrial radiation

The average annual dose received from terrestrial gamma radiation is about 21 mrem (0.21 mSv) in the United States (NCRP 2009). Similar to space radiation, this dose varies geographically across the country with the lowest doses on the Atlantic and Gulf coastal plains and highest doses in the mountains in the western United States.

A.6.1.3 Dose from internal radiation

Inhalation of the short-lived decay products of radon are the major contributors to the annual dose equivalent for internal radionuclides (mostly ^{222}Rn). They contribute an average dose of about 228 mrem (2.28 mSv) per year (NCRP 2009). The average dose from ingestion of radionuclides is about 29 mrem (0.29 mSv) per year, which can be attributed to the naturally occurring radioisotope of potassium, ^{40}K; and radioisotopes of thorium (Th), uranium (U), and their decay series (NCRP 2009).

A.6.1.4 Dose from consumer products

The U.S. average annual dose received by an individual from consumer products is about 13 mrem (0.13 mSv) (NCRP 2009). Almost 90 percent of this dose results from smoking cigarettes, commercial air travel, and building materials (radionuclides present in brick, masonry, cement, concrete, and other materials).

A.6.1.5 Dose from medical sources

Medical exams and procedures account for the largest portion of the average annual dose received from human-made sources. These procedures include x-rays, computed tomography (a more sophisticated type of x-ray), and fluoroscopy, and nuclear medicine. The increase in the use of medical imaging procedures, especially computed tomography, over the last 25 years has resulted in a marked increase in the average annual dose from medical sources received by a person in the United States: 53 mrem/year in the early 1980s to 300 mrem/year in 2006 (NCRP 2009). The actual doses received by individuals who complete such medical exams can be much higher than the average value because not everyone receives such exams each year.

A.6.1.6 Doses from industrial and occupational sources

Small doses received by individuals occur as a result of emissions of radioactive materials from nuclear facilities, emissions from certain mineral extraction facilities, and transportation of radioactive materials. The combination of these sources contributes less than 1 mrem (0.01 mSv) per year to the average dose to an individual (NCRP 2009).

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APPENDIX B

ENVIRONMENTAL PERMITS

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Table B.1. DOE environmental permits and registrations at PORTS

Permit/registered source	Source no.	Issue date	Expiration date	Status
FBP– Clean Air Act Permits				
Title V Permit	P0109662	4/28/2014	5/19/2019	Active
Permit to Install X-627 Groundwater Treatment Facility (06-07283)	P474, T104, T105	3/15/2005	None	Active
Permit to Install and Operate X-326 L-cage Glove Box (P0104170)	P022	11/12/2008	11/12/2018	Active
Permit to Install and Operate X-735 Landfill Cap and Venting System (northern portion) (P0104170)	P023	11/12/2008	11/12/2018	Active
Permit to Install X-670A Cooling Tower (P0106292)	P539	07/29/2010	None	Active
Permit to Install X-333 Low Assay Withdrawal Seal Exhaust System (06-07984)	P117	01/10/2006	None	Inactive
Permit to Install Biodenitrification Vent #1 (06-07928)	P040	11/03/2005	None	Active
Permit to Install Biodenitrification Vent #2 (06-07928)	P041	11/03/2005	None	Active
Permit to Install Biodenitrification Vent #3 (06-07928)	P042	11/03/2005	None	Active
Permit to Install X-700 Radiation Calibration Lab Fume Hood (06-07928)	P045	11/03/2005	None	Active
Permit to Install X-705 Calciners (B Area) (06-07928)	P053	11/03/2005	None	Active
Permit to Install X-720 Instrument Cleaning Room Hood 4 (06-07928)	P065	11/03/2005	None	Active
Permit to Install X-720 Motor Shop Steam Cleaning Booth (06-07928)	P067	11/03/2005	None	Active
Permit to Install X-344 Pigtail Gulper (06-07760)	P430	05/17/2005	None	Active
Permit to Install X-701B In Situ Chemical Oxidation with Recirculation Treatment System (06-07666)	P475, T106	03/15/2005	None	Inactive
Permit to Install X-720 Instrument Cleaning Room Glove Box (06-07000)	P474	11/19/2002	None	Active
Permit to Install X-705 Dry Ice Blaster with HEPA Filter (06-06752)	P473	04/11/2002	None	Active
Permit to Install X-705 8 inch, 12 inch, and 2.5 Ton Uranium Cylinders, Cleaned for Reuse or Disposal (06-06703)	P470	04/11/2002	None	Active
Permit to Install X-344 Toll Transfer Facility (06-06303)	P469	12/12/2000	None	Active
Permit to Install X-343 Feed Vaporization and Sampling (06-06302)	P468	12/12/2000	None	Inactive
Permit to Install 85 Horsepower Trash Pump (06-06170)	P467	05/24/2000	None	Active
Permit to Install X-847 Glove Box (06-5682)	P466	07/21/1999	None	Active

Table B.1. DOE environmental permits and registrations at PORTS (continued)

Permit/registered source	Source no.	Issue date	Expiration date	Status
FBP– Clean Air Act Permits (continued)				
X-624 Groundwater Treatment Facility (now considered a *de minimis* source)	P019	10/28/1992	None	Active
Permit to Install X-623 Groundwater Treatment Facility (06-4613)	P018	01/08/1992	None	Active
Permit to Install X-749 Contaminated Materials Disposal Facility (06-2999)	P027	04/17/1991	None	Active
Permit to Install Gasoline Dispensing Facility (06-02906)	G001	10/31/1990	None	Active
BWCS – Clean Air Act Permits				
Permit No. P0109511 to Install and Operate Process Line 1 (DUF_6 Conversion Facility)	P001	3/23/2012	3/23/2022	Active
Permit No. P0109511 to Install and Operate Process Line 2 (DUF_6 Conversion Facility)	P002	3/23/2012	3/23/2022	Active
Permit No. P0109511 to Install and Operate Process Line 3 (DUF_6 Conversion Facility)	P003	3/23/2012	3/23/2022	Active
Permit No. P0109511 to Install and Operate HVAC System (DUF_6 Conversion Facility)	P004	3/23/2012	3/23/2022	Active
FBP – Clean Water Act/Safe Drinking Water Act Permits				
NPDES Permit	0IO00000*LD	7/23/2015	8/31/2020	Active
Safe Drinking Water Act – License to Operate a Public Water System	OH6632414		Renewed annually	Active
Permit to Install X-622 Groundwater Treatment Facility	06-2951	11/20/1990	None	Active
Permit to Install X-623 Groundwater Treatment Facility	06-3528	1/9/1996	None	Active
Permit to Install X-624 Groundwater Treatment Facility	06-3556	10/28/1992	None	Active
Permit to Install X-627 Groundwater Treatment Facility	06-07283	1/13/2004	None	Active
BWCS – Clean Water Act Permit				
NPDES Permit	0IS00034*BD	5/13/2014	5/31/2019	Active
FBP – Hazardous Waste Permit				
RCRA Part B Permit (DOE/FBP)	Ohio Permit No. 04-66-0680	3/25/2011	3/25/2021	Active
FBP – Registrations				
Underground Storage Tank Registration	66005107		Renewed annually	Active

APPENDIX C

RADIONUCLIDE AND CHEMICAL NOMENCLATURE

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Table C.1. Nomenclature for elements and chemical constituents

Constituent	Symbol
Aluminum	Al
Ammonia	NH_3
Antimony	Sb
Arsenic	As
Barium	Ba
Beryllium	Be
Cadmium	Cd
Calcium	Ca
Chromium	Cr
Cobalt	Co
Copper	Cu
Iron	Fe
Lead	Pb
Lithium	Li
Magnesium	Mg
Manganese	Mn
Mercury	Hg
Nickel	Ni
Nitrogen	N
Nitrate ion	NO_3-
Nitrite ion	NO_2-
Phosphorus	P
Phosphate ion	PO_4^{2-}
Potassium	K
Selenium	Se
Silver	Ag
Sodium	Na
Sulfate ion	SO_4-
Sulfur dioxide	SO_2
Thallium	Tl
Uranium	U
Vanadium	V
Zinc	Zn

Table C.2. Nomenclature and half-life for radionuclides

Radionuclide	Symbol	Half-life (years)
Americium-241	^{241}Am	432.2
Neptunium-237	^{237}Np	2,140,000
Plutonium-238	^{238}Pu	87.7
Plutonium-239	^{239}Pu	24,100
Plutonium-240	^{240}Pu	6,564
Technetium-99	^{99}Tc	211,000
Uranium-233	^{233}U	159,000
Uranium-234	^{234}U	246,000
Uranium-235	^{235}U	704,000,000
Uranium-236	^{236}U	23,400,000
Uranium-238	^{238}U	4,470,000,000

Source: *Derived Concentration Technical Standard* (DOE 2011a), Table A.3.

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U.S. Department of Energy

Portsmouth Gaseous Diffusion Plant

Annual Site Environmental Data 2016

February 2018

U.S. Department of Energy
Portsmouth Gaseous Diffusion Plant
Annual Site Environmental Data – 2016
Piketon, Ohio

U.S. Department of Energy
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February 2018

By
Fluor-BWXT Portsmouth LLC, under Contract DE-AC30-10CC40017

FBP-ER-RCRA-WD-RPT-0267, Revision 1

This document has been approved for public release:

Samuel C. Eldridge (signature on file) 2/21/2018
Classification Office Date

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CONTENTS

TABLES iii

ACRONYMS AND ABBREVIATIONS v

1. INTRODUCTION 1-1

2. ENVIRONMENTAL MONITORING 2-1

3. DOSE 3-1

4. GROUNDWATER 4-1

5. REFERENCES 5-1

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TABLES

2.1 Radionuclide concentrations in FBP and Centrus NPDES outfall water samples – 2016 2-2

2.2 FBP NPDES permit summary – 2016 2-5

2.3 BWCS NPDES permit summary – 2016 2-10

2.4 FBP NPDES discharge and compliance rates – 2016 2-11

2.5 BWCS NPDES discharge and compliance rates – 2016 2-16

2.6 Centrus NPDES discharge monitoring results – 2016 2-17

2.7 Radionuclides in surface water runoff samples from FBP and BWCS cylinder storage yards – 2016 2-18

2.8 Drainage basin monitoring of surface water and sediment for BWCS cylinder storage yards – 2016 2-20

2.9 Ambient air monitoring program summary for radionuclides and fluoride – 2016 2-21

2.10 External radiation monitoring program (mrem) – 2016 2-25

2.11 External radiation monitoring (mrem) at locations near cylinder storage yards – 2016 2-25

2.12 Settleable solids monitoring results – 2016 2-26

2.13 Local surface water monitoring program results – 2016 2-27

2.14 Sediment monitoring program results – 2016 2-31

2.15 Soil and biota (vegetation) monitoring at ambient air monitoring stations – 2016 2-36

2.16 Biota (fish) monitoring program results – 2016 2-39

2.17 Biota (crops) monitoring program results – 2016 2-40

2.18 Biota (deer) monitoring program results – 2016 2-42

2.19 Biota (off-site dairy) monitoring – 2016 2-43

3.1 Emissions (Ci/year) from DOE air emission sources – 2016 3-1

3.2 Predicted radiation doses from airborne releases at PORTS – 2016 3-2

3.3 Dose calculations for ambient air monitoring stations – 2016 3-2

4.1 VOCs detected at the X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility – 2016 4-4

4.2 VOCs detected at the PK Landfill – 2016 4-13

4.3 VOCs detected at the Quadrant I Groundwater Investigative (5-Unit) Area – 2016 4-14

4.4 VOCs detected at the X-749A Classified Materials Disposal Facility – 2016 4-17

4.5 VOCs detected at the Quadrant II Groundwater Investigative (7-Unit) Area – 2016 4-18

4.6 VOCs detected at the X-701B Former Holding Pond – 2016 4-20

4.7 Results for radionuclides at the X-701B Former Holding Pond – 2016 4-26

4.8 Results for chromium at the X-633 Former Recirculating Cooling Water Complex – 2016 4-33

4.9 VOCs detected at the X-616 Former Chromium Sludge Surface Impoundments – 2016 4-34

4.10 Results for chromium at the X-616 Former Chromium Sludge Surface Impoundments – 2016 4-35

4.11 VOCs detected at the X-740 Former Waste Oil Handling Facility – 2016 4-36

4.12 Results for beryllium and chromium at the X-611A Former Lime Sludge Lagoons – 2016 4-39

4.13 VOCs detected at the X-735 Landfills – 2016 4-40

4.14 VOCs detected at the X-734 Landfills – 2016 4-41

4.15 Results for cadmium and nickel at the X-533 Former Switchyard Complex – 2016 4-42

4.16 VOCs detected at the X-344C Former Hydrogen Fluoride Storage Building – 2016 4-43

4.17 VOCs detected at surface water monitoring locations – 2016 4-44

4.18 Results for radionuclides at surface water monitoring locations – 2016 4-45

ACRONYMS AND ABBREVIATIONS

#/100 mL	number per 100 mL
ACP	American Centrifuge Plant
BWCS	BWXT Conversion Services, LLC
°C	degrees Celsius
Ci	curie
cm	centimeter
DOE	U.S. Department of Energy
DUF_6	depleted uranium hexafluoride
FBP	Fluor-BWXT Portsmouth LLC
°F	degrees Fahrenheit
g	gram
GPD	gallons per day
in.	inch
kg	kilogram
L	liter
m	meter
m^3	cubic meter
µg	microgram
mg	milligram
MGD	million gallons per day
mrem	millirem
ND	not detected
ng	nanogram
NPDES	National Pollutant Discharge Elimination System
Ohio EPA	Ohio Environmental Protection Agency
OVEC	Ohio Valley Electric Corporation
PCB	polychlorinated biphenyl
pCi	picocurie
PK	Peter Kiewit
PORTS	Portsmouth Gaseous Diffusion Plant
SU	standard unit
TUa	acute toxicity unit
VOC	volatile organic compound

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1. INTRODUCTION

Environmental monitoring at the Department of Energy (DOE) Portsmouth Gaseous Diffusion Plant (PORTS) is conducted throughout the year. Monitoring demonstrates the site is a safe place to work, plant operations do not adversely affect neighboring communities, and activities comply with federal and state regulations.

This document is a compilation of the environmental monitoring data for calendar year 2016 and is intended as a tool for analysts in environmental monitoring, environmental restoration, and other related disciplines. The data in this document form the basis for the summary information in the *Portsmouth Gaseous Diffusion Plant Annual Site Environmental Report – 2016* (DOE 2018).

Radiological monitoring data presented in this Data Report and discussed in the *Annual Site Environmental Report for 2016* indicate that the maximum dose a member of the public could receive from radionuclides released by PORTS in 2016 or detected by environmental monitoring programs in 2016 is 0.83 millirem (mrem). This dose is significantly less than the 100 mrem limit set in DOE Order 458.1, *Radiation Protection of the Public and the Environment.*

Other non-radiological chemicals such as polychlorinated biphenyls (PCBs), metals, and volatile organic compounds (VOCs) are also monitored. Discharges of metals and other chemicals to surface water are controlled by National Pollutant Discharge Elimination System (NPDES) permits. Emissions of non-radiological air pollutants are controlled by air emission permits issued by Ohio Environmental Protection Agency (Ohio EPA). The *Portsmouth Gaseous Diffusion Plant Annual Site Environmental Report – 2016* (DOE 2018) provides more information about non-radiological chemicals released from PORTS or detected by PORTS monitoring programs during 2016.

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2. ENVIRONMENTAL MONITORING

This section provides environmental monitoring data collected in 2016 by DOE contractors Fluor-BWXT Portsmouth LLC (FBP) and BWXT Conversion Services, LLC (BWCS). Data collected by Centrus for NPDES outfalls associated with the American Centrifuge Plant (ACP) and Lead Cascade are also reported in this section.

The following tables are provided in this section:

- Table 2.1. Radionuclide concentrations in FBP and Centrus NPDES outfall water samples – 2016
- Table 2.2. FBP NPDES permit summary – 2016
- Table 2.3. BWCS NPDES permit summary – 2016
- Table 2.4. FBP NPDES discharge and compliance rates – 2016
- Table 2.5. BWCS NPDES discharge and compliance rates – 2016
- Table 2.6. Centrus NPDES discharge monitoring results – 2016
- Table 2.7 Radionuclides in surface water runoff samples from FBP and BWCS cylinder storage yards – 2016
- Table 2.8. Drainage basin monitoring of surface water and sediment for BWCS cylinder storage yards – 2016
- Table 2.9. Ambient air monitoring program summary for radionuclides and fluoride – 2016
- Table 2.10. External radiation monitoring program (mrem) – 2016
- Table 2.11. External radiation monitoring (mrem) at locations near cylinder storage yards – 2016
- Table 2.12. Settleable solids monitoring results – 2016
- Table 2.13. Local surface water monitoring program results – 2016
- Table 2.14. Sediment monitoring program results – 2016
- Table 2.15. Soil and biota (vegetation) monitoring at ambient air monitoring stations – 2016
- Table 2.16. Biota (fish) monitoring program results – 2016
- Table 2.17. Biota (crops) monitoring program results – 2016
- Table 2.18. Biota (deer) monitoring program results – 2016
- Table 2.19. Biota (off-site dairy) monitoring program results – 2016.

Table 2.1. Radionuclide concentrations in FBP and Centrus NPDES outfall water samples – 2016

NPDES outfall[a]	Parameter[b]	Number of samples[c]	Minimum[d]	Maximum[d]	Average[e]
		FBP Outfalls			
001	Americium-241	4(4)	0	< 0.0622	
	Neptunium-237	4(4)	0	< 0.00937	
	Plutonium-238	4(4)	0	< 0.0169	
	Plutonium-239/240	4(4)	0	< 0.0211	
	Technetium-99	12(5)	< 1.07	111	
	Uranium	12(1)	< 0.189	5.14	1.39
	Uranium-233/234	12(0)	0.263	10.4	2.80
	Uranium-235/236	12(7)	< 0.0171	0.569	
	Uranium-238	12(1)	< 0.0599	1.64	0.442
002	Americium-241	4(4)	0	< 0.0186	
	Neptunium-237	4(4)	0	< 0.0101	
	Plutonium-238	4(4)	0	< 0.00486	
	Plutonium-239/240	4(4)	0	< 0.0253	
	Technetium-99	12(12)	0	< 3.16	
	Uranium	12(0)	0.463	1.74	0.872
	Uranium-233/234	12(0)	0.458	2.63	0.950
	Uranium-235/236	12(11)	< 0.0116	0.174	
	Uranium-238	12(0)	0.154	0.559	0.286
003	Americium-241	4(4)	< 0.00468	< 0.0187	
	Neptunium-237	4(4)	0	< 0.0189	
	Plutonium-238	4(4)	0	< 0.00531	
	Plutonium-239/240	4(4)	< 0.00509	< 0.0425	
	Technetium-99	12(0)	49	99.3	70.6
	Uranium	12(0)	0.999	16.3	4.07
	Uranium-233/234	12(0)	0.749	18.8	4.61
	Uranium-235/236	12(4)	< 0.0539	1.09	
	Uranium-238	12(0)	0.322	5.31	1.33
004	Americium-241	4(4)	< 0.0138	< 0.0395	
	Neptunium-237	4(4)	0	< 0.00509	
	Plutonium-238	4(4)	0	< 0.011	
	Plutonium-239/240	4(4)	0	< 0.0244	
	Technetium-99	12(12)	0	2.02	
	Uranium	12(10)	0.0696	0.309	
	Uranium-233/234	12(5)	0.027	0.168	
	Uranium-235/236	12(12)	0	0.0227	
	Uranium-238	12(10)	0.0222	0.100	

Table 2.1. Radionuclide concentrations in FBP and Centrus NPDES outfall water samples – 2016 (continued)

NPDES outfall[a]	Parameter[b]	Number of samples[c]	Minimum[d]	Maximum[d]	Average[e]
		FBP Outfalls			
005	Americium-241	1(1)	< 0.0189		
	Neptunium-237	1(1)	< 0.0178		
	Plutonium-238	1(1)	< 0		
	Plutonium-239/240	1(1)	< 0.0275		
	Technetium-99	3(3)	0	< 2.24	
	Uranium	3(1)	< 0.155	0.298	
	Uranium-233/234	3(1)	< 0.0768	0.157	
	Uranium-235/236	3(3)	< 0.00562	< 0.0355	
	Uranium-238	3(2)	< 0.0502	0.0994	
009	Americium-241	4(4)	0	< 0.0396	
	Neptunium-237	4(4)	0	< 0.0103	
	Plutonium-238	4(4)	0	< 0.0151	
	Plutonium-239/240	4(4)	< 0.00503	< 0.0203	
	Technetium-99	12(12)	0	6.08	
	Uranium	12(0)	1.67	7.19	4.58
	Uranium-233/234	12(0)	0.75	2.89	1.88
	Uranium-235/236	12(8)	< 0.0629	0.167	
	Uranium-238	12(0)	0.552	2.39	1.52
010	Americium-241	4(4)	< 0.0132	< 0.0235	
	Neptunium-237	4(4)	0	< 0.005	
	Plutonium-238	4(4)	0	< 0.0048	
	Plutonium-239/240	4(4)	< 0.00467	< 0.0144	
	Technetium-99	12(12)	0	3.38	
	Uranium	12(1)	1.47	4.82	2.47
	Uranium-233/234	12(0)	0.591	2.37	1.20
	Uranium-235/236	12(10)	< 0.00608	0.132	
	Uranium-238	12(0)	0.494	1.6	0.820
011	Americium-241	4(4)	< 0.0143	< 0.0253	
	Neptunium-237	4(4)	0	< 0.00958	
	Plutonium-238	4(4)	0	0	
	Plutonium-239/240	4(4)	0	< 0.0392	
	Technetium-99	12(12)	0	4.3	
	Uranium	12(1)	0.692	2.73	1.50
	Uranium-233/234	12(0)	0.295	1.39	0.745
	Uranium-235/236	12(12)	< 0.0239	< 0.0806	
	Uranium-238	12(0)	0.223	0.906	0.497
015	Americium-241	4(4)	< 0.01	< 0.0343	
	Neptunium-237	4(4)	0	< 0.0257	
	Plutonium-238	4(4)	0	0	
	Plutonium-239/240	4(4)	< 0.00505	< 0.0342	
	Technetium-99	12(6)	< 2.01	14.9	
	Uranium	12(1)	0.718	1.58	1.13
	Uranium-233/234	12(0)	0.72	1.65	1.03
	Uranium-235/236	12(11)	< 0.0337	0.113	
	Uranium-238	12(0)	0.231	0.515	0.371

Table 2.1. Radionuclide concentrations in FBP and Centrus NPDES outfall water samples – 2016 (continued)

NPDES outfall[a]	Parameter[b]	Number of samples[c]	Minimum[d]	Maximum[d]	Average[e]
		FBP Outfalls			
608	Americium-241	4(4)	< 0.0147	< 0.0515	
	Neptunium-237	4(4)	0	< 0.0142	
	Plutonium-238	4(4)	0	< 0.0102	
	Plutonium-239/240	4(4)	< 0.0155	< 0.0288	
	Technetium-99	12(0)	15.2	1290	276
	Uranium	12(1)	0.369	1.01	0.713
	Uranium-233/234	12(0)	0.173	0.639	0.361
	Uranium-235/236	12(12)	< 0.0105	0.081	
	Uranium-238	12(0)	0.122	0.335	0.234
610	Americium-241	4(4)	0	< 0.0338	
	Neptunium-237	4(4)	0	< 0.00941	
	Plutonium-238	4(4)	0	< 0.0201	
	Plutonium-239/240	4(4)	0	< 0.0437	
	Technetium-99	6(0)	114	238	160
	Uranium	6(0)	9.49	16.4	12.4
	Uranium-233/234	6(0)	12.7	21.7	16.1
	Uranium-235/236	6(0)	0.705	1.05	0.872
	Uranium-238	6(0)	3.07	5.33	4.02
611	Americium-241	4(4)	< 0.00474	< 0.0297	
	Neptunium-237	4(3)	0.0234	< 0.314	
	Plutonium-238	4(4)	0	< 0.0055	
	Plutonium-239/240	4(4)	< 0.0152	< 0.0427	
	Technetium-99	12(0)	509	1650	727
	Uranium	12(0)	4.17	128	20.0
	Uranium-233/234	12(0)	3.95	180	27.1
	Uranium-235/236	12(0)	0.208	10.2	1.51
	Uranium-238	12(0)	1.37	41.6	6.51
		Centrus Outfalls			
012	Americium-241	4(4)	< 0.031	< 0.072	
	Neptunium-237	4(4)	< 0.070	< 0.14	
	Plutonium-238	4(4)	< 0.020	< 0.085	
	Plutonium-239/240	4(4)	< 0.039	< 0.083	
	Technetium-99	52(52)	< 6.09	< 11.5	
	Uranium	52(0)	0.49	2.03	1.21
013	Americium-241	4(4)	< 0.060	< 0.097	
	Neptunium-237	4(4)	< 0.080	< 0.138	
	Plutonium-238	4(4)	< 0.059	< 0.100	
	Plutonium-239/240	4(4)	< 0.060	< 0.100	
	Technetium-99	52(52)	< 5.86	< 11	
	Uranium	52(0)	0.26	2.1	1.01

[a]FBP internal NPDES Outfalls 608, 610, and 611 discharge to NPDES Outfall 003 (X-6619 Sewage Treatment Plant).
[b]Uranium is reported in µg/L; all other radionuclides are reported in pCi/L.
[c]Number in parentheses is the number of samples that were below the detection limit.
[d]Minimum or maximum values reported as "0" may actually be negative results. Because of the statistical nature of radiation detection, results for samples that have no radioactivity are often negative values because background radioactivity is subtracted out. These negative value results are reported as "0" in the table for simplicity.
[e]Averages were not calculated for outfalls that had greater than 15% of the results below the detection limit. For outfalls with less than 15% of the results below the detection limit, any result below the detection limit was assigned a value at the detection limit to calculate the average for the parameter.

Table 2.2. FBP NPDES permit summary – 2016

Effluent characteristics		Monitoring requirements		Discharge limitations	
Parameter	Units	Measurement frequency	Sampling type	Concentration/Loading[a]	
				Monthly	Daily
FBP Outfall 001 (X-230J7 East Holding Pond)					
Cadmium, total recoverable	µg/L	1/quarter	24-hr composite		
Chlorine, total residual	mg/L	1/week	Grab		
Copper, total recoverable	µg/L	1/quarter	24-hr composite		
Dissolved solids	mg/L	1/week	24-hr composite		
Flow rate	MGD	Daily	24-hr total		
Fluoride, total	mg/L	1/quarter	24-hr composite		
Mercury, total (low level)	ng/L	1/month	Grab	12	
Oil & grease	mg/L	1/week	Grab	10	15
pH	SU	1/week	Grab		6.5–9.0
Precipitation, total	in.	Daily	24-hr total		
Silver, total recoverable	µg/L	1/month	24-hr composite		
Total suspended solids[b]	mg/L	1/week	24-hr composite	20	45
Zinc, total recoverable	µg/L	1/quarter	24-hr composite		
FBP Outfall 002 (X-230K South Holding Pond)					
Cadmium, total recoverable	µg/L	1/quarter	24-hr composite		
Flow rate	MGD	Daily	24-hr total		
Fluoride, total	mg/L	1/quarter	24-hr composite		
Mercury, total (low level)	ng/L	1/quarter	Grab		
pH	SU	1/week	Grab		6.5–9.0
Nitrogen, ammonia (NH_3)	mg/L	1/month	24-hr composite		
Oil & grease	mg/L	1/week	Grab		10
Selenium, total recoverable	µg/L	1/month	24-hr composite		
Silver, total recoverable	µg/L	1/quarter	24-hr composite		
Thallium, total recoverable	µg/L	1/quarter	24-hr composite		
Total suspended solids[b]	mg/L	1/week	24-hr composite	20	45
FBP Outfall 003 (X-6619 Sewage Treatment Plant)					
Acute toxicity, *Ceriodaphnia dubia*	TUa	1/quarter	24-hr composite		
Acute toxicity, *Pimephales promelas*	TUa	1/quarter	24-hr composite		
Carbonaceous biochemical oxygen demand, 5-day	mg/L	1/week	24-hr composite	10 (15.1)	15 (22.7)
Chlorine, total residual[c]	mg/L	Daily	Grab		0.038
Copper, total recoverable	µg/L	1/quarter	24-hr composite		
E. coli[c]	#/100 mL	1/week	Grab		
Fecal coliform[c]	#/100 mL	1/week	Grab	1000	2000
Flow rate	MGD	Daily	24-hr total		
Mercury, total	ng/L	1/month	Grab	66 (0.000098)	1700 (0.0025)

Table 2.2. FBP NPDES permit summary – 2016 (continued)

Effluent characteristics		Monitoring requirements		Discharge limitations	
Parameter	Units	Measurement frequency	Sampling type	Concentration/Loading[a]	
				Monthly	Daily
FBP Outfall 003 (X-6619 Sewage Treatment Plant)					
Nitrogen, ammonia (NH_3)	mg/L	1/2 weeks	24-hr composite		
Nitrite plus nitrate	mg/L	1/quarter	24-hr composite		
Oil & grease	mg/L	1/quarter	Grab		
pH	SU	3/week	Grab		6.5–9.0
Silver, total recoverable	µg/L	1/quarter	24-hr composite		
Thallium, total recoverable	µg/L	1/quarter	24-hr composite		
Total suspended solids	mg/L	1/week	24-hr composite	12 (18.2)	18 (27.3)
Zinc, total recoverable	µg/L	1/quarter	24-hr composite		
FBP Outfall 004 (Cooling Tower Blowdown)					
Acute toxicity, *Ceriodaphnia dubia*	TUa	1/quarter	24-hr composite		
Acute toxicity, *Pimephales promelas*	TUa	1/quarter	24-hr composite		
Chlorine, total residual	mg/L	1/week	Grab		0.038
Copper, total recoverable	µg/L	1/month	24-hr composite		
Dissolved solids	mg/L	1/week	24-hr composite	3500 (8480)	4000 (9690)
Flow rate	MGD	Daily	24-hr total		
Mercury, total	ng/L	1/quarter	Grab		
Oil & grease	mg/L	1/month	Grab	15	20
pH	SU	1/month	Grab		6.5–9.0
Total suspended solids	mg/L	1/month	24-hr composite	15 (43)	27 (65)
Zinc, total recoverable	µg/L	1/quarter	24-hr composite		
FBP Outfall 005 (X-611B Lime Sludge Lagoons)					
Flow rate	MGD	3/week	24-hr total (estimate)		
Lead, total recoverable	µg/L	1/month	Grab		
Mercury, total	ng/L	1/month	Grab		
pH	SU	1/week	Grab		6.5–10.0
Selenium, total recoverable	µg/L	1/month	Grab		5
Total suspended solids[b]	mg/L	1/week	Grab	10	15
FBP Outfall 009 (X-230L North Holding Pond)					
Bis(2-ethylhexyl)phthalate	µg/L	1/month	Composite	8.4	1105
Copper, total recoverable	µg/L	1/month	Grab		
Flow rate	MGD	Daily	24-hr total		
Fluoride, total	mg/L	1/quarter	Grab		
Mercury, total	ng/L	1/quarter	Grab		
Oil & grease	mg/L	1/month	Grab	10	15
pH	SU	1/week	Grab		6.5–9.0

Table 2.2. FBP NPDES permit summary – 2016 (continued)

Effluent characteristics		Monitoring requirements		Discharge limitations	
Parameter	Units	Measurement frequency	Sampling type	Concentration/Loading[a]	
				Monthly	Daily
FBP Outfall 009 (X-230L North Holding Pond)					
Silver, total recoverable	µg/L	1/month	Grab	1.3	2.7
Total suspended solids[b]	mg/L	1/week	Grab	30	45
Zinc, total recoverable	µg/L	1/quarter	Grab		
FBP Outfall 010 (X-230J5 Northwest Holding Pond)					
Flow rate	MGD	Daily	24-hr total		
Lead, total recoverable	µg/L	1/month	24-hr composite		
Mercury, total	ng/L	1/quarter	Composite		
Oil & grease	mg/L	1/month	Grab	10	15
pH	SU	1/2 weeks	Grab		6.5–9.0
Precipitation, total	in.	Daily	24-hr total		
Selenium, total recoverable	µg/L	1/month	24-hr composite		5.6
Total suspended solids[b]	mg/L	1/2 weeks	24-hr composite	30	45
Zinc, total recoverable	µg/L	1/month	24-hr composite		
FBP Outfall 011 (X-230J6 Northeast Holding Pond)					
Cadmium, total recoverable	µg/L	1/quarter	Grab		
Chlorine, total residual	mg/L	1/2 weeks	Grab		
Copper, total recoverable	µg/L	1/month	Grab		
Flow rate	MGD	Daily	24-hr total		
Fluoride, total	mg/L	1/quarter	Grab		
Oil & grease	mg/L	1/2 weeks	Grab	10	15
pH	SU	1/2 weeks	Grab		6.5–9.0
Precipitation, total	in.	Daily	24-hr total		
Selenium, total recoverable	µg/L	1/month	Grab		
Thallium, total recoverable	µg/L	1/quarter	Grab		
Total suspended solids[b]	mg/L	1/2 weeks	Grab	30	45
Zinc, total recoverable	µg/L	1/month	Grab		
FBP Outfall 015 (X-624 Groundwater Treatment Facility)					
Arsenic, total recoverable	µg/L	1/quarter	Grab		
Barium, total recoverable	µg/L	1/quarter	Grab		
Flow rate	MGD	Daily	24-hr total		
PCBs	µg/L	1/quarter	Grab		*d*
pH	SU	1/2 weeks	Grab		6.5–9.0
Silver, total recoverable	µg/L	1/month	Grab	1.3	6.8
Trichloroethene	µg/L	1/2 weeks	Grab	10	10

Table 2.2. FBP NPDES permit summary – 2016 (continued)

Effluent characteristics		Monitoring requirements		Discharge limitations	
Parameter	Units	Measurement frequency	Sampling type	Concentration/Loading[a]	
				Monthly	Daily
FBP Outfall 602 (X-621 Coal Pile Runoff Treatment Facility)					
Flow rate	MGD	Daily	24-hr total (estimate)		
Iron, total[b]	µg/L	1/2 weeks	Grab	3500	7000
Manganese, total[b]	µg/L	1/2 weeks	Grab	2000	4000
pH	SU	1/2 weeks	Grab		6.0–10.0
Precipitation, total	in.	Daily	24-hr total		
Total suspended solids[b]	mg/L	1/2 weeks	Grab	35	50
FBP Outfall 604 (X-700 Biodenitrification Facility)					
Copper, total	µg/L	1/month	24-hr composite		
Iron, total	µg/L	1/month	24-hr composite		
Flow rate	MGD	Daily	24-hr total		
Nickel, total	µg/L	1/month	24-hr composite		
Nitrogen, nitrate	mg/L	1/month	24-hr composite		
pH	SU	1/month	Grab		6.5–9.0
Zinc, total	µg/L	1/month	24-hr composite		
FBP Outfall 605 (X-705 Microfiltration Treatment System)					
Chromium, hexavalent	µg/L	1/month	Grab		
Chromium, total	µg/L	1/month	24-hr composite		
Copper, total	µg/L	1/month	24-hr composite		
Flow rate	MGD	Daily	24-hr total		
Nickel, total	µg/L	1/month	24-hr composite		
Nitrogen, ammonia (NH_3)	mg/L	1/month	24-hr composite		
Nitrogen, nitrate	mg/L	1/month	24-hr composite		
Nitrogen, nitrite	mg/L	1/month	24-hr composite		
Nitrogen, Kjeldahl	mg/L	1/month	24-hr composite		
Oil & grease	mg/L	1/month	Grab		
pH	SU	1/month	Grab		6.5–10.0
Sulfate (SO_4)	mg/L	1/month	24-hr composite		
Total suspended solids	mg/L	1/month	24-hr composite	20	30
Trichloroethene	µg/L	1/month	Grab		
Zinc, total	µg/L	1/month	24-hr composite		
FBP Outfall 608 (X-622 Groundwater Treatment Facility)					
Flow rate	MGD	Daily	24-hr total		
pH	SU	1/2 weeks	Grab		
trans-1,2-dichloroethene	µg/L	1/2 weeks	Grab	25	66
Trichloroethene	µg/L	1/2 weeks	Grab	10	10

Table 2.2. FBP NPDES permit summary – 2016 (continued)

Effluent characteristics		Monitoring requirements		Discharge limitations	
Parameter	Units	Measurement frequency	Sampling type	Concentration/Loading[a]	
				Monthly	Daily
FBP Outfall 610 (X-623 Groundwater Treatment Facility)					
Flow rate	MGD	Daily	24-hr total		
pH	SU	1/2 weeks	Grab		
trans-1,2-dichloroethene	µg/L	1/2 weeks	Grab	25	66
Trichloroethene	µg/L	1/2 weeks	Grab	10	10
FBP Outfall 611 (X-627 Groundwater Treatment Facility)					
Flow rate	MGD	Daily	24-hr total		
pH	SU	1/2 weeks	Grab		
Trichloroethene	µg/L	1/2 weeks	Grab	10	10
FBP Monitoring Station 801 (Upstream Monitoring)					
48-hr acute toxicity, *Ceriodaphnia dubia*	% affected	1/quarter	Grab		
96-hr acute toxicity, *Pimephales promelas*	% affected	1/quarter	Grab		
FBP Monitoring Station 902 (Downstream Far Field Monitoring)					
Water temperature	°C	2/week	24-hr maximum	27.8[c]	29.4[c]
FBP Monitoring Station 903 (Downstream Far Field Monitoring)					
Water temperature	°C	2/week	24-hr maximum	27.8[c]	29.4[c]

[a]If provided in the permit, the loading limit, in kg/day or kg/month, is provided in parentheses.
[b]Limitations do not apply if flow increases as a result of a precipitation or snow melt event and conditions specified in the permit are met.
[c]Summer only (May through October).
[d]No detectable PCBs.

Table 2.3. BWCS NPDES permit summary – 2016

Effluent characteristics		Monitoring requirements		Discharge limitations	
Parameter	Units	Measurement frequency	Sampling type	Concentration	
				Monthly	Daily
BWCS Outfall 001[a]					
Biochemical oxygen demand, 5-day	mg/L	1/week	24-hr composite		
Chlorine, total residual	mg/L	Daily	Grab		0.05
Dissolved solids, sum of	mg/L	1/week	24-hr composite		1500
Flow rate	GPD	Daily	24-hr total		
Nitrogen, ammonia	mg/L	1/week	24-hr composite		
Oil and grease, total	mg/L	1/month	Grab		
pH	SU	Daily	Grab		6.5–9.0
Phosphorus, total	mg/L	1/week	24-hr composite		
Total suspended solids[b]	mg/L	1/week	24-hr composite	30	45
Water temperature	°F	Daily	Maximum	*c*	*c*
BWCS Outfall 602					
Flow rate	GPD	Daily	24-hr total		
pH	SU	Daily	Grab		

[a]These monitoring requirements and limits apply only when process water is being discharged through the outfall.
[b]Limitations do not apply if flow increases as a result of a precipitation or snow melt event and conditions specified in the permit are met.
[c]Maximum daily and monthly average limits vary according to month.

Table 2.4. FBP NPDES discharge and compliance rates – 2016

Parameter	NPDES compliance rate (%)[a]	Number of measurements[b]	Concentration (and loading if applicable) Minimum	Maximum	Average[c]	Units
Outfall 001 (X-230J7 East Holding Pond)						
Cadmium, total recoverable	-	4(2)	< 0.04	0.099		µg/L
Chlorine, total residual	-	48(8)	< 0.01	0.05		mg/L
Copper, total recoverable		4(0)	0.76	2	1.4	µg/L
Dissolved solids	-	48(0)	130	650	224	mg/L
Flow rate	-	366	0.108	2.043	0.597	MGD
Fluoride, total	-	4(0)	0.06	0.13	0.10	mg/L
Mercury, total (low level)	-	22(0)	4.25	27.7	14.7	ng/L
monthly average[d]	75	12	4.25	22.7	10.9	mg/L
Oil & grease	100	48(42)	< 1.46	11		mg/L
monthly average[d]	100	12	0	3.0		mg/L
pH	100	49	6.79	8.51	7.86	SU
Precipitation, total	-	366	0	1.62	0.10	in.
Silver, total recoverable	-	12(7)	< 0.02	0.077		µg/L
Total suspended solids	100	48(7)	< 1.1	26	4.1	mg/L
monthly average[d]	100	12	0.40	8.6	3.5	mg/L
Zinc, total recoverable	-	4(0)	9.4	29	16	µg/L
Outfall 002 (X-230K South Holding Pond)						
Cadmium, total recoverable	-	4(4)	< 0.04	< 0.04		µg/L
Flow rate	-	366	0.009	1.9	0.457	MGD
Fluoride, total	-	4(0)	0.062	0.14	0.11	mg/L
Mercury, total (low level)	-	4(0)	0.6125	6.78	2.80	ng/L
Nitrogen, ammonia (NH_3)		12(6)	< 0.022	0.26		mg/L
Oil & grease	100	48(44)	< 1.44	5.6		mg/L
pH	100	51	7.14	8.52	7.91	SU
Selenium, total recoverable		12(12)	< 1	< 1		µg/L
Silver, total recoverable	-	4(4)	< 0.02	< 0.02		µg/L
Thallium, total recoverable	-	4(3)	< 0.066	0.0855		µg/L
Total suspended solids	100	48(0)	1.6	15.5	5.0	mg/L
monthly average[d]	100	12	2.0	9.9	5.0	mg/L
Outfall 003 (X-6619 Sewage Treatment Plant)						
Acute toxicity, *Ceriodaphnia dubia*	-	4(4)	0	< 1		TUa
Acute toxicity, *Pimephales promelas*	-	4(4)	0	< 1		TUa
Carbonaceous biochemical oxygen demand, 5-day	100	48(46)	< 5.0	7.3		mg/L
monthly average[d]	100	12	0	3.1		mg/L
Carbonaceous biochemical oxygen demand, 5-day (loading)	100	48	0	8.6		kg/day
monthly average[d]	100	12	0	3.6		kg/day
Chlorine, total residual[b]	99	184(8)	< 0.02	0.06	0.03	mg/L
Copper, total recoverable	-	4(0)	0.9	2.2	1.3	µg/L
E. coli[b]		30(0)	4.1	921	108	#/100 mL
Fecal coliform[b]	100	30(0)	4.0	524	34	#/100 mL
monthly average[d]	100	6	10	149	39	#/100 mL

Table 2.4. FBP NPDES discharge and compliance rates – 2016 (continued)

Parameter	NPDES compliance rate (%)[a]	Number of measurements[b]	Concentration (and loading if applicable) Minimum	Maximum	Average[c]	Units
Outfall 003 (X-6619 Sewage Treatment Plant)						
Flow rate	-	366	0.177	0.595	0.326	MGD
Mercury, total (low level)	-	17(0)	2.94	229	22.1	ng/L
monthly average[d]	-	12	3.90	122	18.9	mg/L
Mercury, total (low level) (loading)	-	17	0.00000413	0.000459	0.0000390	kg/day
monthly average[d]	-	12	0.00000388	0.000198	0.0000271	kg/day
Nitrite plus nitrate (NH_3)	-	4(0)	6.4	20.6	10.4	mg/L
Nitrogen, ammonia	-	25(2)	< 0.022	4.2	1.2	mg/L
Oil & grease	-	4(4)	< 1.7	< 2.0		mg/L
pH	100	201	6.81	8.64	7.63	SU
Silver, total recoverable	-	4(1)	< 0.02	0.042		µg/L
Thallium, total recoverable		4(3)	< 0.066	0.13		µg/L
Total suspended solids	100	50(15)	0.8	7.6		mg/L
monthly average[d]	100	12	0.5	3.7		mg/L
Total suspended solids (loading)	100	50	0	10.9		kg/day
monthly average[d]	100	12	0.63	4.1		kg/day
Zinc, total recoverable	-	4(0)	13	28	21	µg/L
Outfall 004 (Cooling Tower Blowdown)						
Acute toxicity, *Ceriodaphnia dubia*		4(4)	0	< 1		TUa
Acute toxicity, *Pimephales promelas*		4(4)	0	< 1		TUa
Chlorine, total residual	92	49(34)	< 0.02	0.04		mg/L
Copper, total recoverable	100	12(0)	9.3	59	27	µg/L
Dissolved solids	100	12(0)	160	830	335	mg/L
monthly average[d]	100	12	160	830	335	mg/L
Dissolved solids (loading)	100	12	41	125	73	kg/day
monthly average[d]	100	12	47	91	70	kg/day
Flow rate	-	359	0.002	0.120	0.068	MGD
Mercury, total (low level)	-	4(0)	0.571	2.91	1.26	ng/L
Oil & grease	100	12(9)	< 1.7	5.2		mg/L
monthly average[d]	100	12	0	5.2		mg/L
pH	100	13	6.52	7.99	7.27	SU
Total suspended solids	100	12(0)	0.6	12	3.6	mg/L
monthly average[d]	100	12	0.6	12	3.6	mg/L
Total suspended solids (loading)	100	12	0.17	1.50	0.59	kg/day
monthly average[d]	100	12	0.20	1.48	0.55	kg/day
Zinc, total recoverable	-	4(0)	12	43	31	µg/L
Outfall 005 (X-611B Lime Sludge Lagoons)						
Flow rate	-	32	0.022	3.927	0.925	MGD
Lead, total recoverable		3(0)	0.36	0.47	0.43	µg/L
Mercury, total (low level)		3(0)	1.89	2.78	2.33	ng/L
pH	100	8	7.86	9.2	8.77	SU
Selenium, total recoverable		3(3)	< 1	< 1		µg/L
Total suspended solids	100	8(0)	1.20	11	5.8	mg/L
monthly average[d]	100	3	2.9	7.7	5.9	mg/L

Table 2.4. FBP NPDES discharge and compliance rates – 2016 (continued)

Parameter	NPDES compliance rate (%)[a]	Number of measurements[b]	Concentration (and loading if applicable) Minimum	Maximum	Average[c]	Units
Outfall 009 (X-230L North Holding Pond)						
Bis(2-ethylhexyl)phthalate	100	12(10)	< 0.58	0.80		µg/L
monthly average[d]	100	12	0	0.80		µg/L
Copper, total recoverable		12(0)	0.54	5.6	1.2	µg/L
Flow rate	-	366	0.006	3.113	0.497	MGD
Fluoride, total	-	4(0)	0.11	0.17	0.14	mg/L
Mercury, total		4(0)	0.581	3.24	1.87	ng/L
Oil & grease	100	12(9)	< 1.6	5.0		mg/L
monthly average[d]	100	12	0	5.0		mg/L
pH	100	52	7.39	8.61	8.03	SU
Silver, total recoverable	100	12(10)	< 0.02	0.041		µg/L
monthly average[d]	100	12	0	0.041		µg/L
Total suspended solids	100	45(1)	< 1.1	29	6.8	mg/L
monthly average[d]	100	12	1.9	14.9	6.5	mg/L
Zinc, total recoverable	-	4(0)	5.3	13	8.9	µg/L
Outfall 010 (X-230J5 Northwest Holding Pond)						
Flow rate	-	366	0.088	0.761	0.274	MGD
Lead, total recoverable		12(4)	< 0.1	0.6		µg/L
Mercury, total	-	4(0)	0.676	1.76	1.25	ng/L
Oil & grease	100	12(9)	< 1.7	1.9		mg/L
monthly average[d]	100	12	0	1.9		mg/L
pH	100	103	6.93	8.50	7.90	SU
Precipitation, total	-	366	0	1.62	0.10	in.
Selenium, total recoverable	100	12(12)	< 1	< 1		µg/L
Total suspended solids	100	24(6)	< 1.1	19		mg/L
monthly average[d]	100	12	0	9.5		mg/L
Zinc, total recoverable	-	12(0)	5.8	29	12	µg/L
Outfall 011 (X-230J6 Northeast Holding Pond)						
Cadmium, total recoverable	-	4(2)	< 0.04	0.155		µg/L
Chlorine, total residual	-	24(8)	< 0.01	0.05		mg/L
Copper, total recoverable	-	12(0)	0.31	1.5	0.91	µg/L
Flow rate	-	366	0.002	0.181	0.032	MGD
Fluoride, total	-	4(0)	0.08	0.18	0.12	mg/L
Oil & grease	100	24(18)	1.54	5.55		mg/L
monthly average[d]	100	12	0	3.8		mg/L
pH	100	25	7.27	8.81	7.98	SU
Precipitation, total	-	366	0	1.62	0.10	in.
Selenium, total recoverable		12(9)	< 1.0	1.3		µg/L
Thallium, total recoverable		4(1)	0.066	0.16		µg/L
Total suspended solids	100	24(4)	1.1	13		mg/L
monthly average[d]	100	12	0	8.3		mg/L
Zinc, total recoverable	-	12(0)	7.6	41	19	µg/L

Table 2.4. FBP NPDES discharge and compliance rates – 2016 (continued)

Parameter	NPDES compliance rate (%)[a]	Number of measurements[b]	Concentration (and loading if applicable) Minimum	Maximum	Average[c]	Units
Outfall 015 (X-624 Groundwater Treatment Facility)						
Arsenic, total recoverable	-	4(3)	< 0.5	1.1		µg/L
Barium, total recoverable	-	4(0)	22	41	31	µg/L
Flow rate	-	346	0.001	0.0315	0.008	MGD
PCBs	100	4(4)	< 0.097	< 0.1		µg/L
pH	100	24	7.42	8.72	7.80	SU
Silver, total recoverable	-	12(2)	< 0.02	0.053		µg/L
Trichloroethene	100	24(0)	0.705	6.7	4.2	µg/L
monthly average[d]	100	12	1.2	5.9	4.2	µg/L
Outfall 602 (X-621 Coal Pile Runoff Treatment Facility)						
Flow rate	-	14	0.022	0.178	0.088	MGD
Iron, total	100	6(0)	61	250	152	µg/L
monthly average[d]	100	5	61	250	148	µg/L
Manganese, total	100	6(0)	76	170	117	µg/L
monthly average[d]	100	5	76	150	110	µg/L
pH	100	6	7.10	9.18	8.61	SU
Precipitation, total	-	152	0	1.31	0.13	in.
Total suspended solids	100	6(0)	6	22	11	mg/L
monthly average[d]	100	5	6	22	11	mg/L
Outfall 604 (X-700 Biodenitrification Facility)						
Copper, total	-	10(0)	0.42	2.3	1.3	µg/L
Flow rate	-	96	0.00866	0.01059	0.0105	µg/L
Iron, total	-	10(0)	130	470	247	MGD
Nickel, total	-	10(0)	0.31	1.2	0.78	µg/L
Nitrogen, nitrate	-	10(1)	< 0.1	20.6	9.4	mg/L
pH	100	10	7.59	8.42	8.05	SU
Zinc, total	-	10(0)	2.3	7.6	4.3	µg/L
Outfall 605 (X-705 Microfiltration Treatment System)						
Chromium, hexavalent	-	3(3)	< 0.01	< 0.01		µg/L
Chromium, total	-	3(2)	< 0.88	0.88		µg/L
Copper, total	-	3(0)	1.3	7.6	4.7	µg/L
Flow rate	-	11	0.003	0.01339	0.007	MGD
Nickel, total	-	3(0)	7	14	11	µg/L
Nitrogen, ammonia (NH_3)	-	3(1)	< 0.022	0.16		mg/L
Nitrogen, nitrate	-	3(0)	1.12	5.15	3.63	mg/L
Nitrogen, nitrite	-	3(3)	< 0.1	< 0.1		mg/L
Nitrogen, Kjeldahl	-	3(2)	< 0.18	0.22		mg/L
Oil & grease	-	3(2)	< 1.7	4.2		mg/L
pH	100	3	8.27	8.51	8.39	SU
Sulfate (SO_4)	-	3(0)	42	60	49	mg/L
Total suspended solids	100	3(3)	< 1.1	< 1.1		mg/L
monthly average[d]	100	3	0	0		mg/L
Trichloroethene	-	3(3)	< 0.16	< 0.16		µg/L
Zinc, total	-	3(0)	2.3	3.9	2.9	µg/L

Table 2.4. FBP NPDES discharge and compliance rates – 2016 (continued)

Parameter	NPDES compliance rate (%)[a]	Number of measurements[b]	Concentration (and loading if applicable) Minimum	Maximum	Average[c]	Units
Outfall 608 (X-622 Groundwater Treatment Facility)						
Flow rate	-	340	0.004	0.086	0.056	MGD
pH	-	23	7.21	8.24	7.87	SU
Trichloroethene	100	23(0)	0.66	4.7	2.1	µg/L
1,2-*trans*-dichloroethene	100	23(23)	< 0.15	< 0.3		µg/L
monthly average[d]	100	12	0	0		µg/L
Outfall 610 (X-623 Groundwater Treatment Facility)						
Flow rate	-	7	0.001	0.0106	0.004	MGD
pH	-	6	7.04	7.75	7.44	SU
Trichloroethene	100	6(5)	< 0.16	0.38		µg/L
monthly average[d]	100	6	0	0.38		µg/L
1,2-*trans*-dichloroethene	100	6(6)	< 0.15	< 0.15		µg/L
monthly average[d]	100	6	0	0		µg/L
Outfall 611 (X-627 Groundwater Treatment Facility)						
Flow rate	-	365	0.014	0.0528	0.030	MGD
pH	-	24	7.27	8.43	8.01	SU
Trichloroethene	100	24(0)	0.84	6.50	2.75	µg/L
monthly average[d]	100	12	1.0	6.1	2.7	µg/L
Monitoring Station 801 (Upstream Monitoring)						
48-hr acute toxicity, *Ceriodaphnia dubia*	-	4(4)	0	0		% affected
96-hr acute toxicity, *Pimephales promelas*	-	4(3)	0	5		% affected
Monitoring Station 902 (Downstream Far Field Monitoring)						
Water temperature	97	98	1	30	18	°C
monthly average	83	12	3	28.8	18	°C
Monitoring Station 903 (Downstream Far Field Monitoring)						
Water temperature	100	98	1	29	17	°C
monthly average	100	12	3	27.8	17	°C

[a]Compliance rates are provided only for those parameters with a limit specified in the NPDES permit (many parameters require monitoring only). At all outfalls except Outfalls 003, 004, and 605, permit limitations do not apply to total suspended solids (and iron and manganese at Outfall 605) if flow increases as a result of precipitation or snow melt and conditions set in the permit are met.
[b]Number in parentheses is the number of samples that were below the detection limit.
[c]Averages were not calculated for outfalls that had greater than 15% of the results below the detection limit. For outfalls with less than 15% of the results below the detection limit, any result below the detection limit was assumed to be zero for calculating the average for the parameter.
[d]To compute the monthly average, parameters that were undetected were assumed to be zero. Exceedances due to flow increases from precipitation or snow melt (see footnote a) were not included in the monthly average calculation.

Note: Some measurements are provided in scientific notation. The number and sign (+ or -) to the right of the "E" indicate the number of places to the right or left of the decimal point. For example, 3.4E-04 is 0.00034 (the decimal point moves four places to the left); 2.1E+02 is 210 (the decimal point moves two places to the right).

Table 2.5. BWCS NPDES discharge and compliance rates – 2016

Parameter	NPDES compliance rate (%)	Number of measurements	Result			Units
			Minimum	Maximum	Average	
		Outfall 001[a]				
		Outfall 602				
Flow rate	100	366	35	15,602	7400	GPD
pH	100	252	5.71	8.54	6.89	SU

[a]This outfall was not used for process water discharges in 2016; therefore, monitoring was not required.

Table 2.6. Centrus NPDES discharge monitoring results – 2016

Parameter	Number of samples[a]	Concentration			Units
		Minimum	Maximum	Average[b]	
Outfall 012 (X-230M Southwest Holding Pond)					
Cadmium	12(0)	0.043	0.71	0.29	µg/L
Chlorine	24(2)	0	0.06	0.03	mg/L
Copper	12(0)	0.37	2.1	1.2	µg/L
Flow rate	366	0.0216	1.428	0.178	MGD
Iron	12(0)	92	1300	429	µg/L
Oil and grease	24(19)	< 1.1	4.5		mg/L
PCBs, total	1(1)	< 0.1			µg/L
pH	24	7.42	8.38	8.04	SU
Selenium	12(12)	< 1	< 1		µg/L
Silver	12(6)	< 0.02	0.059		µg/L
Suspended solids	24(1)	< 1.1	26	6.6	mg/L
Thallium	12(7)	< 0.066	0.14		µg/L
Trichloroethene	12(12)	< 0.16	< 0.16		µg/L
Outfall 013 (X-230N West Holding Pond)					
Antimony	12(0)	0.28	1.3	0.65	µg/L
Arsenic	12(2)	< 0.5	1.2		µg/L
Chlorine	24(2)	< 0.01	0.06	0.03	mg/L
Copper	12(0)	0.96	2.9	1.7	µg/L
Flow rate	366	0.0150	1.158	0.146	MGD
Oil and grease	24(18)	< 1.47	11		mg/L
PCBs, total	1(1)	< 0.1			µg/L
pH	24	7.36	8.99	8.22	SU
Suspended solids	24(5)	< 1.1	15		mg/L
Thallium	12(11)	< 0.066	0.079		µg/L
Zinc	12(0)	5.9	43	18	µg/L
Outfall 613 (X-6002 Particulate Separator)					
Chlorine	19(0)	0.01	0.10	0.05	mg/L
Flow rate	304	0	0.022	0.0002	MGD
Suspended solids	19(4)	< 1.1	10		mg/L

[a]Number in parentheses is the number of samples that were below the detection limit.
[b]Averages were not calculated for outfalls that had greater than 15% of the results below the detection limit. For outfalls with less than 15% of the results below the detection limit, any result below the detection limit was assigned a value at the detection limit for calculating an average for the parameter.

Table 2.7. Radionuclides in surface water runoff samples from FBP and BWCS cylinder storage yards – 2016

Sample location	Parameter	Units	Number of samples[a]	Minimum[b]	Maximum	Average[c]
			FBP cylinder storage yards			
X745-B1	Alpha activity	pCi/L	11(3)	< 1.11	79.5	
	Beta activity	pCi/L	11(1)	< 4.61	98.1	31.7
	Uranium	µg/L	11(0)	0.159	3.57	1.28
X745-B2	Alpha activity	pCi/L	11(0)	6.45	98.3	26.7
	Beta activity	pCi/L	11(0)	6.01	96.7	24.7
	Uranium	µg/L	11(0)	3.29	43.9	19.8
X745-B3	Alpha activity	pCi/L	10(5)	< 0.0786	36.7	
	Beta activity	pCi/L	10(2)	< 3.22	52.7	
	Uranium	µg/L	10(0)	0.086	2.68	1.01
X745-D1	Alpha activity	pCi/L	12(8)	0	308	
	Beta activity	pCi/L	12(4)	< 1.54	414	
	Uranium	µg/L	12(0)	0.193	8.02	2.92
X745-F1	Alpha activity	pCi/L	12(10)	0	81.9	
	Beta activity	pCi/L	12(6)	< 0.581	86	
	Uranium	µg/L	12(0)	0.084	4.98	1.20
X745-F2	Alpha activity	pCi/L	12(4)	< 0.626	82	
	Beta activity	pCi/L	12(2)	5.3	109	
	Uranium	µg/L	12(0)	0.995	12.2	4.37
X745-F3	Alpha activity	pCi/L	12(5)	0	98.6	
	Beta activity	pCi/L	12(3)	< 2.14	101	
	Uranium	µg/L	12(0)	0.611	12.6	3.67
			BWCS cylinder storage yards			
X745-C1	Alpha activity	pCi/L	12(7)	< 0.538	18.1	
	Beta activity	pCi/L	12(2)	< 0.699	12.3	
	Uranium	µg/L	12(0)	0.31	9.2	2.7
X745-C2	Alpha activity	pCi/L	12(4)	< 0.351	8.46	
	Beta activity	pCi/L	12(0)	1.64	4.87	3.11
	Uranium	µg/L	12(0)	0.73	13	7.2
X745-C3	Alpha activity	pCi/L	12(8)	< 0.266	2.28	
	Beta activity	pCi/L	12(0)	0.966	5.09	2.48
	Uranium	µg/L	12(0)	0.40	3.6	2.2
X745-C4	Alpha activity	pCi/L	12(3)	0	5.04	
	Beta activity	pCi/L	12(0)	1.87	4.35	3.31
	Uranium	µg/L	12(0)	0.47	14	6.1
X745-E1	Alpha activity	pCi/L	12(9)	0	3.29	
	Beta activity	pCi/L	12(0)	2.86	8.80	5.58
	Uranium	µg/L	12(1)	< 0.23	2.3	1.3

Table 2.7. Radionuclides in surface water runoff samples from FBP and BWCS cylinder storage yards – 2016 (continued)

Sample location	Parameter	Units	Number of samples[a]	Minimum[b]	Maximum	Average[c]
BWCS cylinder storage yards (continued)						
X745-G1A	Alpha activity	pCi/L	12(3)	< 0.256	8.46	
	Beta activity	pCi/L	12(0)	2.47	9.69	4.74
	Uranium	µg/L	12(0)	1.7	7.1	3.3
X745-G2	Alpha activity	pCi/L	12(8)	0	5.45	
	Beta activity	pCi/L	12(0)	1.49	6.01	3.43
	Uranium	µg/L	12(0)	0.40	4.3	2.4

[a]Number in parentheses is the number of samples that were below the detection limit.
[b]Minimum values reported as "0" may actually be negative results. Because of the statistical nature of radiation detection, results for samples that have no radioactivity are often negative values because background radioactivity is subtracted out. These negative value results are reported as "0" in the table for simplicity.
[c]Averages were not calculated for locations that had greater than 15% of the results below the detection limit. For locations with less than 15% of the results below the detection limit, any result below the detection limit was assigned a value at the detection limit to calculate the average for the parameter.

Table 2.8. Drainage basin monitoring of surface water and sediment for BWCS cylinder storage yards – 2016

Location	Parameter[a]	First quarter[b]			Second quarter[b]		
		SW-F	SW-UF	Sed	SW-F	SW-UF	Sed
UDS X01	Total PCB	0.16U	0.16U	35J	0.16U	0.16U	37JP
RM-8	Total PCB	0.17U	0.16U	13J	0.16U	0.16U	10U
UDS X02	Total PCB	0.16U	0.16U	65	0.16U	0.16U	150
RM-10	Total PCB	0.16U	0.16U	29J	0.16U	0.16U	11U

Location	Parameter[a]	Third quarter[b]			Fourth quarter[b]		
		SW-F	SW-UF	Sed	SW-F	SW-UF	Sed
UDS X01	Total PCB	0.21U	0.21U	38JP	0.22U	0.22U	11U
RM-8	Total PCB	0.21U	0.21U	10U	0.21U	0.21U	13J
UDS X02	Total PCB	0.21U	0.21U	18J	0.23U	0.23U	120
RM-10	Total PCB	0.21U	0.20U	64	0.23U	0.22U	16J

[a]Results for surface water (SW) are reported in µg/L; results for sediment (Sed) are reported in µg/kg.
[b]Abbreviations and data qualifiers are as follows: SW-F – filtered surface water; SW-UF – unfiltered surface water; Sed – sediment; J – the reported value is an estimated concentration greater than the method detection limit but less than the practical quantitation limit; P – the relative percent difference between the primary and secondary column exceeded 40 %. U – undetected.

Table 2.9. Ambient air monitoring program summary for radionuclides and fluoride – 2016

Sampling Location	Parameter[a]	No. of measurements[b]	Minimum[c, d]	Maximum[c]	Average[c, e]
		On-site air samplers			
A8	Americium-241	4(4)	0	8.6E-06	
	Fluoride	41(39)	6.9E-03	2.3E-02	
	Neptunium-237	4(4)	0	0	
	Plutonium-238	4(4)	0	1.3E-06	
	Plutonium-239/240	4(4)	1.3E-06	2.9E-06	
	Technetium-99	12(1)	1.2E-04	2.8E-02	1.2E-02
	Uranium	12(1)	2.6E-05	8.7E-05	5.9E-05
	Uranium-233/234	12(0)	2.2E-05	9.2E-05	4.2E-05
	Uranium-235/236	12(12)	1.0E-06	5.0E-06	
	Uranium-238	12(1)	8.5E-06	2.9E-05	1.9E-05
A10	Americium-241	3(3)	4.7E-07	3.1E-06	
	Fluoride	38(37)	1.3E-02	2.1E-02	
	Neptunium-237	3(3)	0	6.3E-07	
	Plutonium-238	3(3)	0	2.7E-06	
	Plutonium-239/240	3(3)	6.9E-07	5.4E-06	
	Technetium-99	9(0)	5.3E-04	4.0E-02	1.8E-02
	Uranium	9(0)	3.8E-05	2.9E-04	1.2E-04
	Uranium-233/234	9(0)	3.1E-05	1.8E-04	8.5E-05
	Uranium-235/236	9(9)	7.4E-07	1.0E-05	
	Uranium-238	9(0)	1.2E-05	9.7E-05	3.9E-05
A29	Americium-241	4(4)	2.1E-06	4.9E-06	
	Fluoride	47(45)	6.3E-03	2.4E-02	
	Neptunium-237	4(4)	0	2.7E-06	
	Plutonium-238	4(4)	0	1.5E-06	
	Plutonium-239/240	4(4)	0	7.3E-06	
	Technetium-99	12(1)	2.8E-05	3.2E-02	1.4E-02
	Uranium	12(1)	2.6E-05	1.1E-04	6.3E-05
	Uranium-233/234	12(1)	8.2E-06	1.1E-04	4.3E-05
	Uranium-235/236	12(12)	0	4.2E-06	
	Uranium-238	12(1)	8.2E-06	3.6E-05	2.1E-05
A36	Americium-241	4(4)	6.2E-07	3.5E-05	
	Fluoride	33(29)	1.2E-02	7.6E-02	
	Neptunium-237	4(4)	0	9.0E-06	
	Plutonium-238	4(4)	0	4.6E-06	
	Plutonium-239/240	4(4)	0	1.8E-06	
	Technetium-99	12(1)	1.2E-03	2.1E-02	1.2E-02
	Uranium	12(2)	2.4E-05	9.5E-05	
	Uranium-233/234	12(1)	2.9E-05	1.2E-04	6.9E-05
	Uranium-235/236	12(12)	1.5E-06	2.7E-05	
	Uranium-238	12(2)	8.0E-06	3.1E-05	
A40A	Fluoride	48(44)	9.0E-03	2.8E-02	

Table 2.9. Ambient air monitoring program summary for radionuclides and fluoride – 2016 (continued)

Sampling Location	Parameter[a]	No. of measurements[b]	Minimum[c, d]	Maximum[c]	Average[c, e]
		On-site air samplers			
T7	Americium-241	4(4)	4.5E-06	7.8E-06	
	Neptunium-237	4(4)	0	2.1E-06	
	Plutonium-238	4(4)	0	0	
	Plutonium-239/240	4(4)	1.3E-06	3.2E-06	
	Technetium-99	11(0)	4.8E-04	3.1E-02	1.3E-02
	Uranium	11(1)	3.1E-05	9.6E-05	6.2E-05
	Uranium-233/234	11(0)	2.0E-05	9.0E-05	4.1E-05
	Uranium-235/236	11(11)	9.4E-07	7.0E-06	
	Uranium-238	11(1)	1.0E-05	3.1E-05	2.0E-05
		Off-site air samplers			
A3	Americium-241	4(4)	6.0E-07	3.8E-06	
	Fluoride	51(35)	4.4E-03	4.1E-02	
	Neptunium-237	4(4)	0	6.7E-07	
	Plutonium-238	4(4)	0	6.8E-07	
	Plutonium-239/240	4(4)	1.9E-06	4.2E-06	
	Technetium-99	12(1)	1.3E-04	3.5E-02	1.5E-02
	Uranium	12(1)	2.7E-05	9.1E-05	6.5E-05
	Uranium-233/234	12(0)	1.7E-05	6.1E-05	4.1E-05
	Uranium-235/236	12(12)	0	5.4E-06	
	Uranium-238	12(1)	9.0E-06	3.0E-05	2.1E-05
A6	Americium-241	4(4)	2.5E-06	8.6E-06	
	Fluoride	45(44)	1.3E-02	2.5E-02	
	Neptunium-237	4(4)	0	1.2E-06	
	Plutonium-238	4(4)	0	6.8E-07	
	Plutonium-239/240	4(4)	1.2E-06	2.7E-06	
	Technetium-99	12(1)	1.6E-05	4.2E-02	1.5E-02
	Uranium	12(2)	1.8E-05	1.1E-04	
	Uranium-233/234	12(1)	6.7E-06	4.0E-05	2.2E-05
	Uranium-235/236	12(12)	0	4.6E-06	
	Uranium-238	12(2)	6.0E-06	3.5E-05	
A9	Americium-241	4(4)	1.5E-06	6.5E-06	
	Fluoride	52(52)	1.2E-02	2.1E-02	
	Neptunium-237	4(4)	0	8.7E-07	
	Plutonium-238	4(4)	0	2.5E-06	
	Plutonium-239/240	4(4)	1.9E-06	4.6E-06	
	Technetium-99	11(0)	7.1E-04	4.1E-02	1.5E-02
	Uranium	11(1)	1.7E-05	1.8E-04	8.6E-05
	Uranium-233/234	11(1)	6.8E-06	7.4E-05	3.7E-05
	Uranium-235/236	11(11)	8.5E-07	6.3E-06	
	Uranium-238	11(1)	5.4E-06	6.0E-05	2.8E-05

Table 2.9. Ambient air monitoring program summary for radionuclides and fluoride – 2016 (continued)

Sampling Location	Parameter[a]	No. of measurements[b]	Minimum[c, d]	Maximum[c]	Average[c, e]
A12	Americium-241	4(4)	7.0E-07	6.1E-06	
	Fluoride	52(32)	1.2E-02	4.2E-02	
	Neptunium-237	4(4)	0	1.9E-06	
	Plutonium-238	4(4)	0	3.8E-06	
	Plutonium-239/240	4(4)	2.8E-06	4.6E-06	
	Technetium-99	11(0)	7.4E-04	3.3E-02	1.4E-02
	Uranium	11(1)	2.3E-05	1.1E-04	6.8E-05
	Uranium-233/234	11(0)	2.5E-05	8.1E-05	4.6E-05
	Uranium-235/236	11(11)	9.5E-07	7.3E-06	
	Uranium-238	11(1)	7.4E-06	3.4E-05	2.3E-05
A15	Americium-241	4(4)	2.6E-06	7.1E-06	
	Fluoride	50(50)	8.7E-03	3.3E-02	
	Neptunium-237	4(4)	0	1.4E-06	
	Plutonium-238	4(4)	0	1.9E-06	
	Plutonium-239/240	4(4)	1.9E-06	4.6E-06	
	Technetium-99	12(1)	4.8E-05	3.3E-02	1.5E-02
	Uranium	12(0)	3.5E-05	8.9E-05	6.4E-05
	Uranium-233/234	12(0)	1.4E-05	6.0E-05	3.4E-05
	Uranium-235/236	12(12)	0	4.1E-06	
	Uranium-238	12(0)	1.1E-05	2.9E-05	2.1E-05
A23	Americium-241	4(4)	6.5E-07	5.9E-06	
	Fluoride	43(41)	1.2E-05	1.9E-02	
	Neptunium-237	4(4)	0	2.5E-06	
	Plutonium-238	4(4)	6.6E-07	3.4E-06	
	Plutonium-239/240	4(4)	6.1E-07	2.6E-06	
	Technetium-99	12(1)	3.9E-05	3.3E-02	1.6E-02
	Uranium	12(0)	3.9E-05	9.4E-05	6.7E-05
	Uranium-233/234	12(0)	1.5E-05	7.9E-05	5.3E-05
	Uranium-235/236	12(12)	9.6E-07	6.7E-06	
	Uranium-238	12(0)	1.3E-05	3.1E-05	2.2E-05
A24	Americium-241	3(3)	3.8E-06	1.2E-05	
	Fluoride	52(51)	1.2E-02	2.1E-02	
	Neptunium-237	3(3)	0	6.9E-07	
	Plutonium-238	3(3)	0	2.9E-06	
	Plutonium-239/240	3(3)	0	2.3E-06	
	Technetium-99	11(0)	2.5E-04	3.1E-02	1.7E-02
	Uranium	11(0)	5.1E-05	1.3E-04	8.2E-05
	Uranium-233/234	11(0)	2.3E-05	1.0E-04	5.8E-05
	Uranium-235/236	11(11)	1.5E-06	5.5E-06	
	Uranium-238	11(0)	1.7E-05	4.2E-05	2.7E-05

Table 2.9. Ambient air monitoring program summary for radionuclides and fluoride – 2016 (continued)

Sampling Location	Parameter[a]	No. of measurements[b]	Minimum[c, d]	Maximum[c, d]	Average[c, e]
A28	Americium-241	4(4)	1.2E-06	3.8E-06	
	Fluoride	31(24)	1.2E-02	4.2E-02	
	Neptunium-237	4(4)	0	1.6E-06	
	Plutonium-238	4(4)	7.5E-07	2.5E-06	
	Plutonium-239/240	4(4)	1.9E-06	4.5E-06	
	Technetium-99	12(1)	4.5E-05	2.6E-02	1.2E-02
	Uranium	12(3)	2.4E-05	9.2E-05	
	Uranium-233/234	12(2)	5.6E-06	3.3E-05	
	Uranium-235/236	12(12)	0	4.2E-06	
	Uranium-238	12(3)	7.6E-06	3.0E-05	
A37 (background)	Americium-241	4(4)	1.2E-06	4.7E-06	
	Fluoride	46(45)	1.2E-02	2.1E-02	
	Neptunium-237	4(4)	0	1.3E-06	
	Plutonium-238	4(4)	0	2.6E-06	
	Plutonium-239/240	4(4)	0	1.5E-06	
	Technetium-99	11(1)	4.1E-05	2.9E-02	1.4E-02
	Uranium	11(2)	1.8E-05	9.3E-05	
	Uranium-233/234	11(1)	6.6E-06	3.1E-05	1.9E-05
	Uranium-235/236	11(11)	0	3.0E-06	
	Uranium-238	11(2)	6.0E-06	3.1E-05	
A41A	Americium-241	4(4)	2.5E-06	6.6E-06	
	Fluoride	36(25)	1.3E-02	4.4E-02	
	Neptunium-237	4(4)	0	4.0E-06	
	Plutonium-238	4(4)	0	2.7E-06	
	Plutonium-239/240	4(4)	5.9E-07	3.8E-06	
	Technetium-99	12(1)	6.8E-05	2.5E-02	1.3E-02
	Uranium	12(0)	3.7E-05	1.1E-04	6.8E-05
	Uranium-233/234	12(0)	1.7E-05	5.6E-05	2.9E-05
	Uranium-235/236	12(12)	7.3E-07	4.2E-06	
	Uranium-238	12(0)	1.2E-05	3.5E-05	2.3E-05

[a]All parameters are measured in pCi/m^3 with the exception of uranium and fluoride which are measured in $\mu g/m^3$.
[b]Radiological samples for technetium-99, uranium, and uranium isotopes are analyzed monthly, samples for americium-241, neptunium-237, plutonium-238, and plutonium-239/240 are analyzed one month per quarter, and samples for fluoride are analyzed weekly. Number in parentheses is the number of samples that were below the detection limit. If the analytical result for a sample was below the detection limit, the ambient air concentration was calculated based on the detection limit for the sample.
[c]Results are provided in scientific notation. The number and sign (+ or -) to the right of the "E" indicate the number of places to the right or left of the decimal point. For example, 3.4E-04 is 0.00034 (the decimal point moves four places to the left); 2.1E+02 is 210 (the decimal point moves two places to the right).
Ambient concentrations of uranium and uranium isotopes reported in 2016 may be slightly elevated and should be considered estimated. Uranium and uranium isotopes were detected in quality control samples associated with the ambient air samples and subsequently in unused filters obtained from the manufacturer that are placed at the ambient air stations to collect samples. The presence of uranium and uranium isotopes in the unused filters may have caused slightly elevated analytical results for uranium and uranium isotopes. Levels of these constituents in ambient air are calculated based on the analytical results and therefore may be slightly elevated as well. Reported minimum, maximum, and average values include these estimated results.
[d]Values reported as "0" may actually be negative results. Because of the statistical nature of radiation detection, results for samples that have no radioactivity are often negative values because background radioactivity is subtracted out. These negative value results are reported as "0" in the table for simplicity.
[e]Averages are not calculated for locations that had greater than 15% of the results below the detection limit. For locations with less than 15% of the results below the detection limit, any result below the detection limit was assigned a value at the detection limit to calculate the average for the parameter.

Table 2.10. External radiation monitoring program (mrem) – 2016

Location	First quarter	Second quarter	Third quarter	Fourth quarter	Cumulative annual whole body dose[a]
#1404A	22	21	18	21	82
#518	23	21	18	20	82
#862	32	32	29	30	123
#874	148	149	147	149	593
#906	21	20	16	19	76
#933	22	20	17	19	78
A12	25	23	20	21	89
A15	24	24	20	24	92
A23	23	25	19	22	89
A24	25	24	20	22	91
A28	23	22	18	20	83
A29	24	25	20	24	93
A3	22	22	19	21	84
A36	23	23	18	21	85
A40A	24	24	20	21	89
A6	23	22	18	22	85
A8	27	25	22	24	98
A9	24	24	19	21	88
X-230J2	25	24	19	22	90

[a]The annual occupational whole body dose limit set by Title 10 of the *Code of Federal Regulations* Part 20 is 5000 mrem.

Table 2.11. External radiation monitoring (mrem) at locations near cylinder storage yards – 2016

Location	First quarter	Second quarter	Third quarter	Fourth quarter	Cumulative annual whole body dose[a]
#41	167	133	130	153	583
#868	314	308	312	342	1276
#874	176	153	142	156	627
#882	291	265	255	254	1065
#890	91	63	59	67	280

[a]The annual occupational whole body dose limit set by Title 10 of the *Code of Federal Regulations* Part 20 is 5000 mrem.

Table 2.12. Settleable solids monitoring results – 2016

Sampling location	Parameter[a]	Unit	Results[b] April		Results[b] November	
Little Beaver Creek						
EDD-SW01 (FBP Outfalls 001& 015)	Settleable solids	mg/L	7.9		4U	4U[c]
	Suspended solids	mg/L	7.9		4U	4U[c]
FBP Outfall 005	Settleable solids	mg/L	4U		ns	
	Suspended solids	mg/L	6.3		ns	
FBP Outfall 009	Settleable solids	mg/L	4.4		4.6	
	Suspended solids	mg/L	4.4		4.6	
FBP Outfall 011	Settleable solids	mg/L	4U		4U	
	Suspended solids	mg/L	4U		4U	
Big Run Creek						
FBP Outfall 002	Settleable solids	mg/L	4U	4U[c]	4U	
	Suspended solids	mg/L	4U	4U[c]	4U	
Scioto River						
ACP NPDES Outfall 012	Settleable solids	mg/L	4U		4U	
	Suspended solids	mg/L	4U		4U	
WDD-SW03 (FBP Outfall 010 & ACP Outfall 013)	Settleable solids	mg/L	4U		4U	
	Suspended solids	mg/L	4U		4.2	
FBP Outfall 003	Settleable solids	mg/L	4U		4U	
	Suspended solids	mg/L	4U		4U	
FBP Outfall 004	Settleable solids	mg/L	4U		4U	4U[c]
	Suspended solids	mg/L	4U		15.3	14.7[c]
Background locations						
RW-6 (Scioto River)	Settleable solids	mg/L	14	12.4[c]	4.4	
	Suspended solids	mg/L	25	23.8[c]	17	
RW-5 (Big Beaver Creek)	Settleable solids	mg/L	9.8		4U	
	Suspended solids	mg/L	16.7		4U	
LBC-SW12 (Little Beaver Creek)	Settleable solids	mg/L	4U		5.4	
	Suspended solids	mg/L	4U		11.3	

[a]Suspended solids are the solids in a water sample (such as silt or clay particles) that can be trapped by a filter. Settleable solids are a component of suspended solids defined as the particles that settle out of suspension in water within a defined time period.
[b]Abbreviations and data qualifiers are as follows: U – undetected. ns – not sampled.
[c]This result is for the duplicate sample collected from this location. A duplicate sample is a sample collected from the same location at the same time and using the same sampling device (if possible) as the regular sample.

Table 2.13. Local surface water monitoring program results – 2016

Location	Parameter[a]	Second quarter[b,c]	Fourth quarter[b,c]
Scioto River	Americium-241	0U	0.00998U
RW-1A	Neptunium-237	0U	0U
(downstream)	Plutonium-238	-0.00995U	-0.0211U
	Plutonium-239/240	0.0199U	0.0317U
	Technetium-99	-0.857U	-0.714U
	Uranium	1.48	1.97
	Uranium-233/234	0.672	0.702
	Uranium-235/236	0.0298U	0.0472U
	Uranium-238	0.494	0.655
Scioto River	Americium-241	0.0234U	0.0149U
RW-6	Neptunium-237	0.0124U	0.00938U
(upstream)	Plutonium-238	0.00483U	-0.00486U
	Plutonium-239/240	0.00967U	0.0243U
	Technetium-99	-1.61U	-0.597U
	Uranium	1.54J	1.52
	Uranium-233/234	0.435	0.619
	Uranium-235/236	0.0518UJ	0.0337U
	Uranium-238	0.509	0.506
Little Beaver	Americium-241	0.0395U	0.0235U
Creek	Neptunium-237	-0.00479U	0.0083U
RW-7	Plutonium-238	-0.0104U	0.00514U
(downstream)	Plutonium-239/240	0.0156U	0.0154U
	Technetium-99	3.31U	2.96U
	Uranium	1.29J	0.488J
	Uranium-233/234	1.8	0.764
	Uranium-235/236	0.106UJ	0.0655UJ
	Uranium-238	0.416	0.154
RW-8	Americium-241	0U	0.02U
(downstream)	Neptunium-237	0.0161U	0U
	Plutonium-238	0.00524U	0.00516U
	Plutonium-239/240	0.0157U	0.0103U
	Technetium-99	0.38U	1.6U
	Uranium	1.33J	0.674J
	Uranium-233/234	1.57	0.529
	Uranium-235/236	0.0726UJ	0.0408U
	Uranium-238	0.435	0.22
RW-12	Americium-241	0.00944U 0.00999U[d]	0.0148U
(upstream)	Neptunium-237	0.009U 0.00461U[d]	0U
	Plutonium-238	0.0157U 0.0145U[d]	0.00551U
	Plutonium-239/240	0.00522U -0.00484U[d]	0.022U
	Technetium-99	-3.72U -1.24U[d]	-1.21U
	Uranium	0.0522U 0.0816UJ[d]	0.149UJ
	Uranium-233/234	0.0326U 0.0522UJ[d]	0.102
	Uranium-235/236	0.0231U 0.0236U[d]	0.0231U
	Uranium-238	0.014U 0.0237U[d]	0.0465UJ

Table 2.13. Local surface water monitoring program results – 2016 (continued)

Location	Parameter[a]	Second quarter[b,c]		Fourth quarter[b,c]	
Big Beaver Creek RW-13 (downstream)	Americium-241	0.0291U		0.0302U	
	Neptunium-237	0.00467U		0U	
	Plutonium-238	-0.00539U		-0.0103U	
	Plutonium-239/240	0.0162U		0.0259U	
	Technetium-99	1.78U		0.938U	
	Uranium	0.812J		0.53J	
	Uranium-233/234	1.11		0.856	
	Uranium-235/236	0.0895UJ		0.0394U	
	Uranium-238	0.259		0.172	
RW-5 (upstream)	Americium-241	0.0477UJ		0.0239U	
	Neptunium-237	0.00444U		0.0094U	
	Plutonium-238	-0.00491U		-0.015U	
	Plutonium-239/240	0.0197U		0.02U	
	Technetium-99	-0.219U		-1.03U	
	Uranium	0.161UJ		0.663J	
	Uranium-233/234	0.0632UJ		0.837	
	Uranium-235/236	0.0281U		0.0377U	
	Uranium-238	0.0496UJ		0.217	
Big Run Creek RW-2 (downstream)	Americium-241	0.0303U	0.0201U[d]	0.0314U	-0.0145U[d]
	Neptunium-237	-0.00492U	0.00491U[d]	0U	0.0135U[d]
	Plutonium-238	0.00465U	0U[d]	0.0147U	0.0152U[d]
	Plutonium-239/240	0.014U	0.0197U[d]	0.0244U	0.0254U[d]
	Technetium-99	-2.17U	-2.53U[d]	-0.367U	-0.527U[d]
	Uranium	0.289J	0.107U[d]	0.275J	0.251UJ[d]
	Uranium-233/234	0.138	0.144[d]	0.16	0.189[d]
	Uranium-235/236	0.0222U	0.023U[d]	0.0342U	0.00548U[d]
	Uranium-238	0.0935J	0.0324U[d]	0.087J	0.0836UJ[d]
RW-3 (downstream)	Americium-241	0.0239U		0.0195U	
	Neptunium-237	0.00937U		0.0044U	
	Plutonium-238	-0.00526U		0.0051U	
	Plutonium-239/240	0.0158U		0.0357U	
	Technetium-99	-1.52U		0.46U	
	Uranium	0.807J		0.598J	
	Uranium-233/234	0.806		0.489	
	Uranium-235/236	0.0164U		0.0164U	
	Uranium-238	0.269		0.198	

Table 2.13. Local surface water monitoring program results – 2016 (continued)

Location	Parameter[a]	Second quarter[b,c]	Fourth quarter[b,c]
Big Run Creek (continued)	Americium-241	0.0251U	0.0194U
	Neptunium-237	-0.00494U	-0.00442U
RW-33 (upstream)	Plutonium-238	0U	0U
	Plutonium-239/240	0.0151U	0.0319U
	Technetium-99	-2.1U	-2.8U
	Uranium	0.0495U	1.77
	Uranium-233/234	0.0418U	0.693
	Uranium-235/236	0.0173U	0.0397U
	Uranium-238	0.0139U	0.588
Background creeks	Americium-241	0.0147U	0.0335U
RW-10N	Neptunium-237	0U	0U
	Plutonium-238	0.00968U	0.00507U
	Plutonium-239/240	0.0145U	0.0101U
	Technetium-99	-0.97U	-0.707U
	Uranium	0.273J	0.311J
	Uranium-233/234	0.118	0.134
	Uranium-235/236	0.0272U	0.0111U
	Uranium-238	0.0875J	0.103
RW-10S	Americium-241	0.0242U	0.0248U
	Neptunium-237	0U	-0.0044U
	Plutonium-238	-0.0103U	0.0104U
	Plutonium-239/240	0.0206U	0.0261U
	Technetium-99	-0.719U	-2.72U
	Uranium	0.298J	0.4J
	Uranium-233/234	0.156	0.0777UJ
	Uranium-235/236	0.0111U	0.0114U
	Uranium-238	0.0984J	0.133
RW-10E	Americium-241	0.0229U	0.0144U
	Neptunium-237	0.00485U	-0.00431U
	Plutonium-238	-0.0101U	-0.00491U
	Plutonium-239/240	0.0303U	0.0148U
	Technetium-99	-0.195U	-2.93U
	Uranium	0.105U	0.153UJ
	Uranium-233/234	0.0186U	0.0222U
	Uranium-235/236	0.0174U	0.0165U
	Uranium-238	0.0326U	0.0488UJ

Table 2.13. Local surface water monitoring program results – 2016 (continued)

Location	Parameter[a]	Second quarter[b,c]	Fourth quarter[b,c]	
Background creeks	Americium-241	0U	0.00934U	0.0396U[d]
RW-10W	Neptunium-237	0.023U	0.00456U	0.00928U[d]
	Plutonium-238	0.0473U	-0.00517U	0.0112U[d]
	Plutonium-239/240	0.0189U	0.0103U	0.0225U[d]
	Technetium-99	-0.959U	-2.97U	-1.26U[d]
	Uranium	1.51	0.107U	0.11U[d]
	Uranium-233/234	0.105	0.0404U	0.0341U[d]
	Uranium-235/236	0.0284U	0U	0.0182U[d]
	Uranium-238	0.503	0.0359UJ	0.0341U[d]

[a]Results are reported in µg/L (uranium) and pCi/L (all other parameters).
[b]Abbreviations and data qualifiers are as follows: U – undetected. J – the reported result is estimated.
[c]Because of the statistical nature of radiation detection, results for samples that have no radioactivity are often negative values because background radioactivity is subtracted out.
[d]This result is for the duplicate sample collected from this location. A duplicate sample is a sample collected from the same location at the same time and using the same sampling device (if possible) as the regular sample.

Table 2.14. Sediment monitoring program results – 2016

Parameter	Unit	Location/results[a,b]			
		Scioto River and outfalls that discharge to the Scioto River			
		RM-6 Upstream @ Piketon	*RM-1A Downstream @ Lucasville*	*RM-9 Outfall 012*	*RM-10 Outfall 010/Outfall 013*
Aluminum	mg/kg	2720D	6450D	4570D	3820D
Americium-241	pCi/g	0.00336U	0.00254U	0.00474UJ	0.00392U
Antimony	mg/kg	0.0591DNU	0.0584DN	0.0497DNU	0.0579DN
Arsenic	mg/kg	7.39*N	11.2	9.95*N	15.5*N
Barium	mg/kg	36.3	83.3D	54.9	60.8
Beryllium	mg/kg	0.202D	0.416D	0.453D	0.589D
Cadmium	mg/kg	0.289D	0.531D	0.738D	0.253D
Calcium	mg/kg	44600*DN	36400D	1260*DN	2460*DN
Chromium	mg/kg	5.51*N	9.22	11*N	19.6*N
Copper	mg/kg	10.1	19.2	19.1	11.4
Iron	mg/kg	12000D	19600D	30900D	30300D
Lead	mg/kg	8.19D	12.1	8.27D	16.9D
Magnesium	mg/kg	18600D	15600D	1530D	1460D
Manganese	mg/kg	332D	591D	609D	1080D
Mercury	mg/kg	0.0224	0.0368	0.0161	0.0162
Neptunium-237	pCi/g	0U	0U	0.0041UJ	0UJ
Nickel	mg/kg	12	21	39.6	14.7
PCB, total	µg/kg	18.9U	18.9U	19U	70.1
Plutonium-238	pCi/g	-0.000639U	-0.000599U	0.000611U	-0.000687U
Plutonium-239/240	pCi/g	0.00319U	0.00359U	0.00672UJ	0.00206U
Selenium	mg/kg	0.483DN	0.759D	0.398DN	0.393DN
Silicon	mg/kg	872D	772D	778D	562D
Silver	mg/kg	0.498U	0.478U	0.496U	0.498U
Technetium-99	pCi/g	0.104U	-0.0649U	0.0417U	0.364
Thallium	mg/kg	0.149D	0.25D	0.135D	0.109D
Uranium	µg/g	0.882	1.02	0.93	2.73
Uranium-233/234	pCi/g	0.238	0.287	0.348	1.46
Uranium-235/236	pCi/g	0.0148	0.0115	0.0174	0.0724
Uranium-238	pCi/g	0.294	0.34	0.31	0.905
Zinc	mg/kg	46.8N	77.3	72.4N	108N

Table 2.14. Sediment monitoring program results – 2016 (continued)

Parameter	Unit	Location/results[a,b]			
		Little Beaver Creek			
		RM-12 Upstream	*RM-11 X-230J7 Discharge*	*RM-11 X-230J7 Discharge (duplicate sample)*	*RM-8 Downstream @ Outfall 009 Discharge*
Aluminum	mg/kg	5730D	2370D	2520D	4230D
Americium-241	pCi/g	0.000797UJ	0.00218U	0.00626U	0.00251U
Antimony	mg/kg	0.0595DNU	0.151DN	0.151DN	0.0956DN
Arsenic	mg/kg	18*N	14.5*N	12.8*N	21.2*N
Barium	mg/kg	75.8	28.1	29.4	71.9
Beryllium	mg/kg	0.684D	0.27D	0.284D	0.683D
Cadmium	mg/kg	0.101D	0.425D	0.512D	0.648D
Calcium	mg/kg	3510*DN	91900*DN	91900*DN	9290*DN
Chromium	mg/kg	17.8*N	8.33*N	8.28*N	21.2*N
Copper	mg/kg	16.8	21.5	22.9	13.8
Iron	mg/kg	47300D	15800D	15700D	51900D
Lead	mg/kg	21.3D	13.3D	12.6D	17.9D
Magnesium	mg/kg	2810D	41500D	38900D	2580D
Manganese	mg/kg	1150D	578D	574D	1190D
Mercury	mg/kg	0.0133	0.506	0.616	0.0453
Neptunium-237	pCi/g	0.00139UJ	0.0059UJ	0.00643UJ	0.0172
Nickel	mg/kg	16.6	16.9	18.2	36.8
PCB, total	µg/kg	18.1U	80.3	105	84
Plutonium-238	pCi/g	0.000592U	0.00329U	0.0021U	0.000766UJ
Plutonium-239/240	pCi/g	0.00296U	0.00791UJ	0.00981UJ	0.00996UJ
Selenium	mg/kg	0.346DN	1.25DN	1.48DN	0.386DN
Silicon	mg/kg	473D	643D	669D	506D
Silver	mg/kg	0.491U	0.683	0.496U	0.49U
Technetium-99	pCi/g	0.00228U	0.231UJ	0.202UJ	3.45
Thallium	mg/kg	0.0884D	0.182D	0.196D	0.217D
Uranium	µg/g	0.987	1.99	2.24	3.19
Uranium-233/234	pCi/g	0.436	3.01J	3.65J	3.3
Uranium-235/236	pCi/g	0.0198	0.123	0.149	0.155
Uranium-238	pCi/g	0.329	0.65	0.731	1.05
Zinc	mg/kg	48N	199N	221N	119N

Table 2.14. Sediment monitoring program results – 2016 (continued)

Parameter	Unit	Location/results[a,b]		
		Little Beaver Creek	*Big Beaver Creek*	
		RM-7 Downstream @ Confluence	*RM-5 Upstream*	*RM-13 Downstream*
Aluminum	mg/kg	3790D	4450D	3250D
Americium-241	pCi/g	0.00148U	0.00204U	0.00233U
Antimony	mg/kg	0.0617DN	0.0622DNU	0.064DN
Arsenic	mg/kg	16.3*N	8.39*N	9.42*N
Barium	mg/kg	55.3	62.2	45.3
Beryllium	mg/kg	0.531D	0.389D	0.512D
Cadmium	mg/kg	0.626D	0.272D	0.735D
Calcium	mg/kg	11400*DN	55300*DN	9320*DN
Chromium	mg/kg	16.5*N	6.89*N	15.8*N
Copper	mg/kg	12.7	10.6	11.9
Iron	mg/kg	40600D	13700D	25800D
Lead	mg/kg	14.5D	9.4D	12.3D
Magnesium	mg/kg	4340D	32500D	4870D
Manganese	mg/kg	895D	763D	708D
Mercury	mg/kg	0.033	0.0174	0.034
Neptunium-237	pCi/g	0.0171	0.000679U	0.017
Nickel	mg/kg	28.8	15.6	24.9
PCB, total	µg/kg	64.4	19U	56.2
Plutonium-238	pCi/g	0.00107U	-0.000657U	-0.001U
Plutonium-239/240	pCi/g	0.00643UJ	0.0046U	0.00702UJ
Selenium	mg/kg	0.313DN	0.361DN	0.32DN
Silicon	mg/kg	548D	708D	547D
Silver	mg/kg	0.497U	0.498U	0.494U
Technetium-99	pCi/g	7.22	0.124U	6.85
Thallium	mg/kg	0.159D	0.12D	0.15D
Uranium	µg/g	3.27	0.915	2.98
Uranium-233/234	pCi/g	4.49	0.334	4.1
Uranium-235/236	pCi/g	0.227	0.0178	0.196
Uranium-238	pCi/g	1.06	0.305	0.97
Zinc	mg/kg	77.2N	37.2N	106N

Table 2.14. Sediment monitoring program results – 2016 (continued)

Parameter	Unit	Location/results[a,b]			
		Big Run Creek			
		RM-33 Upstream	*RM-3 Downstream*	*RM-3 Downstream (duplicate sample)*	*RM-2 Downstream @ Wakefield*
Aluminum	mg/kg	5480D	4800D	4470D	6110D
Americium-241	pCi/g	0.00741UJ	0.00268U	0.00283UJ	0.00536U
Antimony	mg/kg	0.139DN	0.0781DN	0.0894DN	0.0505DN
Arsenic	mg/kg	29.9*N	15*N	14.3*N	21.5*N
Barium	mg/kg	60.8	105	80.1	65.4
Beryllium	mg/kg	0.932D	0.71D	0.631D	0.684D
Cadmium	mg/kg	0.522D	0.387D	0.361D	0.524D
Calcium	mg/kg	2950*DN	3540*DN	4270*DN	1450*DN
Chromium	mg/kg	23.2*N	20.7*N	17.7*N	17.9*N
Copper	mg/kg	18.7	14.7	14.4	17.4
Iron	mg/kg	58300D	40800D	35900D	44000D
Lead	mg/kg	31.1D	29.1D	24D	24D
Magnesium	mg/kg	2210D	2050D	2360D	1420D
Manganese	mg/kg	1050D	1670D	1220D	876D
Mercury	mg/kg	0.0288	0.0557	0.0408	0.0383
Neptunium-237	pCi/g	0.000857UJ	0.000596U	0.0017U	0.00553U
Nickel	mg/kg	28	18	16.3	24.8
PCB, total	µg/kg	19.6U	35.9	32.5	63
Plutonium-238	pCi/g	-0.000528U	0.00115U	0U	0.00122U
Plutonium-239/240	pCi/g	0.00317U	0.00461UJ	0.00299U	0.00914UJ
Selenium	mg/kg	0.505DN	0.535DN	0.534DN	0.356DN
Silicon	mg/kg	501D	529D	594D	737D
Silver	mg/kg	0.498U	0.493U	0.492U	0.679
Technetium-99	pCi/g	-0.0247U	0.791J	0.581J	0.0949U
Thallium	mg/kg	0.219D	0.292D	0.269D	0.195D
Uranium	µg/g	3.07	2.71	2.53	1.73
Uranium-233/234	pCi/g	0.951	1.34	1.29	1.23
Uranium-235/236	pCi/g	0.0553	0.0638	0.0643	0.0668
Uranium-238	pCi/g	1.02	0.901	0.839	0.572
Zinc	mg/kg	94N	69.1N	67.5N	90.5N

Table 2.14. Sediment monitoring program results – 2016 (continued)

Parameter	Unit	Location/results[a,b]			
		Background creeks			
		RM-10N North background	*RM-10S South background*	*RM-10E East background*	*RM-10W West background*
Aluminum	mg/kg	3600D	5080D	974D	5420D
Americium-241	pCi/g	0UJ	0.00552UJ	0.00446UJ	0.0018UJ
Antimony	mg/kg	0.0493DNU	0.0545DN	0.0453DNU	0.166DN
Arsenic	mg/kg	6.53*N	20.5*N	6.17*N	27.8*N
Barium	mg/kg	48	73.6	15.3	57.9
Beryllium	mg/kg	0.343D	0.694D	0.292D	0.782D
Cadmium	mg/kg	0.685D	0.0875D	0.0453DU	1.86D
Calcium	mg/kg	9260*DN	1290*DN	839*DN	2790*DN
Chromium	mg/kg	6.57*N	32.8*N	7.85*N	16.1*N
Copper	mg/kg	12.9	11	2.5	23.3
Iron	mg/kg	12900D	52700D	10100D	39300D
Lead	mg/kg	11.8D	23.2D	2.99D	18.1D
Magnesium	mg/kg	5900D	921D	407D	2070D
Manganese	mg/kg	503D	1460D	90.9D	535D
Mercury	mg/kg	0.0196	0.0142	0.0117U	0.0366
Neptunium-237	pCi/g	0.00224U	0U	0U	0.00303UJ
Nickel	mg/kg	21.5	12.1	3.09	41.7
PCB, total	µg/kg	19.3U	19.5U	19.8U	18.7U
Plutonium-238	pCi/g	0.00245UJ	0UJ	0.00131U	0.00461U
Plutonium-239/240	pCi/g	0.00123UJ	0.00133UJ	0.00394U	0.00264U
Selenium	mg/kg	0.371DN	0.219DN	0.129DN	0.771DN
Silicon	mg/kg	789D	695D	371D	580D
Silver	mg/kg	0.575	0.494U	0.498U	0.488U
Technetium-99	pCi/g	0.0766U	-0.0401U	0.00713U	0.0455U
Thallium	mg/kg	0.14D	0.0767D	0.0453DU	0.432D
Uranium	µg/g	0.806	1.24	0.259	3.42
Uranium-233/234	pCi/g	0.266	0.563J	0.0886	1.12
Uranium-235/236	pCi/g	0.0138	0.0225	0.00484UJ	0.0522
Uranium-238	pCi/g	0.269	0.414	0.0862	1.14
Zinc	mg/kg	66N	43.8N	11.5N	135N

[a]Abbreviations and data qualifiers are as follows: * – duplicate analysis is not within control limits. D – the result is reported from a dilution. J – the reported result is estimated. N – sample spike recovery is not within control limits. U – undetected.
[b]Because of the statistical nature of radiation detection, results for samples that have no radioactivity are often negative values because background radioactivity is subtracted out.

Table 2.15. Soil and biota (vegetation) monitoring at ambient air monitoring stations – 2016

Parameter[a]	Location/results[b,c]			
	A8 – On site at northwest boundary		*T7 – On site near X-230L North Holding Pond*	
	Vegetation	Soil	Vegetation	Soil
Americium-241	0.000647U	0.0016U	0.00033U	0.00454U
Neptunium-237	0.000351U	0.00201U	-0.000387U	0.0019U
Plutonium-238	0U	0.0014U	0.000323U	0.00192U
Plutonium-239/240	0.00141U	0.00187U	0U	0.00672UJ
Technetium-99	-0.102U	0.161UJ	-0.0788U	-0.055U
Uranium	0.000000158U	2.12	0.0011U	1.11
Uranium-233/234	0.00098U	0.785	0.000929U	0.384
Uranium-235/236	0U	0.0328	0.000385U	0.0199
Uranium-238	0U	0.708	0.00031U	0.369
	A10 – On site on northwest segment of Perimeter Road		*A29 – On site at OVEC*	
	Vegetation	Soil	Vegetation	Soil
Americium-241	0.00108U	0.00313U	0.00251U	0.00668UJ
Neptunium-237	0U	0.000927U	-0.000348U	-0.00158U
Plutonium-238	-0.000768U	0.00126U	0U	0.000956U
Plutonium-239/240	0.00154U	0.00189U	0.000352U	0.00956J
Technetium-99	-0.0391U	0.037U	-0.119U	0.0255U
Uranium	0.0184UJ	0.633	0.00000015U	0.752
Uranium-233/234	0.00544UJ	0.308	0.000932U	0.248
Uranium-235/236	0.000423U	0.0128	0U	0.0226
Uranium-238	0.00612UJ	0.211	0U	0.249
	A36 – On site at X-611 Water Treatment Plant		*A6 – North of PORTS in Piketon*	
	Vegetation	Soil	Vegetation	Soil
Americium-241	0.000988U	0.00587U	0.00123U	0.0026U
Neptunium-237	0.000944U	0.00178U	0U	0.00465U
Plutonium-238	0.00104U	0.00237U	0.000316U	0.000449U
Plutonium-239/240	0.000347U	0.00534U	0.000633U	0.00584UJ
Technetium-99	-0.0879U	0.0756U	-0.00678U	-0.00758U
Uranium	0.00257U	0.681	0.00405U	1.1
Uranium-233/234	0.00502UJ	0.307	0U	0.281
Uranium-235/236	0.00125U	0.0141	0.000772U	0.0255
Uranium-238	0.000669U	0.227	0.00124U	0.366

Table 2.15. Soil and biota (vegetation) monitoring at ambient air monitoring stations – 2016 (continued)

Parameter[a]	Location/results[b,c]			
	A24 – North of PORTS at Schuster Road		*A41A - North of PORTS at Zahns Corner*	
	Vegetation	Soil	Vegetation	Soil
Americium-241	0U	0.00503UJ	0.00185U	0.00201U
Neptunium-237	-0.000319U	0.000825U	0.000315U	0.000743U
Plutonium-238	-0.000323U	0.000522U	0.000634U	0U
Plutonium-239/240	0.000647U	0.00365U	0.000317U	0.0118
Technetium-99	-0.0737U	-0.0249U	-0.0559U	0.0201U
Uranium	0.00388U	1	0.002U	0.915
Uranium-233/234	0.00125U	0.339	0.000921U	0.319
Uranium-235/236	0.000387U	0.0241	0.000382U	0.0149
Uranium-238	0.00125U	0.332	0.000614U	0.305
	A23 – Northeastern PORTS boundary		*A12 – Eastern PORTS boundary*	
	Vegetation	Soil	Vegetation	Soil
Americium-241	0.000968U	0.00291U	0.000653U	0.00369U
Neptunium-237	0.000324U	0.00308U	0.000921U	0.0197
Plutonium-238	0U	0.00239U	0U	0.00185U
Plutonium-239/240	0.000322U	0.0129	0.000361U	0.0116
Technetium-99	-0.0157U	0.0381U	-0.0642U	0.0245U
Uranium	0.0218J	0.777	0.0105UJ	1.01
Uranium-233/234	0.0102	0.288	0.00231U	0.343
Uranium-235/236	0.000362U	0.0137	0.000478U	0.0147
Uranium-238	0.00728J	0.259	0.00346UJ	0.337
	A15 – Southeast of PORTS on Loop Road		*A3 – Southern PORTS boundary*	
	Vegetation	Soil	Vegetation	Soil
Americium-241	0.000593U	0.00499U	0.0018U	0.00505UJ
Neptunium-237	0U	-0.000799U	-0.000341U	-0.000534U
Plutonium-238	-0.000336U	0.000465U	0.000405U	0.000532U
Plutonium-239/240	-0.000336U	0.0163	0.00122U	0.0112
Technetium-99	-0.0023U	0.00105U	-0.102U	0.064U
Uranium	0.00988U	0.899	0.000253U	0.761
Uranium-233/234	0.00426UJ	0.34	0.00307U	0.363
Uranium-235/236	0.00144U	0.0225	0.000545U	0.0165
Uranium-238	0.0031UJ	0.298	0U	0.253

Table 2.15. Soil and biota (vegetation) monitoring at ambient air monitoring stations – 2016 (continued)

Parameter[a]	Location/results[b,c]			
	A9 – South of PORTS		*A28 – Southwest of PORTS on Camp Creek Road*	
	Vegetation	Soil	Vegetation	Soil
Americium-241	0.000645U	0.013	0.000637U	0.00546UJ
Neptunium-237	0U	0U	0U	0.00145U
Plutonium-238	-0.000752U	0.00226U	-0.000609U	-0.00101U
Plutonium-239/240	0.00113U	0.0226	0.000914U	0.00955J
Technetium-99	-0.0576U	0.00157U	-0.0681U	-0.0487U
Uranium	0.00532U	0.961	0.00159U	0.856
Uranium-233/234	0.00513UJ	0.319	0.00207U	0.278
Uranium-235/236	0.0012U	0.0149	-0.000369U	0.0141
Uranium-238	0.0016U	0.321	0.000593U	0.286
	A37 – Background station near Otway			
	Vegetation	Soil		
Americium-241	0.000708U	0.00822UJ		
Neptunium-237	-0.000654U	0.000846U		
Plutonium-238	0.00105U	-0.000472U		
Plutonium-239/240	0.00105U	0.016		
Technetium-99	-0.0428U	0.0614U		
Uranium	0.00217U	0.954		
Uranium-233/234	0.00131U	0.362		
Uranium-235/236	-0.00163U	0.0193		
Uranium-238	0.000983U	0.318		
	Duplicate vegetation samples		*Duplicate soil samples*	
	A24	A36	A37	T7
Americium-241	0.00126U	0.00221U	0.00393U	0.00537U
Neptunium-237	0.00032U	-0.000334U	0U	0.00101U
Plutonium-238	-0.000334U	0U	-0.000521U	0.00204U
Plutonium-239/240	0.000669U	0.00101U	0.0172	0.00306U
Technetium-99	-0.0537U	-0.0593U	-0.00959U	0.00303U
Uranium	0.00263U	0.00113U	0.963	0.964
Uranium-233/234	0.00037U	0.00495UJ	0.371	0.362
Uranium-235/236	0.000922U	0U	0.0198	0.0198
Uranium-238	0.000741U	0.00038U	0.32	0.321

[a]All parameters are measured in pCi/g with the exception of uranium which is measured in µg/g.
[b]Abbreviations and data qualifiers are as follows: U – undetected. J – the reported result is estimated.
[c]Because of the statistical nature of radiation detection, results for samples that have no radioactivity are often negative values because background radioactivity is subtracted out.

Table 2.16. Biota (fish) monitoring program results – 2016

Parameter	Unit	Location/fish/results[a,b]		
		Big Beaver Creek (RW-13) bass	*Big Beaver Creek (RW-13) bass (duplicate sample)*	*Big Beaver Creek (RW-15) bass*
Americium-241	pCi/g	0.000854U	0.000576U	0.000594U
Neptunium-237	pCi/g	0.000535U	0U	0U
Plutonium-238	pCi/g	0U	-0.000328U	-0.000308U
Plutonium-239/240	pCi/g	0.00119U	0.00197U	0.00123U
PCB, total	µg/kg	17.9	12.1	33.8
Technetium-99	pCi/g	-0.00111U	-0.075U	-0.0882U
Uranium	µg/g	0.00116U	0.00195U	0.000328U
Uranium-233/234	pCi/g	0.00141U	0.00055U	0.000285U
Uranium-235/236	pCi/g	0.0007U	0.000684U	0.000709U
Uranium-238	pCi/g	0.000281U	0.00055U	0U
		Scioto River (RW-1A) catfish	*Scioto River (RW-6) catfish*	*Little Beaver Creek (RW-8) bass*
Americium-241	pCi/g	0.00153U	0.000571U	0.00249U
Neptunium-237	pCi/g	-0.000275U	0U	0.000316U
Plutonium-238	pCi/g	0U	-0.000322U	0.000923U
Plutonium-239/240	pCi/g	0.0014U	0.000966U	0.00154U
PCB, total	µg/kg	50.7	37.5P	307D
Technetium-99	pCi/g	-0.0852U	-0.0232U	-0.058U
Uranium	µg/g	0.00327U	0.00371U	0.00247U
Uranium-233/234	pCi/g	0.00105U	0.0017U	0.0021U
Uranium-235/236	pCi/g	0.000326U	0.000707U	0.00149U
Uranium-238	pCi/g	0.00105U	0.00114U	0.000599U

[a]Abbreviations and data qualifiers are as follows: U – undetected. D – the result is reported from a dilution. P – the relative percent difference between the primary and secondary column exceeded 40 %.
[b]Because of the statistical nature of radiation detection, results for samples that have no radioactivity are often negative values because background radioactivity is subtracted out.

Table 2.17. Biota (crops) monitoring program results – 2016

Parameter	Unit	Location/crop/results[a,b]		
		Off-site #2 corn	*Off-site #2 corn (duplicate sample)*	*Off-site #2 cucumbers*
Americium-241	pCi/g	0.00189U	0.00118U	0.000926U
Neptunium-237	pCi/g	0.000283U	-0.000302U	0.000565U
Plutonium-238	pCi/g	0.000316U	-0.000595U	-0.000661U
Plutonium-239/240	pCi/g	0.00189U	0.000892U	0.000331U
Technetium-99	pCi/g	0.0559U	0.0493U	-0.0487U
Uranium	µg/g	0.005U	0.0012U	0.00107U
Uranium-233/234	pCi/g	0.00084U	0U	0.000603U
Uranium-235/236	pCi/g	0U	0.000722U	0.000375U
Uranium-238	pCi/g	0.00168U	0.00029U	0.000301U
		Off-site #3 yellow squash	*Off-site #3 lettuce*	
Americium-241	pCi/g	0.000317U	0.000714U	
Neptunium-237	pCi/g	0.000573U	-0.000281U	
Plutonium-238	pCi/g	-0.000287U	0.000598U	
Plutonium-239/240	pCi/g	0U	0.0012U	
Technetium-99	pCi/g	0.0149U	0.0026U	
Uranium	µg/g	0.00138U	0.00215U	
Uranium-233/234	pCi/g	0.000294U	0.000724U	
Uranium-235/236	pCi/g	0.0011U	0U	
Uranium-238	pCi/g	0.000294U	0.000724U	
		Off-site #4 tomatoes	*Off-site #4 cucumber*	
Americium-241	pCi/g	0.00105U	0.000992U	
Neptunium-237	pCi/g	0.000307U	-0.000314U	
Plutonium-238	pCi/g	-0.000606U	0.000346U	
Plutonium-239/240	pCi/g	0.00182U	0.00138U	
Technetium-99	pCi/g	-0.0433U	-0.00486U	
Uranium	µg/g	-0.0027U	0.000353U	
Uranium-233/234	pCi/g	0.000759U	0.000613U	
Uranium-235/236	pCi/g	-0.000944U	0.000762U	
Uranium-238	pCi/g	-0.000759U	0U	

Table 2.17. Biota (crops) monitoring program results – 2016 (continued)

Parameter	Unit	Location/crop/results[a,b]	
		Off-site #5 raspberries	*Off-site #5 blackberries*
Americium-241	pCi/g	0.00128U	0.00152U
Neptunium-237	pCi/g	-0.000877U	0U
Plutonium-238	pCi/g	-0.000961U	0.000591U
Plutonium-239/240	pCi/g	-0.000321U	0.000591U
Technetium-99	pCi/g	0.00945U	-0.0226U
Uranium	µg/g	0.00193U	0.00246U
Uranium-233/234	pCi/g	0.00118U	0.000596U
Uranium-235/236	pCi/g	0.000367U	0.00148U
Uranium-238	pCi/g	0.000591U	0.000596U
		Off-site #6 green beans	*Off-site #6 eggplant*
Americium-241	pCi/g	-0.000333U	0.00103U
Neptunium-237	pCi/g	0.000298U	0U
Plutonium-238	pCi/g	-0.000375U	-0.000353U
Plutonium-239/240	pCi/g	0.00187U	0.000706U
Technetium-99	pCi/g	0.00438U	-0.0616U
Uranium	µg/g	0.000172U	0.00019U
Uranium-233/234	pCi/g	0.000298U	-0.00033U
Uranium-235/236	pCi/g	0.000371U	0.00041U
Uranium-238	pCi/g	0U	0U

[a]Abbreviations and data qualifiers are as follows: U – undetected.
[b]Because of the statistical nature of radiation detection, results for samples that have no radioactivity are often negative values because background radioactivity is subtracted out.

Table 2.18. Biota (deer) monitoring program results – 2016

Parameter	Unit	February 2016[a,b]	November 2016[a,b]
		liver	
Americium-241	pCi/g	0.000303U	0.000606U
Neptunium-237	pCi/g	0.000609U	0.000525U
Plutonium-238	pCi/g	0.000297U	0U
Plutonium-239/240	pCi/g	0.000892U	0.00076U
Technetium-99	pCi/g	-0.0226U	0.0496U
Uranium	µg/g	0.00254U	0.0000000479U
Uranium-233/234	pCi/g	0.000993U	0.000298UJ
Uranium-235/236	pCi/g	0.00124U	0UJ
Uranium-238	pCi/g	0.000662U	0U
		muscle	
Americium-241	pCi/g	0.00183U	0U
Neptunium-237	pCi/g	0.00139U	0.000585U
Plutonium-238	pCi/g	-0.000642U	0.00032U
Plutonium-239/240	pCi/g	0.000642U	0.00128U
Technetium-99	pCi/g	-0.0465U	-0.00884U
Uranium	µg/g	0.00133U	0.00346U
Uranium-233/234	pCi/g	0.000849U	0.00116UJ
Uranium-235/236	pCi/g	0.00106U	0UJ
Uranium-238	pCi/g	0.000283U	0.00116U
		kidney	
Americium-241	pCi/g	0.00062U	0.00183U
Neptunium-237	pCi/g	0.00102U	0.000588U
Plutonium-238	pCi/g	0U	0.000334U
Plutonium-239/240	pCi/g	0.00124U	0.00167U
Technetium-99	pCi/g	0.212	-0.0168U
Uranium	µg/g	0.00346U	0.00117U
Uranium-233/234	pCi/g	0.000559U	0.000283UJ
Uranium-235/236	pCi/g	0.00209U	0.000704UJ
Uranium-238	pCi/g	0.000839U	0.000283U

[a]Abbreviations and data qualifiers are as follows: U – undetected. J – the reported result is estimated.
[b]Because of the statistical nature of radiation detection, results for samples that have no radioactivity are often negative values because background radioactivity is subtracted out.

Table 2.19. Biota (off-site dairy) monitoring program results– 2016

Parameter	Units	Milk[a,b]	Eggs[a,b]
Americium-241	pCi/g	0.000664U	0.00227U
Neptunium-237	pCi/g	0.00123U	0.000697U
Plutonium-238	pCi/g	0.000911U	0U
Plutonium-239/240	pCi/g	0.00182U	0.000382U
Technetium-99	pCi/g	0.0201U	0.0291U
Uranium	µg/g	-0.000852U	0.00595U
Uranium-233/234	pCi/g	0.000286U	0.000645U
Uranium-235/236	pCi/g	0U	0.000401U
Uranium-238	pCi/g	-0.000286U	0.00194U

[a]Abbreviations and data qualifiers are as follows: U – undetected.
[b]Because of the statistical nature of radiation detection, results for samples that have no radioactivity are often negative values because background radioactivity is subtracted out.

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3. DOSE

This section provides summary tables of air emissions and dose assessments completed by DOE for compliance with the National Emission Standards for Hazardous Air Pollutants for airborne radionuclide emissions. The following tables are provided in this section:

- Table 3.1. Emissions (Ci/year) from DOE air emission sources – 2016
- Table 3.2. Predicted radiation doses from airborne releases at PORTS – 2016
- Table 3.3. Dose calculations for ambient air monitoring stations – 2016.

Table 3.1. Emissions (Ci/year) from DOE air emission sources – 2016

Radionuclide	Group 1[a]	Group 2[b]	Group 3[c]	DUF_6 facility[d]
Americium-241	1.954E-07	-	6.934E-08	-
Neptunium-237	1.113E-07	-	5.448E-07	-
Plutonium-238	2.189E-07	-	9.698E-08	-
Plutonium-239/240	1.371E-07	-	1.388E-07	-
Technetium-99	1.442E-03	6.309E-04	2.212E-03	-
Uranium-233/234	6.312E-05	3.947E-06	1.349E-04	1.44E-06
Uranium-235	5.047E-06	9.362E-06	5.117E-06	6.61E-08
Uranium-238	4.405E-04	1.075E-03	4.237E-05	3.54E-06
Thorium-228	3.740E-08	1.958E-07	3.390E-10	-
Thorium-230	3.750E-05	2.938E-06	3.400E-10	-
Thorium-231	5.047E-06	2.440E-06	5.095E-06	1.99E-07
Thorium-232	2.290E-09	1.672E-08	2.070E-11	-
Thorium-234	4.395E-04	1.010E-05	4.146E-05	1.82E-05
Protactinium-234m	4.395E-04	1.010E-05	4.146E-05	1.82E-05
Total	2.873E-03	1.745E-03	2.483E-03	4.16E-05

[a]Group 1 consists of the X-326 Top Purge/Emergency Jet Vents, X-326 Seal Exhaust Vents, X-710 Vents, XT-847 Glove Box, and X-622 Groundwater Treatment Facility.
[b]Group 2 consists of the X-344A Gulper Vent and X-344A Cold Trap Vent.
[c]Group 3 consists of the X-330 Vents, X-333 Vents, X-700 Vents, X-705 Vents, X-623 Groundwater Treatment Facility, X-624 Groundwater Treatment Facility, and X-627 Groundwater Treatment Facility.
[d]DUF_6 – depleted uranium hexafluoride.

Note: Measurements are provided in scientific notation. The number and sign (+ or -) to the right of the "E" indicate the number of places to the right or left of the decimal point. For example, 3.4E-04 is 0.00034 (the decimal point moves four places to the left); 2.1E+02 is 210 (the decimal point moves two places to the right).

Table 3.2. Predicted radiation doses from airborne releases at PORTS – 2016

Effective dose to:	All PORTS releases (DOE and Centrus)
Maximally exposed individual (mrem/year)	0.016
Population[a] (person-rem/year)	0.06

[a]Population within 50 miles (80 kilometers) of plant site.

Table 3.3. Dose calculations for ambient air monitoring stations – 2016

Station	Parameter[a]	Dose[b] (mrem/year)	Total dose for station[c]	Net dose for station[d]
A3	Americium-241	1.5E-09		
	Neptunium-237	4.9E-10		
	Plutonium-238	2.4E-10		
	Plutonium-239/240	1.4E-09		
	Technetium-99	3.5E-03		
	Uranium-233/234	5.6E-07		
	Uranium-235/236	2.8E-08	(0.0035)	(0.00060)
	Uranium-238	3.4E-07	3.5E-03	6.0E-04
A6	Americium-241	3.4E-09		
	Neptunium-237	8.5E-10		
	Plutonium-238	2.4E-10		
	Plutonium-239/240	9.0E-10		
	Technetium-99	4.2E-03		
	Uranium-233/234	3.7E-07		
	Uranium-235/236	1.0E-08	(0.0042)	(0.0013)
	Uranium-238	2.9E-07	4.2E-03	1.3E-03
A8	Americium-241	3.4E-09		
	Neptunium-237	0		
	Plutonium-238	2.1E-10		
	Plutonium-239/240	9.7E-10		
	Technetium-99	2.5E-03		
	Uranium-233/234	8.5E-07		
	Uranium-235/236	2.6E-08	(0.0025)	
	Uranium-238	3.2E-07	2.5E-03	0
A9	Americium-241	2.6E-09		
	Neptunium-237	6.3E-10		
	Plutonium-238	9.0E-10		
	Plutonium-239/240	1.5E-09		
	Technetium-99	4.1E-03		
	Uranium-233/234	6.9E-07		
	Uranium-235/236	3.3E-08	(0.0041)	(0.0012)
	Uranium-238	6.7E-07	4.1E-03	1.2E-03

Table 3.3. Dose calculations for ambient air monitoring stations – 2016 (continued)

Station	Parameter[a]	Dose[b] (mrem/year)	Total dose for station[c]	Net dose for station[d]
A10	Americium-241	1.0E-05		
	Neptunium-237	1.1E-07		
	Plutonium-238	2.9E-09		
	Plutonium-239/240	3.2E-08		
	Technetium-99	4.0E-03		
	Uranium-233/234	1.7E-06		
	Uranium-235/236	5.2E-08	(0.0040)	(0.0011)
	Uranium-238	6.9E-07	4.0E-03	1.1E-03
A12	Americium-241	3.8E-06		
	Neptunium-237	2.5E-08		
	Plutonium-238	1.4E-09		
	Plutonium-239/240	8.7E-09		
	Technetium-99	3.3E-03		
	Uranium-233/234	7.5E-07		
	Uranium-235/236	3.8E-08	(0.0033)	(0.00040)
	Uranium-238	3.8E-07	3.3E-03	4.0E-04
A15	Americium-241	1.2E-05		
	Neptunium-237	6.7E-08		
	Plutonium-238	1.8E-09		
	Plutonium-239/240	1.4E-08		
	Technetium-99	3.2E-03		
	Uranium-233/234	5.6E-07		
	Uranium-235/236	2.1E-08	(0.0033)	(0.00040)
	Uranium-238	3.3E-07	3.3E-03	4.0E-04
A23	Americium-241	1.3E-06		
	Neptunium-237	3.9E-08		
	Plutonium-238	1.2E-09		
	Plutonium-239/240	1.0E-08		
	Technetium-99	3.2E-03		
	Uranium-233/234	7.3E-07		
	Uranium-235/236	3.5E-08	(0.0032)	(0.00030)
	Uranium-238	3.5E-07	3.2E-03	3.0E-04
A24	Americium-241	7.4E-06		
	Neptunium-237	5.8E-08		
	Plutonium-238	1.3E-09		
	Plutonium-239/240	1.0E-08		
	Technetium-99	2.9E-03		
	Uranium-233/234	9.3E-07		
	Uranium-235/236	2.8E-08	(0.0029)	
	Uranium-238	4.5E-07	2.9E-03	0

Table 3.3. Dose calculations for ambient air monitoring stations – 2016 (continued)

Station	Parameter[a]	Dose[b] (mrem/year)	Total dose for station[c]	Net dose for station[d]
A28	Americium-241	4.0E-06		
	Neptunium-237	2.4E-08		
	Plutonium-238	1.4E-09		
	Plutonium-239/240	1.1E-08		
	Technetium-99	2.5E-03		
	Uranium-233/234	3.5E-07		
	Uranium-235/236	2.4E-08	(0.0025)	
	Uranium-238	3.9E-07	2.5E-03	0
A29	Americium-241	1.1E-05		
	Neptunium-237	2.9E-08		
	Plutonium-238	8.9E-10		
	Plutonium-239/240	7.4E-09		
	Technetium-99	3.2E-03		
	Uranium-233/234	1.0E-06		
	Uranium-235/236	2.4E-08	(0.0032)	
	Uranium-238	4.8E-07	3.2E-03	3.0E-04
A36	Americium-241	1.4E-08		
	Neptunium-237	6.5E-09		
	Plutonium-238	1.7E-09		
	Plutonium-239/240	5.8E-10		
	Technetium-99	2.1E-03		
	Uranium-233/234	1.1E-06		
	Uranium-235/236	1.4E-07	(0.0021)	
	Uranium-238	3.3E-07	2.1E-03	0
A37	Americium-241	1.9E-09		
	Neptunium-237	9.4E-10		
	Plutonium-238	9.2E-10		
	Plutonium-239/240	4.9E-10		
	Technetium-99	2.9E-03		
	Uranium-233/234	2.2E-07		
	Uranium-235/236	1.5E-08	(0.0029)	
	Uranium-238	2.5E-07	2.9E-03	-
A41A	Americium-241	2.6E-09		
	Neptunium-237	2.9E-09		
	Plutonium-238	9.7E-10		
	Plutonium-239/240	1.3E-09		
	Technetium-99	2.5E-03		
	Uranium-233/234	5.2E-07		
	Uranium-235/236	2.2E-08	(0.0025)	
	Uranium-238	3.2E-07	2.5E-03	0

Table 3.3. Dose calculations for ambient air monitoring stations – 2016 (continued)

Station	Parameter[a]	Dose[b] (mrem/year)	Total dose for station[c]	Net dose for station[d]
T7	Americium-241	3.1E-09		
	Neptunium-237	1.5E-09		
	Plutonium-238	0		
	Plutonium-239/240	1.0E-09		
	Technetium-99	3.1E-03		
	Uranium-233/234	8.4E-07		
	Uranium-235/236	3.6E-08	(0.0031)	(0.00020)
	Uranium-238	3.5E-07	3.1E-03	2.0E-04

[a]Parameters listed in **bold** type were detected at least once in the samples collected in 2016 (see Table 2.9).
[b]The dose calculation is based on the maximum detection of each parameter at each station. For parameters that were not detected, half of the highest undetected result for the parameter was used to calculate the activity of each parameter in ambient air that is the basis for the dose. Measurements are provided in scientific notation. The number and sign (+ or -) to the right of the "E" indicate the number of places to the right or left of the decimal point. For example, 3.4E-04 is 0.00034 (the decimal point moves four places to the left); 2.1E+02 is 210 (the decimal point moves two places to the right).
[c]The total dose is provided in scientific notation and standard numeric format (in parentheses).
[d]The net dose is calculated by subtracting the total dose at Station A37 (background) from the total dose calculated for each station (the net dose is recorded as zero for stations with a gross dose less than the background station). The net dose is provided in scientific notation and standard numeric format (in parentheses).

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4. GROUNDWATER

This section summarizes analytical results for routine groundwater monitoring at PORTS in 2016 at the following locations:

- X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility
- Peter Kiewit (PK) Landfill
- Quadrant I Groundwater Investigative (5-Unit) Area
- X-749A Classified Materials Disposal Facility
- Quadrant II Groundwater Investigative (7-Unit) Area
- X-701B Former Holding Pond
- X-633 Former Recirculating Cooling Water Complex
- X-616 Former Chromium Sludge Surface Impoundments
- X-740 Former Waste Oil Handling Facility
- X-611A Former Lime Sludge Lagoons
- X-735 Landfills
- X-734 Landfills
- X-533 Former Switchyard Complex
- X-344C Former Hydrogen Fluoride Storage Building
- Surface water monitoring locations
- Exit pathway monitoring locations.

Results for radiological parameters and VOCs are reported in this section. Only those VOCs that were detected in at least one sampling event are listed in this section.

All results are included for radiological parameters, even if a specific constituent was not detected at a specific well or location during any sampling event in 2016. Sampling for radionuclides in many of the monitoring areas or wells is completed biennially (i.e., every two years in odd numbered years). Therefore, samples collected in 2016 at the X-749 Contaminated Materials Disposal Facility/ X-120 Former Training Facility, Quadrant I Groundwater Investigative (5-Unit) Area, X-749A Classified Materials Disposal Facility, Quadrant II Groundwater Investigative (7-Unit) Area, X-735 Landfills, and X-734 Landfills were not analyzed for radionuclides. Sampling for radionuclides is not part of the monitoring programs for PK Landfill, X-633 Former Recirculating Cooling Water Complex, X-616 Former Chromium Sludge Surface Impoundments, X-740 Former Waste Oil Handling Facility, X-611A Former Lime Sludge Lagoons, X-533 Former Switchyard Complex, and X-344C Former Hydrogen Fluoride Storage Building.

Results for chromium at the X-616 Former Chromium Sludge Surface Impoundments are included in this section because chromium is a primary contaminant in this area. Results are provided for metals at the X-633 Former Recirculating Cooling Water Complex, X-611A Former Lime Sludge Lagoons, and X-533 Former Switchyard Complex because metals are the only analytical parameters for these areas.

Two VOCs, acetone and methylene chloride, were frequently detected in both environmental and blank samples (field and trip blanks) collected in 2016. Acetone and methylene chloride are common laboratory contaminants that are not typically detected in the PORTS groundwater plumes. Detections of acetone and methylene chloride are often qualified by the laboratory with a “B”, which indicates that the analyte was also detected in the laboratory blank associated with the environmental sample and may be present due to laboratory contamination. 1,2-Dichlorobenzene was also detected in at least one laboratory blank associated with the IGWMP samples in 2016.

Other VOCs, including 2-butanone, chloroform, tetrachloroethene, toluene, and 1,2-dichlorobenzene were detected in trip and/or field blanks during 2016. These detections indicate that samples (both environmental samples and blank samples) may become contaminated with low concentrations of VOCs during other portions of the sampling process, although contamination can still occur in the laboratory. Other sources of contamination may include storage areas for sampling equipment (such as bottles and blank water), areas in which samples are collected or prepared, sample containers, and storage areas after samples are collected (such as refrigerators or sample shipping containers).

The primary purpose of the groundwater data is to determine the nature and extent of contamination in groundwater and associated surface water at PORTS. Data collected in 2016 meet this purpose.

Complete groundwater monitoring results for sampling completed as required by the *Integrated Groundwater Monitoring Plan* (DOE 2015) are provided in the *2016 Groundwater Monitoring Report for the Portsmouth Gaseous Diffusion Plant* (DOE 2017). The *2016 Groundwater Monitoring Report for the Portsmouth Gaseous Diffusion Plant* also provides the following information not included in this Data Report:

- Results for special studies conducted during 2016 at the X-633 Former Recirculating Cooling Water Complex and X-630 Former Recirculating Cooling Water Complex.

- Results for duplicate samples (samples collected from the same location, at the same time, and from the same sampling device as the regular sample), which are collected at a frequency of one per ten sampling locations per groundwater monitoring area. Duplicate samples are analyzed for the same parameters as the regular sample associated with the sampling location.

The following tables are included in this section:

- Table 4.1. VOCs detected at the X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility – 2016

- Table 4.2. VOCs detected at the PK Landfill – 2016

- Table 4.3. VOCs detected at the Quadrant I Groundwater Investigative (5-Unit) Area – 2016

- Table 4.4. VOCs detected at the X-749A Classified Materials Disposal Facility – 2016

- Table 4.5. VOCs detected at the Quadrant II Groundwater Investigative (7-Unit) Area – 2016

- Table 4.6. VOCs detected at the X-701B Former Holding Pond – 2016

- Table 4.7. Results for radionuclides at the X-701B Former Holding Pond – 2016

- Table 4.8. Results for chromium at the X-633 Former Recirculating Cooling Water Complex – 2016

- Table 4.9. VOCs detected at the X-616 Former Chromium Sludge Surface Impoundments – 2016

- Table 4.10. Results for chromium at the X-616 Former Chromium Sludge Surface Impoundments – 2016

- Table 4.11. VOCs detected at the X-740 Former Waste Oil Handling Facility – 2016

- Table 4.12. Results for beryllium and chromium at the X-611A Former Lime Sludge Lagoons – 2016
- Table 4.13. VOCs detected at the X-735 Landfills – 2016
- Table 4.14. VOCs detected at the X-734 Landfills – 2016
- Table 4.15. Results for cadmium and nickel at the X-533 Former Switchyard Complex – 2016
- Table 4.16. VOCs detected at the X-344C Former Hydrogen Fluoride Storage Building – 2016
- Table 4.17. VOCs detected at surface water monitoring locations – 2016
- Table 4.18. Results for radionuclides at surface water monitoring locations – 2016.

Results for exit pathway monitoring locations sampled during 2016 (that are part of the monitoring programs for other areas) are provided in the tables for their respective monitoring areas as follows:

- Table 4.1: VOCs detected at the X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility (wells X749-14B, X749-44G, X749-45G, X749-64B, X749-68G, X749-96G, X749-97G and X749-98G).
- Table 4.7: Results for radionuclides at X-701B Former Holding Pond area well X701-48G (VOCs were not detected in well X701-48G in 2016).
- Tables 4.17 and 4.18: VOCs and radionuclides detected at surface water monitoring locations BRC-SW02, LBC-SW04, UND-SW02, and WDD-SW03.

The following laboratory data qualifiers are used in the tables in this section:

Data qualifier	Meaning
*	Organics (VOCs): surrogate values were outside control limits.
B	Inorganics (metals): the result was less than the practical quantitation limit but greater than or equal to the instrument detection limit. Organics (VOCs): the analyte was detected in the laboratory blank sample.
E	Organics (VOCs): the result exceeds the calibration range.
J	The reported value is estimated.
U	Undetected

Table 4.1. VOCs detected at the X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility – 2016

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
PK-09G	Chloroform	µg/L			0.18 J	
	cis-1,2-Dichloroethene	µg/L			7.2	
	Methylene chloride	µg/L			0.42 BJ	
	Trichloroethene	µg/L			380	
STSW-101G	1,1,1-Trichloroethane	µg/L		6.3		4.2
	1,1,2-Trichloroethane	µg/L		0.6 J		0.45 J
	1,1-Dichloroethane	µg/L		17		11
	1,1-Dichloroethene	µg/L		37		28
	1,2-Dichloroethane	µg/L		3.7		1.8
	Acetone	µg/L		3.5 J		1.9 U
	Chloroform	µg/L		1.4		0.88 J
	cis-1,2-Dichloroethene	µg/L		11		9
	Tetrachloroethene	µg/L		0.66 J		0.67 J
	Trichloroethene	µg/L		40		35
STSW-102G	1,1,1-Trichloroethane	µg/L		5.4		5.9
	1,1,2-Trichloroethane	µg/L		0.27 U		0.27 J
	1,1-Dichloroethane	µg/L		64		56
	1,1-Dichloroethene	µg/L		30		37
	1,2-Dichloroethane	µg/L		23		19
	Chloroform	µg/L		2.7		2.6
	cis-1,2-Dichloroethene	µg/L		18		18
	Trichloroethene	µg/L		140		140
WP-03G	Acetone	µg/L	6.2 BJ	1.9 *U	1.9 U	1.9 U
	Methylene chloride	µg/L	0.32 U	0.32 U	0.47 BJ	0.32 U
WP-07G	Acetone	µg/L	1.9 U	1.9 U	6.2 J	1.9 U
	Chloromethane	µg/L	0.3 U	0.3 U	0.38 J	0.3 U
	Methylene chloride	µg/L	0.32 U	0.32 U	0.45 BJ	0.32 U
X120-05G	Trichloroethene	µg/L			2.5	
X120-08G	1,1,1-Trichloroethane	µg/L			3.7	
	1,1,2-Trichloroethane	µg/L			0.59 J	
	1,1-Dichloroethane	µg/L			8.2	
	1,1-Dichloroethene	µg/L			29	
	1,2-Dichloroethane	µg/L			0.88 J	
	Chloroform	µg/L			0.92 J	
	cis-1,2-Dichloroethene	µg/L			0.76 J	
	Tetrachloroethene	µg/L			0.23 J	
	Trichloroethene	µg/L			16	
X120-10G	1,1,1-Trichloroethane	µg/L			4.6	
	1,1,2-Trichloroethane	µg/L			0.97 J	
	1,1-Dichloroethane	µg/L			14	
	1,1-Dichloroethene	µg/L			49	
	1,2-Dichloroethane	µg/L			1.3	
	Chloroform	µg/L			1.4	
	cis-1,2-Dichloroethene	µg/L			0.8 J	
	Trichloroethene	µg/L			12	
X120-11G	1,1-Dichloroethene	µg/L		0.51 J		0.68 J
	cis-1,2-Dichloroethene	µg/L		6.4		13
	trans-1,2-Dichloroethene	µg/L		0.33 J		0.25 J
	Trichloroethene	µg/L		210		190
	Vinyl chloride	µg/L		0.1 U		0.19 J

Table 4.1. VOCs detected at the X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility – 2016 (continued)

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X749-04G	Chloroform	µg/L			0.24 J	
	cis-1,2-Dichloroethene	µg/L			0.44 J	
	Methylene chloride	µg/L			0.48 BJ	
	Tetrachloroethene	µg/L			1.5	
	Trichloroethene	µg/L			280	
X749-05G	1,1-Dichloroethane	µg/L			0.63 J	
	1,1-Dichloroethene	µg/L			0.33 J	
	Carbon tetrachloride	µg/L			0.44 J	
	Chloroform	µg/L			1.1	
	cis-1,2-Dichloroethene	µg/L			1	
	Methylene chloride	µg/L			0.51 BJ	
	Tetrachloroethene	µg/L			1.6	
	Trichloroethene	µg/L			86	
X749-06G	1,1,1-Trichloroethane	µg/L		36		37
	1,1,2-Trichloroethane	µg/L		2.9		4.5
	1,1-Dichloroethane	µg/L		140		230
	1,1-Dichloroethene	µg/L		120		190
	1,2-Dichloroethane	µg/L		3.4		4.1
	Chloroform	µg/L		17		20
	cis-1,2-Dichloroethene	µg/L		41		63
	Methylene chloride	µg/L		0.76 BJ		1.3 U
	Tetrachloroethene	µg/L		14		17
	Trichloroethene	µg/L		590		790
	Vinyl chloride	µg/L		0.76 J		0.97 J
X749-07G	1,1,1-Trichloroethane	µg/L		12		5.7
	1,1-Dichloroethane	µg/L		20		39
	1,1-Dichloroethene	µg/L		20		20
	1,2-Dichloroethane	µg/L		9.9		18
	Chloroform	µg/L		1.5		1.2
	cis-1,2-Dichloroethene	µg/L		5.2		8.8
	Tetrachloroethene	µg/L		0.55 J		0.39 J
	Trichloroethene	µg/L		67		69
	Vinyl chloride	µg/L		0.1 U		0.33 J
X749-08G	1,1,1-Trichloroethane	µg/L		6.8		5.3
	1,1-Dichloroethane	µg/L		1.6		1.2
	1,1-Dichloroethene	µg/L		6.7		5.7
	Chloroform	µg/L		0.18 J		0.16 U
	cis-1,2-Dichloroethene	µg/L		1.6		1.4
	Trichloroethene	µg/L		13		9.6
X749-09GA	1,1,1-Trichloroethane	µg/L		9.8		16
	1,1-Dichloroethane	µg/L		3		4.7
	1,1-Dichloroethene	µg/L		7.5		13
	Chloroform	µg/L		0.23 J		0.42 J
	cis-1,2-Dichloroethene	µg/L		1.9		3.3
	trans-1,2-Dichloroethene	µg/L		0.15 U		0.18 J
	Trichloroethene	µg/L		6		11
X749-10GA	1,1-Dichloroethane	µg/L		0.48 J		3.7
	1,1-Dichloroethene	µg/L		1.1		6.6
	Acetone	µg/L		1.9 U		2.7 BJ
	cis-1,2-Dichloroethene	µg/L		0.41 J		2.9

Table 4.1. VOCs detected at the X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility – 2016 (continued)

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X749-10GA	Methylene chloride	µg/L		2 B		0.32 U
	Trichloroethene	µg/L		0.16 U		0.28 J
	Vinyl chloride	µg/L		0.1 U		1.6
X749-13G	1,1,1-Trichloroethane	µg/L		3.3		5
	1,1-Dichloroethane	µg/L		0.92 J		1.3
	1,1-Dichloroethene	µg/L		5.6		7
	Chloroform	µg/L		0.24 J		0.38 J
	cis-1,2-Dichloroethene	µg/L		1		1.2
	Methylene chloride	µg/L		1.9 BJ		0.32 U
	Trichloroethene	µg/L		9.6		13
X749-14B	Methylene chloride	µg/L		0.32 U		0.52 BJ
X749-20G	1,1,1-Trichloroethane	µg/L			0.56 J	
	1,1-Dichloroethane	µg/L			1.6	
	1,1-Dichloroethene	µg/L			1.1	
	cis-1,2-Dichloroethene	µg/L			1.2	
	Trichloroethene	µg/L			15	
X749-21G	1,1,1-Trichloroethane	µg/L		1.1		6.5
	1,1-Dichloroethane	µg/L		0.26 J		2.2
	1,1-Dichloroethene	µg/L		0.57 J		4.8
	cis-1,2-Dichloroethene	µg/L		0.15 U		1.1
	Methylene chloride	µg/L		0.32 U		0.56 BJ
	Trichloroethene	µg/L		1.7		8.6
X749-22G	1,1-Dichloroethane	µg/L		2.6		3.4
	1,1-Dichloroethene	µg/L		3.9		4.6
	cis-1,2-Dichloroethene	µg/L		0.96 J		1.2
	Methylene chloride	µg/L		0.32 U		0.81 BJ
	Vinyl chloride	µg/L		0.6 J		0.66 J
X749-26G	1,1,1-Trichloroethane	µg/L		1.7		3.1
	1,1-Dichloroethane	µg/L		4.1		8.4
	1,1-Dichloroethene	µg/L		5.3		9
	1,2-Dichloroethane	µg/L		1.7		4.3
	Chloroform	µg/L		0.4 J		0.69 J
	cis-1,2-Dichloroethene	µg/L		0.96 J		1.8
	Trichloroethene	µg/L		11		16
X749-27G	1,1,1-Trichloroethane	µg/L		34		15
	1,1,2-Trichloroethane	µg/L		1.3		1
	1,1-Dichloroethane	µg/L		130		33
	1,1-Dichloroethene	µg/L		180		58
	1,2-Dichloroethane	µg/L		82		12
	Acetone	µg/L		1.9 U		2.8 J
	Chloroethane	µg/L		1.7 J		0.41 U
	Chloroform	µg/L		14		4.9
	cis-1,2-Dichloroethene	µg/L		33		12
	Tetrachloroethene	µg/L		1.7		1.4
	Trichloroethene	µg/L		230		110
	Vinyl chloride	µg/L		0.68 J		0.12 J
X749-28G	1,1,1-Trichloroethane	µg/L			5.5	
	1,1,2-Trichloroethane	µg/L			0.3 J	
	1,1-Dichloroethane	µg/L			5.2	
	1,1-Dichloroethene	µg/L			17	

Table 4.1. VOCs detected at the X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility – 2016 (continued)

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X749-28G	1,2-Dichloroethane	µg/L			0.54 J	
	Chloroform	µg/L			0.96 J	
	cis-1,2-Dichloroethene	µg/L			0.7 J	
	Tetrachloroethene	µg/L			0.36 J	
	Trichloroethene	µg/L			35	
X749-29G	1,1-Dichloroethene	µg/L			0.26 J	
	Chloroform	µg/L			0.38 J	
	cis-1,2-Dichloroethene	µg/L			0.51 J	
	Trichloroethene	µg/L			31	
X749-30G	1,1-Dichloroethene	µg/L			1.3	
	Chloroform	µg/L			0.53 J	
	cis-1,2-Dichloroethene	µg/L			0.74 J	
	Trichloroethene	µg/L			35	
X749-33G	1,1,1-Trichloroethane	µg/L		12		14
	1,1,2-Trichloroethane	µg/L		0.88 J		1.3
	1,1-Dichloroethane	µg/L		33		35
	1,1-Dichloroethene	µg/L		62		70
	1,2-Dichloroethane	µg/L		13		10
	Acetone	µg/L		1.9 U		2.6 J
	Chloroethane	µg/L		0.7 J		0.41 U
	Chloroform	µg/L		3.8		4.5
	cis-1,2-Dichloroethene	µg/L		6.5		9.1
	Methylene chloride	µg/L		0.36 BJ		0.32 U
	Tetrachloroethene	µg/L		1.2		1.6
	Trichloroethene	µg/L		100		130
	Vinyl chloride	µg/L		0.19 J		0.13 J
X749-35G	1,1,1-Trichloroethane	µg/L			40	
	1,1-Dichloroethane	µg/L			6.5	
	1,1-Dichloroethene	µg/L			24	
	Acetone	µg/L			1.9 BJ	
	Chloroform	µg/L			0.19 J	
	cis-1,2-Dichloroethene	µg/L			5.4	
	Tetrachloroethene	µg/L			0.2 J	
	Trichloroethene	µg/L			60	
	Vinyl chloride	µg/L			0.4 J	
X749-36G	1,1,1-Trichloroethane	µg/L			0.57 J	
	1,1-Dichloroethane	µg/L			1	
	1,1-Dichloroethene	µg/L			3.7	
	cis-1,2-Dichloroethene	µg/L			0.21 J	
	Trichloroethene	µg/L			3.2	
X749-37G	1,1,1-Trichloroethane	µg/L		2.7		2.7
	1,1,2-Trichloroethane	µg/L		0.29 J		0.34 J
	1,1-Dichloroethane	µg/L		8.2		9.6
	1,1-Dichloroethene	µg/L		22		19
	1,2-Dichloroethane	µg/L		0.62 J		0.89 J
	Chloroform	µg/L		0.45 J		0.49 J
	cis-1,2-Dichloroethene	µg/L		4.4		4.4
	Tetrachloroethene	µg/L		0.5 J		0.43 J
	Trichloroethene	µg/L		23		21
X749-38G	1,1,1-Trichloroethane	µg/L		2.3		13

Table 4.1. VOCs detected at the X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility – 2016 (continued)

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X749-38G	1,1,2-Trichloroethane	µg/L		0.27 U		1.2
	1,1-Dichloroethane	µg/L		7.3		30
	1,1-Dichloroethene	µg/L		19		71
	1,2-Dichloroethane	µg/L		0.6 J		3.4
	Acetone	µg/L		1.9 U		2.1 J
	Chloroform	µg/L		0.39 J		2.7
	cis-1,2-Dichloroethene	µg/L		3.8		21
	Tetrachloroethene	µg/L		0.43 J		1.5
	Trichloroethene	µg/L		21		86
	Vinyl chloride	µg/L		0.1 U		0.12 J
X749-40G	Chloroform	µg/L			0.48 J	
	Trichloroethene	µg/L			0.26 J	
X749-41G	Chloroform	µg/L		0.29 J		0.29 J
	cis-1,2-Dichloroethene	µg/L		2.8		2.6
	trans-1,2-Dichloroethene	µg/L		0.84 J		0.73 J
	Trichloroethene	µg/L		330		450
X749-42G	1,1,1-Trichloroethane	µg/L		0.49 J		0.42 J
	1,1-Dichloroethane	µg/L		0.87 J		0.78 J
	1,1-Dichloroethene	µg/L		3		2.7
	Trichloroethene	µg/L		2.6		4
X749-43G	1,1,1-Trichloroethane	µg/L			0.17 J	
	1,1-Dichloroethane	µg/L			0.33 J	
	1,1-Dichloroethene	µg/L			0.76 J	
	Trichloroethene	µg/L			0.54 J	
X749-44G	1,1-Dichloroethane	µg/L	0.22 U	0.22 U	0.22 J	0.46 J
	1,1-Dichloroethene	µg/L	0.23 U	0.23 U	0.23 U	0.34 J
	Trichloroethene	µg/L	0.17 J	0.42 J	0.34 J	0.74 J
X749-45G	1,1-Dichloroethane	µg/L	3	1.2	0.96 J	0.22 U
	1,1-Dichloroethene	µg/L	1.9	0.79 J	0.53 J	0.23 U
	1,2-Dichloroethane	µg/L	0.9 J	0.13 U	0.13 U	0.13 U
	cis-1,2-Dichloroethene	µg/L	4.1	1.1	1.1	0.15 U
	Trichloroethene	µg/L	5.6	2.8	1.8	0.34 J
X749-50B	1,1-Dichloroethane	µg/L			0.74 J	
	1,2-Dichloroethane	µg/L			0.35 J	
X749-54B	1,1-Dichloroethane	µg/L		2.4		3.3
	Trichloroethene	µg/L		0.69 J		0.77 J
	Vinyl chloride	µg/L		0.35 J		0.79 J
X749-67G	1,1,1-Trichloroethane	µg/L	6.7	7.3	5.3	8.5
	1,1,2-Trichloroethane	µg/L	0.49 J	0.53 J	0.54 U	0.53 J
	1,1-Dichloroethane	µg/L	66	88	69	88
	1,1-Dichloroethene	µg/L	58	65	57	59
	1,2-Dichloroethane	µg/L	24	27	20	31
	Acetone	µg/L	3 BJ	1.9 U	3.8 U	1.9 U
	Chloroethane	µg/L	1.2 J	1.2 J	0.82 U	0.88 J
	Chloroform	µg/L	3.4	3.7	3	3.9
	cis-1,2-Dichloroethene	µg/L	43	47	43	42
	Methylene chloride	µg/L	0.32 U	0.61 BJ	0.64 U	0.32 U
	Tetrachloroethene	µg/L	0.23 J	0.25 J	0.4 U	0.22 J
	trans-1,2-Dichloroethene	µg/L	0.34 J	0.53 J	0.31 J	0.33 J
	Trichloroethene	µg/L	190	260	200	230

Table 4.1. VOCs detected at the X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility – 2016 (continued)

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X749-67G	Vinyl chloride	µg/L	0.41 J	0.47 J	0.25 J	0.31 J
X749-97G	1,1-Dichloroethane	µg/L	0.32 J	0.22 U	0.22 U	0.22 U
	Acetone	µg/L	4.8 BJ	1.9 U	1.9 U	1.9 U
	Chloromethane	µg/L	0.3 U	0.3 U	0.41 J	0.3 U
	cis-1,2-Dichloroethene	µg/L	0.22 J	0.15 U	0.15 U	0.15 U
	Toluene	µg/L	0.17 U	0.17 U	0.17 J	0.17 U
	Trichloroethene	µg/L	0.98 J	0.19 J	0.23 J	0.16 U
X749-99M	Chloromethane	µg/L			0.35 J	
X749-100M	Methylene chloride	µg/L			0.42 BJ	
X749-102G	1,1-Dichloroethane	µg/L	0.33 J	0.22 U	0.22 U	0.32 J
	1,1-Dichloroethene	µg/L	0.41 J	0.23 U	0.23 U	0.36 J
	Methylene chloride	µg/L	0.32 U	0.32 U	0.57 BJ	0.32 U
	Trichloroethene	µg/L	0.42 J	0.23 J	0.16 U	0.41 J
X749-103G	1,1-Dichloroethane	µg/L	0.22 U	0.22 U	0.22 U	0.25 J
	1,1-Dichloroethene	µg/L	0.23 U	0.23 U	0.23 U	0.31 J
	Acetone	µg/L	1.9 U	4.2 J	3.7 UJ	1.9 U
	Trichloroethene	µg/L	0.16 U	0.16 U	0.16 U	0.38 J
X749-104G	Acetone	µg/L		5.2 J		1.9 U
X749-106G	1,1,1-Trichloroethane	µg/L		17		12
	1,1,2-Trichloroethane	µg/L		1.6		1.6
	1,1-Dichloroethane	µg/L		24		22
	1,1-Dichloroethene	µg/L		91		70
	1,2-Dichloroethane	µg/L		2.4		2.1
	Acetone	µg/L		26		2.3 J
	Chloroform	µg/L		2.5		2.1
	cis-1,2-Dichloroethene	µg/L		3.9		3.7
	Tetrachloroethene	µg/L		0.91 J		0.2 U
	Trichloroethene	µg/L		59		51
	Vinyl chloride	µg/L		0.1 U		0.14 J
X749-107G	1,1,1-Trichloroethane	µg/L		18		12
	1,1,2-Trichloroethane	µg/L		1.8		1.7
	1,1-Dichloroethane	µg/L		29		24
	1,1-Dichloroethene	µg/L		120		77
	1,2-Dichloroethane	µg/L		2.8		2.4
	Acetone	µg/L		7 J		2.9 J
	Chloroform	µg/L		3		2.5
	cis-1,2-Dichloroethene	µg/L		4.7		3.9
	Tetrachloroethene	µg/L		0.93 J		0.79 J
	Trichloroethene	µg/L		75		56
	Vinyl chloride	µg/L		0.1 U		0.13 J
X749-108G	1,1,1-Trichloroethane	µg/L		29		26
	1,1,2-Trichloroethane	µg/L		2.1		2.1
	1,1-Dichloroethane	µg/L		34		31
	1,1-Dichloroethene	µg/L		93		88
	1,2-Dichloroethane	µg/L		3.1		2.8
	Acetone	µg/L		1.9 U		3.6 J
	Chloroform	µg/L		3.4		3.3
	cis-1,2-Dichloroethene	µg/L		5		4.6
	Methylene chloride	µg/L		0.38 BJ		0.32 U
	Tetrachloroethene	µg/L		1.4		1.3

Table 4.1. VOCs detected at the X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility – 2016 (continued)

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X749-108G	Trichloroethene	µg/L		90		86
	Vinyl chloride	µg/L		0.1 U		0.21 J
X749-109G	1,1,1-Trichloroethane	µg/L		1.5		2.7
	1,1,2-Trichloroethane	µg/L		0.27 U		0.27 J
	1,1-Dichloroethane	µg/L		4.4		8.1
	1,1-Dichloroethene	µg/L		7.9		16
	1,2-Dichloroethane	µg/L		0.81 J		1.3
	Chloroform	µg/L		0.32 J		0.7 J
	cis-1,2-Dichloroethene	µg/L		2		3.7
	Trichloroethene	µg/L		11		19
X749-110G	1,1,1-Trichloroethane	µg/L		1		1.5
	1,1-Dichloroethane	µg/L		5.3		6
	1,1-Dichloroethene	µg/L		7.3		8.5
	1,2-Dichloroethane	µg/L		1.8		1.9
	Chloroethane	µg/L		0.49 J		0.43 J
	Chloroform	µg/L		0.7 J		0.45 J
	cis-1,2-Dichloroethene	µg/L		7.2		7.9
	Methylene chloride	µg/L		2.2 B		0.32 U
	trans-1,2-Dichloroethene	µg/L		0.15 U		0.31 J
	Trichloroethene	µg/L		27		27
	Vinyl chloride	µg/L		0.1 U		0.18 J
X749-113G	1,1,1-Trichloroethane	µg/L		14		15
	1,1,2-Trichloroethane	µg/L		0.27 J		0.42 J
	1,1-Dichloroethane	µg/L		19		22
	1,1-Dichloroethene	µg/L		31		35
	1,2-Dichloroethane	µg/L		10		12
	Acetone	µg/L		1.9 U		5.8 J
	Chloroform	µg/L		2.2		2.3
	cis-1,2-Dichloroethene	µg/L		2.7		3.7
	Methylene chloride	µg/L		0.32 U		0.75 BJ
	Tetrachloroethene	µg/L		0.41 J		0.35 J
	Trichloroethene	µg/L		48		51
X749-114G	Benzene	µg/L			0.17 J	
	cis-1,2-Dichloroethene	µg/L			1.4	
	Trichloroethene	µg/L			0.25 J	
X749-115G	Chloroform	µg/L			0.21 J	
	cis-1,2-Dichloroethene	µg/L			9.7	
	Methylene chloride	µg/L			0.41 BJ	
	Trichloroethene	µg/L			330	
X749-117G	Chloroform	µg/L			1.8	
	cis-1,2-Dichloroethene	µg/L			0.23 J	
	Tetrachloroethene	µg/L			0.53 J	
	Trichloroethene	µg/L			30	
X749-118G	1,1-Dichloroethane	µg/L			2	
	1,1-Dichloroethene	µg/L			0.39 J	
	Acetone	µg/L			3 J	
	Carbon tetrachloride	µg/L			0.34 J	
	Chloroform	µg/L			0.51 J	
	cis-1,2-Dichloroethene	µg/L			1.6	
	Tetrachloroethene	µg/L			1.4	

Table 4.1. VOCs detected at the X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility – 2016 (continued)

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X749-118G	Trichloroethene	µg/L			72	
X749-119G	Chloroform	µg/L			1.4	
	cis-1,2-Dichloroethene	µg/L			0.46 J	
	Trichloroethene	µg/L			17	
X749-120G	1,1,1-Trichloroethane	µg/L			490	
	1,1,2,2-Tetrachloroethane	µg/L			0.22 J	
	1,1-Dichloroethane	µg/L			5100	
	1,1-Dichloroethene	µg/L			1900	
	1,2-Dichloroethane	µg/L			100 J	
	1,2-Dimethylbenzene	µg/L			4.3	
	2-Butanone	µg/L			10	
	4-Methyl-2-pentanone	µg/L			7.4	
	Acetone	µg/L			120	
	Benzene	µg/L			7.6	
	Chloroethane	µg/L			3.6	
	Chloroform	µg/L			300 J	
	cis-1,2-Dichloroethene	µg/L			1600	
	Ethylbenzene	µg/L			0.44 J	
	m,p-Xylenes	µg/L			3.7	
	Methylene chloride	µg/L			250 BJ	
	Tetrachloroethene	µg/L			310 J	
	Toluene	µg/L			7	
	trans-1,2-Dichloroethene	µg/L			4.4	
	Trichloroethene	µg/L			9700	
	Vinyl chloride	µg/L			41	
X749-121G	1,1,1-Trichloroethane	µg/L			31	
	1,1,2-Trichloroethane	µg/L			0.46 J	
	1,1-Dichloroethane	µg/L			16	
	1,1-Dichloroethene	µg/L			220	
	1,2-Dichloroethane	µg/L			0.58 J	
	Acetone	µg/L			6.3 J	
	Chloroethane	µg/L			6.5	
	Chloroform	µg/L			0.87 J	
	cis-1,2-Dichloroethene	µg/L			12	
	Methylene chloride	µg/L			0.41 BJ	
	Tetrachloroethene	µg/L			0.48 J	
	Trichloroethene	µg/L			88	
	Vinyl chloride	µg/L			1.3	
X749-122G	1,1,1-Trichloroethane	µg/L			300	
	1,1,2-Trichloroethane	µg/L			3	
	1,1-Dichloroethane	µg/L			83	
	1,1-Dichloroethene	µg/L			310	
	1,2-Dichloroethane	µg/L			3.9	
	Benzene	µg/L			2.3	
	Chloroethane	µg/L			0.88 J	
	Chloroform	µg/L			3.3	
	cis-1,2-Dichloroethene	µg/L			54	
	Methylene chloride	µg/L			1.4 BJ	
	trans-1,2-Dichloroethene	µg/L			0.92 J	
	Trichloroethene	µg/L			750	

Table 4.1. VOCs detected at the X-749 Contaminated Materials Disposal Facility/X-120 Former Training Facility – 2016 (continued)

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X749-122G	Vinyl chloride	µg/L			1.6 J	
X749-BG9G	Methylene chloride	µg/L		1.4 BJ		0.32 U
	Trichloroethene	µg/L		0.21 J		0.24 J
X749-PZ02G	Trichloroethene	µg/L		0.42 J		0.45 J
X749-PZ03G	Acetone	µg/L		3.1 J		1.9 J
X749-PZ04G	1,1-Dichloroethane	µg/L	0.68 J	0.62 J	0.66 J	0.36 J
	1,1-Dichloroethene	µg/L	0.3 J	0.23 J	0.23 J	0.23 U
	Acetone	µg/L	5.6 BJ	1.9 U	1.9 U	2.2 J
	Chloromethane	µg/L	0.3 U	0.3 U	0.45 J	0.3 U
	cis-1,2-Dichloroethene	µg/L	0.24 J	0.21 J	0.19 J	0.15 U
	Methylene chloride	µg/L	0.32 U	0.32 BJ	0.32 U	0.32 U
	Trichloroethene	µg/L	1.8	1.5	1.6	0.89 J
X749-PZ05G	Acetone	µg/L	6.8 BJ	1.9 U	3.4 UJ	2 J
X749-PZ06G	1,1,1-Trichloroethane	µg/L		12 J		10
	1,1,2-Trichloroethane	µg/L		1.3		1.3
	1,1-Dichloroethane	µg/L		25 J		23
	1,1-Dichloroethene	µg/L		44 J		57
	1,2-Dichloroethane	µg/L		2.2 J		2.3
	Acetone	µg/L		1.9 U		2.3 J
	Chloroform	µg/L		2.2		2.1
	cis-1,2-Dichloroethene	µg/L		3.8		3.7
	Tetrachloroethene	µg/L		0.48 J		0.43 J
	Trichloroethene	µg/L		53 J		47
X749-PZ07G	1,1-Dichloroethene	µg/L			0.45 J	
	Methylene chloride	µg/L			0.32 BJ	
	Trichloroethene	µg/L			0.99 J	
X749-PZ10G	1,1,1-Trichloroethane	µg/L		7.5		7.6
	1,1,2-Trichloroethane	µg/L		0.33 J		1.1 U
	1,1-Dichloroethane	µg/L		0.43 J		0.88 U
	1,1-Dichloroethene	µg/L		73		95
	Acetone	µg/L		1.9 U		120
	Chloroform	µg/L		20		25
	cis-1,2-Dichloroethene	µg/L		0.46 J		0.63 J
	Methylene chloride	µg/L		3.6 B		4 BJ
	Trichloroethene	µg/L		340		400
X749-WPW	1,1,1-Trichloroethane	µg/L		120		100
	1,1,2-Trichloroethane	µg/L		3.1 J		2.2 J
	1,1-Dichloroethane	µg/L		77		66
	1,1-Dichloroethene	µg/L		330		260
	1,2-Dichloroethane	µg/L		8.1		8.4
	Acetone	µg/L		27 J		19 J
	Benzene	µg/L		4.9 J		1.3 J
	Chloroethane	µg/L		2.1 U		3.2 J
	Chloroform	µg/L		4.7 J		12
	cis-1,2-Dichloroethene	µg/L		940		70
	Tetrachloroethene	µg/L		3 J		4.4 J
	trans-1,2-Dichloroethene	µg/L		2.1 J		0.75 U
	Trichloroethene	µg/L		1500		1300
	Vinyl chloride	µg/L		17		14

Table 4.2 VOCs detected at the PK Landfill – 2016

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
PK-10G	Trichloroethene	µg/L		0.16 U		0.18 J
PK-15B	cis-1,2-Dichloroethene	µg/L		0.18 J		0.2 J
	Vinyl chloride	µg/L		0.1 U		0.25 J
PK-16G	Acetone	µg/L		1.9 U		1.9 J
	cis-1,2-Dichloroethene	µg/L		0.15 U		1.4
PK-17B	1,1-Dichloroethane	µg/L		2.8		4.2
	1,1-Dichloroethene	µg/L		0.44 J		0.52 J
	Benzene	µg/L		0.26 J		0.39 J
	Chlorobenzene	µg/L		0.88 J		2
	cis-1,2-Dichloroethene	µg/L		45		62
	trans-1,2-Dichloroethene	µg/L		1.5		2
	Trichloroethene	µg/L		1		1.2
	Vinyl chloride	µg/L		20		19
PK-18B	Acetone	µg/L		1.9 U		2.4 J
PK-19B	1,1-Dichloroethane	µg/L		1.9		1
	Acetone	µg/L		1.9 U		3.8 J
	Chloroethane	µg/L		1.9 J		2.7
	Vinyl chloride	µg/L		0.43 J		0.2 J
PK-21B	1,1-Dichloroethane	µg/L		100		150
	1,1-Dichloroethene	µg/L		0.9 J		0.98 J
	1,2-Dichloroethane	µg/L		0.46 J		0.77 J
	Acetone	µg/L		1.9 U		2.8 J
	Benzene	µg/L		0.51 J		0.81 J
	cis-1,2-Dichloroethene	µg/L		8.5		12
	Trichloroethene	µg/L		0.23 J		0.33 J
	Vinyl chloride	µg/L		13		13
PK-PL6	1,1,1-Trichloroethane	µg/L	2.6	2.4	1.2	0.16 U
	1,1-Dichloroethane	µg/L	5.2	7.5	6	1.2
	1,1-Dichloroethene	µg/L	1.3	1.7	1.2	0.23 U
	Acetone	µg/L	2.2 BJ	1.9 U	1.9 U	1.9 U
	cis-1,2-Dichloroethene	µg/L	1.3	1.9	1.6	0.86 J
	Trichloroethene	µg/L	1.3	1.8	1	0.47 J
	Vinyl chloride	µg/L	0.16 J	0.48 J	0.65 J	0.1 U
PK-PL6A	1,1,1-Trichloroethane	µg/L	5.2	5.3	3	0.91 J
	1,1-Dichloroethane	µg/L	8.5	14	13	9.6
	1,1-Dichloroethene	µg/L	3	4.1	3.3	0.88 J
	Acetone	µg/L	2.1 BJ	1.9 U	1.9 U	1.9 U
	cis-1,2-Dichloroethene	µg/L	1.8	3	2.9	2.5
	Trichloroethene	µg/L	2.5	3.5	2.3	0.98 J
	Vinyl chloride	µg/L	0.32 J	1.2	1.9	0.33 J

Table 4.3. VOCs detected at the Quadrant I Groundwater Investigative (5-Unit) Area – 2016

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X230K-14G	cis-1,2-Dichloroethene	µg/L			0.36 J	
	Trichloroethene	µg/L			3.5	
X230K-15G	cis-1,2-Dichloroethene	µg/L			0.18 J	
	Trichloroethene	µg/L			1.1	
X231A-01G	1,1-Dichloroethane	µg/L			0.42 J	
	cis-1,2-Dichloroethene	µg/L			0.31 J	
	Trichloroethene	µg/L			7.4	
X231A-02G	1,1,1-Trichloroethane	µg/L			1.3	
	1,1-Dichloroethane	µg/L			1.8	
	1,1-Dichloroethene	µg/L			18	
	Chloroform	µg/L			0.86 J	
	cis-1,2-Dichloroethene	µg/L			30	
	Methylene chloride	µg/L			0.39 J	
	Trichloroethene	µg/L			340	
	Trichlorofluoromethane	µg/L			5.8	
X231A-04G	1,1-Dichloroethene	µg/L			0.62 J	
	Chloroform	µg/L			0.21 J	
	cis-1,2-Dichloroethene	µg/L			2	
	Trichloroethene	µg/L			18	
X231B-02G	1,1-Dichloroethene	µg/L	4.7		2.3	
	Chloroform	µg/L	1.4 J		0.94 J	
	cis-1,2-Dichloroethene	µg/L	23		32	
	Methylene chloride	µg/L	1.3 U		2.4 BJ	
	trans-1,2-Dichloroethene	µg/L	0.77 J		0.79 J	
	Trichloroethene	µg/L	450		620	
	Vinyl chloride	µg/L	0.4 U		0.29 J	
X231B-03G	1,1,1-Trichloroethane	µg/L	3.2		1.8	
	1,1,2-Trichloroethane	µg/L	0.71 J		0.72 J	
	1,1-Dichloroethane	µg/L	2.6		2.2	
	1,1-Dichloroethene	µg/L	95		110	
	Benzene	µg/L	0.27 J		0.2 J	
	Chloroform	µg/L	0.58 J		0.43 J	
	cis-1,2-Dichloroethene	µg/L	7.2		6.4	
	Methylene chloride	µg/L	0.32 U		0.73 BJ	
	Tetrachloroethene	µg/L	0.22 J		0.25 J	
	trans-1,2-Dichloroethene	µg/L	0.65 J		0.36 J	
	Trichloroethene	µg/L	110		110	
X231B-06G	1,1,1-Trichloroethane	µg/L	66 E		60	
	1,1,2-Trichloroethane	µg/L	0.92 J		1.9 J	
	1,1-Dichloroethane	µg/L	60		57	
	1,1-Dichloroethene	µg/L	99		190	
	1,2-Dichloroethane	µg/L	1.6		1.9 J	
	Acetone	µg/L	1.9 U		9 J	
	Benzene	µg/L	0.25 J		0.72 J	
	Chloroethane	µg/L	0.52 J		0.82 U	
	Chloroform	µg/L	0.36 J		0.79 J	
	cis-1,2-Dichloroethene	µg/L	7.2		18	
	Methylene chloride	µg/L	0.32 U		26 B	
	Tetrachloroethene	µg/L	0.81 J		1.4 J	
	Trichloroethene	µg/L	160		490	

Table 4.3. VOCs detected at the Quadrant I Groundwater Investigative (5-Unit) Area – 2016 (continued)

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X231B-06G	Vinyl chloride	µg/L	0.63 J		0.48 J	
X231B-12G	1,1,1-Trichloroethane	µg/L			1.1	
	1,1-Dichloroethene	µg/L			6	
	Acetone	µg/L			3.4 J	
	Methylene chloride	µg/L			3.4 B	
	Trichloroethene	µg/L			2.4	
X231B-14G	1,1,1-Trichloroethane	µg/L			1.4	
	1,1-Dichloroethane	µg/L			1.3	
	1,1-Dichloroethene	µg/L			22	
	Acetone	µg/L			4.3 J	
	Chloroform	µg/L			1.1	
	cis-1,2-Dichloroethene	µg/L			6.2	
	Methylene chloride	µg/L			13 B	
	Trichloroethene	µg/L			120	
X231B-15G	1,1-Dichloroethene	µg/L			0.28 J	
	Chloroform	µg/L			0.36 J	
	cis-1,2-Dichloroethene	µg/L			0.18 J	
	Trichloroethene	µg/L			0.7 J	
X231B-16G	1,1,1-Trichloroethane	µg/L			0.49 J	
	1,1-Dichloroethene	µg/L			1.9	
	Chloroform	µg/L			5.4	
	Trichloroethene	µg/L			0.26 J	
X231B-20G	1,1,1-Trichloroethane	µg/L			0.45 J	
	1,1-Dichloroethene	µg/L			21	
	Chloroform	µg/L			1.2	
	cis-1,2-Dichloroethene	µg/L			0.4 J	
	Trichloroethene	µg/L			51	
	Trichlorofluoromethane	µg/L			1.2 J	
X231B-23G	1,1,1-Trichloroethane	µg/L			0.2 J	
	1,1-Dichloroethene	µg/L			1	
	Chloroform	µg/L			0.22 J	
	Trichloroethene	µg/L			1.2	
X231B-32B	Trichloroethene	µg/L			0.21 J	
X231B-36G	Chloroform	µg/L			0.6 J	
	cis-1,2-Dichloroethene	µg/L			0.81 J	
	Trichloroethene	µg/L			220	
X231B-37G	1,1-Dichloroethane	µg/L			1.2	
	1,1-Dichloroethene	µg/L			1.4	
	Benzene	µg/L			0.16 J	
	cis-1,2-Dichloroethene	µg/L			9.6	
	Toluene	µg/L			0.86 J	
	trans-1,2-Dichloroethene	µg/L			1.1	
	Trichloroethene	µg/L			11	
	Vinyl chloride	µg/L			0.65 J	
X326-09G	1,1-Dichloroethene	µg/L	390 J		440	
	Acetone	µg/L	4200 B		270 BJ	
	Chloroform	µg/L	200 J		170	
	cis-1,2-Dichloroethene	µg/L	270 J		170	
	Methylene chloride	µg/L	330 BJ		37 J	
	Trichloroethene	µg/L	41000		26000	

Table 4.3. VOCs detected at the Quadrant I Groundwater Investigative (5-Unit) Area – 2016 (continued)

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X326-10G	1,1-Dichloroethene	µg/L			9.1	
	cis-1,2-Dichloroethene	µg/L			1	
	Trichloroethene	µg/L			10	
X626-07G	1,1,1-Trichloroethane	µg/L	4.7		6.2	
	1,1,2-Trichloroethane	µg/L	1.1 U		3.4	
	1,1-Dichloroethane	µg/L	2.4 J		3.2	
	1,1-Dichloroethene	µg/L	480		460	
	1,2-Dichloroethane	µg/L	0.52 U		1.6 J	
	1,4-Dichlorobenzene	µg/L	0.88 J		0.32 U	
	Acetone	µg/L	43 B		3.8 U	
	Benzene	µg/L	1.1 J		1.3 J	
	Chlorobenzene	µg/L	1.1 J		0.34 U	
	Chloroform	µg/L	0.64 U		0.74 J	
	cis-1,2-Dichloroethene	µg/L	1.7 J		1.1 J	
	Methylene chloride	µg/L	2.5 BJ		0.64 U	
	Trichloroethene	µg/L	500		350	
X760-03G	Chloroform	µg/L			0.29 J	
	cis-1,2-Dichloroethene	µg/L			3.5	
	Methylene chloride	µg/L			0.38 BJ	
	Trichloroethene	µg/L			210	
	Vinyl chloride	µg/L			0.14 J	
X760-07G	1,1-Dichloroethene	µg/L			0.56 J	
	Chloroform	µg/L			0.36 J	
	cis-1,2-Dichloroethene	µg/L			15	
	Trichloroethene	µg/L			690	
	Vinyl chloride	µg/L			0.43 J	
X770-17GA	Acetone	µg/L	9.6 BJ		3.8 U	
	cis-1,2-Dichloroethene	µg/L	0.86 J		0.73 J	
	Methylene chloride	µg/L	1.6 BJ		2.4 UJ	
	Trichloroethene	µg/L	260		280 J	

Table 4.4 VOCs detected at the X-749A Classified Materials Disposal Facility – 2016

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X749A-02G	Methylene chloride	µg/L		0.32 BJ		
X749A-12G	cis-1,2-Dichloroethene	µg/L		5.8		
	Trichloroethene	µg/L		3.7		
X749A-14G	Acetone	µg/L		2.6 J		
X749A-18G	cis-1,2-Dichloroethene	µg/L		0.2 J		
	Trichloroethene	µg/L		4		
X749A-19G	cis-1,2-Dichloroethene	µg/L		3.7		
	Trichloroethene	µg/L		19		

Table 4.5. VOCs detected at the Quadrant II Groundwater Investigative (7-Unit) Area – 2016

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X700-02G	1,1,1-Trichloroethane	µg/L	5.1 J			
	1,1-Dichloroethane	µg/L	13			
	cis-1,2-Dichloroethene	µg/L	1900			
	Methylene chloride	µg/L	7.9 BJ			
	trans-1,2-Dichloroethene	µg/L	5.4 J			
	Trichloroethene	µg/L	4600			
	Vinyl chloride	µg/L	190			
X700-03G	cis-1,2-Dichloroethene	µg/L	0.45 J		0.27 J	
X700-04G	1,1-Dichloroethene	µg/L	33 J			
	Chloroethane	µg/L	33 J			
	cis-1,2-Dichloroethene	µg/L	3100			
	trans-1,2-Dichloroethene	µg/L	31 J			
	Trichloroethene	µg/L	1500			
	Vinyl chloride	µg/L	5100			
X700-05G	1,1,2-Trichloroethane	µg/L	180 J			
	1,1-Dichloroethene	µg/L	170 J			
	cis-1,2-Dichloroethene	µg/L	110000			
	Trichloroethene	µg/L	120000			
	Vinyl chloride	µg/L	5600			
X700-06G	1,1,2-Trichloroethane	µg/L	900 J			
	Chloroform	µg/L	480 J			
	cis-1,2-Dichloroethene	µg/L	2300			
	Trichloroethene	µg/L	1100000			
X701-26G	1,1-Dichloroethene	µg/L	1.1		0.23 U	
	Chloroform	µg/L	0.32 J		0.38 J	
	Tetrachloroethene	µg/L	1.9		2.3	
	Trichloroethene	µg/L	2.5		0.57 J	
X701-27G	1,1,1-Trichloroethane	µg/L	0.72 J		0.84 J	
	1,1-Dichloroethane	µg/L	0.5 J		0.57 J	
	1,1-Dichloroethene	µg/L	1.6		1.7	
	cis-1,2-Dichloroethene	µg/L	2.5		3.8	
	Methylene chloride	µg/L	0.32 U		0.36 BJ	
	Trichloroethene	µg/L	9.4		13	
X701-69G	cis-1,2-Dichloroethene	µg/L	230			
	trans-1,2-Dichloroethene	µg/L	5.5			
	Trichloroethene	µg/L	840			
	Vinyl chloride	µg/L	0.6 J			
X705-02G	1,1-Dichloroethene	µg/L	0.53 J			
	Acetone	µg/L	2.7 J			
	cis-1,2-Dichloroethene	µg/L	0.66 J			
	Methylene chloride	µg/L	0.38 BJ			
	Trichloroethene	µg/L	46			
X705-03G	1,1-Dichloroethane	µg/L	1.4			
	1,1-Dichloroethene	µg/L	7.4			
	1,2-Dichloroethane	µg/L	0.2 J			
	cis-1,2-Dichloroethene	µg/L	7.9			
	Methylene chloride	µg/L	0.37 BJ			
	Tetrachloroethene	µg/L	0.51 J			
	trans-1,2-Dichloroethene	µg/L	0.46 J			
	Trichloroethene	µg/L	88			

Table 4.5. VOCs detected at the Quadrant II Groundwater Investigative (7-Unit) Area – 2016 (continued)

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X705-04G	1,1-Dichloroethene	µg/L	0.36 J			
	Carbon tetrachloride	µg/L	4.9			
	Chloroform	µg/L	120			
	Methylene chloride	µg/L	0.33 BJ			
	Tetrachloroethene	µg/L	0.85 J			
	Trichloroethene	µg/L	19			
X720-01G	1,1,1-Trichloroethane	µg/L	12 J			
	1,1-Dichloroethane	µg/L	12 J			
	1,1-Dichloroethene	µg/L	72			
	cis-1,2-Dichloroethene	µg/L	1700			
	Methylene chloride	µg/L	29 BJ			
	Trichloroethene	µg/L	6000			
	Vinyl chloride	µg/L	130			
X720-08G	1,1-Dichloroethene	µg/L	92			
	cis-1,2-Dichloroethene	µg/L	25			
	Methylene chloride	µg/L	16 BJ			
	Tetrachloroethene	µg/L	19 J			
	Trichloroethene	µg/L	6500			
X720-09G	1,1,1-Trichloroethane	µg/L	2000			
	1,1-Dichloroethane	µg/L	170 J			
	1,1-Dichloroethene	µg/L	10000			
	1,2-Dimethylbenzene	µg/L	210 J			
	cis-1,2-Dichloroethene	µg/L	1800			
	Ethylbenzene	µg/L	140 J			
	m,p-Xylenes	µg/L	380 J			
	Methylene chloride	µg/L	450 BJ			
	Tetrachloroethene	µg/L	490 J			
	Toluene	µg/L	610			
	Trichloroethene	µg/L	340000			
	Vinyl chloride	µg/L	90 J			

Table 4.6. VOCs detected at the X-701B Former Holding Pond – 2016

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
LBC-PZ03G	1,1,2-Trichloroethane	µg/L	0.27 U		0.29 J	
	1,1-Dichloroethene	µg/L	0.23 U		0.28 J	
	cis-1,2-Dichloroethene	µg/L	280		290	
	trans-1,2-Dichloroethene	µg/L	1.9		2.2	
	Trichloroethene	µg/L	26		60	
	Vinyl chloride	µg/L	0.23 J		0.43 J	
LBC-PZ06G	Trichloroethene	µg/L	0.25 J		0.16 U	
LBC-PZ07G	cis-1,2-Dichloroethene	µg/L			0.21 J	
X230J7-01GA	cis-1,2-Dichloroethene	µg/L	0.86 J		0.55 J	
	Methylene chloride	µg/L	0.64 U		2.8 BJ	
	Trichloroethene	µg/L	280		370	
X230J7-02GA	cis-1,2-Dichloroethene	µg/L	4.4		7.9	
	Trichloroethene	µg/L	310		310	
	Vinyl chloride	µg/L	0.2 U		0.32 J	
X230J7-03GA	cis-1,2-Dichloroethene	µg/L	240		190	
	Tetrachloroethene	µg/L	2 U		2.2 J	
	trans-1,2-Dichloroethene	µg/L	5 J		5.4 J	
	Trichloroethene	µg/L	1600		2300	
	Vinyl chloride	µg/L	6.5 J		5.3 J	
X230J7-04GA	Trichloroethene	µg/L			3.9	
X237-EPW	1,1,2,2-Tetrachloroethane	µg/L			9.1 J	
	cis-1,2-Dichloroethene	µg/L			1500	
	trans-1,2-Dichloroethene	µg/L			7.6 J	
	Trichloroethene	µg/L			5600	
X237-WPW	1,1,2,2-Tetrachloroethane	µg/L			61 J	
	cis-1,2-Dichloroethene	µg/L			4000	
	Tetrachloroethene	µg/L			60 J	
	trans-1,2-Dichloroethene	µg/L			45 J	
	Trichloroethene	µg/L			46000	
	Vinyl chloride	µg/L			300	
X701-01G	1,1-Dichloroethene	µg/L	0.91 J		1.7	
	cis-1,2-Dichloroethene	µg/L	20		42	
	trans-1,2-Dichloroethene	µg/L	0.66 J		1.4	
	Trichloroethene	µg/L	110		210	
	Vinyl chloride	µg/L	0.29 J		0.68 J	
X701-02G	1,1-Dichloroethene	µg/L	0.33 J		0.24 J	
	cis-1,2-Dichloroethene	µg/L	4.7		3.5	
	Trichloroethene	µg/L	17		12	
X701-06G	1,1-Dichloroethane	µg/L	0.91 J		0.65 J	
	1,1-Dichloroethene	µg/L	8.4		5.7	
	Chloroform	µg/L	0.4 J		0.34 J	
	cis-1,2-Dichloroethene	µg/L	21		25	
	trans-1,2-Dichloroethene	µg/L	0.48 J		0.65 J	
	Trichloroethene	µg/L	280		210	
	Vinyl chloride	µg/L	0.5 J		0.72 J	
X701-15G	1,1-Dichloroethene	µg/L	0.46 U		1.5 J	
	cis-1,2-Dichloroethene	µg/L	460		1500	
	trans-1,2-Dichloroethene	µg/L	4.7		12	
	Trichloroethene	µg/L	3.9		11	
	Vinyl chloride	µg/L	0.46 J		0.75 J	

Table 4.6. VOCs detected at the X-701B Former Holding Pond – 2016 (continued)

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X701-16G	Acetone	µg/L	5.6 J		1.9 U	
	Methylene chloride	µg/L	0.32 BJ		0.32 U	
	Trichloroethene	µg/L	0.16 U		0.19 J	
X701-20G	1,1,2,2-Tetrachloroethane	µg/L	110 J		140 J	
	1,1,2-Trichloroethane	µg/L	110 U		77 J	
	cis-1,2-Dichloroethene	µg/L	1800		1400	
	Methylene chloride	µg/L	470 UJ		72 BJ	
	Tetrachloroethene	µg/L	120 J		150 J	
	trans-1,2-Dichloroethene	µg/L	92 J		74 J	
	Trichloroethene	µg/L	65000		75000	
X701-21G	1,2-Dichlorobenzene	µg/L	0.28 J		0.27 J	
	Chloroform	µg/L	0.17 J		0.2 J	
	cis-1,2-Dichloroethene	µg/L	26		41	
	trans-1,2-Dichloroethene	µg/L	0.21 J		0.41 J	
	Trichloroethene	µg/L	15		49	
	Vinyl chloride	µg/L	1.4		3.1	
X701-23G	cis-1,2-Dichloroethene	µg/L			0.29 J	
	Trichloroethene	µg/L			3.1	
X701-24G	1,1,2-Trichloroethane	µg/L	3.16		27 U	
	1,1-Dichloroethane	µg/L	0.36 J		22 U	
	1,1-Dichloroethene	µg/L	2.17		23 U	
	cis-1,2-Dichloroethene	µg/L	352		1400	
	Methylene chloride	µg/L	1 U		39 BJ	
	Tetrachloroethene	µg/L	2.2		20 U	
	trans-1,2-Dichloroethene	µg/L	3.93		29 J	
	Trichloroethene	µg/L	2340		14000	
	Vinyl chloride	µg/L	4.09		54 J	
X701-30G	cis-1,2-Dichloroethene	µg/L	0.16 J		0.21 J	
	Trichloroethene	µg/L	4.9		5.7	
	Trichlorofluoromethane	µg/L	0.99 J		1.1 J	
X701-31G	Trichloroethene	µg/L			0.19 J	
X701-38G	1,2-Dichlorobenzene	µg/L			0.19 J	
	Chloroform	µg/L			0.17 J	
X701-42G	1,2-Dichlorobenzene	µg/L			0.33 J	
	cis-1,2-Dichloroethene	µg/L			31	
	Trichloroethene	µg/L			4.6	
	Vinyl chloride	µg/L			2	
X701-61B	1,2-Dimethylbenzene	µg/L			0.33 J	
	m,p-Xylenes	µg/L			2.4	
	Trichloroethene	µg/L			1.1	
X701-66G	Chloroform	µg/L	10 UJ		16 J	
	cis-1,2-Dichloroethene	µg/L	190		320	
	Tetrachloroethene	µg/L	8 U		13 J	
	Trichloroethene	µg/L	5300		9100	
	Vinyl chloride	µg/L	4 U		12 J	
X701-77G	cis-1,2-Dichloroethene	µg/L			62	
	Tetrachloroethene	µg/L			9.2 J	
	Trichloroethene	µg/L			3400	
X701-79G	cis-1,2-Dichloroethene	µg/L			6.1	
	Trichloroethene	µg/L			160	

Table 4.6. VOCs detected at the X-701B Former Holding Pond – 2016 (continued)

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X701-127G	1,1,2,2-Tetrachloroethane	µg/L	84 U		44 J	
	1,1,2-Trichloroethane	µg/L	150 J		64 J	
	cis-1,2-Dichloroethene	µg/L	950		1100	
	Tetrachloroethene	µg/L	80 U		41 J	
	trans-1,2-Dichloroethene	µg/L	60 U		23 J	
	Trichloroethene	µg/L	36000		44000 J	
X701-128G	cis-1,2-Dichloroethene	µg/L	340		380	
	Tetrachloroethene	µg/L	27 J		35 J	
	Trichloroethene	µg/L	25000		27000	
X701-130G	1,1,1-Trichloroethane	µg/L			47 J	
	1,1-Dichloroethene	µg/L			47 J	
	Chloroform	µg/L			73 J	
	cis-1,2-Dichloroethene	µg/L			1200	
	Tetrachloroethene	µg/L			260	
	Toluene	µg/L			250	
	Trichloroethene	µg/L			300000	
	Vinyl chloride	µg/L			65 J	
X701-141G	1,1,2-Trichloroethane	µg/L			0.33 J	
	cis-1,2-Dichloroethene	µg/L			2.4	
	Trichloroethene	µg/L			210	
X701-142G	1,1,1-Trichloroethane	µg/L	0.4 J		6.4 U	
	1,1,2-Trichloroethane	µg/L	8.7		17 J	
	1,1-Dichloroethane	µg/L	0.59 J		8.8 U	
	1,1-Dichloroethene	µg/L	5.12		12 J	
	1,2-Dichloroethane	µg/L	0.63 J		5.2 U	
	Chloroform	µg/L	0.37 J		6.4 U	
	cis-1,2-Dichloroethene	µg/L	1860		6200	
	Methylene chloride	µg/L	1 U		14 J	
	Tetrachloroethene	µg/L	1.54		8 U	
	trans-1,2-Dichloroethene	µg/L	28.7		49	
	Trichloroethene	µg/L	4070		7500	
	Vinyl chloride	µg/L	16.6		61	
X701-143G	1,1-Dichloroethene	µg/L	7.5 U		2.6 J	
	cis-1,2-Dichloroethene	µg/L	1590		1600	
	trans-1,2-Dichloroethene	µg/L	7.5 U		11	
	Trichloroethene	µg/L	12 J		100	
	Vinyl chloride	µg/L	275		90	
X701-144G	cis-1,2-Dichloroethene	µg/L	123			
	trans-1,2-Dichloroethene	µg/L	1.94 J			
	Trichloroethene	µg/L	0.82 J			
	Vinyl chloride	µg/L	107			
X701-BW1G	Acetone	µg/L			3.8 BJ	
X701-BW2G	1,1,1-Trichloroethane	µg/L			20 J	
	1,1-Dichloroethene	µg/L			61 J	
	Acetone	µg/L			280 J	
	Chloroform	µg/L			190	
	cis-1,2-Dichloroethene	µg/L			270	
	Methylene chloride	µg/L			37 J	
	Tetrachloroethene	µg/L			25 J	
	trans-1,2-Dichloroethene	µg/L			21 J	

Table 4.6. VOCs detected at the X-701B Former Holding Pond – 2016 (continued)

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X701-BW2G	Trichloroethene	µg/L			36000	
X701-BW3G	1,1-Dichloroethane	µg/L			0.36 J	
	1,1-Dichloroethene	µg/L			1.1	
	cis-1,2-Dichloroethene	µg/L			78	
	Methylene chloride	µg/L			0.32 J	
	Tetrachloroethene	µg/L			0.22 J	
	trans-1,2-Dichloroethene	µg/L			0.46 J	
	Trichloroethene	µg/L			76	
	Vinyl chloride	µg/L			11	
X701-BW4G	Acetone	µg/L	4.6 J		2 BJ	
	cis-1,2-Dichloroethene	µg/L	5.2		7.7	
	Methylene chloride	µg/L	0.55 BJ		0.32 U	
	trans-1,2-Dichloroethene	µg/L	0.28 J		0.62 J	
	Trichloroethene	µg/L	1.1		1.8	
	Vinyl chloride	µg/L	0.24 J		0.49 J	
X701-EW121G	1,1,2,2-Tetrachloroethane	µg/L	150 J		170 J	
	cis-1,2-Dichloroethene	µg/L	1200		860	
	Tetrachloroethene	µg/L	200 J		170 J	
	trans-1,2-Dichloroethene	µg/L	120 J		87 J	
	Trichloroethene	µg/L	92000		80000	
X701-EW122G	1,1,2,2-Tetrachloroethane	µg/L	100 J		170 J	
	cis-1,2-Dichloroethene	µg/L	320 J		380	
	Tetrachloroethene	µg/L	180 J		180 J	
	trans-1,2-Dichloroethene	µg/L	60 U		53 J	
	Trichloroethene	µg/L	29000		42000	
X701-IRMPZ03G	1,1,2-Trichloroethane	µg/L	3.6 J		1.4 U	
	1,1-Dichloroethene	µg/L	1.5 J		1.9 J	
	Acetone	µg/L	10 J		9.5 U	
	cis-1,2-Dichloroethene	µg/L	630		790	
	Methylene chloride	µg/L	1.5 BJ		2.1 J	
	trans-1,2-Dichloroethene	µg/L	8.6		6.1	
	Trichloroethene	µg/L	500		1400	
	Vinyl chloride	µg/L	1.4 J		1.6 J	
X701-IRMPZ05G	cis-1,2-Dichloroethene	µg/L	1280			
	Trichloroethene	µg/L	1660			
X701-IRMPZ07G	cis-1,2-Dichloroethene	µg/L	5000			
	Trichloroethene	µg/L	68000			
	Vinyl chloride	µg/L	360 J			
X701-IRMPZ08G	Acetone	µg/L	25 J		3.1 J	
	cis-1,2-Dichloroethene	µg/L	590		130	
	Methylene chloride	µg/L	5 BJ		0.34 BJ	
	trans-1,2-Dichloroethene	µg/L	3.9 J		1	
	Trichloroethene	µg/L	1500		120	
	Vinyl chloride	µg/L	1 U		0.33 J	
X701-TC01G	1,1,1-Trichloroethane	µg/L	35 J		100	
	1,1-Dichloroethene	µg/L	9.2 U		47 J	
	cis-1,2-Dichloroethene	µg/L	1700		6800	
	Methylene chloride	µg/L	13 U		64 BJ	
	Tetrachloroethene	µg/L	23 J		56 J	
	trans-1,2-Dichloroethene	µg/L	34 J		110	

Table 4.6. VOCs detected at the X-701B Former Holding Pond – 2016 (continued)

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X701-TC01G	Trichloroethene	µg/L	6700		23000	
	Vinyl chloride	µg/L	37 J		150	
X701-TC03G	1,1,1-Trichloroethane	µg/L	130 J		140 J	
	1,1,2,2-Tetrachloroethane	µg/L	260		230	
	Chloromethane	µg/L	130 J		91 J	
	cis-1,2-Dichloroethene	µg/L	6100		8000	
	Methylene chloride	µg/L	64 U		190 BJ	
	Tetrachloroethene	µg/L	70 J		85 J	
	trans-1,2-Dichloroethene	µg/L	620		950	
	Trichloroethene	µg/L	48000		58000	
	Vinyl chloride	µg/L	20 U		88 J	
X701-TC05G	1,1,1-Trichloroethane	µg/L	130		130	
	1,1,2,2-Tetrachloroethane	µg/L	210		240	
	Acetone	µg/L	190 U		990 J	
	Chloromethane	µg/L	140 J		130 J	
	cis-1,2-Dichloroethene	µg/L	3600		3700	
	Methylene chloride	µg/L	32 U		110 BJ	
	Tetrachloroethene	µg/L	64 J		50 J	
	trans-1,2-Dichloroethene	µg/L	550		610	
	Trichloroethene	µg/L	29000		24000	
X701-TC10G	1,1,1-Trichloroethane	µg/L	30 J		19 J	
	1,1,2,2-Tetrachloroethane	µg/L	25 J		16 J	
	1,1,2-Trichloroethane	µg/L	27 U		13 J	
	1,1-Dichloroethene	µg/L	23 U		10 J	
	Acetone	µg/L	230 J		76 U	
	cis-1,2-Dichloroethene	µg/L	1700		1300	
	Tetrachloroethene	µg/L	28 J		17 J	
	trans-1,2-Dichloroethene	µg/L	130		95	
	Trichloroethene	µg/L	12000		11000	
	Vinyl chloride	µg/L	75 J		43	
X701-TC17G	1,1,1-Trichloroethane	µg/L	27 J		18 J	
	1,1,2,2-Tetrachloroethane	µg/L	21 U		24 J	
	1,1,2-Trichloroethane	µg/L	27 U		14 J	
	2-Butanone	µg/L	200 U		140 J	
	Acetone	µg/L	680 J		970 B	
	Bromomethane	µg/L	21 U		9.9 J	
	Chloroform	µg/L	16 U		12 J	
	Chloromethane	µg/L	97 J		150	
	cis-1,2-Dichloroethene	µg/L	190		78	
	Methylene chloride	µg/L	32 U		18 BJ	
	Tetrachloroethene	µg/L	45 J		19 J	
	trans-1,2-Dichloroethene	µg/L	15 U		9.8 J	
	Trichloroethene	µg/L	14000		5900	
X701-TC22G	1,1,1-Trichloroethane	µg/L	64 U		57 J	
	1,1,2,2-Tetrachloroethane	µg/L	84 U		76 J	
	cis-1,2-Dichloroethene	µg/L	1200		1200	
	Methylene chloride	µg/L	130 U		65 J	
	Tetrachloroethene	µg/L	85 J		160 J	
	trans-1,2-Dichloroethene	µg/L	190 J		120 J	
	Trichloroethene	µg/L	31000		54000	

Table 4.6. VOCs detected at the X-701B Former Holding Pond – 2016 (continued)

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X701-TC28G	1,1,1-Trichloroethane	µg/L	210 J		200 J	
	1,1,2,2-Tetrachloroethane	µg/L	210 U		190 J	
	1,1,2-Trichloroethane	µg/L	270 U		150 J	
	Acetone	µg/L	2000 J		1200 BJ	
	cis-1,2-Dichloroethene	µg/L	530 J		560	
	Methylene chloride	µg/L	320 U		160 BJ	
	Tetrachloroethene	µg/L	910 J		790	
	Trichloroethene	µg/L	220000		190000	
X701-TC48G	1,1,1-Trichloroethane	µg/L	3.2 J		2.1 J	
	1,1,2,2-Tetrachloroethane	µg/L	9.3 J		5.9	
	1,1,2-Trichloroethane	µg/L	13		9.5	
	2-Butanone	µg/L	73		89	
	Acetone	µg/L	780		560 B	
	Benzene	µg/L	3.1 J		4	
	Bromomethane	µg/L	3.5 J		3.8 J	
	Chloroform	µg/L	4.7 J		3.9 J	
	Chloromethane	µg/L	86		62	
	cis-1,2-Dichloroethene	µg/L	26		22	
	Methylene chloride	µg/L	3.2 U		3.7 BJ	
	Tetrachloroethene	µg/L	14		7.5	
	trans-1,2-Dichloroethene	µg/L	3.7 J		3.4 J	
	Trichloroethene	µg/L	1700		660	
X701-TC54G	1,1,1-Trichloroethane	µg/L	190 J		160 U	
	1,1,2,2-Tetrachloroethane	µg/L	910		900 J	
	cis-1,2-Dichloroethene	µg/L	360 J		350 J	
	Tetrachloroethene	µg/L	570		560 J	
	Trichloroethene	µg/L	190000		160000	
X701-TC61G	1,1,1-Trichloroethane	µg/L	120 J		160 U	
	1,1,2,2-Tetrachloroethane	µg/L	660		660 J	
	Acetone	µg/L	2500 BJ		1900 U	
	cis-1,2-Dichloroethene	µg/L	700		870 J	
	Tetrachloroethene	µg/L	480		490 J	
	trans-1,2-Dichloroethene	µg/L	110 J		150 U	
	Trichloroethene	µg/L	110000		140000	
X701-TC67G	1,1,2,2-Tetrachloroethane	µg/L	31 J		27 J	
	Acetone	µg/L	470 BJ		190 U	
	cis-1,2-Dichloroethene	µg/L	190		220	
	Tetrachloroethene	µg/L	66 J		66 J	
	Trichloroethene	µg/L	16000		17000	
X744G-02G	cis-1,2-Dichloroethene	µg/L	1.6		2.2	
	Trichloroethene	µg/L	26		33	
	Trichlorofluoromethane	µg/L	5		5.6	
X744G-03G	Acetone	µg/L	1.9 U		6.1 J	
	cis-1,2-Dichloroethene	µg/L	0.58 J		0.5 J	
	Trichloroethene	µg/L	6.7		5.9	

Table 4.7. Results for radionuclides at the X-701B Former Holding Pond – 2016

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
LBC-PZ03G	Technetium-99	pCi/L	2.9 U			
	Uranium	µg/L	0.235 UJ			
	Uranium-233/234	pCi/L	0.0494 UJ			
	Uranium-235/236	pCi/L	0.0168 U			
	Uranium-238	pCi/L	0.0763 UJ			
LBC-PZ06G	Technetium-99	pCi/L	1.17 U			
	Uranium	µg/L	0.17 UJ			
	Uranium-233/234	pCi/L	0.0141 U			
	Uranium-235/236	pCi/L	0.00584 U			
	Uranium-238	pCi/L	0.0563 UJ			
X230J7-01GA	Technetium-99	pCi/L	3.73 U			
	Uranium	µg/L	0.00809 U			
	Uranium-233/234	pCi/L	0.00468 U			
	Uranium-235/236	pCi/L	0.0175 U			
	Uranium-238	pCi/L	0 U			
X230J7-02GA	Technetium-99	pCi/L	106			
	Uranium	µg/L	0.196 UJ			
	Uranium-233/234	pCi/L	0.0684 UJ			
	Uranium-235/236	pCi/L	0.0106 U			
	Uranium-238	pCi/L	0.0641 UJ			
X230J7-03GA	Americium-241	pCi/L	0.04 UJ			
	Neptunium-237	pCi/L	0.0142 U			
	Plutonium-238	pCi/L	0 U			
	Plutonium-239/240	pCi/L	0.00982 U			
	Technetium-99	pCi/L	63.4			
	Uranium	µg/L	0.422			
	Uranium-233/234	pCi/L	0.111			
	Uranium-235/236	pCi/L	0.012 U			
	Uranium-238	pCi/L	0.14			
X230J7-04GA	Technetium-99	pCi/L			0.536 U	
	Uranium	µg/L			0.142 U	
	Uranium-233/234	pCi/L			0.0265 U	
	Uranium-235/236	pCi/L			0.00825 U	
	Uranium-238	pCi/L			0.0464 U	
X701-01G	Technetium-99	pCi/L	-2.63 U			
	Uranium	µg/L	4.73 J			
	Uranium-233/234	pCi/L	2.19			
	Uranium-235/236	pCi/L	0.0923 UJ			
	Uranium-238	pCi/L	1.57			
X701-02G	Technetium-99	pCi/L	-1.33 U			
	Uranium	µg/L	0.78			
	Uranium-233/234	pCi/L	0.497			
	Uranium-235/236	pCi/L	0.0412 U			
	Uranium-238	pCi/L	0.256			
X701-06G	Technetium-99	pCi/L	32.6			
	Uranium	µg/L	1.1			
	Uranium-233/234	pCi/L	0.58			
	Uranium-235/236	pCi/L	0.0341 U			
	Uranium-238	pCi/L	0.365			
X701-15G	Technetium-99	pCi/L	4.21 U			

Table 4.7. Results for radionuclides at the X-701B Former Holding Pond – 2016 (continued)

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X701-15G	Uranium	µg/L	0.153 UJ			
	Uranium-233/234	pCi/L	0.0798 UJ			
	Uranium-235/236	pCi/L	0.0165 U			
	Uranium-238	pCi/L	0.0488 UJ			
X701-16G	Technetium-99	pCi/L	4.49 U			
	Uranium	µg/L	0.113 UJ			
	Uranium-233/234	pCi/L	0.0232 U			
	Uranium-235/236	pCi/L	0.00576 U			
	Uranium-238	pCi/L	0.0371 UJ			
X701-18G	Technetium-99	pCi/L			0.0798 U	
	Uranium	µg/L			0.0679 U	
	Uranium-233/234	pCi/L			0.0382 U	
	Uranium-235/236	pCi/L			0.0238 U	
	Uranium-238	pCi/L			0.0191 U	
X701-19G	Technetium-99	pCi/L	3 U			
	Uranium	µg/L	0.0666 U			
	Uranium-233/234	pCi/L	0.0233 U			
	Uranium-235/236	pCi/L	-0.0058 U			
	Uranium-238	pCi/L	0.0233 U			
X701-20G	Americium-241	pCi/L	0.0137 U		0.0352 U	
	Neptunium-237	pCi/L	0.0145 U		0.00875 U	
	Plutonium-238	pCi/L	-0.0107 U		-0.00509 U	
	Plutonium-239/240	pCi/L	0.00537 U		-0.00509 U	
	Technetium-99	pCi/L	193		227	
	Uranium	µg/L	0.199 UJ		0.256 UJ	
	Uranium-233/234	pCi/L	0.0246 U		0.0961	
	Uranium-235/236	pCi/L	0.0184 U		0 U	
	Uranium-238	pCi/L	0.0641 UJ		0.086 UJ	
X701-21G	Technetium-99	pCi/L	439			
	Uranium	µg/L	0.137 U			
	Uranium-233/234	pCi/L	0.0632 UJ			
	Uranium-235/236	pCi/L	0.00561 U			
	Uranium-238	pCi/L	0.0451 U			
X701-23G	Technetium-99	pCi/L			12.6	
	Uranium	µg/L			0.0383 U	
	Uranium-233/234	pCi/L			0.0249 U	
	Uranium-235/236	pCi/L			0.0186 U	
	Uranium-238	pCi/L			0.00997 U	
X701-24G	Americium-241	pCi/L	0.0421 UJ			
	Neptunium-237	pCi/L	0.00928 U			
	Plutonium-238	pCi/L	0.0053 U			
	Plutonium-239/240	pCi/L	0.0318 U			
	Technetium-99	pCi/L	6.56 UJ			
	Uranium	µg/L	0.17 UJ			
	Uranium-233/234	pCi/L	0.0953			
	Uranium-235/236	pCi/L	0.0125 U			
	Uranium-238	pCi/L	0.0552 UJ			
X701-25G	Technetium-99	pCi/L	0.218 U			
	Uranium	µg/L	0.0168 U			
	Uranium-233/234	pCi/L	0.00474 U			

Table 4.7. Results for radionuclides at the X-701B Former Holding Pond – 2016 (continued)

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X701-25G	Uranium-235/236	pCi/L	0.0059 U			
	Uranium-238	pCi/L	0.00474 U			
X701-30G	Technetium-99	pCi/L	7.6			
	Uranium	µg/L	0.282			
	Uranium-233/234	pCi/L	0.148			
	Uranium-235/236	pCi/L	0.0172 U			
	Uranium-238	pCi/L	0.0922			
X701-31G	Technetium-99	pCi/L			1.29 U	
	Uranium	µg/L			0.216 UJ	
	Uranium-233/234	pCi/L			0.0802 UJ	
	Uranium-235/236	pCi/L			0.0117 U	
	Uranium-238	pCi/L			0.0708 UJ	
X701-38G	Technetium-99	pCi/L			0.172 U	
	Uranium	µg/L			0.0662 U	
	Uranium-233/234	pCi/L			0.0477 U	
	Uranium-235/236	pCi/L			0.0066 U	
	Uranium-238	pCi/L			0.0212 U	
X701-42G	Technetium-99	pCi/L			564	
	Uranium	µg/L			0.0749 UJ	
	Uranium-233/234	pCi/L			0.0586 UJ	
	Uranium-235/236	pCi/L			0.0168 U	
	Uranium-238	pCi/L			0.0226 U	
X701-48G	Americium-241	pCi/L			0.0159 U	
	Neptunium-237	pCi/L			0 U	
	Plutonium-238	pCi/L			-0.00484 U	
	Plutonium-239/240	pCi/L			0.0291 U	
	Technetium-99	pCi/L			-0.49 U	
	Uranium	µg/L			0.0482 U	
	Uranium-233/234	pCi/L			0.0226 U	
	Uranium-235/236	pCi/L			0.0169 U	
	Uranium-238	pCi/L			0.0136 U	
X701-58B	Technetium-99	pCi/L			-1.27 U	
	Uranium	µg/L			0.124 U	
	Uranium-233/234	pCi/L			0.232	
	Uranium-235/236	pCi/L			0.0236 U	
	Uranium-238	pCi/L			0.0379 UJ	
X701-61B	Technetium-99	pCi/L			-0.696 U	
	Uranium	µg/L			0.115 UJ	
	Uranium-233/234	pCi/L			0.102	
	Uranium-235/236	pCi/L			0.019 U	
	Uranium-238	pCi/L			0.0356 U	
X701-66G	Americium-241	pCi/L	0 U		0.0408 UJ	
	Neptunium-237	pCi/L	0.00899 U		0 U	
	Plutonium-238	pCi/L	0 U		-0.0159 U	
	Plutonium-239/240	pCi/L	0.0284 U		0.0318 U	
	Technetium-99	pCi/L	717		998	
	Uranium	µg/L	0.341		0.348	
	Uranium-233/234	pCi/L	0.11		0.144	
	Uranium-235/236	pCi/L	0 U		0.00577 U	
	Uranium-238	pCi/L	0.115		0.116	

Table 4.7. Results for radionuclides at the X-701B Former Holding Pond – 2016 (continued)

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X701-77G	Technetium-99	pCi/L			40.8	
	Uranium	µg/L			0.0465 U	
	Uranium-233/234	pCi/L			0.0365 U	
	Uranium-235/236	pCi/L			0 U	
	Uranium-238	pCi/L			0.0156 U	
X701-79G	Technetium-99	pCi/L			63.2	
	Uranium	µg/L			0.04 UJ	
	Uranium-233/234	pCi/L			0.0388 UJ	
	Uranium-235/236	pCi/L			0.0241 U	
	Uranium-238	pCi/L			0.0097 U	
X701-127G	Americium-241	pCi/L	0.00981 U		-0.0147 U	
	Neptunium-237	pCi/L	0.00481 U		-0.00482 U	
	Plutonium-238	pCi/L	0.0202 U		0.0052 U	
	Plutonium-239/240	pCi/L	0.0152 U		0.026 U	
	Technetium-99	pCi/L	81.1		106	
	Uranium	µg/L	0.0705 U		0.131 UJ	
	Uranium-233/234	pCi/L	0.0569 UJ		0.0655 UJ	
	Uranium-235/236	pCi/L	0 U		0.0116 U	
	Uranium-238	pCi/L	0.0237 U		0.0421 UJ	
X701-128G	Americium-241	pCi/L	-0.0144 U			
	Neptunium-237	pCi/L	0 U			
	Plutonium-238	pCi/L	-0.0158 U			
	Plutonium-239/240	pCi/L	0.00526 U			
	Technetium-99	pCi/L	31.7			
	Uranium	µg/L	0.166 UJ			
	Uranium-233/234	pCi/L	0.0471 UJ			
	Uranium-235/236	pCi/L	0 U			
	Uranium-238	pCi/L	0.0557 UJ			
X701-130G	Technetium-99	pCi/L			1920	
	Uranium	µg/L			5.54	
	Uranium-233/234	pCi/L			8.95	
	Uranium-235/236	pCi/L			0.472	
	Uranium-238	pCi/L			1.79	
X701-BW1G	Technetium-99	pCi/L			1.42 U	
	Uranium	µg/L			0.12 U	
	Uranium-233/234	pCi/L			0.0371 U	
	Uranium-235/236	pCi/L			0.0198 U	
	Uranium-238	pCi/L			0.0371 U	
X701-BW2G	Technetium-99	pCi/L			937	
	Uranium	µg/L			0.102 U	
	Uranium-233/234	pCi/L			0.0294 U	
	Uranium-235/236	pCi/L			0 U	
	Uranium-238	pCi/L			0.0343 U	
X701-BW3G	Technetium-99	pCi/L			106	
	Uranium	µg/L			0.112 U	
	Uranium-233/234	pCi/L			0.0247 U	
	Uranium-235/236	pCi/L			0.0185 U	
	Uranium-238	pCi/L			0.0346 U	
X701-BW4G	Technetium-99	pCi/L	209			
	Uranium	µg/L	0.11 U			

Table 4.7. Results for radionuclides at the X-701B Former Holding Pond – 2016 (continued)

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X701-BW4G	Uranium-233/234	pCi/L	0.031 UJ			
	Uranium-235/236	pCi/L	0.011 U			
	Uranium-238	pCi/L	0.0354 UJ			
X701-EW121G	Technetium-99	pCi/L	182		171	
	Uranium	µg/L	0.468		0.348	
	Uranium-233/234	pCi/L	0.0931 UJ		0.148	
	Uranium-235/236	pCi/L	0 U		0.0136 U	
	Uranium-238	pCi/L	0.157		0.115	
X701-EW122G	Technetium-99	pCi/L	336		305	
	Uranium	µg/L	0.464		0.623	
	Uranium-233/234	pCi/L	0.148		0.212	
	Uranium-235/236	pCi/L	0.0147 U		0.0214 U	
	Uranium-238	pCi/L	0.154		0.206	
X701-TC01G	Americium-241	pCi/L	0.00467 U		0.00907 U	
	Neptunium-237	pCi/L	0.00847 U		-0.00476 U	
	Plutonium-238	pCi/L	0.016 U		-0.00485 U	
	Plutonium-239/240	pCi/L	0 U		0.0242 U	
	Technetium-99	pCi/L	158		270	
	Uranium	µg/L	14.5		5.98 J	
	Uranium-233/234	pCi/L	10.9		3.16	
	Uranium-235/236	pCi/L	0.629		0.178	
	Uranium-238	pCi/L	4.79		1.98	
X701-TC03G	Americium-241	pCi/L	0.0332 U		0 U	
	Neptunium-237	pCi/L	0.0129 U		0.00507 U	
	Plutonium-238	pCi/L	0.0107 U		0 U	
	Plutonium-239/240	pCi/L	0.016 U		0.0335 U	
	Technetium-99	pCi/L	1020		824	
	Uranium	µg/L	4.56 J		3.97	
	Uranium-233/234	pCi/L	1.62		1.32	
	Uranium-235/236	pCi/L	0.0556 UJ		0.0445 U	
	Uranium-238	pCi/L	1.52		1.33	
X701-TC05G	Americium-241	pCi/L	0.00466 U		0.015 U	
	Neptunium-237	pCi/L	0.00463 U		0.00516 U	
	Plutonium-238	pCi/L	-0.0104 U		0 U	
	Plutonium-239/240	pCi/L	0.0209 U		0 U	
	Technetium-99	pCi/L	1110		941	
	Uranium	µg/L	5.42 J		8.09 J	
	Uranium-233/234	pCi/L	2.23		3.22	
	Uranium-235/236	pCi/L	0.129 UJ		0.109 UJ	
	Uranium-238	pCi/L	1.8		2.7	
X701-TC10G	Americium-241	pCi/L	-0.0047 U		0.00929 U	
	Neptunium-237	pCi/L	-0.0045 U		0.00949 U	
	Plutonium-238	pCi/L	0 U		-0.0107 U	
	Plutonium-239/240	pCi/L	0.0206 U		0.00537 U	
	Technetium-99	pCi/L	391		268	
	Uranium	µg/L	8.49		28	
	Uranium-233/234	pCi/L	3.7		12.1	
	Uranium-235/236	pCi/L	0.185		0.555	
	Uranium-238	pCi/L	2.83		9.32	
X701-TC17G	Americium-241	pCi/L	0.0332 U		0.0294 U	

Table 4.7. Results for radionuclides at the X-701B Former Holding Pond – 2016 (continued)

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X701-TC17G	Neptunium-237	pCi/L	-0.0041 U		0.00475 U	
	Plutonium-238	pCi/L	0.00528 U		0 U	
	Plutonium-239/240	pCi/L	0.0106 U		0.0104 U	
	Technetium-99	pCi/L	392		355	
	Uranium	µg/L	30.3		53.9	
	Uranium-233/234	pCi/L	12.5		21.7	
	Uranium-235/236	pCi/L	0.508		1.04	
	Uranium-238	pCi/L	10.1		17.9	
X701-TC22G	Americium-241	pCi/L	0.0435 U		0.0161 U	
	Neptunium-237	pCi/L	0 U		0.00947 U	
	Plutonium-238	pCi/L	-0.0058 U		0 U	
	Plutonium-239/240	pCi/L	0.0116 U		0.0334 U	
	Technetium-99	pCi/L	616		455	
	Uranium	µg/L	3.85		1.51	
	Uranium-233/234	pCi/L	1.03		0.464	
	Uranium-235/236	pCi/L	0.0963 UJ		0.0271 U	
	Uranium-238	pCi/L	1.28		0.502	
X701-TC28G	Americium-241	pCi/L	0.369		-0.0146 U	
	Neptunium-237	pCi/L	0 U		0 U	
	Plutonium-238	pCi/L	-0.0048 U		0 U	
	Plutonium-239/240	pCi/L	0.0194 U		0.0148 U	
	Technetium-99	pCi/L	494		410	
	Uranium	µg/L	18.1		18.4	
	Uranium-233/234	pCi/L	7.06		7.18	
	Uranium-235/236	pCi/L	0.387		0.413	
	Uranium-238	pCi/L	6.01		6.12	
X701-TC48G	Americium-241	pCi/L	0.0511 UJ		0.0213 U	
	Neptunium-237	pCi/L	0.00459 U		0.00494 U	
	Plutonium-238	pCi/L	0 U		0 U	
	Plutonium-239/240	pCi/L	0.0305 U		0.0198 U	
	Technetium-99	pCi/L	174		171	
	Uranium	µg/L	73 J		93.9 J	
	Uranium-233/234	pCi/L	27.3 J		34.5 J	
	Uranium-235/236	pCi/L	1.29 J		1.94 J	
	Uranium-238	pCi/L	24.3 J		31.3 J	
X701-TC54G	Americium-241	pCi/L	0.00925 U		0.0397 U	
	Neptunium-237	pCi/L	0.00898 U		0.00477 U	
	Plutonium-238	pCi/L	0 U		-0.00984 U	
	Plutonium-239/240	pCi/L	0.00482 U		0.0295 U	
	Technetium-99	pCi/L	603		516	
	Uranium	µg/L	2.67		2.45	
	Uranium-233/234	pCi/L	0.69		0.828	
	Uranium-235/236	pCi/L	0.0245 U		0.0501 U	
	Uranium-238	pCi/L	0.894		0.817	
X701-TC61G	Americium-241	pCi/L	0.0184 U		0.00474 U	
	Neptunium-237	pCi/L	0 U		-0.00455 U	
	Plutonium-238	pCi/L	0.00514 U		0.0103 U	
	Plutonium-239/240	pCi/L	0.0206 U		0.0103 U	
	Technetium-99	pCi/L	663		581	
	Uranium	µg/L	2.11		1.72	

Table 4.7. Results for radionuclides at the X-701B Former Holding Pond – 2016 (continued)

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X701-TC61G	Uranium-233/234	pCi/L	0.622		0.566	
	Uranium-235/236	pCi/L	0.0464 U		0.00684 U	
	Uranium-238	pCi/L	0.703		0.577	
X701-TC67G	Americium-241	pCi/L	0.0181 U		0.0201 U	
	Neptunium-237	pCi/L	0.0045 U		0 U	
	Plutonium-238	pCi/L	0.0146 U		0.0051 U	
	Plutonium-239/240	pCi/L	0.0195 U		0.00511 U	
	Technetium-99	pCi/L	147		142	
	Uranium	µg/L	0.271		0.373	
	Uranium-233/234	pCi/L	0.107		0.142	
	Uranium-235/236	pCi/L	0.0174 U		0.0252 U	
	Uranium-238	pCi/L	0.0885		0.121	

Table 4.8. Results for chromium at the X-633 Former Recirculating Cooling Water Complex – 2016

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X633-07G	Chromium	µg/L		370		510
X633-PZ04G	Chromium	µg/L		24		53

Table 4.9. VOCs detected at the X-616 Former Chromium Sludge Surface Impoundments – 2016

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X616-02G	1,1-Dichloroethene	µg/L	0.27 J			
	Trichloroethene	µg/L	0.27 J			
X616-05G	Trichlorofluoromethane	µg/L	0.32 J			
X616-09G	1,1,1-Trichloroethane	µg/L	2.7		4.8	
	1,1-Dichloroethane	µg/L	2.6		3.7	
	1,1-Dichloroethene	µg/L	26		42	
	Acetone	µg/L	1.9 U		4.8 J	
	cis-1,2-Dichloroethene	µg/L	3.1		3.1	
	Trichloroethene	µg/L	21		29	
	Trichlorofluoromethane	µg/L	0.29 U		0.59 J	
X616-13G	1,1,1-Trichloroethane	µg/L	3.1		4.6	
	1,1-Dichloroethane	µg/L	0.79 J		0.99 J	
	1,1-Dichloroethene	µg/L	21		31	
	cis-1,2-Dichloroethene	µg/L	0.38 J		0.59 J	
	Trichloroethene	µg/L	12		18	
	Trichlorofluoromethane	µg/L	7.1		8.7	
X616-14G	1,1,1-Trichloroethane	µg/L	1.4		1.6	
	1,1-Dichloroethane	µg/L	0.31 J		0.3 J	
	1,1-Dichloroethene	µg/L	8.1		9	
	Trichloroethene	µg/L	2.4		2.8	
	Trichlorofluoromethane	µg/L	0.83 J		0.92 J	
X616-16G	1,1-Dichloroethene	µg/L	0.24 J			
	cis-1,2-Dichloroethene	µg/L	1			
	Trichloroethene	µg/L	0.96 J			
X616-20B	1,1,1-Trichloroethane	µg/L	0.36 J		0.48 J	
	1,1-Dichloroethane	µg/L	0.53 J		0.63 J	
	1,1-Dichloroethene	µg/L	5.6		6.2	
	cis-1,2-Dichloroethene	µg/L	0.58 J		0.66 J	
	Trichloroethene	µg/L	15		20	
X616-25G	cis-1,2-Dichloroethene	µg/L	0.63 J		0.59 J	
	Trichloroethene	µg/L	1.3		1.3	
X616-28B	1,1,1-Trichloroethane	µg/L	0.88 J			
	1,1-Dichloroethene	µg/L	0.49 J			
	Trichloroethene	µg/L	0.38 J			

Table 4.10. Results for chromium at the X-616 Former Chromium Sludge Surface Impoundments – 2016

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X616-05G	Chromium	µg/L	1400			

Table 4.11. VOCs detected at the X-740 Former Waste Oil Handling Facility – 2016

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X740-02G	1,1,1-Trichloroethane	µg/L		2.9		2.5
	1,1-Dichloroethane	µg/L		2.6		2.6
	1,1-Dichloroethene	µg/L		4.8		4.6
	Trichloroethene	µg/L		6		5.8
X740-03G	1,1-Dichloroethane	µg/L		2		2.7
	1,1-Dichloroethene	µg/L		46		85
	1,2-Dichloroethane	µg/L		4.9		6.7
	Chloroethane	µg/L		4.6		6.7
	cis-1,2-Dichloroethene	µg/L		250		480
	Toluene	µg/L		0.17 U		0.87 J
	trans-1,2-Dichloroethene	µg/L		0.58 J		1 J
	Trichloroethene	µg/L		4.2		2.8
	Vinyl chloride	µg/L		7.7		9.6
X740-08G	1,1,1-Trichloroethane	µg/L		1.7		
	1,1-Dichloroethane	µg/L		13		
	1,1-Dichloroethene	µg/L		2.8		
	cis-1,2-Dichloroethene	µg/L		12		
	trans-1,2-Dichloroethene	µg/L		4.2		
	Trichloroethene	µg/L		7.6		
X740-09B	1,1,1-Trichloroethane	µg/L		7.8		4 U
	1,1-Dichloroethane	µg/L		23		18 J
	1,1-Dichloroethene	µg/L		210		150
	1,2-Dichloroethane	µg/L		51		44
	Chloroform	µg/L		1.1 J		4 U
	cis-1,2-Dichloroethene	µg/L		1100		860
	Methylene chloride	µg/L		2.2 BJ		14 J
	Tetrachloroethene	µg/L		9.2		7.2 J
	trans-1,2-Dichloroethene	µg/L		2.1 J		3.8 U
	Trichloroethene	µg/L		430		410
	Vinyl chloride	µg/L		3.1 J		2.5 U
X740-10G	1,1,1-Trichloroethane	µg/L		1.2		1.3
	1,1-Dichloroethane	µg/L		4.1		6.1
	1,1-Dichloroethene	µg/L		31		49
	1,2-Dichloroethane	µg/L		6.4		7.7
	cis-1,2-Dichloroethene	µg/L		100		190
	Tetrachloroethene	µg/L		2.4		2.3
	trans-1,2-Dichloroethene	µg/L		0.28 J		0.47 J
	Trichloroethene	µg/L		100		150
	Vinyl chloride	µg/L		0.31 J		0.36 J
X740-11G	1,1,1-Trichloroethane	µg/L		0.96 J		
	1,1-Dichloroethane	µg/L		0.44 J		
	1,1-Dichloroethene	µg/L		6.9		
	1,2-Dichloroethane	µg/L		2.6		
	Chloroform	µg/L		0.26 J		
	Trichloroethene	µg/L		27		
X740-14B	Trichloroethene	µg/L		1.9		
X740-18G	1,1-Dichloroethene	µg/L		2		1.2 J
	1,2-Dichloroethane	µg/L		0.26 J		0.26 U
	2-Butanone	µg/L		160		130
	Acetone	µg/L		220		240

Table 4.11. VOCs detected at the X-740 Former Waste Oil Handling Facility – 2016 (continued)

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X740-18G	Chloroethane	µg/L		1.7 J		1.2 J
	cis-1,2-Dichloroethene	µg/L		21		13
	trans-1,2-Dichloroethene	µg/L		0.42 J		0.3 U
	Trichloroethene	µg/L		0.27 J		0.32 U
	Vinyl chloride	µg/L		2.7		0.2 U
X740-19G	1,1-Dichloroethane	µg/L		0.22 U		0.23 J
	1,1-Dichloroethene	µg/L		1.3		1.7
	1,2-Dichloroethane	µg/L		0.61 J		0.56 J
	cis-1,2-Dichloroethene	µg/L		5.9		8.5
	Tetrachloroethene	µg/L		0.58 J		0.45 J
	Trichloroethene	µg/L		8.8		8.4
X740-20G	1,1-Dichloroethene	µg/L		0.23 J		0.37 J
	cis-1,2-Dichloroethene	µg/L		1.3		2
	Trichloroethene	µg/L		3.2		3.8
X740-21G	1,1-Dichloroethene	µg/L		0.51 J		0.95 J
	cis-1,2-Dichloroethene	µg/L		0.57 J		1.4
	Tetrachloroethene	µg/L		0.22 J		0.25 J
	Trichloroethene	µg/L		7.1		11
X740-22G	1,1,1-Trichloroethane	µg/L		1.2		1.5 J
	1,1-Dichloroethane	µg/L		0.82 J		0.98 J
	1,1-Dichloroethene	µg/L		10		14
	1,2-Dichloroethane	µg/L		2.8		3.4 J
	Chloroform	µg/L		0.21 J		0.64 U
	cis-1,2-Dichloroethene	µg/L		6.2		8.5
	Methylene chloride	µg/L		0.32 U		1.8 J
	Tetrachloroethene	µg/L		1.6		1.6 J
	Trichloroethene	µg/L		71		98
X740-23M	Acetone	µg/L		1.9 U		3.3 J
X740-PZ04M	Acetone	µg/L		1.9 U		2.6 J
X740-PZ10G	1,1,1-Trichloroethane	µg/L		0.6 J		
	1,1-Dichloroethane	µg/L		0.22 J		
	1,1-Dichloroethene	µg/L		0.84 J		
	cis-1,2-Dichloroethene	µg/L		0.19 J		
	Tetrachloroethene	µg/L		0.41 J		
	Trichloroethene	µg/L		13		
X740-PZ12G	1,1,1-Trichloroethane	µg/L		1.5		1.5 J
	1,1-Dichloroethane	µg/L		0.59 J		0.64 J
	1,1-Dichloroethene	µg/L		5.5		5.8
	1,2-Dichloroethane	µg/L		2.8		2.8
	Chloroform	µg/L		0.32 J		0.34 J
	cis-1,2-Dichloroethene	µg/L		0.19 J		0.3 U
	Tetrachloroethene	µg/L		0.87 J		0.85 J
	Trichloroethene	µg/L		58		69
X740-PZ14G	1,1,1-Trichloroethane	µg/L		1.5		
	1,1-Dichloroethane	µg/L		0.88 J		
	1,1-Dichloroethene	µg/L		14		
	1,2-Dichloroethane	µg/L		4.7		
	Chloroform	µg/L		0.44 J		
	cis-1,2-Dichloroethene	µg/L		0.7 J		
	Methylene chloride	µg/L		0.44 BJ		

Table 4.11. VOCs detected at the X-740 Former Waste Oil Handling Facility – 2016 (continued)

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X740-PZ14G	Tetrachloroethene	µg/L		1.2		
	Trichloroethene	µg/L		87		
X740-PZ17G	1,1,1-Trichloroethane	µg/L		1.1		
	1,1-Dichloroethane	µg/L		0.36 J		
	1,1-Dichloroethene	µg/L		5.4		
	1,2-Dichloroethane	µg/L		2.1		
	Chloroform	µg/L		0.21 J		
	Trichloroethene	µg/L		27		

Table 4.12. Results for beryllium and chromium at the X-611A Former Lime Sludge Lagoons – 2016

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
F-07G	Beryllium	µg/L	1		0.3 B	
	Chromium	µg/L	4.4		42	
F-08B	Beryllium	µg/L	0.08 U		0.16 B	
	Chromium	µg/L	0.5 U		0.5 U	
X611-01B	Beryllium	µg/L	0.08 U		0.08 U	
	Chromium	µg/L	0.9 B		3.6	
X611-02BA	Beryllium	µg/L	0.3 B		0.08 U	
	Chromium	µg/L	0.5 U		1.4 B	
X611-03G	Beryllium	µg/L	0.13 B		0.08 U	
	Chromium	µg/L	0.5 U		0.5 U	
X611-04BA	Beryllium	µg/L	0.42 B		1	
	Chromium	µg/L	0.5 U		0.5 U	

Table 4.13. VOCs detected at the X-735 Landfills – 2016

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X735-01GA	Methylene chloride	µg/L		0.88 J		
X735-02GA	Methylene chloride	µg/L		1.1 J		
X735-03GA	Methylene chloride	µg/L		0.89 J		
X735-16B	Methylene chloride	µg/L		1 J		
X735-17B	Methylene chloride	µg/L		0.59 J		
X735-19G	Iodomethane	µg/L		0.27 J		

Table 4.14. VOCs detected at the X-734 Landfills – 2016

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
RSY-02B	Methylene chloride	µg/L		2.9 B		0.51 BJ
X734-01G	Chloromethane	µg/L		0.3 U		2.6
	Methylene chloride	µg/L		0.32 U		0.57 BJ
X734-02B	Acetone	µg/L		5.1 J		1.9 U
	Methylene chloride	µg/L		0.32 U		0.93 BJ
X734-03G	1,2-Dichlorobenzene	µg/L		0.15 U		0.18 J
	1,4-Dichlorobenzene	µg/L		0.16 U		0.19 J
	Methylene chloride	µg/L		0.32 U		0.74 BJ
X734-04G	Chloromethane	µg/L		0.3 U		0.91 J
	Methylene chloride	µg/L		0.32 U		0.66 BJ
X734-05B	Benzene	µg/L		0.67 J		1.5
	Ethylbenzene	µg/L		0.16 U		0.29 J
	Methylene chloride	µg/L		0.32 U		0.64 BJ
	Toluene	µg/L		0.25 J		0.52 J
X734-06G	Methylene chloride	µg/L		0.32 U		0.57 BJ
X734-10G	Methylene chloride	µg/L		0.32 U		0.68 BJ
X734-14G	Methylene chloride	µg/L		1.7 BJ		0.65 BJ
X734-15G	1,2-Dichlorobenzene	µg/L		0.15 U		0.19 BJ
	Methylene chloride	µg/L		1.6 BJ		1 BJ
X734-16G	1,2-Dichlorobenzene	µg/L		0.15 U		0.2 BJ
	Acetone	µg/L		16		1.9 U
	Methylene chloride	µg/L		1.1 BJ		1 BJ
X734-18G	Methylene chloride	µg/L		0.32 U		1 BJ
X734-20G	Methylene chloride	µg/L		0.32 U		1 BJ
X734-22G	Methylene chloride	µg/L		0.32 U		0.99 BJ
X734-23G	cis-1,2-Dichloroethene	µg/L		4.6		6
	trans-1,2-Dichloroethene	µg/L		0.22 J		0.32 J
	Vinyl chloride	µg/L		1.2		1.6

Table 4.15. Results for cadmium and nickel at the X-533 Former Switchyard Complex – 2016

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
F-03G	Cadmium	µg/L		48		53
	Nickel	µg/L		490		590
TCP-01G	Cadmium	µg/L		15		9.5
	Nickel	µg/L		180		130
X533-03G	Cadmium	µg/L		25		31
	Nickel	µg/L		350		400

Table 4.16. VOCs detected at the X-344C Former Hydrogen Fluoride Storage Building – 2016

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
X344C-01G	cis-1,2-Dichloroethene	µg/L	2			
	Methylene chloride	µg/L	0.65 BJ			
	trans-1,2-Dichloroethene	µg/L	0.2 J			
	Trichloroethene	µg/L	0.43 J			
	Vinyl chloride	µg/L	0.22 J			

Table 4.17. VOCs detected at surface water monitoring locations – 2016

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
BRC-SW01	Acetone	µg/L	1.9 U	1.9 U	2.3 J	27 UJ
	Bromodichloromethane	µg/L	1.7	0.51 J	0.6 J	0.22 J
	Bromoform	µg/L	0.19 U	0.24 J	0.93 J	0.89 J
	Chloroform	µg/L	2.1	0.69 J	0.9 J	0.17 J
	Dibromochloromethane	µg/L	0.96 J	0.56 J	0.98 J	0.38 J
BRC-SW02	Acetone	µg/L	1.9 U	6.6 J	22	1.9 U
	Methylene chloride	µg/L	0.33 J	0.32 U	0.32 U	3.3 UJ
BRC-SW05	Acetone	µg/L	1.9 U	1.9 U	35	1.9 U
	Methylene chloride	µg/L	0.33 J	0.32 U	0.32 U	4.7 UJ
EDD-SW01	Bromodichloromethane	µg/L	0.68 J	1	0.71 J	1.3
	Bromoform	µg/L	0.19 U	0.37 J	0.19 U	1.7
	Chloroform	µg/L	0.78 J	1.5	1.1	0.52 J
	cis-1,2-Dichloroethene	µg/L	2.4	1.2	1.3	0.37 J
	Dibromochloromethane	µg/L	0.85 J	1	0.63 J	2.1
	Trichloroethene	µg/L	3.5	1.1	1.5	0.41 J
LBC-SW01	Acetone	µg/L	4.3 BJ	1.9 U	1.9 U	1.9 U
	Bromodichloromethane	µg/L	0.17 U	0.47 J	0.4 J	1.1
	Bromoform	µg/L	0.19 U	0.19 U	0.19 U	1.6
	Chloroform	µg/L	0.22 J	0.68 J	0.6 J	0.42 J
	cis-1,2-Dichloroethene	µg/L	0.7 J	0.76 J	0.34 J	0.31 J
	Dibromochloromethane	µg/L	0.17 U	0.5 J	0.42 J	1.9
	Trichloroethene	µg/L	1.1	0.62 J	0.72 J	0.34 J
LBC-SW02	Bromodichloromethane	µg/L	0.17 U	0.25 J	0.17 U	0.42 J
	Bromoform	µg/L	0.19 U	0.19 U	0.19 U	1.2
	Chloroform	µg/L	0.16 U	0.34 J	0.16 U	0.16 U
	cis-1,2-Dichloroethene	µg/L	1.9	0.23 J	0.15 U	0.15 U
	Dibromochloromethane	µg/L	0.34 J	0.28 J	0.17 U	0.81 J
	Trichloroethene	µg/L	4.6	0.28 J	0.18 J	0.16 U
LBC-SW03	cis-1,2-Dichloroethene	µg/L	0.22 J	0.15 U	0.15 U	0.15 U
	Trichloroethene	µg/L	0.52 J	0.16 U	0.16 U	0.16 U
NHP-SW01	Dibromochloromethane	µg/L	0.35 J	0.17 U	0.17 U	0.17 U
UND-SW01	1,1-Dichloroethene	µg/L	0.23 U	0.23 U	0.23 U	0.32 J
	cis-1,2-Dichloroethene	µg/L	0.16 J	0.24 J	0.42 J	0.61 J
	Methylene chloride	µg/L	0.33 J	0.32 U	0.32 U	2.9 UJ
	Trichloroethene	µg/L	1.9	3	4.4	4.4
UND-SW02	Methylene chloride	µg/L	0.35 J	0.32 U	0.32 U	2.6 UJ
WDD-SW01	Bromodichloromethane	µg/L	0.17 U	0.25 J	0.17 J	0.17 U
	Bromoform	µg/L	0.19 U	0.2 J	0.19 U	0.19 U
	Chloroform	µg/L	0.2 J	0.25 J	0.16 J	0.16 U
	Dibromochloromethane	µg/L	0.17 U	0.31 J	0.3 J	0.17 U
	Methylene chloride	µg/L	0.45 J	0.32 U	0.32 U	1.9 UJ
WDD-SW02	Acetone	µg/L	1.9 U	1.9 U	6.1 J	1.9 U
WDD-SW03	Bromodichloromethane	µg/L	0.17 U	0.17 U	0.17 U	0.18 J
	Bromoform	µg/L	0.19 U	0.19 U	0.19 U	1.3
	Dibromochloromethane	µg/L	0.17 U	0.17 U	0.17 U	0.53 J
	Methylene chloride	µg/L	0.35 J	0.32 U	0.32 U	1.9 UJ

Table 4.18. Results for radionuclides at surface water monitoring locations – 2016

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
BRC-SW01	Americium-241	pCi/L		0.00478 U		-0.0204 U
	Neptunium-237	pCi/L		0.0228 U		-0.00478 U
	Plutonium-238	pCi/L		-0.0058 U		0.00512 U
	Plutonium-239/240	pCi/L		0.00582 U		0.0307 U
	Technetium-99	pCi/L	5.34 UJ	-1.15 U	-0.0815 U	0.0799 U
	Uranium	µg/L	2.29 J	0.426	1.02	0.0811 U
	Uranium-233/234	pCi/L	2.16	0.478	1.82	0.198
	Uranium-235/236	pCi/L	0.0948 UJ	0.0385 U	0.0825 U	0.00547 U
	Uranium-238	pCi/L	0.753	0.137	0.331	0.0264 U
BRC-SW02	Americium-241	pCi/L		0.0143 U		0.0264 U
	Neptunium-237	pCi/L		0 U		0.00883 U
	Plutonium-238	pCi/L		-0.0058 U		0 U
	Plutonium-239/240	pCi/L		0.0175 U		0.0153 U
	Technetium-99	pCi/L	4.68 UJ	-2.84 U	0.941 U	2.82 U
	Uranium	µg/L	1.05 J	0.815	1.26	0.608
	Uranium-233/234	pCi/L	0.854	0.611	1.82	0.514
	Uranium-235/236	pCi/L	0.0508 UJ	0.0346 U	0.0861 U	0.0222 U
	Uranium-238	pCi/L	0.345	0.269	0.411	0.201
BRC-SW05	Americium-241	pCi/L		0.0152 U		0 U
	Neptunium-237	pCi/L		0 U		0.00935 U
	Plutonium-238	pCi/L		0 U		-0.00496 U
	Plutonium-239/240	pCi/L		0.0154 U		0.00992 U
	Technetium-99	pCi/L	2.91 U	-2.03 U	0.872 U	3.23 U
	Uranium	µg/L	1.23	0.721	1.35	0.61
	Uranium-233/234	pCi/L	1.04	0.794	2	0.555
	Uranium-235/236	pCi/L	0.0283 U	0.0497 UJ	0.0945 U	0.0354 U
	Uranium-238	pCi/L	0.409	0.235	0.439	0.199
EDD-SW01	Americium-241	pCi/L		0.014 U		0.0398 U
	Neptunium-237	pCi/L		0.00446 U		0.0133 U
	Plutonium-238	pCi/L		0 U		-0.00984 U
	Plutonium-239/240	pCi/L		0.00514 U		0.0295 U
	Technetium-99	pCi/L	36	1.99 U	6.22 U	3.65 U
	Uranium	µg/L	3.16	1.25 J	0.598	0.271
	Uranium-233/234	pCi/L	5.3	2.4	1.12	0.348
	Uranium-235/236	pCi/L	0.305	0.0507 UJ	0.0369 U	0.041 U
	Uranium-238	pCi/L	1.01	0.412	0.195	0.0847 U
LBC-SW01	Americium-241	pCi/L		0.0236 U		0.00496 U
	Neptunium-237	pCi/L		0 U		0 U
	Plutonium-238	pCi/L		0 U		0.0048 U
	Plutonium-239/240	pCi/L		0.0165 U		0.0144 U
	Technetium-99	pCi/L	15	-0.217 U	4.7 U	1.41 U
	Uranium	µg/L	1.27 J	0.752	0.611	0.205 U
	Uranium-233/234	pCi/L	2.31	1.55	0.845	0.359
	Uranium-235/236	pCi/L	0.103 UJ	0.0336 U	0.0284 U	0.0232 U
	Uranium-238	pCi/L	0.411	0.247	0.201	0.0653 U
LBC-SW02	Americium-241	pCi/L		0.0143 U		0.00503 U
	Neptunium-237	pCi/L		0.00447 U		-0.00445 U
	Plutonium-238	pCi/L		-0.0107 U		-0.0066 U
	Plutonium-239/240	pCi/L		0.0268 U		0.0198 U
	Technetium-99	pCi/L	15.4	0.195 U	5 U	3.98 U

Table 4.18. Results for radionuclides at surface water monitoring locations – 2016 (continued)

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
LBC-SW02	Uranium	µg/L	1.33 J	0.881	0.59	0.293
	Uranium-233/234	pCi/L	2.25	1.6	0.824	0.377
	Uranium-235/236	pCi/L	0.12	0.0709 UJ	0.0398 U	0.0347 U
	Uranium-238	pCi/L	0.427	0.285	0.192	0.0931
LBC-SW03	Americium-241	pCi/L		0.0246 U		0.0207 U
	Neptunium-237	pCi/L		0.00941 U		0.0047 U
	Plutonium-238	pCi/L		0.0182 U		0 U
	Plutonium-239/240	pCi/L		0.0182 U		0.027 U
	Technetium-99	pCi/L	13.7	-1.06 U	8.22	2.68 U
	Uranium	µg/L	1.02 J	0.823	0.432	0.421
	Uranium-233/234	pCi/L	1.74	1.29	0.704	0.507
	Uranium-235/236	pCi/L	0.0992 UJ	0.0287 U	0.0584 U	0.035 U
	Uranium-238	pCi/L	0.329	0.272	0.136	0.136
LBC-SW04	Americium-241	pCi/L		0.0234 U		0.0203 U
	Neptunium-237	pCi/L		0.014 U		0.00896 U
	Plutonium-238	pCi/L		0.00564 U		-0.0253 U
	Plutonium-239/240	pCi/L		0.0226 U		-0.00506 U
	Technetium-99	pCi/L	12	-0.562 U	4.9 U	4.87 U
	Uranium	µg/L	1.84 J	1.47 J	1.38	0.664
	Uranium-233/234	pCi/L	1.94	1.32	1.37	0.685
	Uranium-235/236	pCi/L	0.0693 UJ	0.07 UJ	0.0793 U	0.0579 U
	Uranium-238	pCi/L	0.608	0.483	0.451	0.214
NHP-SW01	Americium-241	pCi/L		0.0096 U		-0.0196 U
	Neptunium-237	pCi/L		0 U		0 U
	Plutonium-238	pCi/L		-0.0057 U		-0.00962 U
	Plutonium-239/240	pCi/L		0.0113 U		0.0241 U
	Technetium-99	pCi/L	1.28 U	0.677 U	4.74 U	2.98 U
	Uranium	µg/L	5.69 J	6.55 J	3.85	4.95
	Uranium-233/234	pCi/L	2.45	3.24	1.6	1.81
	Uranium-235/236	pCi/L	0.176	0.146	0.157	0.101 U
	Uranium-238	pCi/L	1.89	2.18	1.27	1.65
UND-SW01	Americium-241	pCi/L		0.0326 U		0.0642 U
	Neptunium-237	pCi/L		0.00904 U		0.00876 U
	Plutonium-238	pCi/L		0.00508 U		0.00954 U
	Plutonium-239/240	pCi/L		0.0407 UJ		0.00954 U
	Technetium-99	pCi/L	3.38 U	-1.15 U	0.804 U	3.11 U
	Uranium	µg/L	1.9	2.5 J	2.7	1.95
	Uranium-233/234	pCi/L	0.819	0.954	1.06	0.821
	Uranium-235/236	pCi/L	0.0223 U	0.0885 UJ	0.0399 U	0.0404 U
	Uranium-238	pCi/L	0.636	0.826	0.903	0.649
UND-SW02	Americium-241	pCi/L		0 U		0.0332 U
	Neptunium-237	pCi/L		0 U		0.00423 U
	Plutonium-238	pCi/L		-0.0102 U		0 U
	Plutonium-239/240	pCi/L		0.0204 U		0.0214 U
	Technetium-99	pCi/L	2.84 U	-2.61 U	-1.23 U	3.25 U
	Uranium	µg/L	1.87	2.05 J	0.452	0.954
	Uranium-233/234	pCi/L	0.713	0.745	0.166	0.446
	Uranium-235/236	pCi/L	0.0393 U	0.0116 U	0.0278 U	0.0165 U
	Uranium-238	pCi/L	0.622	0.688	0.148	0.318
WDD-SW01	Americium-241	pCi/L		0.0234 U		0.0309 U

Table 4.18. Results for radionuclides at surface water monitoring locations – 2016 (continued)

Sampling Location	Parameter	Unit	First quarter	Second quarter	Third quarter	Fourth quarter
WDD-SW01	Neptunium-237	pCi/L		0.00464 U		0.00436 U
	Plutonium-238	pCi/L		0.00505 U		0 U
	Plutonium-239/240	pCi/L		0.0151 U		0.0154 U
	Technetium-99	pCi/L	2.99 U	-3.53 U	1.06 U	2.06 U
	Uranium	µg/L	3.53 J	2.92 J	1.43	1.5
	Uranium-233/234	pCi/L	1.72	1.27	0.735	0.761
	Uranium-235/236	pCi/L	0.122	0.0822 UJ	0.0538 U	0.0111 U
	Uranium-238	pCi/L	1.17	0.968	0.471	0.501
WDD-SW02	Americium-241	pCi/L		0.0091 U		0.0147 U
	Neptunium-237	pCi/L		0 U		0.00446 U
	Plutonium-238	pCi/L		0 U		0.00968 U
	Plutonium-239/240	pCi/L		0.0105 U		0.00969 U
	Technetium-99	pCi/L	2.71 U	-4.34 U	1.5 U	2.6 U
	Uranium	µg/L	2	2.93 J	1.51	1.71
	Uranium-233/234	pCi/L	0.982	1.46	0.928	0.828
	Uranium-235/236	pCi/L	0.0389 U	0.0884 UJ	0.0226 U	0.0281 U
	Uranium-238	pCi/L	0.665	0.972	0.505	0.57
WDD-SW03	Americium-241	pCi/L		0.00987 U		0.0104 U
	Neptunium-237	pCi/L		-0.0048 U		-0.00899 U
	Plutonium-238	pCi/L		0 U		0.00491 U
	Plutonium-239/240	pCi/L		0.0334 U		0.0197 U
	Technetium-99	pCi/L	3.7 U	-0.194 U	0.956 U	1.84 U
	Uranium	µg/L	2.96 J	2.64 J	1.73	1.8
	Uranium-233/234	pCi/L	1.52	1.48	0.881	0.582
	Uranium-235/236	pCi/L	0.126	0.0688 UJ	0.0869 U	0.0287 U
	Uranium-238	pCi/L	0.975	0.876	0.569	0.601

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5. REFERENCES

DOE 2015. *Integrated Groundwater Monitoring Plan for the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio,* DOE/PPPO/03-0032&D8, U.S. Department of Energy, Piketon, OH, July.

DOE 2017. *2016 Groundwater Monitoring Report for the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio,* DOE/PPPO/03-0786&D1, U.S. Department of Energy, Piketon, OH, March.

DOE 2018. *U.S. Department of Energy Portsmouth Gaseous Diffusion Plant Annual Site Environmental Report – 2016, Piketon, Ohio,* DOE/PPPO/03-0813&D1, U.S. Department of Energy, Piketon, OH, February.

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