U.S. Department of Energy

Portsmouth Annual Environmental Report for 2006

The changing mission of the Portsmouth Gaseous Diffusion Plant . . .

Shutdown of the gaseous diffusion uranium enrichment process and demolition of structures no longer needed such as the X-616 Liquid Effluent Control Facility

Construction of the Depleted Uranium Hexafluoride Conversion Facility

Removal of wastes from the X-7725 Building for construction of the USEC American Centrifuge uranium enrichment facility

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U.S. Department of Energy
Portsmouth Annual Environmental Report
for 2006
Piketon, Ohio

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managing the
Environmental Remediation Activities at the
Portsmouth Gaseous Diffusion Plant
under contract DE-AC24-05OH20192
for the
U.S. DEPARTMENT OF ENERGY

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per review by:

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PORTS Classification/Information Office Date

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ACRONYMS

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DOE	U.S. Department of Energy
DOE PORTS	facilities operated by the DOE (not leased to USEC) at the Portsmouth Gaseous Diffusion Plant
EMS	Environmental Management System
EPA	Environmental Protection Agency
GCEP	gaseous centrifuge enrichment plant
LPP	LATA/Parallax Portsmouth, LLC
mg/kg	milligram per kilogram (equivalent to part per million)
mg/L	milligram per liter (equivalent to part per million)
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
mrem	millirem
NPDES	National Pollutant Discharge Elimination System
PCB	polychlorinated biphenyl
pCi/g	picocurie per gram
pCi/L	picocurie per liter
pCi/m^3	picocurie per cubic meter
PK	Peter Kiewit
PORTS	Portsmouth Gaseous Diffusion Plant
ppb	part per billion
ppm	part per million
RCRA	Resource Conservation and Recovery Act
TPMC	Theta Pro2Serve Management Company, LLC
TSCA	Toxic Substances Control Act
UDS	Uranium Disposition Services
USEC	United States Enrichment Corporation

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DEFINITIONS

absorption – Taking up of energy from radiation by the medium 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 body of rock below the ground surface that is capable of yielding quantities of groundwater to wells and springs. A subsurface zone that yields economically important amounts of water to wells.

atom –Smallest particle 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 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 Resource Conservation and Recovery Act requirements.

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

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

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

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 and multiples of the curie are commonly used:

> **kilocurie (kCi)** – 10^{3} Ci, one thousand curies; 3.7×10^{13} disintegrations per second.
> **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.

derived concentration guide – 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 an effective dose equivalent of 0.1 rem or a dose equivalent of 5 rem to any tissue, including skin and the lens of the eye. The guidelines for radionuclides in air and water are provided in DOE Order 5400.5, *Radiation Protection of the Public and the Environment.*

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

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

- **dose equivalent** – The product of the absorbed dose (rad) in tissue and a quality factor. Dose equivalent is expressed in units of rem (or sievert) (1 rem = 0.01 sievert).

- **committed dose equivalent** – The calculated total dose equivalent 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 dose equivalent is expressed in units of rem (or sievert).

- **committed effective dose equivalent** – The sum of the committed dose equivalents to various tissues in the body, each multiplied by an appropriate weighting factor. Committed effective dose equivalent is expressed in units of rem (or sievert).

- **effective dose equivalent** – The sum of the dose equivalents received by all organs or tissues of the body after each one has been multiplied by the appropriate weighting factor. The effective dose equivalent includes the committed effective dose equivalent from internal deposition of radionuclides and the effective dose equivalent attributable to sources external to the body.

- **collective dose equivalent/collective effective dose equivalent** – The sums of the dose equivalents or effective dose equivalents of all individuals in an exposed population within a 50-mile (80-km) radius, expressed in units of person-rem (or person-sievert). When the collective dose equivalent of interest is for a specific organ, the units would be organ-rem (or organ-sievert). The 50-mile distance is measured from a point located centrally with respect to major facilities or DOE program activities.

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.

effluent – A liquid or gaseous waste 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 with waste 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 – 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 natural radionuclides enter the body by ingestion of food or liquids or by inhalation. Radon is the major contributor to the annual dose equivalent for internal radionuclides.

irradiation – Exposure to 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 equivalent.

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 equivalent 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. A radionuclide is a radioactive nuclide.

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 – 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 probably cause cancer and other adverse health effects in humans.

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

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

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

quality factor – 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 quality factor is used because some types of radiation, such as alpha particles, are more biologically damaging than others.

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 equivalent (absorbed dose in rads multiplied by the radiation quality factor). Dose equivalent 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) – Legislation that regulates the transport, treatment, and disposal of solid and hazardous wastes.

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 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 – Mixture of fine, nonsettling particles of any solid within a liquid or gas.

terrestrial radiation – Ionizing radiation emitted from radioactive materials in the earth's soils such as potassium-40, 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. All transuranics are radioactive.

trichloroethene – 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 trichloroethene may cause health effects such as liver and lung damage and abnormal heartbeat; moderate levels may cause dizziness or headache. The International Agency for Research on Cancer considers trichloroethene a probable human carcinogen.

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 – 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 in soil and groundwater. Volatile organic compounds found at PORTS include trichloroethene, vinyl chloride, benzene, and dichloroethenes.

weighting factor – A tissue specific number that represents the fraction of the total 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 Environmental Report is prepared to summarize environmental activities, primarily environmental monitoring, at the Portsmouth Gaseous Diffusion Plant (PORTS) for calendar year 2006. The report fulfills a requirement of the U.S. Department of Energy (DOE) Order 231.1A, *Environment, Safety and Health Reporting*, for preparation of an annual summary of environmental data to characterize environmental management performance.

SITE AND OPERATIONS OVERVIEW

PORTS, which began operation in 1954, 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. PORTS is located on 5.8 square miles in Pike County, Ohio. The county has approximately 27,700 residents.

In 1993, the DOE began leasing the uranium enrichment production and operations facilities at PORTS to the United States Enrichment Corporation (USEC). The DOE is responsible for certain environmental restoration and waste management activities, uranium programs, and long-term stewardship of nonleased facilities at PORTS.

LATA/Parallax Portsmouth, LLC (LPP) and Theta Pro2Serve Management Company, LLC (TPMC) managed DOE PORTS programs throughout 2006. A third DOE contractor, Uranium Disposition Services, LLC (UDS), is responsible for the construction and initial operation of the Depleted Uranium Hexafluoride Conversion Facility at PORTS and the surveillance and maintenance of depleted uranium cylinders. Depleted uranium hexafluoride, which is a product of the gaseous diffusion process, is stored in cylinders on site. The Depleted Uranium Hexafluoride Conversion Facility will convert depleted uranium hexafluoride into uranium oxide, which will be shipped off site.

PORTS production facilities that were used for the separation of uranium isotopes by the gaseous diffusion process are currently leased to USEC; however, most activities associated with the gaseous diffusion process of uranium enrichment ceased in 2001. USEC is responsible for cold shutdown operations, removal of uranium deposits from process equipment, and the proposed gas centrifuge uranium enrichment facility. USEC, Inc. (the parent company of USEC) is currently constructing the American Centrifuge uranium enrichment plant at PORTS. The plant is expected to begin uranium enrichment operations in 2009 and create hundreds of jobs.

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 USEC operations at PORTS. USEC 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.

ENVIRONMENTAL COMPLIANCE

DOE PORTS or the responsible DOE contractor has been issued a permit for discharge of water to surface streams, several air emission permits, and a permit for the storage of hazardous waste. The DOE is also responsible for preparing a number of reports for compliance with environmental regulations. These reports include an annual groundwater monitoring report, an annual 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, an annual summary of air emissions from the X-6002 boilers, a monthly summary of National Pollutant Discharge Elimination System (NPDES) monitoring, a quarterly radiological discharge monitoring report, an annual hazardous chemical inventory, and an annual toxic chemical release inventory.

USEC is responsible for compliance activities directly associated with its operations, including air emission permits for uranium enrichment facilities, water discharge permits for several holding ponds and water treatment facilities, and management of wastes generated by USEC operations.

In 2006, DOE PORTS received a Notice of Violation from the U.S. Environmental Protection Agency (EPA) for alleged violations of hazardous waste regulations pertaining to recordkeeping and emergency plan requirements. The DOE submitted responses to the alleged deficiencies identified in the Notice of Violation. The Notice of Violation and DOE's responses are summarized in Section 2.4.2.

ENVIRONMENTAL PROGRAMS

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.

Environmental Restoration Program

Environmental restoration is the process of cleaning up waste sites and facilities to demonstrate that risks to human health and the environment are either eliminated or reduced to safe levels. The DOE established the Environmental Restoration Program to find, analyze, and correct site contamination problems.

The Ohio Consent Decree and the U.S. EPA Administrative Consent Order require investigation and cleanup of PORTS in accordance with the Resource Conservation and Recovery Act (RCRA) Corrective Action Program. The site is divided into quadrants to facilitate the investigation and cleanup. Corrective actions are underway in each quadrant.

A project to remediate volatile organics in Quadrant I at the southern edge of the X-749/X-120 groundwater plume in the area of the X-749 South Barrier Wall and the DOE property boundary continued during 2006. Hydrogen release compounds, which act as an accelerant to the natural microbial process breaking down volatile organics into nontoxic compounds, were injected into the soil at over 150 locations during March and April 2004. Based on data collected from 2004 through 2006, the hydrogen release compounds briefly caused decreases in volatile organics in the treatment zones, but break down of the volatile organics is no longer occurring because the hydrogen release compounds have been depleted. Additional injections of the hydrogen release compounds will not take place because of the short duration of this treatment technique. At the end of 2006, DOE was evaluating other options for control of the X-749/X-120 plume in the X-749 South Barrier Wall area.

In December 2003, the Ohio EPA issued the Decision Document for corrective actions required for the X-701B area in Quadrant II. These corrective actions include construction of landfill caps in the western portion of the area and groundwater treatment through injection of a chemical oxidant followed by phytoremediation, if necessary. Phase I field activities for groundwater remediation were completed during September through November of 2005 to determine operating parameters for the oxidant injection system. A work plan for completion of the groundwater remediation at X-701B was approved by Ohio EPA in September 2006, and Phase IIa oxidant injections were completed in October 2006.

As required by the Ohio EPA, corrective actions in Quadrants III and IV were maintained and monitored in 2006.

Waste Management Program

The DOE PORTS Waste Management Program directs the safe storage, treatment, and disposal of waste generated from past plant operations, ongoing plant maintenance, and ongoing environmental restoration projects. In 2006, more than 15.5 million pounds of waste from PORTS were recycled, treated, or disposed at off-site facilities.

Waste management activities are conducted in compliance with DOE Orders, Ohio EPA regulations, and U.S. EPA regulations. Waste management requirements are varied and often complex because of the variety of wastes generated by DOE PORTS activities. The types of waste managed by DOE PORTS include:

- *Low-level radioactive waste* – radioactive waste not classified as high level or transuranic waste.

- *Hazardous (RCRA) waste* – waste that contains one or more of the wastes listed under RCRA or that exhibits one or more of the four RCRA hazardous characteristics: ignitability, corrosivity, reactivity, and toxicity.

- *PCB wastes* – waste containing PCBs, a class of synthetic organic chemicals. Disposal of PCB materials is regulated under the Toxic Substances Control Act (TSCA).

- *Subtitle D solid wastes* – Waste that includes construction and demolition debris, industrial waste, and sanitary waste, as defined by Ohio regulations.

Many of the wastes generated by DOE PORTS are a combination of these first three waste types; for example, some wastes are both RCRA hazardous waste and low-level radioactive waste.

Supplemental policies also have been implemented for waste management including: minimizing waste generation; characterizing and certifying wastes before they are stored, processed, treated, or disposed; pursuing volume reduction (such as blending and bulking); on-site storage in preparation for safe and compliant final treatment and/or disposal; and recycling.

Public Awareness Program

The 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 220), 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 or email eic@falcon1.net). Additional information is provided by the DOE Site Office (740-897-5010) and the LPP Office of Public Affairs (740-897-2336).

The latest Annual Environmental Report and other information can also be obtained from the PORTS web site at www.lpports.com.

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, the *Portsmouth Environmental Bulletin* is distributed to more than 4,000 recipients, including those on the community relations mailing list, neighbors within 2 miles of the plant, and plant employees and retirees.

ENVIRONMENTAL MONITORING

Environmental monitoring at PORTS includes air, water, soil, and biota (animals, vegetation, and crops) and includes measurement of both radiological and chemical parameters. Environmental monitoring programs may be required by regulations, permit requirements, and DOE Orders, but also may be developed to address public concerns about plant operations. The DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* describes the environmental monitoring programs for DOE PORTS.

In 2006, environmental monitoring information was collected for the following programs:

- Airborne discharges,
- Ambient air,
- Direct radiation,
- Discharges to surface water,
- Local surface water,
- Sediment,
- Soil,
- Vegetation, and
- Biota.

Data collected for these programs in 2006 are consistent with data collected in previous years and indicate that radionuclides and chemicals released by PORTS operations have a minimal effect on human health and the environment. The DOE also collects extensive environmental monitoring information on groundwater at PORTS. Groundwater monitoring is discussed in Chapter 6, Groundwater Programs.

DOSE

Potential impacts on human health from radionuclides released by PORTS operations are calculated based on environmental monitoring data. This impact, commonly called 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. The U.S. EPA sets a 10 millirem (mrem)/year limit for the dose from radionuclides released to the air, and the DOE sets a 100 mrem/year limit for the dose from radionuclides from all potential pathways (air, water, and direct radiation). A person living in southern Ohio receives a dose of approximately 300 mrem/year from natural sources of radiation (National Council on Radiation Protection 1987). Figure 1 provides a comparison of the doses from various common radiation sources.

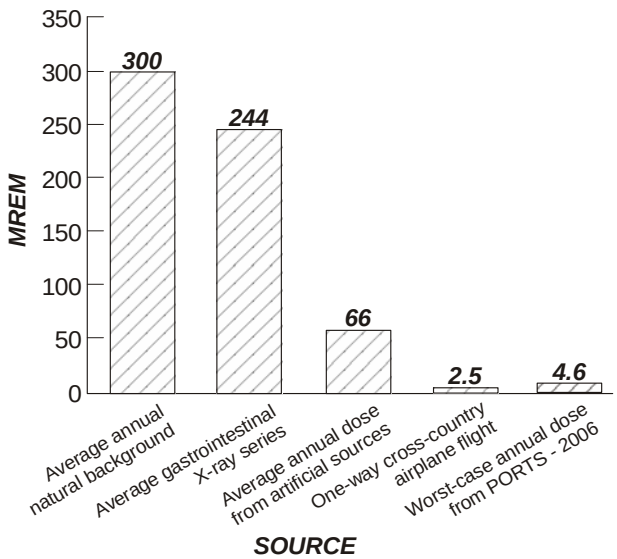

Figure 1. Comparison of dose from various common radiation sources.

This Annual 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 both the DOE and USEC. The maximum dose that a member of the public could receive from radiation released by PORTS in 2006 is 4.6 mrem, based on a maximum dose of 0.017 mrem from airborne radionuclides, 0.025 mrem from radionuclides released to the Scioto River, 1.2 mrem from direct radiation from the PORTS depleted uranium cylinder storage yards, and 3.4 mrem based on exposure to radionuclides detected at off-site monitoring locations in 2006. This dose calculation uses a worst-case approach; that is, the calculation assumes that the same individual is exposed to the most extreme conditions from each pathway. This dose (4.6 mrem) is significantly less than the 100 mrem/year limit set by DOE for the dose to a member of the public from radionuclides from all potential pathways. The dose to a member of the public from airborne radionuclides released by PORTS (0.017 mrem) is also significantly less than the 10 mrem/year standard set by U.S. EPA.

GROUNDWATER PROGRAMS

Groundwater monitoring at DOE PORTS includes RCRA hazardous waste units, solid waste disposal units, and RCRA Corrective Action Program units. The *Integrated Groundwater Monitoring Plan* describes the groundwater monitoring program for PORTS, which has been reviewed and approved by the Ohio EPA. In general, samples are collected from wells at 11 groundwater monitoring areas and surface water locations that are part of the groundwater monitoring program. Samples are analyzed for metals, volatile organic compounds, and/or radiological constituents. DOE PORTS then evaluates constituents detected in the groundwater to assess the potential for each constituent to affect human health and the environment.

Some groundwater monitoring is conducted in order to meet DOE Order requirements. Exit pathway monitoring assesses the effect of DOE PORTS on regional groundwater quality and quantity.

Five groundwater contamination plumes have been identified on site at PORTS. The primary groundwater contaminant is trichloroethene. Remediation of groundwater is being conducted, in part, under Ohio EPA's RCRA Corrective Action Program. The contaminated groundwater plumes present at PORTS did not change significantly in 2006. Trichloroethene and several other volatile organics continue to be detected at concentrations of 4 micrograms per liter (μg/L or parts per billion) or less in an off-site well approximately 45 feet south of the DOE property line that is part of the X-749/X-120 plume. In 2006, trichloroethene was not detected in groundwater beyond the DOE property boundary at concentrations that exceed the EPA drinking water standard of 5 μg/L.

The *Integrated Groundwater Monitoring Plan* also addresses monitoring of residential water supplies near PORTS 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 outside the site boundaries.

QUALITY ASSURANCE AND QUALITY CONTROL

Data reliability is of the utmost importance for monitoring releases and measuring radiation in the environment. To demonstrate that the monitoring and measurement results are accurate, DOE PORTS has implemented a quality assurance and quality control program based on guidelines from the U.S. EPA, the American Society for Testing and Materials, and other federal and state agencies. The DOE PORTS staff administers numerous quality control activities to verify reliability of the data on a day-to-day basis. DOE PORTS also participates actively in quality control programs administered by agencies outside the site such as the U.S. EPA.

1. INTRODUCTION

1.1 SUMMARY

The Portsmouth Gaseous Diffusion Plant (PORTS) is located on a 5.8-square-mile site in a rural area of Pike County, Ohio. U.S. Department of Energy (DOE) activities at PORTS include environmental restoration, waste management, and long-term stewardship of the facilities that are not leased to the United States Enrichment Corporation (USEC). Production facilities for the separation and enrichment of uranium isotopes are leased to USEC, but most activities associated with the gaseous diffusion process of uranium enrichment ceased in 2001. In 2006, USEC, Inc. (the parent company of USEC) began testing of the small-scale demonstration centrifuge for uranium enrichment at PORTS (the Lead Cascade of the American Centrifuge uranium enrichment plant). USEC, Inc. is also planning the construction of its commercial scale American Centrifuge uranium enrichment plant at PORTS. In general, USEC activities are not covered by this document, with the exception of some environmental compliance information provided in Chapter 2 and radiological and non-radiological environmental monitoring program information discussed in Chapters 4 and 5.

1.2 BACKGROUND INFORMATION

PORTS, which began operation in 1954, is owned by the DOE (see Figure 1.1). Effective July 1, 1993, the DOE leased the uranium production facilities at the site to USEC, which was established by the Energy Policy Act of 1992. The DOE is responsible for certain environmental restoration and waste management activities, uranium programs, and long-term stewardship of nonleased facilities at PORTS.

Figure 1.1 The Portsmouth Gaseous Diffusion Plant.

LATA/Parallax Portsmouth, LLC (LPP) and Theta Pro2Serve Management Company, LLC (TPMC) managed DOE PORTS programs throughout 2006. LPP is responsible for the following activities: 1) environmental restoration of contaminated areas; 2) monitoring and reporting on environmental compliance; 3) disposition of legacy radioactive waste; 4) decontamination and decommissioning of inactive facilities; 5) disposition of highly enriched uranium; and 6) operation of the site's waste storage facilities. TPMC provides infrastructure services including the following: 1) maintenance of facilities, grounds, and roadways; 2) janitorial services; 3) operation and maintenance of the boiler system that provides heat to DOE facilities; 4) security access for DOE facilities; and 5) information technology/network support for DOE operations.

A third DOE contractor, Uranium Disposition Services, LLC (UDS), is responsible for the construction and initial operation of the Depleted Uranium Hexafluoride Conversion Facility at PORTS and surveillance and maintenance of depleted uranium cylinders. Depleted uranium hexafluoride, which is a product of the gaseous diffusion process, is stored in cylinders on site. The Depleted Uranium Hexafluoride Conversion Facility will convert depleted uranium hexafluoride into uranium oxide, which will be shipped off site. Construction of the facility is expected to be complete in late 2007 with operations beginning in 2008.

USEC, which became a privately held company in 1998, enriched uranium at PORTS via the gaseous diffusion process for use in commercial nuclear power reactors until May 2001, at which time USEC ceased production at PORTS. USEC is transitioning the gaseous diffusion production facilities at PORTS to a cold shutdown mode under a contract with the DOE. Cold shutdown activities include removing lube oils and oil contaminated with polychlorinated biphenyls (PCBs) from equipment and removing uranium hexafluoride deposits within the gaseous diffusion process equipment. USEC is also processing uranium to remove technetium-99.

In 2002, USEC, Inc. decided to site the Lead Cascade at PORTS, which is a small-scale demonstration centrifuge for uranium enrichment. In January 2004, USEC, Inc. announced that its commercial scale American Centrifuge uranium enrichment plant would be built at PORTS. The plant is expected to begin uranium enrichment operations in 2009. In October 2006, USEC, Inc. introduced uranium hexafluoride feedstock to the Lead Cascade. The Lead Cascade will operate for up to five years on total recycle to generate process operating and economic data. Both of these facilities (the Lead Cascade and the commercial scale American Centrifuge Cascade) are housed in existing buildings at PORTS that were constructed for DOE's Gaseous Centrifuge Enrichment Plant, which was cancelled in 1985.

This report is intended to fulfill the requirements of DOE Order 231.1A, *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. 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 *2006 Groundwater Monitoring Report* and the *2006 Annual Hazardous Waste Report*, which are available at the DOE PORTS Environmental Information Center.

1.3 DESCRIPTION OF SITE LOCALE

DOE PORTS is located in a rural area of Pike County, Ohio, on a 5.8-square-mile site (see Figure. 1.2). 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 1.3 depicts the plant site and its immediate environs.

Pike County has approximately 27,700 residents. 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 4,400 residents. The nearest residential center in this area is Piketon, which is about 5 miles north of the plant on U.S. Route 23 with a population of about 1,900. Several residences are adjacent to the southern half of the eastern boundary and along Wakefield Mound Road (old U.S. 23), directly west of the plant.

Additional cities within 50 miles of the plant are Portsmouth (population 20,909), 22 miles south; Chillicothe (population 21,796), 27 miles north; and Jackson (population 6,184), 18 miles east (U.S. Census 2000). The total population within 50 miles of the plant is approximately 600,000 persons.

Figure. 1.2. Location of PORTS within the State of Ohio.

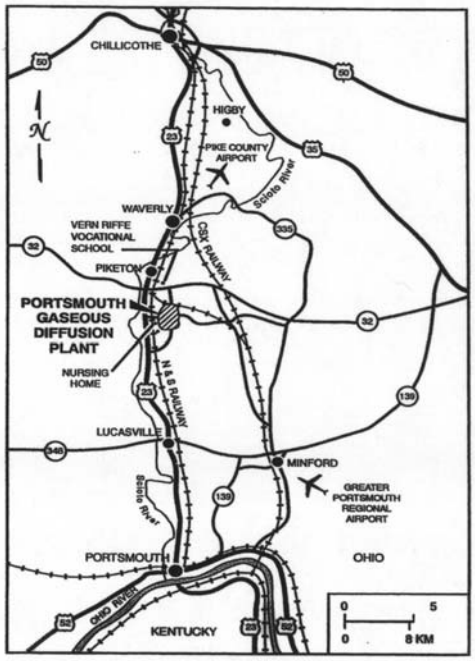

Figure. 1.3. Location of PORTS in relation to the geographic region.

1.4 DESCRIPTION OF SITE OPERATIONS

The DOE, through its managing contractors, is responsible for the Environmental Restoration, Waste Management, and Uranium Programs at the plant, as well as other nonleased DOE property. The Environmental Restoration Program performs remedial investigations and remedial actions to define the nature and extent of contamination, to evaluate the risk to public health and the environment, and to remediate areas of contamination at PORTS. The goal of the Environmental Restoration Program is to verify that releases from past operations at DOE PORTS are thoroughly investigated and that remedial actions are taken to protect human health and the environment.

The Waste Management Program is responsible for managing wastes generated at the site. Wastes must be identified and stored in accordance with all environmental regulations. The Waste Management Program also arranges 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.

The Uranium Program is responsible for the cost-effective management of PORTS facilities and real property retained by the DOE. Responsibilities include managing contracts between DOE PORTS and other subcontractors for such services as maintenance, utilities, chemical operations, uranium material handling, and laboratory analysis. The Uranium Program also oversees the management and coordination of the PORTS Depleted Uranium Hexafluoride Program and warehousing of uranium materials.

2. COMPLIANCE SUMMARY

2.1 SUMMARY

DOE PORTS or the responsible DOE contractor holds a permit for discharge of water to surface streams, several air emission permits, and a permit for the storage of hazardous wastes. The DOE is responsible for preparing a number of reports for compliance with environmental regulations. These reports include an annual groundwater monitoring report, an annual 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, an annual summary of air emissions from the X-6002 boilers, a monthly summary of National Pollutant Discharge Elimination System (NPDES) monitoring, a quarterly radiological discharge monitoring report, an annual hazardous chemical inventory, and an annual toxic chemical release inventory. Additional information on each of these reports is provided within this chapter.

USEC is responsible for compliance activities directly associated with the operations that are leased from the DOE, including air emission permits for uranium enrichment facilities, water discharge permits for several holding ponds and water treatment facilities, and management of wastes generated by current USEC operations.

DOE PORTS is inspected regularly by the federal, state, and local agencies responsible for enforcing environmental regulations at PORTS. In 2006, DOE PORTS received a Notice of Violation from the U.S. Environmental Protection Agency (EPA) concerning recordkeeping and emergency plan requirements arising from a hazardous waste inspection. This Notice of Violation and the DOE's responses are summarized in Section 2.4.2. No deficiencies were identified by the Ohio EPA or the Pike County Health Department in 2006 during other inspections of groundwater remediation/monitoring areas and related facilities, hazardous waste facilities, and closed solid waste landfills.

2.2 INTRODUCTION

The DOE is responsible for the Environmental Restoration Program, Waste Management Program, Uranium Program, and operation of all facilities not leased to USEC. The DOE also retains responsibility for certain "legacy" wastes, which contain constituents such as asbestos and PCBs that were used in DOE operations prior to the lease agreement. USEC is responsible for compliance activities directly associated with the operations that are leased from the DOE, including air emission permits for uranium enrichment facilities and water discharge permits for several holding ponds and water treatment facilities. USEC is also responsible for the management of wastes generated by current USEC operations.

DOE PORTS has an NPDES permit for discharge of water to surface streams, several 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 DOE PORTS environmental permits and registrations for 2006.

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

DOE PORTS conducts self-assessments to identify environmental issues and consults the regulatory agencies to identify the appropriate actions necessary to achieve and maintain compliance.

2.3 COMPLIANCE STATUS

This section discusses the DOE PORTS compliance status 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 PORTS compliance status 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

DOE PORTS is not on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priorities List of sites requiring priority cleanup. The U.S. EPA Administrative Consent Order, issued on September 29, 1989 (amended in 1994 and 1997), and Consent Decree with the State of Ohio, issued on August 29, 1989, require the investigation and cleanup of surface water and air releases, groundwater contamination plumes, and solid waste management units at PORTS. The U.S. EPA and Ohio EPA oversee environmental remediation activities at DOE PORTS under the RCRA Corrective Action Program and CERCLA Program.

PORTS was divided into quadrants based on groundwater flow patterns to facilitate the expedient cleanup of contaminated sites in accordance with RCRA corrective action and closure requirements. The Environmental Restoration Program at PORTS addresses requirements of the Ohio Consent Decree and U.S. EPA Administrative Consent Order. Chapter 3, Section 3.2, 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 the Act and vary depending on the type of hazardous substance released. During 2006, DOE PORTS 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. In October 2006, LPP notified state and local authorities that hydrogen peroxide is now present at PORTS in quantities exceeding the threshold planning quantity. Hydrogen peroxide is being used for the remediation at the X-701B Holding Pond (see Chapter 3, Section 3.2.2).

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 2006, DOE PORTS had no reportable quantity releases.

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 the U.S. EPA. This report is submitted annually to state and local authorities. DOE PORTS reported the following chemicals for 2006: aluminum oxide, argon, asbestos, calcium chloride, calcium oxide, carbon dioxide, citric acid, diesel fuel, ethylene glycol, fluorotrichloromethane (Freon-11), gasoline, hydrogen peroxide, kerosene, lubricating oil, fuel oil, methanol, nitric acid, nitrogen, PCBs, propane, sodium chloride, sodium fluoride, sodium hydroxide, sulfuric acid, transformer oil, triuranium octaoxide, uranium dioxide, uranium hexafluoride, uranium metal, uranium tetrafluoride, and uranium trioxide.

The Toxic Chemical Release Inventory is sent annually to the 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 (including USEC) in amounts that exceed threshold quantities specified by the U.S. EPA. For this report, the U.S. EPA defines a release to include on-site treatment, off-site disposal, and recycling conducted in accordance with regulations.

For 2006, DOE PORTS reported the release, on-site treatment, and/or off-site transfer of three chemicals: lead compounds (present in waste disposed or recycled by DOE PORTS), nitrate compounds (produced by an additive used in the recirculating hot water system that heats DOE PORTS), and sulfuric acid (produced by fuel burned by the DOE heating system). USEC reported the release, off-site transfer, and/or on-site treatment of seven chemicals: chlorine, dichlorotetrafluoroethane, nitrate compounds, sulfuric acid, hydrochloric acid, methanol, and lead compounds.

2.3.1.3 Resource Conservation and Recovery Act

RCRA regulates the generation, accumulation, storage, transportation, and disposal of solid and hazardous wastes. Wastes are designated as hazardous by the EPA because of various chemical properties, including ignitibility, corrosivity, reactivity, and toxicity. RCRA also regulates wastes that are called "solid waste," although these wastes can be solids, liquids, sludges, or other materials.

Hazardous waste. In 2006, DOE PORTS and LPP held a permit to store hazardous waste in the X-7725 and X-326 facilities. The permit, often called a Part B Permit, was issued to DOE PORTS in 1995 and renewed by the Ohio EPA in 2001. 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 the Ohio EPA.

In January 2004, USEC, Inc. announced that its American Centrifuge Plant will be sited at PORTS. This facility will be installed in the existing X-7725 building; the DOE will close permitted RCRA storage areas within this building prior to allowing USEC, Inc. use of the areas. In general, closure of RCRA storage areas includes removing stored waste, cleaning the area (as necessary), sampling to ensure that the area meets closure standards set by the Ohio EPA, and submittal of a report and certification to the Ohio EPA. The Ohio EPA reviews the report and approves the closure, at which time the area can be removed from the facility's Part B Permit. Nine storage areas that comprise approximately 2 acres of floor space within the X-7725 building were closed during 2006. Of the total original RCRA-permitted storage area in the X-7725 building (6.5 acres), 4.6 acres had been closed by the end of 2006.

Facilities such as PORTS that generate or store hazardous waste are required to submit an annual report to the Ohio EPA. This annual 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. PORTS submitted the report for calendar year 2006 to the Ohio EPA in February 2007. Chapter 3, Section 3.3, Waste Management Program, provides additional information on wastes from PORTS that were recycled, treated, or disposed in 2006.

RCRA may also require groundwater monitoring at hazardous waste units. As discussed in Chapter 6, groundwater monitoring requirements at PORTS have been integrated into one document, the *Integrated Groundwater Monitoring Plan*. Hazardous waste units included in the *Integrated Groundwater Monitoring Plan* are the X-231B Southwest Oil Biodegradation Plot, X-616 Chromium Sludge Surface Impoundments, X-701B Holding Pond, X-701C Neutralization Pit, X-735 RCRA Landfill (northern portion), and X-749 Contaminated Materials Storage Yard (northern portion). Other hazardous waste units at PORTS (the X-744Y Container Storage Area, X-701B surface impoundments, and X-230J7 Holding Pond) are being remediated as part of the RCRA Corrective Action Program at PORTS and are also monitored in accordance with the *Integrated Groundwater Monitoring Plan.* Chapter 6 discusses the groundwater monitoring requirements for these units.

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*. Chapter 6 discusses the groundwater monitoring programs for these units.

2.3.1.4 Federal Facility Compliance Act

DOE PORTS currently stores waste that is a mixture of RCRA hazardous waste and low-level radioactive waste. 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 October 1992, allows for the storage of mixed hazardous/low-level radioactive waste 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, the Ohio EPA issued Director's Final Findings and Orders allowing the storage of mixed waste beyond one year and approving the DOE PORTS 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 2006 was submitted to the Ohio EPA in December 2006.

2.3.1.5 Toxic Substances Control Act

The Toxic Substances Control Act (TSCA) regulates the use, storage, and disposal of PCBs. The electrical power system at PORTS, which is leased by USEC, uses oil-based circuit breaker transformers and large high-voltage capacitors, both containing PCB oil, to supply electricity to the enrichment cascade. Approximately 129 PCB transformers and 11,099 large PCB capacitors are either in service or stored for reuse at PORTS.

In February 1992, a TSCA Federal Facilities Compliance Agreement between the DOE and U.S. EPA addressing PCB issues became effective and resolved several 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 production 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 the U.S. EPA. DOE PORTS was in compliance with the requirements and milestones of this Federal Facilities Compliance Agreement during 2006.

DOE PORTS operates a number of storage areas for PCB wastes. An annual document log is prepared to meet 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 2006. The *2006 PCB Document Log for the Portsmouth Gaseous Diffusion Plant* was prepared in June 2007. Approximately 471 tons (427,429 kilograms) of PCB waste were shipped off site in 2006.

In 2005, DOE received approval from U.S. EPA to manage paint containing greater than 50 parts per million (ppm) PCBs that may be present in paint on the exterior of the depleted uranium cylinders in storage in the X-745C, X-745E and X-745G Cylinder Storage Yards. The agreement includes monitoring of PCBs in surface water and sediment in drainage basins downstream from the DOE cylinder storage yards. Chapter 5, Sections 5.4.3 and 5.5.2 provide the results of this sampling.

2.3.1.6 Federal Insecticide, Fungicide, and Rodenticide Act

No restricted-use pesticides were used by DOE PORTS in 2006.

2.3.2 Radiation Protection

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

2.3.2.1 DOE Order 5400.5, *Radiation Protection of the Public and the Environment*

DOE Order 5400.5 provides guidance and establishes radiation protection standards and control practices designed to protect the public and the environment from undue radiological risk from operations of DOE and DOE contractors. The order 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 for 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 radioactive waste is managed in a manner that is protective of worker and public health and safety, and the environment.

Low-level radioactive waste is generated and stored in accordance with the *Authorization Agreement and Radioactive Waste Management Basis for Portsmouth Gaseous Diffusion Plant Facilities and Material Storage Areas* and its implementing procedures. Chapter 3, Section 3.3 provides additional information about the Waste Management Program at DOE PORTS.

2.3.3 Air Quality and Protection

This section discusses the DOE PORTS compliance status with U.S. EPA and Ohio EPA regulations pertaining to air emissions (both radionuclides and non-radiological pollutants) and stratospheric ozone protection.

2.3.3.1 Clean Air Act

DOE PORTS had six permitted air emission sources, three registered air emission sources, and four permitted sources under construction by UDS at the end of 2006 (see Appendix B). Radiological air emissions from these sources are discussed in Chapter 4 and non-radiological air emissions are discussed in Chapter 5.

DOE PORTS is not a major source of air pollutants as defined in Title 40 of the *Code of Federal Regulations*, Part 70. USEC is the only major source at the PORTS site, with three boilers at the X-600 Steam Plant emitting the majority of the pollutants that cause the designation as a major source. Chapter 5, Section 5.3.1, provides additional information for PORTS non-radiological air emissions.

2.3.3.2 Clean Air Act, Title VI, Stratospheric Ozone Protection

As part of the Stratospheric Ozone Protection Plan, the 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 in units or devices. The appliance 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 contractor technicians who service air conditioning/refrigeration units under DOE control have been trained in accordance with U.S. EPA requirements.

USEC uses an ozone-depleting substance, specifically dichlorotetrafluoroethane, as a coolant in the cascade system formerly used to produce enriched uranium**.** In 2006, USEC estimated that 37,000 pounds of dichlorotetrafluoroethane were released to the air.

2.3.3.3 National Emission Standards for Hazardous Air Pollutants

The National Emission Standards for Hazardous Air Pollutants require PORTS to submit an annual estimate of radiological emissions from DOE PORTS sources. The DOE is responsible for six sources of radionuclide emissions including the X-622, X-623, X-624, X-627 Groundwater Treatment Facilities, the X-326 L-cage Glove Box, and the X-744G Glove Box, which has been removed from service. A glove box is an enclosure with built-in sleeves and gloves that is used by a person to repackage or transfer hazardous material without directly exposing the person to the material. The groundwater treatment facilities are radionuclide sources subject to these standards, because the facilities use air strippers to remove volatile organic compounds from groundwater that is also contaminated with radionuclides.

Radiological emissions from DOE PORTS in 2006 are based on emissions from the X-326 L-cage Glove Box and the X-622, X-623, X-624, and X-627 Groundwater Treatment Facilities. Emissions from the groundwater treatment facilities were conservatively estimated based on periodic emissions testing and annual throughput (X-622 and X-627) or influent/effluent sampling and annual throughput (X-623 and X-624). Emissions from the X-326 Glove box were based on the mass of the materials transferred within the glove box, analytical data available for each material, and emission factors provided by the EPA. Based on these assumptions, radiological air emissions from the X-326 Glove Box and the X-622, X-623, X-624, and X-627 Groundwater Treatment Facilities in 2006 were 0.00063 curie. Chapter 4, Section 4.3.3, provides the radiological dose calculations from these emissions.

2.3.4 Water Quality and Protection

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

2.3.4.1 Clean Water Act

The DOE PORTS NPDES permit, effective December 2002, encompasses eight monitored outfalls. Three of the outfalls are classified as point-source discharges to waters of the state, and the other five outfalls are internal outfalls classified as effluents. Water from four of these internal outfalls is treated in the USEC Sewage Treatment Plant before reaching waters of the state. Water from the fifth internal outfall is discharged to the X-2230M Holding Pond, which discharges to DOE PORTS NPDES Outfall 012. Chapter 4, Section 4.3.5.1, and Chapter 5, Section 5.4.1.1, provide additional information on the DOE PORTS NPDES outfalls.

None of the DOE PORTS NPDES permit limitations was exceeded during 2006; therefore, the overall DOE NPDES compliance rate for 2006 was 100%.

2.3.5 Other Environmental Statutes

This section discusses the DOE PORTS compliance status with other U.S. EPA and Ohio EPA regulations, including underground storage tank regulations, the Endangered Species Act, and others.

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 are owned by DOE PORTS and leased to USEC. The registrations for these tanks are renewed annually.

2.3.5.2 National Environmental Policy Act

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

DOE PORTS has a formal program dedicated to compliance pursuant to DOE Order 451.1, *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. Routine operation and maintenance activities are also evaluated to assess potential environmental impacts. Most activities at PORTS qualify for a categorical exclusion as defined in the regulations. These activities are considered routine and have no significant individual or cumulative environmental impacts.

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 site-wide threatened and endangered species habitat survey and an Indiana bat (*Myotis sodalis*) survey were completed in August 1996. No Indiana bats were found at PORTS. Few potential critical habitats were identified, and a report of the survey activities and results was provided to the Ohio Department of Natural Resources as required by the Federal Fish and Wildlife permit obtained to conduct the survey. No additional activities were completed in 2006.

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 Ohio State Historic Preservation Office are made as required by Section 106 of the Act. A programmatic agreement among the DOE, the Ohio Historic Preservation Office, and the Advisory Council on Historic Preservation concerning the management of historical and cultural properties at DOE PORTS is under development.

Phase I of the historical/archaeological survey was completed in September 1996. Fieldwork for Phase II of the project was completed in May 1997. Artifacts from the 1940s and 1950s were uncovered as well as remains from former dwellings that were present prior to construction of PORTS. Results from the survey will be coordinated with the Ohio Historic Preservation Office, and a Cultural Resources Management Plan will be developed.

In 2006, the DOE and the Ohio Historic Preservation Office entered into a Memorandum of Agreement for the demolition of four inactive support facilities at PORTS. The facilities, the X-105 Electronic Maintenance Building, the X-701D Water Deionization Building, the X-720A Maintenance and Stores Gas Manifold Shed, and the X-770 Mechanical Test Building, are considered contributing elements to the Portsmouth Gaseous Diffusion Plant Historic District. DOE agreed to maintain in DOE files and provide to the Ohio Historic Preservation Office a description of the function of each facility within the overall processes at PORTS, photographs and engineering drawings of the facilities, and maps showing the facility locations.

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 is completed by DOE PORTS annually. An archaeological survey of an area in the southwest corner of PORTS was completed in 2003. No sensitive archaeological sites were identified on DOE property in this area.

2.3.5.6 Farmland Protection Policy Act

The Farmland Protection Policy Act of 1981 requires federal agencies to consider the effects of their proposed actions on prime farmland. Prime farmland is generally defined as land that has the best combination of physical and chemical characteristics for producing crops of statewide or local importance. When required, prime farmland surveys are conducted, and consultations with the U.S. Department of Agriculture's Natural Resources Conservation Service are made. No prime farmland activities were conducted at DOE PORTS in 2006.

2.3.6 DOE Order 450.1, *Environmental Protection Program*

DOE Order 450.1, *Environmental Protection Program,* 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.

LPP, TPMC, and UDS 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. Because the UDS facility is under construction and will not be operational until 2008, UDS has not yet established measurable environmental objectives and targets. DOE completed the self-declaration protocol for establishment of the EMS in June 2006.

2.3.7 Executive Orders

An Executive Order is issued by a member of the executive branch of the government. Most Executive Orders are issued by the President to various federal agencies, including the DOE. This section discusses the DOE PORTS compliance status with Executive Orders pertaining to the environment.

2.3.7.1 Executive Order 13148, *Greening the Government through Leadership in Environmental Management*

Executive Order 13148 requires federal facilities to comply with Emergency Planning and Community Right-to-Know requirements. Section 2.3.1.2 summarizes DOE PORTS activities conducted during 2006 to comply with these requirements.

Additional Executive Order 13148 goals include pollution prevention and phasing out the procurement of ozone depleting substances. Chapter 3, Section 3.4, discusses pollution prevention activities at DOE PORTS, and Section 2.3.3.2 describes DOE PORTS compliance activities for stratospheric ozone protection.

2.3.7.2 Executive Order 13101, *Greening the Government through Waste Prevention, Recycling, and Federal Acquisition*

Chapter 3, Section 3.4, provides a summary of the DOE PORTS pollution prevention program and pollution prevention activities for 2006.

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

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

The site-wide wetland survey report was completed and submitted to the Corps of Engineers in 1996. There are 41 jurisdictional wetlands and four non-jurisdictional wetlands totaling 34.361 acres at PORTS. During 2006, no DOE activities were conducted in jurisdictional wetlands.

2.4 OTHER MAJOR ENVIRONMENTAL ISSUES AND ACTIONS

This section summarizes environmental inspection at DOE PORTS during 2006 and the results of these inspections.

2.4.1 Environmental Program Inspections

During 2006, five inspections of the DOE PORTS programs were conducted by federal, state, or local agencies. Table 2.1 lists these inspections.

Table 2.1. Environmental inspections at DOE PORTS for 2006

Date	Agency	Type	Findings
February 8	Ohio EPA	NPDES (X-2230M and X-2230N Holding Ponds)	None
April 28	Pike County Health Department and Ohio EPA	Closed solid waste landfills: X-749A, X-749, and X-735 (solid waste portion)	None
June 19-23	Ohio EPA and U.S. EPA	Multi-media	See Section 2.4.2
July 18	Federal Energy Regulatory Commission	X-611A and X-735B Impoundments	None
November 6	Ohio EPA	RCRA	None

2.4.2 Inspection Findings

DOE PORTS received a Notice of Violation from the U.S. EPA on June 18, 2007 for the inspection completed June 19-23, 2006. The Notice of Violation identified two alleged violations: 1) a Land Disposal Restriction form (part of the paperwork required to ship hazardous waste) that was not maintained on site by UDS, and 2) a deficiency in the emergency notification reporting and recordkeeping requirements in the UDS Spill Prevention, Control, and Countermeasures Plan/RCRA Contingency Plan. DOE PORTS submitted responses to the alleged violations stating that the missing Land Disposal Restriction Form had been maintained by UDS at its off-site offices and that the form was immediately sent to the UDS office at PORTS after the U.S. EPA inspectors informed DOE of its absence. UDS procedures will be developed to include recordkeeping requirements for hazardous waste shipments.

U.S. EPA also alleged that the deficiency in the UDS Spill Prevention, Control, and Countermeasures Plan/RCRA Contingency Plan constituted a violation of contingency plan requirements. DOE and LPP maintain a RCRA Contingency Plan as part of the DOE/LPP permit for storage of hazardous waste. The DOE/LPP Contingency Plan is separate from the UDS Spill Prevention, Control, and Countermeasures Plan/RCRA Contingency Plan and contains the reporting and recordkeeping requirements cited by U.S. EPA. UDS is not a party to the DOE/LPP hazardous waste storage permit. DOE responded to the alleged violation by contending that DOE and LPP are not in violation of contingency plan requirements because the DOE/LPP Contingency Plan contains the required language. DOE noted that UDS plans to obtain a separate EPA ID number in anticipation of future hazardous waste generation and UDS will ensure that the UDS Contingency Plan meets requirements for hazardous waste generators.

2.5 UNPLANNED RELEASES

No unplanned releases from DOE PORTS were reported in 2006.

2.6 SUMMARY OF PERMITS

Appendix B lists the permits held by DOE PORTS in 2006.

3. ENVIRONMENTAL PROGRAM INFORMATION

3.1 SUMMARY

Environmental Restoration activities in 2006 included continued monitoring of a special groundwater remediation project in the southern portion of the X-749/X-120 groundwater plume in Quadrant I and implementation of the first phase of remedial actions required for the X-701B area in Quadrant II. These remedial actions will include construction of landfill caps in the western portion of the area, groundwater treatment through injection of a chemical oxidant, and phytoremediation, if necessary.

In 2006, more than 15.5 million pounds of waste from DOE PORTS were recycled, treated, or disposed at off-site facilities. Activities undertaken by the Waste Minimization, Pollution Prevention, Training, Inactive Facilities Removal, and Public Awareness programs are also discussed in this chapter.

Chapter 2, Section 2.3.6, provides information on DOE Order 450.1 and implementation of the DOE PORTS Environmental Management System.

3.2 ENVIRONMENTAL RESTORATION PROGRAM

The DOE established the Environmental Restoration Program in 1989 to identify, control, and remediate environmental contamination at PORTS. The Environmental Restoration Program addresses inactive sites through remedial action and deals with active facilities through eventual decontamination and decommissioning. Options for correcting or mitigating the contaminated sites and facilities include removal, containment, and treatment of contaminants. Because PORTS is a large facility, it is divided into quadrants (Quadrant I, II, III, and IV) to facilitate the cleanup process.

The Environmental Restoration Program was established to fulfill the cleanup requirements of the Ohio Consent Decree and U.S. EPA Administrative Consent Order. As required by these enforcement actions, DOE PORTS Environmental Restoration Program activities are conducted in accordance with the RCRA corrective action process, which consists of the following:

- *Description of current conditions* – to provide knowledge of the groundwater, surface water, soil, and air.
- *RCRA facility assessment* – to identify releases of contaminants and determine the need for further investigation.
- *RCRA facility investigation* – to determine the nature and extent of any contamination.
- *Cleanup alternatives study/corrective measures study* – to evaluate and select a remediation alternative.
- *Corrective measures implementation* – to implement the selected remediation measure.

DOE PORTS has completed the description of current conditions, RCRA facility assessment, RCRA facility investigation, and cleanup alternatives study/corrective measures study for each quadrant. Following the approval of the final cleanup alternative study/corrective measure study, the Ohio EPA

selects the remedial alternatives that will undergo further review for determining the final remedial actions for each quadrant (the Preferred Plan). Upon concurrence from the U.S. EPA and completion of the public review and comment period, the U.S. EPA and Ohio EPA select the final remedial actions for each quadrant. The Ohio EPA issues a decision document to select the final remedial actions.

Implementation of corrective measures is underway in each quadrant. Corrective measures implementations are described for each quadrant in the sections presented below. Table 3.1 lists completed activities for the groundwater monitoring areas at PORTS, which include corrective measures required by decision document and other actions.

The Ohio EPA has deferred further investigation and/or corrective action for certain areas known as "deferred units." Deferred units are areas that are in or adjacent to current production and operational areas such that remedial activities would interrupt operations, or are areas that could become recontaminated from ongoing operations. The Ohio EPA has deferred investigation/corrective action for these units until decontamination and decommissioning of PORTS or until the unit no longer meets the requirements for deferred unit status.

3.2.1 Quadrant I

The *Quadrant I Cleanup Alternative Study/Corrective Measures Study* was approved by the Ohio EPA in 2000. The Ohio EPA issued the Decision Document for Quadrant I in 2001. The following sections discuss the remedial actions required for the X-749/X-120/Peter Kiewit (PK) Landfill and the Quadrant I Groundwater Investigative Area. Deferred units in Quadrant I will be addressed during decontamination and decommissioning of PORTS.

3.2.1.1 X-749/X-120/PK Landfill

The remedial actions identified for X-749/X-120 groundwater plume 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.

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. The first phase was completed in 2002. Hybrid poplar trees were planted in two areas of the X-749/X-120 groundwater plume: one area immediately east of the X-749 Landfill and one area on the southern edge of the plume. The second phase, which encompasses the southern and western portion of the plume, was completed in 2003. A certification report for both phases of this project was submitted to the Ohio EPA in December 2003 and approved by the Ohio EPA in January 2004.

A five-year review was completed for the PK Landfill in 2002 to evaluate the effectiveness of the corrective measures implemented at this area (the groundwater collection systems and landfill cap - see Table 3.1). The U.S. EPA and Ohio EPA approved the report contingent upon additional evaluation and monitoring at PK Landfill. A monitoring plan entitled *Comprehensive Monitoring Program for the X-749 and Peter Kiewit Landfill Areas for the Portsmouth Gaseous Diffusion Plant* was developed and implemented in 2003 to provide additional data to evaluate the performance of the groundwater collection systems and landfill cap for the PK Landfill and to monitor the effect of the new X-749 barrier wall on groundwater quality and movement in the northern area of the X-749 plume and at the PK Landfill. Data were collected for this monitoring program throughout 2004, and an annual summary report was submitted to the Ohio EPA in December 2004.

Table 3.1. Corrective actions completed at PORTS

Quadrant/monitoring area	Corrective action/year completed
Quadrant I X-749/X-120 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
Quadrant I 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 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
Quadrant I X-749A Classified Materials Disposal Facility	Cap – 1994
Quadrant II Quadrant II Groundwater Investigative Area	Operation of X-700 and X-705 building sumps – 1989 X-622T Groundwater Treatment Facility – 1992 Removal of X-720 Neutralization Pit (NP) – 1998 Removal of X-701C Neutralization Pit – 2001 Removal of contaminated soil near X-720 NP – 2001 X-627 Groundwater Treatment Facility – 2004 (replaced the X-622T facility)
Quadrant II X-701B Holding Pond	X-237 Groundwater Collection System – 1991 X-624 Groundwater Treatment Facility – 1991 (upgraded 2006) Extraction wells (3) – 1993 X-623 Groundwater Treatment Facility – 1993 X-701B sump – 1995 Groundwater remediation by oxidant injection Phase I oxidant injections – 2005 Phase IIa oxidant injections - 2006
Quadrant III X-740 Waste Oil Handling Facility	Phytoremediation – 1999

Table 3.1. Corrective actions completed at PORTS (continued)

Quadrant/monitoring area	Corrective action/year completed
Quadrant IV X-611A Former Lime Sludge Lagoons	Soil cover/prairie habitat – 1996
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

The report [*Annual (2004) Summary Report of the Comprehensive Monitoring Plan Data for the X-749/Peter Kiewit Landfill Area*] found that the barrier wall on the south and east sides of the X-749 Landfill, installed in 2001-2002, is impeding additional contamination from flowing out of the landfill, and that the groundwater collection system and sump pump in the southwestern corner of the X-749 Landfill is removing water from the landfill. Additionally, the PK Landfill cap is performing adequately to impede surface water from percolating through landfill waste and potentially contaminating groundwater. The PK Landfill groundwater collection systems are intended to prevent groundwater beneath the landfill from reaching Big Run Creek, although low concentrations of volatile organic compounds have been detected in wells between the collection systems and Big Run Creek. Construction of a barrier wall on the upgradient (west and north) sides of the PK Landfill does not appear to be necessary based on evaluation of the PK Landfill cap, construction of the X-749 barrier walls, and evaluation of monitoring data. The report recommended discontinuing the monitoring conducted solely for this special report. The Ohio EPA approved the report in March 2005, and monitoring was discontinued starting in the second quarter of 2005.

A project was begun in 2004 to remediate volatile organics at the southern edge of the X-749/X-120 groundwater plume in the area of the X-749 South Barrier Wall (an interim remedial measure constructed in 1994) and the DOE property boundary. Hydrogen release compounds, which act as an accelerant to the natural microbial process that breaks down volatile organics into nontoxic compounds, were injected into the soil in over 150 locations during March and April 2004. Additional sampling monitored the concentrations of volatile organics, gases, and other breakdown products in the groundwater. Based on data collected from 2004 through 2006, optimal breakdown of the volatile organics was briefly achieved in the treatment zones, but is no longer occurring due to depletion of the hydrogen release compounds. Additional hydrogen release compounds will not be injected because of the short duration of this remedial technique. At the end of 2006, DOE was evaluating other options for control of the X-749/X-120 groundwater plume in the X-749 South Barrier Wall Area. Chapter 6 provides 2006 groundwater monitoring results for the X-749/X-120/PK Landfill area.

3.2.1.2 Quadrant I Groundwater Investigative Area

Remedial actions identified for the Quadrant I Groundwater Investigative Area are: (1) installation of multimedia caps over the X-231A and X-231B Biodegradation Plots and (2) installation of 11 additional groundwater extraction wells to extract contaminated groundwater for treatment in the X-622 Groundwater Treatment Facility. A five-year review of these remedial actions will be completed and submitted to Ohio EPA in 2008. Table 3.1 lists the remedial actions completed for the Quadrant I Groundwater Investigative Area.

Operation of the groundwater extraction wells is affecting the concentrations of contaminants detected in some of the wells in the groundwater plume. Chapter 6, Section 6.4.2.3, provides information on the groundwater monitoring completed in this area during 2006.

3.2.2 Quadrant II

The *Quadrant II Cleanup Alternative Study/Corrective Measures Study* was approved by the Ohio EPA on March 26, 2001. After approval of the document, however, the 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 January 2003, the Ohio EPA informed the DOE that a separate Preferred Plan and Decision Document would be prepared for the X-701B area. The Ohio EPA issued the Preferred Plan in September 2003 and the X-701B Decision Document in December 2003.

Remedial actions required for soil in the X-701B area include removal of contaminated soil in the western portion of the area and consolidation of the soil under two landfill caps to be constructed over the X-701B Holding Pond/East Retention Basin and the West Retention Basin. Two landfill caps will be constructed so that an existing storm water drainage pipe will not be covered. Groundwater remediation will be accomplished by injection of a chemical oxidant followed by phytoremediation, if necessary.

Phase I field activities for groundwater remediation began in September 2005 to determine operating parameters for the oxidant injection system including injection methodology, rate, pressure and spacing; reagent concentration; and reagent volume. Phase I field activities were completed in November 2005, and a report was submitted to the Ohio EPA in March 2006. Based on the results of the Phase I field activities, DOE developed a work plan for the completion of the groundwater remediation at X-701B. Ohio EPA approved the work plan in September 2006, and Phase IIa oxidant injections were completed in October 2006.

Deferred units in Quadrant II will be addressed during decontamination and decommissioning of PORTS. In 2003, the DOE agreed to conduct an annual review of all deferred units at PORTS to confirm that the status of the units has not changed. The annual update to the Deferred Unit Plan was submitted to the Ohio EPA in January 2007. A number of deferred units are in the groundwater plume in the Quadrant II Groundwater Investigative Area. The DOE has evaluated existing Quadrant II monitoring data for deferred units to determine whether actions could be taken to reduce or eliminate sources of contamination; however, operation of the sumps in buildings X-700 and X-705 appears to be sufficient to control groundwater contamination in this area.

Chapter 6 provides 2006 groundwater monitoring results for the following areas in Quadrant II that require groundwater monitoring: X-701B Holding Pond, Quadrant II Groundwater Investigative Area, and X-633 Pumphouse/Cooling Towers Area (a deferred unit).

3.2.3 Quadrant III

The *Quadrant III Cleanup Alternative Study/Corrective Measures Study* was approved by the Ohio EPA in 1998. The Decision Document for Quadrant III required phytoremediation of the groundwater plume near the X-740 Waste Oil Handling Facility. Deferred units in Quadrant III will be addressed during decontamination and decommissioning of PORTS.

Over 700 hybrid poplar trees were planted on a 2.6-acre area above the X-740 groundwater plume in 1999. Groundwater monitoring of both the elevation of groundwater in the aquifer and the concentration of contaminants in the groundwater plume is used to monitor the system. Chapter 6, Section 6.4.7.1, provides information about the groundwater monitoring completed for this area in 2006.

In 2003, a five-year review was completed for the X-740 groundwater plume to evaluate the effectiveness of the phytoremediation system. The report, entitled *Five-Year Evaluation Report for the X-740 Phytoremediation Project*, indicates that the trees in the phytoremediation system do not noticeably affect the overall groundwater flow in the Gallia at this area, although the trees do appear to influence water levels in individual wells. Concentrations of trichloroethene in the X-740 groundwater plume have not decreased appreciably.

Upon review of the 2003 Five-Year Evaluation Report, the Ohio EPA required another evaluation of this area in three years to determine if the phytoremediation system is effective in remediating the groundwater plume. Additional data to be collected for this evaluation includes soil moisture at specified depths below ground surface, wind speed/direction, rainfall, air/soil temperature, tree growth rates, and sap flow measurements. This evaluation was submitted to Ohio EPA in 2007.

Chapter 6 provides 2006 groundwater monitoring results for the following areas in Quadrant III that require groundwater monitoring: X-616 Chromium Sludge Surface Impoundments and X-740 Waste Oil Handling Facility.

3.2.4 Quadrant IV

The *Quadrant IV Cleanup Alternative Study/Corrective Measures Study* was approved by the Ohio EPA in 1998. The DOE received the Decision Document for Quadrant IV in 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 Landfill Area). Deferred units in Quadrant IV will be addressed during decontamination and decommissioning of PORTS.

In 2002, a five-year review was completed for the X-611A Former Lime Sludge Lagoons to evaluate the effectiveness of the corrective measures implemented at this area. The report found that the soil cover and prairie habitat constructed at the X-611A Former Lime Sludge Lagoons is meeting the objectives for this unit by eliminating exposure pathways to the contaminants of concern present in the sludge located beneath the soil cover in this area.

Chapter 6 provides 2006 groundwater monitoring results for the following areas in Quadrant IV that require groundwater monitoring: X-611A Former Lime Sludge Lagoons, X-735 Landfills, X-734 Landfills, and X-533 Switchyard Area (a deferred unit).

3.3 WASTE MANAGEMENT PROGRAM

The DOE PORTS Waste Management Program directs the safe storage, treatment, and disposal of waste generated by past and present operations and from current Environmental Restoration projects. DOE PORTS also stores USEC-generated waste in the RCRA Part B permitted storage areas. Waste managed under the program is divided into the following seven categories, which are defined below:

- *Low-level radioactive waste* – radioactive waste not classified as high level or transuranic waste.

- *Hazardous (RCRA) waste* – waste that contains one or more of the wastes listed under RCRA or 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 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.

- *Subtitle D 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 low-level radioactive waste).

In 2006, more than 15.5 million pounds of waste from PORTS were recycled, treated, or disposed at off-site facilities (see Table 3.2). Future waste management projects include continuing shipments for disposal of low-level radioactive waste and mixed waste, and the treatment of mixed and PCB/mixed waste at off-site commercial facilities.

Waste management requirements are varied and are sometimes complex because of the variety of waste streams generated by DOE PORTS activities. DOE Orders, Ohio EPA regulations, and U.S. EPA regulations must be satisfied to demonstrate compliance for 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.

3.4 WASTE MINIMIZATION AND POLLUTION PREVENTION PROGRAM

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

Table 3.2. Waste Management Program off-site treatment, disposal, and recycling accomplishments for 2006

Waste type	Waste stream	Quantity (pounds)	Treatment, disposal, or recycling facility
RCRA	Aerosol cans, waste paints, thinners, solvents, and other wastes	3755	Veolia Environmental Services
LLW[a]	Waste oils and other wastes	7849	Diversified Scientific Solutions
LLW	Sludge, empty drums, scrap metal, unused chemicals, burnables, and other wastes	2,233,439	Energy Solutions
LLW	Scrap metals from former Gaseous Centrifuge Enrichment Plant (GCEP) and alumina waste	10,673,882	Nevada Test Site
LLW	Various chemicals, cleaners, and other solutions	9292	PermaFix
LLW	Wooden and plastic pallets, plastic pipe	203,686	Race LLC
PCB	Lubricating oils	107,452	TSCA incinerator
PCB/LLW	Capacitors and other solids	39,891	Materials & Energy Corp
PCB/LLW	Light ballasts, scrap metal, plastics, rags, sludges, and other solids	552,860	Energy Solutions
PCB/LLW	Transformer	32,447	Environmental Protection Services
PCB/LLW	Floor sweepings, gravel, and other solids	13,138	PermaFix
PCB/LLW/ RCRA	Burnables, ballasts, metals, plastics, and other solids, liquids, and sludges	141,776	Energy Solutions
PCB/LLW/ RCRA	Lab wastes and other solid materials	1426	Materials & Energy Corp
PCB/LLW/ RCRA	Waste oil/solvents/water solutions	41,317	TSCA incinerator
PCB/LLW/ RCRA	Scrap metals, aerosol cans, and other debris	5710	PermaFix
RCRA/LLW	Solvents, lab wastes, diesel fuel, activated carbon, and other wastes	113,215	Diversified Scientific Solutions
RCRA/LLW	Labpacks, chemicals, and other solids	419,062	Materials & Energy Corp

Table 3.2. Waste Management Program off-site treatment, disposal, and recycling accomplishments for 2006 (continued)

Waste type	Waste stream	Quantity (pounds)	Treatment, disposal, or recycling facility
RCRA/LLW	Scrap metal, GCEP wastes, burnables, clean-up materials, and other solids, liquids, and sludges	752,286	Energy Solutions
RCRA/LLW	Liquids and solids contaminated with metals and solvents, flammable liquids, and waste paint/paint sludge	145,835	PermaFix
Industrial waste	Recyclable circuit boards	406	Veolia
Industrial waste	Cleaning solutions and solids, sample returns, rags, and other waste	848	Energy Solutions
Industrial waste	Insulation containing non-friable asbestos	9000	Pike County Landfill
Industrial waste	Roofing, concrete, metal, and other debris from demolition of X-106B, X-615, and X-616 facilities	49,862 (estimated cubic feet)	Pike County Landfill

[a]Low-level radioactive waste.

is described in the *Environmental Sustainability Plan* and integrates the tenets of an environmental management system. The PORTS Environmental Sustainability Program includes elements of pollution prevention, waste minimization, affirmative procurement, sustainable design, and energy and water efficiency.

DOE PORTS 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 PORTS projects and activities.

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

- 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.

Highlights of the DOE PORTS Environmental Sustainability Program in fiscal year 2006 include the following accomplishments:

- recycling approximately 6460 pounds of office and mixed paper, 6400 pounds of cardboard, and 507 pounds of aluminum cans;

- recycling approximately 129,191 pounds of scrap metal (iron/steel) and 353 pounds of plastic;

- recycling universal wastes such as batteries and fluorescent light tubes;

- procuring 60% of toner cartridges that are reconditioned or remanufactured (used cartridges that have been restored to original factory specification);

- providing approximately 465 gallons of excess paint to the local Boy Scouts for their use; and

- beginning use of 80/20 biodiesel in on-site tractors and mowers.

In addition, DOE PORTS established and administered energy reduction programs focused on accomplishing the goals of Executive Order 13123, *Greening the Government through Efficient Energy Management*, and DOE Order 430.2A, *Departmental Energy and Utilities Management*. An audit of a large DOE office building resulted in the installation of a lighting control system to automatically switch off lights after hours and on weekends, which is expected to reduce electrical usage by approximately 140,000 kilowatt hours and save approximately $11,200. Photocells were installed at the loading dock to switch exterior lights off during daylight hours and timers were installed on two 500-gallon water heaters to turn off the water heaters when the building is unoccupied. The boilers for the Recirculating Heating Water System that heats DOE buildings were shut down from June through September saving $174,000 in natural gas costs and reducing greenhouse gas emissions by nearly 2 million pounds. These energy conservation measures and others were submitted for the DOE Best-in-Class Pollution Prevention Award and White House Closing the Circle Award.

3.5 INACTIVE FACILITIES REMOVAL

DOE began demolition of a number of inactive, surplus PORTS facilities during 2006. Table 3.3 lists the facilities removed during 2006.

Table 3.3 Inactive facilities removed from DOE PORTS in 2006

Facility	Location (Quadrant)
X-230J8 Environmental Storage Building	I
X-230J1 Environmental Monitoring Station	II
X-701D Water Deionization Building	II
X-720A Maintenance & Stores Gas Manifold Shed	II
X-105 Electronic Maintenance Building	II
X-740 Waste Oil Storage Facility	III
X-106B Old Fire Training Building	III
X-616 Liquid Effluent Control Facility	III
X-615 Old Sewage Treatment Plant	III
X-344C Hydrogen Fluoride Storage Building	IV
X-344E Gas Ventilation Stack	IV
X-344F Safety Building	IV
X-342C Waste Hydrogen Fluoride Neutralization Pit	IV

3.6 ENVIRONMENTAL TRAINING PROGRAM

DOE PORTS provides environmental training to increase employee awareness of environmental activities and to enhance the knowledge and qualifications of personnel performing tasks associated with environmental assessment, planning, and restoration. The program includes on- and off-site classroom instruction, on-the-job training, seminars, and specialized workshops and courses. Environmental training conducted or prepared by DOE PORTS includes hazardous waste training required by RCRA and numerous Occupational Safety and Health Administration training requirements.

3.7 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.

DOE PORTS opened a public Environmental Information Center in February 1993 to provide public access to all documents used to make decisions on remedial actions being taken at the plant. The Information Center is located just north of PORTS at the Ohio State University Endeavor Center (Room 220), 1862 Shyville Road, Piketon, Ohio 45661. The email address is eic@falcon1.net. 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 or email eic@falcon1.net). The latest Annual Environmental Report and other information can also be obtained from the PORTS web site at www.lpports.com.

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. The *Portsmouth Environmental Bulletin* is distributed to more than 4,000 recipients, including those on the community relations mailing list, neighbors within 2 miles of the plant, plant employees, and plant retirees.

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 LPP Office of Public Affairs (740-897-2336) also provides information on the program.

4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

4.1 SUMMARY

Environmental monitoring at PORTS includes air, water, soil, sediment, and biota (animals, vegetation, and crops) as well as measurement of both radiological and chemical parameters. 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 2006, environmental monitoring information was collected by both the DOE and USEC. Unlike other chapters of this report that focus on DOE activities at PORTS, this chapter includes monitoring information collected by USEC.

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. The U.S. EPA sets a 10 mrem/year limit for the dose from radionuclides released to the air, and the DOE sets a 100 mrem/year limit for the dose from radionuclides from all potential pathways. A person living in southern Ohio receives a dose of approximately 300 mrem/year from natural sources of radiation.

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 direct radiation, and from radionuclides detected in 2006 by environmental monitoring programs for sediment, soil, crops, and dairy products (milk and eggs). The maximum dose a member of the public could receive from radiation released by PORTS in 2006 (both the DOE and USEC) or detected by environmental monitoring programs in 2006 is 4.6 mrem/year. This dose calculation uses a worst-case approach; that is, the calculation assumes that the same individual is exposed to the most extreme conditions from each pathway. Table 4.1 summarizes this dose information.

Table 4.1. Summary of potential doses to the public from PORTS in 2006

Source of dose	Dose (mrem)/year[a]
Airborne radionuclides	0.017
Radionuclides released to the Scioto River	0.025
Direct radiation from depleted uranium cylinder storage yards	1.2
Radionuclides detected by environmental monitoring programs (sediment, soil, crops, milk, and eggs)	3.4
Total	4.6

[a]100 mrem/year is the DOE limit.

4.2 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 impacts 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 DOE PORTS such as limitations on discharges to air and water. DOE Orders 231.1A, *Environment Safety and Health Reporting*, and 5400.5, *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 PORTS. 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 total 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 during the Cold War.

Environmental monitoring data are collected by both the DOE and USEC. Because USEC data are important in developing a complete picture of environmental monitoring at PORTS, these data are included in this report. This chapter provides information on the USEC NPDES monitoring program. USEC data are provided for informational purposes only; the DOE cannot certify the accuracy of USEC data.

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

- Airborne discharges,
- Ambient air,
- Radiation,
- Discharges to surface water,
- Surface water,
- Sediment,
- Soil,
- Vegetation, and
- Biota.

The 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 Portsmouth area receives a dose of approximately 300 mrem/year from sources of natural radiation. 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 the U.S. EPA and the DOE. Airborne releases of radionuclides from DOE facilities are regulated by the U.S. EPA under the Clean Air Act and the National Emission Standards for Hazardous Air Pollutants. These regulations set an annual dose limit of 10 mrem/year to any member of the public as a result of airborne radiological releases.

The DOE regulates radionuclide emissions to all environmental media through DOE Orders 450.1, *Environmental Protection Program*, and 5400.5, *Radiation Protection of the Public and the Environment.* DOE Order 5400.5 sets an annual dose limit of 100 mrem/year to any member of the public from all radionuclide releases from a facility. The National Emission Standards for Hazardous Air Pollutants apply only to airborne radiological releases.

Small quantities of radionuclides were released to the environment from DOE PORTS operations during 2006. 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 2006 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 direct external radiation emanating from buildings or other objects. For 2006, doses are estimated for exposure to atmospheric releases, direct radiation, and releases to surface water (the Scioto River).

Doses are also estimated for exposure to radionuclides from PORTS operations that were detected in 2006 as part of the DOE PORTS environmental monitoring programs. 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 usually completed based on the monitoring data. In 2006, doses are estimated for exposure to radionuclides detected by the monitoring programs for sediment, soil, crops, milk, and eggs. Exposure to radionuclides detected in groundwater at PORTS is not included because contaminated groundwater at PORTS is not a source of drinking water.

In addition, DOE Order 5400.5 sets an absorbed dose rate limit of 1 rad per day to native aquatic organisms. This chapter discusses the dose calculations completed to demonstrate compliance with this requirement.

DOE PORTS workers and visitors 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 natural 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 rarely detected at PORTS but may be included as a conservative measure in the calculations used to determine the potential dose received from PORTS operations.

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. Absorbed dose is measured in units of rad (or gray) (1 rad = 0.01 gray).

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

- *Effective dose equivalent* – the sum of the dose equivalents received by all organs or tissues of the body after each one has been multiplied by an appropriate weighting factor. In this report, the term "effective dose equivalent" is often shortened to "dose."

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

4.3.2 Airborne Emissions

Airborne discharges of radionuclides from PORTS are regulated under the Clean Air Act National Emission Standards for Hazardous Air Pollutants. Releases of radionuclides are used to calculate a dose to members of the public. Section 4.3.3 discusses the results of this dose calculation.

USEC is responsible for most of the sources that emit radionuclides, although the gaseous diffusion uranium enrichment process is not operating. USEC emissions currently result from reprocessing of uranium hexafluoride feedstock, equipment decontamination, and the Lead Cascade (the demonstration centrifuge for uranium enrichment). In 2006, USEC reported emissions of 0.0268 curie (a measure of radioactivity) from its radionuclide emission sources.

DOE PORTS is responsible for six radiological emission sources. Two of these sources, X-326 L-cage Glove Box and X-744G Glove Box are used to repackage wastes or other materials that contain radionuclides. The X-326 L-Cage Glove Box was used in 2006, but the X-744G Glove Box was not (it was removed from service in 2005). The remaining four sources, the X-622, X-623, X-624, and X-627 Groundwater Treatment Facilities, treat groundwater contaminated with radionuclides. Emissions from the X-622 and X-627 Groundwater Treatment Facilities are based on the maximum concentrations of

radionuclides emitted from the facilities during emissions testing and the number of hours each facility operated during the year. Emissions from the X-623 and X-624 Groundwater Treatment Facilities were calculated based on influent and effluent sampling at each facility and annual throughput. Emissions from the X-326 Glove Box were based on the mass of the materials transferred within the glove box, analytical data available for each material, and emission factors provided by U.S. EPA. Emissions for 2006 were calculated to be 0.00063 curie.

4.3.3 Dose Calculation Based on Airborne Emissions

A dose calculation for atmospheric, or airborne, radionuclides is required by the U.S. EPA under the program called the National Emission Standards for Hazardous Air Pollutants. The effect of radionuclides released to the atmosphere by DOE PORTS during 2006 was characterized by calculating effective dose equivalents to the maximally exposed person (the individual who resides at the most exposed point near the plant) and to the entire population (approximately 600,000 residents) within 50 miles of the plant. Dose calculations were made using a computer program called CAP88 (Beres 1990), which was developed under sponsorship of the U.S. EPA for use in demonstrating compliance with the National Emission Standards for Hazardous Air Pollutants for radionuclides. The program uses models to calculate concentrations of radionuclides in the air and on the ground and in foodstuffs (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 the four DOE PORTS groundwater treatment facilities and the X-326 L-cage Glove Box as 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 National Emission Standards for Hazardous Air Pollutants 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 DOE PORTS. These assumptions most likely result in a significant 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 DOE air emission sources at PORTS in 2006 was 0.012 mrem/year. USEC also completes the dose calculations described above for the air emission sources leased to USEC (e.g., the uranium enrichment facilities and other sources). The combined dose from USEC and DOE sources is 0.017 mrem/year, well below the 10-mrem/year limit applicable to PORTS and the approximate 300-mrem/year dose that the average individual in the United States receives from natural sources of radiation.

The collective dose equivalent (or population dose) to the entire population within 50 miles of PORTS was 0.067 person-rem/year, based on USEC calculations of 0.014 person-rem/year from USEC sources and 0.053 person-rem/year from DOE sources. The population dose to the nearest community, Piketon, was calculated to be 0.023 person-rem/year, based on USEC calculations of 0.0037 person-rem/year from USEC sources and 0.0195 person-rem/year from DOE sources.

4.3.4 Dose Calculation Based on Ambient Air Monitoring

The 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, uranium-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 the DOE and USEC 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 concentration of each radionuclide in air. The following assumptions were made to calculate the dose at each station: (1) the highest concentration of each radionuclide detected in 2006 was assumed to be present for the entire year; or (2) if a radionuclide was not detected, the radionuclide was assumed to be present at half the detection limit for the analytical method.

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 ranged from 0 (at stations with a gross dose less than the background station) to 0.00063 mrem/year at station A36, which is on site at the X-611 Water Treatment Plant.

The highest net dose measured at the ambient air monitoring stations (0.00063 mrem/year) is approximately 4% of the dose calculated from the combined DOE and USEC point source emissions (0.017 mrem/year). This dose is significantly less than the 10 mrem/year NESHAP limit for airborne radiological releases and 100 mrem/year DOE limit for all radiological releases from a facility.

4.3.5 Discharges of Radionuclides from NPDES Outfalls

DOE contractors and USEC are responsible for NPDES outfalls at PORTS. This section describes these outfalls and the discharges of radionuclides from these outfalls during 2006.

4.3.5.1 DOE outfalls

The responsible DOE contractor holds the NPDES permit for NPDES outfalls associated with DOE activities. DOE PORTS has eight discharge points, or outfalls, through which water is discharged from the site (see Figure 4.2). Three outfalls discharge directly to surface water, four discharge to the USEC X-6619 Sewage Treatment Plant (USEC NPDES Outfall 003), and one discharges to the X-2230M Holding Pond (DOE Outfall 012). Outfall 612 is currently inactive because the X-625 Groundwater Treatment Facility was placed on stand-by with the approval of the Ohio EPA in July 2003. A brief description of each DOE outfall at PORTS follows.

DOE NPDES Outfall 012 (X-2230M Holding Pond) – The X-2230M Holding Pond accumulates treated water from DOE NPDES Outfall 612 and precipitation runoff, non-contact cooling water, and steam condensate from the southern 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.

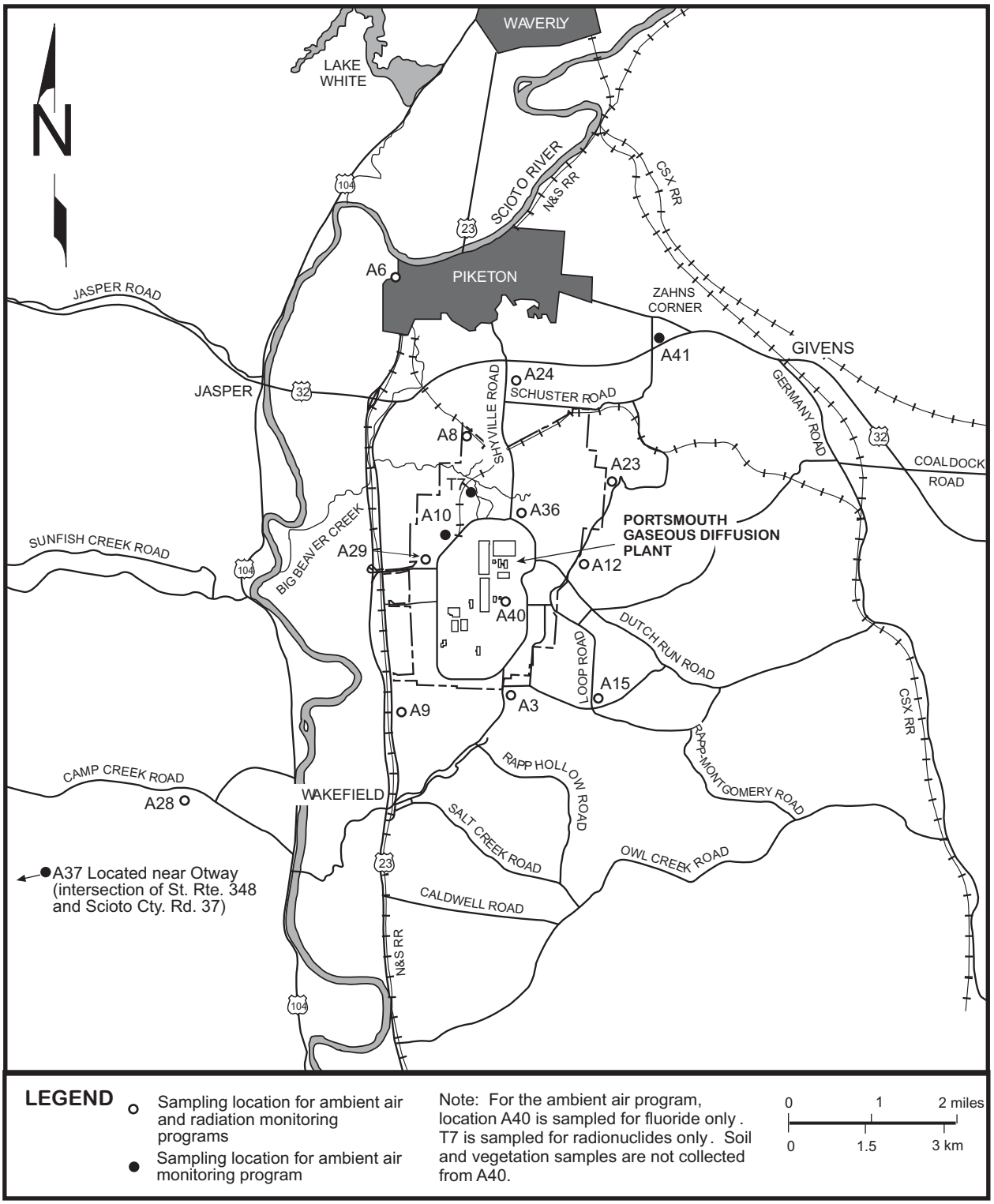

Figure 4.1. DOE ambient air and radiation monitoring locations.

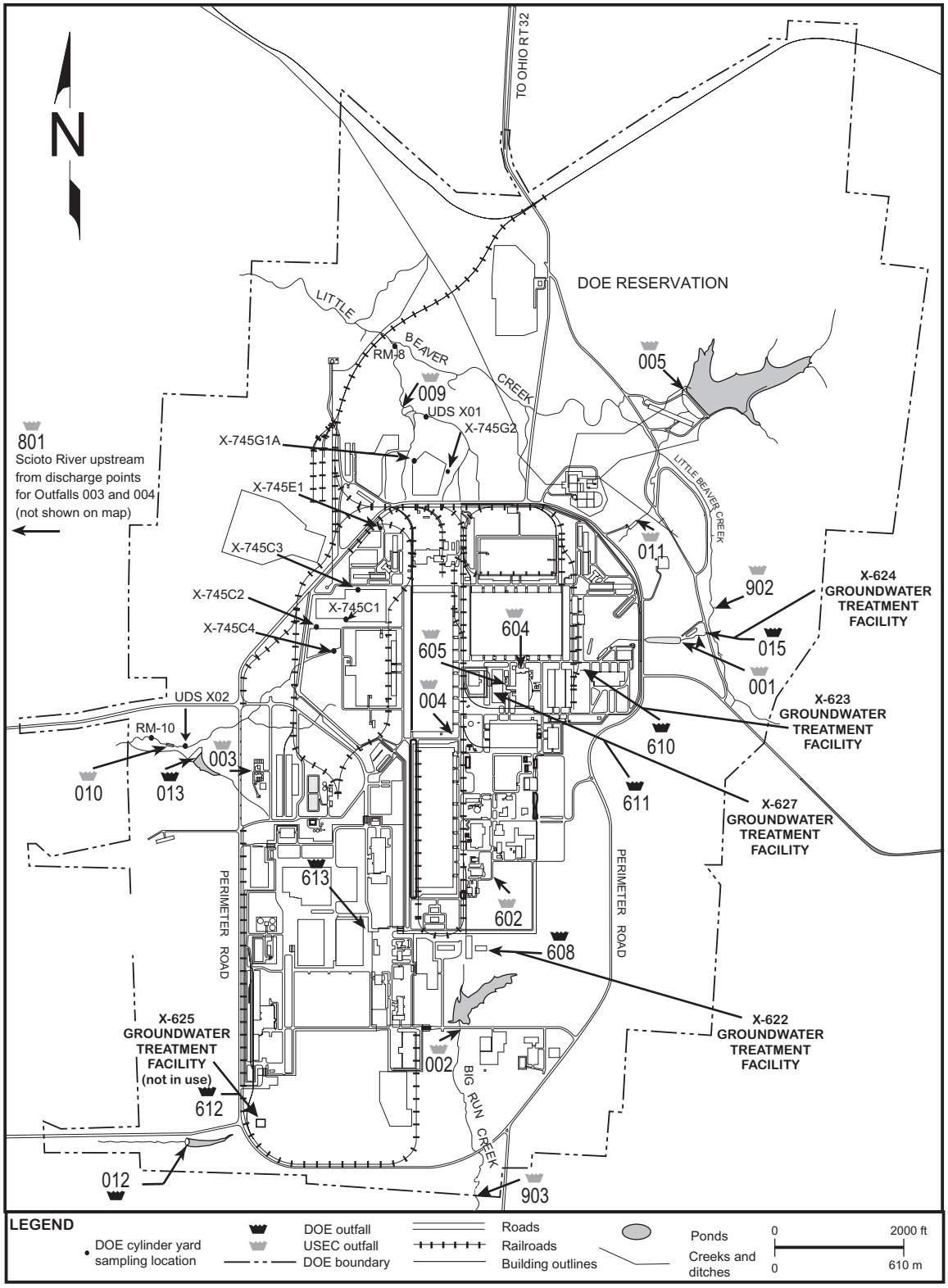

Figure 4.2. DOE and USEC NPDES outfalls/monitoring points and DOE cylinder storage yards sampling locations.

DOE NPDES Outfall 013 (X-2230N Holding Pond) – The X-2230N 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 the West Ditch, which flows to the Scioto River.

DOE NPDES Outfall 015 (X-624 Groundwater Treatment Facility) – The X-624 Groundwater Treatment Facility removes volatile organic compounds from contaminated groundwater originating from the X-701B plume interceptor trenches. These groundwater interceptor trenches were constructed to control the migration of volatile organic compound-contaminated groundwater toward Little Beaver Creek. Treated water is released to a ditch that flows to Little Beaver Creek.

DOE NPDES Outfall 608 (X-622 Groundwater Treatment Facility) – The X-622 Groundwater Treatment Facility removes volatile organic compounds 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 3.2). Treated water is discharged to the sanitary sewer and then through USEC NPDES Outfall 003.

DOE NPDES Outfall 610 (X-623 Groundwater Treatment Facility) – The X-623 Groundwater Treatment Facility removes volatile organic compounds from contaminated groundwater originating from site remediation activities in the X-701B Holding Pond area in Quadrant II and from miscellaneous well development and purge waters. Treated water is discharged to the sanitary sewer and then through USEC NPDES Outfall 003.

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

DOE NPDES Outfall 612 (X-625 Groundwater Treatment Facility) – On July 9, 2003, the X-625 Groundwater Treatment Facility was placed on stand-by with approval from the Ohio EPA. This facility removed volatile organic compounds from groundwater collected by the horizontal well in the western portion of the X-749/X-120 groundwater plume. Treated water was discharged to the X-2230M Holding Pond that discharges through DOE NPDES Outfall 012.

DOE 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 DOE buildings at PORTS. Treated water is discharged to the sanitary sewer and then through USEC NPDES Outfall 003.

When in use, DOE contractors monitor the NPDES outfalls for radiological discharges by collecting water samples and analyzing the samples for total uranium, uranium isotopes (uranium-233/234, uranium-235, uranium-236, and uranium-238), technetium-99, and transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), with the exception of Outfall 613. Outfall 613 is not monitored for radionuclides because no source exists for radiological contamination of the water discharged from Outfall 613.

Discharges of radionuclides in liquids through DOE NPDES outfalls have no significant impact on public health and the environment. Uranium discharges in 2006 from external DOE NPDES outfalls (Outfalls 012, 013, and 015) were estimated at 0.68 kilogram. Total radioactivity released from the external outfalls was 0.00055 curie of uranium isotopes.

Discharges of radionuclides were calculated using monthly monitoring data from the DOE NPDES outfalls. Analytical results below the detection limit were assigned a value of zero in the calculations to determine the quantities of uranium and radiation discharged through the DOE NPDES outfalls. Discharges of radionuclides from external DOE 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 for all radiological releases from a facility.

No technetium-99 or transuranics (americium-241, neptunium-237, plutonium-238, and plutonium-239/240) were detected in samples collected from the DOE external NPDES outfalls during 2006.

4.3.5.2 USEC outfalls

USEC is responsible for 11 NPDES outfalls through which water is discharged from the site (see Figure 4.2). Eight outfalls discharge directly to surface water, and three discharge to another USEC NPDES outfall before leaving the site. A brief description of each USEC NPDES outfall follows.

USEC 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, and oil can be diverted and contained. Water from this holding pond is discharged to a ditch that flows to Little Beaver Creek.

USEC NPDES Outfall 002 (X-230K South Holding Pond) – The X-230K South Holding Pond receives non-contact cooling water, steam condensate, foundation drainage, treated coal pile runoff, 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.

USEC NPDES Outfall 003 (X-6619 Sewage Treatment Plant) – The X-6619 Sewage Treatment Plant treats PORTS sewage 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 chlorination to treat wastewater prior to release to the Scioto River.

USEC NPDES Outfall 004 (Cooling Tower Blowdown) – Outfall 004 was relocated in 2000 to the junction of Pike Avenue and 15th Avenue at PORTS. It monitors blowdown water from various cooling towers on site prior to discharge to the Scioto River.

USEC 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 rainfall.

USEC 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, and oil can be contained. Water from this holding pond is discharged to an unnamed stream that flows to Little Beaver Creek.

USEC 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, and oil can be diverted and contained. Water from this holding pond is discharged to the West Ditch, which flows to the Scioto River.

USEC 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, and oil can be diverted and contained. Water from this holding pond is discharged to an unnamed stream that flows to Little Beaver Creek.

USEC NPDES Outfall 602 (X-621 Coal Pile Runoff Treatment Facility) – The X-621 Coal Pile Runoff Treatment Facility treats storm water runoff from the coal pile at the X-600 Steam Plant. The treated water is discharged to the X-230K South Holding Pond (USEC NPDES Outfall 002).

USEC 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 (USEC NPDES Outfall 003).

USEC 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 (USEC NPDES Outfall 003).

In 2006, USEC also monitored three additional monitoring points that are not discharge points as described in the previous paragraphs. USEC NPDES Station Number 801 is a background monitoring location on the Scioto River upstream from USEC NPDES Outfalls 003 and 004. USEC NPDES Station Number 902 is a monitoring location on Little Beaver Creek downstream from USEC NPDES Outfall 001, and USEC NPDES Station Number 903 is a monitoring location on Big Run Creek downstream from USEC NPDES Outfall 002.

Uranium discharges in 2006 from external USEC NPDES outfalls (Outfalls 001, 002, 003, 004, 005, 009, 010, and 011) were estimated at 10.4 kilograms. Radioactivity released from the external outfalls was 0.04 curie of technetium-99. These values were calculated using quarterly discharge monitoring reports for the USEC NPDES outfalls. Analytical results below the detection limit were assigned a value of zero in the calculations to determine the quantities of uranium and radiation (technetium-99) discharged through the USEC NPDES outfalls. Transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240) were not detected in any of the samples collected from USEC NPDES outfalls in 2006.

Discharges of radionuclides from external USEC 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 for all radiological releases from a facility.

4.3.6 Dose Calculation for Releases to Surface Water

Radionuclides are measured at the DOE and USEC NPDES external outfalls (three DOE outfalls and eight USEC 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 average annual flow rate of the Scioto River.

Total uranium mass [in micrograms per liter (μg/L)] and activity [in picocuries per liter (pCi/L)] for americium-241, neptunium-237, plutonium-238, plutonium-239/240, and technetium-99 were measured in the water discharged from the DOE or USEC outfalls. As a conservative measure, radionuclides that were not detected were assumed to be present at the detection limit. Total uranium 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 recent years. The maximum individual dose was calculated using the above-mentioned measured radionuclide discharges from the plant outfalls and the average annual flow rate of the Scioto River. All discharge radioactivity levels were expressed in total activity per year (curie/year) and used along with the average river flow to calculate radioactivity per volume.

The dose calculations were derived from the procedures developed for a similar DOE facility: *LADTAPXL: An Improved Electronic Spreadsheet Version of LADTAP II* (Hamby 1991). Environmental pathways considered were ingestion of water, ingestion of fish, swimming, boating, and shoreline activities. The calculations assume that a person eats 21 kilograms (46 pounds) of fish caught in the Scioto River, drinks 730 liters (190 gallons) of river water, swims for 27 hours, boats for 105 hours, and occupies the shoreline for 69 hours during the year. Based on the calculations across all isotopes found in the outfalls, this individual could receive an annual dose of about 0.025 mrem. This exposure scenario is very conservative because the Scioto River is not used for drinking water downstream of PORTS (91% of the hypothetical dose from liquid effluents is from drinking water) and it is unlikely that a person would eat 46 pounds of fish from the river (6% of the hypothetical dose). This dose (0.025 mrem) is significantly less than the 100 mrem/year DOE limit for all radiological releases from a facility.

4.3.7 Radiological Dose Calculation for Direct Radiation

The DOE PORTS Radiological Protection Organization monitors direct radiation levels in active DOE PORTS facilities 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 PORTS activities.

Due to increased security at PORTS following September 11, 2001, the general public no longer has uncontrolled access to the entire perimeter of the PORTS facility (Perimeter Road). Some portions of Perimeter Road were reopened to the public in 2005; however, other portions of the road remain closed to the general public. Perimeter Road passes close to the edge of the cylinder yards, which emit radiation from depleted uranium cylinders stored in these areas. This portion of Perimeter Road remains closed to the public; however certain members of the public, such as delivery people, are allowed on this portion of the road. Therefore, data from direct radiation monitoring at the cylinder yards are used to assess potential exposure to the members of the public that drive on Perimeter Road.

In 2006, the average effective dose equivalent recorded at the cylinder yards near Perimeter Road was 1155 mrem/year, based on exposure to ionizing radiation for an entire year (i.e., 24 hours/day, 7 days/week, 52 weeks/year - 8,736 hours/year). The radiological exposure to members of the general

public is estimated as the time that a person drives on Perimeter Road past the cylinder yards, which is conservatively 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).

Based on these assumptions, exposure to a member of the public from radiation from the cylinder yards is approximately 1.2 mrem/year. The average yearly dose to a person in the United States is approximately 366 mrem: 300 mrem from natural radiation sources and 66 mrem from manmade radiation sources (see Appendix A). The potential estimated dose from the cylinder yards to a member of the public is approximately 0.4 percent of the average yearly radiation exposure for a person in the United States and is significantly less than the 100 mrem/year DOE limit for all radiological releases from a facility.

4.3.8 Radiological Dose Results for DOE PORTS Workers and Visitors

The Radiation Exposure Information Reporting System report is an electronic file created annually to comply with DOE Order 231.1A. This report contains exposure results for all monitored individuals at DOE PORTS, including visitors, with a positive exposure during the previous calendar year. The 2006 Radiation Exposure Information Reporting System report indicated that there were no visitors with a positive exposure.

Over 400 DOE PORTS workers were monitored during 2006. Of these workers, only 46 received a measurable dose (defined as 10 mrem or more). Seventeen cylinder yard workers received a measurable dose that averaged 70 mrem. Twenty-nine other DOE PORTS workers received a measurable dose that averaged 18 mrem.

No administrative guidelines or regulatory dose limits were exceeded in 2006.

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. 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. Detections of technetium-99 and transuranics most likely result from activities at PORTS.

The DOE sets a limit of 100 mrem/year 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 detections of radionuclides in environmental media (residential drinking water [well water], sediment, soil, and vegetation) and biota (deer, fish, crops, and dairy products) at off-site sampling locations. Detections of radionuclides on the PORTS facility are not used to assess risk because the public does not have access to the facility. This dose calculation uses a worst-case approach; that is, the calculation assumes that the same individual is exposed to the most extreme conditions from each pathway.

In 2006, dose calculations were completed for public exposure to radionuclides detected in sediment, soil, crops, milk, and eggs. Radionuclides were not detected in fish samples collected during 2006, and deer were not sampled in 2006 (no radionuclides were detected in the deer sampled during 2005). Chapter 6, Section 6.4.13, provides additional information concerning detections of radionuclides in residential drinking water.

The following sections provide brief descriptions of the dose calculations for each monitoring program. Methodologies used to complete each risk calculation are based on information developed and approved by the U.S. EPA including the *Exposure Factors Handbook* (U.S. EPA 1997) and *Internal Dose Conversion Factors for Calculation of Dose to the Public* (DOE 1988). 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 2006 are significantly less than the DOE limit of 100 mrem/year.

Table 4.2. Summary of potential doses to the public from radionuclides detected by PORTS environmental monitoring programs in 2006

Source of dose	Dose (mrem/year)[a]
Sediment	0.055
Soil	0.077
Crops	0.005
Milk	3.2
Eggs	0.09
Total	3.4

[a]100 mrem/year is the DOE limit.

4.3.9.1 Dose calculation for sediment

The dose calculation for sediment is based on the detection of 9.47 picocuries per gram (pCi/g) of technetium-99, 4.73 pCi/g of uranium-233/234, 0.181 pCi/g of uranium-235, 0.0543 pCi/g of uranium-236, and 1.33 pCi/g of uranium-238 in the sediment sample collected in 2006 from monitoring location RM-13, an off-site sampling location on Big Beaver Creek downstream from PORTS. Based on exposure factors from 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 0.055 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 detection of 0.921 pCi/g of uranium-233/234 and 1.26 pCi/g of uranium-238 at the ambient air sampling station along the northeastern boundary of PORTS (A23). Based on exposure factors from 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 0.077 mrem/year. Section 4.6.7 provides additional information on the soil monitoring program as well as a map of soil monitoring locations.

4.3.9.3 Dose calculation for crops

The dose calculation for crops is based on the detection of uranium-233/234 at 0.0921 pCi/g in a cucumber collected from off-site location #5. Based on exposure factors from U.S. EPA's *Exposure Factors Handbook* (U.S. EPA 1997), the dose that could be received by a person consuming this crop is 0.005 mrem/year. Section 4.6.9.2 provides additional information on this monitoring program.

4.3.9.4 Dose calculation for milk

The dose calculation for consumption of milk is based on detections of plutonium-239/240 at 0.585 pCi/L and technetium-99 at 1150 pCi/L in the regular sample of locally produced milk collected in December 2006 and detections of technetium-99 at 2650 pCi/L, uranium-233/234 at 0.206 pCi/L, and uranium-238 at 0.367 pCi/L in the duplicate sample collected at the same time. The dose that could be received from each of these samples was calculated based on exposure factors from U.S. EPA's *Exposure Factors Handbook* (U.S. EPA 1997). The two doses were then averaged to determine the dose that could be received by a person consuming milk throughout the year that contains radionuclides at these levels (3.2 mrem/year). Section 4.6.9.4 provides additional information on this monitoring program.

4.3.9.5 Dose calculation for eggs

The dose calculation for consumption of eggs is based on the detections of technetium-99 at 8800 and 8140 pCi/L in regular and duplicate samples of locally produced eggs collected in December 2006. The dose calculation uses the average (8470 pCi/L) of these sample results. Based on exposure factors from U.S. EPA's *Exposure Factors Handbook* (U.S. EPA 1997), the dose that could be received by a person consuming eggs throughout the year that contain technetium-99 at this level is 0.09 mrem/year. Section 4.6.9.4 provides additional information on this monitoring program.

4.4 PROTECTION OF BIOTA

DOE Order 5400.5 sets an absorbed dose rate of 1 rad/day to native aquatic organisms. The DOE Technical Standard *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2002) was used to demonstrate compliance with this limit.

Analytical data for radionuclides detected in sediment and water collected at approximately the same location are used to assess compliance with the 1 rad/day limit for aquatic organisms. Data used in the evaluation are sampling data collected at sampling location RW/RM-7, which are off-site surface water and sediment sampling locations just before Little Beaver Creek flows into Big Beaver Creek. Sections 4.6.4 and 4.6.5 provide more information about these sampling programs.

The maximum values of transuranic radionuclides, technetium-99, and uranium isotopes detected in sediment or surface water samples collected from these locations in 2006 were entered into the RESRAD-BIOTA program that is designed to implement the DOE Technical Standard (DOE 2002). The assessment indicates that the concentrations of radionuclides detected in water and sediment at this location do not result in a dose of more than 1 rad/day to aquatic organisms.

Although there are no formal DOE limits for the dose rate to terrestrial biota, it is recommended that DOE sites meet international limits for terrestrial biota that are 1 rad/day for terrestrial plants and 0.1 rad/day for terrestrial animals. Analytical data for surface water and soil collected from the northern side of the PORTS reservation (surface water sampling location NHP-SW01 and soil sampling location A8) were used to assess the dose recommendations for terrestrial plants and animals. These locations were selected because concentrations of uranium detected in surface water and soil from these locations were among the highest detected in samples collected in 2006. Chapter 6, Section 6.4.12 and Section 4.6.7, provide additional information for the surface water monitoring programs and soil sampling program, respectively.

Data for the highest concentrations of radionuclides detected at these locations in 2006 were entered into the RESRAD-BIOTA program that is designed to implement the DOE Technical Standard (DOE

2002). The assessment indicates that the concentrations of radionuclides detected in water and soil at this location do 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 DOE PORTS in 2006.

4.6 ENVIRONMENTAL RADIOLOGICAL MONITORING

This section discusses the radiological monitoring programs at PORTS: ambient air monitoring, environmental 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 USEC 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 concentrations of radionuclides (radionuclides that occur naturally, such as uranium). These radionuclides are isotopic uranium (uranium-233/234, uranium-235, uranium-236, and uranium-238), technetium-99, and selected transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240).

In 2006, samples were collected from 15 ambient air monitoring stations located within and around PORTS (see Section 4.3.4, Figure 4.1). A background ambient air monitoring station (A37) is located approximately 13 miles southwest of the plant. The analytical results from air sampling stations closer to the plant are compared to these background measurements.

In 2006, neptunium-237 was detected in the December sample collected from Station A29, which is on site near the Ohio Valley Electric Corporation. The ambient activity of neptunium-237 based on the sample detection was 0.000011 picocurie per cubic meter (pCi/m^3), which is well below the DOE derived concentration guide of 0.02 pCi/m^3. No other transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240) were detected in ambient air samples collected during 2006. Technetium-99 was detected in one or two samples collected from Stations A8, A10, A36, and T7 at a maximum ambient activity of 0.0032 pCi/m^3. This maximum ambient activity of 0.0032 pCi/m^3 is well below the DOE derived concentration guide of 2000 pCi/m^3.

Uranium-233/234 and uranium-238 were detected in each of the samples. The highest average activities of both uranium-233/234 (0.0004 pCi/m$^{3)}$ and uranium-238 (0.00036 pCi/m^3) were detected at Station A36, which is on site in the northeast portion of the facility, near the intersection of Shyville Road and Perimeter Road.

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 (0.000096 mrem/year) was at station A24, which is north of PORTS on Shyville Road. This hypothetical dose is well below the 10 mrem/year limit applicable to PORTS. Section 4.3.4 provides additional information about this dose calculation.

4.6.2 Environmental Radiation

Radiation is measured by the DOE at 19 locations that include most of the ambient air monitoring locations (see Section 4.3.4, Figure 4.1) and other on-site locations (see Figure 4.3). Measuring devices are placed at the monitoring locations at the beginning of each quarter, remain at the monitoring location throughout the quarter, and are removed from the monitoring location at the end of the quarter and sent to the laboratory for processing. Radiation is measured in millirems as a whole body dose, which is the dose that a person would receive if they were continuously present at the monitored location.

Three locations detected elevated levels of radiation in 2006: location #874, which monitors the X-745C Depleted Uranium Cylinder Storage Yard; location #862, which is south of the cylinder yards and west of the X-530A Switchyards; and location #933, which is east of the X-744G building in the X-701B Holding Pond groundwater monitoring area. The cumulative whole body dose calculated for each of the 16 locations excluding locations #874, #862, and #933 ranged from 67 to 96 mrem. The cumulative whole body doses at locations #874, #862, and #933 were 713 mrem, 122 mrem, and 140 mrem, respectively.

In addition, the dose resulting from radiation emanating from the DOE cylinder storage yards is measured at five locations around the northwest corner of PORTS just inside Perimeter Road (see Figure 4.3). These locations are not accessible to the general public. The cumulative annual whole body doses at locations #41 and #890 were 207 mrem and 181 mrem, respectively. Locations #874 and #882 recorded cumulative annual whole body doses of 675 mrem and 914 mrem, respectively, and location #868 recorded a cumulative annual whole body dose of 1518 mrem. 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 2006. Section 4.3.7 provides a dose calculation for members of the public, such as delivery people, that are allowed on the portion of Perimeter Road near the DOE cylinder storage yards. The potential estimated dose from the cylinder yards to a member of the public (1.2 mrem/year) is significantly less than DOE's 100 mrem/year dose limit to the public for radionuclides from all potential pathways.

4.6.3 Surface Water from DOE Cylinder Storage Yards

The Ohio EPA requires monthly collection of surface water samples from four locations: X-745C1 at the X-745C Depleted Uranium Hexafluoride Cylinder Storage Yards, X-745E1 at the X-745E Depleted Uranium Hexafluoride Cylinder Storage Yard, and X-745G1A and X-745G2 at the X-745G Depleted Uranium Hexafluoride Cylinder Storage Yard. The DOE voluntarily collects samples at three additional locations (X-745C2, X-745C3, and X-745C4). Figure 4.2 shows the sampling locations. Samples collected during 2006 were analyzed for total uranium, uranium isotopes (uranium-233/234, uranium-235, uranium-236, and uranium-238), technetium-99, and transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240).

During 2006, maximum detections of technetium-99, uranium, and uranium isotopes were as follows: technetium-99 at 9.17 pCi/L, uranium at 13.02 μg/L, uranium-233/234 at 5.241 pCi/L, uranium-235 at 0.2452 pCi/L, and uranium-238 at 5.981 pCi/L. Transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240) and uranium-236 were not detected in any of the samples collected in 2006. Surface water from the cylinder storage yards flows to USEC NPDES outfalls prior to discharge from the site; therefore, releases of radionuclides from the cylinder yards are monitored by sampling conducted at the USEC outfalls. Radionuclides detected at USEC outfalls (see Section 4.3.5.2) are used in the dose calculation for releases to surface water (see Section 4.3.6).

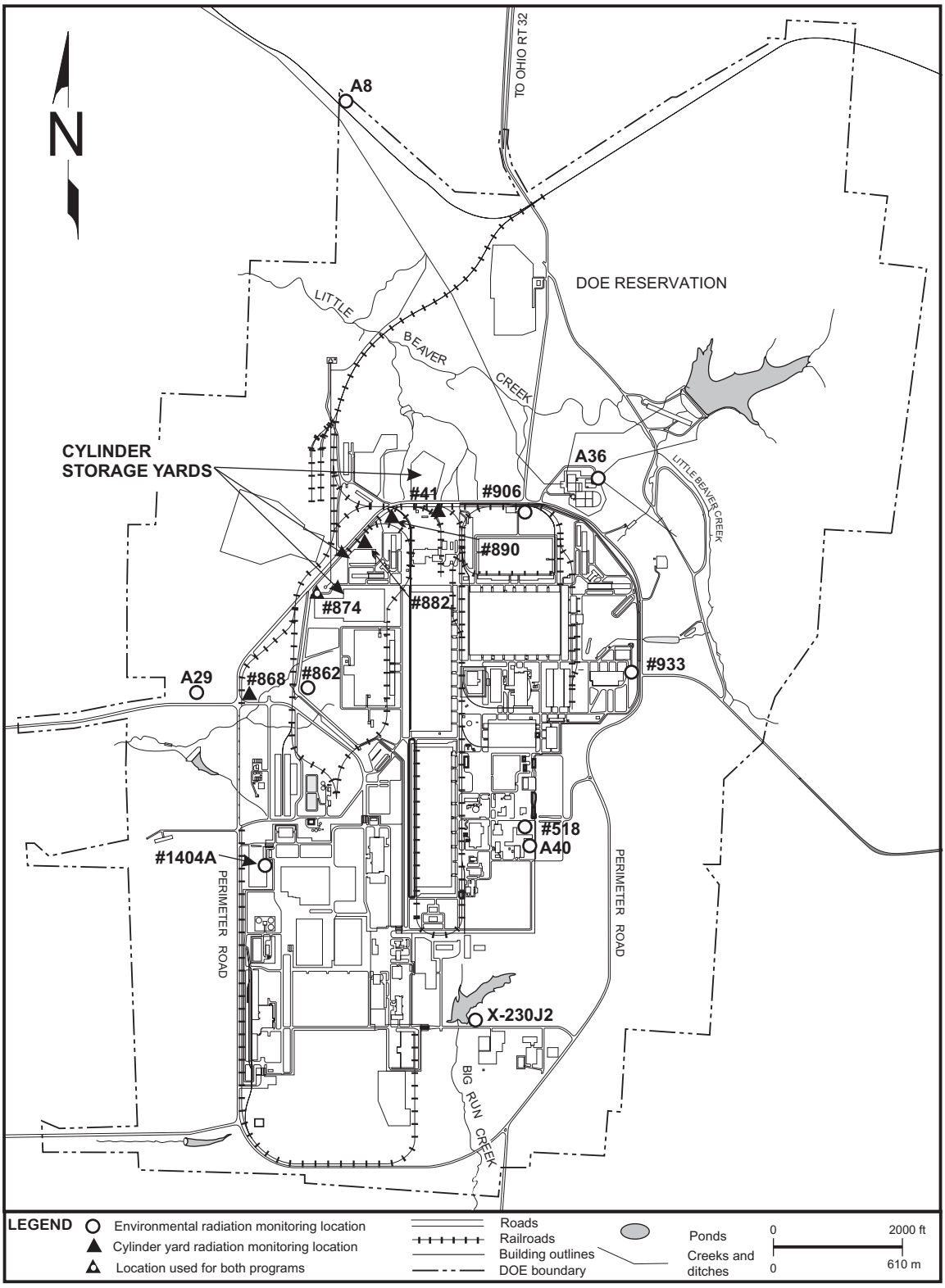

Figure 4.3. On-site radiation and cylinder yard dose monitoring locations.

4.6.4 Local Surface Water

In 2006, 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, total uranium, and uranium isotopes (uranium-233/234, uranium-235, uranium-236, and uranium-238) in accordance with the DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant*.

No transuranics were detected in any of the local surface water samples collected in 2006. Technetium-99 was detected in the fourth quarter samples collected from Little Beaver Creek sampling locations RW-7 and RW-8 at activities less than 9 pCi/L. These detections are considerably less than the DOE derived concentration guide for technetium-99 in drinking water (100,000 pCi/L).

Maximum detections of uranium and uranium isotopes in local surface water samples were detected at locations RW-1 (Scioto River downstream from PORTS), RW-8 (Little Beaver Creek), and RW-7 (Little Beaver Creek). Uranium was detected at 2.04 μg/L (RW-1), uranium-233/234 was detected at 2.09 pCi/L (RW-7), and uranium-238 was detected at 0.683 pCi/L (RW-1 and RW-8). Uranium-235 and uranium-236 were not detected in any of the local surface water samples collected in 2006. Detections of uranium and uranium isotopes in local surface water samples in 2006 remain well below the DOE derived concentration guide for the respective uranium isotope in drinking water (500 pCi/L for uranium-233/234 and 600 pCi/L for uranium-238).

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

Technetium-99 is often detected in sediment samples collected at locations downstream from PORTS. In 2006, technetium-99 was detected at 16 of the 17 sediment sampling locations including all four of the background locations. Technetium-99 activities at the background locations ranged from 0.305 to 0.577 pCi/g. Technetium-99 is not routinely detected at the background locations and is present in the environment only as a result of PORTS activities. It appears that many of the detections of technetium-99, especially those less than 1 pCi/g, may result from analytical interferences or errors. Technetium-99 at activities greater than 1 pCi/g was detected in samples collected from upstream and downstream locations on Big Beaver Creek (RM-5 and RM-13), downstream locations on Little Beaver Creek (RM-7 and RM-8), and a downstream location on Big Run Creek (RM-3). Detections of technetium-99 above 1 pCi/g are consistent with data from previous sampling events (2002 through 2005). Section 4.3.9.1 provides a dose assessment for a member of the public based on exposure to sediment. The potential estimated dose from sediment is significantly less than DOE's 100 mrem/year dose limit to the public for radionuclides from all potential pathways.

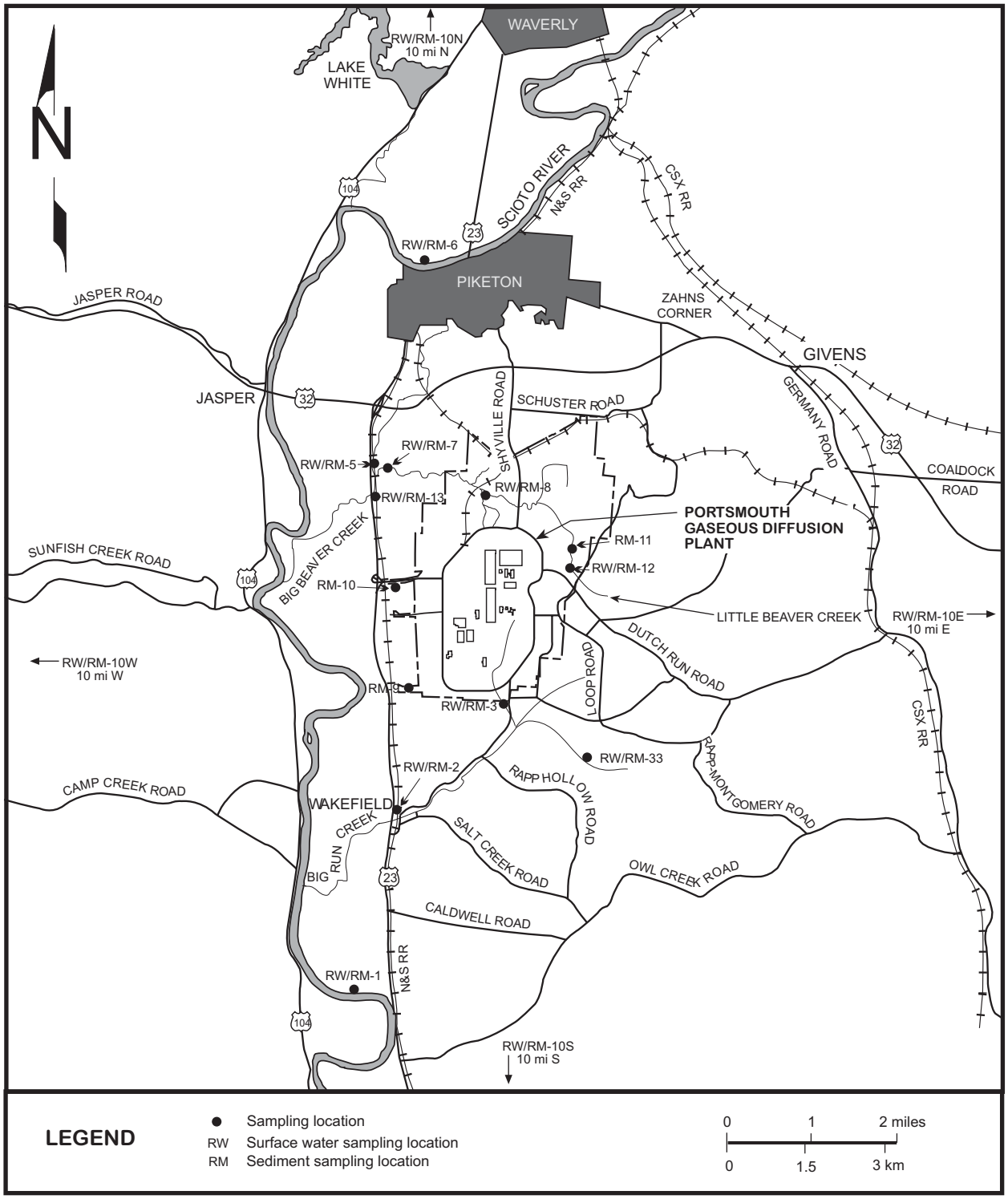

Figure 4.4. Local surface water/sediment monitoring locations.

Uranium and uranium isotopes are naturally occurring, but may also be present due to PORTS activities. Uranium and uranium isotopes detected in the 2006 samples have been detected at similar levels in previous sampling events from 1999 through 2005. Transuranics were not detected in any of the sediment samples collected in 2006.

Section 4.3.9.1 provides a dose assessment to a member of the public based on the highest detections of technetium-99 and uranium isotopes at the downstream sampling location on Big Beaver Creek (RM-13). This off-site sampling location had the highest levels of radionuclides detected in 2006: 9.47 pCi/g of technetium-99, 4.73 pCi/g of uranium-233/234, 0.181 pCi/g of uranium-235, 0.0543 pCi/g of uranium-236, and 1.33 pCi/g of uranium-238. The total potential dose to a member of the public resulting from PORTS operations (4.6 mrem/year), which includes this dose calculation (0.055 mrem/year), is well below the DOE standard of 100 mrem/year.

4.6.6 Settleable Solids

The DOE collects water samples from 11 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 5400.5, *Radiation Protection of the Public and the Environment*, Chapter II, paragraph 3a(4). This paragraph states:

> *To prevent the buildup of radionuclide concentrations in sediments, liquid process waste streams containing radioactive material in the form of settleable solids may be released to natural waterways if the concentration of radioactive material in the solids present in the waste stream does not exceed 5 pCi (0.2 becquerel) per gram above background level, of settleable solids for alpha-emitting radionuclides or 50 pCi (2 becquerels) per gram above background level, of settleable solids for beta-gamma-emitting radionuclides.*

The sampling locations consist of two background surface water locations (BG-SW01 and BG-US23), six surface water sampling locations (BRC-SW02, EDD-SW01, LBC-SW04, NHP-SW01, UND-SW02, and WDD-SW03), and three NPDES effluent locations (J6-SW01, X-616, and X-6619). Two samples are collected semiannually (June and December) from each monitoring location. One sample is analyzed for total suspended solids, total alpha activity, and total beta activity. The other sample is analyzed for non-settleable solids, total alpha activity, and total beta activity.

In 2006, the DOE standards (5 pCi/g for alpha activity and 50 pCi/g for beta activity) were not exceeded at any location.

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

Plutonium-239/240 was detected at 0.307 pCi/g in the soil sample collected on site at the X-611 Water Treatment Plant (ambient air station A36). Transuranics were not detected at any of the other sampling locations. Technetium-99 was not detected in any of the soil samples collected from the ambient air monitoring stations in 2006. Section 4.3.9.2 provides a dose assessment for a member of the public based on exposure to soil. The potential estimated dose from soil is significantly less than DOE's 100 mrem/year dose limit to the public for radionuclides from all potential pathways.

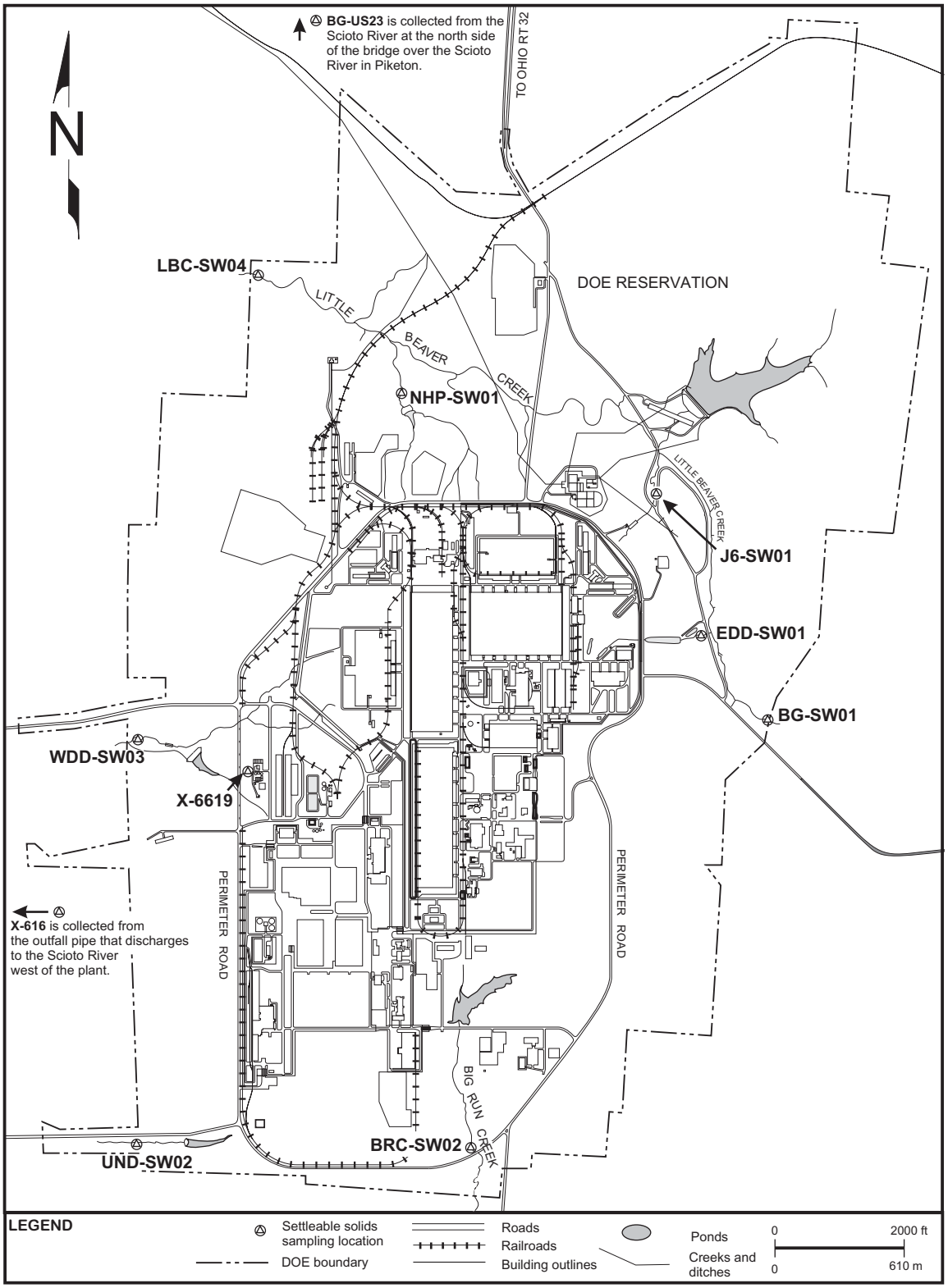

Figure 4.5. DOE settleable solids monitoring locations.

Uranium (total), uranium-233/234, and uranium-238 were detected at all of the sampling locations. Uranium-235 and uranium-236 were not detected in any of the soil samples collected in 2006. Uranium and uranium isotopes were detected at similar concentrations or activities 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 uranium-233/234 (0.912 pCi/g) and uranium-238 (1.26 pCi/g) at the ambient air station at the northeast boundary of PORTS (A23). The total potential dose to a member of the public resulting from PORTS operations (4.6 mrem/year), which includes this dose calculation (0.077 mrem/year), is well below the DOE standard of 100 mrem/year.

4.6.8 Vegetation

To assess the uptake of radionuclides into plant material, vegetation samples 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, total uranium, and uranium isotopes (uranium-233/234, uranium-235, uranium-236, and uranium-238) in accordance with the DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant*.

No transuranics were detected in vegetation samples collected in 2006. Technetium-99 was detected at activities less than 1 pCi/g in samples collected from five locations (A6, A8, A15, A29, and A36). Technetium-99 has only been detected once in samples collected from 2002-2005 for this program: at A29 (on site at Ohio Valley Electric Corporation) in 2002. These detections may be due to analytical interferences or errors as previously mentioned in the discussion of sediment sampling results (Section 4.6.5).

Uranium and uranium-238 were detected in samples collected from six stations (A6, A8, A9, A12, A29, and A41). Uranium was detected at concentrations less than 0.3 microgram per gram (μg/g) and uranium-238 at activities less than 0.1 pCi/g. Uranium and uranium isotopes are detected infrequently, but have been detected at similar levels in previous sampling (2002-2005). Section 4.3.9.3 provides a dose assessment for a member of the public based on consumption of vegetative biota, specifically crops. The potential estimated dose from vegetative biota is significantly less than DOE's 100 mrem/year dose limit to the public for radionuclides from all potential pathways.

4.6.9 Biological Monitoring

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

4.6.9.1 Deer

No deer samples were collected during 2006. Samples of liver, kidney, and muscle from a deer killed on site in a collision with a motor vehicle in December 2005 were analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, total uranium, and uranium isotopes (uranium-233/234, uranium-235, uranium-236, and uranium-238). None of these radionuclides were detected in the samples.

4.6.9.2 Fish

In 2006, fish samples were collected from a downstream sampling location on Little Beaver Creek (RW-8). Samples were analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, total uranium, and uranium isotopes (uranium-233/234, uranium-235, uranium-236, and uranium-238). No radionuclides were detected in the fish sample.

4.6.9.3 Crops

In 2006, 14 crop samples, including green peppers, corn, green beans, tomatoes, cucumbers, turnips, and watermelon, were collected from five residential locations near PORTS.

Each sample was analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, total uranium, and uranium isotopes (uranium-233/234, uranium-235, uranium-236, and uranium-238). Uranium-233/234 was detected at 0.0912 pCi/g in the cucumber sample collected from off-site location #5. None of these radionuclides were detected in any of the other samples.

Section 4.3.9.3 provides a dose assessment to a member of the public based on consumption of cucumbers containing uranium-233/234 at 0.0912 pCi/g. The total potential dose to a member of the public resulting from PORTS operations (4.6 mrem/year), which includes this dose calculation (0.005 mrem/year), is well below the DOE standard of 100 mrem/year.

4.6.9.4 Milk and eggs

In 2006, samples of locally produced milk and eggs were collected from an off-site location near PORTS. Each sample was split into two samples (called regular and duplicate samples) and analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240), technetium-99, total uranium, and uranium isotopes (uranium-233/234, uranium-235, uranium-236, and uranium-238). Regular and duplicate samples are used to assess the accuracy of sampling activities and laboratory analyses, although there is an inherent level of variability in environmental samples.

Technetium-99 was detected at 1150 pCi/L and plutonium-239/240 was detected at 0.585 pCi/L in the regular milk sample. In the duplicate sample, technetium-99 was detected at 2650 pCi/L, uranium-233/234 was detected at 0.206 pCi/L, and uranium-238 was detected at 0.367 pCi/L. The results for these regular and duplicate samples do not correlate well, in that plutonium-239/240, uranium-233/234, and uranium-238 were detected in one sample but not the other and technetium-99 was detected in the duplicate sample at more than twice the activity of the regular sample. These results indicate that analytical interferences or errors may be affecting the sample results.

As a conservative measure, Section 4.3.9.4 provides a dose assessment to a member of the public based on consumption of milk containing these radionuclides, although some of the detections may not be accurate. The total potential dose to a member of the public resulting from PORTS operations (4.6 mrem/year), which includes this dose calculation (3.2 mrem/year), is well below the DOE standard of 100 mrem/year.

Technetium-99 was detected in each egg sample at 8800 pCi/L in the regular sample and 8140 pCi/L in the duplicate sample. These results are an acceptable level of variability between regular and duplicate samples. Section 4.3.9.5 provides a dose assessment to a member of the public based on consumption of eggs containing technetium-99 at 8470 pCi/L (the average of 8800 and 8140 pCi/L). The total potential

dose to a member of the public resulting from PORTS operations (4.6 mrem/year), which includes this dose calculation (0.09 mrem/year), is well below the DOE standard of 100 mrem/year.

4.7 RELEASE OF PROPERTY CONTAINING RESIDUAL RADIOACTIVE MATERIAL

In 2006, no DOE property (equipment, excess materials, etc.) was released to the public that contained residual radioactive material that exceeded the release limits for DOE PORTS. The release limits are established in accordance with DOE Order 5400.5 and Title 10 of the *Code of Federal Regulations*, Part 835.

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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 completed to reduce public concerns about plant operations. Non-radiological data collected in 2006 are similar to data collected in previous years.

5.2 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* specifies non-radiological monitoring requirements for ambient air, local surface water, sediment, and fish. Non-radiological data are not collected for some sampling locations and some monitoring programs.

Environmental permits issued by the EPA to the DOE, DOE contractors, or USEC specify discharge limitations, monitoring requirements, and/or reporting requirements for air emissions and water discharges. Because USEC data are important in developing a complete picture of environmental monitoring at PORTS, these data are included in this report. USEC information is provided for informational purposes only; the DOE cannot certify the accuracy of USEC data. Data from the following environmental monitoring programs are included in this chapter:

- Air,
- Surface water,
- Sediment, and
- Biota (fish).

The 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 and in the surrounding area.

5.3.1 Airborne Discharges

DOE PORTS operates several sources of conventional air pollutants such as nitrogen oxides, sulfur dioxide, and particulate matter. The boilers that provide heat for DOE facilities account for almost all of the conventional air pollutants emitted by DOE sources. The DOE reported the following emissions from the boilers for 2006 in the Ohio EPA Fee Emissions Report: 0.062 ton of particulate matter, 0.045 ton of sulfur dioxide, 2.241 tons of nitrogen oxides, 0.0000053 ton of lead, and 0.555 ton of organic compounds.

Other emissions sources at DOE PORTS, which include two landfill venting systems, two glove boxes (one not used in 2006), two aboveground storage tanks in the X-6002A Fuel Oil Storage Facility, and four groundwater treatment facilities, emit less than 1 ton per year of conventional air pollutants (on an individual basis), and therefore do not require reporting in the Ohio EPA Fee Emissions Report.

Another potential air pollutant present at DOE PORTS is asbestos released by renovation or demolition of plant facilities. Asbestos emissions are controlled by a system of work practices. The amount of asbestos removed and disposed is reported to the Ohio EPA. In 2006, 40.8 tons of material contaminated with asbestos were shipped from DOE PORTS. These wastes included scrap metal, pipe insulation, and other construction debris that was contaminated with asbestos.

USEC reported the following emissions of non-radiological air pollutants for 2006 in the Ohio EPA Fee Emissions Report: 25.43 tons of particulate matter, 2.80 tons of organic compounds, 1726.51 tons of sulfur dioxide, and 225.89 tons of nitrogen oxides. These emissions are associated with the boilers at the X-600 Steam Plant, which provide steam for PORTS, a boiler at the X-611 Water Treatment Plant, and diesel-powered compressors for emergency use.

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) or from USEC activities associated with the former gaseous diffusion process.

In 2006, samples for fluoride were collected weekly from 15 ambient air monitoring stations in and around PORTS (see Chapter 4, Figure 4.1). A background ambient air monitoring station (A37) is located approximately 13 miles southwest of the plant; however, this station did not operate for several months due to mechanical issues. Therefore, analytical results from an air station southwest of the plant (A28) are used to compare to air sampling stations closer to the plant. In 2006, the average ambient concentration of fluoride measured in samples collected at station A28 was 0.039 microgram per cubic meter ($\mu g/m^3$). Average ambient concentrations of fluoride measured at the other stations ranged from 0.033 $\mu g/m^3$ at Station A8, located on the northwestern plant boundary, to 0.065 $\mu g/m^3$ at Station A3, located on the southeastern PORTS boundary.

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 both the DOE and USEC NPDES-permitted outfalls. Non-radiological parameters are also monitored in the Scioto River upstream and downstream of PORTS to determine whether discharges

from PORTS affect water quality in the river. PCBs are monitored in surface water discharges and surface water downstream from the DOE depleted uranium cylinder storage yards.

5.4.1 Water Discharges (NPDES Outfalls)

Both the DOE and USEC are responsible for NPDES outfalls at PORTS. This section describes non-radiological discharges from these outfalls during 2006.

5.4.1.1 DOE NPDES outfalls

Non-radiological discharges from DOE NPDES outfalls are regulated by the DOE PORTS NPDES permit issued to LPP, the responsible DOE contractor. DOE PORTS has eight discharge points, or outfalls, through which water is discharged from the site. Three outfalls discharge directly to surface water, four discharge to the USEC X-6619 Sewage Treatment Plant (USEC NPDES Outfall 003), and one discharges to the X-2230M Holding Pond (DOE Outfall 012). Outfall 612 is currently inactive because the X-625 Groundwater Treatment Facility was placed on stand-by with the approval of the Ohio EPA in July 2003. Chapter 4, Section 4.3.5.1, provides a brief description of each DOE outfall and provides a site diagram showing each DOE PORTS NPDES outfall (see Chapter 4, Figure 4.2).

The 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. For example, the DOE outfalls that discharge water from the groundwater treatment facilities (Outfalls 015, 608, 610, 611, and 612) are monitored for trichloroethene because the groundwater treatment facilities treat water contaminated with this chemical. Chemicals monitored at each DOE outfall are as follows:

- DOE NPDES Outfall 012 (X-2230M Holding Pond) – chlorine, iron, oil and grease, suspended solids, total PCBs, and trichloroethene.

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

- DOE NPDES Outfall 015 (X-624 Groundwater Treatment Facility) – total PCBs and trichloroethene.

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

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

- DOE NPDES Outfall 611 (X-627 Groundwater Treatment Facility) – trichloroethene.

- DOE NPDES Outfall 612 (X-625 Groundwater Treatment Facility) – iron and trichloroethene. This outfall is currently inactive because the X-625 Groundwater Treatment Facility was placed on stand-by with approval from the Ohio EPA on July 9, 2003.

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

In 2006, none of the discharge limitations for DOE NPDES outfalls was exceeded; therefore, the overall DOE NPDES compliance rate with the NPDES permit was 100%.

5.4.1.2 USEC NPDES outfalls

USEC is responsible for 11 NPDES outfalls through which water is discharged from the site (see Chapter 4, Figure 4.2). Eight outfalls discharge directly to surface water, and three discharge to another USEC NPDES outfall before leaving the site. Chapter 4, Section 4.3.5.2, provides a brief description of each USEC NPDES outfall. Chemicals monitored at each USEC outfall are as follows:

- USEC NPDES Outfall 001 (X-230J7 East Holding Pond) – cadmium, chlorine, dissolved solids fluoride, oil and grease, silver, suspended solids, zinc.

- USEC NPDES Outfall 002 (X-230K South Holding Pond) – cadmium, fluoride, mercury, oil and grease, silver, suspended solids, thallium.

- USEC NPDES Outfall 003 (X-6619 Sewage Treatment Plant) – ammonia-nitrogen, biochemical oxygen demand, chlorine, copper, fecal coliform (May-October only), mercury, nitrite + nitrate, oil and grease, silver, suspended solids, zinc.

- USEC NPDES Outfall 004 (Cooling Tower Blowdown) – chlorine, copper, dissolved solids, mercury, oil and grease, suspended solids, zinc.

- USEC NPDES Outfall 005 (X-611B Lime Sludge Lagoon) – suspended solids.

- USEC NPDES Outfall 009 (X-230L North Holding Pond) – cadmium, fluoride, oil and grease, suspended solids, zinc.

- USEC NPDES Outfall 010 (X-230J5 Northwest Holding Pond) – cadmium, mercury, oil and grease, suspended solids, zinc.

- USEC NPDES Outfall 011 (X-230J6 Northeast Holding Pond) – cadmium, chlorine, copper, fluoride, oil and grease, suspended solids, zinc.

- USEC NPDES Outfall 602 (X-621 Coal Pile Runoff Treatment Facility) – iron, manganese, suspended solids.

- USEC NPDES Outfall 604 (X-700 Biodenitrification Facility) – copper, iron, nickel, nitrate-nitrogen, zinc.

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

The USEC NPDES Permit also identifies additional monitoring points that are not discharge points as described in the previous paragraphs. USEC NPDES Station Number 801 is a background monitoring location on the Scioto River upstream from USEC NPDES Outfalls 003 and 004. Samples are collected from this monitoring point to measure toxicity to minnows and another aquatic organism (*Ceriodaphnia*).

USEC NPDES Station Number 902 is a monitoring location on Little Beaver Creek downstream from USEC NPDES Outfall 001. USEC NPDES Station Number 903 is a monitoring location on Big Run Creek downstream from USEC NPDES Outfall 002. Water temperature is the only parameter measured at each of these monitoring points.

In 2006, the overall USEC NPDES compliance rate was 99.8%. During 2006, USEC experienced four exceedences of its NPDES permit limits as described below:

- The daily concentration discharge limitation for suspended solids at USEC NPDES Outfall 011, 45 milligrams per liter (mg/L), was exceeded in April 2006, the sample result was 91.6 mg/L.

- The monthly average discharge limitation for suspended solids at USEC NPDES Outfall 011, 30 mg/L, was exceeded in April 2006, the average was 45.8 mg/L.

- The monthly average temperature limitation at USEC NPDES Station Number 902, 16.7 °C, was exceeded in April 2006, the average was 18 °C.

- The monthly average temperature limitation at USEC NPDES Station Number 903, 16.7 °C, was exceeded in April 2006, the average was 17.9 °C.

In addition, USEC was issued a Notice of Violation in September 2006 for discharge of an oil sheen from Outfall 011, which was observed by an Ohio EPA inspector.

5.4.2 Local Surface Water Monitoring

Non-radiological monitoring of local surface water locations was conducted on the Scioto River upstream and downstream of PORTS (sampling locations RW-6 and RW-1 – see Chapter 4, Figure 4.4). Samples from the Scioto River are analyzed for total phosphate – phosphorus, fluoride, 29 metals, and PCBs. Each of these measurements, with the exception of PCBs, will detect naturally-occurring constituents; therefore, measurements from the upstream location are compared to the downstream location to assess whether PORTS activities have affected the river. Natural variation and manmade activities not related to PORTS can also cause sample variation.

Semiannual samples were collected for fluoride and total phosphate – phosphorus. In 2006, the concentrations of fluoride were not appreciably different in upstream and downstream samples : 0.37 and 0.24 mg/L (ppm) in the upstream samples and 0.39 and 0.24 mg/L in the downstream samples. Concentrations of total phosphate – phosphorus were not appreciably different in upstream and downstream samples collected in 2006: 0.27 and 0.44 mg/L in upstream samples and 0.27 and 0.48 mg/L in downstream samples.

Quarterly samples were collected for PCBs and 29 metals from the upstream and downstream Scioto River sampling locations. PCBs were not detected in any of the samples collected in 2006. No significant differences in the concentrations of metals were noted at the upstream and downstream Scioto River sampling locations. Discharges of non-radiological constituents from PORTS do not appear to affect surface water quality in the Scioto River downstream from PORTS.

5.4.3 Surface Water Monitoring Associated with DOE Cylinder Storage Yards

Surface water samples (filtered and unfiltered) are collected quarterly from four locations in the drainage basins downstream from the DOE depleted uranium cylinder storage yards (UDS X01, RM-8, UDS X02, and RM-10 - see Chapter 4, Figure 4.2) and analyzed for PCBs. No PCBs were detected in surface water samples collected in 2006, with the exception of the third quarter unfiltered sample collected from UDS X02 (one of the western drainage basin monitoring locations). However, this detection was qualified by the laboratory with a “B,” which indicates that the analyte was also detected in the laboratory blank associated with the environmental sample. The detection of PCBs in the laboratory blank sample means that the detection in the sample collected at UDS X02 is most likely due to

laboratory contamination. Section 5.5.2 presents the results for sediment samples collected as part of this program.

5.5 SEDIMENT

In 2006, sediment monitoring at PORTS included local streams and the Scioto River upstream and downstream from PORTS and drainage basins downstream from the DOE depleted uranium 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 2006, samples were analyzed for 30 metals and PCBs, in addition to the radiological parameters discussed in Chapter 4.

PCBs, primarily PCB-1260, were detected in some of the sediment samples collected in 2006 at concentrations up to 57 micrograms per kilogram (μg/kg) or parts per billion (ppb). PCB-1260 was detected in samples collected from Little Beaver Creek at the confluence from the X-230L North Holding Pond (RM-8), Little Beaver Creek west of the PORTS boundary (RM-7), upstream Big Beaver Creek (RM-5), upstream Big Run Creek (RM-33), downstream Big Run Creek at the PORTS boundary (RM-3), and the West Drainage Ditch USEC Outfall 010/DOE Outfall 013 (RM-10). PCB-1248 was detected in both the upstream and downstream Scioto River sampling locations (RM-6 and RM-1, respectively). PCB-1260 is associated with PORTS activities, although it is also present in the environment from other sources. PCB-1248 is not usually detected at PORTS and is most likely present in the Scioto River samples as a result of contamination not attributable to PORTS. The detections of PCBs in sediment around PORTS are less than the risk-based concentration of PCBs for protection of human health developed by U.S. EPA Region 9 and utilized by Ohio EPA: 220 μg/kg.

The results of metals sampling conducted in 2006 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 the DOE Cylinder Storage Yards

Sediment samples are collected quarterly from four locations in the drainage basins downstream from the DOE depleted uranium cylinder storage yards (UDS X01, RM-8, UDS X02, and RM-10) and analyzed for PCBs.

In 2006, PCBs (PCB-1260) were detected in sediment samples collected from three of the four sampling locations (UDS X01, RM-8, and UDS X02) at concentrations ranging from 45 to 140 μg/kg (ppb). These concentrations are well 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 depleted uranium cylinders at PORTS that may have paint on the exterior of the cylinders that contains more than 50 ppm PCBs.

Section 5.4.3 presents the results for surface water samples collected as part of this program.

5.6 BIOLOGICAL MONITORING - FISH

In 2006, fish were collected from a downstream sampling location on Little Beaver Creek (RW-8) as part of the routine fish monitoring program at PORTS. Chapter 4, Figure 4.4, shows the surface water monitoring location where the fish were caught. Fish samples were analyzed for chromium and 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.

Chromium was detected at 0.34 milligram per kilogram (mg/kg) in the blue gill sample analyzed for chromium. This concentration of chromium is similar to or less than concentrations of chromium detected in fish caught in 2004-2005 (0.208 to 8.18 mg/kg).

The chromium detected in these fish in 2006 is most likely due to naturally-occurring chromium. Chromium occurs naturally in soil and is often present in stream sediment and surface water. For example, chromium is usually detected in samples of surface water collected at the upstream Scioto River sampling location (RW-6) and in the sediment sample collected from this location.

PCB-1260 was detected at 320 μg/kg (ppb) in the large mouth bass sample analyzed for PCBs. Concentrations of PCBs in fish 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 2005). These limits are set for the following consumption rates: unrestricted, 1/week, 1/month, 6/year, and do not eat. This concentration of PCBs is between the 1/week limit (220 μg/kg) and the 1/month limit (1000 μg/kg).

The Ohio Sport Fish Consumption Advisory, available from the 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.

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6. GROUNDWATER PROGRAMS

6.1 SUMMARY

Groundwater monitoring at DOE PORTS is required by a combination of state and federal regulations, legal agreements with the Ohio EPA and U.S. 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.

In general, the contaminated groundwater plumes present at PORTS did not change significantly in 2006. Trichloroethene and several other volatile organics continue to be detected at concentrations of 4 μg/L (4 ppb) or less in an off-site well located approximately 45 feet south of the DOE property line that is part of the X-749/X-120 plume. Trichloroethene has not been detected in groundwater beyond the DOE property boundary at concentrations that exceed the EPA drinking water standard of 5 μg/L. The *2006 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. This document and other documents referenced in this chapter are available in the PORTS Environmental Information Center.

6.2 INTRODUCTION

This chapter provides an overview of groundwater monitoring at PORTS and the results of the groundwater monitoring program for 2006. The following sections provide an overview of the DOE PORTS groundwater monitoring program followed by a review of the history and 2006 monitoring data for each area.

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 DOE PORTS permitted NPDES outfalls.

6.3 OVERVIEW OF GROUNDWATER MONITORING AT DOE 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 PORTS, agreements between the 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, dated November 1998, was reviewed and approved by the Ohio EPA and implemented at PORTS starting on April 1, 1999. The *Integrated Groundwater Monitoring Plan* is periodically revised and approved by the Ohio EPA.

In 2006, groundwater monitoring at PORTS was performed under the *Integrated Groundwater Monitoring Plan* dated October 2004 and replacement pages dated May 2005 that resolved a minor issue with monitoring at the X-749A and X-735 Landfills. However, the results of two special studies at the X-749/X-120/PK Landfill Area in Quadrant I caused changes to the monitoring of this area that are not part of the October 2004 *Integrated Groundwater Monitoring Plan*. The Ohio EPA approved the *Annual (2004) Summary Report of the Comprehensive Monitoring Plan Data for the X-749/Peter Kiewit Landfill Areas* in a letter dated March 14, 2005. Approval of this report discontinued sampling conducted solely for the report beginning in the second quarter of 2005. The Ohio EPA approved the *Evaluation of the Groundwater Monitoring Network for the X-749/X-120/PK Landfill Area* in a letter dated June 2, 2005, and the changes to the monitoring program for the X-749/X-120/PK Landfill area provided in this report were implemented beginning in the third quarter of 2005. In general, the evaluation decreased the number of parameters and frequency of monitoring at X-749/X-120/PK Landfill wells, although the monitoring frequency and number of parameters increased at some wells.

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

PORTS is the largest industrial user of water in the vicinity and obtains water from three water supply well fields that are next to the Scioto River south of Piketon. The wells tap the Scioto River Valley buried aquifer. In 2006, total groundwater production from the water supply well fields averaged approximately 3.1 million gallons per day for the entire site (including USEC activities). 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. In addition, the DOE has filed a deed notification at the Pike County Auditor's Office that restricts the use of groundwater beneath the PORTS site.

Two water-bearing zones are present beneath 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.

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 11 areas within the quadrants of the site designated by the RCRA Corrective Action Program. These areas (see Figure 6.1) are:

- X-749/X-120/PK Landfill,
- Quadrant I Groundwater Investigative Area/X-749A Classified Materials Disposal Facility,
- Quadrant II Groundwater Investigative Area,
- X-701B Holding Pond,
- X-633 Pumphouse/Cooling Towers Area,
- X-616 Chromium Sludge Surface Impoundments,
- X-740 Waste Oil Handling Facility,
- X-611A Former Lime Sludge Lagoons,
- X-735 Landfills,
- X-734 Landfills, and
- X-533 Switchyard Area.

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.

In general, samples are collected from wells (or surface water locations) at each area listed above and are analyzed for metals, volatile organic compounds, and/or radiological constituents. Table 6.1 lists the analytical requirements for each groundwater monitoring area and other monitoring programs described in this chapter. DOE PORTS then compares constituents detected in the groundwater to standards called preliminary remediation goals to assess the potential for each constituent to affect human health and the environment.

Five areas of groundwater contamination, commonly called groundwater plumes, have been identified at PORTS. Groundwater contamination consists of volatile organic compounds (primarily trichloroethene) and radionuclides such as uranium and technetium-99. The areas that contain groundwater plumes are X-749/X-120/PK Landfill, Quadrant I Groundwater Investigative Area/X-749A Classified Materials Disposal Facility, Quadrant II Groundwater Investigative Area, X-701B Holding Pond, and X-740 Waste Oil Handling Facility. Other areas are monitored to evaluate areas of 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 2006.

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

In the southernmost portion of PORTS, groundwater concerns focus on three contaminant sources: X-749 Contaminated Materials Disposal Facility, X-120 Old Training Facility, and PK Landfill.

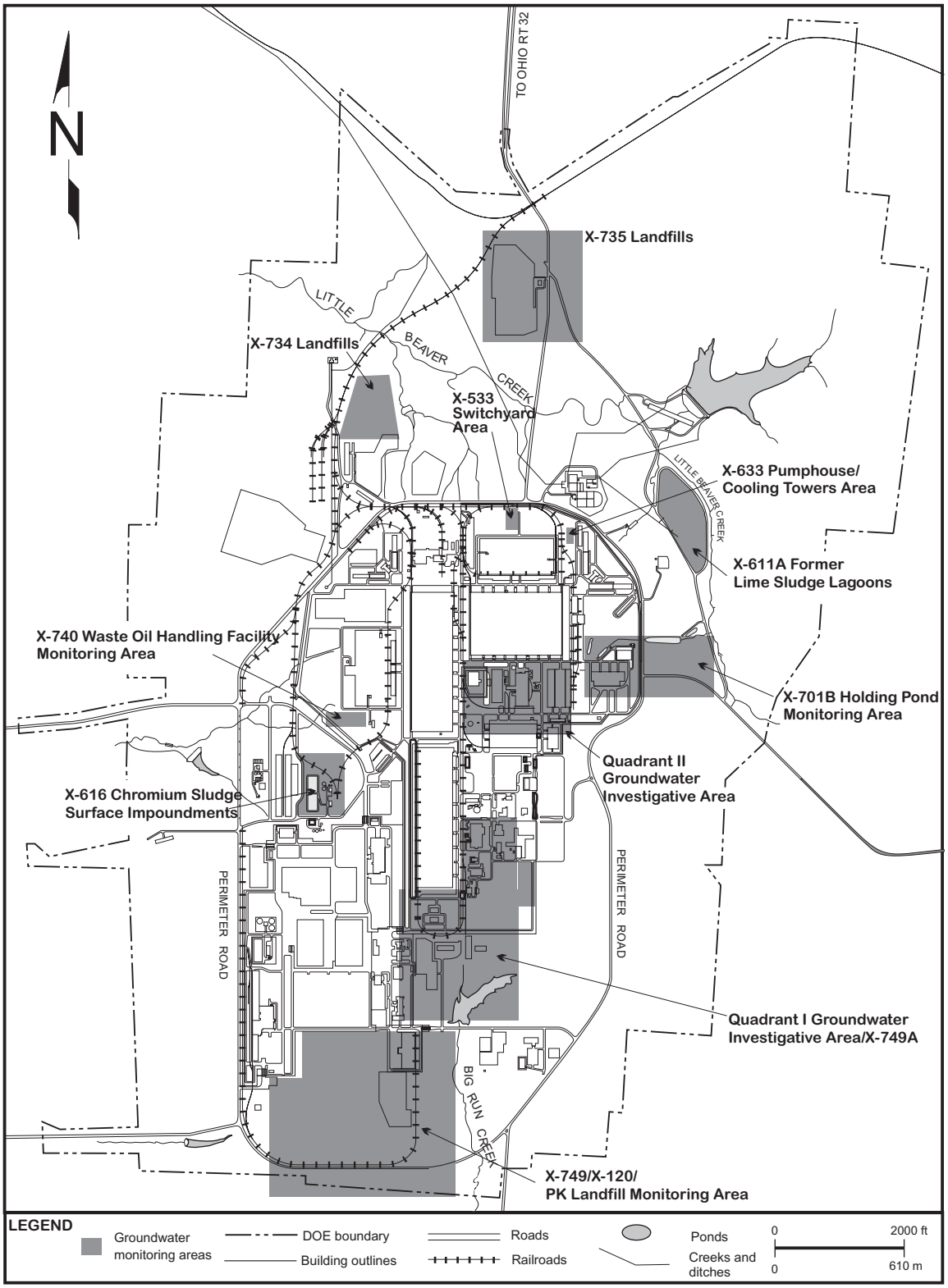

Figure 6.1. Groundwater monitoring areas at PORTS.

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

Monitoring Area or Program	Analytes	
X-749/X-120/PK Landfill[a,b]		
X-749/X-120 plume	volatile organic compounds[c] technetium-99 total U, $^{233/234}U$, ^{235}U, ^{236}U, ^{238}U[d] alkalinity	chloride sulfate total metals[d]: Ca, Fe, Mg, K, Na transuranics[d]: ^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}Pu$
PK Landfill	volatile organic compounds[c] technetium-99 total U, $^{233/234}U$, ^{235}U, ^{236}U, ^{238}U[d] alkalinity chloride sulfate	total metals[d]: As, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Ni, K, Se, Na, V, Zn transuranics[d]: ^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}Pu$
Quadrant I Groundwater Investigative Area[a,b]		
X-231B plume	volatile organic compounds[c] technetium-99 total U, $^{233/234}U$, ^{235}U, ^{236}U, ^{238}U[d] alkalinity chloride	sulfate total metals[d]: Ca, Fe, Mg, Mn, K, Na transuranics[d]: ^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}Pu$
X-749A Classified Materials Disposal Facility	volatile organic compounds[e] technetium-99 total U, $^{233/234}U$, ^{235}U, ^{236}U, ^{238}U[c] alkalinity chloride sulfate nitrite nitrate ammonia	total metals[d]: Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Ni, K, Se, Ag, Na, Tl, V, Zn transuranics[d]: ^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}Pu$ chemical oxygen demand total dissolved solids
Quadrant II Groundwater Investigative Area[a]	volatile organic compounds[c] technetium-99 total U, $^{233/234}U$, ^{235}U, ^{236}U, ^{238}U[d] alkalinity	chloride sulfate total metals[d]: Ca, Fe, Mg, K, Na transuranics[d]: ^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}Pu$
X-701B Holding Pond[a,b]	volatile organic compounds[c] technetium-99 total U, $^{233/234}U$, ^{235}U, ^{236}U, ^{238}U[d] alkalinity chloride	sulfate total metals[d]: Ca, Cd, Co, Cr, Fe, Mg, Mn, K, Pb, Na, Ni, Tl transuranics[d]: ^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}Pu$
X-633 Pumphouse/Cooling Towers Area	total metals[d]: Cr	

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

Monitoring Area or Program	Analytes	
X-616 Chromium Sludge Surface Impoundments	volatile organic compounds[c] technetium-99 total U, $^{233/234}U$, ^{235}U, ^{236}U, ^{238}U[d] alkalinity	chloride sulfate total metals[d]: Ca, Fe, Mg, K, Na, Ba, Cd, Cr, Pb, Mn, Ni, Sb, Tl
X-740 Waste Oil Handling Facility[a]	volatile organic compounds[c] technetium-99 total U, $^{233/234}U$, ^{235}U, ^{236}U, ^{238}U[d] alkalinity	chloride sulfate total metals[d]: Ca, Fe, Mg, K, Na transuranics[d]: ^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}Pu$
X-611A Former Lime Sludge Lagoons	total metals[d]: Be, Cr	
X-735 Landfills	volatile organic compounds[e] technetium-99 total U, $^{233/234}U$, ^{235}U, ^{236}U, ^{238}U[d] alkalinity chloride sulfate nitrite nitrate ammonia	total metals[d]: Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Hg, Pb, Mg, Mn, Ni, K, Se, Ag, Na, Tl, V, Zn transuranics[d]: ^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}Pu$ chemical oxygen demand total dissolved solids
X-734 Landfills	volatile organic compounds[e] technetium-99 total U, $^{233/234}U$, ^{235}U, ^{236}U, ^{238}U[d] alkalinity chloride sulfate nitrite nitrate ammonia	total metals[d]: Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Ni, K, Se, Ag, Na, Tl, V, Zn transuranics[d]: ^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}Pu$ chemical oxygen demand total dissolved solids
X-533 Switchyard Area	total metals[d]: Cd, Co, Ni	
Surface Water	volatile organic compounds[c] technetium-99 total U, $^{233/234}U$, ^{235}U, ^{236}U, ^{238}U[d] alkalinity	chloride sulfate total metals[d]: Ca, Fe, Mg, K, Na transuranics[d]: ^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}Pu$
Water Supply	volatile organic compounds[c] technetium-99 total U, $^{233/234}U$, ^{235}U, ^{236}U, ^{238}U[d] alkalinity	chloride sulfate total metals[d]: Ca, Fe, Mg, K, Na transuranics[d]: ^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}Pu$

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

Monitoring Area or Program	Analytes		
Exit Pathway[b]	volatile organic compounds[c] technetium-99 total U, $^{233/234}U$, ^{235}U, ^{236}U, ^{238}U[d] alkalinity	chloride sulfate total metals[d]: transuranics[d]:	 Ca, Fe, Mg, K, Na ^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}Pu$

[a]Selected well(s) in this area are sampled once every two years for a comprehensive list of over 200 potential contaminants (Title 40, Code of Federal Regulations, Part 264 Appendix IX – Appendix to Ohio Administrative Code Rule 3745-54-98).

[b]Not all wells at this area are analyzed for all listed analytes.

[c]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, trichloroethene, trichlorofluoromethane (CFC-11), vinyl chloride, xylenes (M+P xylenes).

[d]Appendix C lists the symbols for metals and transuranic radionuclides.

[e]Volatile organic compounds listed in footnote c 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.

6.4.1.1 X-749 Contaminated Materials Disposal Facility/X-120 Old Training Facility

The X-749 Contaminated Materials Disposal Facility is a landfill located in the south-central section of the facility. The landfill covers approximately 7.5 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 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 extend 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 DOE NPDES Outfall 608, which flows to the USEC Sewage Treatment Plant.

The leading edge of the contaminated groundwater plume emanating from the X-749 landfill has been approaching 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, volatile organics have moved beyond the wall. A project was begun in 2004 to remediate volatile organics in this area. Hydrogen release compounds, which act as an accelerant to the natural microbial process that breaks down volatile organics into nontoxic compounds, were injected into the soil in over 150 locations during March and April 2004. Sampling data collected through 2006 indicates that optimal reductive dechlorination of chlorinated solvents was briefly achieved in the treatment zones, but is no longer effective due to the depletion of the hydrogen release compounds.

The X-120 Old Training Facility covered an area of approximately 11.5 acres near the present-day XT-847 building. The X-120 facility, which no longer exists, 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 volatile organic compounds, primarily trichloroethene. 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. On July 9, 2003, operation of the X-625 Groundwater Treatment Facility and horizontal well was placed on stand-by with approval from Ohio EPA. The horizontal well and treatment facility did not operate during 2006.

The *Comprehensive Monitoring Program for the X-749 and Peter Kiewit Landfill Areas for the Portsmouth Gaseous Diffusion Plant* was developed in 2003 to evaluate the effect of the X-749 barrier wall installed in 2001-2002 on groundwater quality and migration in the northern area of the X-749 plume and at the PK Landfill. Groundwater quality monitoring required by the program began in the fourth quarter of 2003 and continued through the first quarter of 2005. The program found that the barrier wall on the south and east sides of the X-749 landfill, installed in 2001-2002, is impeding additional contamination from flowing out of the landfill, and that the groundwater collection system and sump pump in the southwestern corner of the X-749 landfill is removing water from the landfill.

Fifty-seven wells were sampled during 2006 to monitor the X-749/X-120 area. Table 6.1 lists the analytical parameters for the wells in this area.

6.4.1.2 PK Landfill

The PK Landfill is located west of Big Run Creek just south of the X-230K Holding Pond. The 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. A cap was constructed over the landfill in 1998.

In 2002, a 5-year review was completed for the PK Landfill to evaluate the effectiveness of the corrective measures implemented at this area (see the report entitled *X-611A Prairie and the X-749B Peter Kiewit Landfill Five-Year Evaluation Report for the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio*). In response to the findings of the 5-year review, the *Comprehensive Monitoring Program for the X-749 and Peter Kiewit Landfill Areas for the Portsmouth Gaseous Diffusion Plant* was developed to provide additional data to evaluate the effectiveness of the landfill cap and groundwater collection systems, to determine whether a barrier wall is needed on the north and west sides of the PK Landfill, and to monitor the effect of the X-749 barrier wall installed in 2001-2002 as previously described (see Section 6.4.1.1). The *Annual (2004) Summary Report of the Comprehensive Monitoring Plan Data for the X-749/Peter Kiewit Landfill Areas* found that the landfill cap and groundwater collection systems are performing adequately and construction of a barrier wall on the upgradient (west and north) sides of the PK Landfill does not appear to be necessary.

In 2006, 9 wells, 2 sumps, and 2 manholes were sampled to monitor the PK Landfill area. Table 6.1 lists the analytical parameters for the wells, sumps, and manholes in this area.

6.4.1.3 Monitoring results for the X-749/X-120/PK Landfill in 2006

A contaminated groundwater plume is associated with the X-749/X-120/PK Landfill groundwater monitoring area (see Figure 6.2). The most extensive and most concentrated constituents associated with the X-749/X-120 plume are volatile organic compounds, particularly trichloroethene.

In recent years, concentrations of trichloroethene have been increasing in the southern area of this plume, known as the X-749 South Barrier Wall Area, near the DOE property boundary. In the second quarter of 2006, the concentration of trichloroethene detected in the sample collected from well X749-97G (on site immediately south of the X-749 South Barrier Wall) increased to 46 μg/L. Although trichloroethene is usually detected in this well, previous detections did not exceed 10 μg/L. Concentrations of trichloroethene detected in samples collected from this well in the third and fourth quarters of 2006 remained elevated (32 and 40 μg/L, respectively).

Concentrations of trichloroethene also increased in well X749-102G, which is on DOE property approximately 117 feet west of the X-749 South Barrier Wall. In quarterly sampling during 2006, concentrations of trichloroethene ranged from non-detect to 11 μg/L. In 2005, concentrations of trichloroethene detected in samples collected from well X749-102G ranged from 4.5 to 7 μg/L.

Figure 6.2. Trichloroethene-contaminated Gallia groundwater plume at the X-749/X-120/PK Landfill – 2006.

Volatile organic compounds continue to be detected in well WP-03, which is the westernmost well of the four off-site wells in this area. Although concentrations of volatile organics have increased in this well since 2004, none of the detections are above the respective preliminary remediation goals. Concentrations of volatile organics detected in quarterly samples collected from well WP-03 during 2006 remained relatively stable; for example, concentrations of trichloroethene detected in the well ranged from 3.2 to 4 μg/L. These concentrations are below the EPA drinking water standard for trichloroethene of 5 μg/L.

In addition to volatile organic compounds, inorganics (metals) and radionuclides have also been detected in the groundwater beneath the X-749 area. Remediation of groundwater is being accomplished in accordance with the RCRA Corrective Action Program.

Some of the wells associated with the PK Landfill also appear to be contaminated with low levels of volatile organic compounds, but usually at concentrations below preliminary remediation goals. Vinyl chloride, however, was detected in samples collected from wells PK-17B and PK-21B at concentrations ranging from 7.6 to 29 μg/L, which are above the preliminary remediation goal of 2 μg/L. Vinyl chloride is typically detected in these wells.

6.4.2 Quadrant I Groundwater Investigative Area/X-749A Classified Materials Disposal Facility

In the northern portion of Quadrant I, groundwater concerns are focused on two areas: the Quadrant I Groundwater Investigative Area and the X-749A Classified Materials Disposal Facility. The X-231B Southwest Oil Biodegradation Plot is a part of the Quadrant I Groundwater Investigative Area and was monitored prior to implementation of the *Integrated Groundwater Monitoring Plan*. The X-749A was also monitored prior to implementation of the *Integrated Groundwater Monitoring Plan* under requirements for solid waste landfills.

6.4.2.1 X-231B Southwest Oil Biodegradation Plot

The X-231B Southwest Oil Biodegradation Plot was used from 1976 to 1983 for land application of contaminated oil/solvent mixtures generated from the enrichment process and maintenance activities. The X-231B area, located west of the X-600 Steam Plant, consisted of two disposal plots, each surrounded by an elevated soil berm, that were periodically fertilized and plowed to enhance aeration and promote biological degradation of waste oil.

Three groundwater extraction wells were installed in the Gallia in 1991 as part of the X-231B interim remedial measure. Eleven additional groundwater extraction wells were installed in 2001-2002 and began operation in 2002. The extracted groundwater is treated at the X-622 Groundwater Treatment Facility and discharged through DOE NPDES Outfall 608, which flows into the USEC Sewage Treatment Plant. A multimedia landfill cap was installed over this area in 2000 to minimize water infiltration and control the spread of contamination.

Twenty-two wells are sampled semiannually as part of the monitoring program for the Quadrant I Groundwater Investigative Area. An additional 16 wells are sampled annually or biennially. Table 6.1 lists the analytical parameters for the wells in this area.

6.4.2.2 X-749A Classified Materials Disposal Facility

The 6-acre X-749A Classified Materials Disposal Facility is a landfill that operated from 1953 through 1988 for the disposal of wastes classified under the Atomic Energy Act. 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 a USEC NPDES-permitted outfall.

In 2005, the monitoring program for the X-749A landfill was revised based on Ohio EPA comments on the *2004 Groundwater Monitoring Report*. The extraction wells in the Quadrant I Groundwater Investigative Area have caused a change in the direction of groundwater flow at the X-749A landfill, which required changes to the monitoring program for the X-749A landfill. In 2006, nine wells were sampled as part of the routine monitoring program for the X-749A landfill. Table 6.1 lists the analytical parameters for the wells in this area.

6.4.2.3 Monitoring results for the Quadrant I Groundwater Investigative Area/X-749A in 2006

A contaminated groundwater plume consisting primarily of trichloroethene is associated with the Quadrant I Groundwater Investigative Area (see Figure 6.3). Other volatile organic compounds are also present in the plume. The plume perimeter did not change significantly from 2005 to 2006.

Concentrations of trichloroethene detected in several wells within the plume have decreased when compared to data collected prior to 2002 because of the 11 new extraction wells in the Quadrant I Groundwater Investigative Area, which began operation in April 2002. For example, trichloroethene was detected at 11 and 13 μg/L in samples collected during 2006 from well X231B-12G, which is in the middle western edge of the plume. Concentrations of trichloroethene detected in samples from this well in 1999-2001 ranged from 96 to 260 μg/L.

Concentrations of trichloroethene detected in well X326-09G (on the western edge of the plume at the southwest corner of the X-326 building) increased to 9000 μg/L in the third quarter of 2006. Concentrations of trichloroethene detected in this well have been increasing since the well was installed in 2002. These increasing concentrations could be due to the extraction wells, which may be causing groundwater with higher concentrations of trichloroethene to flow from beneath the X-326 building.

Inorganics (metals) and radionuclides have also been detected in the groundwater beneath the area. Remediation of groundwater is being accomplished in accordance with the RCRA Corrective Action Program.

Statistical evaluations of data collected from wells at the X-749A landfill are also completed to monitor the landfill for releases. Both control limits for alkalinity were exceeded in the sample collected from well X749A-01G during the fourth quarter of 2006. Verification resampling conducted in January 2007 confirmed the exceedence. In examining alkalinity data for the upgradient well for the X749A landfill (X749A-07G), it appears that there may be an increasing trend in concentrations of alkalinity in the background well. Therefore, the exceedence in well X749A-01G may not be caused by a release from the landfill, but may be due to an overall increasing trend in levels of alkalinity in groundwater in this area. DOE is working with Ohio EPA to determine the actions to be taken to assess the X-749A landfill. None of the control limits for the statistical monitoring parameters were exceeded in the other X-749A wells during 2006.

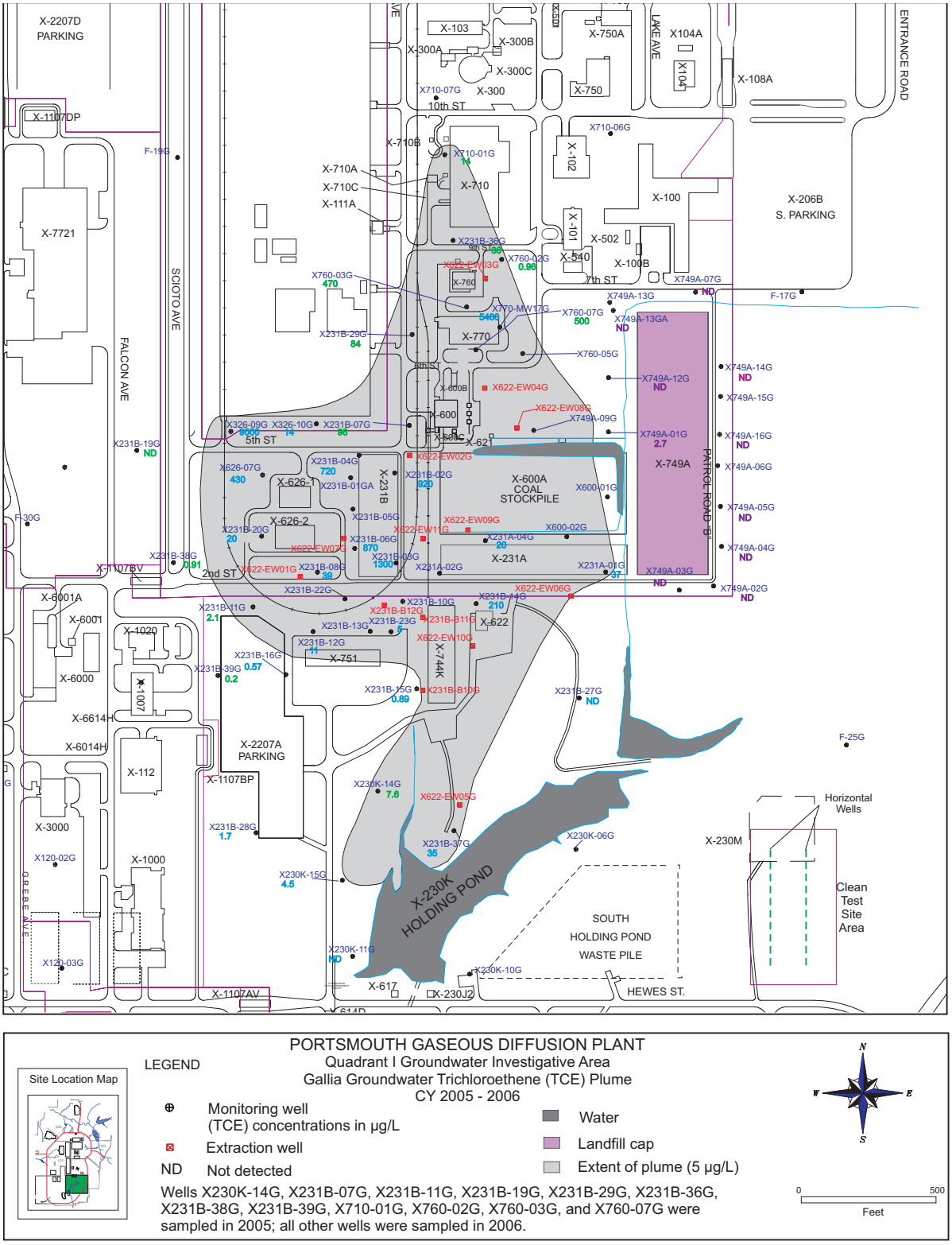

Figure 6.3. Trichloroethene-contaminated Gallia groundwater plume at the Quadrant I Groundwater Investigative Area – 2006.

6.4.3 Quadrant II Groundwater Investigative Area

The Quadrant II Groundwater Investigative 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 trichloroethene and/or trichloroethane from metal cleaning operations. The X-701C Neutralization Pit was located within a trichloroethene plume centered around the X-700 and X-705 buildings. The pit was removed in 2001.

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 DOE NPDES Outfall 611, which flows to the USEC Sewage Treatment Plant. Eleven wells are sampled annually as part of the monitoring program for this area. An additional 14 wells are sampled biennially. Table 6.1 lists the analytical parameters for the wells in this area.

6.4.3.1 Monitoring results for the Quadrant II Groundwater Investigative Area in 2006

A contaminated groundwater plume consisting primarily of trichloroethene is associated with the Quadrant II Groundwater Investigative Area (see Figure 6.4). The plume perimeter did not change significantly from 2005 to 2006. Numerous other volatile organics were also detected within the plume. Inorganics (metals) and radionuclides were also detected in 2006. Remediation of groundwater is being accomplished in accordance with the RCRA Corrective Action Program.

6.4.4 X-701B Holding Pond

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

The X-701B Holding Pond was used from the beginning of plant operations in 1954 until November 1988. The pond was designed for neutralization and settlement of acid waste from several sources. Trichloroethane and trichloroethene 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 Holding Pond. The X-744Y Waste Storage Yard is south of the X-701B Holding Pond. The yard is approximately 15 acres and surrounds the X-744G Bulk Storage Building. RCRA hazardous waste was managed in this area.

A contaminated groundwater plume extends from the X-701B Holding Pond to Little Beaver Creek. Three groundwater extraction wells were installed southeast of the X-701B Holding Pond as part of the ongoing RCRA closure of the unit. These wells were designed to intercept contaminated groundwater emanating from the holding pond area before it could join the existing groundwater contaminant plume. Extracted groundwater is processed at the X-623 Groundwater Treatment Facility and discharged through DOE NPDES Outfall 610, which flows to the USEC Sewage Treatment Plant. This facility also processes water recovered from a shallow sump in the bottom of the X-701B Holding Pond.

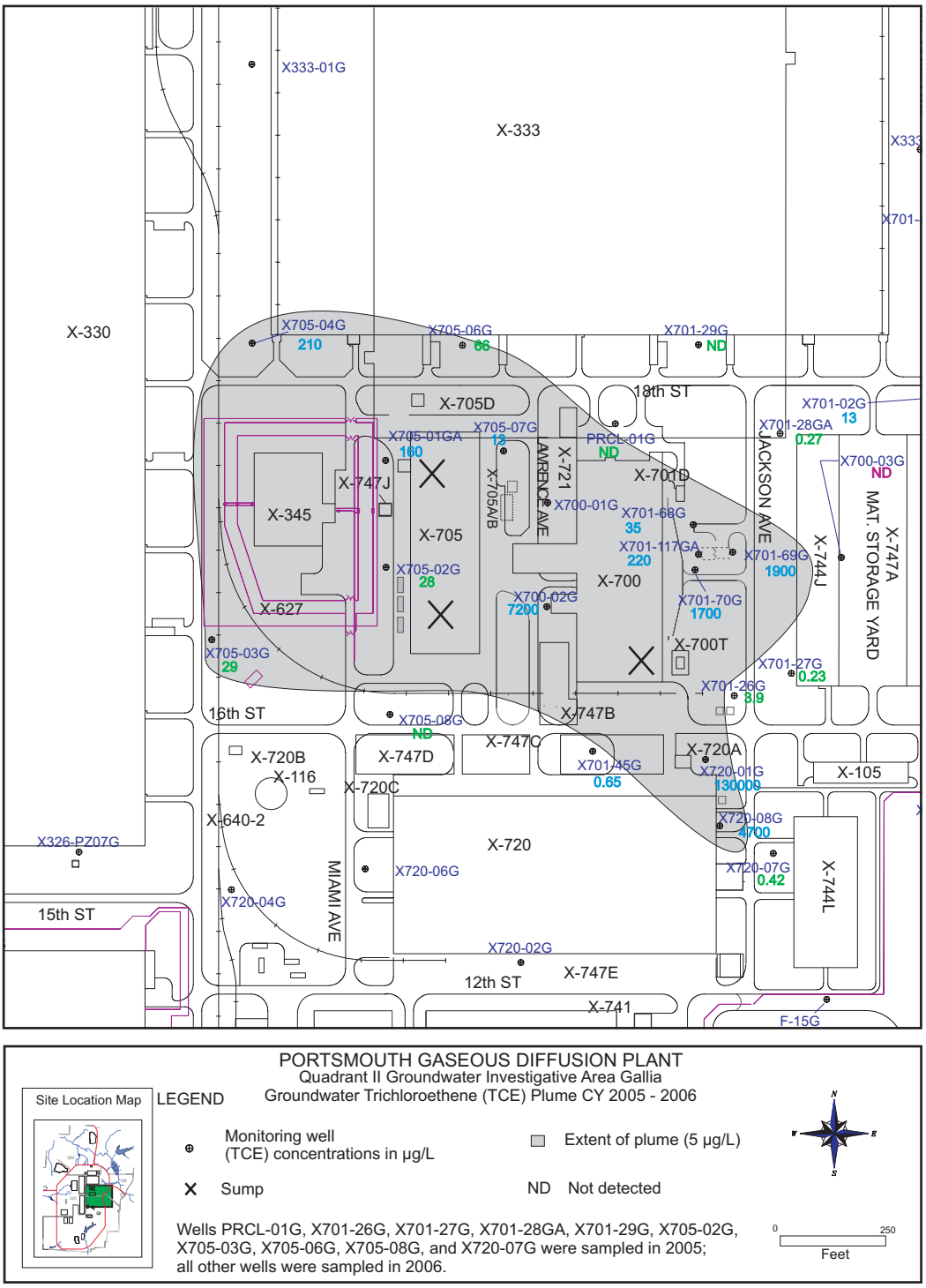

Figure 6.4. Trichloroethene-contaminated Gallia groundwater plume at the Quadrant II Groundwater Investigative Area – 2006.

Two groundwater interceptor trenches (French drains) are used to intercept trichloroethene-contaminated groundwater emanating from X-701B. These interceptor trenches, called the X-237 Groundwater Collection System, have significantly reduced trichloroethene 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 DOE NPDES Outfall 015, which flows to Little Beaver Creek.

Thirty-four wells are sampled semiannually as part of the monitoring program for this area. An additional 11 wells are sampled annually or biennially. Table 6.1 lists the analytical parameters for the wells in this area.

6.4.4.1 Monitoring results for the X-701B Holding Pond in 2006

The trichloroethene plume at this groundwater monitoring area contains the highest concentrations of trichloroethene measured in groundwater at PORTS, approximately 500,000 μg/L in one of the groundwater monitoring wells near the middle of the plume. Numerous other volatile organics are also detected in samples collected from the monitoring wells in this area. The plume perimeter did not change significantly from 2005 to 2006 (see Figure 6.5). Additionally, the second trichloroethene plume in the X-701B monitoring area (the plume southwest of the X-744G Bulk Storage Building) did not change significantly in 2006.

Samples from five wells in the western portion of the monitoring area were analyzed for selected metals (cadmium, chromium, cobalt, lead, manganese, nickel, and thallium). In third quarter 2006 samples, three metals were detected above the respective preliminary remediation goal in the sample collected from well X701-09G: chromium at 350 μg/L, manganese at 18,000 μg/L, and nickel at 140 μg/L. The turbidity in this well (a measurement of suspended solids or cloudiness of the water) was higher than usual, however, which may have contributed to the elevated concentrations of metals detected in this sample.

Samples from five wells in or near the X-744Y Storage Yard and X-744G Bulk Storage Building were analyzed for cadmium and nickel, which were detected above preliminary remediation goals in three of the five wells. These results are typical for the X-744 area wells.

Radionuclides were also detected in the groundwater in this area. Remediation of groundwater is being accomplished in accordance with the RCRA Corrective Action Program.

6.4.5 X-633 Pumphouse/Cooling Towers Area

The X-633 Pumphouse/Cooling Towers Area consists 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.

The X-633 Pumphouse/Cooling Towers Area 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 to assess the area for metals contamination. Based on the results of this study, this area was added to the PORTS groundwater monitoring program. Two wells (see Figure 6.6) are sampled semiannually for chromium as part of the monitoring program for this area.

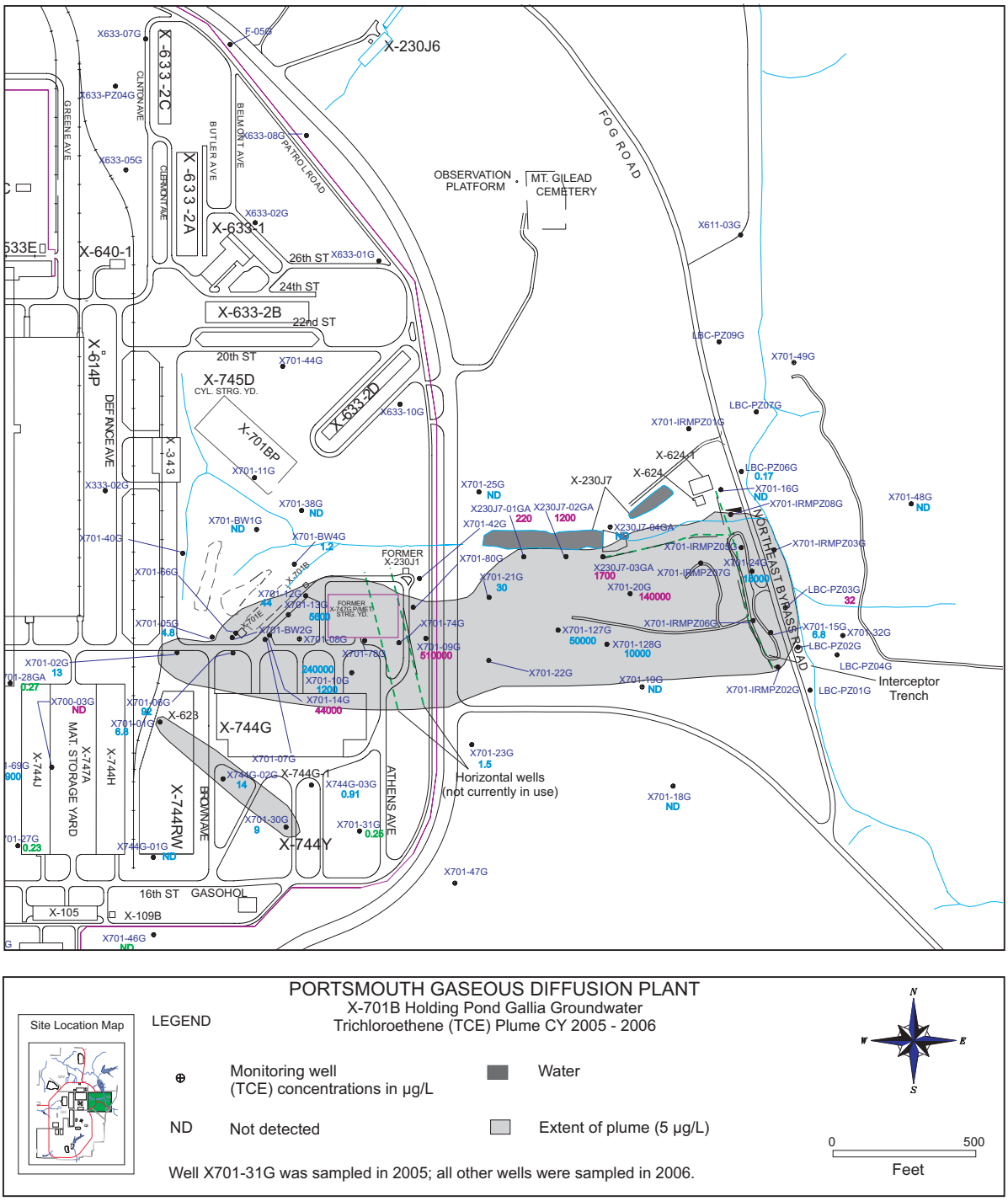

Figure 6.5. Trichloroethene-contaminated Gallia groundwater plume at the X-701B Holding Pond – 2006.

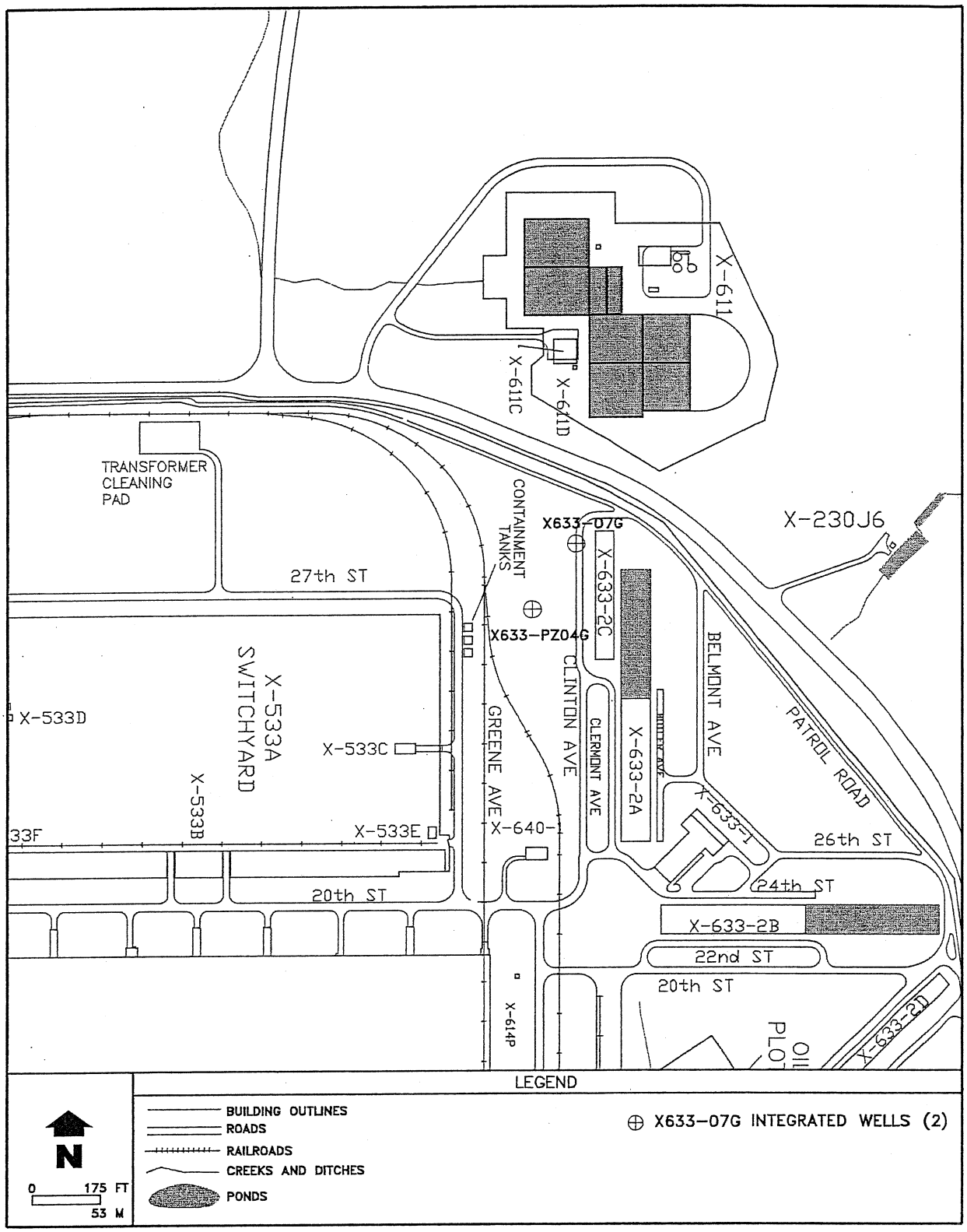

Figure 6.6. Groundwater monitoring wells at the X-633 Pumphouse/Cooling Towers Area.

6.4.5.1 Monitoring results for the X-633 Pumphouse/Cooling Towers Area in 2006

Chromium was detected in both of the X-633 monitoring wells in 2006. Samples collected from well X633-07G contained chromium at concentrations above the preliminary remediation goal of 100 μg/L: 510 μg/L (second quarter) and 790 μg/L (fourth quarter). Samples collected from well X633-PZ04G also contained chromium but at levels well below the preliminary remediation goal. These results are typical for these wells.

6.4.6 X-616 Chromium Sludge Surface Impoundments

The X-616 Chromium Sludge Surface Impoundments 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. Seven wells are sampled annually and nine wells are sampled biennially as part of the monitoring program for this area. Table 6.1 lists the analytical parameters for the wells in this area.

6.4.6.1 Monitoring results for the X-616 Chromium Sludge Surface Impoundments in 2006

Chromium is of special concern at the X-616 because of the previous use of the area. Chromium is routinely detected above the preliminary remediation goal (100 μg/L) in the samples collected from well X616-05G and was detected at 580 μg/L in the sample collected in 2006. Chromium was not detected at concentrations above the preliminary remediation goal in any other X-616 well. Concentrations of chromium detected in well X616-05G have exceeded the preliminary remediation goal in previous years as well. Figure 6.7 shows the concentrations of chromium in wells at the X-616. Nickel was also 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.

Volatile organic compounds were detected at low levels in samples collected from five wells in this area. The only volatile organic compounds detected above the preliminary remediation goals were 1,1-dichloroethene and trichloroethene. Remediation of groundwater is being accomplished in accordance with the RCRA Corrective Action Program.

6.4.7 X-740 Waste Oil Handling Facility

The X-740 Waste Oil Handling Facility, which is located on the western half of PORTS south of the X-530A Switchyard, consists of two hazardous waste management units: the X-740 Waste Storage Facility and the X-740 Hazardous Waste Storage Tank (sump), which was located within the building. 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. The tank/sump, which was operated until 1990, was used 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 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.

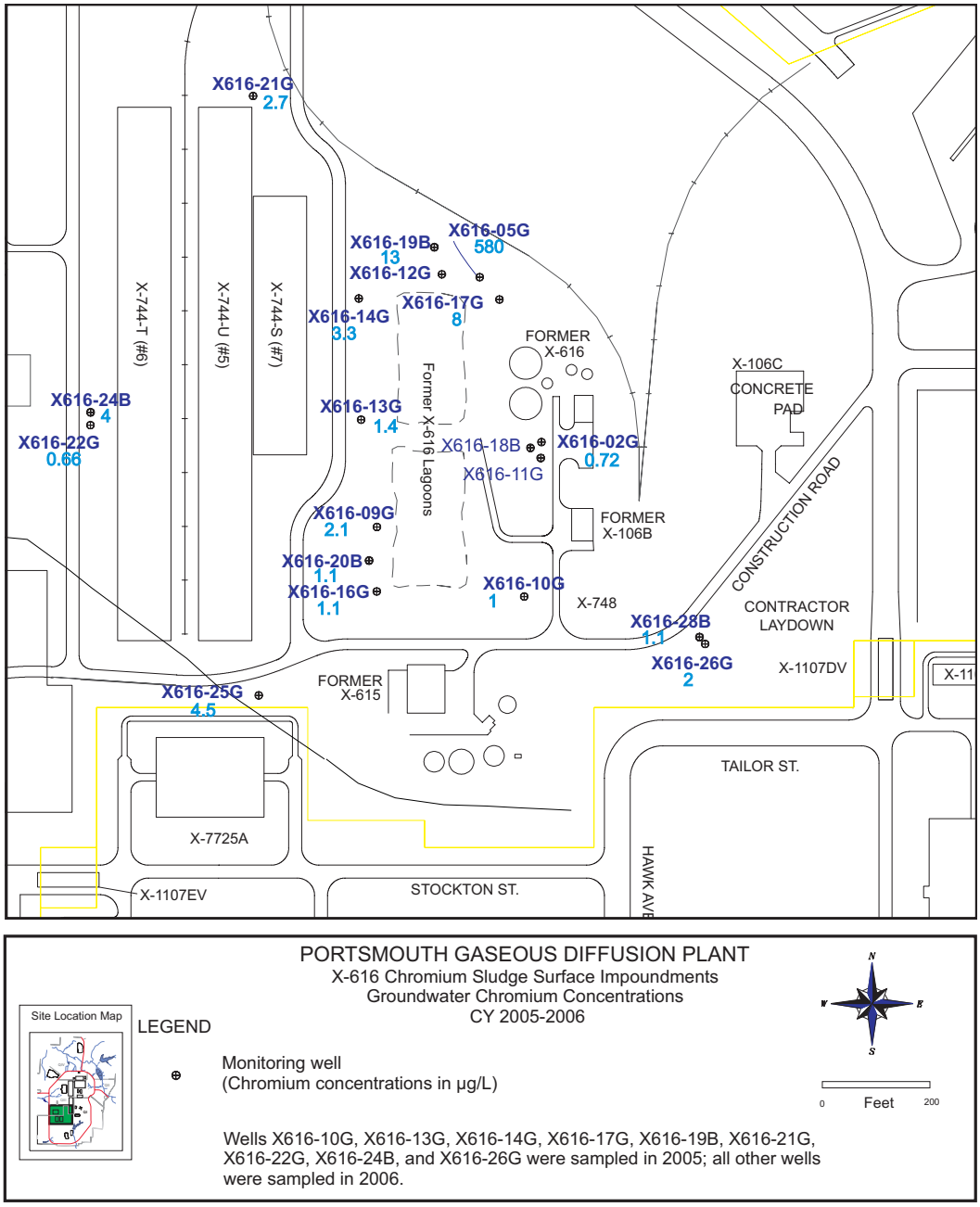

Figure 6.7. Chromium concentrations in groundwater at the X-616 Chromium Sludge Surface Impoundments – 2006.

In 1999, poplar trees were planted in a 2.6-acre area above the groundwater plume near the X-740 Waste Oil Handling Facility. This remediation technique, called phytoremediation, uses plants to remove or degrade contaminants in soil and groundwater. The monitoring program for the X-740 area includes monitoring of water levels around the trees to evaluate water usage by the trees, in addition to routine monitoring of groundwater wells for contaminants.

Eleven wells are sampled semiannually, three wells are sampled annually, and four wells are sampled biennially as part of the monitoring program for this area. Table 6.1 lists the analytical parameters for the wells in this area.

6.4.7.1 Monitoring results for the X-740 Waste Oil Handling Facility in 2006

Water level measurements are collected on a frequent basis from the X-740 monitoring wells during the growing season to determine whether the poplar trees that comprise the phytoremediation system for this area are using water as intended. Hourly water level measurements collected at two X-740 Gallia wells from July 1 through September 30, 2006 indicated groundwater usage by the trees.

A contaminated groundwater plume consisting of primarily trichloroethene is located near the X-740 Waste Oil Handling Facility (see Figure 6.8). Concentrations of trichloroethene detected in the X-740 wells, as well as the plume perimeter, were similar to data collected in previous years. Inorganics (metals) and radionuclides were also detected in 2006. Remediation of groundwater is being accomplished in accordance with the RCRA Corrective Action Program.

6.4.8 X-611A Former Lime Sludge Lagoons

The X-611A Former Lime Sludge Lagoons were 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 cover a surface area of approximately 18 acres. The lagoons were constructed in a low-lying area that included Little Beaver Creek. As a result, approximately 1500 feet of Little Beaver Creek was 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. 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.

6.4.8.1 Monitoring results for the X-611A Former Lime Sludge Lagoons in 2006

The six monitoring wells at X-611A (see Figure 6.9) are sampled and analyzed for beryllium and chromium. In 2006, chromium was detected in each well in this area at concentrations between 0.58 and 5.6 μg/L. These results are below the preliminary remediation goal (100 μg/L).

Beryllium was detected in both samples collected from well F-07G at 8.6 μg/L (first quarter) and 3 μg/L (third quarter). The result for the first quarter is above the preliminary remediation goal (6.5 μg/L for Gallia wells), and the result for the third quarter sample is below the preliminary remediation goal. Samples collected from well F-07G routinely contain beryllium at concentrations just below or just above the preliminary remediation goal. Beryllium was not detected above the preliminary remediation goal in any other samples collected from X-611A wells in 2006.

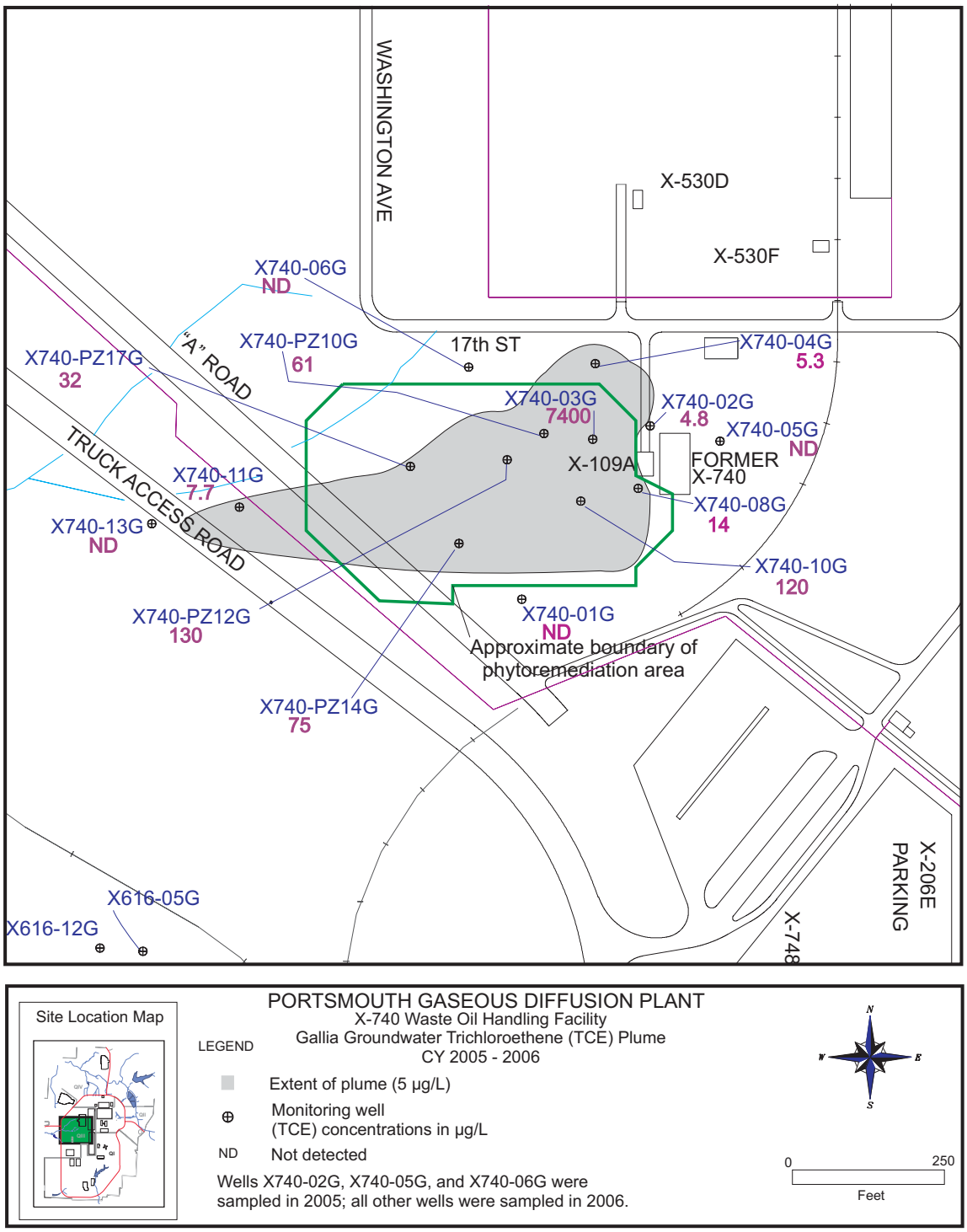

Figure 6.8. Trichloroethene-contaminated Gallia groundwater plume near the X-740 Waste Oil Handling Facility – 2006.

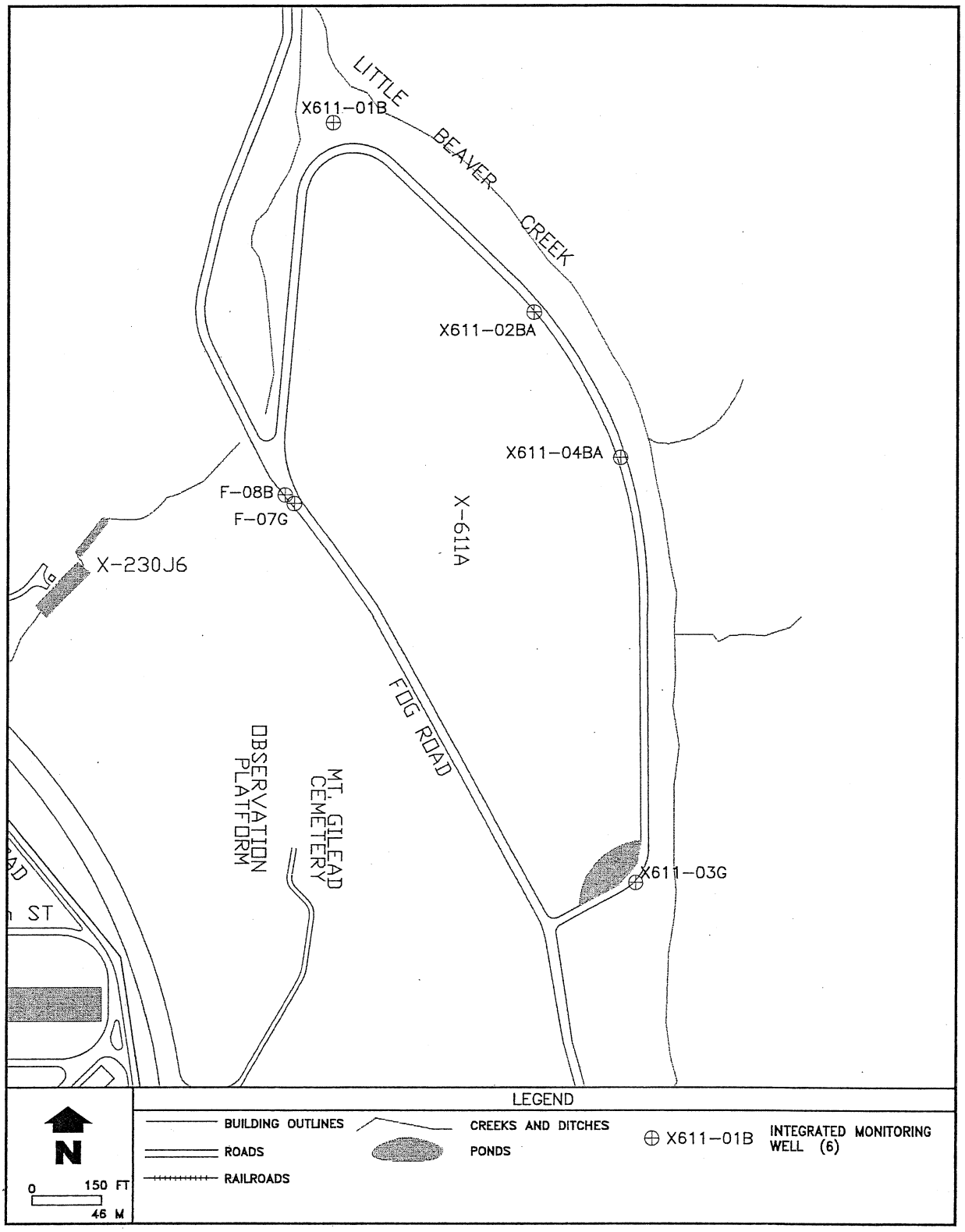

Figure 6.9. Monitoring wells at the X-611A Former Lime Sludge Lagoons.

6.4.9 X-735 Landfills

Several distinct waste management units are contained within the X-735 Landfills area. The main units consist of the hazardous waste landfill, referred to as the X-735 Landfill (Northern Portion), 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 closed 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 the 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 December 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 Landfill (Northern Portion).

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. Eighteen wells are sampled semiannually under the routine monitoring program for this area. Table 6.1 lists the analytical parameters and Figure 6.10 shows the monitoring wells in this area.

6.4.9.1 Monitoring results for the X-735 Landfills in 2006

Statistical evaluations of data collected from wells at the X-735 Landfills are completed to monitor the landfill for releases. In general, analytical results from previous sampling events are used to calculate control limits for selected monitoring parameters at designated X-735 monitoring wells. For example, analytical results for alkalinity from eight sampling events at well X735-05GA between 1998 and 2001 are used to calculate two control limits for alkalinity at this well (these data are considered the baseline data). For each sampling event, results for alkalinity in well X735-05G are evaluated against these limits. If the limits are exceeded, it is possible that a release from the landfill has occurred, although exceedences can also happen due to variations in groundwater quality and other reasons.

Assessment monitoring at the X-735 Landfills began in 2004 and continued through 2006 because of exceedences in the control limits for several monitoring parameters at several of the Gallia monitoring wells for the X-735 Landfills. Assessment monitoring is intended to determine the concentration, rate, and extent of migration of contaminants in the groundwater. Data for assessment monitoring at the X-735 Landfills in 2006 are provided in the *2006 Groundwater Monitoring Report for the Portsmouth Gaseous Diffusion Plant*.

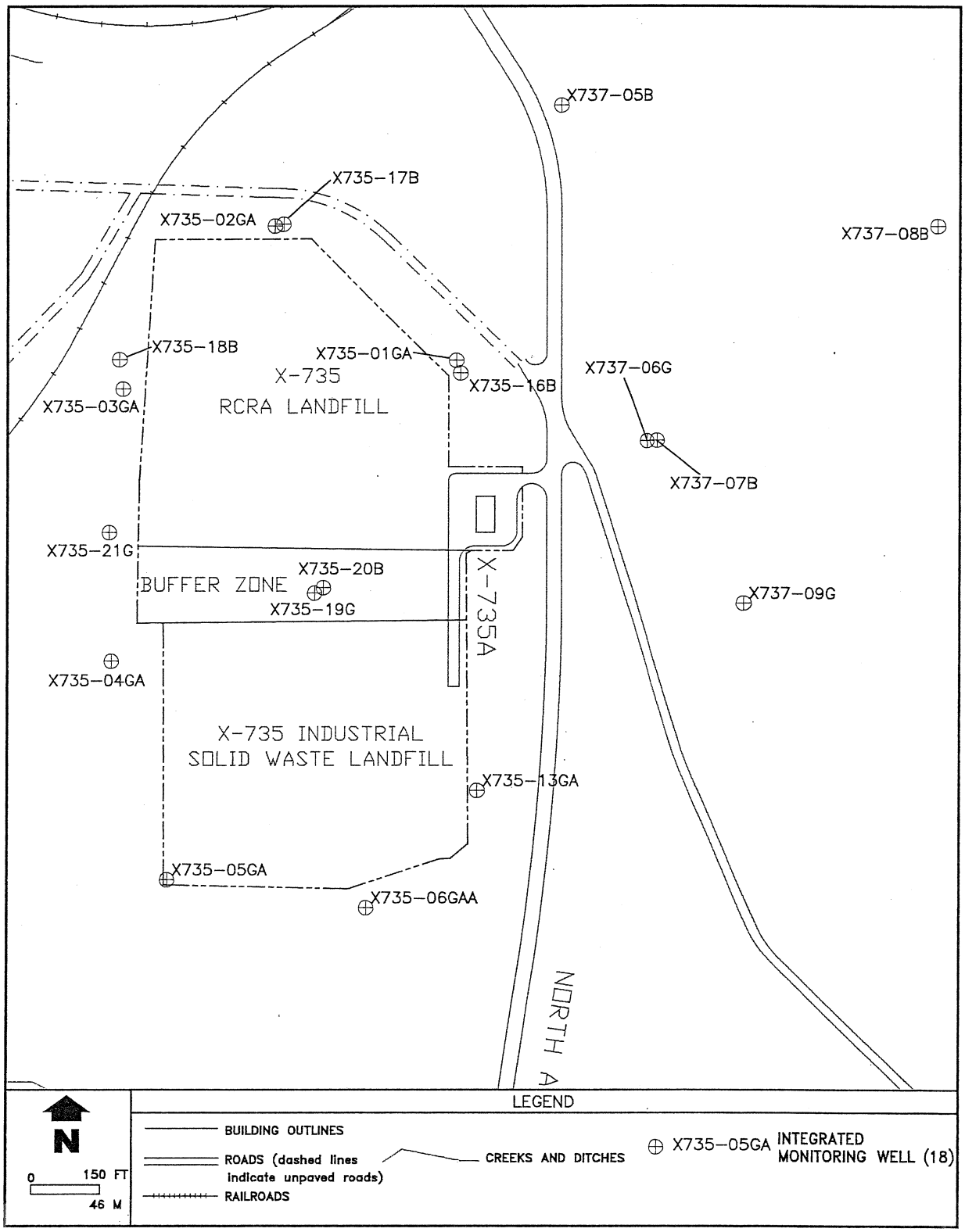

Figure 6.10. Monitoring wells at the X-735 Landfills.

Based on the results of assessment monitoring, DOE developed the *Corrective Measures Plan for the X-735 Landfill* in 2006. Ohio EPA had not approved this plan by the end of 2006.

In addition to assessment monitoring, routine monitoring required by the *Integrated Groundwater Monitoring Plan* was completed during 2006. Samples collected during the second quarter of 2006 were analyzed for volatile organic compounds. No volatile organics were detected in the routine X-735 samples collected in the second quarter of 2006 with the exception of methylene chloride and acetone, which are common laboratory contaminants and not indicative of a release.

No transuranic radionuclides or technetium-99 were detected in the X-735 wells sampled during 2006.

6.4.10 X-734 Landfills

The X-734 Landfills 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 include 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 Sanitary Landfill was closed in accordance with the solid waste regulations in effect at that time, and no groundwater monitoring of the unit was required. The X-734 Landfills were capped in 1999-2000 as part of the remedial actions required for Quadrant IV.

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.

6.4.10.1 Monitoring results for the X-734 Landfills in 2006

Volatile organic compounds (not including sample contaminants acetone and methylene chloride) were detected in samples collected from seven wells in the X-734 monitoring area in 2006. Vinyl chloride is the only compound that exceeded the preliminary remediation goal (2 μg/L). In the second quarter and fourth quarter samples collected from well X734-23G, vinyl chloride was detected at 4.2 and 3.7 μg/L, respectively. The presence of vinyl chloride, *cis*-1,2-dichloroethene, and *trans*-1,2-dichloroethene in well X734-23G, along with the absence of trichloroethene may indicate that natural reductive dechlorination of the trichloroethene is occurring beneath the X-734 Landfills.

Cobalt is also monitored in the X-734 Landfills area. Cobalt was detected in five wells in 2006 (X734-01G, X734-06G, X734-15G, X734-16G, and X734-23G) at concentrations equal to or exceeding the preliminary remediation goal of 13 μg/L for Gallia wells. These detections ranged from 13 to 110 μg/L and are typical for these wells. Additional inorganics (metals) and radionuclides were also detected in 2006. Control and monitoring of groundwater is being accomplished in accordance with the RCRA Corrective Action Program.

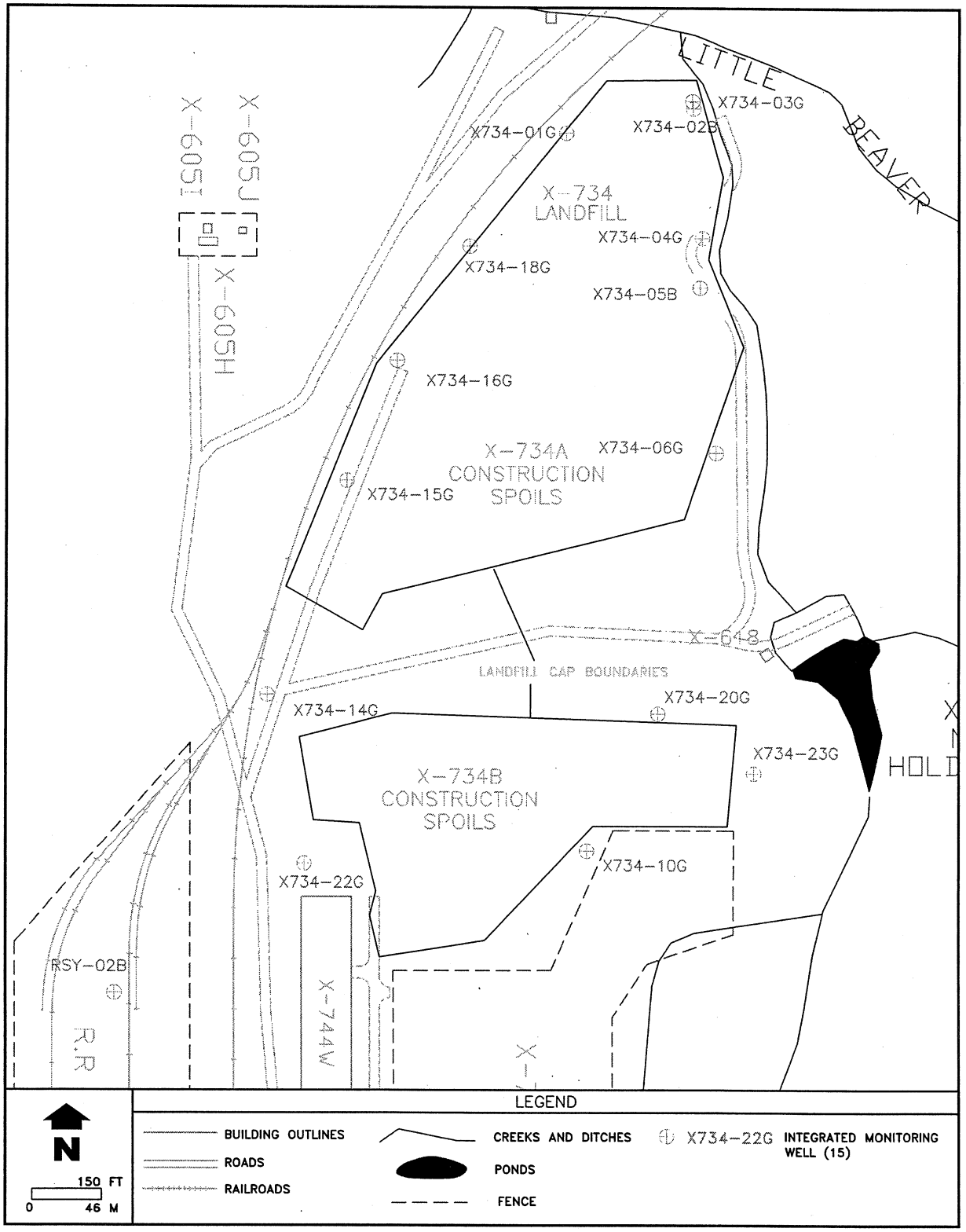

Figure 6.11. Monitoring wells at the X-734 Landfills.

6.4.11 X-533 Switchyard Area

The X-533 Switchyard Area consists 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.

The X-533 Switchyard Area 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 to assess the area for metals contamination. The area was added to the PORTS groundwater monitoring program because the study identified three metals (cadmium, cobalt, and nickel) that may have contaminated groundwater in this area. Three wells are sampled semiannually for cadmium, cobalt, and nickel.

6.4.11.1 Monitoring results for the X-533 Switchyard Area in 2006

Two Gallia wells that monitor the X-533 Switchyard Area (see Figure 6.12) were sampled in the second and fourth quarters of 2006 and analyzed for cadmium, cobalt, and nickel. Each of the well samples contained these metals at concentrations above the preliminary remediation goals (6.5 μg/L for cadmium, 13 μg/L for cobalt, and 100 μg/L for nickel). Concentrations of cadmium detected in the wells ranged from 10 to 38 μg/L, concentrations of cobalt detected in the wells ranged from 32 to 70 μg/L, and concentrations of nickel detected in the wells ranged from 170 to 430 μg/L. These results are typical for these wells.

6.4.12 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 13 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 plume groundwater discharges.

- Little Beaver Creek sample location LBC-SW03 assesses potential contamination from the Former X-611A Lime Sludge Lagoons.

- Big Run Creek sample locations BRC-SW01 and BRC-SW02 assess potential groundwater discharges related to the X-231B Southwest Oil Biodegradation Plot, the Quadrant I Groundwater Investigative Area plume, and the X-749/X-120/PK Landfill area plume, all of which discharge into the X-230K Holding Pond and Big Run Creek.

- Southwestern Drainage Ditch sample locations UND-SW01 and UND-SW02 assess potential groundwater releases to this creek and the X-2230M 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.

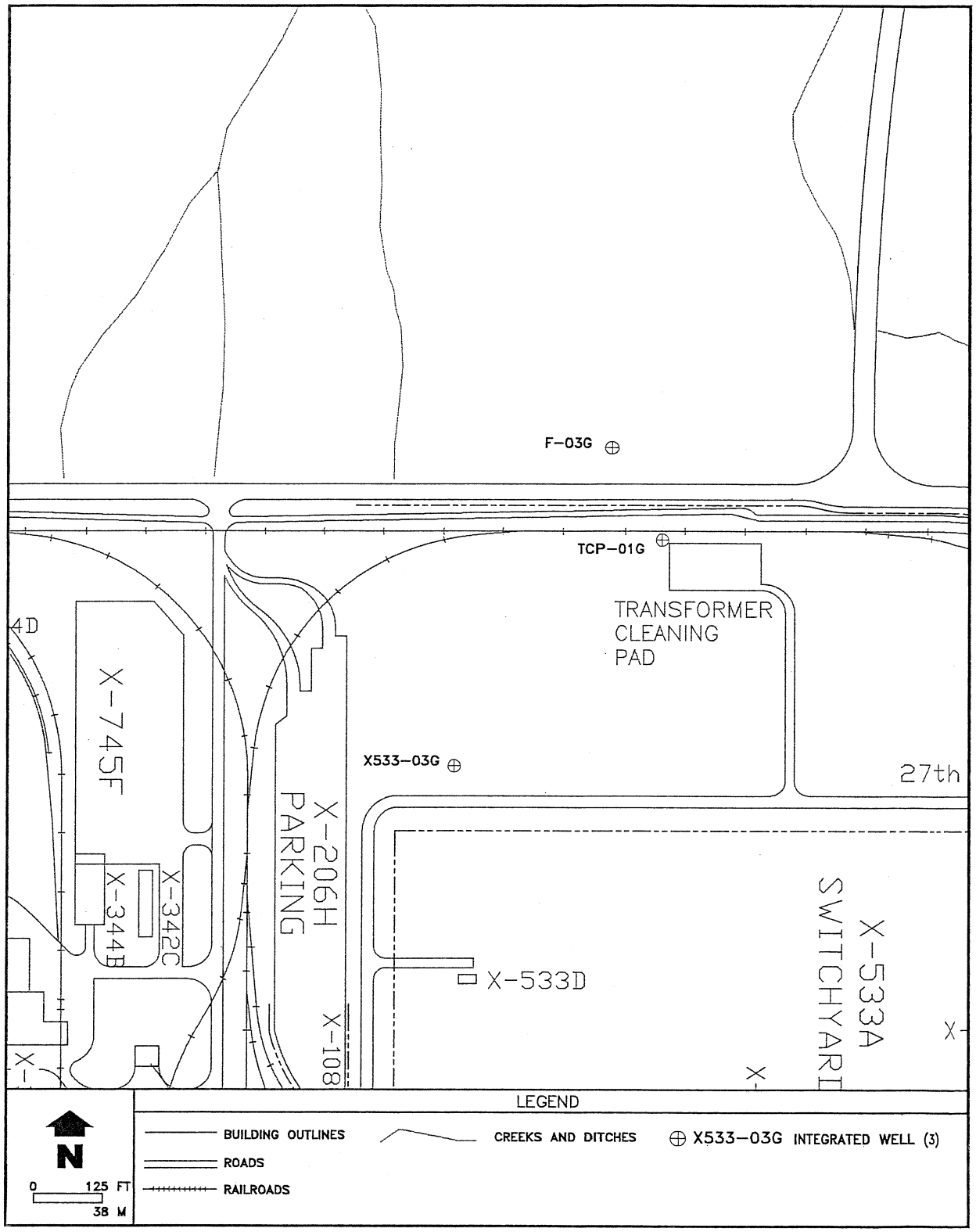

Figure 6.12. Monitoring wells at the X-533 Switchyard Area.

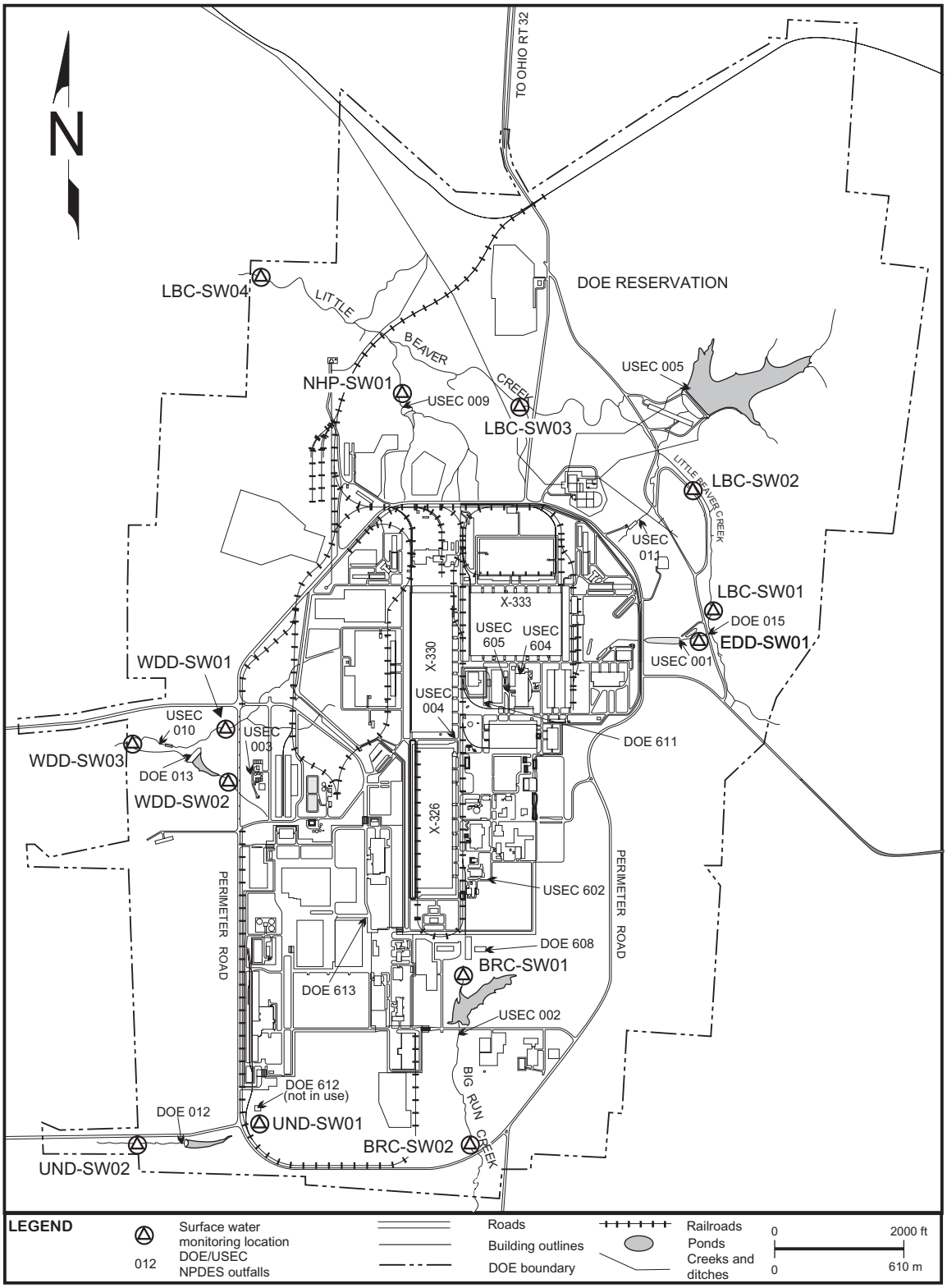

Figure 6.13. Surface water monitoring locations.

- 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 Holding Pond.

6.4.12.1 Monitoring results for surface water in 2006

Since 1990, trichloroethene has been detected regularly at low levels in samples collected from the Southwestern Drainage Ditch (UND-SW01, located inside the perimeter road). Trichloroethene was detected at concentrations ranging from 1.7 to 6.9 μg/L in three of the four samples collected from the Southwestern Drainage Ditch at UND-SW01 in 2006. Trichloroethene was not detected in the sample collected at UND-SW01 in the fourth quarter, but trichloroethene was detected at an estimated concentration of 1.5 μg/L in the sample collected from UND-SW02, which is downstream from UND-SW01. Trichloroethene was not detected in the first through third quarter samples collected at UND-SW02. Several other volatile organic compounds were detected at estimated concentrations less than 1 μg/L in the samples collected from UND-SW01 (*cis*-1,2-dichloroethene, 1,1-dichloroethene, and 1,1-dichloroethane). Concentrations of volatile organic compounds detected at the Southwestern Drainage Ditch sampling location UND-SW01 (trichloroethene, *cis*-1,2-dichloroethene, 1,1-dichloroethene, and 1,1-dichloroethane) and UND-SW02 (trichloroethene) were below applicable Ohio EPA water quality criteria (if available) for the protection of human health in the Ohio River drainage basin. These criteria are 810 μg/L for trichloroethene and 32 μg/L for 1,1-dichloroethene.

Trichloroethene and/or *cis*-1,2-dichloroethene were also detected at estimated concentrations less than 0.6 μg/L in samples collected during 2006 from East Drainage Ditch sampling location EDD-SW01 and Little Beaver Creek sampling locations LBC-SW01 and LBC-SW02. The detections of trichloroethene were well below the applicable Ohio EPA water quality criterion for trichloroethene (810 μg/L) for the protection of human health in the Ohio River drainage basin.

Discharges of trichloroethene from DOE NPDES Outfall 015 in 2006 were all below the discharge limitation set by Ohio EPA. None of the compounds detected in these samples was detected at sampling location LBC-SW04, which monitors Little Beaver Creek at the PORTS boundary. Therefore, these compounds were not present in the surface water exiting the PORTS site.

Trihalomethanes are a category of volatile organic compounds 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 applicable Ohio EPA 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).

Surface water samples are analyzed for transuranic radionuclides (americium-241, neptunium-237, plutonium-238, and plutonium-239/240). No transuranics were detected in the surface water samples collected during 2006.

In the first quarter of 2006, technetium-99 was detected in the East Drainage Ditch sample and each Little Beaver Creek sample at activities ranging from 12.7 pCi/L (LBC-SW01) to 22.8 pCi/L (EDD-SW01). Technetium-99 was not detected in any of the surface water samples collected during the second, third, or fourth quarters of 2006. These detections are well below the EPA drinking water standard for technetium-99 (900 pCi/L, based on a 4 mrem/year dose from beta emitters).

Uranium was routinely detected in surface water samples at concentrations similar to those detected in 2005. Because uranium occurs naturally in rocks and soil, some or all of the uranium detected in these samples may be due to naturally-occurring uranium. Detections of uranium and uranium isotopes in surface water samples in 2006 were well below the DOE derived concentration guide for the respective uranium isotope in drinking water (500 pCi/L for uranium-233/234 and 600 pCi/L for uranium-235 and uranium-238).

6.4.13 Water Supply Monitoring

Routine monitoring of 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 Residential Groundwater Monitoring Requirements contained in the *Integrated Groundwater Monitoring Plan.*

The purpose of the program is to determine whether residential drinking water sources have been adversely affected by plant operations. 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).

Six residential drinking water sources participated in the program in 2006 (see Figure 6.14). Wells are sampled semiannually with two samples collected from each well: a regular sample and a duplicate sample. Each sample is analyzed for the parameters listed in Table 6.1. The PORTS water supply (RES-012 on Figure 6.14) is also sampled as part of this program. Sampling locations may be added or deleted if requested by a resident and as program requirements dictate. Typically, sampling locations are deleted when a resident obtains a public water supply.

In the third quarter, trichloroethene was detected at an estimated concentration of 0.2 μg/L in both residential water supply samples collected at location RES-004 (south of PORTS on the east side of Big Run Creek). These detections cannot be related to PORTS groundwater contamination because the water-bearing formations are not hydrogeologically connected. The detections are less than the EPA drinking water standard for trichloroethene (5 μg/L).

Chloromethane was also detected at an estimated concentration of 0.42 μg/L in one of the two third quarter samples collected from RES-014 (south of PORTS on Wakefield Mound Road). This detection is most likely associated with cross-contamination or contamination of the sample containers. No other volatile organic compounds were detected in the water supply samples collected during 2006, with the exception of the common sample contaminants acetone and methylene chloride, which were also detected in some of the laboratory blanks and trip blanks associated with the samples and do not indicate any water quality problems.

Metals detected in the water supply samples were within naturally-occurring concentrations found in the area. No transuranics (americium-241, neptunium-237, plutonium-238, and plutonium-239/240) or technetium-99 were detected in any of the water supply samples collected in 2006. Low levels of uranium and uranium isotopes detected in some of the wells are consistent with naturally-occurring concentrations found in common geologic materials.

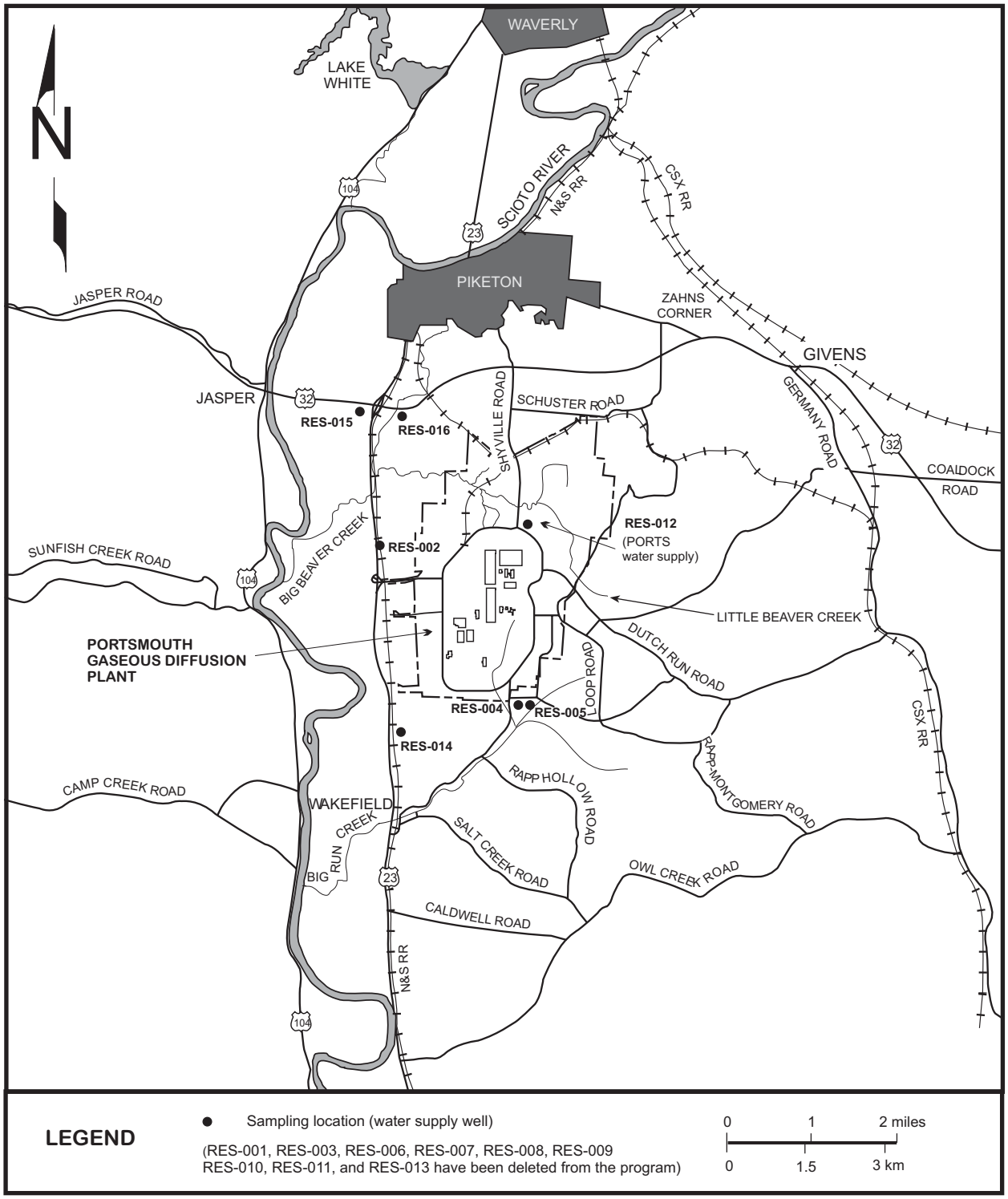

Figure 6.14. Water supply monitoring locations.

6.5 DOE ORDER MONITORING PROGRAMS

The surveillance monitoring program at DOE PORTS consists of exit pathway monitoring. Exit pathway monitoring assesses the effect of the facility on off-site 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 groundwater discharges 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. Sample contaminants acetone and methylene chloride were detected in a few of the samples collected from these locations in 2006. Trihalomethanes (bromodichloromethane, bromoform, chloroform, and dibromochloromethane), which are common residuals in chlorinated drinking water, were detected in samples collected from Big Run Creek and 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.

Trichloroethene was detected at an estimated concentration of 1.5 μg/L in the fourth quarter sample collected from UND-SW02. This detection is less than both the applicable Ohio EPA non-drinking water quality criterion for trichloroethene (810 μg/L) for the protection of human health in the Ohio River drainage basin and the EPA drinking water standard for trichloroethene (5 μg/L). Technetium-99 was detected at 14.5 pCi/L in the first quarter sample collected from LBC-SW04, which is less than the EPA drinking water standard for technetium-99 (900 pCi/L, based on a 4 mrem dose from beta emitters).

Metals, including uranium, were detected at concentrations consistent with background concentrations for these parameters. Section 6.4.12.1 provides additional information for these monitoring results.

In 2006, volatile organic compounds, including trichloroethene, were detected in three of the exit pathway groundwater monitoring wells (X749-44G, X749-45G, and X749-97G) that monitor the X-749 South Barrier Wall and are part of the monitoring program for the X-749/X-120/PK Landfill monitoring area (see Figure 6.2 and Section 6.4.1.3). Concentrations of trichloroethene detected in the samples from these wells were 31 and 32 μg/L in well X749-44G, 22 and 57 μg/L in well X749-45G, and 8.6 to 46 μg/L in well X749-97G. These detections exceed the EPA drinking water standard for trichloroethene (5 μg/L); however, these monitoring wells are located within the PORTS boundary. Remediation of groundwater is being accomplished in accordance with the RCRA Corrective Action Program.

No transuranics or technetium-99 were detected in exit pathway monitoring wells sampled for radionuclides during 2006.

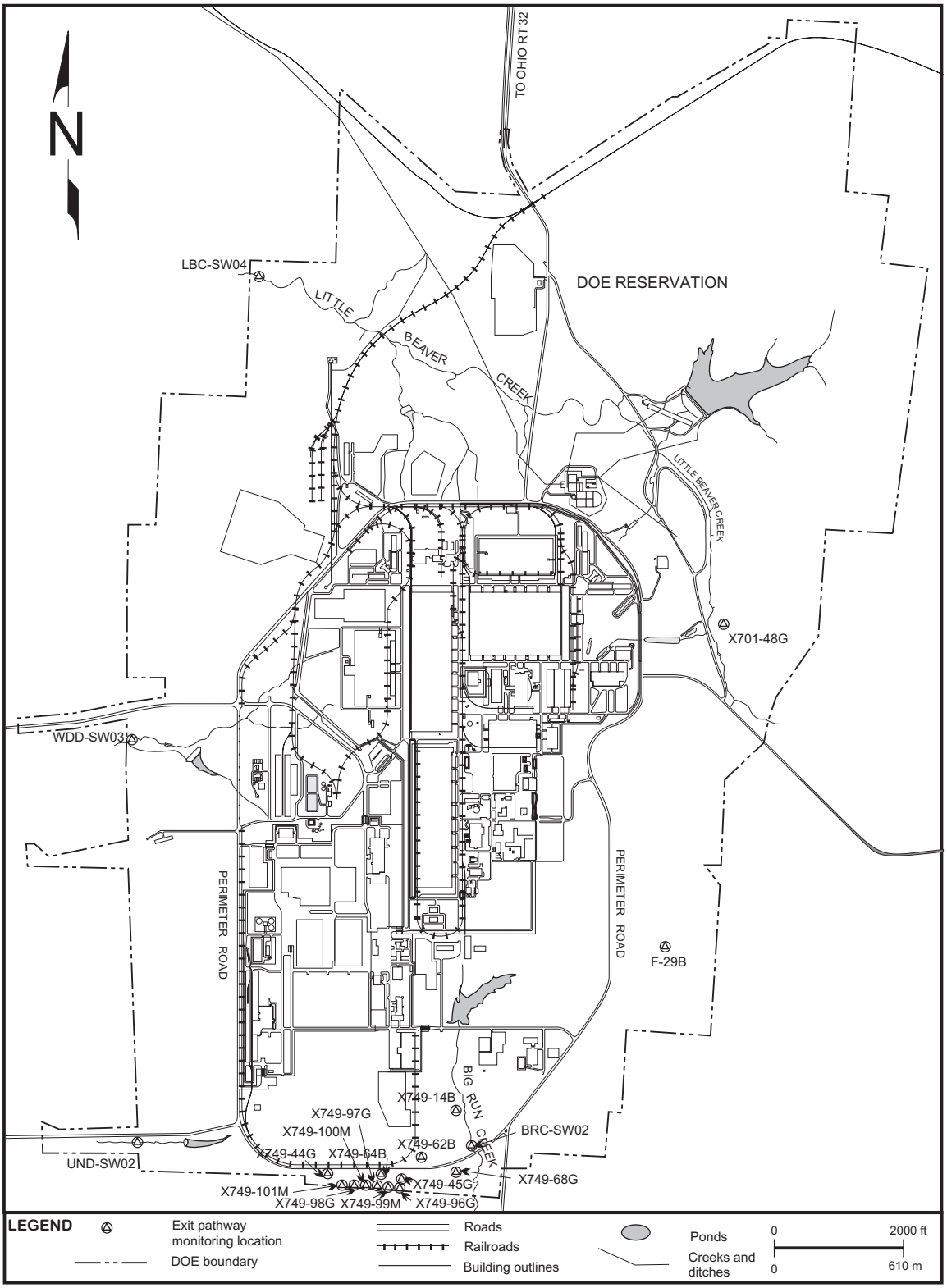

Figure 6.15. Exit pathway monitoring locations.

6.6 GROUNDWATER TREATMENT FACILITIES

In 2006, a combined total of approximately 25.2 million gallons of water were treated at the X-622, X-623, X-624, and X-627 Groundwater Treatment Facilities. Approximately 97 gallons of trichloroethene 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 trichloroethene removed by DOE PORTS groundwater treatment facilities in 2006

Facility	Gallons of water treated	Gallons of TCE removed
X-622	12,326,000	1
X-623	2,993,752	64
X-624	2,149,481	9
X-627	7,754,769	23

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:

- Groundwater collection system and associated sump (X749-WPW) on the southwest boundary of the X-749 Landfill;
- Groundwater collection system and associated sumps (PK-PL6 and PK-PL6A) on the eastern boundary of the PK Landfill; and
- Fourteen extraction wells located in the Quadrant I Groundwater Investigative Area.

The facility processed approximately 12.3 million gallons of groundwater during 2006, thereby removing approximately 1 gallon of trichloroethene from the water. Treated water from the facility discharges through DOE NPDES Outfall 608, which flows to the USEC Sewage Treatment Plant. No NPDES permit limitations were exceeded at Outfall 608 in 2006.

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. The X-623 Groundwater Treatment Facility treats trichloroethene-contaminated groundwater from a sump in the bottom of the X-701B Holding Pond and three groundwater extraction wells (#1, #2, and #3) east of the holding pond

The facility treated approximately 3 million gallons of water during 2006, thereby removing approximately 64 gallons of trichloroethene from the water. Treated water from the facility discharges through DOE NPDES Outfall 610, which flows to the USEC Sewage Treatment Plant. No NPDES permit limitations were exceeded at Outfall 610 in 2006.

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 trichloroethene-contaminated groundwater from the X-701B groundwater plume, specifically the X-237

Groundwater Collection System, which consists of north-south and east-west collection trenches and sumps #1 and #2.

The X-624 Groundwater Treatment Facility treated approximately 2.1 million gallons of water in 2006, thereby removing approximately 9 gallons of trichloroethene from the water. Treated water from the facility discharges through DOE NPDES Outfall 015, which discharges to Little Beaver Creek. The X-624 Groundwater Treatment Facility did not operate from July 17, 2006 through September 30, 2006 due to construction in the area. Water from the treatment facility was transported to the X-623 Groundwater Treatment Facility for processing. No NPDES permit limitations were exceeded at Outfall 015 in 2006.

6.6.4 X-625 Groundwater Treatment Facility

On July 9, 2003, the X-625 Groundwater Treatment Facility was placed on stand-by with approval from Ohio EPA. The X-625 Groundwater Treatment Facility did not operate in 2006.

6.6.5 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 Area plume, and contaminated groundwater is extracted from sumps located in the basement of each building.

Approximately 7.8 million gallons of groundwater were processed during 2006, thereby removing 23 gallons of trichloroethene from the water. Treated water from the facility discharges through DOE NPDES Outfall 611, which flows to the USEC Sewage Treatment Plant. No NPDES permit limitations were exceeded at Outfall 611 in 2006.

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7. QUALITY ASSURANCE

7.1 SUMMARY

Quality assurance and quality control are essential components of environmental monitoring at DOE 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 PORTS programs.

7.2 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 PORTS 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 at DOE 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 the 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 at DOE PORTS. Quality Assurance Project Plans were used by LPP during 2006 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 PORTS contract requirements. Procedures are developed from guidelines and regulations created by DOE or other regulatory agencies that have authority over DOE PORTS activities. These procedures specify sampling protocol, sampling devices, and 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 PORTS quality assurance program 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 PORTS only uses 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 they are received by DOE PORTS, analytical laboratory data 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.

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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 DOE 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).

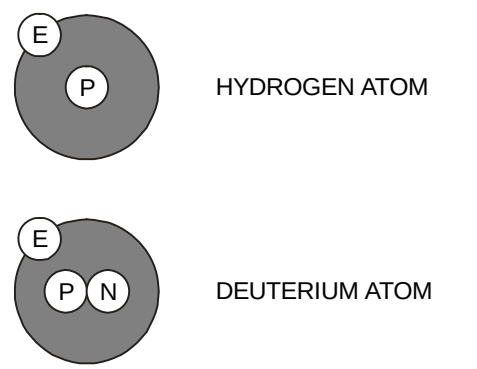
> *radioactivity*—A particular type of radiation emitted by a radioactive substance, such as alpha radioactivity (McGraw-Hill 1989).

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.



	PROTONS	NEUTRONS
HYDROGEN	1	0
DEUTERIUM	1	1

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.

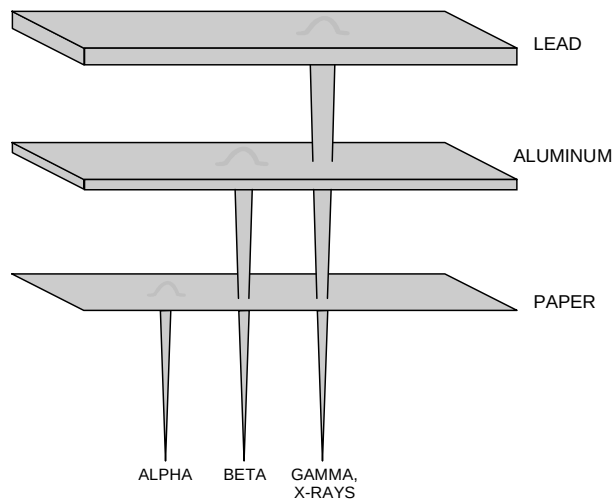


Figure A.2. Penetrating power of radiation.

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 cosmic, terrestrial, or internal, depending on its origin.

A.3.1.1 Cosmic 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 cosmic radiation. Because the atmosphere provides some shielding against cosmic radiation, the intensity of this radiation increases with altitude above sea level. For example, a person in Denver, Colorado, is exposed to more cosmic 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-235 (^{235}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 fallout from atmospheric atomic bomb tests. (Atmospheric testing of atomic weapons has been suspended in the United States and most parts of the world.) Also, about one-half of 1% of the U.S. population performs work in which radiation in some form is present.

A.3.2.1 Consumer products

Some consumer products are sources of radiation. In some of these products, such as smoke detectors and airport X-ray baggage inspection systems, radiation is essential to the performance of the device. In other products, such as television and tobacco products, the radiation occurs incidentally to the product function.

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 from diagnostic or therapeutic X-rays 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 Other sources

Other sources of radiation include fallout from atmospheric atomic bomb tests; 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.

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.

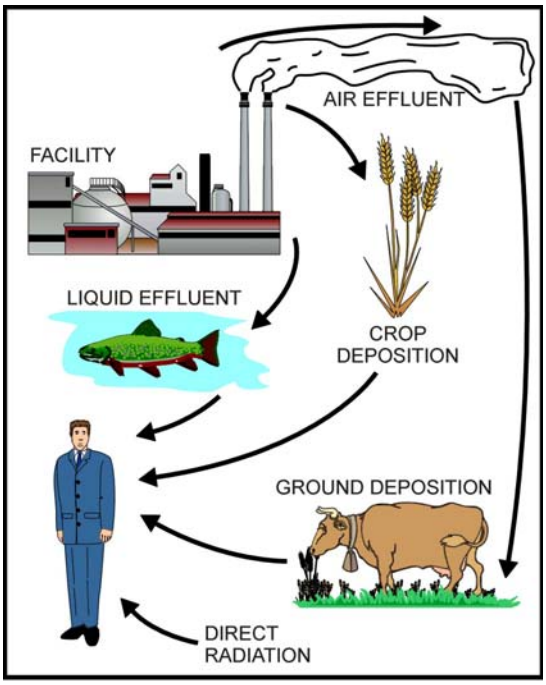


Figure A.3. Possible radiation pathways.

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 = 3.75E+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 = 3.7×10^{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 Equivalent

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 equivalents are defined as follows:

- **dose equivalent** – The product of the absorbed dose (rad) in tissue and a quality factor. Dose equivalent is expressed in units of rem (or sievert) (1 rem = 0.01 sievert).

- **committed dose equivalent** – The calculated total dose equivalent 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 dose equivalent is expressed in units of rem (or sievert).

- **committed effective dose equivalent** – The sum of the committed dose equivalents to various tissues in the body, each multiplied by an appropriate weighting factor. Committed effective dose equivalent is expressed in units of rem (or sievert).

- **effective dose equivalent** – The sum of the dose equivalents received by all organs or tissues of the body after each one has been multiplied by the appropriate weighting factor. The effective dose equivalent includes the committed effective dose equivalent from internal deposition of radionuclides and the effective dose equivalent attributable to sources external to the body.

- **collective dose equivalent/collective effective dose equivalent** – The sums of the dose equivalents or effective dose equivalents of all individuals in an exposed population within a 50-mile (80-km) radius, expressed in units of person-rem (or person-sievert). When the collective dose equivalent of interest is for a specific organ, the units would be organ-rem (or organ-sievert). The 50-mile distance is measured from a point located centrally with respect to major facilities or DOE program activities.

A.6 DOSE

Many terms are used to report dose. Several factors are taken into account, including the amount of radiation absorbed, the organ absorbing the radiation, and the effect of the radiation over a 50-year period. The term "dose" in this report includes the committed effective dose equivalent and effective dose equivalent attributable to penetrating radiation from sources external to the body.

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 cosmic radiation

The average annual dose received by residents of the United States from cosmic radiation is about 27 mrem (0.27 mSv) (National Council on Radiation Protection 1987). The average annual dose from cosmic radiation received by residents in the Portsmouth area is about 50 mrem (0.50 mSv).

A.6.1.2 Dose from terrestrial radiation

The average annual dose received from terrestrial gamma radiation is about 28 mrem (0.28 mSv) in the United States. This dose varies geographically across the country (National Council on Radiation Protection 1987); typical reported values are 16 mrem (0.16 mSv) at the Atlantic and Gulf coastal plains and 63 mrem (0.63 mSv) at the eastern slopes of the Rocky Mountains.

A.6.1.3 Dose from internal radiation

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 200 mrem (2.00 mSv) per year. This dose estimate is based on an average radon concentration of about 1 pCi/L (0.037 Bq/L) (National Council on Radiation Protection 1987).

Table A.2. Comparison and description of various dose levels

Dose level	Description
1 mrem (0.01 mSv)	Approximate daily dose from natural background radiation, including radon
2.5 mrem (0.025 mSv)	Cosmic dose to a person on a one-way airplane flight from New York to Los Angeles
10 mrem (0.10 mSv)	Annual exposure limit, set up by the U.S. EPA, for exposures from airborne emissions from operations of nuclear fuel cycle facilities, including power plants and uranium mines and mills
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
50 mrem (0.50 mSv)	Average yearly dose from cosmic radiation received by people in the Portsmouth area
66 mrem (0.66 mSv)	Average yearly dose to people in the United States from human-made sources
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
110 mrem (1.10 mSv)	Average occupational dose received by U.S. commercial radiation workers in 1980
244 mrem (2.44 mSv)	Average dose from an upper gastrointestinal diagnostic X-ray series
300 mrem (3.00 mSv)	Average yearly dose to people in the United States from all sources of natural background radiation
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 Radiations 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

Adapted from Savannah River Site Environmental Report for 1993, Summary Pamphlet, WSRC-TR-94-076, Westinghouse Savannah River Company, 1994.

The average dose from other internal radionuclides is about 39 mrem (0.39 mSv) per year, most of which can be attributed to the naturally occurring isotope of potassium, ^{40}K. The concentration of radioactive potassium in human tissues is similar in all parts of the world (National Council on Radiation Protection 1987).

A.6.1.4 Dose from consumer products

The U.S. average annual dose received by an individual from consumer products is about 10 mrem (0.10 mSv) (National Council on Radiation Protection 1987).

A.6.1.5 Dose from medical sources

Nuclear medicine examinations, which involve the internal administration of radiopharmaceuticals, generally account for the largest portion of the dose received from human-made sources. The radionuclides used in specific tests, however, are not distributed uniformly throughout the body. In these cases, comparisons are made using the concept of effective dose equivalent, which relates exposure of organs or body parts to one effective whole-body dose. The average annual effective dose equivalent from medical examinations is 53 mrem (0.53 mSv), including 39 mrem (0.39 mSv) for diagnostic X-rays and 14 mrem (0.14 mSv) for nuclear medicine procedures (National Council on Radiation Protection 1989). The actual doses received by individuals who complete such medical exams are much higher than these values, but not everyone receives such exams each year (National Council on Radiation Protection 1989).

A.6.1.6 Doses from other sources

Small doses received by individuals occur as a result of radioactive fallout from atmospheric atomic bomb tests, 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 (National Council on Radiation Protection 1987).

A comprehensive U.S. EPA report of 1984 projected the average occupational dose to monitored radiation workers in medicine, industry, the nuclear fuel cycle, government, and miscellaneous industries to be 105 mrem (1.05 mSv) per year for 1985, down slightly from 110 mrem (1.10 mSv) per year in 1980 (Kumazawa et al. 1984).

APPENDIX B

ENVIRONMENTAL PERMITS

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Table B.1. DOE PORTS environmental permits and registrations

Permit/registered source	Source no.	Issue date	Expiration date	Status
		Clean Air Act Permits		
Permit to Install X-627 Groundwater Treatment Facility	P474, T104, T105	1/13/2004	PTO application submitted October 4, 2004	Active
Permit to Operate X-6002 Recirculating Hot Water Plant North Boiler and South Boiler	B007, B008	2/05/2004	02/05/2009	Active
Permit to Operate X-326 L-cage Glove Box	P022	5/5/1995	PTO renewal submitted 4/27/1998	Active
Permit to Operate X-624 Groundwater Treatment Facility	P019		PTO renewal submitted 11/4/1998; PTO under appeal	Active
Permit to Operate X-735 Landfill Cap and Venting System (northern portion)	P023	5/26/1995	PTO renewal submitted 4/27/1998	Active
Permit to Operate X-744G Glove Box	P007		PTO renewal submitted 11/4/1998; PTO under appeal	Source no longer operating
Registered Source X-345 Security Fuel Oil Tank	T005		None	Active
Registered Source X-623 Groundwater Treatment Facility	P018		None	Active
Registered Source X-749 Contaminated Materials Disposal Facility	P027		None	Active
Permit to Install UDS Process Line 1	P001	10/5/2004	9/28/2008	Under construction
Permit to Install UDS Process Line 2	P002	10/5/2004	9/28/2008	Under construction
Permit to Install UDS Process Line 3	P003	10/5/2004	9/28/2008	Under construction
Permit to Install UDS Conversion Building HVAC System	P004	10/5/2004	9/28/2008	Under construction
		Clean Water Act Permits		
NPDES Permit DOE	0IO00000*ID	11/12/2002	11/30/07	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	1/919/96	None	Active
Permit to Install X-624 Groundwater Treatment Facility	06-3556	10/28/1992	None	Active
Permit to Install X-625 Groundwater Treatment Facility	06-5733	3/12/1999	None	Active
Permit to Install X-627 Groundwater Treatment Facility	06-07283	1/13/2004	None	Active
Permit to Install X-6002 Particulate Separator	06-6658	10/2/2001	None	Active
Construction Storm Water Permit (UDS)	OHC000002	12/23/2003	None	Active
Permit to Install Sewer Line (UDS)	06-7612	9/22/2004	None	Active
U.S. Army Corps of Engineers, Section 404 Nationwide Permit No. 39 (UDS)		3/17/2004	None	Active

Table B.1. DOE PORTS environmental permits and registrations (continued)

Permit/registered source	Source no.	Issue date	Expiration date	Status
	Hazardous Waste Permit			
RCRA Part B Permit (DOE/LPP)	Ohio Permit No. 04-66-0680	3/15/2001	3/15/2011	Active
	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	NO_3
Nitrite	NO_2
Phosphorus	P
Phosphate	PO_4
Potassium	K
Selenium	Se
Silver	Ag
Sodium	Na
Sulfate	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	87.75
Plutonium-239	^{239}Pu	24,100
Plutonium-240	^{240}Pu	6,569
Technetium-99	^{99}Tc	213,000
Uranium-233	^{233}U	159,200
Uranium-234	^{234}U	244,500
Uranium-235	^{235}U	703,800,000
Uranium-236	^{236}U	23,415,000
Uranium-238	^{238}U	4,468,000,000

Source: *Radioactive Decay Tables: A Handbook of Decay Data for Application to Radioactive Dosimetry and Radiological Assessments (*DOE/TIC-11026), as reported in the *Oak Ridge Reservation Annual Site Environmental Report for 2005* (DOE/ORO-2218).

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