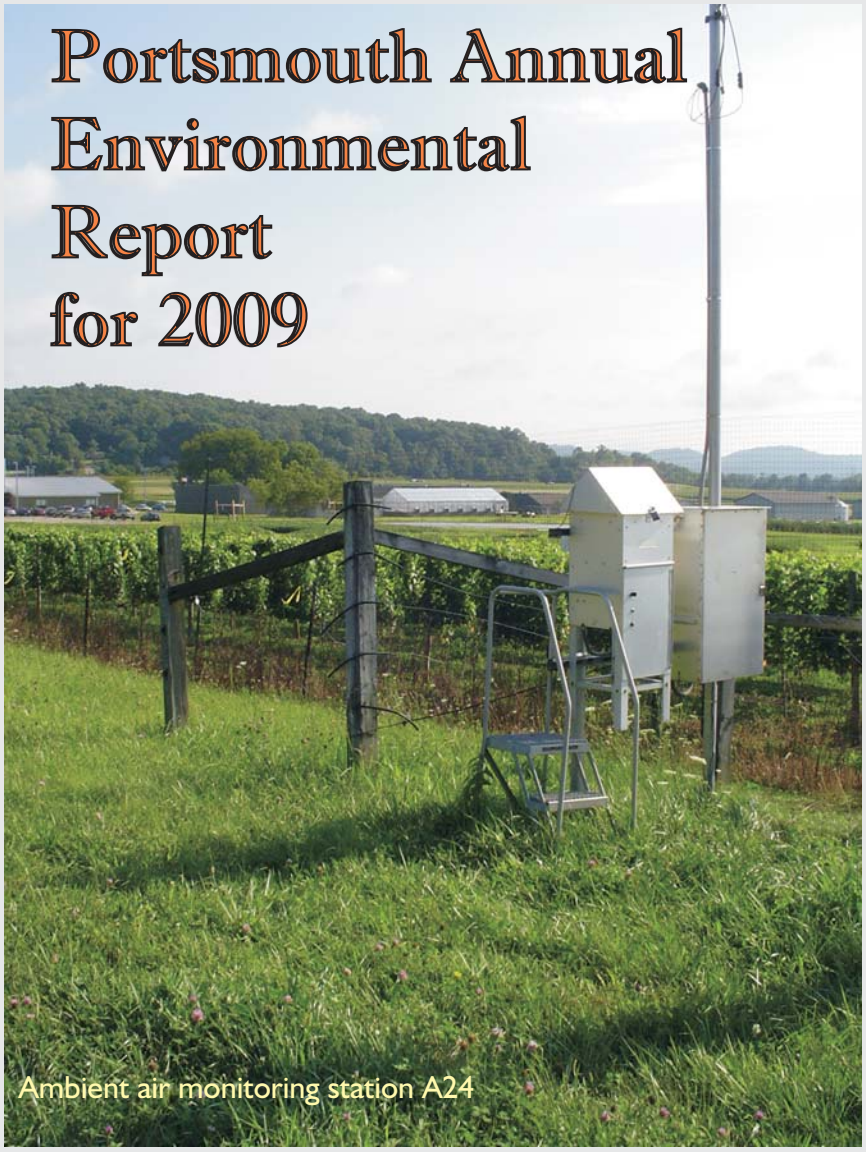
U.S. Department of Energy

Portsmouth Annual Environmental Report for 2009



Ambient air monitoring station A24

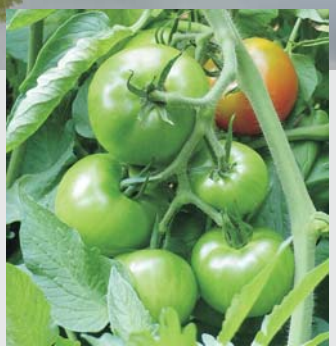
Environmental monitoring at the Portsmouth Gaseous Diffusion Plant measures the facility's effect on the environment

Air, soil, and vegetation samples are collected at ambient air monitoring stations around the area

Water and sediment samples are collected from local streams and the Scioto River

Scioto River near PORTS

Samples of crops and dairy products (milk and eggs) are collected from local communities



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U.S. Department of Energy
Portsmouth Annual Environmental Report
for 2009
Piketon, Ohio

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This document is approved for public release
per review by:

Henry H. Thomas 09/21/2010

PORTS Classification/Information Office Date

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ACRONYMS

ARRA	American Recovery and Reinvestment Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
D&D	decontamination and decommissioning
DOE	U.S. Department of Energy
EMS	Environmental Management System
EPA	Environmental Protection Agency
LLW	low-level radioactive waste
LPP	LATA/Parallax Portsmouth, LLC
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
MWH	megawatt-hour
NCRP	National Council on Radiation Protection
NESHAP	National Emission Standards for Hazardous Air Pollutants
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, LLC
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.

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

deferred unit – An area at PORTS that is in or adjacent to current production and operational areas such that remedial activities would interrupt operations, or an area that could become recontaminated from ongoing operations.

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

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

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

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

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

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

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 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.

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

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

millirem (mrem) – The dose that is one-thousandth of a rem.

monitoring – Process whereby the quantity and quality of factors that can affect the environment or human health are measured periodically to regulate and control potential impacts.

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

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

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

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

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

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

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

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

preliminary remediation goal – 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 (absorbed dose in rads multiplied by the radiation quality factor). Dose is frequently reported in units of millirem (mrem), which is one-thousandth of a rem.

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

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

Resource Conservation and Recovery Act (RCRA) – Federal legislation that regulates the transport, treatment, and disposal of solid and hazardous wastes.

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 (CERCLA) 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 as contaminants 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 2009. 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, respectively. PORTS is located on 5.9 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). PORTS gaseous diffusion production facilities that were used for uranium enrichment are currently leased to USEC; however, most activities associated with the gaseous diffusion process ceased in 2001. USEC is responsible for cold shutdown operations and removal of uranium deposits from process equipment. Further, USEC, Inc., the parent company of USEC, is developing a gas centrifuge uranium enrichment facility, the American Centrifuge Plant.

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), Theta Pro2Serve Management Company, LLC (TPMC) and Uranium Disposition Services, LLC (UDS) managed DOE PORTS programs throughout 2009. LPP was responsible for the following activities: 1) environmental restoration of contaminated areas; 2) environmental monitoring and reporting; 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 provided infrastructure services including the following: 1) maintenance of facilities, grounds, and roadways; 2) janitorial services; 3) security access for DOE facilities; and 4) information technology/network support for DOE operations.

UDS was responsible for construction of the Depleted Uranium Hexafluoride Conversion Facility at PORTS, the surveillance and maintenance of depleted uranium cylinders, and environmental compliance and monitoring activities associated with UDS operations. Depleted uranium hexafluoride, which was 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 and hydrogen fluoride, which will be shipped off site. The uranium oxide will be disposed as waste, and the hydrogen fluoride will be sold for reuse.

In 2009, DOE Headquarters continued the planning process for decontamination and decommissioning (D&D) of the PORTS gaseous diffusion facilities and associated buildings. D&D includes removing equipment, demolishing buildings, disposing of wastes, and investigating potential contamination beneath the demolished buildings.

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 permits for discharge of water to surface streams, 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; a biennial report of specified non-radiological air emissions; a monthly report of National Pollutant Discharge Elimination System (NPDES) monitoring data; a quarterly radiological discharge monitoring report for NPDES outfalls; 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 current USEC operations.

DOE PORTS received one Notice of Violation during 2009. During a hazardous waste inspection on December 16, 2009, the Ohio Environmental Protection Agency (EPA) identified a deficiency in the paperwork required for one shipment of hazardous waste. The paperwork was immediately corrected and procedures for preparation and review of the documentation for hazardous waste shipments were revised to address these deficiencies. There was no environmental harm or risk to human health from the error in completing the hazardous waste shipment paperwork.

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.

In 2009, DOE PORTS received $118 million in funding under the American Recovery and Reinvestment Act (ARRA). Five projects that involve environmental remediation, D&D of inactive facilities, or materials disposition were underway at the end of 2009. These projects are: environmental remediation (source removal) at the X-701B Holding Pond; D&D of the X-533 Switchyard Complex, X-633 Cooling Towers Complex, and X-760 Chemical Engineering Building; and repackaging and disposition of excess uranium materials.

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 1989 Ohio Consent Decree and the 1989 U.S. EPA Administrative Consent Order (as amended in 1994 and 1997) 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, also called remedial actions, are underway in each quadrant.

In 2009, DOE contractors installed an additional groundwater extraction well in the Quadrant I Groundwater Investigative Area, conducted an investigation of potential contaminant sources in the Quadrant II Groundwater Investigative Area, and evaluated remedial alternatives for the X-701B Holding Pond and the groundwater plume near the former X-740 Waste Oil Handling Facility. DOE proposed to excavate soil in the western portion of the X-701B area and directly mix oxidant into the contaminated soil. Ohio EPA approved this additional action in October 2009 and excavation and soil mixing began in December 2009.

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 2009, approximately 7 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 listed under RCRA or waste 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-contaminated materials is regulated under the Toxic Substances Control Act (TSCA).

- *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 the first three waste types listed above; for example, some wastes are both RCRA hazardous waste and low-level radioactive waste (called mixed waste).

In addition to complying with DOE Orders and Ohio EPA/U.S. EPA regulations, the DOE has also implemented supplemental policies for waste management at PORTS 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 207), 1862 Shyville Road, Piketon, Ohio 45661. The Information Center is open 9 a.m. to noon Monday and Tuesday, noon to 4 p.m. Wednesday and Thursday, or by appointment (call 740-289-8898). The email address is eic@wems-llc.com. Additional information is provided by the DOE Site Office (740-897-5010) and the LPP Office of Public Affairs (740-897-2336). This Annual Environmental Report and other information can also be obtained from the PORTS web site at www.pppo.energy.gov.

The PORTS Site Specific Advisory Board, comprised of up to 20 citizens from the local area, provides public input and recommendations to the DOE on environmental remediation, waste management, and related issues at PORTS. Additional information about the board can be obtained at www.ports-ssab.org or by calling 740-289-5249.

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

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 2009, 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
- Biota

Data collected for these programs in 2009 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 the United States receives an average dose of approximately 311 mrem/year from natural sources of radiation (National Council on Radiation Protection [NCRP] 2009). Figure 1 provides a comparison of the doses from various common radiation sources.

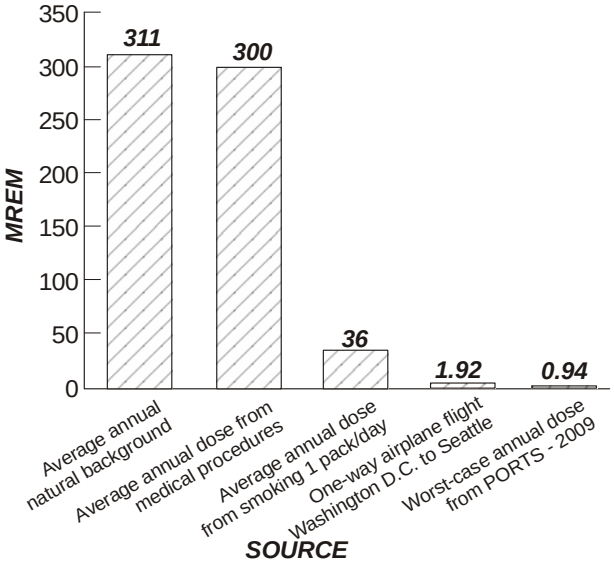

Figure 1. Comparison of dose from various common radiation sources (NCRP 2009).

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 2009 is 0.94 mrem, based on a maximum dose of 0.024 mrem from airborne radionuclides, 0.037 mrem from radionuclides released to the Scioto River, 0.72 mrem from direct radiation from the PORTS depleted uranium cylinder storage yards, and 0.16 mrem based on exposure to radionuclides detected at off-site monitoring locations in 2009. 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 (0.94 mrem) is significantly less than the 100 mrem/year limit set by the 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 (0.024 mrem) is also significantly less than the 10 mrem/year standard set by U.S. EPA.

GROUNDWATER PROGRAMS

Groundwater monitoring at DOE PORTS is performed at 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 13 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 in the following areas: X-749/X-120/Peter Kiewit (PK) Landfill (Quadrant I), Quadrant I Groundwater Investigative Area, Quadrant II Groundwater Investigative Area, X-701B Holding Pond (Quadrant II), and X-740 Waste Oil Handling Facility (Quadrant III). The primary groundwater contaminant is trichloroethene. Other monitoring areas may have groundwater contaminated with metals or may be monitored to comply

with regulatory requirements for closed landfills. Remediation of groundwater is being conducted primarily under Ohio EPA's RCRA Corrective Action Program.

Concentrations of trichloroethene are decreasing and the groundwater plumes are shrinking in both monitoring areas in Quadrant I (the X-749/X-120/PK Landfill area and the Quadrant I Groundwater Investigative Area). Although trichloroethene is still detected in one off-site monitoring well associated with the X-749/X-120/PK Landfill groundwater plume, concentrations of trichloroethene in the well have decreased to less than 1 µg/L from concentrations up to 4 µg/L in 2006. 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. In general, the other contaminated groundwater plumes present at PORTS did not change significantly in 2009.

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 wells 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 5.9-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 2009, USEC, Inc. (the parent company of USEC) continued operation of the small-scale demonstration centrifuge for uranium enrichment at PORTS (the Lead Cascade). USEC, Inc. has also begun preparatory activities and initial construction of its commercial scale American Centrifuge 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, respectively.

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), Theta Pro2Serve Management Company, LLC (TPMC), and Uranium Disposition Services, LLC (UDS) managed DOE PORTS programs throughout 2009. LPP was 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 provided infrastructure services including the following: 1) maintenance of facilities, grounds, and roadways; 2) janitorial services; 3) security access for DOE facilities; and 4) information technology/network support for DOE operations.

UDS was responsible for construction of the Depleted Uranium Hexafluoride Conversion Facility at PORTS, surveillance and maintenance of depleted uranium cylinders, and environmental compliance and monitoring activities associated with UDS operations. 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 and hydrogen fluoride, which will be shipped off site. The uranium oxide will be disposed as waste, and the hydrogen fluoride will be sold for reuse. Construction of the facility was completed in May 2008. Systems testing and operational readiness reviews were in progress in 2009 with operation of the facility expected to begin in 2010.

USEC, which became a publicly-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. The X-533 Switchyard that supplied power to the former gaseous diffusion process was deactivated in November 2008 and was being prepared for return to DOE in 2009.

In 2002, USEC, Inc. decided to site the Lead Cascade at PORTS, which is a small-scale demonstration centrifuge for uranium enrichment. The Lead Cascade began operating in October 2006 and continued throughout 2009 to generate operational and economic data. In 2004, USEC, Inc. announced that its commercial scale American Centrifuge Plant would be built at PORTS. Preparation for and the initial construction of the American Centrifuge Plant continued until mid-2009, when construction was put on hold pending receipt of additional funding. Consequently, construction of the American Centrifuge Plant was on hold as of the end of 2009. Both of these facilities (the Lead Cascade and the American Centrifuge Plant) are housed in existing buildings at PORTS that were constructed for DOE's Gaseous Centrifuge Enrichment Plant, which was cancelled in 1985.

The gas centrifuge uranium enrichment process requires much less electricity than the gaseous diffusion process. Gas centrifuge uranium enrichment uses a rotor that spins at a high speed within a casing to separate uranium-235 from uranium-238 (resulting in enriched uranium). Gaseous diffusion uranium enrichment uses a porous barrier to separate uranium-235 molecules from uranium-238 molecules.

In 2009, DOE Headquarters continued the planning process for the decontamination and decommissioning (D&D) of the PORTS gaseous diffusion facilities and associated buildings that was initiated in 2007. D&D includes removing equipment, demolishing buildings, disposing of wastes, and investigating potential contamination beneath the demolished buildings.

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 *2009 Groundwater Monitoring Report* and the *2009 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 5.9-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 670,000 persons.

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

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

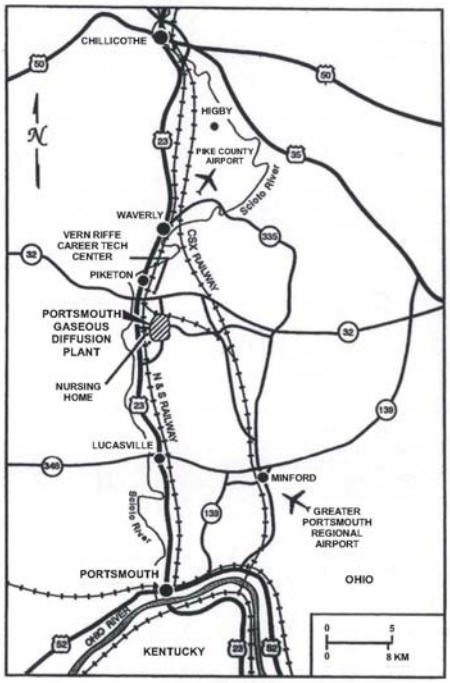

Figure 1.3. Location of PORTS in relation to the geographic region.

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 (LPP or UDS) 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, a biennial fee report of specified non-radiological air emissions, a monthly report of National Pollutant Discharge Elimination System (NPDES) monitoring data, a quarterly radiological discharge monitoring report for NPDES outfalls, 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. DOE PORTS received one Notice of Violation during 2009. During a hazardous waste inspection on December 16, 2009, the Ohio Environmental Protection Agency (EPA) identified a deficiency in the paperwork required for one shipment of hazardous waste. The paperwork was immediately corrected and procedures for preparation and review of the documentation for hazardous waste shipments were revised to address these deficiencies. There was no environmental harm or risk to human health from the error in completing the hazardous waste shipment paperwork. Section 2.4.1 provides more information about this Notice of Violation.

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. 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 and/or DOE PORTS contractors (LPP or UDS) hold two NPDES permits 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 (LPP and UDS) environmental permits and registrations for 2009.

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 CERCLA and vary depending on the type of hazardous substance released. During 2009, 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 December 2009, LPP notified state and local authorities that sodium persulfate and calcium hydroxide (hydrated lime) are now stored on site in quantities exceeding the threshold planning quantity (10,000 lbs). These chemicals are used in the remediation project at the X-701B Holding Pond area (see Chapter 3, Section 3.2.2.1).

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 2009, 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 2009: aluminum oxide, argon, asbestos, calcium chloride, calcium hydroxide, calcium oxide, carbon dioxide, chlorine, citric acid, diesel fuel, ethylene glycol, gasoline, hydrogen fluoride, hydrogen peroxide, kerosene, lubricating oil, fuel oil, methanol, nitric acid, nitrogen, PCBs, propylene glycol, sodium chloride, sodium hydroxide, sodium persulfate, sodium polyacrylate, 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 2009, DOE PORTS reported the release and/or off-site disposal of two chemicals: lead compounds and nitrate compounds. Releases were in compliance with applicable NPDES or air emission permits. Lead compounds were present in waste disposed off site by DOE PORTS. Nitrate compounds were produced by the recirculating hot water system used to heat former DOE PORTS buildings. The air and water permits associated with the former DOE buildings and recirculating hot water system were transferred to USEC in 2007 and 2008; however, the lease agreement between DOE and USEC for the buildings was not finalized until July 31, 2009. Therefore, DOE remained responsible for these releases from January through July of 2009.

USEC reported the release, off-site transfer, and/or on-site treatment of seven chemicals in 2009: chlorine, dichlorotetrafluoroethane, nitrate compounds, nitric acid, sulfuric acid, hydrochloric acid, 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. "Solid wastes," as defined by the EPA, can be solids, liquids, sludges, or other materials. Hazardous wastes are a subset of solid wastes, and are designated as hazardous by the EPA because of various chemical properties, including ignitability, corrosivity, reactivity, and toxicity.

Hazardous waste. During 2009, DOE and LPP held a permit to store hazardous waste within seven designated areas of the X-326 building (38,105 square feet or 0.9 acre). 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.

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 2009 to the Ohio EPA in February 2010. Chapter 3, Section 3.3, Waste Management Program, provides additional information on wastes from PORTS that were recycled, treated, or disposed in 2009.

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 monitored in accordance with the *Integrated Groundwater Monitoring Plan* include 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), X-749 Contaminated Materials Storage Yard (northern portion), X-744Y Container Storage Area, X-701B surface impoundments, and X-230J7 Holding Pond. Chapter 6 discusses the groundwater monitoring requirements for these units.

A groundwater report that summarizes the results of monitoring completed in accordance with the *Integrated Groundwater Monitoring Plan* is submitted annually to Ohio EPA. Chapter 6 discusses these monitoring results for 2009.

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 results for these units in 2009.

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 2009 was submitted to the Ohio EPA in December 2009.

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. One hundred-nineteen PCB transformers and approximately 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 (the former gaseous diffusion

facilities) to collect PCB oil leaks. When leaks or spills of PCBs occur, they are managed in accordance with the Federal Facilities Compliance Agreement.

Annual reports of progress made toward milestones specified in the Federal Facilities Compliance Agreement are submitted to the U.S. EPA. DOE PORTS was in compliance with the requirements and milestones of this Federal Facilities Compliance Agreement during 2009.

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 2009. The *2009 PCB Document Log for the Portsmouth Gaseous Diffusion Plant* was prepared in June 2010. Approximately 11 tons (10,017 kilograms) of PCB waste were shipped off site in 2009.

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

2.3.1.6 Federal Insecticide, Fungicide, and Rodenticide Act

No restricted-use pesticides were used by DOE PORTS in 2009.

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

In 2009, DOE PORTS had three permitted air emission sources, two registered air emission sources, and one *de minimis* source subject to requirements for radiological emissions. Four additional permitted sources have been constructed by UDS but did not operate in 2009. Appendix B lists the DOE PORTS air emission sources. Radiological air emissions from the DOE air emission 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 and emission reporting requirements.

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.

An ozone-depleting substance, specifically dichlorotetrafluoroethane, was used as a coolant and remains present in the cascade system formerly used to produce enriched uranium**.** In 2009, USEC estimated that 22,500 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 the DOE to submit an annual report for radiological emissions from DOE air emission sources. The DOE and LPP are responsible for five sources of radionuclide emissions including the X-622, X-623, X-624, X-627 Groundwater Treatment Facilities, and the X-326 L-cage Glove Box. 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. There were no emissions from UDS air emission sources in 2009 because the facility was not operating.

Radiological emissions from DOE PORTS in 2009 are based on emissions from the X-622, X-623, X-624, and X-627 Groundwater Treatment Facilities. The X-326 L-cage Glove Box was not used in 2009; therefore there were no emissions from this source. Emissions from the groundwater treatment facilities were conservatively estimated based on quarterly influent/effluent sampling and quarterly throughput. Based on these assumptions, radiological air emissions from the X-622, X-623, X-624, and X-627 Groundwater Treatment Facilities in 2009 were 0.054 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

DOE PORTS contractors, LPP and UDS, hold two NPDES permits that allow discharges of water to surface streams. The current LPP NPDES permit encompasses one outfall classified as point-source discharge to waters of the state, and three internal outfalls classified as effluents.

Water from the three internal LPP outfalls is treated in the USEC X-6619 Sewage Treatment Plant (USEC NPDES Outfall 003) before reaching waters of the state. Chapter 4, Section 4.3.5.1, and Chapter 5, Section 5.4.1.1, provide additional information on the LPP NPDES outfalls.

UDS was issued an NPDES permit that became effective on June 1, 2007 for the discharge of process wastewaters from the Depleted Uranium Hexafluoride Conversion Facility. One outfall is monitored under the permit; the discharge from this outfall flows through USEC NPDES Outfall 010 (the X-230J5 Northwest Holding Pond) before reaching waters of the state. Chapter 4, Section 4.3.5.1, and Chapter 5, Section 5.4.1.2, provide additional information on the UDS NPDES outfall.

During 2009, discharges from the UDS NPDES outfall occurred only from January through October. These discharges only consisted of precipitation runoff; no process wastewater was discharged through the UDS NPDES outfall during 2009.

Data required to demonstrate compliance with the NPDES permits are submitted to Ohio EPA in monthly operating reports (see Chapter 5, Section 5.4.1.1). None of the LPP NPDES permit effluent limitations was exceeded during 2009; therefore, the overall LPP NPDES compliance rate for 2009 was 100%. UDS had a number of exceedences of NPDES permit effluent limitations in 2009 (see Chapter 5, Section 5.4.1.2); therefore the overall UDS NPDES compliance rate for 2009 was 87%.

A quarterly discharge monitoring report that provides radiological monitoring data for the LPP NPDES outfalls is also submitted to Ohio EPA (see Chapter 4, Section 4.3.5). The UDS outfall is not monitored for radionuclides.

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 the DOE 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 2009.

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 PORTS is under development.

Phase I of the historical/archaeological survey was completed in 1997. Artifacts from the 1940s and 1950s were uncovered during the Phase I survey as well as remains from former dwellings that were present prior to construction of PORTS. DOE submitted the *Phase I History/Architectural Survey Report for the Portsmouth Gaseous Diffusion Plant* to the Ohio Historic Preservation Office in May 2008. The survey report documents the inventory of resources at PORTS and proposes a historic district boundary for the facility. In 2009, DOE received comments on the *Phase I History/Architectural Survey Report for the Portsmouth Gaseous Diffusion Plant* from the Ohio Historic Preservation Office.

Phase II field investigations were conducted in 2009 at two farmstead sites on the northeastern portion of the PORTS property: the 33PK212 Railside Farmstead and the 33PK213 Log Pen Farmstead. Neither site was recommended as eligible for inclusion on the National Register of Historic Places, and no additional work was recommended. In 2009, the DOE also notified the Ohio Historic Preservation Office of the proposed demolition of the X-533 Switchyard and the X-633 Recirculating Cooling Water Tower Complex.

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.

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 2009.

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 2010, UDS has not yet established measurable environmental objectives and targets. DOE completed the self-declaration protocol for establishment of the EMS in June 2006. An independent assessment of the LPP EMS completed in 2008 found that LPP is effectively implementing a comprehensive Environmental Management Program based on DOE Order 450.1. An independent assessment of environmental reporting conducted in May 2009 did not identify any deficiencies.

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 13423, *Strengthening Federal Environmental, Energy, and Transportation Management*

On January 24, 2007, Executive Order 13423 was issued requiring federal facilities to conduct their environmental, transportation, and energy-related activities in an environmentally, economically and fiscally sound, integrated, continuously improving, efficient, and sustainable manner.

Chapter 3, Section 3.4, provides a summary of the DOE PORTS Environmental Sustainability Program and associated activities for 2009.

2.3.7.2 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 2009, no DOE activities were conducted in jurisdictional wetlands.

2.4 OTHER MAJOR ENVIRONMENTAL ISSUES AND ACTIONS

This section summarizes environmental inspections at DOE PORTS during 2009 and the results of these inspections.

2.4.1 Environmental Program Inspections

During 2009, 14 inspections of the DOE PORTS programs were conducted by federal, state, or local agencies. Table 2.1 lists these inspections.

DOE PORTS and LPP received a Notice of Violation on December 18, 2009, based on the RCRA compliance inspection conducted on December 16, 2009. When reviewing the documentation that accompanied a shipment of hazardous waste, Ohio EPA discovered that a form called the Land Disposal Restriction Notice had not been accurately completed by LPP. LPP immediately corrected the Land Disposal Restriction Notice and provided the corrected form to the facility that received the waste. LPP has revised its procedures for completing and reviewing the documentation associated with shipments of hazardous waste. There was no environmental harm or risk to human health from the error in completing the paperwork associated with the hazardous waste shipment.

2.5 UNPLANNED RELEASES

No unplanned releases from DOE PORTS were reported in 2009.

2.6 SUMMARY OF PERMITS

Appendix B lists the permits held by DOE PORTS in 2009.

Table 2.1. Environmental inspections at DOE PORTS for 2009

Date	Agency	Type	Notices of Violation
February 24	Ohio EPA	RCRA compliance and RCRA Corrective Action surveillance and maintenance (X-720 Neutralization Pit area, X-700 tanks, X-533 Switchyard, X-633 Pumphouse/Cooling Towers)	None
April 2	Ohio EPA	RCRA Corrective Action surveillance and maintenance (X-735 Landfills)	None
May (multiple dates)	Ohio EPA	RCRA Corrective Action surveillance and maintenance (Five-Unit area groundwater extraction system)	None
June 4	Ohio EPA	Clean Air Act compliance	None
June 18	Pike County Health Department and Ohio EPA	Closed solid waste landfills: X-749A, X-749, and X-735 (solid waste portion)	None
June 22	Ohio EPA and U.S. EPA	RCRA compliance	None
June 30	Ohio EPA	RCRA Corrective Action surveillance and maintenance (X-749 phytoremediation area)	None
July (multiple dates)	Ohio EPA	RCRA Corrective Action surveillance and maintenance (X-734, X231A, X-231B, X-749A)	None
August 11	Ohio EPA	RCRA Corrective Action surveillance and maintenance (X-705A/B, X-700 tanks, X-627, former X-701C neutralization pit area, X-616)	None
September 16	Ohio EPA	RCRA compliance	None
September/ October (multiple dates)	Ohio EPA	RCRA Corrective Action surveillance and maintenance (Don Marquis substation, X-624, X-749 southeastern phytoremediation area)	None
October 7	Ohio EPA	RCRA Corrective Action surveillance and maintenance (X-230J7 Holding Pond, PK Landfill)	None
October 21	Ohio EPA	RCRA Corrective Action surveillance and maintenance (X-611A)	None
December 14	Ohio EPA	NPDES permit compliance	None
December 16	Ohio EPA	RCRA compliance	See Section 2.4.1

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3. ENVIRONMENTAL PROGRAM INFORMATION

3.1 SUMMARY

In 2009, DOE contractors installed an additional groundwater extraction well in the Quadrant I Groundwater Investigative Area, conducted an investigation of potential contaminant sources in the Quadrant II Groundwater Investigative Area, and evaluated remedial alternatives for the X-701B Holding Pond and the groundwater plume near the former X-740 Waste Oil Handling Facility. DOE proposed to excavate soil in the western portion of the X-701B area and directly mix oxidant into the contaminated soil. Ohio EPA approved this additional action in October 2009 and excavation and soil mixing began in December 2009.

In 2009, DOE PORTS received $118 million in funding under the American Recovery and Reinvestment Act (ARRA). Five projects that involve environmental remediation, D&D of inactive facilities, or materials disposition were funded by ARRA and underway at the end of 2009. These projects are environmental remediation (source removal) at the X-701B Holding Pond as described in the previous paragraph; D&D of the X-533 Switchyard Complex, X-633 Cooling Towers Complex, and X-760 Chemical Engineering Building; and repackaging and disposition of excess uranium materials.

In 2009, approximately 7 million pounds of waste from DOE PORTS were recycled, treated, or disposed at off-site facilities. Activities undertaken by the Environmental Sustainability, 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 EMS.

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 soil and groundwater associated with active facilities through eventual D&D. 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 identify and evaluate remedial alternatives to address contamination identified during the RCRA facility investigation.

- *Corrective measures implementation* – to implement the selected remedial alternative(s).

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 remedial actions is underway in each quadrant. Remedial actions 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 remedial actions required by decision document and other actions. Remedial actions required by a decision document are reviewed by Ohio EPA on a schedule agreed upon by Ohio EPA and DOE (approximately every five years) to ensure that the remedial actions are performing as intended by the decision document and are protective of human health and the environment. No five-year reviews were completed during 2009.

The Ohio EPA has deferred further investigation and/or remedial 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/remedial action of soil and groundwater associated with these units until D&D of PORTS or until the unit no longer meets the requirements for deferred unit status.

In 2009, DOE Headquarters continued the planning process for D&D of the PORTS gaseous diffusion facilities and associated buildings. DOE and Ohio EPA were working together to develop the Director's Final Findings and Orders (a legal agreement between the DOE and Ohio EPA) that will provide the requirements for D&D of PORTS.

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, which provided the required remedial actions for the X-749/X-120 groundwater plume and the Quadrant I Groundwater Investigative Area (the Five-Unit Groundwater Investigative Area and X-231A/X-231B Oil Biodegradation Plots). Remedial actions required for the X-749B Peter Kiewit Landfill (PK Landfill) were provided in separate Decision Documents issued by Ohio EPA in 1996 and U.S. EPA in 1997. The following sections discuss the remedial actions required for the X-749/X-120 groundwater plume, PK Landfill, and the Quadrant I Groundwater Investigative Area. Soil and groundwater associated with the deferred units in Quadrant I will be addressed during D&D of PORTS.

3.2.1.1 X-749/X-120 groundwater plume

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.

Table 3.1. Remedial actions completed at PORTS in groundwater monitoring areas

Quadrant/monitoring area	Remedial 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 X-749 South Barrier Wall Area extraction wells – 2007 Two additional extraction wells in the groundwater collection trench on the southwest side of the X-749 Landfill – 2008
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 (Five-Unit 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 Groundwater extraction well (1) – 2009
Quadrant I X-749A Classified Materials Disposal Facility	Cap – 1994
Quadrant II Quadrant II Groundwater Investigative Area (Seven-Unit 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 – 1998 Removal of X-701C Neutralization Pit – 2001 Removal of contaminated soil near X-720 Neutralization Pit – 2001 X-627 Groundwater Treatment Facility – 2004 (replaced the X-622T facility)
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 Phase IIb and IIc oxidant injections – 2007 Phase IId, IIe, and IIf oxidant injections – 2008

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

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

Phytoremediation is a process that uses plants to remove, degrade, or contain contaminants in soil and/or groundwater. Phytoremediation at the X-749/X-120 groundwater plume was installed in two phases during 2002 and 2003. The *Preliminary Evaluation Report for the X-749/X-120 Phytoremediation System*, completed in January 2008, provided a preliminary evaluation of the phytoremediation system. The trees selected for the phytoremediation system had just begun to develop sufficient leaf area (approximately equal to root volume) so that groundwater was transpired through the trees; therefore, a complete system evaluation could not be completed. Water level data and tree core sampling results indicated that contaminated groundwater was being transpired by the trees; however, the volume of contaminated groundwater uptake by the trees was uncertain. Continued operation of the phytoremediation system was recommended in order for the trees to grow and develop a more extensive root system. The next review of the remedial actions implemented at the X-749/X-120 groundwater plume will be submitted to Ohio EPA in 2011.

In 2009, monitoring data collected from wells in the X-749/X-120 groundwater plume indicated that the extraction wells installed in the X-749 South Barrier Wall area and the groundwater collection trench on the southwest side of the X-749 Landfill are reducing concentrations of trichloroethene within the groundwater plume and causing the plume perimeter to shrink. Chapter 6, Section 6.4.1.4, provides additional information about the 2009 groundwater monitoring results for the X-749/X-120 groundwater plume.

3.2.1.2 PK Landfill

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

The second five-year review for the PK Landfill was completed in 2008. This report, the *Second Five-Year Review for the X-749B Peter Kiewit Landfill*, found that the remedial actions implemented at the PK Landfill (the groundwater collection systems and landfill cap) were achieving remedial action objectives by eliminating exposure pathways and reducing the potential for contaminant transport. Concentrations of many of the contaminants detected in the PK Landfill wells, sumps, and manholes had decreased significantly from 1999 to 2007. Contaminants detected in the PK Landfill wells, sumps, and

manholes were not detected in surface water samples collected from Big Run Creek adjacent to or downstream from PK Landfill. Based on these data, construction of a barrier wall on the upgradient sides of the PK Landfill did not appear to be necessary. The next review of the remedial actions implemented at the PK Landfill will be submitted to Ohio EPA in 2013.

Chapter 6, Section 6.4.1.4, provides 2009 groundwater monitoring results for the PK Landfill area.

3.2.1.3 Quadrant I Groundwater Investigative Area

Remedial actions identified for the Quadrant I Groundwater Investigative Area (also called the Five-Unit 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. The caps were constructed in 2000 and operation of the groundwater extraction wells began in 2002. In 2009, an additional extraction well was installed south of the X-326 Process Building to control and remediate a newly identified source of trichloroethene beneath the building. Table 3.1 lists the remedial actions completed for the Quadrant I Groundwater Investigative Area.

A five-year review of both the groundwater extraction system for the Quadrant I Groundwater Investigative Area and the multi-layered caps for the X-231A and X-231B Oil Biodegradation Plots was completed in 2008. This report, the *First Five-Year Review for the Five-Unit Groundwater Investigative Area and X-231A/X-231B Oil Biodegradation Plots*, found that the remedial actions had eliminated potential exposure pathways to contaminants and reduced concentrations of trichloroethene in the groundwater, although more slowly than expected. The next review of the remedial actions implemented at the Quadrant I Groundwater Investigative Area and X-231A/B Oil Biodegradation Plots will be submitted to Ohio EPA in 2013.

Chapter 6, Section 6.4.2.3, provides information on the groundwater monitoring completed in the Quadrant I Groundwater Investigative Area during 2009.

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 X-701B Preferred Plan in September 2003 and the X-701B Decision Document in December 2003.

Chapter 6 provides 2009 groundwater monitoring results for the following areas in Quadrant II that require groundwater monitoring: X-701B Holding Pond (Section 6.4.4.1), Quadrant II Groundwater Investigative Area (Section 6.4.3.1), and X-633 Pumphouse/Cooling Towers Area (a deferred unit) (Section 6.4.5.1).

3.2.2.1 X-701B Holding Pond

Remedial actions required by the Decision Document include groundwater remediation by injection of a chemical oxidant. Following groundwater remediation, remedial actions 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.

Phase I field activities for the X-701B groundwater remediation began in 2005 to determine operating parameters for the oxidant injection system. 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, which was approved by Ohio EPA in 2006. Six rounds of oxidant injections were completed between October 2006 and October 2008. Following the October 2008 injections, DOE PORTS requested an independent review of the X-701B project by DOE Headquarters to evaluate remediation results to date and provide recommendations for a path forward.

The review of the X-701B oxidant injections determined that the method used to inject oxidant into the contaminated area was not able to address contaminants in the deepest portion of the contaminated soil. If contaminants remain in this portion of the soil, they would continue to be released into the groundwater plume. Therefore, DOE proposed to excavate soil in the western portion of the X-701B area and directly mix oxidant into the contaminated soil. Ohio EPA approved this additional action in October 2009 and excavation and soil mixing began in December 2009. This remediation of the X-701B groundwater plume is one of the projects funded by ARRA.

3.2.2.2 Quadrant II Groundwater Investigative Area

A number of deferred units are in the groundwater plume in the Quadrant II Groundwater Investigative Area (also know as the Seven-Unit Area). A special investigation conducted in 2009, which sampled soil and groundwater, identified areas of higher trichloroethene concentrations that appeared to be associated with continuing sources of groundwater contamination in the southeastern portion of the plume. At the end of 2009, DOE was evaluating options to remediate these contaminant sources.

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. Soil and groundwater associated with the deferred units in Quadrant III will be addressed during D&D of PORTS.

Over 700 hybrid poplar trees were planted on a 2.6-acre area above the X-740 groundwater plume in 1999. 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*, indicated that the trees in the phytoremediation system did not noticeably affect the overall groundwater flow in the Gallia at this area, although the trees did appear to influence water levels in individual wells. Concentrations of trichloroethene in the X-740 groundwater plume had 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 was effective in remediating the groundwater plume. Additional data collected for this evaluation included soil moisture at specified depths below ground surface, wind speed/direction, rainfall, air/soil temperature, tree growth rates, and sap flow measurements. The *Supplemental Evaluation to the Five-Year Evaluation Report for the X-740 Phytoremediation System*, submitted to Ohio EPA in January 2007, found that the phytoremediation system had not performed as expected to remove trichloroethene from groundwater in this area.

In response to Ohio EPA comments on this report, DOE developed a work plan for additional remedial activities for the X-740 area. Three rounds of oxidant injections were completed in May, June/July, and September of 2008 to remove trichloroethene from the groundwater. Although the oxidant briefly reduced trichloroethene concentrations detected in some of the wells, trichloroethene concentrations in groundwater returned to typical levels in 2009. At the end of 2009, the DOE was evaluating additional alternatives to remediate groundwater in the X-740 area.

Chapter 6 provides 2009 groundwater monitoring results for the following areas in Quadrant III that require groundwater monitoring: X-616 Chromium Sludge Surface Impoundments (Section 6.4.6.1) and X-740 Waste Oil Handling Facility (Section 6.4.7.1).

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 Landfills). Soil and groundwater associated with the deferred units in Quadrant IV will be addressed during D&D of PORTS.

Ohio EPA and U.S. EPA issued a Decision Document for the X-611A area in 1996, which required a soil cover over the former lagoons and establishment of a prairie habitat. The soil cover and planting of the prairie were completed in 1997. The *Second Five-Year Review for the X-611A Prairie* was submitted to Ohio EPA in 2008. The report found that the soil cover and prairie habitat were continuing to meet the remedial action objectives for this unit by eliminating exposure pathways to the contaminants in the sludge at this area. The next review of the remedial actions implemented at the X-611A area will be submitted to Ohio EPA in 2013.

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

The *First Five-Year Review for the X-734 Landfill Area* was submitted to Ohio EPA in 2008. The report found that construction of the caps on the landfills had achieved remedial action objectives by isolating contaminants in soil and sediment from potential receptors. The caps were preventing contaminants in soil and sediment from migrating to groundwater and surface water. The next review of the remedial actions implemented at the X-734 Landfills will be submitted to Ohio EPA in 2013.

Chapter 6 provides 2009 groundwater monitoring results for the following areas in Quadrant IV that require groundwater monitoring: X-611A Former Lime Sludge Lagoons (Section 6.4.8.1), X-735 Landfills (Section 6.4.9.1), X-734 Landfills (Section 6.4.10.1), and X-533 Switchyard Area (a deferred unit) (Section 6.4.11.1).

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

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

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

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

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

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

In 2009, approximately 7 million pounds of waste from PORTS were recycled, treated, or disposed at off-site facilities (see Table 3.2). A project funded by ARRA, the disposition of excess uranium materials, was initiated in 2009. Over 500,000 pounds of uranium materials were disposed at Nevada Test Site in 2009.

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.

Table 3.2. Waste Management Program off-site treatment, disposal, and recycling accomplishments for 2009

Waste type	Waste stream	Quantity (pounds)	Treatment, disposal, or recycling facility
RCRA	Soil, plastics, and other solids contaminated with metals and/or solvents	18,402	PermaFix
LLW[a]	Depleted uranium tetrafluoride	7423	Materials & Energy Corp
LLW	Scrap metal, demolition debris, soil, and other solids	5,536,199	EnergySolutions
LLW	Uranium materials, scrap metal, and other solids	1,349,259	Nevada Test Site
PCB	Light ballasts and other contaminated solids	11,949	PermaFix
PCB/LLW	Sheet metal, empty containers, concrete, and other solids contaminated with PCBs	5037	EnergySolutions
PCB/LLW/ RCRA	Miscellaneous solids contaminated with PCBs and metals or organics	1266	EnergySolutions
PCB/LLW/ RCRA	Liquids or solids contaminated with PCBs and organics	3832	Diversified Scientific Solutions
RCRA/LLW	Carbon contaminated with solvents from groundwater treatment facilities	10,750	Diversified Scientific Solutions
RCRA/LLW	Solids (soil, incinerator ash, trap material, etc.) and liquids contaminated with metals or solvents	43,169	EnergySolutions
RCRA/LLW	Soil, plastic, and other solids contaminated with solvents from X-701B remediation project	10,538	PermaFix
Universal waste	Light bulbs (fluorescent, mercury vapor, incandescent, and compact fluorescent)	837	PermaFix
Universal waste	Batteries (ni-cad, lead acid, and gell cell)	108	PermaFix
Universal waste	Waste oil (recyclable)	3522	PermaFix

[a]Low-level radioactive waste.

3.4 ENVIRONMENTAL SUSTAINABILITY 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 is described in the *Environmental Sustainability Plan* and integrates the tenets of an EMS. 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 EMS 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.

In 2009, DOE PORTS received the 2009 Federal Electronics Challenge Silver Level Award for achievement and leadership in managing federal electronics. DOE PORTS achievements included the following:

- establishing and promoting a policy to give preference to procurement of electronics registered by the Electronic Product Environmental Assessment Tool and ensuring that over 95% of computers and monitors were registered;
- modifying existing procurement policies and directives to give preference to environmentally-preferable electronic products;
- ensuring the DOE PORTS Environmental Management System addressed electronics stewardship;
- establishing and promoting a policy for personal computer power management; and

- establishing and promoting a policy to promote internal reuse, donation through Computers for Learning, federal government reuse, and donation to states or non-profits (in that order) as the preferred disposition methods for electronic equipment at the end of its first life.

Additional highlights of the DOE PORTS Environmental Sustainability Program in fiscal year 2009 include the following accomplishments:

- donating four excess flatbed railcars to the Moonville Rail Trail Association that will use the rail cars as bridge spans in its Vinton County, Ohio, public rail trail;

- utilizing a membrane interface probe instead of conventional soil sampling methods to identify soil contaminated with trichloroethene during an environmental investigation, thereby avoiding the generation of approximately 161 cubic feet of soil and other materials regulated as low-level radioactive waste and RCRA hazardous waste;

- reprocessing 377 pounds (171 kilograms) of highly enriched uranium for reuse at the Tennessee Valley Authority and the National Nuclear Security Administration, thereby avoiding transportation and disposal costs associated with material;

- recycling approximately 28,263 pounds of office and mixed paper, 9480 pounds of cardboard, 1367 pounds of aluminum cans, 661 pounds of toner cartridges, 2954 pounds of iron/steel, and 2712 pounds of plastic; and

- transferring 24 desktop computers, 158 monitors, and 37 printers to the Oak Ridge National Recycle Center for 100% recycling of all electronics.

In addition, DOE PORTS continued energy reduction programs focused on accomplishing the goals of Executive Order 13423, *Strengthening Federal Environmental, Energy, and Transportation Management*, and DOE Order 430.2B, *Departmental Energy, Renewable Energy, and Transportation Management*. DOE PORTS accomplished the following energy reduction efforts in fiscal year 2009:

- changing the firewater system in the X-330 and X-333 Buildings from wet to dry systems, thereby eliminating the need for space heaters and resulting in an estimated annual savings of 5000 to 9000 megawatt-hours (MWH);

- changing a system in the X-633 Pumphouse to eliminate use of a 1250 horsepower pump resulting in an estimated annual savings of 6000 MWH;

- shutting down the X-533 Switchyard and rerouting power to one major on-site switchyard resulting in an estimated annual savings of 7000 MWH and additional operational cost savings; and

- modifying the X-1000 Office Building heating, ventilation, and air conditioning system to control the system electronically resulting in improved indoor air quality and estimated annual power savings of 9000 MWH.

3.5 INACTIVE FACILITIES REMOVAL

In 2009, DOE PORTS received funding under ARRA for D&D of three inactive, surplus facilities: X-533 Switchyard Complex, X-633 Cooling Towers Complex, and X-760 Chemical Engineering Building. Planning for removal of these facilities was begun in 2008 as non-time critical removal actions under CERCLA and continued in 2009 with the development of Engineering Evaluation/Cost Analyses for the removal of each facility as well as other planning documentation. Demolition of the facilities began in 2010.

DOE continued demolition of other inactive, surplus PORTS facilities during 2009. Table 3.3 lists the facilities removed from 2006 (when the removals began) through 2009.

Table 3.3 Inactive facilities removed from DOE PORTS 2006 – 2009

Facility	Year removed	Location (Quadrant)
X-746 Shipping and Receiving Building	2009	I
X-744T Lithium Storage Warehouse	2008	I
X-744U Lithium Storage Warehouse	2008	I
X-770 Mechanical Testing Facility	2007	I
X-230J8 Environmental Storage Building	2006	I
X-230J1 Environmental Monitoring Station	2006	II
X-701D Water Deionization Building	2006	II
X-720A Maintenance & Stores Gas Manifold Shed	2006	II
X-105 Electronic Maintenance Building	2006	II
X-740 Waste Oil Storage Facility	2006	III
X-106B Old Fire Training Building	2006	III
X-616 Liquid Effluent Control Facility	2006	III
X-615 Old Sewage Treatment Plant	2006	III
X-344C Hydrogen Fluoride Storage Building	2006	IV
X-344E Gas Ventilation Stack	2006	IV
X-344F Safety Building	2006	IV
X-342C Waste Hydrogen Fluoride Neutralization Pit	2006	IV

In September 2009, D&D activities were completed for the X-746 Shipping and Receiving Building, including building demolition and soil sampling beneath and around the former building. No contamination that required additional sampling or remediation was identified around or beneath the building.

The X-770 Mechanical Testing Facility, a deferred unit with potentially contaminated soils, was demolished during 2007. This facility was located in the northern portion of the Quadrant I Groundwater Investigative Area (see Section 3.2.1.3 and Chapter 6, Section 6.4.2 for more information about the Quadrant I Groundwater Investigative Area). In 2008, DOE developed and implemented a work plan to investigate the soil beneath and around the former building. Two rounds of soil sampling were completed in September/October and December of 2008, which identified areas of soil contaminated with trichloroethene on the south and east sides of the former building. Based on the results of this investigation, DOE developed a remediation work plan to remove the concrete pad and contaminated soil associated with the former building. This plan was under development at the end of 2009.

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.

The PORTS Site Specific Advisory Board, comprised of up to 20 citizens from the local area, provides public input and recommendations to the DOE on environmental remediation, waste management, and related issues at PORTS. Additional information about the board can be obtained at www.ports-ssab.org or by calling 740-289-5249.

DOE PORTS also maintains a public Environmental Information Center to provide public access to documents used to make decisions on remedial actions being taken at PORTS. The Information Center is located just north of PORTS at the Ohio State University Endeavor Center (Room 207), 1862 Shyville Road, Piketon, Ohio 45661. The email address is eic@wems-llc.com. Hours for the Information Center are 9 a.m. to noon Monday and Tuesday, noon to 4 p.m. Wednesday and Thursday, or by appointment (call 740-289-8898). This Annual Environmental Report and other information can also be obtained from the PORTS web site at www.pppo.energy.gov.

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

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.

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4. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

4.1 SUMMARY

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

Environmental monitoring programs are required by state and federal regulations, permits, and DOE Orders. These programs may also be developed to address public concerns about plant operations. In 2009, environmental monitoring information was collected by DOE contractors (LPP and UDS) and USEC. Unlike other chapters of this report that focus primarily on DOE activities at PORTS, this chapter also includes information on air emissions and water discharges from 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 the United States receives an average dose of approximately 311 mrem/year from natural sources of radiation (National Council on Radiation Protection [NCRP] 2009).

This chapter includes radiological dose calculations for the dose to the public from radionuclides released to the air and surface water (the Scioto River), from direct radiation, and from radionuclides detected in 2009 by environmental monitoring programs for sediment, soil, vegetation, crops, and eggs. The maximum dose a member of the public could receive from radiation released by PORTS in 2009 (both the DOE and USEC) or detected by environmental monitoring programs in 2009 is 0.94 mrem/year. This summary of the dose calculations uses a worst-case approach; that is, the summary of the dose calculations 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 2009

Source of dose	Dose (mrem/year)[a]
Airborne radionuclides	0.024
Radionuclides released to the Scioto River	0.037
Direct radiation from depleted uranium cylinder storage yards	0.72
Radionuclides detected by environmental monitoring programs (sediment, soil, vegetation, crops, and eggs)	0.16
Total	0.94

[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 beginning in the late 1950s.

Environmental monitoring data are collected by DOE contractors 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 and air emissions of radionuclides. 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
- 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 United States receives an average dose of approximately 311 mrem/year from sources of natural radiation (NCRP 2009). Appendix A provides additional information on radiation and dose.

Releases of radionuclides from PORTS activities can result in a dose to a member of the public in addition to the dose received from natural sources of radiation. PORTS activities that release radionuclides are regulated by 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 (NESHAP). 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 NESHAP apply only to airborne radiological releases.

Small quantities of radionuclides were released to the environment from PORTS operations during 2009. 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 2009 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 2009, 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 2009 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 2009, doses are estimated for exposure to radionuclides detected by the monitoring programs for sediment, soil, vegetation, crops, 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 occasionally detected at PORTS but may be included as a conservative measure in the calculations used to determine the potential dose received from PORTS operations. Technetium-99 and transuranic radionuclides (americium-241, plutonium-238, and plutonium-239/240) are present in the environment in very small amounts due to radioactive fallout in the atmosphere from nuclear weapons testing by various countries around the world.

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

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

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

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

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

4.3.2 Airborne Emissions

Airborne discharges of radionuclides from PORTS are regulated under the Clean Air Act NESHAP. Releases of radionuclides are used to calculate a dose to members of the public, which is reported annually to U.S. EPA. Section 4.3.3 discusses the results of this dose calculation.

USEC operations account for many of the sources that emit radionuclides, although the gaseous diffusion uranium enrichment process is not operational. USEC emissions currently result from reprocessing of uranium hexafluoride feedstock, equipment decontamination, and the Lead Cascade (the demonstration centrifuge for uranium enrichment). In 2009, USEC reported emissions of 0.0305 curie (a measure of radioactivity) from its radionuclide emission sources.

DOE PORTS and LPP are responsible for five radiological emission sources. One source, the X-326 L-cage Glove Box, is used to repackage wastes or other materials that contain radionuclides. The remaining four sources, the X-622, X-623, X-624, and X-627 Groundwater Treatment Facilities, treat groundwater contaminated with radionuclides. There were no emissions from UDS air emission sources in 2009.

Emissions from the groundwater treatment facilities were calculated based on quarterly influent and effluent sampling at each facility and quarterly throughput. There were no emissions from the X-326 L-cage Glove Box in 2009. Emissions from the DOE sources in 2009 were calculated to be 0.054 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 NESHAP and is provided to the U.S. EPA in an annual report. The effect of radionuclides released to the atmosphere by PORTS during 2009 was characterized by calculating the effective dose to the maximally exposed person (the individual who resides at the most exposed point near the plant) and to the entire population (approximately 670,000 residents) within 50 miles of the plant. Dose calculations were made using a computer program called CAP88-PC Version 3.0, which was developed under sponsorship of the U.S. EPA for use in demonstrating compliance with the radionuclide NESHAP. The program uses models to calculate levels of radionuclides in the air, on the ground, and in 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 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 NESHAP background documents. This pattern specifies that 70% of the vegetables and produce, 44% of the meat, and 40% of the milk consumed by each person are produced in the local area (e.g., in a home garden). The remaining portion of each food is assumed to be produced within 50 miles of DOE PORTS. These assumptions most likely result in an overestimate of the dose received by a member of the public, since it is unlikely that a person spends the entire year outside at home and consumes food from the local area as described above.

The maximum potential dose to an off-site individual from radiological releases from DOE air emission sources at PORTS in 2009 was 0.019 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 0.024 mrem/year, well below the 10-mrem/year limit applicable to PORTS and the approximate 311-mrem/year dose that the average individual in the United States receives from natural sources of radiation (NCRP 2009).

The collective dose (or population dose) is the sum of the individual doses to the entire population within 50 miles of PORTS. In 2009, the population dose from PORTS emissions was 0.31 person-rem/year, based on USEC calculations of 0.14 person-rem/year from USEC sources and 0.17 person-rem/year from DOE sources. The population dose based on PORTS emissions is negligible; for example, the average population dose to all people within 50 miles of PORTS from the ingestion of naturally-occurring radionuclides in water and food is approximately 19,430 person-rem/year based on an average dose of approximately 29 mrem/year to an individual (NCRP 2009).

4.3.4 Dose Calculation Based on Ambient Air Monitoring

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 level of each radionuclide in air. The following assumptions were made to calculate the dose at each station: (1) the highest level of each radionuclide detected in 2009 was assumed to be present for the entire year; or (2) if a radionuclide was not detected, the radionuclide was assumed to be present for the entire year at half the highest undetected result.

The dose associated with each radionuclide at each ambient air monitoring station was added to obtain the gross dose for each station. The net dose for each station was obtained by subtracting the dose measured at the background station (A37). The net dose is considered zero at stations with a gross dose less than the dose measured at the background station. The net dose for each station ranged from 0 at station A6 in Piketon to 0.00024 mrem/year at station A24, which is north of PORTS at Schuster Road.

The highest net dose measured at the ambient air monitoring stations (0.00024 mrem/year at station A24) is 1% of the dose calculated from the combined DOE and USEC point source emissions (0.024 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 (LPP and UDS) and USEC are responsible for NPDES outfalls at PORTS. The UDS outfall is not monitored for radionuclides; therefore, it is not discussed in this section. A description of the LPP and USEC outfalls and the discharges of radionuclides from these outfalls during 2009 are included in this section. Quarterly reports that provide radiological monitoring data for the NPDES outfalls are submitted to Ohio EPA by LPP and USEC for their respective outfalls.

4.3.5.1 LPP outfalls

LPP currently holds an NPDES permit for four outfalls through which water is discharged from the site (see Figure 4.2).

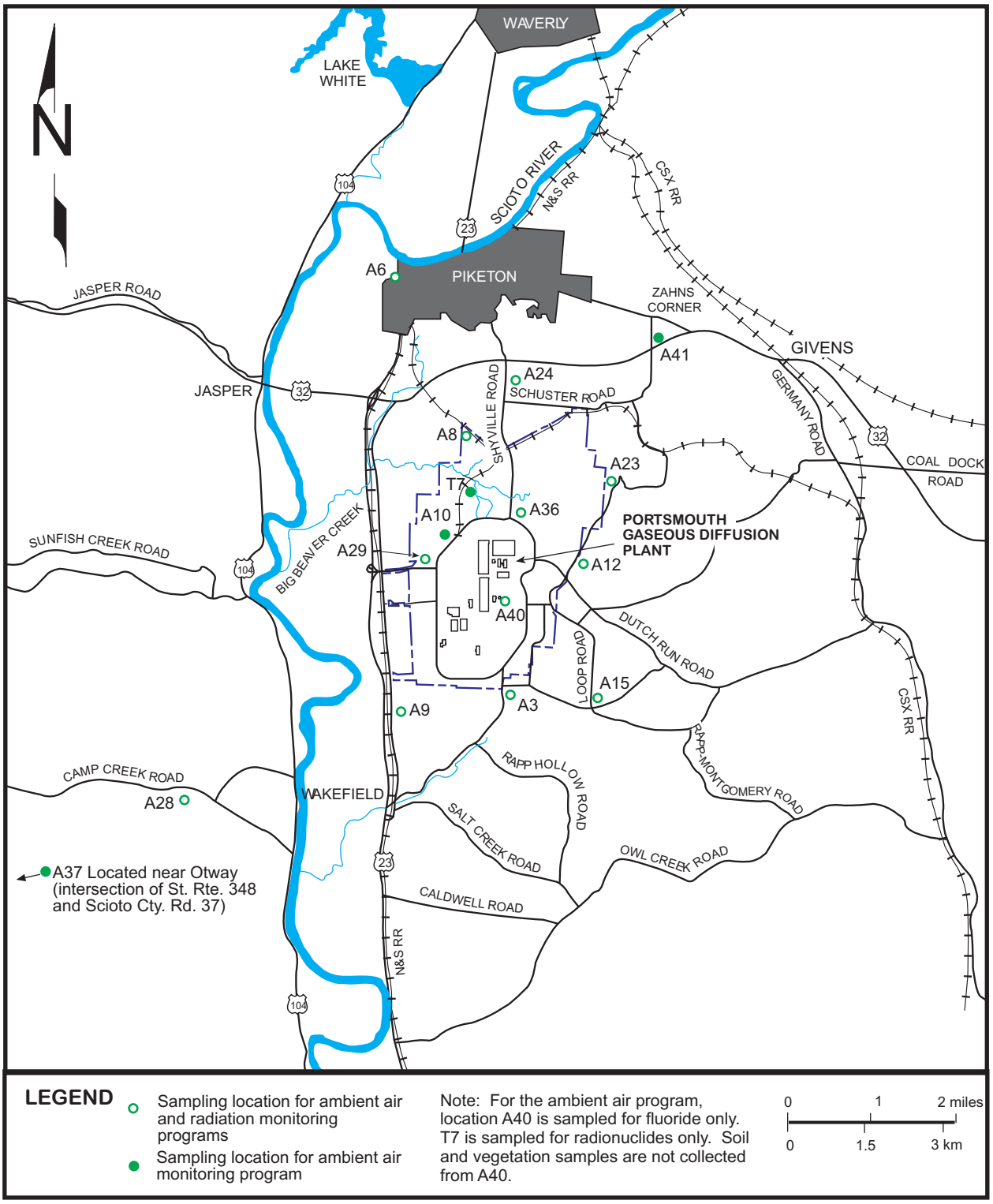

Figure 4.1. DOE ambient air and radiation monitoring locations.

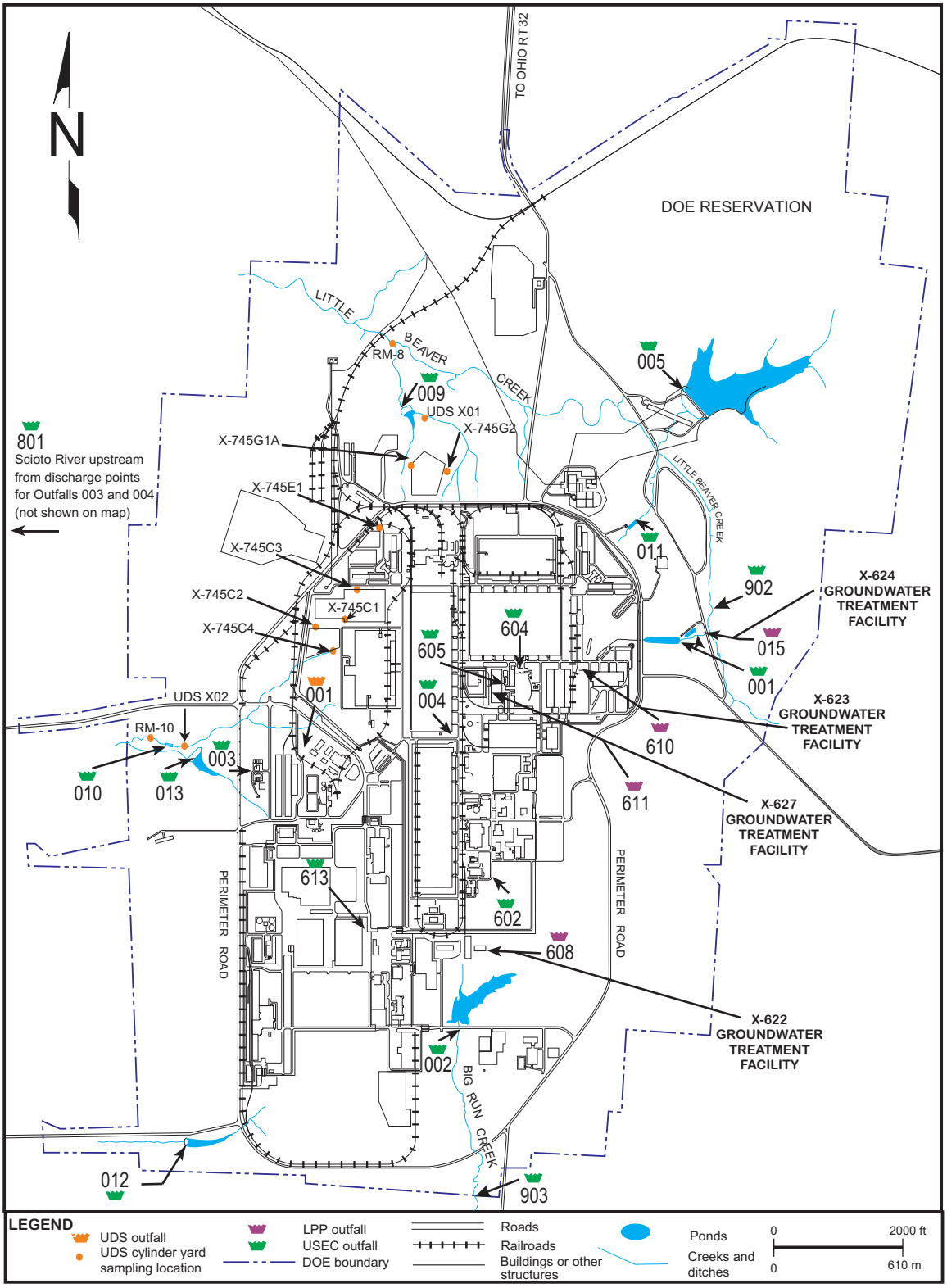

Figure 4.2. PORTS NPDES outfalls/monitoring points and UDS cylinder storage yards sampling locations.

Of the four LPP outfalls, one outfall discharges directly to Little Beaver Creek and the remaining three outfalls discharge to the USEC X-6619 Sewage Treatment Plant (USEC NPDES Outfall 003). A brief description of each LPP outfall at PORTS follows.

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

LPP 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 3.2.1). Treated water is discharged to the sanitary sewer and then through USEC NPDES Outfall 003.

LPP 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.

LPP 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-700 and X-705 buildings, which are part of Quadrant II. Treated water is discharged to the sanitary sewer and then through USEC NPDES Outfall 003.

LPP monitors 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).

Discharges of radionuclides in liquids through LPP NPDES outfalls have no significant impact on public health and the environment. Uranium discharges in 2009 from Outfall 015 (the only LPP outfall that discharges directly to surface water) were estimated at 0.014 kilogram. Total radioactivity released from Outfall 015 was 0.000018 curie of uranium isotopes.

Discharges of radionuclides were calculated using monthly monitoring data from LPP NPDES Outfall 015. 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 outfall. Discharges of radionuclides from Outfall 015 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 Outfall 015 during 2009.

4.3.5.2 USEC outfalls

USEC is currently responsible for 14 NPDES outfalls through which water is discharged from the site (see Figure 4.2). Ten outfalls discharge directly to surface water, and four 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 is located at 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 012 (X-2230M Southwest Holding Pond) – The X-2230M Southwest Holding Pond accumulates 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.

USEC NPDES Outfall 013 (X-2230N West Holding Pond) – The X-2230N West Holding Pond accumulates precipitation runoff, non-contact cooling water, and steam condensate from the 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.

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).

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

In 2009, 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 2009 from external USEC NPDES outfalls (Outfalls 001, 002, 003, 004, 005, 009, 010, 011, 012, and 013) were estimated at 11.05 kilograms. Radioactivity released from the external outfalls was 0.08 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 2009.

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 and data from external LPP outfalls 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 LPP and USEC NPDES external outfalls (one LPP outfall and ten 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 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 LPP 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 the years prior to shutdown of the gaseous diffusion uranium enrichment operations. The maximum individual dose was calculated using the above-mentioned measured radionuclide discharges from the plant outfalls and the annual flow rate of the Scioto River.

The dose calculations were derived from the procedures developed for a similar DOE facility: *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. This exposure scenario is very conservative because the Scioto River is not used for drinking water downstream of PORTS (90% of the hypothetical dose from liquid effluents is from drinking water). The dose from radionuclides released to the Scioto River in 2009 (0.037 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

Radiation is emitted from the depleted uranium cylinders stored on site at PORTS in the X-745C, X-745E, and X-745G Depleted Uranium Hexafluoride Cylinder Storage Yards, which are located in the northwest portion of the site near Perimeter Road. Due to increased security at PORTS following September 11, 2001, the general public no longer has uncontrolled access to the portion of Perimeter Road near the cylinder yards; 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.

Environmental radiation is measured at five locations along Perimeter Road near the boundaries of the UDS cylinder storage yards in accordance with the DOE *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant* (see Section 4.6.2). In 2009, the average effective dose equivalent recorded at the cylinder yards near Perimeter Road was 727 mrem/year, based on exposure to ionizing radiation for an entire 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 0.72 mrem/year. The average annual dose to a person in the United States from all radiation sources (natural and manmade) is approximately 620 mrem (NCRP 2009). The potential estimated dose from the cylinder yards to a member of the public is approximately 0.1 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 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.

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 2009 Radiation Exposure Information Reporting System report indicated that no visitors received a measurable dose (defined as 10 mrem or more).

Eleven hundred eighty-one DOE PORTS workers (LPP, TPMC, and UDS) were monitored during 2009. The monitored workers received an average dose of 1.3 mrem/person. No administrative guidelines or regulatory dose limits were exceeded in 2009.

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. Technetium-99 and transuranics could come from PORTS operations because they were present in recycled uranium processed by PORTS during the Cold War. Technetium-99 and transuranics could also come from sources other than PORTS because they are generally present in the environment in very small amounts due to radioactive fallout in the atmosphere from nuclear weapons testing by various countries around the world.

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, and soil) and biota (vegetation, 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. The summary of these dose calculations uses a worst-case approach; that is, the summary of the dose calculations assumes that the same individual is exposed to the most extreme conditions from each pathway.

In 2009, dose calculations were completed for public exposure to radionuclides detected in sediment, soil, vegetation, crops, and eggs. Radionuclides were not detected in deer, fish, and milk samples collected during 2009. 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 2009 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 2009

Source of dose	Dose (mrem/year)[a]
Sediment	0.052
Soil	0.078
Vegetation	0.014
Crops	0.0014
Eggs	0.019
Total	0.16

[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 following detections of radionuclides in the sediment sample collected in 2009 from monitoring location RM-7, an off-site sampling location on Little Beaver Creek downstream from PORTS: americium-241 (0.02173 pCi/g), neptunium-237 (0.08866 pCi/g), plutonium-238 (0.01444 pCi/g), plutonium-239/240 (0.06676 pCi/g), technetium-99 (57.4 pCi/g), uranium-233/234 (2.01 pCi/g), uranium-235 (0.07306 pCi/g), and uranium-238 (0.5539 pCi/g). 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 0.052 mrem/year. Section 4.6.5 provides additional information on the sediment monitoring program as well as a map of sediment sampling locations.

4.3.9.2 Dose calculation for soil

The dose calculation for soil is based on the detections of 1.05 pCi/g of uranium-233/234, 0.05005 pCi/g of uranium-235, and 1.089 pCi/g of uranium-238 in soil at the ambient air sampling station in Piketon (A6). 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 0.078 mrem/year. Section 4.6.7 provides additional information on the soil monitoring program.

4.3.9.3 Dose calculation for vegetation

The dose calculation for vegetation is based on the detections of 0.4415 pCi/g of uranium-233/234, 0.02318 pCi/g of uranium-235, and 0.4581 pCi/g of uranium-238 in vegetation and 0.8317 pCi/g of uranium-233/234, 0.04178 pCi/g of uranium-235, and 0.9464 pCi/g of uranium-238 in soil at sampling location A24, which is north of PORTS at Schuster Road. The dose calculation of 0.014 mrem/year is based on human consumption of beef cattle that would eat grass contaminated at this level and exposure factors from U.S. EPA's *Exposure Factors Handbook* (U.S. EPA 1997). Section 4.6.8 provides additional information on the vegetation monitoring program.

4.3.9.4 Dose calculation for crops

The dose calculation for crops is based on the detection of uranium-233/234 at 0.02682 pCi/g in a melon collected from off-site location #4. 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 melon contaminated at this level throughout the year is 0.0014 mrem/year. Section 4.6.9.3 provides additional information on the monitoring program for crops.

4.3.9.5 Dose calculation for eggs

The dose calculation for eggs is based on the detection of uranium-233/234 at an average level of 0.008485 pCi/g in the regular and duplicate egg samples collected from a location in Wakefield. Uranium-233/234 was detected at 0.009984 pCi/g in the regular sample and 0.006986 pCi/g in the duplicate sample; the average level of uranium-233/234 detected in the eggs is 0.008485 pCi/g. 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 contaminated at this level throughout the year is 0.019 mrem/year. Section 4.6.9.4 provides additional information on the dairy (milk and eggs) 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 surface 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 the local surface water and sediment sampling programs, respectively.

The maximum values of transuranic radionuclides, technetium-99, and uranium isotopes detected in sediment or surface water samples collected from these locations in 2009 were entered into the RESRAD-BIOTA program that is designed to implement the DOE Technical Standard (DOE 2002). The assessment indicates that the levels 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 RW-8 and soil sampling location A8) were used to assess the dose recommendations for terrestrial plants and animals. These locations were selected because levels of uranium isotopes detected in surface water and soil from these locations were among the highest detected in samples collected in 2009. Sections 4.6.4 and 4.6.7 provide additional information for the local surface water and soil sampling programs, respectively.

Data for the highest levels of radionuclides detected at these locations in 2009 were entered into the RESRAD-BIOTA program that is designed to implement the DOE Technical Standard (DOE 2002). The assessment indicates that the levels 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 2009.

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 levels 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 2009, samples were collected from 15 ambient air monitoring stations located within and around PORTS (see Section 4.3.4, Figure 4.1), including a background ambient air monitoring station (A37) located approximately 13 miles southwest of the plant. The analytical results from air sampling stations closer to the plant are compared to the background measurements.

No transuranic radionuclides were detected in the samples collected from the ambient air stations in 2009. Technetium-99 was detected at stations A23 (the northeastern plant boundary), and A24 (north of the plant on Schuster Road). The maximum activity of technetium-99 in ambient air was 0.0031 picocurie per cubic meter (pCi/m^3) at station A24, which is well below the DOE derived concentration guide of 2000 pCi/m^3.

Uranium-233/234 and uranium-238 were detected in all of the samples. The highest average activity of uranium-233/234 (0.00083 pCi/m^3) was detected at station A29 (on site at the Ohio Valley Electric Corporation). The highest average activity of uranium-238 (0.00073 pCi/m^3) was detected at station A28 (southwest of the plant on Camp Creek Road). These average activities are well below the DOE derived concentration guides for uranium-233/234 (0.09 pCi/m^3) and uranium-238 (0.1 pCi/m^3).

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 (0.00024 mrem/year) was at station A24, which is north of the plant on Schuster 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 continuously 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. A new measuring device replaces the removed device. Radiation is measured in millirems as a whole body dose, which is the dose that a person would receive if they were continuously present at the monitored location.

Three locations detected elevated levels of radiation in 2009: 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 other 16 locations (i.e., excluding locations #874, #862, and #933) ranged from 61 to 95 mrem and averaged 79 mrem. The cumulative whole body doses at locations #874, #862, and #933 were 687 mrem, 124 mrem, and 173 mrem, respectively. The control and trip blanks associated with all of the results for this monitoring program, which measure background radiation, averaged 80 mrem.

In addition, radiation is measured at five locations around the northwest corner of PORTS just inside Perimeter Road near the UDS depleted uranium cylinder storage yards (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 249 mrem and 211 mrem, respectively. Locations #874 and #882 recorded cumulative annual whole body doses of 688 mrem and 937 mrem, respectively, and location #868 recorded a cumulative annual whole body dose of 1549 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 2009.

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 UDS cylinder storage yards. The potential estimated dose from the cylinder yards to a member of the public (0.72 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 UDS 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 around the X-745C storage yard (X-745C2, X-745C3, and X-745C4). Figure 4.2 shows the sampling locations. Samples collected during 2009 were analyzed for alpha activity, beta activity, and total uranium.

Uranium was detected at a maximum concentration of 15.9 µg/L in the sample collected during March 2009 at sampling location X-745C1. Detections of alpha activity and beta activity during 2009 were less than 20 pCi/L (alpha activity) and 25 pCi/L (beta activity). 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). The dose from radionuclides released to surface water (the Scioto River) in 2009 (0.037 mrem) is significantly less than the 100 mrem/year DOE limit for all radiological releases from a facility.

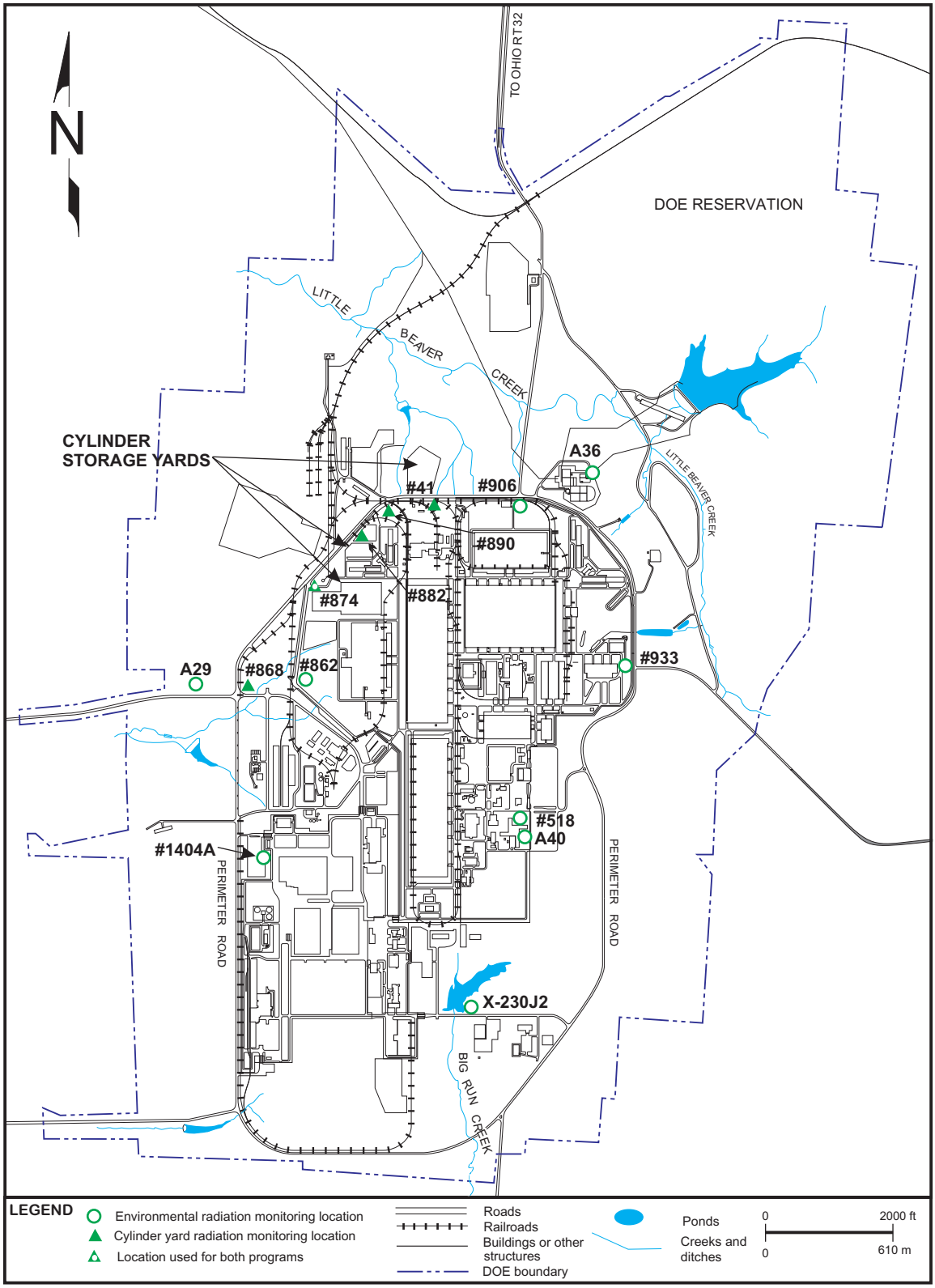

Figure 4.3. On-site radiation and cylinder yard dose monitoring locations.

4.6.4 Local Surface Water

In 2009, 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 or technetium-99 were detected in any of the surface water samples collected in 2009. Maximum detections of uranium and uranium isotopes in local surface water samples were detected at location RW-8 (Little Beaver Creek). Uranium was detected at 6.21 µg/L, uranium-233/234 was detected at 2.691 pCi/L, uranium-235 was detected at 0.1132 pCi/L, and uranium-238 was detected at 2.075 pCi/L. Uranium-236 was not detected in any of the local surface water samples collected in 2009. Detections of uranium and uranium isotopes in local surface water samples in 2009 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-235 and 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.*

Uranium and uranium isotopes are naturally occurring, but may also be present due to PORTS activities. Maximum detections of uranium and uranium isotopes in sediment samples were detected at locations RM-10W (the background sampling location west of PORTS), RM-11 (on site near USEC NPDES Outfalls 010 and 013), and RM-8 (Little Beaver Creek). Uranium was detected at 2.882 µg/g (RM-10W), uranium-233/234 was detected at 3.554 pCi/g (RM-11), uranium-235 was detected at 0.1436 pCi/g (RM-11), uranium-236 was detected at 0.008971 pCi/g (RM-8), and uranium-238 was detected at 0.963 pCi/g (RM-10W). Uranium and uranium isotopes detected in the 2009 samples have been detected at similar levels in previous sampling events from 1999 through 2008.

Transuranic radionuclides were detected at very low activities in two sediment sampling locations upstream from PORTS (RM-5 – upstream on Big Beaver Creek and RM-33 – upstream on Big Run Creek), one background location (RM-10S – 10 miles south of PORTS), and five locations downstream from PORTS (locations on Little Beaver Creek, Big Beaver Creek, and the Scioto River). The highest detections for each transuranic radionuclide were at one of the downstream sampling locations on Little Beaver Creek (RM-7). Americium-241 was detected at 0.02173 pCi/g, neptunium-237 was detected at 0.08866 pCi/g, plutonium-238 was detected at 0.01444 pCi/g, and plutonium-239/240 was detected at 0.06676 pCi/g. These detections are much less than the U.S. EPA preliminary remediation goal for each radionuclide in residential soil: americium-241 – 1.87 pCi/g, neptunium-237 – 1 pCi/g, plutonium-238 – 2.97 pCi/g, and plutonium-239/240 – 2.59 pCi/g.

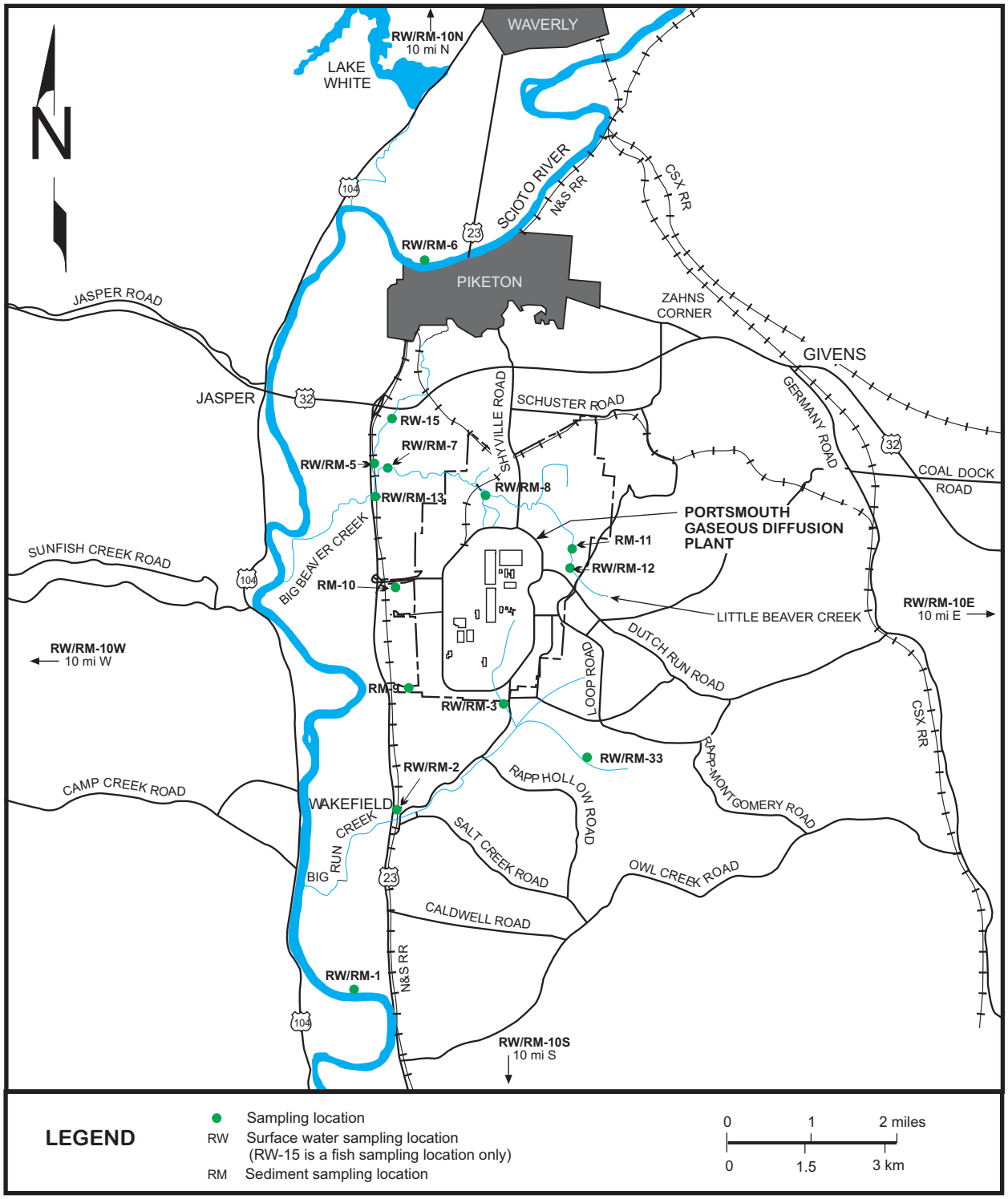

Figure 4.4. Local surface water/sediment monitoring locations.

Technetium-99 is often detected in sediment samples collected at locations downstream from PORTS. In 2009, technetium-99 was detected in the sample collected from the downstream location on Big Beaver Creek (RM-13), the downstream location on Big Run Creek (RM-3), the west drainage ditch location near USEC NPDES Outfalls 010 and 013 (RM-10), and downstream locations on Little Beaver Creek (RM-11, RM-7, and RM-8). The highest detection (57.4 pCi/g) was at location RM-7, a downstream location on Little Beaver Creek. These detections of technetium-99 are consistent with data from previous sampling events (2002 through 2008).

Section 4.3.9.1 provides a dose assessment to a member of the public based on detections of transuranics, technetium-99 and uranium isotopes at the downstream sampling location on Little Beaver Creek just before it flows into Big Beaver Creek (RM-7). This off-site sampling location had the following levels of radionuclides detected in 2009 that would cause the highest dose to a member of the public: 0.02173 pCi/g of americium-241, 0.08866 pCi/g of neptunium-237, 0.01444 pCi/g of plutonium-238, 0.06676 pCi/g of plutonium-239/240, 57.4 pCi/g of technetium-99, 2.01 pCi/g of uranium-233/234, 0.07306 pCi/g of uranium-235, and 0.5539 pCi/g of uranium-238. The total potential dose to a member of the public resulting from PORTS operations (0.94 mrem/year), which includes this dose calculation (0.052 mrem/year), is well below the DOE standard of 100 mrem/year.

4.6.6 Settleable Solids

The DOE collects semiannual water samples from three NPDES effluent 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.*

Two samples are collected from each of the three monitoring locations. The first sample is analyzed for total suspended solids, total alpha activity, and total beta activity. The second sample is analyzed for non-settleable solids, total alpha activity, and total beta activity.

In 2009, alpha and beta activity were not detected in the samples, therefore; 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*.

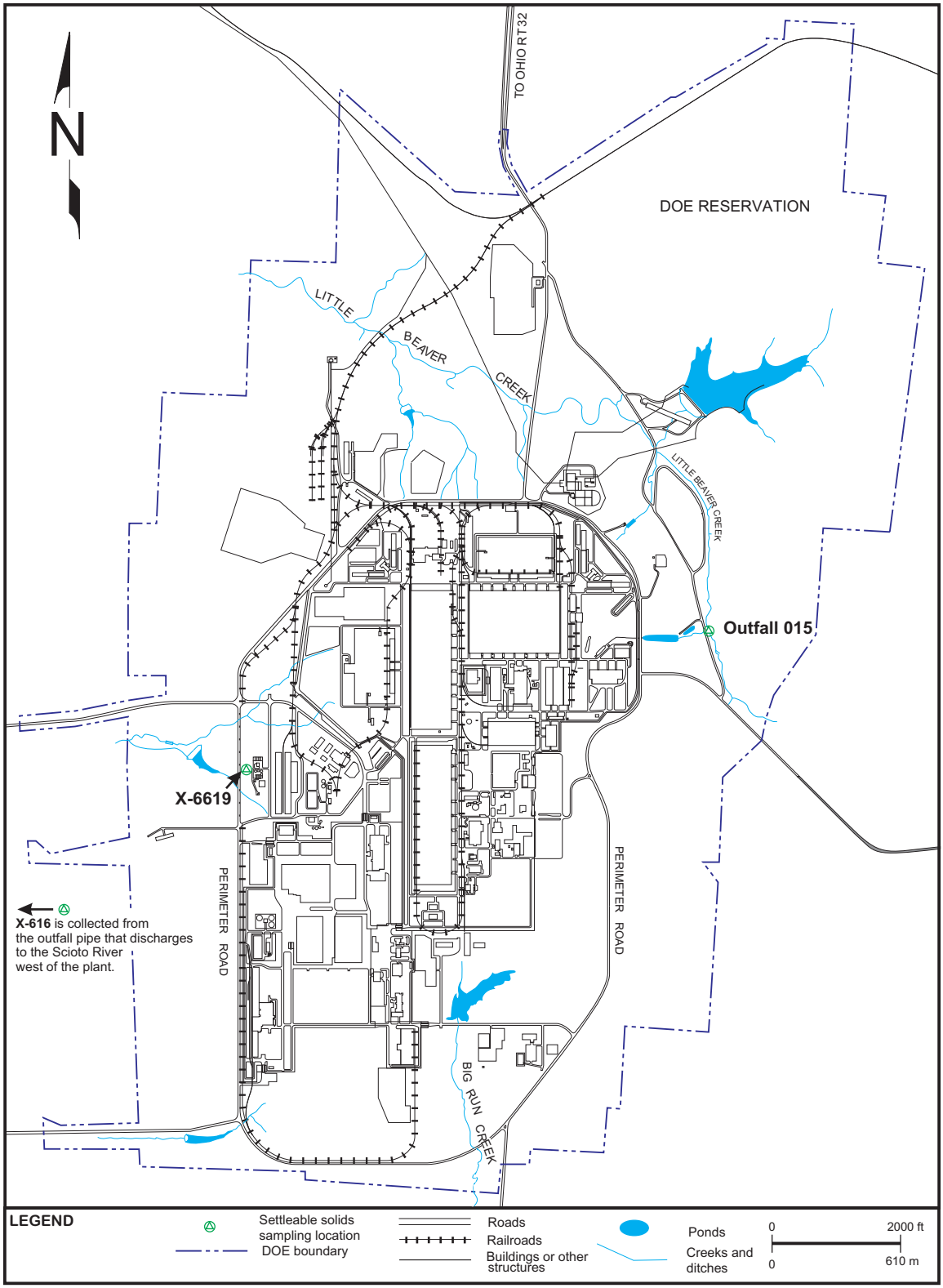

Figure 4.5. DOE settleable solids monitoring locations.

No transuranics or technetium-99 were detected in the soil samples collected during 2009. Uranium (total), uranium-233/234, uranium-235, and uranium-238 were detected at most of the sampling locations. Uranium-236 was not detected in any of the soil samples collected in 2009. Uranium and uranium isotopes were detected at similar levels at all the soil sampling locations, including the background location (A37), which suggests that the uranium detected in these samples is due to naturally-occurring uranium.

Section 4.3.9.2 provides a dose assessment based on the detections of uranium-233/234 (1.05 pCi/g), uranium-235 (0.05005 pCi/g), and uranium-238 (1.089 pCi/g) in soil at the off-site ambient air station with the detections of radionuclides that could cause the highest dose to a member of the public (station A6 in Piketon). The total potential dose to a member of the public resulting from PORTS operations (0.94 mrem/year), which includes this dose calculation (0.078 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 2009. Technetium-99 was detected at 0.361 and 0.141 pCi/g, respectively, in the samples collected from stations A23 (the northeastern plant boundary) and A36 (on site near the X-611 Water Treatment Plant). Technetium-99 is occasionally detected at low activities less than 1 pCi/g at the ambient air monitoring stations.

Uranium, uranium-233/234, uranium-235, and/or uranium-238 were detected in the samples collected from nine of the fifteen monitoring stations, including the background monitoring station A37. Uranium and uranium isotopes are detected occasionally, and have been detected at similar levels in previous sampling (2002 through 2008). Section 4.3.9.3 provides a dose assessment for a member of the public based on consumption of beef cattle that would eat grass contaminated with radionuclides that could cause the highest dose to a member of the public (station A24). The total potential dose to a member of the public resulting from PORTS operations (0.94 mrem/year), which includes this dose calculation (0.014 mrem/year), is well below the DOE standard of 100 mrem/year.

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

Samples of liver, kidney, and muscle from deer killed on site in collisions with motor vehicles were collected in April and November of 2009. The 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 samples.

4.6.9.2 Fish

In 2009, fish were caught at downstream locations on the Scioto River (RW-1) and Little Beaver Creek (RW-8) as well as upstream locations on the Scioto River (RW-6) and Big Beaver Creek (RW-15). The 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 samples.

4.6.9.3 Crops

In 2009, 17 crop samples, including peppers, corn, tomatoes, cucumbers, melon, and zucchini, 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). No transuranics or technetium-99 were detected in any of the samples. Uranium-233/234 was detected at 0.02682 pCi/g in the melon sample. No other radionuclides were detected in the samples.

Section 4.3.9.4 provides a dose assessment to a member of the public based on consumption of melon containing uranium-233/234 at 0.02682 pCi/g. The total potential dose to a member of the public resulting from PORTS operations (0.94 mrem/year), which includes this dose calculation (0.0014 mrem/year), is well below the DOE standard of 100 mrem/year.

4.6.9.4 Milk and eggs

Two samples (a regular and a duplicate sample) were collected in 2009 of milk produced by a dairy near Waverly and eggs from a farm near Lucasville. 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). No radionuclides were detected in the milk samples collected during 2009.

Uranium-233/234 was detected at 0.009984 pCi/g in the regular egg sample and at 0.006986 pCi/g in the duplicate sample. Uranium is occasionally detected at low levels in the dairy samples. No other radionuclides were detected in the egg samples.

Section 4.3.9.5 provides a dose assessment to a member of the public based on consumption of eggs containing uranium-233/234 at an average level of 0.008485 pCi/g (the average of 0.009984 and 0.006986 pCi/g). The total potential dose to a member of the public resulting from PORTS operations (0.94 mrem/year), which includes this dose calculation (0.019 mrem/year), is well below the DOE standard of 100 mrem/year.

4.7 RELEASE OF PROPERTY CONTAINING RESIDUAL RADIOACTIVE MATERIAL

In 2009, no DOE property (equipment, excess materials, etc.) was released to the public that contained 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.

5. ENVIRONMENTAL NON-RADIOLOGICAL PROGRAM INFORMATION

5.1 SUMMARY

Non-radiological environmental monitoring at PORTS includes air, water, sediment, and fish. Monitoring of non-radiological parameters is required by state and federal regulations and/or permits, but is also performed to reduce public concerns about plant operations. Non-radiological data collected in 2009 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, surface water, sediment, and fish. Non-radiological data are not collected for all sampling locations or all monitoring programs.

Environmental permits issued by the Ohio 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 for air emissions and discharges to water 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
- 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 boundaries and in the surrounding area.

5.3.1 Airborne Discharges

DOE PORTS operates several sources of conventional air pollutants such as organic compounds and particulate matter. These air emission sources include two landfill venting systems, one glove box, and four groundwater treatment facilities. These air emission sources are regulated as minor sources by Ohio EPA. Air emissions are estimated every two years for the Ohio EPA biennial emission fee statement.

To calculate air emissions, DOE PORTS assumes that each source emits the maximum allowable amount of each pollutant as provided in the permit or registration for each source. Using this worst-case scenario, DOE PORTS estimated emissions of particulate matter to be 0.0015 ton and organic compounds to be 2.249 tons in 2009. These emissions were reported to Ohio EPA in the fee statement due April 15, 2010.

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 2009, 137.46 tons of material contaminated with asbestos were shipped from DOE PORTS. These wastes included demolition debris from D&D of the X-746 and X-344C Buildings, and miscellaneous materials from the X-326 Building.

USEC reported the following emissions of non-radiological air pollutants for 2009 in the Ohio EPA Fee Emissions Report: 0.202 ton of lead, 48.919 tons of particulate matter, 13.7513 tons of organic compounds, 2051.16 tons of sulfur dioxide, and 225.666 tons of nitrogen oxides. These emissions are associated with three boilers at the X-600 Steam Plant, which provide steam for PORTS, the X-6002 boilers, gravel roads and parking areas (due to construction activities for the American Centrifuge Plant), and compressors associated with the X-326 dry air systems (diesel engine-powered).

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 2009, samples for fluoride were collected weekly from 15 ambient air monitoring stations in and around PORTS (see Chapter 4, Figure 4.1) including a background ambient air monitoring station (A37) located approximately 13 miles southwest of the plant. In 2009, the average ambient concentration of fluoride measured in samples collected at background station A37 was 0.036 microgram per cubic meter ($\mu g/m^3$). Average ambient concentrations of fluoride measured at the stations around PORTS ranged from 0.030 $\mu g/m^3$ at station A10, located on-site near the Don Marquis substation, to 0.072 $\mu g/m^3$ at station A40 (on-site near the X-100 Administration Building). There is no standard for fluoride in ambient air. The data indicate that ambient concentrations of fluoride at background locations are not appreciably different from concentrations near PORTS.

5.4 WATER

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

5.4.1 Water Discharges (NPDES Outfalls)

DOE contractors (LPP and UDS) and USEC are responsible for NPDES outfalls at PORTS. This section describes non-radiological discharges from these outfalls during 2009.

5.4.1.1 LPP NPDES outfalls

In 2009, LPP was responsible for four discharge points, or outfalls, through which water is discharged from the site. One outfall discharges directly to surface water and three discharge to the USEC X-6619 Sewage Treatment Plant (USEC NPDES Outfall 003). Chapter 4, Section 4.3.5.1, provides a brief description of each LPP outfall and provides a site diagram showing each LPP 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 and sets discharge limitations for some of these parameters. The LPP outfalls discharge water from the groundwater treatment facilities; therefore, the outfalls are monitored for selected volatile organic compounds (*trans*-1,2-dichloroethene and/or trichloroethene) because the groundwater treatment facilities treat water contaminated with volatile organics. Chemicals and water quality parameters monitored at each LPP outfall are as follows:

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

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

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

- LPP NPDES Outfall 611 (X-627 Groundwater Treatment Facility) – pH and trichloroethene.

The monitoring data detailed in the previous paragraph are submitted to Ohio EPA in a monthly operating report. In 2009, none of the discharge limitations for LPP NPDES outfalls were exceeded; therefore, the overall LPP NPDES compliance rate with the NPDES permit was 100%.

5.4.1.2 UDS NPDES outfalls

UDS holds an NPDES permit for the discharge of process wastewaters from the Depleted Uranium Hexafluoride Conversion Facility to the West Ditch, which flows to USEC NPDES Outfall 010 (the X-230J5 Northwest Holding Pond) and then to the Scioto River. Chapter 4, Figure 4.2 shows the location of the UDS NPDES outfall. Water discharged from UDS Outfall 001 is monitored for the following chemicals and water quality parameters: temperature, biochemical oxygen demand, pH, suspended solids, oil and grease, ammonia-nitrogen, phosphorus, chlorine, and dissolved solids.

The monitoring data are submitted to Ohio EPA in a monthly operating report. Although the UDS facility was not operating in 2009, the UDS NPDES Outfall 001 discharged from January through October. These discharges consisted only of precipitation run-off. Beginning in November of 2008, all UDS system testing process effluents were taken to USEC for treatment prior to discharge through a USEC NPDES outfall.

In February 2009, the daily concentration limit for total dissolved solids was exceeded twice due to the use of salt as a de-icing agent on roads and sidewalks around the UDS facilities. The average monthly temperature limit was also exceeded in February due to warmer than typical weather. The discharge limitations for total suspended solids were exceeded on numerous occasions during 2009. The exceedences were generally due to precipitation and the accumulation of sediment within the storm sewers around the UDS facilities. Rain often causes higher concentrations of suspended solids in surface water. Many NPDES permits, including the USEC NPDES permit, include a provision that the discharge limitations for suspended solids do not apply if flow increases due to precipitation; however, the UDS NPDES permit does not include this provision. Only precipitation run-off was discharged through the UDS outfall during 2009.

UDS and Ohio EPA are discussing modifications to the UDS NPDES permit to address precipitation events and permit limitations for solids. The overall UDS NPDES compliance rate in 2009 was 87%.

5.4.1.3 USEC NPDES outfalls

USEC is responsible for 14 NPDES outfalls through which water is discharged from the site (see Chapter 4, Figure 4.2). Ten outfalls discharge directly to surface water, and four 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 and water quality parameters 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, pH, silver, suspended solids, and zinc.

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

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

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

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

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

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

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

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

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

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

- USEC NPDES Outfall 604 (X-700 Biodenitrification Facility) – copper, iron, nickel, nitrate-nitrogen, pH, and 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, pH, sulfate, suspended solids, trichloroethene, and zinc.

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

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.

The monitoring data are submitted to Ohio EPA in a monthly operating report. In 2009, two exceedences of discharge limitations were reported as discussed below:

- On August 17, 2009, the 24-hour maximum temperature limit of 29.4°Celsius (°C) was exceeded at NPDES Station Number 902. The maximum temperature recorded was 30°C. Hot, dry weather caused this exceedence.

- On December 9, 2009, the maximum concentration for total residual chlorine (0.038 mg/L) was exceeded at Outfall 004 for a period of 3.75 hours. Residual chlorine was measured at 0.5 mg/L. Routine refilling of the halogen feed system associated with the X-630 Cooling Tower resulted in higher levels of chlorine in the cooling water blowdown. Adjustments to the dechlorination treatment brought residual chlorine levels below the permit limitation.

In 2009, the overall USEC NPDES compliance rate with the NPDES permit was 99%.

5.4.2 Surface Water Monitoring Associated with UDS Cylinder Storage Yards

Surface water samples (filtered and unfiltered) are collected quarterly from four locations in the drainage basins downstream from the UDS depleted uranium cylinder storage yards (UDS X01, RM-8, UDS X02, and RM-10 - see Chapter 4, Figure 4.2) and analyzed for PCBs. PCB-1254 was detected at 0.22 µg/L in the filtered surface water sample collected in the first quarter at sampling location RM-8. This detection (0.22 µg/L) is less than the 0.5 ppb (0.5 µg/L) 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. PCBs were not detected in any of the other surface water samples (filtered or unfiltered) collected during 2009. Section 5.5.2 presents the results for sediment samples collected as part of this program.

5.5 SEDIMENT

In 2009, sediment monitoring at PORTS included local streams and the Scioto River upstream and downstream from PORTS and drainage basins downstream from the UDS 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 2009, samples were analyzed for 20 metals and PCBs, in addition to the radiological parameters discussed in Chapter 4.

PCBs, primarily PCB-1260 and PCB-1254, were detected in some of the sediment samples collected in 2009 at concentrations up to 187 micrograms per kilogram (µg/kg) or parts per billion (ppb). PCB-1260 and/or PCB-1254 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), Little Beaver Creek at the discharge point from the X-230J7 Pond (RM-11), downstream Big Beaver Creek (RM-13), downstream Big Run Creek at the PORTS boundary (RM-3), the Southwest Drainage Ditch near USEC Outfall 012 (RM-9), and the West Drainage Ditch near USEC Outfalls 010 and 013 (RM-10). PCBs (PCB-1016, PCB-1254, and/or PCB-1260) were also detected in the upstream and downstream Scioto River sampling locations (RM-6 and RM-1, respectively). PCB-1260 and PCB-1254 are associated with PORTS activities, although they can also be present in the environment from other sources. PCB-1016 is not usually detected at PORTS and is 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 2009 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 UDS Cylinder Storage Yards

Sediment samples are collected quarterly from four locations in the drainage basins downstream from the UDS depleted uranium cylinder storage yards (UDS X01, RM-8, UDS X02, and RM-10) and analyzed for PCBs. These locations are on site at PORTS and not accessible to the public.

In 2009, total PCBs (PCB-1242, PCB-1254 and/or PCB-1260) were detected in at least one of the sediment samples collected from each location at concentrations up to 608 µg/kg (ppb). These concentrations are below the 1 ppm (1000 ppb) reference value set forth in the U.S. EPA Region 5 *TSCA Approval for Storage for Disposal of PCB Bulk Product (Mixed) Waste,* which applies to the storage of depleted uranium cylinders at PORTS that may have paint on the exterior of the cylinders that contains more than 50 ppm PCBs.

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

5.6 BIOLOGICAL MONITORING - FISH

In 2009, fish were collected from upstream locations on Big Beaver Creek (RW-15) and the Scioto River (RW-6) as well as downstream sampling locations on Little Beaver Creek (RW-8) and the Scioto River (RW-1) as part of the routine fish monitoring program at PORTS. Chapter 4, Figure 4.4, shows the surface water monitoring locations where the fish were caught. Fish samples were analyzed for PCBs, in addition to the radiological parameters discussed in Chapter 4. Fish samples collected for this program included only the fish fillet, that is, only the portion of the fish that would be eaten by a person. Fish samples collected from the Scioto River consisted of freshwater drum (RW-6) and a mixture of freshwater drum and catfish (RW-1). The sample collected from Big Beaver Creek upstream from PORTS (RW-15) was a mixture of sunfish and large mouth bass. Two samples were collected from Little Beaver Creek (RW-8); one sunfish sample and one large mouth bass sample.

PCBs were detected in the samples collected from the Scioto River downstream from PORTS (RW-1) and both Little Beaver Creek samples (RW-8). The downstream Scioto River fish sample (RW-1) contained PCB-1254 at an estimated concentration of 66.7 µg/kg. The largemouth bass sample from Little Beaver Creek contained PCB-1260 at an estimated concentration of 225 µg/kg. The sunfish sample from Little Beaver Creek contained total PCBs at an estimated concentration of 678 µg/kg (PCB-1254 at 120 µg/kg and PCB-1260 at 558 µg/kg). PCBs were not detected in the fish samples collected from the Scioto River at RW-6 or Big Beaver Creek at RW-15. 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 2008). These limits are set for the following consumption rates: unrestricted, 1/week, 1/month, 6/year, and do not eat. These concentrations of PCBs detected in fish collected from Little Beaver Creek (225 and 678 µg/kg) are above the 1/week maximum limit (220 µg/kg) and below the 1/month maximum limit (1000 µg/kg). The concentration of PCBs detected in the fish collected from the Scioto River (66.7 µg/kg) is just above the unrestricted limit (50 µg/kg) and below the 1/week maximum limit (220 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.

Concentrations of trichloroethene are decreasing and the groundwater plumes are shrinking in both monitoring areas in Quadrant I (the X-749/X-120/PK Landfill area and the Quadrant I Groundwater Investigative Area). Although trichloroethene is still detected in one off-site monitoring well associated with the X-749/X-120/PK Landfill groundwater plume, concentrations of trichloroethene in this off-site well have decreased to less than 1 µg/L from concentrations up to 4 µg/L in 2006. 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.

In 2009, a special investigation was conducted in the Quadrant II Groundwater Investigative Area that identified areas of groundwater in the southeastern portion of the plume with higher concentrations of trichloroethene than previously known. The western perimeter of the plume in the Quadrant II Groundwater Investigative Area is also further west than previously identified. The other areas of contaminated groundwater present at PORTS did not change significantly in 2009.

The *2009 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 2009. The following sections provide an overview of the DOE PORTS groundwater monitoring program followed by a review of the history and 2009 monitoring data for each area. Chapter 3, Section 3.2 provides additional information about the remedial actions implemented at a number of the areas discussed in this chapter to reduce or eliminate groundwater contamination.

This chapter also includes information on the groundwater treatment facilities at PORTS. These facilities receive contaminated groundwater from the groundwater monitoring areas and treat the water prior to discharge through the permitted LPP 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 by DOE and approved by the Ohio EPA. An annual groundwater report is submitted to Ohio EPA in accordance with the *Integrated Groundwater Monitoring Plan*.

Groundwater monitoring in January through June of 2009 was completed in accordance with the *Integrated Groundwater Monitoring Plan* dated August 2007. A revised *Integrated Groundwater Monitoring Plan* was implemented beginning in July of 2009. Revisions included changes in monitoring parameters and/or sampling frequencies for wells in the X-701B Holding Pond area, X-616 Chromium Sludge Surface Impoundments, and X-734 Landfills. The monitoring program for the X-749/X-120/PK Landfill was also revised based on the results of special studies conducted in the area. Wells that monitor the X-740 Waste Oil Handling Facility and the northwestern portion of the X-701B Holding Pond area were also removed from the IGWMP based on remedial actions planned or taking place in these areas.

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

6.3.2 Groundwater Use and Geology

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

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

6.3.3. Monitoring Activities

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

6.4 GROUNDWATER MONITORING AREAS

The *Integrated Groundwater Monitoring Plan* requires groundwater monitoring of 11 areas within the quadrants of the site designated by the RCRA Corrective Action Program. These areas (see Figure 6.1) are:

- Quadrant I
  - X-749/X-120/PK Landfill,
  - Quadrant I Groundwater Investigative Area/X-749A Classified Materials Disposal Facility,
- Quadrant II
  - Quadrant II Groundwater Investigative Area,
  - X-701B Holding Pond,
  - X-633 Pumphouse/Cooling Towers Area,
- Quadrant III
  - X-616 Chromium Sludge Surface Impoundments,
  - X-740 Waste Oil Handling Facility,
- Quadrant IV
  - 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 radionuclides. 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 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 2009.

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

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

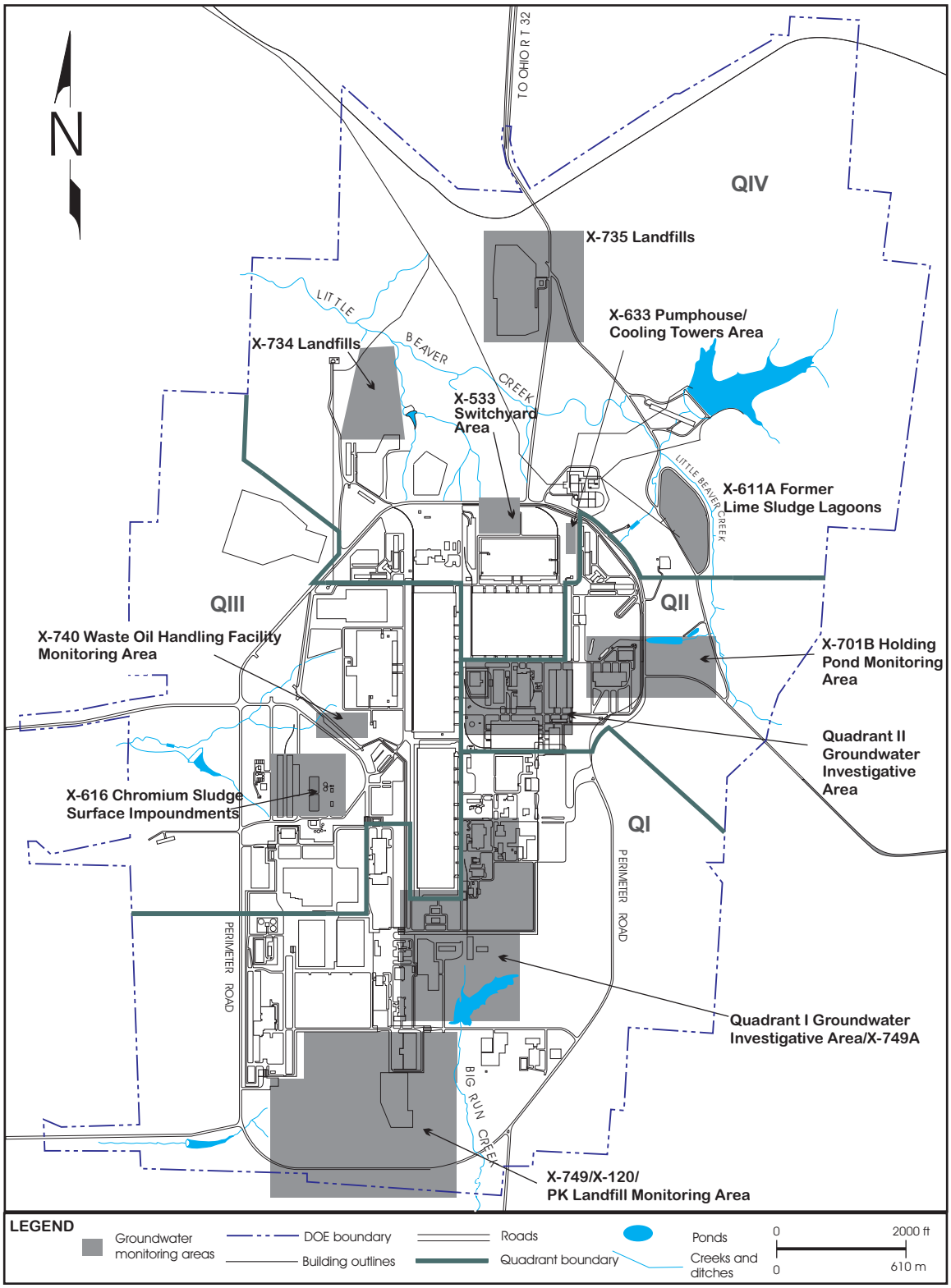

Figure 6.1. Groundwater monitoring areas at PORTS.

Table 6.1. Analytical parameters for monitoring areas and programs at PORTS in 2009

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

Table 6.1. Analytical parameters for monitoring areas and programs at PORTS – 2009 (continued)

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

Table 6.1. Analytical parameters for monitoring areas and programs at PORTS – 2009 (continued)

Monitoring Area or Program	Analytes		
Exit Pathway[b]	volatile organic compounds[c] transuranics[d]: ^{241}Am, ^{237}Np, ^{238}Pu, $^{239/240}$Pu 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

[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 in 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.

[f]Appendix II constituents (selected metals, organics, and pesticides) as listed in Ohio Administrative Code Rule 3745-29-10 effective June 1, 1994.

6.4.1.1 X-749 Contaminated Materials Disposal Facility

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

In 2002 and 2003, hybrid poplar trees were planted in several areas of the X-749/X-120 groundwater plume. The trees are used in a process called phytoremediation to degrade or contain contaminants in soil and/or groundwater. Chapter 3, Section 3.2.1.1, provides additional information about the remedial actions implemented to address the X-749/X-120 groundwater plume.

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. In 2007, four groundwater extraction wells were installed in the X-749 South Barrier Wall Area, and in 2008, two extraction wells were installed in the groundwater collection system on the southwest side of the landfill. These extraction wells are controlling migration of the plume off plant property and reducing concentrations of trichloroethene in groundwater.

In addition to routine sampling required by the *Integrated Groundwater Monitoring Plan*, monitoring of the X-749/X-120 groundwater plume also included sampling required by the *Work Plan for the X-749/X-120 Area Groundwater Optimization Project.* Ninety-seven wells were sampled during 2009 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 X-120 Old Training Facility

The X-120 Old Training Facility, which is west and north of the X-749 Contaminated Materials Disposal Facility, covered an area of approximately 11.5 acres 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. In 2003, operation of the X-625 Groundwater Treatment Facility and horizontal well ceased with the approval of Ohio EPA due to the limited amount of groundwater collected by the well.

Ninety-seven wells were sampled during 2009 to monitor the X-749/X-120 area. Table 6.1 lists the analytical parameters for the wells in this area.

6.4.1.3 PK Landfill

The PK Landfill is located west of Big Run Creek just south of the X-230K Holding Pond in Quadrant I. 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. Chapter 3, Section 3.2.1.2, provides additional information about the remedial actions implemented at PK Landfill.

In 2009, nine wells, two manholes, and two sumps were sampled to monitor the PK Landfill area. Table 6.1 lists the analytical parameters for the wells, manholes, and sumps in this area.

6.4.1.4 Monitoring results for the X-749/X-120/PK Landfill in 2009

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

Concentrations of trichloroethene are decreasing in numerous wells within the X-749/X-120 plume due to the extraction wells installed in the X-749 South Barrier Wall Area (X749-EW01G, X749-EW02G, X749-EW03G, and X749-EW04G) and the additional extraction wells installed in the collection trench on the southwest side of the X-749 Landfill (X749-EW05G and X749-EW06G). The decreasing trichloroethene concentrations within the plume mean that the higher concentrations of trichloroethene in and around the X-749 Landfill (over 100 µg/L) are no longer connected to the area of higher concentrations (100 to 1000 µg/L) to the west and south of the landfill. The decrease in trichloroethene concentrations in two wells (X749-27G and X749-113G) appears to indicate that the new extraction wells installed in the groundwater collection system on the southwest side of the trench are controlling the trichloroethene source within the landfill and migration of higher trichloroethene concentrations outside the landfill.

Concentrations of trichloroethene in the X-749 South Barrier Wall Area south of the extraction wells have decreased to less than 6 µg/L, which is just above the EPA drinking water standard of 5 µg/L. By the end of 2009, trichloroethene was detected in only one off-site monitoring well (WP-03G) at a concentration less than 1 µg/L. Trichloroethene had also been detected at concentrations less than 5 µg/L in off-site monitoring wells WP-01G and WP-07G in previous sampling events in 2009 or 2008. Figure 6.2 provides data for selected X-749/X-120 monitoring wells that illustrate the decreasing trichloroethene concentrations in the wells.

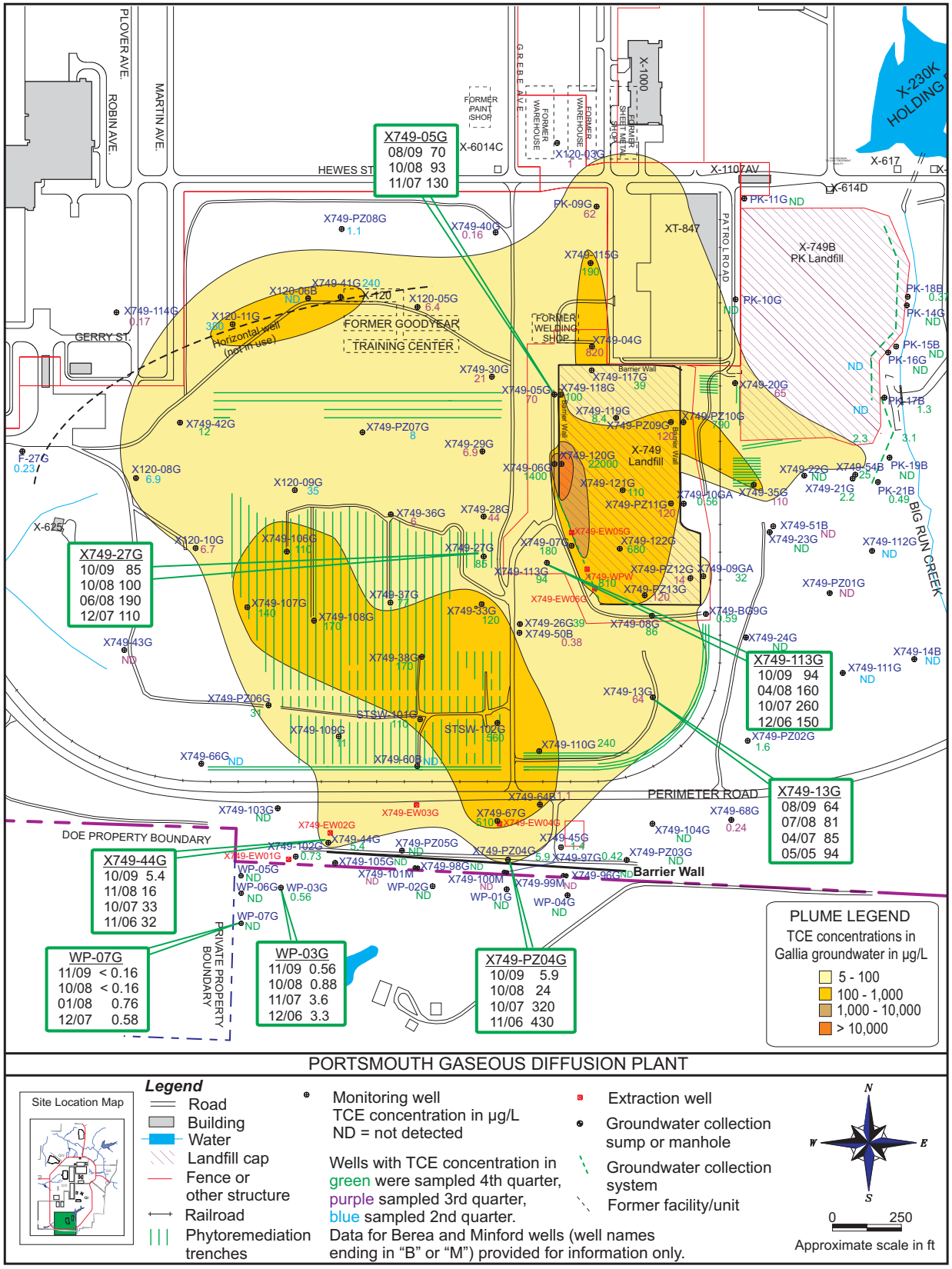

Figure 6.2. Trichloroethene-contaminated Gallia groundwater plume at the X-749/X-120/PK Landfill – 2009.

Some of the wells associated with the PK Landfill are also 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 8.9 to 18 µg/L, which exceed 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.

6.4.2.1 Quadrant I Groundwater Investigative Area

The Quadrant I Groundwater Investigative Area, also called the Five-Unit Groundwater Investigative Area, consists of a groundwater plume resulting from a number of potential sources of groundwater contamination: the X-231A and X-231B Oil Biodegradation Plots, X-600 Coal-Fired Steam Plant, X-600A Coal Pile Yard, X-621 Coal Pile Runoff Treatment Facility, X-710 Technical Services Building, X-749A Classified Materials Disposal Facility, the X-760 Pilot Investigation Building, and the X-770 Mechanical Testing Facility. The X-231B Southwest Oil Biodegradation Plot was monitored prior to implementation of the *Integrated Groundwater Monitoring Plan*.

Three groundwater extraction wells were installed in 1991 as part of an interim remedial measure for the X-231B Southwest Oil Biodegradation Plot. Eleven additional groundwater extraction wells were installed in 2001-2002 as part of the remedial actions required by the Quadrant I Decision Document. These wells began operation in 2002. An additional extraction well south of the X-326 Process Building began operating in April in 2009. The extracted groundwater is treated at the X-622 Groundwater Treatment Facility and discharged through LPP NPDES Outfall 608, which flows into the USEC Sewage Treatment Plant. Multimedia landfill caps were installed over the former X-231B area and a similar area, X-231A, in 2000 to minimize water infiltration and control the spread of contamination. Chapter 3, Section 3.2.1.3, provides additional information about the remedial actions implemented in the Quadrant I Groundwater Investigative Area.

Twenty-eight wells were sampled in 2009 as part of the monitoring program for the Quadrant I Groundwater Investigative Area. 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.

Assessment monitoring of the X-749A Landfill began in 2007 and continued in 2009. Sixteen wells associated with the landfill were sampled in 2009. 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 2009

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 perimeter of the groundwater plume in the Quadrant I Groundwater Investigative Area shrank in 2009 due to decreasing concentrations of trichloroethene detected in two wells in the southern portion of the plume (X230K-14G and X231B-12G). Concentrations of trichloroethene are also decreasing in a number of wells within the plume. Trichloroethene is increasing in one well (X326-09G) in the western portion of the plume; a groundwater extraction well (X622-EW12G) began operating in 2009 to remediate this contaminant source. Figure 6.3 provides data for selected Quadrant I Groundwater Investigative Area monitoring wells that illustrate the decreasing and increasing trichloroethene concentrations in the wells.

Assessment monitoring began at the X-749A Landfill in 2007 and continued through 2009. Monitoring of the X-749A Landfill will continue as required by the *Integrated Groundwater Monitoring Plan* and Ohio EPA.

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. In 2009, an investigation was completed to identify other potential sources contributing to the groundwater plume in this area. Chapter 3, Section 3.2.2 provides additional information about the Quadrant II Groundwater Investigative Area.

The natural groundwater flow direction in this area is to the east toward Little Beaver Creek. The groundwater flow pattern has been changed in this area by use of sump pumps in the basements of the X-700 and X-705 buildings. Thus, the groundwater plume in this area does not spread but instead flows toward the sumps where it is collected and then treated at the X-627 Groundwater Treatment Facility. This facility discharges through LPP NPDES Outfall 611, which flows to the USEC Sewage Treatment Plant. Eighteen wells are sampled annually or biennially as part of the monitoring program for this area. Table 6.1 lists the analytical parameters for the wells in this area.

6.4.3.1 Monitoring results for the Quadrant II Groundwater Investigative Area in 2009

A contaminated groundwater plume consisting primarily of trichloroethene is associated with the Quadrant II Groundwater Investigative Area (see Figure 6.4). A special investigation conducted in 2009, which sampled groundwater in temporary wells, determined that the western edge of the Quadrant II Groundwater Investigative Area plume is further west than previously known and appears to extend under the X-330 Process Building. Trichloroethene concentrations are increasing in two wells in the western portion of the plume (X705-02G and X705-03G), which may be related to the higher concentrations of trichloroethene identified near the X-330 Process Building. Trichloroethene concentrations are decreasing in two wells in the northern portion of the plume (X705-06G and X705-07G).

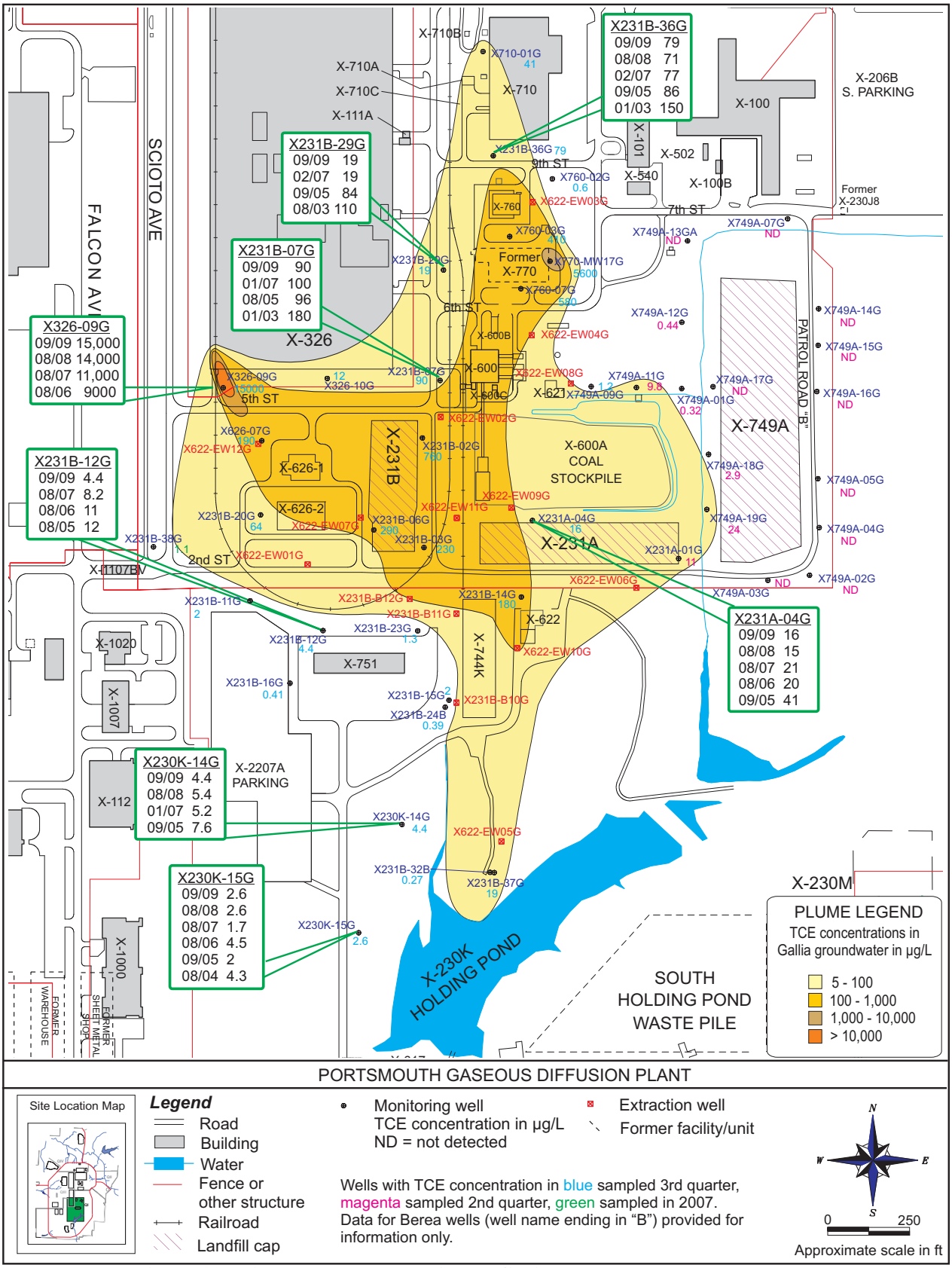

Figure 6.3. Trichloroethene-contaminated Gallia groundwater plume at the Quadrant I Groundwater Investigative Area – 2009.

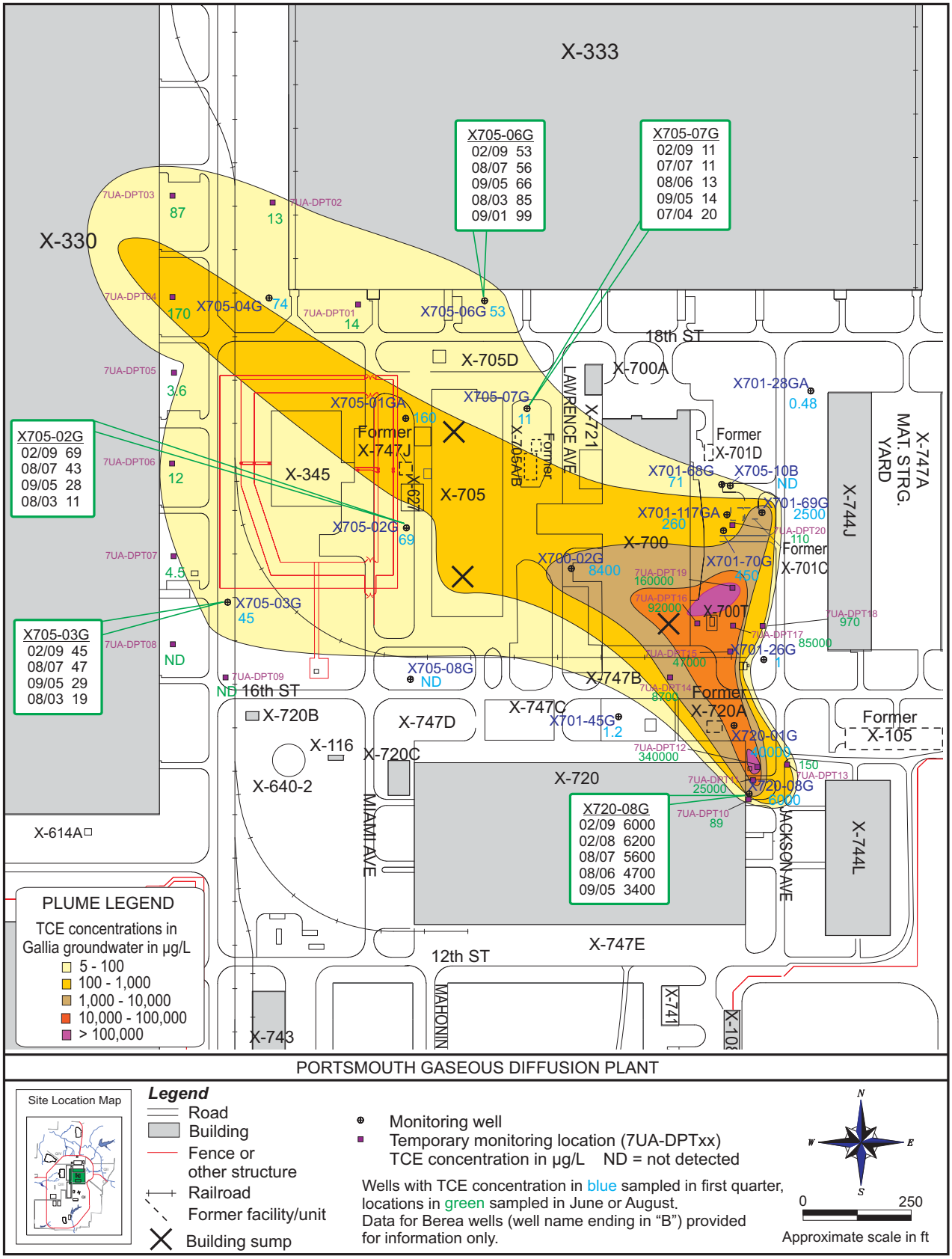

Figure 6.4. Trichloroethene-contaminated Gallia groundwater plume at the Quadrant II Groundwater Investigative Area – 2009.

Areas of higher trichloroethene concentrations were also identified within the southeastern portion of the plume near the former X-720 Neutralization Pit on the northeast side of the X-720 Building and the X-700T Aboveground Storage Tank. Figure 6.4 provides data for selected Quadrant II Groundwater Investigative Area monitoring wells that illustrate the decreasing and increasing trichloroethene concentrations in the wells.

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 towards 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 LPP 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.

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, control 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 LPP NPDES Outfall 015, which flows to Little Beaver Creek.

Remedial actions have begun in the X-701B Pond area to reduce concentrations of trichloroethene in soil and groundwater. Chapter 3, Section 3.2.2, provides additional information about remedial actions at the X-701B Holding Pond area.

Forty-one wells were sampled in 2009 as part of the monitoring program for this area. 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 2009

The trichloroethene plume associated with the X-701B Holding Pond area contains the highest concentrations of trichloroethene measured in groundwater at PORTS, routinely over 250,000 µg/L in two of the groundwater monitoring wells near the middle of the plume. The plume perimeter did not change significantly from 2008 to 2009 (see Figure 6.5), although concentrations of trichloroethene are decreasing in one well in the center of the plume (X701-21G). In most other wells within the X-701B plume, concentrations of trichloroethene detected in 2009 were consistent with previous data.

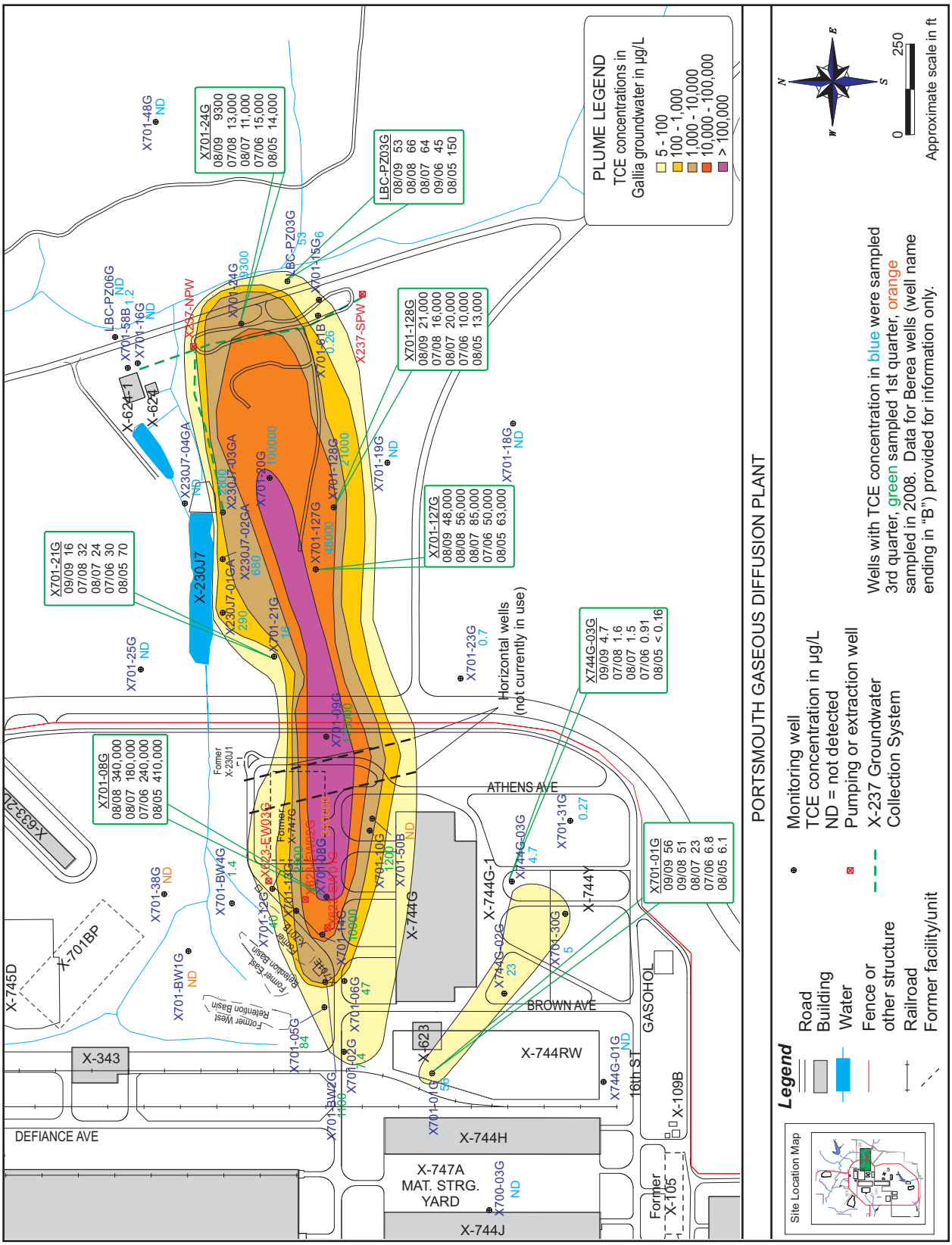

Figure 6.5.Trichloroethene-contaminated Gallia groundwater plume at the X-701B Holding Pond – 2009.

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 2009; however concentrations of trichloroethene are increasing in two of the wells that monitor this plume (X701-01G and X744G-03G). Data for these wells are shown on Figure 6.5.

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 (X701-01G, X744G-01G, and X744G-02G). These results are typical for the X-744 area wells.

6.4.5 X-633 Pumphouse/Cooling Towers Area

The X-633 Pumphouse/Cooling Towers Area in Quadrant II 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 in 1998 and 1999 to assess the area for metals contamination. Based on the results for these samples, this area was added to the PORTS groundwater monitoring program. Two wells are sampled semiannually for chromium as part of the monitoring program for this area.

6.4.5.1 Monitoring results for the X-633 Pumphouse/Cooling Towers Area in 2009

Chromium was detected in both of the X-633 monitoring wells in 2009. Samples collected from well X633-07G contained chromium at concentrations above the preliminary remediation goal of 100 µg/L: 310 µg/L (second quarter) and 560 µg/L (fourth quarter). Samples collected from well X633-PZ04G also contained chromium but at concentrations well below the preliminary remediation goal. These results are typical for these wells. Figure 6.6 shows the chromium concentrations detected in the X-633 Pumphouse/Cooling Tower area wells.

6.4.6 X-616 Chromium Sludge Surface Impoundments

The X-616 Chromium Sludge Surface Impoundments in Quadrant III were two unlined surface impoundments used from 1976 to 1985 for storage of sludge generated by the treatment of water from the PORTS process cooling system. A corrosion inhibitor containing chromium was used in the cooling water system. Sludge containing chromium was produced by the water treatment system and was pumped into and stored in the X-616 impoundments. The sludge was removed from the impoundments and remediated as an interim action in 1990 and 1991. The unit was certified closed in 1993. 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.

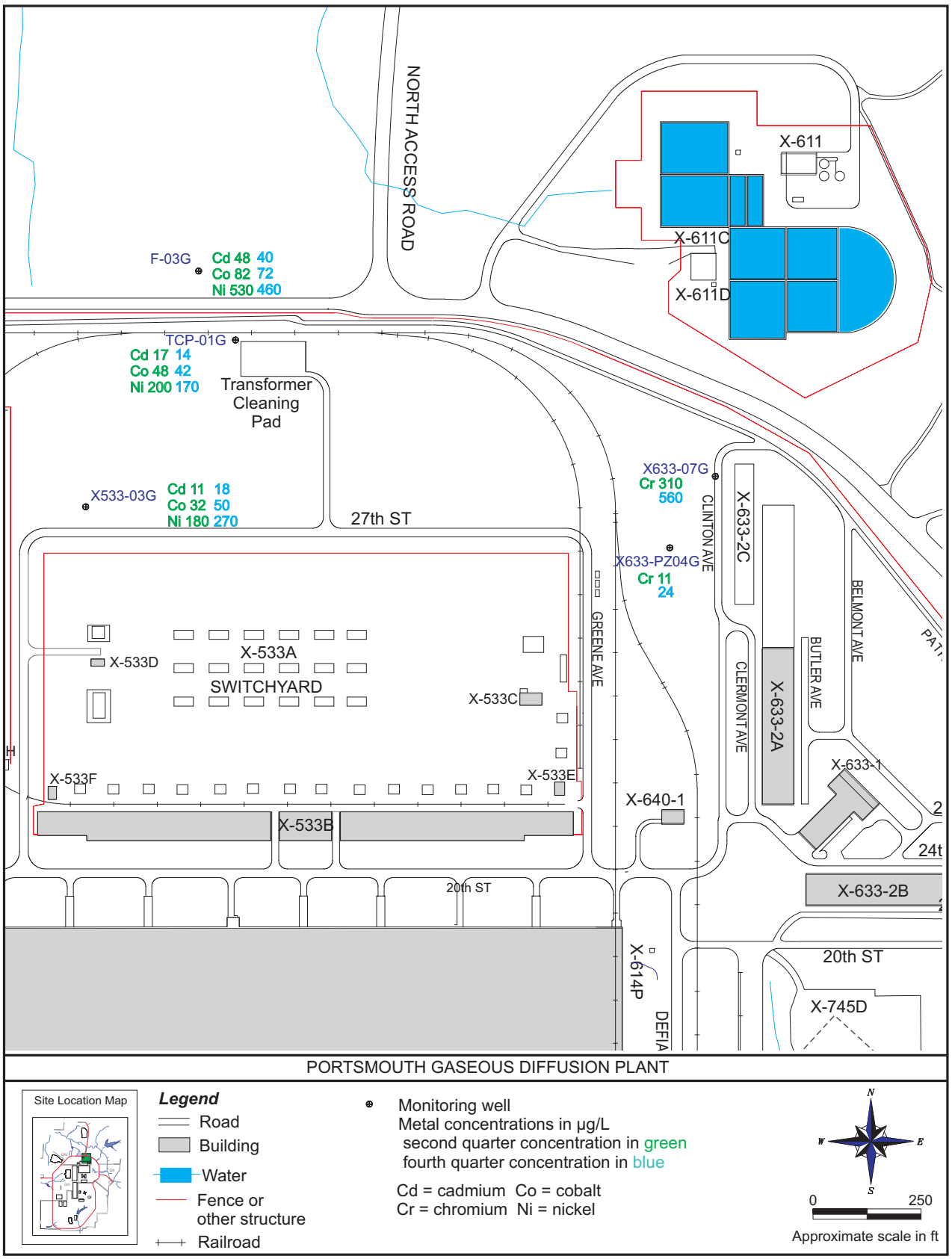

Figure 6.6. Metal concentrations in groundwater at the X-633 Pumphouse/Cooling Towers Area and X-533 Switchyard Area – 2009.

6.4.6.1 Monitoring results for the X-616 Chromium Sludge Surface Impoundments in 2009

Chromium is of special concern at X-616 because of the previous use of the area. In 2009, chromium was detected at 500 µg/L in the sample collected from well X616-05G. Chromium was not detected at concentrations above the preliminary remediation goal (100 µg/L) 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. 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. Figure 6.7 shows the concentrations of chromium and nickel in wells at the X-616 Chromium Sludge Surface Impoundments.

Volatile organic compounds were detected at low levels in samples collected from seven wells in this area. The only volatile organic compounds detected above the preliminary remediation goals were 1,1-dichloroethene and trichloroethene, which were detected in wells X616-09G and/or X616-20B. Figure 6.7 shows the concentrations of trichloroethene detected in the X-616 wells.

6.4.7 X-740 Waste Oil Handling Facility

The former X-740 Waste Oil Handling Facility, which was demolished in 2006, was located on the western half of PORTS south of the X-530A Switchyard in Quadrant III. The X-740 facility, which operated from 1983 until 1991, was used as an inventory and staging facility for waste oil and waste solvents that were generated from various plant operational and maintenance activities. A sump within the building was used between 1986 and 1990 to collect residual waste oil and waste solvents from containers crushed in a hydraulic drum crusher at the facility. The facility and sump were initially identified as hazardous waste management units in 1991. The X-740 Waste Oil Handling Facility (both the facility and sump identified as hazardous waste management units) underwent closure, and closure certification was approved by Ohio EPA in 1998.

In 1999, poplar trees were planted in a 2.6-acre phytoremediation area above the groundwater plume near the X-740 Waste Oil Handling Facility. Because phytoremediation has not worked as anticipated to reduce the concentrations of volatile organics in groundwater in this area, three rounds of oxidant injections were completed during 2008. Additional alternatives for groundwater remediation in this area were evaluated in 2009. Chapter 3, Section 3.2.3, provides additional information about these remedial activities.

Seventeen wells were sampled in the first and/or second quarters of 2009. Table 6.1 lists the analytical parameters for the wells in this area. With implementation of the revised *Integrated Groundwater Monitoring Plan* in the third quarter of 2009, routine monitoring at the X-740 Waste Oil Handling Facility was discontinued. Monitoring of the area will continue as part of the special studies to evaluate remedial alternatives for the area.

6.4.7.1 Monitoring results for the X-740 Waste Oil Handling Facility in 2009

A contaminated groundwater plume consisting of primarily trichloroethene is located near the X-740 Waste Oil Handling Facility (see Figure 6.8) in Quadrant III. The perimeter of the X-740 groundwater plume did not change significantly in 2009. The oxidant that was injected into the X-740 groundwater plume during May through September of 2008 briefly reduced trichloroethene concentrations detected in some of the wells (X740-03G and X740-09B), but concentrations generally returned to typical levels in 2009. Figure 6.8 provides data from before, during, and after the oxidant injections for selected wells that monitor the X-740 groundwater plume.

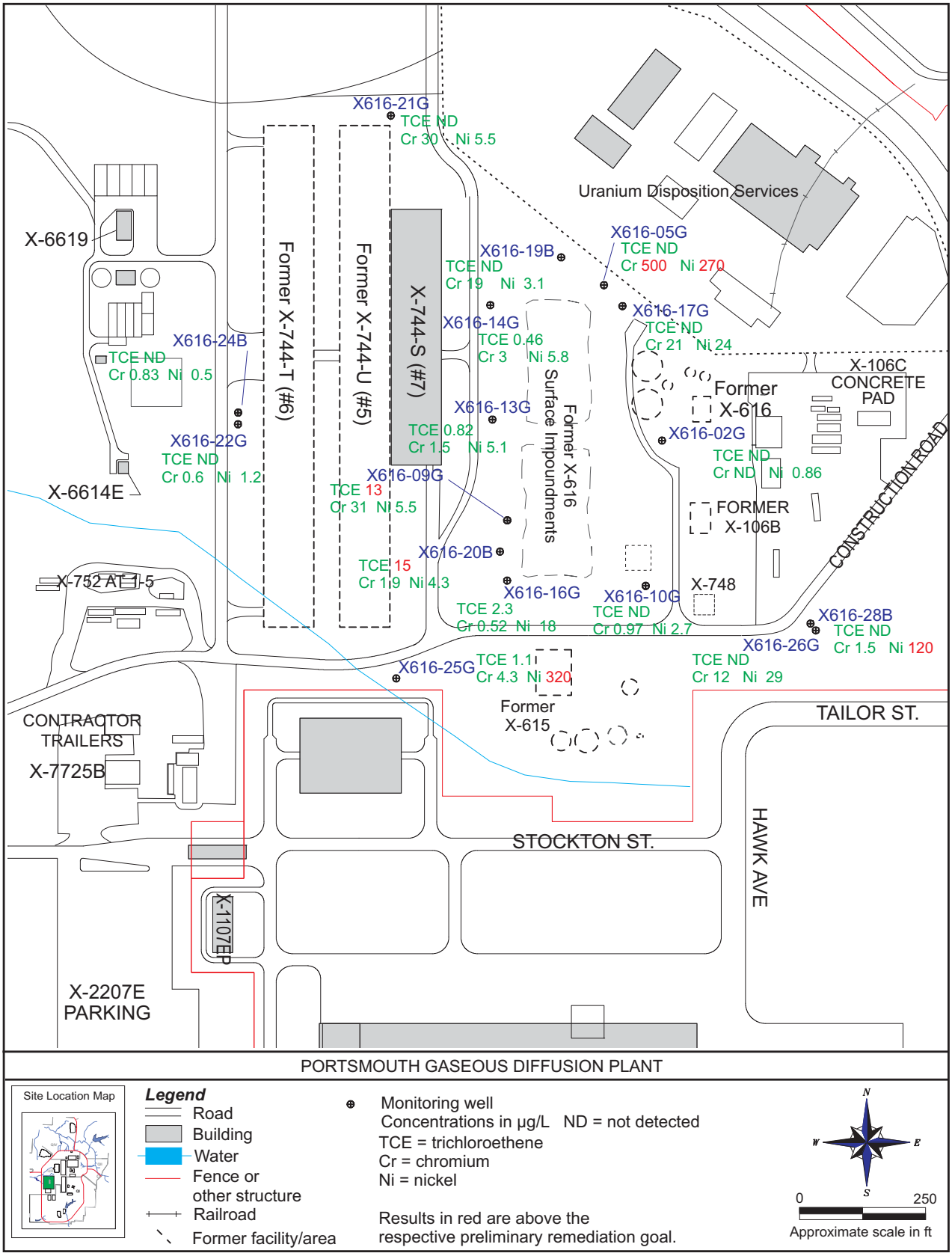

Figure 6.7. Trichloroethene and metal concentrations in groundwater at the X-616 Chromium Sludge Surface Impoundments – 2009.

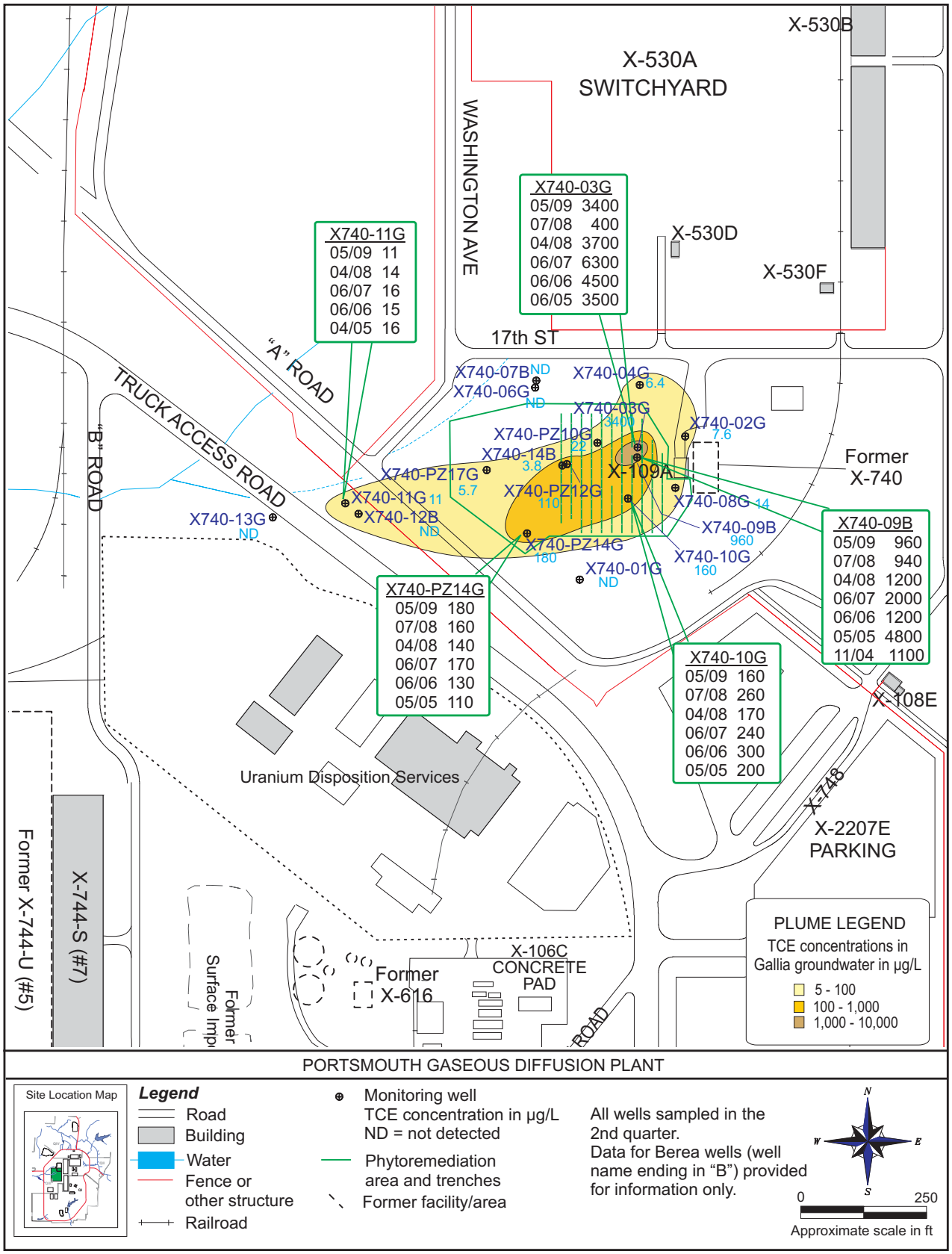

Figure 6.8. Trichloroethene-contaminated Gallia groundwater plume near the X-740 Waste Oil Handling Facility – 2009.

6.4.8 X-611A Former Lime Sludge Lagoons

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

As part of the RCRA Corrective Action Program, a prairie habitat has been developed in this area by placing a soil cover over the north, middle, and south lagoons. A soil berm was also constructed outside the northern boundary of the north lagoon to facilitate shallow accumulation of water in this low-lying area. Chapter 3, Section 3.2.4, provides more information about this remediation. Six wells are sampled semiannually as part of the monitoring program for this area. Table 6.1 lists the analytical parameters for the wells in this area.

6.4.8.1 Monitoring results for the X-611A Former Lime Sludge Lagoons in 2009

The six monitoring wells at X-611A are sampled and analyzed for beryllium and chromium. In 2009, chromium was detected in four of the six wells in this area at concentrations between 0.62 and 9.5 µg/L. These results are below the preliminary remediation goal (100 µg/L). Beryllium was detected in four of the six wells at concentrations between 0.092 and 5 µg/L. These results are below the preliminary remediation goal (6.5 µg/L for Gallia wells and 7 µg/L for Berea wells). Figure 6.9 shows the concentrations of beryllium and chromium detected in the X-611A wells in 2009.

6.4.9 X-735 Landfills

Several distinct waste management units are contained within the X-735 Landfills area in Quadrant IV. The main units consist of the hazardous waste landfill, referred to as the X-735 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 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.

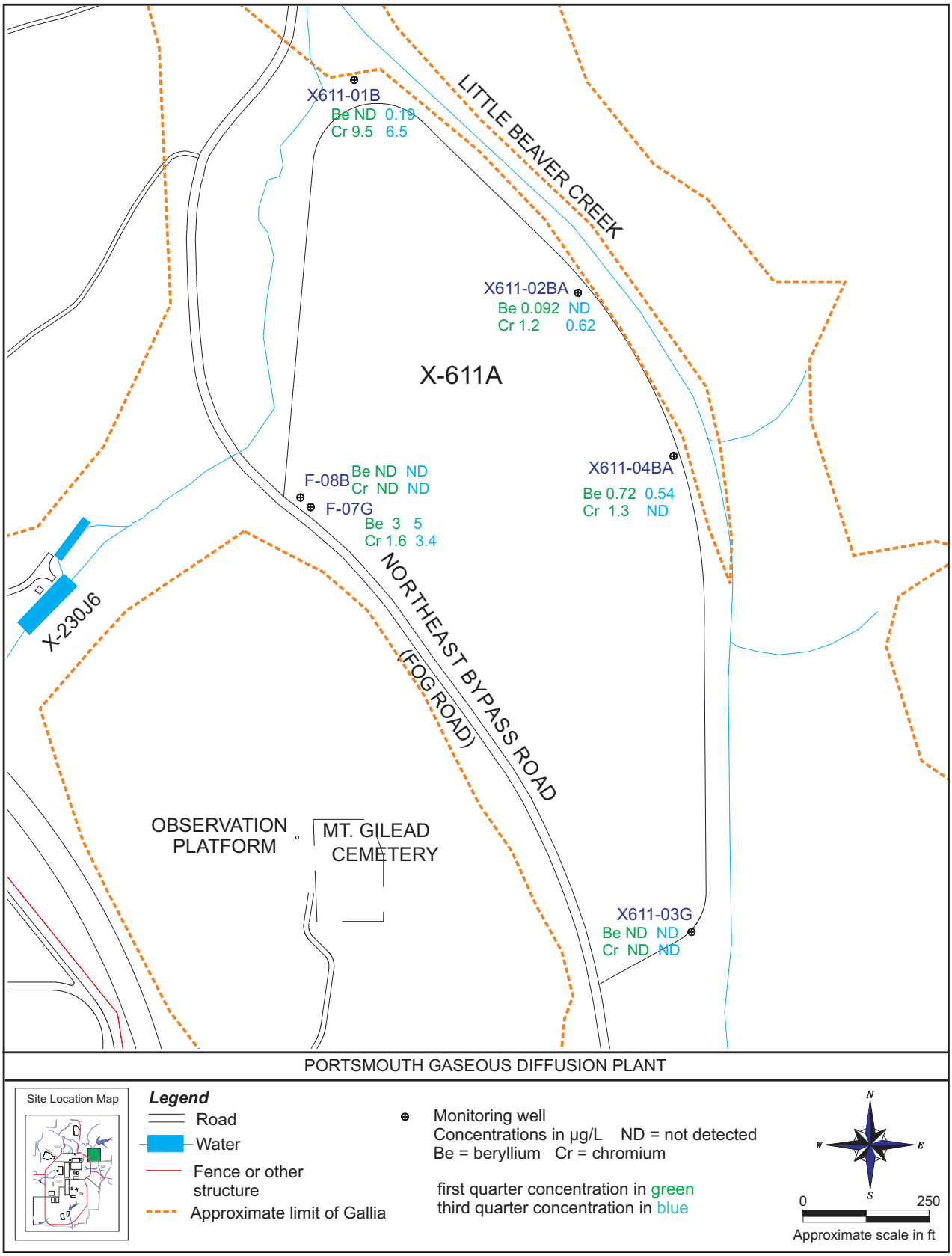

Figure 6.9. Metal concentrations in groundwater at the X-611A Former Lime Sludge Lagoons – 2009.

The *Integrated Groundwater Monitoring Plan* incorporates monitoring requirements for the hazardous and solid waste portions of the X-735 Landfills. In addition, the *Corrective Measures Plan for the X-735 Landfill* was approved by Ohio EPA on March 4, 2008. This plan provides the monitoring requirements for Gallia wells that monitor the X-735 Landfill. Corrective measures monitoring was implemented because Ohio EPA determined that assessment monitoring of the landfill, completed between 2005 and 2007, identified that a small release of leachate constituents is occurring or has occurred from the X-735 Landfills. Twenty-three wells were sampled in 2009 as part of the monitoring programs for this area. Table 6.1 lists the analytical parameters and Figure 6.10 shows the monitoring wells in this area.

6.4.9.1 Monitoring results for the X-735 Landfills in 2009

Several volatile organics were detected in two X-735 monitoring wells in 2009 (X735-01G and X735-03G); however, each of these detections were 1 µg/L or less and below the applicable preliminary remediation goal. As required by the corrective measures monitoring program, concentrations of three metals (cobalt, mercury, and nickel) detected in downgradient Gallia wells are compared to concentration limits based on drinking water standards or site background concentrations. Concentrations of cobalt and nickel detected in the X-735 Landfills downgradient Gallia wells sampled during 2009 did not exceed these limits. Mercury was detected at 2.6 µg/L in the fourth quarter sample collected from well X735-21G, which exceeds the concentration limit of 2 µg/L. As required by the corrective measures monitoring program, the well was resampled in January 2010. The verification sample contained mercury at 1.3 µg/L, which is less than the concentration limit of 2 µg/L.

No transuranics or technetium-99 were detected in the samples collected from the X-735 monitoring wells in 2009. If detected, uranium and uranium isotopes were present at levels typical for these wells and below applicable preliminary remediation goals and drinking water standards.

6.4.10 X-734 Landfills

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

The X-734 Landfills were closed in accordance with regulations in effect at that time, and no groundwater monitoring of the area was required. However, the RCRA Facility Investigation conducted in the early 1990s identified the presence of volatile organics, metals, and radionuclides in soil and/or groundwater in the area. The X-734 Landfills were capped in 1999-2000 as part of the remedial actions required for Quadrant IV. Chapter 3, Section 3.2.4, provides more information about the remedial actions for this area.

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

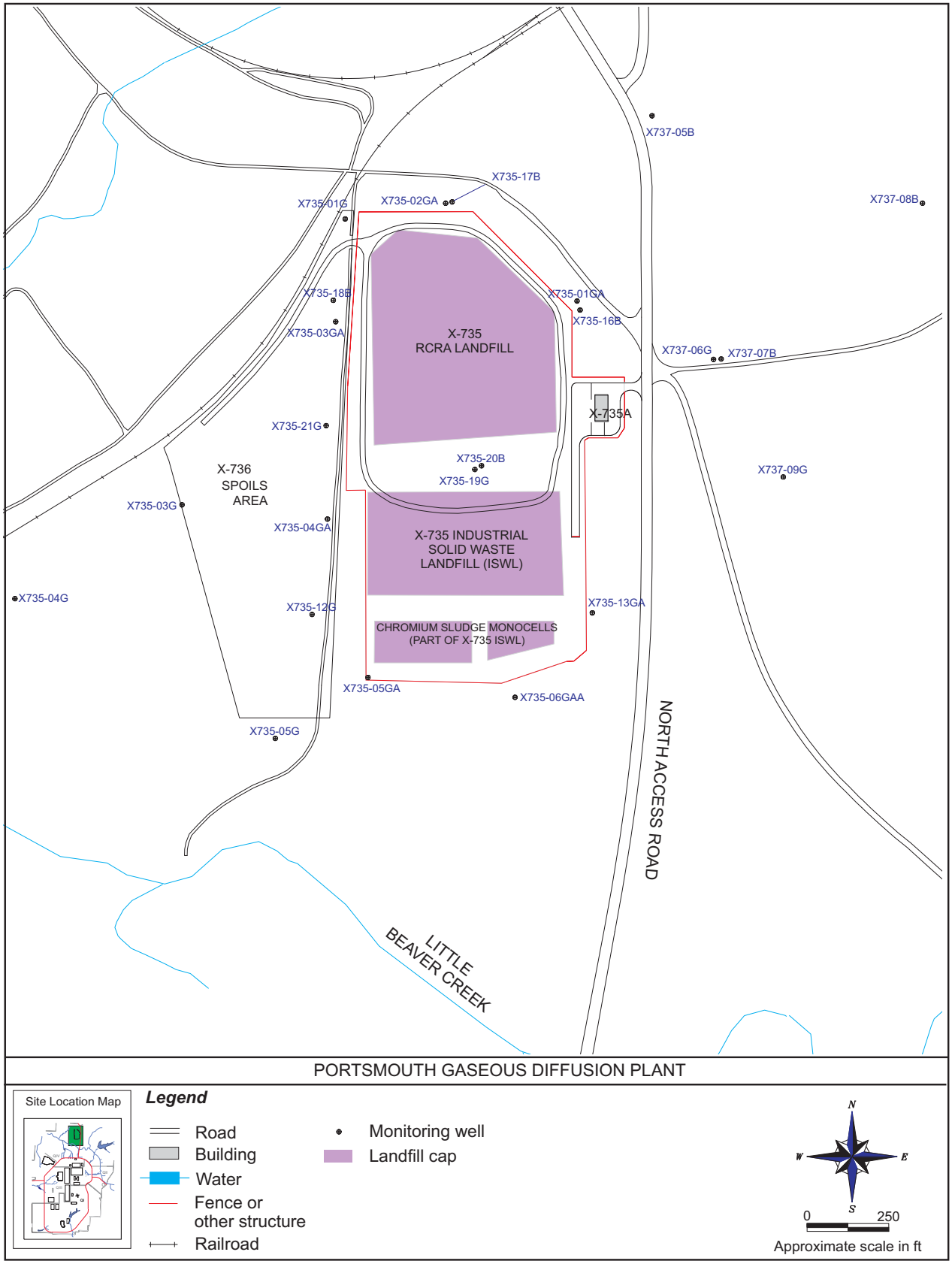

Figure 6.10. Monitoring wells at the X-735 Landfills.

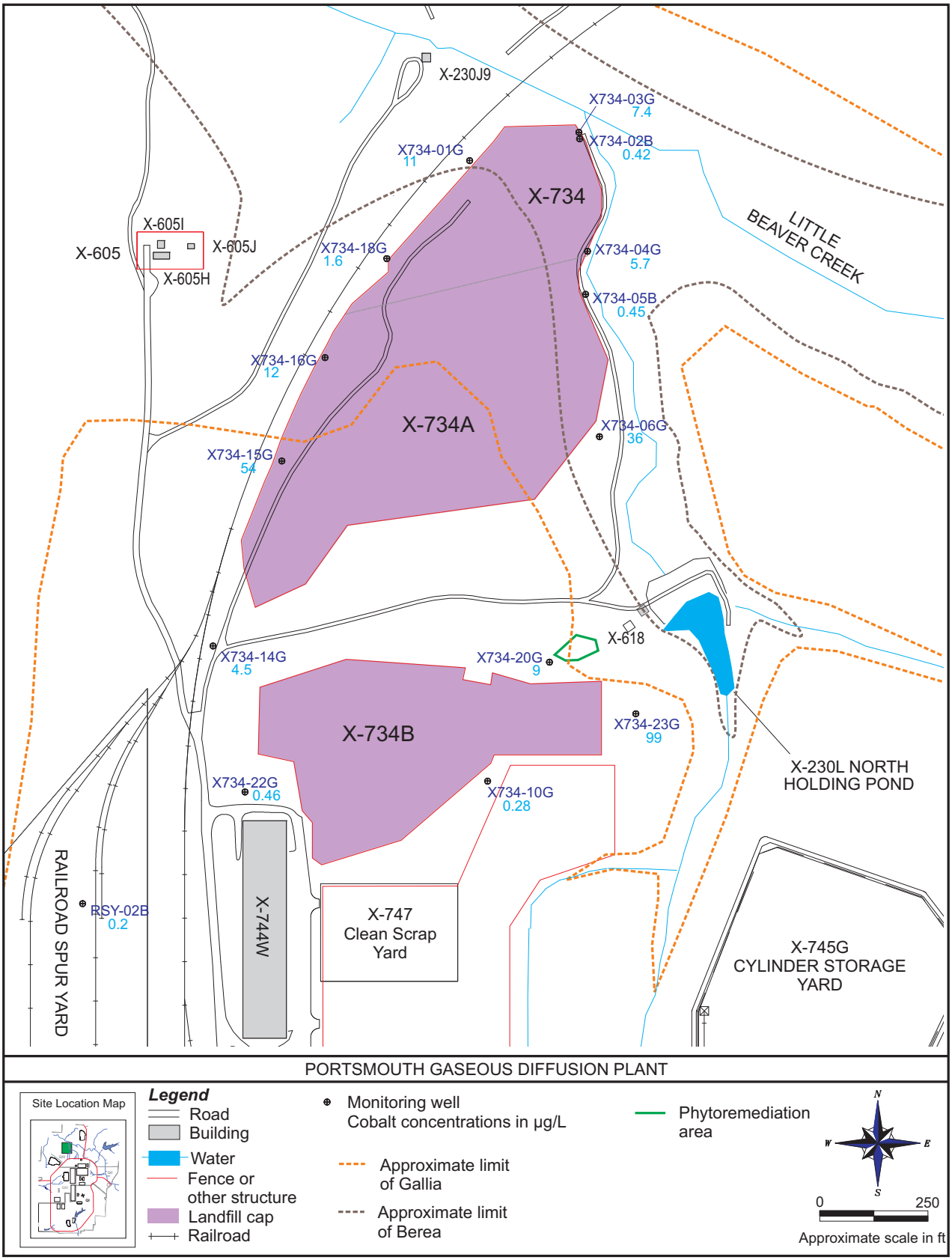

Figure 6.11. Cobalt concentrations in groundwater at the X-734 Landfills – 2009.

6.4.10.1 Monitoring results for the X-734 Landfills in 2009

Volatile organic compounds were detected in samples collected from five wells in the X-734 monitoring area in 2009: wells X734-03G, X734-04G, X734-05B, X734-15G, and X734-23G. Vinyl chloride was the only compound detected that exceeded the preliminary remediation goal (2 µg/L). In the second quarter, vinyl chloride was detected at 3 µg/L in the sample collected from well X734-23G. The presence of vinyl chloride, *cis*-1,2-dichloroethene, and *trans*-1,2-dichloroethene in well X734-23G, along with the low concentrations or absence of trichloroethene, may indicate that trichloroethene is breaking down naturally beneath the X-734 Landfills.

Cobalt is also monitored in the X-734 Landfills area. In 2009, cobalt was detected in three wells (X734-06G, X734-15G, and X734-23G) at concentrations exceeding the preliminary remediation goal of 13 µg/L for Gallia wells (see Figure 6.11).

No transuranics or technetium-99 were detected in any of the X-734 Landfills well samples collected in 2009. If detected, uranium and uranium isotopes were present at levels typical for these wells and below applicable preliminary remediation goals and drinking water standards.

6.4.11 X-533 Switchyard Area

The X-533 Switchyard Area in Quadrant IV 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 in 1998 and 1999 to assess the area for metals contamination. The area was added to the PORTS groundwater monitoring program because the sampling identified 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 2009

Three wells that monitor the X-533 Switchyard Area were sampled in the second and fourth quarters of 2009 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 11 to 48 µg/L, concentrations of cobalt detected in the wells ranged from 32 to 82 µg/L, and concentrations of nickel detected in the wells ranged from 170 to 530 µg/L. Figure 6.6 shows the concentrations of metals detected in the X-533 wells in 2009.

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 6.12). 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:

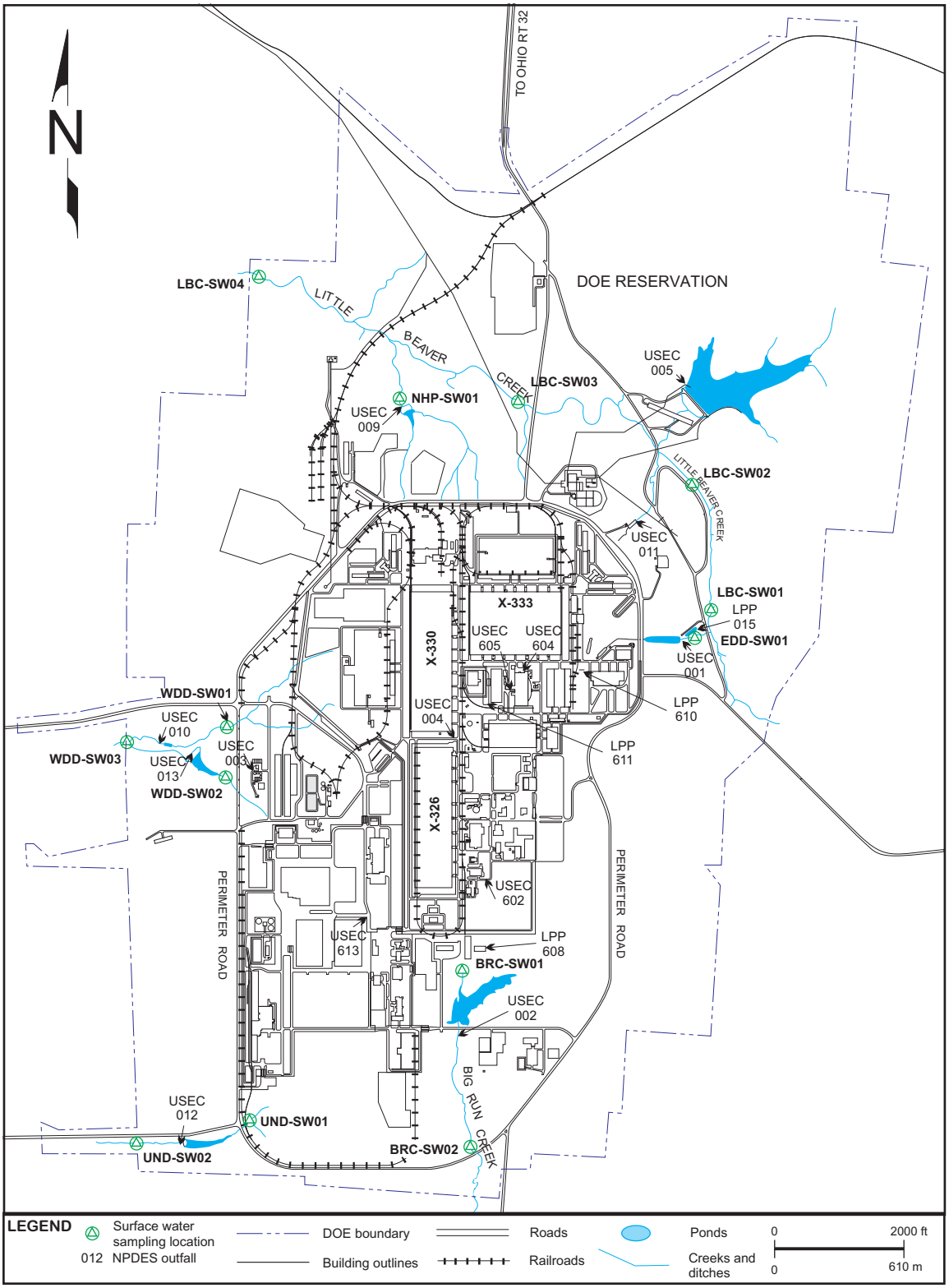

Figure 6.12. Surface water monitoring locations.

- 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 locations LBC-SW02 and 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 from the Quadrant I Groundwater Investigative Area plume and the PK Landfill area to the X-230K Holding Pond (Quadrant I Groundwater Investigative Area only) 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 Southwest Holding Pond from the western portion of the X-749/X-120 groundwater plume.

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

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

6.4.12.1 Monitoring results for surface water in 2009

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).

Since 1990, trichloroethene has been detected regularly at low levels in samples collected from the Southwestern Drainage Ditch (UND-SW01, located inside Perimeter Road). In 2009, trichloroethene was detected at concentrations ranging from 0.25 to 5.7 µg/L in the four samples collected from the Southwestern Drainage Ditch at UND-SW01. Other volatile organics detected in one or more samples collected at UND-SW01 are 1,1-dichloroethane, 1,1-dichloroethene, and *cis*-1,2-dichloroethene. Each of these detections was estimated at concentrations of less than 1 µg/L. Concentrations of volatile organic compounds detected at the Southwestern Drainage Ditch sampling location UND-SW01 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. With the exception of 2-butanone and acetone, which are sample contaminants, no volatile organics were detected at UND-SW02, which is downstream from UND-SW01.

Trichloroethene and/or *cis*-1,2-dichloroethene were routinely detected at estimated concentrations less than 1 µg/L in the samples collected from East Drainage Ditch sampling location EDD-SW01 and Little Beaver Creek sampling locations LBC-SW01 and LBC-SW02. Neither of these chemicals were detected in samples collected from downstream Little Beaver Creek sampling locations LBC-SW03 and LBC-SW04. 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.

Trichloroethene, tetrachloroethene, and/or *cis*-1,2-dichloroethene were detected at estimated concentrations less than 0.6 µg/L in two samples collected from Big Run Creek in 2009. These detections are below applicable Ohio EPA water quality criteria (if available) for the protection of human health in the Ohio River drainage basin: 810 µg/L for trichloroethene and 89 µg/L for tetrachloroethene.

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 2009.

In the first quarter of 2009, technetium-99 was detected at activities less than 16 pCi/L in samples collected from the East Drainage Ditch and Little Beaver Creek at locations EDD-SW01, LBC-SW01, and LBC-SW02. Technetium-99 is occasionally detected at these locations. Technetium-99 was also detected at 18 pCi/L in the fourth quarter sample collected from Big Run Creek at sampling location BRC-SW01. 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 and uranium isotopes were detected at levels higher than typically detected in the third quarter sample collected from Big Run Creek sampling location BRC-SW01. Uranium was present at 20.9 µg/L, uranium-233/234 at 6.27 pCi/L, uranium-235 at 0.3192 pCi/L, and uranium-238 at 6.994 pCi/L. The concentration of uranium detected in the sample is less than the drinking water standard for uranium (30 µg/L). Detections of uranium isotopes 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). Uranium and uranium isotopes were detected in the other 2009 surface water samples at concentrations similar to those detected in previous years. 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.

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 *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).

One residential well was added to the monitoring program in 2009 (RES-017); therefore, six residential drinking water sources participated in the program in 2009 (see Figure 6.13). Wells are sampled semiannually with samples analyzed for the parameters listed in Table 6.1. The PORTS water supply (RES-012 on Figure 6.13) 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.

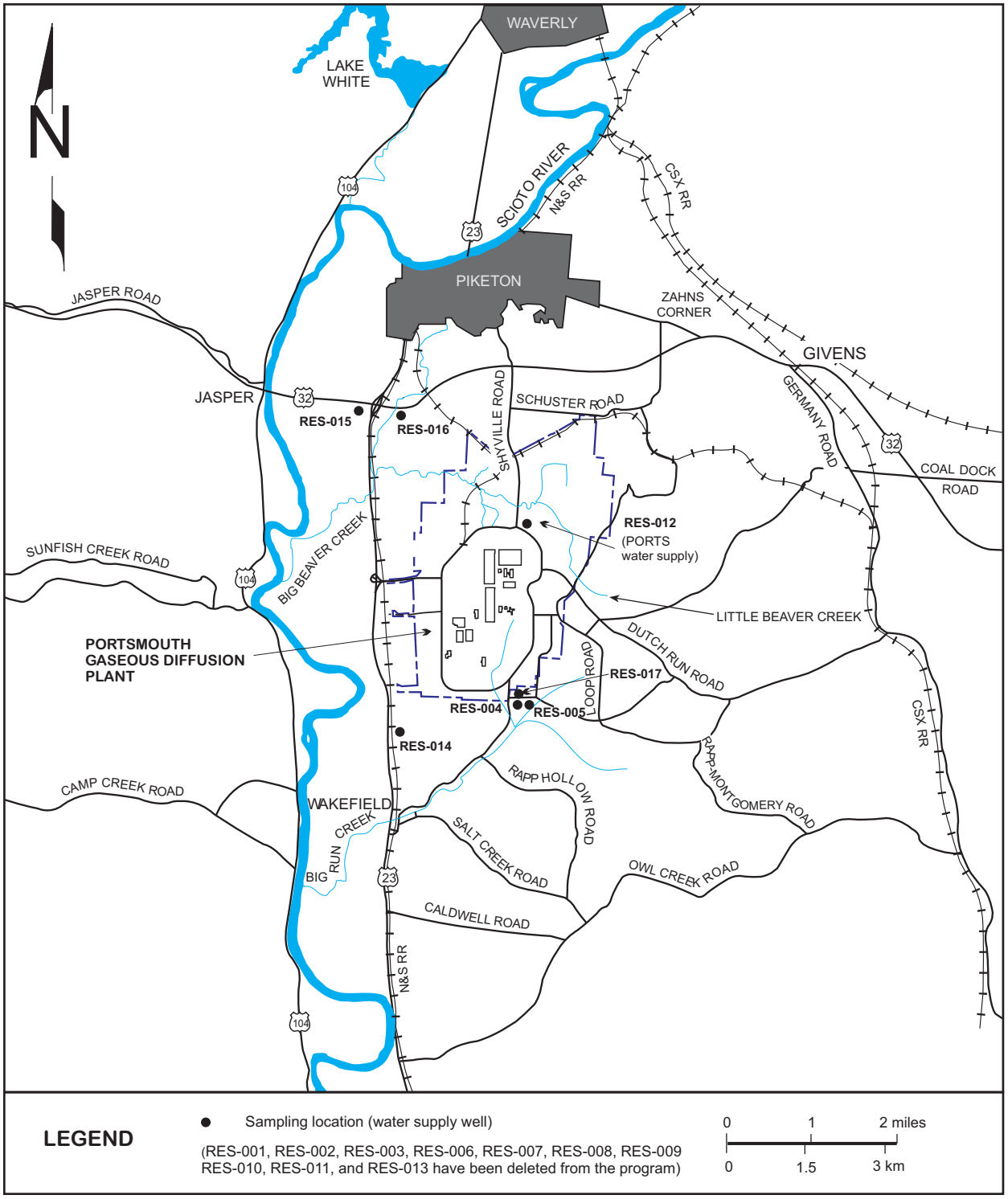

Figure 6.13. Water supply monitoring locations.

Two samples (a regular and duplicate sample) were collected from the new residential sampling location (RES-017) during each sampling event in 2009. In the second quarter, trichloroethene was detected at estimated concentrations of 0.16 and 0.23 µg/L in the regular and duplicate samples, respectively. In the third quarter, trichloroethene was detected at estimated concentrations of 0.48 and 0.51 µg/L, respectively. These detections are less than the drinking water standard for trichloroethene (5 µg/L). No other volatile organic compounds were detected in the samples. Big Run Creek is located between RES-017 and the affected water-bearing formation (i.e., Gallia groundwater) located in the southern portion of the plant site west of Big Run Creek. The Gallia groundwater drains into Big Run Creek.

No other volatile organic compounds (other than sample contaminants acetone and methylene chloride) were detected in the other residential water supply samples collected during 2009. Trihalomethanes (bromodichloromethane, dibromochloromethane, and chloroform) were detected in the first quarter sample collected from the PORTS water supply. These compounds are common residuals in treated drinking water.

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 2009. Low levels of uranium and uranium isotopes detected in some of the wells are consistent with naturally-occurring concentrations found in groundwater in the area.

6.5 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 surface water and groundwater quality.

6.5.1 Exit Pathway Monitoring

Selected locations on local streams and drainage channels near the PORTS boundary are sampling points of the exit pathway monitoring program because surface water from PORTS NPDES outfalls and groundwater discharge to these surface waters. Monitoring wells near the PORTS boundary are also used in the exit pathway monitoring program. Figure 6.14 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. Trihalomethanes (bromodichloromethane, bromoform, chloroform, and dibromochloromethane), which are common residuals in chlorinated drinking water, were detected in samples collected from the Western Drainage Ditch and Big Run Creek at concentrations well below Ohio EPA non-drinking water quality criteria for trihalomethanes for the protection of human health in the Ohio River drainage basin (see Section 6.4.12.1).

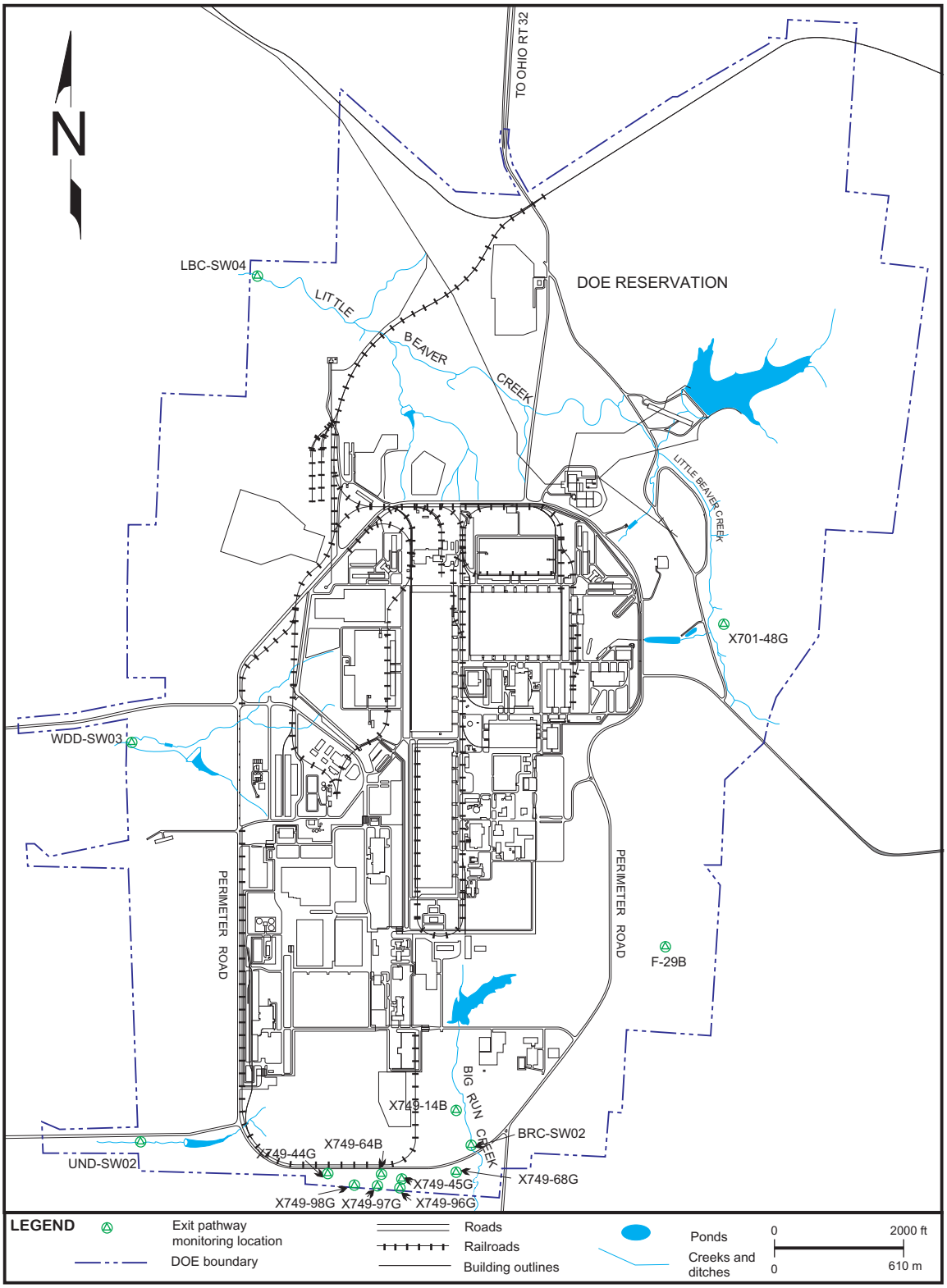

Figure 6.14. Exit pathway monitoring locations.

In 2009, concentrations of volatile organic compounds, including trichloroethene, decreased in three on-site exit pathway groundwater monitoring wells (X749-44G, X749-45G, and X749-97G) that monitor the X-749 South Barrier Wall Area 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 on-site wells were 5.4 µg/L in well X749-44G, 1.4 µg/L in well X749-45G, and 0.42 µg/L in well X749-97G. The concentration of trichloroethene detected in well X749-44G exceeds the EPA drinking water standard for trichloroethene (5 µg/L); however, the monitoring well is located within the PORTS boundary.

In 2009, no transuranics or technetium-99 were detected in exit pathway monitoring wells sampled for radionuclides during 2009 or in the surface water sampling locations that are part of the exit pathway monitoring program.

6.6 GROUNDWATER TREATMENT FACILITIES

In 2009, a combined total of approximately 33.4 million gallons of water were treated at the X-622, X-623, X-624, and X-627 Groundwater Treatment Facilities. Approximately 64 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 2009

Facility	Gallons of water treated	Gallons of TCE removed
X-622	20,227,200	3
X-623	2,258,300	26
X-624	3,181,800	13
X-627	7,768,200	22

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

The facility processed approximately 20.2 million gallons of groundwater during 2009, thereby removing approximately 3 gallons of trichloroethene from the water. Treated water from the facility discharges through LPP NPDES Outfall 608, which flows to the USEC Sewage Treatment Plant. No NPDES permit limitations were exceeded at Outfall 608 in 2009.

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 (X623-EW01G, X623-EW02G, and X623-EW03G) east of the holding pond. In 2009, water collected during excavation activities associated with the X-701B soil remediation project was also treated at the X-623 Groundwater Treatment Facility.

The facility treated approximately 2.3 million gallons of water during 2009, thereby removing approximately 26 gallons of trichloroethene from the water. Treated water from the facility discharges through LPP NPDES Outfall 610, which flows to the USEC Sewage Treatment Plant. No NPDES permit limitations were exceeded at Outfall 610 in 2009.

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 3.2 million gallons of water in 2009, thereby removing approximately 13 gallons of trichloroethene from the water. Treated water from the facility discharges through LPP NPDES Outfall 015, which discharges to Little Beaver Creek. No NPDES permit limitations were exceeded at Outfall 015 in 2009.

6.6.4 X-627 Groundwater Treatment Facility

The X-627 Groundwater Treatment Facility consists of an air stripper with offgas activated carbon filtration and aqueous phase activated carbon filtration. The X-700 and X-705 buildings are located above the Quadrant II Groundwater Investigative 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 2009, thereby removing 22 gallons of trichloroethene from the water. Treated water from the facility discharges through LPP NPDES Outfall 611, which flows to the USEC Sewage Treatment Plant. No NPDES permit limitations were exceeded at Outfall 611 in 2009.

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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. Analytical laboratories used by DOE PORTS during 2009 participated in the DOE Consolidated Audit Program and Mixed-Analyte Performance Evaluation Program.

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 2009 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 analytical laboratory data are received by DOE PORTS, they are independently evaluated using a systematic process that compares the data to established quality assurance/quality control criteria. An independent data validator checks documentation produced by the analytical laboratory to verify that the laboratory has provided data that meet established criteria.

In 2009, samples collected by DOE PORTS for environmental monitoring programs such as NPDES monitoring, groundwater monitoring required by the *Integrated Groundwater Monitoring Plan*, and environmental monitoring required by the *Environmental Monitoring Plan for the Portsmouth Gaseous Diffusion Plant*, were sent to analytical laboratories that participated in DOE programs to ensure data quality. The DOE Consolidated Audit Program implements annual performance qualification audits of environmental laboratories. The DOE Mixed-Analyte Performance Evaluation Program provides semiannual performance testing and evaluation of analytical laboratories.

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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).

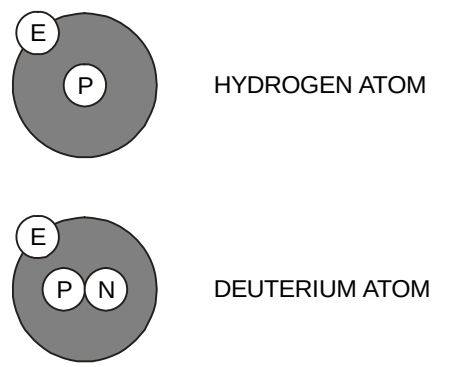
> *radioactivity*—A particular type of radiation emitted by a radioactive substance, such as alpha radioactivity (McGraw-Hill 1989).

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.

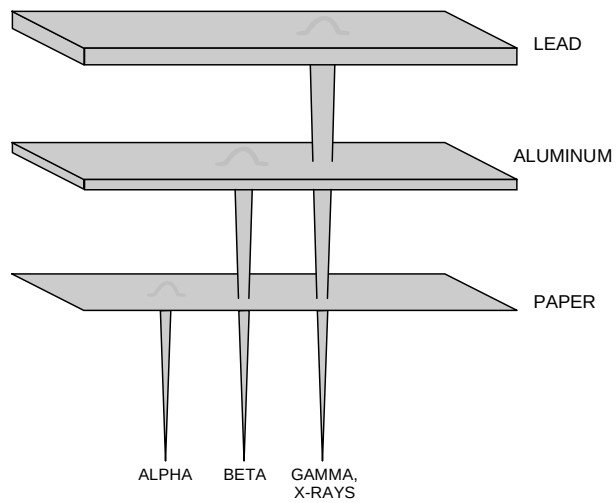


Figure A.2. Penetrating power of radiation.

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

A.3.1.1 Space radiation

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

A.3.1.2 Terrestrial radiation

Terrestrial radiation refers to radiation emitted from radioactive materials in the earth's rocks, soils, and minerals. Radon (Rn); radon progeny, the relatively short-lived decay products of radium-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 industrial or occupational sources. About one-half of 1% of the U.S. population performs work in which radiation in some form is present. Atmospheric testing of atomic weapons was a source of human-made radiation, but testing has been suspended in the United States and most parts of the world. Fallout from atmospheric weapons testing is not currently a significant contributor to background radiation (Health Physics Society 2010).

A.3.2.1 Consumer products and activities

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

A.3.2.2 Medical sources

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

A.3.2.3 Industrial and occupational sources

Other sources of radiation include emissions of radioactive materials from nuclear facilities such as uranium mines, fuel processing plants, and nuclear power plants; emissions from mineral extraction facilities; and the transportation of radioactive materials. Workers in certain occupations may also be exposed to radiation due to their jobs. These occupations include positions in medicine, aviation, research, education, and government.

A.4 PATHWAYS OF RADIATION

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

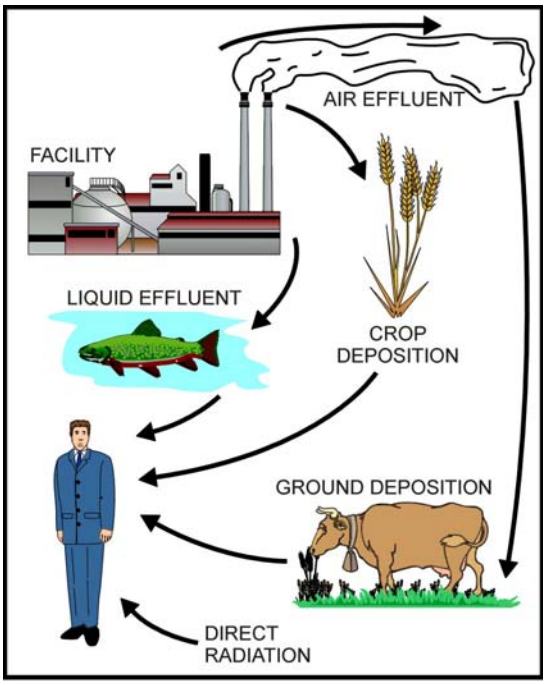


Figure A.3. Possible radiation pathways.

A.5 MEASURING RADIATION

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

A.5.1 Activity

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

Table A.1. Units of radiation measures

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

A.5.2 Absorbed Dose

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

A.5.3 Dose

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

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

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

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

- **collective dose/collective effective dose** – The sums of the doses or effective doses of all individuals in an exposed population expressed in units of person-rem (or person-sievert). When the collective dose of interest is for a specific organ, the units would be organ-rem (or organ-sievert). This dose is also called the population dose.

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 and effective dose 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 space radiation

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

A.6.1.2 Dose from terrestrial radiation

The average annual dose received from terrestrial gamma radiation is about 21 mrem (0.21 mSv) in the United States (NCRP 2009). Similar to space radiation, this dose varies geographically across the country with the lowest doses on the Atlantic and Gulf coastal plains and highest doses in the mountains in the western United States.

A.6.1.3 Dose from internal radiation

Inhalation of the short-lived decay products of radon are the major contributors to the annual dose equivalent for internal radionuclides (mostly ^{222}Rn). They contribute an average dose of about 228 mrem (2.28 mSv) per year (NCRP 2009).

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

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

Adapted from Savannah River Site Environmental Report for 1993, Summary Pamphlet, WSRC-TR-94-076, Westinghouse Savannah River Company, 1994 and NCRP Report No. 160, *Ionizing Radiation Exposure of the Population of the United States* (NCRP 2009).

The average dose from ingestion of radionuclides is about 29 mrem (0.29 mSv) per year, which can be attributed to the naturally occurring isotope of potassium, ^{40}K; and isotopes of thorium (Th), uranium (U), and their decay series (NCRP 2009).

A.6.1.4 Dose from consumer products

The U.S. average annual dose received by an individual from consumer products is about 13 mrem (0.13 mSv) (NCRP 2009). Almost 90 percent of this dose results from smoking cigarettes, commercial air travel, and building materials (radionuclides present in brick, masonry, cement, concrete, and other materials).

A.6.1.5 Dose from medical sources

Medical exams and procedures account for the largest portion of the average annual dose received from human-made sources. These procedures include x-rays, computed tomography (a more sophisticated type of x-ray), and fluoroscopy, and nuclear medicine. The increase in the use of medical imaging procedures, especially computed tomography, over the last 25 years has resulted in a marked increase in the average annual dose from medical sources received by a person in the United States: 53 mrem/year in the early 1980s to 300 mrem/year in 2006 (NCRP 2009). The actual doses received by individuals who complete such medical exams can be much higher than the average value because not everyone receives such exams each year.

A.6.1.6 Doses from industrial and occupational sources

Small doses received by individuals occur as a result of emissions of radioactive materials from nuclear facilities, emissions from certain mineral extraction facilities, and transportation of radioactive materials. The combination of these sources contributes less than 1 mrem (0.01 mSv) per year to the average dose to an individual (NCRP 2009).

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 Operate X-627 Groundwater Treatment Facility	P474, T104, T105	2/26/2008	2/26/2013	Active
Permit to Install and Operate X-326 L-cage Glove Box	P022	11/12/2008	11/12/2018	Active
Permit to Install and Operate X-735 Landfill Cap and Venting System (northern portion)	P023	11/12/2008	11/12/2018	Active
X-624 Groundwater Treatment Facility (now considered a *de minimis* source)	P019		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		Construction complete
Permit to Install UDS Process Line 2	P002	10/5/2004		Construction complete
Permit to Install UDS Process Line 3	P003	10/5/2004		Construction complete
Permit to Install UDS Conversion Building HVAC System	P004	10/5/2004		Construction complete
		Clean Water Act Permits		
NPDES Permit DOE (UDS)	0IS00034*AD	4/25/2007	5/31/2012	Active
NPDES Permit DOE (LPP)	0IO00000*JD	4/15/2008	4/30/2013	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	1/919/1996	None	Active
Permit to Install X-624 Groundwater Treatment Facility	06-3556	10/28/1992	None	Active
Permit to Install X-627 Groundwater Treatment Facility	06-07283	1/13/2004	None	Active
		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

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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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