2013 Paducah Site
Annual Site Environmental Report

PAD-REG-1021

This report is intended to fulfill the requirements of U.S. Department of Energy Order (DOE) 231.1B. The data and information contained in this report were collected in accordance with the Paducah Site Environmental Monitoring Plan (LATA Kentucky 2012; LATA Kentucky 2013a) approved by DOE. This report is not intended to provide the results of all sampling conducted at the Paducah Site. Additional data collected for other site purposes, such as environmental restoration, remedial investigation reports, and waste management characterization sampling, are presented in other documents that have been prepared in accordance with applicable DOE guidance and/or federal or state laws.

PAD-REG-1021

Paducah Site
Annual Site Environmental Report
for Calendar Year 2013

October 2014

Prepared for the
U.S. DEPARTMENT OF ENERGY
Office of Environmental Management

Prepared by
LATA ENVIRONMENTAL SERVICES OF KENTUCKY, LLC
managing the
Environmental Remediation Activities at the
Paducah Gaseous Diffusion Plant
under contract DE-AC30-10CC40020

THIS PAGE INTENTIONALLY LEFT BLANK

CONTENTS

THIS PAGE INTENTIONALLY LEFT BLANK

FIGURES

TABLES

THIS PAGE INTENTIONALLY LEFT BLANK

ACRONYMS

ACO	Administrative Consent Order
AFV	alternative fuel vehicle
ALARA	as low as reasonably achievable
AO	Agreed Order
ASER	Annual Site Environmental Report
ASTM	American Society for Testing and Materials
BCG	biota concentration guideline
BGOU	Burial Grounds Operable Unit
BWCS	B&W Conversion Services, LLC
CAA	Clean Air Act
CAB	Paducah Citizens Advisory Board
CAP	corrective action plan
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
CWA	Clean Water Act
CX	categorical exclusion
CY	calendar year
D&D	decontamination and decommissioning
DCS	derived concentration technical standard
DNAPL	dense nonaqueous-phase liquid
DOE	U.S. Department of Energy
DOECAP	U.S. Department of Energy Consolidated Audit Program
DQO	data quality objective
EA	environmental assessment
ED	effective dose
EDD	electronic data deliverable
EDE	effective dose equivalent
EIC	Environmental Information Center
EIS	environmental impact statement
EISA	Energy Independence and Security Act
EM	environmental management
EMP	Environmental Monitoring Plan
EMS	Environmental Management System
EO	Executive Order
EOC	Emergency Operations Center
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ERPP	Environmental Radiation Protection Program
FFA	Federal Facility Agreement
FFC Act	Federal Facilities Compliance Act
FFCA	Federal Facility Compliance Agreement
FR	*Federal Register*
FY	fiscal year
GDP	gaseous diffusion plant
GHG	greenhouse gas
GSR	green and sustainable remediation
HAP	hazardous air pollutant
HPSB	high performance and sustainable buildings

ILA	industrial, landscaping, and agricultural
ISMS	Integrated Safety Management System
ISO	International Organization for Standardization
KAR	*Kentucky Administrative Regulations*
KDEP	Kentucky Department for Environmental Protection
KDOW	Kentucky Division of Water
KDWM	Kentucky Division of Waste Management
KPDES	Kentucky Pollutant Discharge Elimination System
LATA Kentucky	LATA Environmental Services of Kentucky, LLC
MCL	maximum contaminant level
MEI	maximally exposed individual
MW	monitoring well
N/A	not applicable
NEPA	National Environmental Policy Act
NEPCS	Northeast Plume Containment System
NESHAP	National Emission Standards for Hazardous Air Pollutants
NOD	Notice of Deficiency
NOV	Notice of Violation
NPL	National Priorities List
NRHP	National Register of Historic Places
NWPGS	Northwest Plume Groundwater System
OREIS	Oak Ridge Environmental Information System
PEMS	Project Environmental Measurements System
PGDP	Paducah Gaseous Diffusion Plant
PPPO	Portsmouth/Paducah Project Office
PUE	power usage effectiveness
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act
RGA	Regional Gravel Aquifer
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SMP	Site Management Plan
SOW	statement of work
SSP	Site Sustainability Plan
SST	Swift & Staley Team
STP	Site Treatment Plan
SWMU	solid waste management unit
TED	total effective dose
TLD	thermoluminescent dosimeter
TSCA	Toxic Substances Control Act
UCRS	Upper Continental Recharge System
UDS	Uranium Disposition Services, LLC
UE	uranium enrichment
USEC	United States Enrichment Corporation
UST	underground storage tank
WKWMA	West Kentucky Wildlife Management Area
WM/PP	waste minimization/pollution prevention
WMP	Watershed Monitoring Plan

REQUEST FOR COMMENTS

The U.S. Department of Energy (DOE) requires an annual site environmental report from each of the sites operating under its authority. This report presents the results from the various environmental monitoring programs and activities carried out during the year. This *Paducah Site Annual Site Environmental Report for Calendar Year 2013* was prepared to fulfill DOE requirements. This report is a public document that is distributed to government regulators, businesses, special interest groups, and members of the public.

This report is based on thousands of environmental samples collected at or near the Paducah Site. Significant efforts were made to provide the data collected and details of the site environmental management programs in a clear and concise manner. The editors of this report encourage comments in order to better address the needs of our readers in future site environmental reports. You can complete a comment form online using the following link:

http://form.jotform.us/form/42224884876163

If you prefer, written comments may be sent to the following address:

U.S. Department of Energy
Portsmouth/Paducah Project Office
1017 Majestic Drive, Suite 200
Lexington, Kentucky 40513

THIS PAGE INTENTIONALLY LEFT BLANK

EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE) manages work at the Paducah Site to comply with and adhere to all applicable laws, regulations, and site-specific regulatory permits. DOE continues to implement projects in a manner that protects site personnel, the environment, and the community and strives to maintain full compliance with all current environmental regulations.

The purpose of this Annual Site Environmental Report is to summarize calendar year (CY) 2013 environmental management activities at the Paducah Site, including effluent monitoring, environmental surveillance, and environmental compliance status and to highlight significant site program efforts. Annually, DOE implements programs to measure any impacts that its operations have on the environment or the public. Surveillance under these programs includes analyses of surface water, groundwater, sediment, ambient air, and direct radiation.

DOE and its contractors are committed to enhancing environmental stewardship and to reducing any impacts that site operations may cause to the environment. The Paducah Site implements sound stewardship practices in the protection of land, air, water, and other natural or cultural resources potentially impacted by their operations. An environmental stewardship scorecard assesses agency performance under the Environmental Management System. The environmental stewardship scorecard for PGDP in fiscal year 2013 was green (which indicates standards for the Environmental Management System implementation have been met).

The Paducah Site received six notices of violation during CY 2013 for alleged violations related to the Kentucky Pollutant Discharge Elimination System permit. Efforts to address the toxicity continue to be implemented. A preliminary evaluation conducted by an Oak Ridge National Laboratory toxicologist in 2014 indicated that pathogen interference in the fathead minnow tests is a likely explanation for much of the apparent toxicity detected in Outfall 017 tests (i.e., the toxicity likely is unrelated to plant operations). Exceedances for total residual chlorine appear to have been caused by natural algae growth in the plant ditches and lagoons. Corrective actions have been implemented to address the issues. The exceedance for zinc appears to be an outlier with no source or explanation, and the levels for the following months were well below the permit limits. No penalties were assessed for these alleged violations.

During CY 2013, 810 tons of waste from 10 different waste streams was disposed of in the C-746-U Landfill. Among other waste, disposal included building demolition debris from the C-340 facility. During routine sampling of landfill leachate during the summer of 2013, an increase in radiological contaminants was noted. These levels were 15.2% above the 2012 discharge concentrations based on the time-weighted averages for 2013, but did not exceed the derived concentration technical standard established by DOE (DOE 2011).

Groundwater programs continue to remediate contamination in off-site plumes and on-site source areas. Sediment analysis results show an overall downward trending, and ambient air monitoring results continue either to be not detected or below permitted limits. The worst-case internal/external dose of radiation (based on calculations) from the plant that could be received by a member of the public is more than 200 times lower than the acceptable DOE annual dose limit.

DOE continues to implement the environmental cleanup program at the Paducah Gaseous Diffusion Plant. Highlights of accomplishments through 2013 include the following: removed approximately 574 gal of trichloroethene from contaminant source areas at Paducah; completed demolition of C-340; converted approximately 8,199 metric tons of depleted uranium hexafluoride to a more stable oxide and hydrofluoric acid; and recycled 882,289 lb of materials.

1. INTRODUCTION

The U.S. Department of Energy (DOE) requires that environmental monitoring be conducted and documented for all of its facilities under the purview of DOE Order 231.1B, *Environment, Safety, and Health Reporting*. Several other laws, regulations, and DOE directives require compliance with environmental standards. The purpose of this Annual Site Environmental Report (ASER) is to summarize calendar year (CY) 2013 environmental management (EM) activities at the Paducah Site, including effluent monitoring, environmental surveillance, and environmental compliance status and to highlight significant site program efforts. References in this report to the Paducah Site generally mean the property, programs, and facilities at or near Paducah Gaseous Diffusion Plant (PGDP) for which DOE has ultimate responsibility. Several documents are referenced within this ASER; where available, electronic hyperlinks to the documents are provided within the file.

Environmental monitoring consists of the following two major activities: effluent monitoring and environmental surveillance. Effluent monitoring is the direct measurement or the collection and analysis of samples of liquid and gaseous discharges to the environment. Environmental surveillance is the direct measurement or the collection and analysis of samples consisting of ambient air, surface water, groundwater, and sediment. Effluent monitoring and environmental surveillance are performed to characterize and quantify contaminants, assess radiation exposure, demonstrate compliance with applicable standards and permit requirements, and detect and assess the effects, if any, on the local population and environment. Multiple samples are collected throughout the year and are analyzed for radioactivity, chemical constituents, and various physical properties.

The overall goals for DOE/EM are to protect site personnel, the environment, and the community and to maintain full compliance with all current environmental regulations. The current environmental strategy is to prevent noncompliance, to identify any current compliance issues, and to develop a system for resolution. The long-range goal of DOE/EM is to control and reduce exposures of the public, workers, and biota to harmful chemicals and radiation.

Three prime contractors perform work supporting DOE missions at the PGDP: B&W Conversion Services, LLC, (BWCS); Swift & Staley Team (SST); and LATA Environmental Services of Kentucky, LLC (LATA Kentucky). In July 1993, DOE leased the production areas of the site to the United States Enrichment Corporation (USEC), a private company. At the end of 2013, USEC continued to lease the gaseous diffusion plant (GDP) from DOE. **This report does not include USEC environmental monitoring activities.**

1.1 SITE LOCATION

The Paducah Site is located in a generally rural area of McCracken County, Kentucky. In 2013, Paducah Gaseous Diffusion Plant (PGDP) was an active uranium enrichment (UE) facility and extensive support facilities. USEC announced that they were going to cease operations; USEC began ceasing enrichment at the end of May 2013. In August 2013, USEC provided DOE with the required two-year notification for return of the Paducah plant. The UE process was housed in six large buildings. The plant is on a 3,556-acre DOE site, approximately 650 acres of which are within a fenced security area, approximately 800 acres are located outside the security fence, 133 acres are in acquired easements, and the remaining 1,986 acres are licensed to the Commonwealth of Kentucky as part of the West Kentucky Wildlife Management Area (WKWMA). The plant is in western McCracken County, 10 miles west of Paducah, Kentucky, and 3.5 miles south of the Ohio River (Figure 1.1).

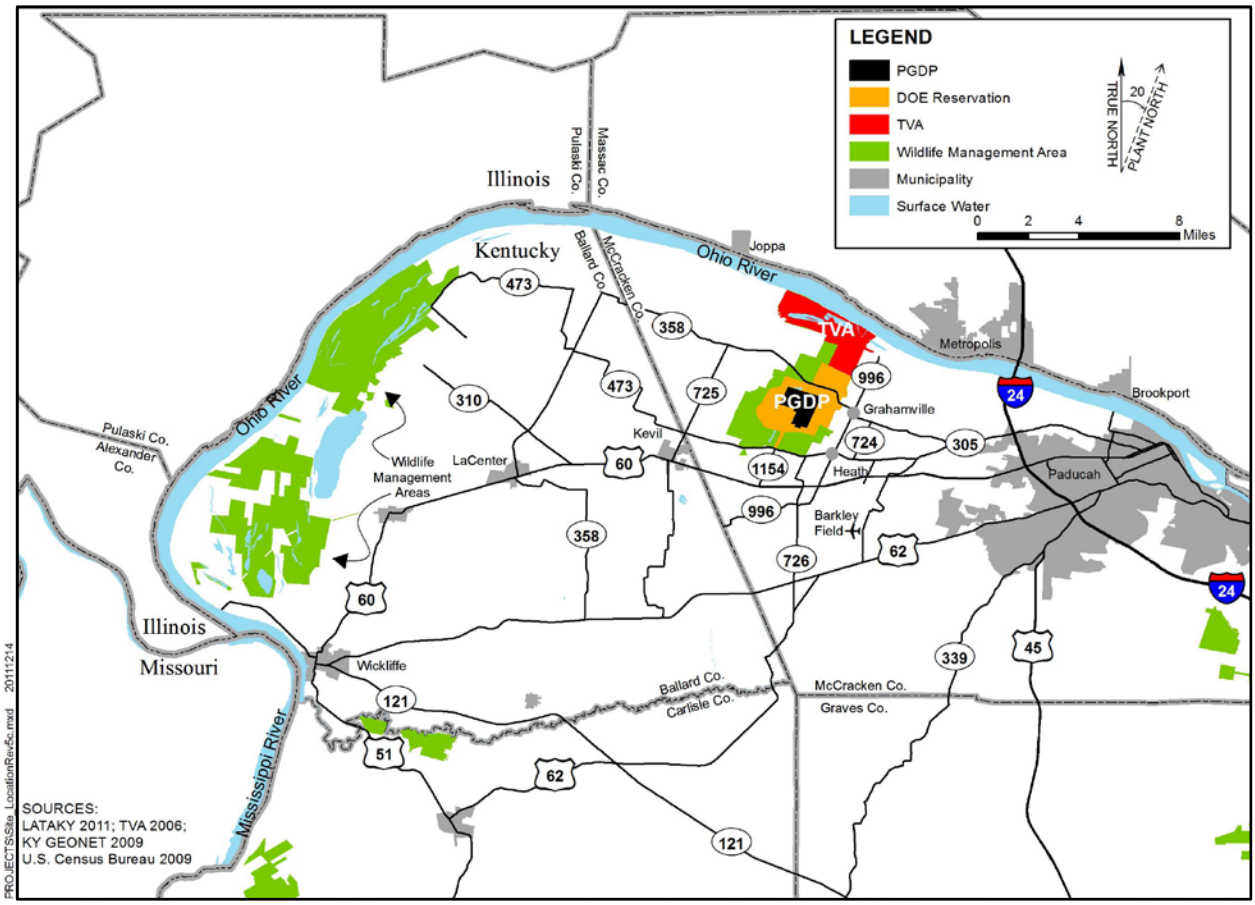

Figure 1.1. Location of the Paducah Site

A buffer zone of at least 400 yd surrounds the entire fenced area. During World War II, the Kentucky Ordnance Works was operated in an area southwest of the plant on what is now a wildlife management area.

1.2 GENERAL ENVIRONMENTAL SETTING

1.2.1 Climate

The Paducah Site is located in the humid continental zone where summers are warm (July averages 79°F) and winters are moderately cold (January averages 35°F). Yearly precipitation averages about 49 inches. The prevailing wind is from the south-southwest at approximately 10 miles per hour.

1.2.2 Surface Water Drainage

The Paducah Site is situated in the western part of the Ohio River basin. The confluence of the Ohio River with the Tennessee River is about 15 miles upstream of the site, and the confluence of the Ohio River with the Mississippi River is about 35 miles downstream. PGDP is located on a local drainage divide. Surface water from the east side of the plant flows east-northeast toward Little Bayou Creek, and surface water from the west side of the plant flows west-northwest toward Bayou Creek. Bayou Creek is a perennial stream that flows toward the Ohio River along a 9-mile course. Little Bayou Creek is an

intermittent stream that flows north toward the Ohio River along a 7-mile course. The two creeks converge 3 miles north of the plant before emptying into the Ohio River.

Flooding in the area is associated with Bayou Creek, Little Bayou Creek, and the Ohio River. Maps of the calculated 100-year flood elevations show that all three drainage systems have 100-year floodplains located within the DOE boundary at PGDP, but not within the industrialized area of PGDP (FEMA 2013).

1.2.3 Wetlands

More than 1,100 separate wetlands, totaling over 1,600 acres, were found in a study area of about 12,000 acres in and around the Paducah Site (COE 1994). More than 60% of the total wetland area is forested.

1.2.4 Soils and Hydrogeology

Soils of the area are predominantly silty loams that are poorly drained, acidic, and have little organic content. The local groundwater flow system at the Paducah Site is described in Chapter 6.

1.2.5 Vegetation

Much of the Paducah Site has been impacted by human activity. Vegetation communities on the reservation are indicative of old field succession (e.g., grassy fields, field scrub-shrub, and upland mixed hardwoods). The open grassland areas, most of which are managed by WKWMA personnel, are mowed periodically or burned to maintain early successional vegetation, which is dominated by members of the *Compositae* family and various grasses. Species commonly cultivated for wildlife forage are corn, millet, milo, and soybean (CH2M HILL 1992).

Field scrub-shrub communities consist of sun tolerant wooded species such as persimmon, maples, black locust, sumac, and oaks (CH2M HILL 1991). The undergrowth varies depending on the location of the woodlands. Wooded areas near maintained grasslands have an undergrowth dominated by grasses. Other communities contain a thick undergrowth of shrubs, including sumac, pokeweed, honeysuckle, blackberry, and grape.

Upland mixed hardwoods contain a variety of upland and transitional species. Dominant species include oaks, shagbark and shellbark hickory, and sugarberry (CH2M HILL 1991). The undergrowth here varies, with limited undergrowth for more mature stands of trees, to dense undergrowth similar to that described for a scrub-shrub community.

1.2.6 Wildlife

Wildlife species indigenous to hardwood forests, scrub-shrub, and open grassland communities are present at the Paducah Site. A list of representative species is provided in *Results of the Site Investigation Phase 1* (CH2M HILL 1991). Additionally, the Ohio River, which is 3 miles north of the Paducah Site, serves as a major flyway for migratory waterfowl (DOE 1995a). Fish populations in Bayou Creek and Little Bayou Creek are dominated numerically by various species of shiner and sunfish.

1.2.7 Threatened and Endangered Species

A threatened and endangered species investigation identified federally listed, proposed, or candidate species potentially occurring at or near the Paducah Site (COE 1994). Updated information is obtained on

a regular basis from federal and Commonwealth of Kentucky sources. Currently, potential habitat for 13 species of federal concern exists in the study area. Eleven of these species are listed as "endangered" under the Endangered Species Act of 1973, 1 is "threatened," and 1 is proposed for listing (Chapter 2, Table 2.3). While there are potential habitats for endangered species on DOE property, none of the federally listed or candidate species has been found on DOE property at the Paducah Site.

1.3 SITE MISSION

DOE established the Portsmouth/Paducah Project Office (PPPO) on October 1, 2003, to provide focused leadership to the EM missions at the Portsmouth, Ohio, and Paducah, Kentucky, GDPs.

The PPPO Lexington, Kentucky, office opened in January 2004, and is located midway between the Kentucky and Ohio facilities. Although the PPPO manager is located in the Lexington office, frequent and routine site interactions occur by this office at both the Portsmouth and Paducah sites' operations. Additionally, DOE maintains a strong presence at the sites on a daily basis through the Portsmouth and Paducah Operations Oversight Groups. The PPPO's goal is to accelerate the site cleanup at the Portsmouth and Paducah GDPs, eliminating potential environmental threats, reducing the DOE footprint at each of the sites, and reducing life-cycle cost.

DOE's PPPO mission is to accomplish the following at the Portsmouth and Paducah Sites.

- Environmental Remediation
- Waste Management
- Depleted Uranium Hexafluoride (DUF_6) Conversion
- Decontamination and Decommissioning (D&D)

1.4 PRIMARY OPERATIONS AND ACTIVITIES AT THE PADUCAH SITE

The following two major programs are operated by DOE at the Paducah Site: (1) EM and (2) Uranium Programs. Environmental Restoration, Waste Management, and D&D are projects under the EM Program. The mission of the Environmental Restoration Project is to ensure that releases from past operations at the Paducah Site are investigated and that appropriate response action is taken for protection of human health and the environment in accordance with the Federal Facility Agreement (FFA) (EPA 1998). The mission of the Waste Disposition Project is to characterize and dispose of waste stored on-site in compliance with regulatory requirements and DOE Orders. The major mission of the D&D Project is to D&D excess buildings (i.e., inactive with no reuse potential) to minimize or eliminate the possible health and environmental hazards caused by the uncontrolled release of hazardous substances from contaminated structures. The major missions of the Uranium Program are to maintain safe, compliant storage of the DOE DUF_6 inventory until final disposition, operation of a facility for the conversion of DUF_6 to a more stable oxide and hydrofluoric acid, and to manage facilities and grounds not leased to USEC. The environmental monitoring summarized in this report supports all DOE programs/projects. Additional information regarding these activities is found in Section 3.1.

The Energy Policy Act of 1992 transferred operational responsibility for the UE enterprise to the USEC, a government corporation that became a publicly held company in 1998. In accordance with the Energy Policy Act of 1992, USEC assumed responsibility on July 1, 1993, for enrichment operations and leased from DOE the real property, facilities, and infrastructure necessary for enrichment operations. USEC enriched uranium at the Paducah Site to supply nuclear fuel to electric utilities worldwide. DOE retains

ownership of all facilities, as well as the responsibility for managing the disposition of legacy waste material and environmental cleanup.

1.5 DEMOGRAPHIC INFORMATION

The population of McCracken County, Kentucky is approximately 66,000 (DOC 2013). The major city in McCracken County is Paducah, Kentucky, whose population is approximately 25,000 (DOC 2013). Three small communities are located within 3 miles of the DOE property boundary at PGDP: Heath and Grahamville to the east and Kevil to the southwest. The closest commercial airport is Barkley Regional Airport, approximately 5 miles to the southeast. The population within a 50-mile radius of PGDP is about 534,000 according to the 2010 census. Within a 10-mile radius of PGDP, the population is about 89,000 (ESRI 2012).

THIS PAGE INTENTIONALLY LEFT BLANK

2. COMPLIANCE SUMMARY

Principal regulating agencies are the U.S. Environmental Protection Agency (EPA), Region 4, and the Kentucky Department for Environmental Protection (KDEP). These agencies issue permits, review compliance reports, participate in joint monitoring programs, inspect facilities and operations, and oversee compliance with applicable laws and regulations.

The EPA develops, promulgates, and enforces environmental protection regulations and technology-based standards as directed by statutes passed by the U.S. Congress. In most instances, EPA has delegated regulatory authority to KDEP when the Kentucky program meets or exceeds EPA requirements.

2.1 ENVIRONMENTAL RESTORATION AND WASTE MANAGEMENT

2.1.1 Comprehensive Environmental Response, Compensation, and Liability Act

DOE and EPA Region 4 entered into an Administrative Consent Order (ACO) in August 1988 under Sections 104 and 106 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The ACO was in response to the off-site groundwater contamination detected at the Paducah Site in July 1988.

On May 31, 1994, the Paducah Site was placed on the EPA National Priorities List (NPL), which is a list of sites across the nation designated by EPA as having the highest priority for site remediation. The EPA uses the Hazard Ranking System to determine which sites should be included on the NPL.

Section 120 of CERCLA requires federal agencies with facilities on the NPL to enter into an FFA with the EPA. The FFA, which was signed February 13, 1998, by DOE, EPA, and KDEP, established a decision making process for remediation of the Paducah Site and coordinates CERCLA remedial action requirements with Resource Conservation and Recovery Act (RCRA) corrective action requirements. DOE, EPA, and KDEP agreed to terminate the CERCLA ACO because those activities could be continued under the FFA. The FFA requires DOE to submit an annual Site Management Plan (SMP) to EPA and KDEP. The FY 2013 SMP document was submitted to EPA and KDEP in November 2012. The final version of the SMP was approved in January 2013 and further modified in July 2013 (DOE 2013a). The SMP summarizes the remediation work completed to date, outlines remedial priorities, and contains schedules for completing future work. The SMP is submitted to the regulators annually in November to update the enforceable milestones and to include any new strategic approaches. A link to this document can be found in the References Section.

Significant enforceable milestones required under CERCLA and the FFA for CY 2013 at the Paducah Site are listed in Table 2.1.

2.1.2 Superfund Amendments and Reauthorization Act

The Superfund Amendments and Reauthorization Act (SARA) amended CERCLA on October 17, 1986. SARA reflected EPA's experience in administering the complex Superfund program and made several important changes and additions to the program. Changes of particular importance are (1) increased the focus on human health problems posed by hazardous waste sites, and (2) encouraged greater citizen participation in making decisions on how sites should be cleaned up.

Table 2.1. CERCLA and FFA Significant Milestones for CY 2013

Milestone	Date Agreed	Date Completed
Burial Grounds Operable Unit (BGOU) Feasibility Study Report for Solid Waste Management Units (SWMUs) 5 and 6—D2/R3	2/15/2013	2/11/2013
Southwest Plume SWMU 1 (Soil Mixing) 90% Remedial Design Report—D1	2/16/2013	2/19/2013*
Soils Operable Unit Remedial Investigation Report—D2/R1	3/16/2013	2/7/2013
Northeast Plume Remediation Action Work Plan—D1	3/28/2013	3/28/2013
FFA Semiannual Progress Report—First Half of Fiscal Year (FY) 2013	4/30/2013	4/30/2013
BGOU Proposed Plan for SWMUs 5 and 6—D1	5/16/2013	5/2/2013
Southwest Plume SWMU 1 (Soil Mixing) 90% Remedial Design Report—D2	6/21/2013	6/21/2013
C-400 Operations and Maintenance Plan Phase IIa—D2	6/23/2013	6/19/2013
Southwest Plume Sources, SWMUs 211-A and 211-B Final Characterization Report—D1	6/26/2013	6/26/2013
Final Characterization Notification for SWMUs 211-A and 211-B	7/10/2013	7/10/2013
BGOU Proposed Plan for SWMUs 5 and 6—D2	7/17/2013	7/17/2013
Southwest Plume SWMU 1 (Soil Mixing) Remedial Action Work Plan—D1	7/21/2013	7/22/2013*
Northeast Plume Optimization Explanation of Significant Differences—D2	8/8/2013	8/5/2013
Northeast Plume Remediation Action Work Plan—D2	8/18/2013	8/19/2013*
Northeast Plume Operation and Maintenance Plan—D3/R4	8/25/2013	8/22/2013
CERCLA Five Year Remedy Review—D1	8/29/2013	8/29/2013
Southwest Plume SWMU 1 (Soil Mixing) 90% Remedial Design Report—D2/R1	9/22/2013	9/23/2013*
C-400 Steam Treatability Study Work Plan—D1	10/21/2013	10/18/2013
C-400 Remedial Action Work Plan for Phase IIa—D2/R3	10/24/2013	10/23/2013
FFA Semiannual Progress Report—Second Half of FY 2013	11/16/2013	11/14/2013
Site Management Plan for FY 2014—D1	12/6/2013	12/5/2013
Southwest Plume Sources, SWMUs 211-A and 211-B Final Characterization Report—D2	12/10/2013	12/10/2013
Southwest Plume SWMU 1 (Soil Mixing) Remedial Action Work Plan—D2	12/20/2013	12/19/2013
C-340 Removal Action Report—D1	12/31/2013	12/10/2013

*Date agreed to was a Saturday, Sunday, or holiday, so document was submitted the following business day, per the FFA.

2.1.3 Resource Conservation and Recovery Act

Regulatory standards for the characterization, treatment, storage, and disposal of solid and hazardous waste are established by RCRA. Waste generators must follow specific requirements outlined in RCRA regulations for handling solid and hazardous wastes. Owners and operators of hazardous waste treatment, storage, and disposal facilities are required to obtain operating and/or postclosure permits for waste treatment, storage, and disposal activities. The Paducah Site generates solid waste, hazardous waste, and mixed waste (i.e., hazardous waste mixed with radionuclides) and operates three permitted hazardous waste storage and treatment facilities (C-733, C-746-Q, and C-752-A). The closed C-404 Hazardous Waste Landfill also is managed under requirements of the RCRA regulations and permit.

2.1.4 Resource Conservation and Recovery Act Hazardous Waste Permit

RCRA Part A and Part B permit applications for storage and treatment of hazardous wastes initially were submitted for the Paducah Site in the late 1980s. At that time, EPA had authorized the Commonwealth of Kentucky to administer exclusively the RCRA-based program for treatment, storage, and disposal units, but had not given the authorization to administer 1984 Hazardous and Solid Waste Amendments provisions.

The current hazardous waste management facility permit was issued to DOE on September 30, 2004. The permit became effective on October 31, 2004, and is valid until October 31, 2014. A renewal application was under development in CY 2013.

For CY 2013, there were no Notices of Violation (NOVs) issued for the Hazardous Waste Facility Permit (KY8-890-008-982).

2.1.5 Federal Facility Compliance Act—Site Treatment Plan

The Federal Facilities Compliance Act (FFC Act) was enacted in October 1992. This act waived the immunity from fines and penalties that had existed for federal facilities for violations of hazardous waste management, as defined by RCRA. It also contained provisions for the development of site treatment plans (STPs) for the treatment of DOE mixed waste and for the approval of such plans by the Commonwealth of Kentucky. As a result of the complex issues and problems associated with the treatment of mixed chemical hazardous and radioactive waste (mixed waste), DOE and KDEP signed, after consideration of stakeholder input, an Agreed Order (AO)/STP on September 10, 1997. The STP facilitates compliance with the FFC Act. During 2011, DOE completed disposal of mixed wastes listed in the STP. No wastes were added to the FFC Act STP during 2012 or 2013.

2.1.6 National Environmental Policy Act

An evaluation of the potential environmental impact of certain proposed federal activities is required by the National Environmental Policy Act (NEPA). In addition, an examination of alternatives to certain proposed actions is required. Compliance with NEPA, as administered by DOE's NEPA Implementing Procedures (10 *CFR* § 1021) and the Council on Environmental Quality Regulations (40 *CFR* § 1500–1508), ensures that consideration is given to environmental values and factors in federal planning and decision making. In accordance with 10 *CFR* § 1021, the Paducah Site conducts NEPA reviews for proposed non-CERCLA actions and determines if any proposal requires preparation of an environmental impact statement (EIS), an environmental assessment (EA), or is a categorical exclusion (CX) from preparation of either an EIS or an EA. The Paducah Site maintains records of all NEPA reviews.

The PPPO began drafting an EA in 2012 to assess the environmental impacts associated with potential transfer of PGDP real property to third parties for possible economic development. Work continued on this EA in 2013.

Numerous minor activities conducted in 2013 were within the scope of an approved EIS, EA, or the previously approved CXs for routine maintenance, small-scale facility modifications, and site characterization. The DOE Paducah Site Office and the PPPO NEPA compliance officer approve and monitor the internal applications of previously approved CX determinations.

In accordance with Section II.E of the June 13, 1994, DOE Secretarial Policy Statement on NEPA, preparation of separate NEPA documents for environmental restoration activities conducted under CERCLA no longer is required. Instead, the DOE CERCLA process incorporates "NEPA values." The

NEPA values are environmental issues that affect the quality of the human environment. Documentation of NEPA values in CERCLA documents allows the decision makers to consider the potential effects of proposed actions on the human environment. Actions conducted under CERCLA are discussed in Chapter 3 of this report.

2.1.7 Toxic Substances Control Act

In 1976, the Toxic Substances Control Act (TSCA) was enacted with a twofold purpose: (1) to ensure that information on the production, use, and environmental and health effects of chemical substances or mixtures is obtained by the EPA; and (2) to provide the means by which the EPA can regulate chemical substances/mixtures [e.g., polychlorinated biphenyls (PCBs), asbestos, chlorofluorocarbons, and lead].

2.1.8 Polychlorinated Biphenyls

The Paducah Site complies with PCB regulations (40 *CFR* § 761) and the TSCA-UE-Federal Facility Compliance Agreement (FFCA). The UE TSCA FFCA was signed and went into effect on February 20, 1992 (EPA 1992) and subsequently was modified on September 25, 1997 (BJC 1998). The major activities performed in 2013 are documented in the PCB Annual Document (LATA Kentucky 2014a). A link to this document can be found in the References Section.

2.2 RADIATION PROTECTION

The Atomic Energy Act of 1954 provides authority to DOE to implement DOE Order 458.1, *Radiation Protection of the Public and the Environment,* and DOE Order 435.1, *Radioactive Waste Management.* Under these orders, DOE establishes the requirements for protection of the public and the environment against any undue risk from radiation associated with radiological activities at DOE sites and ensures radioactive waste is managed in a manner that is protective of worker and public health, safety, and the environment. Authorized limits have been approved for the C-746-U Landfill and for DOE-owned property outside the Limited Area. These limits implement DOE Order 458.1 and ensure that doses to the public meet DOE standards and are as low as reasonably achievable (ALARA), that groundwater is protected, that future remediation would not be needed, and that no radiological protection requirements are violated.

The PGDP complies with DOE Order 435.1 and DOE Order 458.1.[1] The programs described below outline ways PGDP complies with these DOE Orders.

2.2.1 DOE Order 458.1, Radiation Protection of the Public and the Environment

To help ensure compliance with the requirements of DOE Order 458.1 for the PGDP, LATA Kentucky implements an Environmental Radiation Protection Program (ERPP) (LATA Kentucky 2013b). The goals of the ERPP are as follows:

(1) To conduct radiological activities so that exposure to members of the public is maintained within the dose limits established by the Order;

[1] DOE Order 458.1 replaced Order 5400.5 on February 11, 2011, and was added to the BWCS contract on April 11, 2014. Order 458.1 states that contractor requirements documents that have been incorporated into a contract remain in effect unless and until the contract is modified either to eliminate requirements that no longer are applicable or to substitute a new set of requirements. Order 458.1 was implemented under the LATA Kentucky contract in 2013.

(2) To control the radiological clearance of real and personal property;

(3) To ensure that potential radiation exposures to members of the public are ALARA;[2]

(4) To monitor routine and nonroutine radiological releases and to assess the radiation dose to members of the public; and

(5) To provide protection of the environment from the effects of radiation and radioactive material.

2.2.2 DOE Order 435.1, Radioactive Waste Management

The Paducah Site manages low-level, high-level, and transuranic waste in compliance with DOE Order 435.1 using a number of storage and disposal units. Procedures utilized for management of these wastes ensure compliance with this Order. The quality assurance (QA) programs in place (see Section 7) ensure compliance with these procedures.

2.3 AIR QUALITY AND PROTECTION

2.3.1 Clean Air Act

Authority for enforcing compliance with the Clean Air Act (CAA) and subsequent amendments resides with EPA Region 4 and/or the Kentucky Division for Air Quality. The Paducah Site complies with federal and Commonwealth of Kentucky rules by implementing the CAA and its amendments.

The DUF_6 Conversion Facility operates under KDEP Conditional Major Operating Air Permit No. F-10-035 R1. The facility has two emission points. Emission point U001 is the stack for the Conversion Building. The Conversion Building houses four parallel process lines. The operation utilizes a one-step fluidized bed process to convert DUF_6 to uranium oxide powder that is collected and packaged for reuse or disposal. This is accomplished by reacting DUF_6 gas with steam, nitrogen, and hydrogen that produces hydrofluoric acid, as a saleable end product, and uranium oxide powder. Emissions from oxide handling are controlled by a high-efficiency particulate air filter system. Low levels of hydrogen fluoride (HF) off-gassed from the conversion process are captured by a primary and secondary caustic scrubber system. Emission point U002 is the HF storage and load-out area. Air that is displaced during filling and emptying of HF storage tanks is vented through a dedicated scrubber system.

Additional sources of emissions in 2013 were the Northwest Plume Groundwater System (NWPGS) and the Northeast Plume Containment System (NEPCS). These systems are interim remedial actions under CERCLA that address the containment of groundwater contamination at the Paducah Site. Instead of being permitted under the CAA, the substantive requirements of the CAA for the emissions associated with these CERCLA actions are applied to the actions as ARARs. These systems remove trichloroethene (TCE) contamination from the groundwater by air stripping. At the NWPGS, the TCE-laden groundwater passes through an air stripper to remove the TCE. The off-gas from the air stripper then passes through a

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

carbon adsorption system to remove the TCE prior to atmospheric discharge. At the NEPCS, a cooling tower system acts as an air stripper for TCE. Concentrations of TCE in the Northeast Plume are sufficiently low that a carbon adsorption system is not required to keep emissions below regulatory threshold levels.

For CY 2013, DOE did not receive any NOVs under the CAA.

2.3.2 National Emission Standards for Hazardous Air Pollutants Program

Airborne emission of radionuclides from DOE facilities are regulated under 40 *CFR* § 61, Subpart H, the National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations. DOE also manages radionuclide air emissions in accordance with the EPA-approved NESHAP Management Plan for Emission of Radionuclides (LATA Kentucky 2013c). Potential radionuclide sources at the Paducah Site in 2013 were from DUF_6 Conversion Facility, NEPCS, NWPGS, fugitive dust source emissions, and other miscellaneous sources. The fugitive dust source emissions include piles of contaminated scrap metal, roads, and roofs. DOE utilized ambient air monitoring data to verify insignificant levels of radionuclides in off-site ambient air. The miscellaneous sources include transport and disposal of contaminated materials in the C-746-U Landfill and decontamination of machinery and equipment unused in remediation activities (e.g., well drilling). In 2012, DOE began monitoring its own network of air monitors. Ambient air data were collected at 9 sites surrounding PGDP in order to measure radionuclides emitted from Paducah Site sources, including fugitive emissions. Several of the air monitors utilized are solar. These solar air monitors (Figure 2.1) are environmentally friendlier, more dependable, and less energy-consuming than the electrical models they replaced. These results are discussed in further detail in Chapter 4.

Figure 2.1. Solar Air Monitor near the DUF_6 Conversion Facility

2.4 WATER QUALITY AND PROTECTION

2.4.1 Clean Water Act

The Clean Water Act (CWA) was established primarily through the passage of the Federal Water Pollution Control Act Amendments of 1972. The CWA established the following four major programs for control of water pollution:

(1) Regulating point-source discharges into waters of the United States;
(2) Controlling and preventing spills of oil and hazardous substances;
(3) Regulating discharges of dredge and fill materials into "waters of the United States"; and
(4) Providing financial assistance for construction of publicly owned sewage treatment works.

The Paducah Site is affected primarily by the regulations for point source discharges regulated under the Kentucky Pollutant Discharge Elimination System (KPDES) permit.

2.4.2 Kentucky Pollutant Discharge Elimination System

The CWA applies to all nonradiological DOE discharges to waters of the United States. At the Paducah Site, the regulations are applied through issuance of a KPDES permit for effluent discharges to Bayou Creek and Little Bayou Creek. The Kentucky Division of Water (KDOW) issued KPDES Permit Number KY0004049 to the Paducah Site. The KPDES permit calls for monitoring as an indicator of discharge-related effects in the receiving streams. Discharge monitoring reports are issued monthly. Additionally, the KPDES permit requires the development and implementation of a best management practices plan to control projects with the potential to impact stormwater pollutants. These best management practices are flowed to work projects through the site Environmental Management System (EMS) and work control.

Six NOVs were received during CY 2013 for alleged violations related to the KPDES permit. Each NOV was for an alleged violation of a water quality standard. Efforts to address the toxicity continue to be implemented. A preliminary evaluation conducted by an Oak Ridge National Laboratory toxicologist in 2014 indicated that pathogen interference in the fathead minnow tests is a likely explanation for much of the apparent toxicity detected in Outfall 017 tests (i.e., the toxicity likely is unrelated to plant operations) (BWCS 2014). Exceedances for total residual chlorine appear to have been caused by natural algae growth in the plant ditches and lagoons. Corrective actions have been implemented to address the issues. The exceedance for zinc appears to be an outlier with no source or explanation, and the levels for the following months were well below the permit limits. No penalties were assessed for these alleged violations.

(1) Exceeding whole effluent toxicity at Outfall 017 February 22, November 21, and December 19, 2012. The KPDES permit limit for Toxicity is a chronic toxicity unit (TUc) < 1. The result for February 22, 2012, was TUc = 13.4. The result for November 21, 2012, was TUc = 5.55. The result for December 19, 2012, was TUc = 1.25.

(2) Exceeding daily maximum permitted limits for total residual chlorine in Outfall 001 during the months of April, May, and June 2013 (the reported daily maximums were 0.04 mg/L for April, 0.03 and 0.02 mg/L for May, and 0.03 mg/L for June; the permitted limit is 0.019 mg/L).

(3) Exceeding average and daily maximum permitted limits for total recoverable zinc in Outfall 017 during May 2013 (the reported average and daily maximum were 0.429 mg/L and 0.431 mg/L, respectively; the permitted limits are 0.216 mg/L for both).

(4) Exceeding whole effluent toxicity at Outfall 017 on May 21, 2013 (the reported toxicity result was 6.02 TUc and the permitted limit is < 1 TUc).

(5) Exceeding whole effluent toxicity at Outfall 017 on July 24, 2013 (the reported toxicity result was 4.57 TUc and the permitted limit is < 1 TUc).

(6) Exceeding daily maximum permitted limits for total residual chlorine in Outfall 001 during July 2013 (the reported daily maximum was 0.02 mg/L and the permitted limit is 0.019 mg/L).

A summary of the CY 2013 KPDES permit exceedances or noncompliances and solutions is provided in Table 2.2.

Table 2.2. KPDES Noncompliances in CY 2013

Permit Type	Outfall	Parameter	Number of Permit Exceedances	Number of Samples Taken	Number of Compliant Samples	Percent Compliance	Month(s) of Exceedance(s)	Description/ Solution
KPDES	017	Zinc	1	27	26	96%	May	Corrective actions previously were implemented under the October 25, 2012, Agreed Order to ensure compliance with the permit requirements for zinc. No additional corrective actions are planned since the high zinc result for May is an outlier with no source or explanation and the levels for the following months were well below the permit limits.
KPDES	017	Chronic Toxicity	2	13	9	69%	May and July	The Toxicity Reduction Evaluation Plan revised in March 2013, and approved by KDOW on April 3, 2013, continues to be implemented to address toxicity issues.
KPDES	001	Total Residual Chlorine	5	59	54	92%	April, May, June, and July	A corrective action plan (CAP) to address total residual chlorine exceedances at Outfall 001 was submitted to KDOW. The CAP indicated discharges to KPDES Outfall 001 were influenced by natural algae growth in the plant ditches and lagoons and that the coloration due to the algae might be causing bias in the readings. A new instrument now is being used and does not indicate total residual chlorine in the outfall.

2.4.3 Stormwater Management and the Energy Independence and Security Act of 2007

In compliance with the Energy Independence and Security Act (EISA), the Paducah Site implements energy and water audits. The audit covers building envelope, lighting, possible deployment of occupancy sensors, and leaking or old water fixtures. The findings of these audits are addressed immediately. A list of previous audits is presented in the Site Sustainability Plan (SSP) (SST 2012).

2.4.4 Safe Drinking Water Act

The Paducah Site supplies on-site drinking water facilities from the Ohio River. The drinking water facilities are operated and managed by USEC in accordance with the Safe Drinking Water Act (SDWA) regulations. Remote facilities utilize bottled water.

The SDWA also sets a framework for the Underground Injection Control program to control the injection of wastes into groundwater. The C-400 Interim Remedial Action used reinjection of treated groundwater at subsurface electrodes to maintain electrical conductivity and facilitate heat transfer. The requirements of injection for CERCLA projects are met through application of applicable or relevant and appropriate requirements.

2.5 OTHER ENVIRONMENTAL STATUTES

2.5.1 Endangered Species Act

The Endangered Species Act of 1973, as amended, provides for the designation and protection of endangered and threatened animals and plants. The act also serves to protect ecosystems on which such species depend. At the Paducah Site, proposed projects are reviewed, in conjunction with the EMS or the CERCLA process, to determine if activities have the potential to impact these species. If necessary, project-specific field surveys are performed to identify threatened and endangered species and their habitats, and mitigating measures are designed, as needed. When appropriate, DOE initiates consultation with the U.S. Fish and Wildlife Service and Kentucky Department of Fish and Wildlife Resources prior to implementing a proposed project. No consultations were necessary during 2013.

Table 2.3 includes 13 federally listed, proposed, or candidate species that have been identified as potentially occurring at or near the Paducah Site. None of these species have been reported as sighted on the DOE Reservation, although potential summer habitat exists there for the Indiana Bat (Garland 2008). No DOE project at the Paducah Site during 2013 impacted any of these identified species or their potential habitats.

Table 2.3. Federally Listed, Proposed, and Candidate Species Potentially Occurring within the Paducah Site Study Area[a]

Group	Common Name	Scientific Name	Endangered Species Act Status
Mammals	Indiana Bat	*Myotis sodalis*	Endangered
	Northern Long-eared Bat	*Myotis septentrionalis*	Proposed
Mussels	Fanshell	*Cyprogenia stegaria*	Endangered
	Pink Mucket	*Lampsilis abrupta*	Endangered
	Ring Pink	*Obovaria retusa*	Endangered
	Orangefoot Pimpleback	*Plethobasus cooperianus*	Endangered
	Clubshell	*Pleurobema clava*	Endangered
	Rough Pigtoe	*Pleurobema plenum*	Endangered
	Fat Pocketbook	*Potamilus capax*	Endangered
	Spectaclecase	*Cumberlandia monodonta*	Endangered

Table 2.3. Federally Listed, Proposed, and Candidate Species Potentially Occurring within the Paducah Site Study Area[a] (Continued)

Group	Common Name	Scientific Name	Endangered Species Act Status
	Sheepnose	*Plethobasus cyphyus*	Endangered
	Rabbitsfoot	*Quadrula c. cylindrical*	Threatened
Birds	Interior Least Tern	*Sterna antillarum athalassos*	Endangered

[a] All of the listed species are identified as an Endangered, Threatened, or Candidate Species known or with the potential to be located within McCracken County, Kentucky, by the U.S. Fish and Wildlife Service (November 2013).

2.5.2 National Historic Preservation Act

The National Historic Preservation Act of 1966 is the primary law governing a federal agency's responsibility for identifying and protecting historic properties [cultural resources included in or eligible for inclusion in the National Register of Historic Places (NRHP)]. Historic properties include buildings of historic significance and archeological sites. PGDP buildings were assessed in the Cultural Resources Management Plan (BJC 2006). Archeological resources will be addressed as undisturbed land is developed for site use, or if undisturbed sites are considered to be impacted by DOE operations.

The Cultural Resources Management Plan identified an NRHP-eligible historic district at the facility. The PGDP Historic District contains 101 contributing properties and is eligible for the NRHP under National Register Criterion A for its military significance during the Cold War and for its role in commercial nuclear power development. The PGDP historic district encompasses the area of the process buildings; the switchyards; the C-100 Administration Building; cooling towers and pump houses; security facilities; water treatment facilities; storage tanks; and the support, maintenance, and warehouse buildings. A map and the rationale for designating the area as such are included in the Cultural Resources Management Plan.

2.5.3 Migratory Bird Treaty Act

DOE's 2013 updated Memorandum of Understanding on Migratory Bird with the U.S. Fish and Wildlife and Executive Order (EO) 13186, *Responsibilities of Federal Agencies to Protect Migratory Birds*, direct federal agencies to take certain actions to further implement the Migratory Bird Treaty Act. The Migratory Bird Treaty Act of 1918 is applicable to PGDP. DOE takes measures to minimize impacts to migratory birds by avoiding disturbance of active nests. Work control documents implement this restriction.

2.5.4 Asbestos Program

Numerous facilities at the Paducah Site contain asbestos materials. Compliance programs for asbestos management include identification of asbestos materials, monitoring, abatement, and disposal. Procedures and program plans are maintained that delineate scope, roles, and responsibilities for maintaining compliance with EPA, Occupational Safety and Health Administration, and Kentucky regulatory requirements, as applicable. During D&D of the C-340 Metals Plant and removal of building transite, insulation containing asbestos that previously had been inaccessible was made accessible. Abatement of this asbestos was performed at that time, prior to proceeding with demolition (DOE 2014). Similar activities are occurring with D&D of the C-410 Feed Plant.

2.5.5 Pollutants and Sources Subject to Regulation

Any stationary source with the potential to emit more than 10 tons/year of any hazardous air pollutant (HAP) or 25 tons/year of any combination of HAPs is considered a major source and is subject to

regulation. DUF_6 has the potential to emit more than 10 tons per year of HF and is therefore a major source; however, DUF_6's HF emissions are limited to no more than 9 tons per year. As such, the Kentucky Division for Air Quality considers DUF_6 to be a conditional major source (in Kentucky, a conditional major source is a source where emissions are limited below Title V's major source threshold).

2.5.6 Stratospheric Ozone Protection

During 2013, DOE operated only refrigeration units that contain less than 50 lb of ozone-depleting substances; therefore, the only CAA Title VI provision that applies to the Paducah Site is the requirement to control refrigerants from leaking systems. DOE does not operate any systems that contain large amounts of refrigerants; therefore, there is no possibility of large releases of ozone depleting substances.

2.5.7 Floodplain/Wetlands Environmental Review Requirements

Title 10 *CFR* § 1022 establishes procedures for compliance with EO 11988, *Floodplain Management*, and EO 11990, *Protection of Wetlands*. DOE activities did not result in significant impacts to floodplains or wetlands at the Paducah Site in 2013.

2.5.8 Underground Storage Tanks Managed under RCRA Kentucky UST Regulations

Underground storage tank (UST) systems at the Paducah Site were used to store petroleum products such as gasoline, diesel fuel, and waste oil. These USTs are regulated under RCRA Subtitle I (40 *CFR* § 280) and Kentucky UST regulations (401 *KAR* Chapter 42).

Of the 18 USTs that have been reported to Kentucky Division of Waste Management (KDWM) under the UST Program, only 2 still are operational, 14 have been closed in accordance with approved closure plans, and 2 were determined not to exist. Both of the operational USTs operate under USEC's responsibility. There were no additional actions taken in 2013.

2.5.9 Solid Waste Management

PGDP disposes of a portion of its solid waste at its contained landfill facility, C-746-U. Construction of the C-746-U Landfill began in 1995 and was completed in 1996. The operation permit was received from KDWM in November 1996. Disposal of waste at the landfill began in February 1997. A new operation permit for the C-746-U Landfill was received from KDWM in November 2006 and is set to expire in 2016. Operating and groundwater reports for the C-746-U Landfill are submitted quarterly to KDWM.

In May 2013, DOE submitted a revised Groundwater Assessment Report for the C-746-U Solid Waste Landfill at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, to address comments to the report noted in a Technical Notice of Deficiency (NOD) (LATA Kentucky 2013d). This Technical NOD that was received from KDWM in August 2012 was for deficiencies in the report, not for risks to human health. The C-746-U Landfill required assessment in response to the finding that some constituents were found in groundwater samples from monitoring wells (MWs) located in the vicinity of the C-746-U Landfill above background levels. The C-746-U Landfill originally was determined to need further assessment on March 2, 1999. The 1999 groundwater assessment demonstrated that some contaminants from PGDP were migrating into the area of the C-746-U Landfill, while other contaminants were attributed to corrosion of the stainless steel MW casings. As a result of these findings, the corroded MWs were replaced. In 2006, additional sampling began to establish background from a statistically valid set of data. The Groundwater Assessment Report determined that there is no evidence that would indicate a release from the C-746-U Landfill.

During 2013, the office waste generated by DOE and its contractors at the plant site was taken off-site for disposal. Only office waste generated at the C-746-U Landfill itself is disposed of at the landfill. Waste Path Services, LLC, in Calvert City, Kentucky, provides off-site disposal services of the office waste from the Paducah Site. The City of Kevil picks up the office waste from the office complexes in Kevil, Kentucky, that house many of the administrative personnel who support activities at the site. Recycling is discussed in Section 3.1.2.

2.6 DEPARTMENTAL SUSTAINABILITY; FEDERAL LEADERSHIP IN ENVIRONMENTAL, ENERGY AND ECONOMIC PERFORMANCE

2.6.1 Departmental Sustainability

DOE Order 436.1, *Departmental Sustainability*, was enacted May 2, 2011. To address requirements in the order, the site made a commitment to pursue the U.S. Green Building Council's Leadership in Energy and Environmental Design and incorporate Guiding Principles for Federal Leadership in High Performance and Sustainable Buildings (HPSB) design in construction of future buildings. The Paducah Site presently has no buildings that meet the Guiding Principles of HPSB. No large renovation projects are viable at this time for buildings at the Paducah Site, but the site continues to implement small upgrades as opportunities present themselves through maintenance replacements such as heating, ventilation and air conditioning units, etc.

2.6.2 Federal Leadership in Environmental, Energy and Economic Performance

On October 5, 2009, the President signed EO 13514, *Federal Leadership in Environmental, Energy and Economic Performance*. This EO requires federal agencies to inventory, report, and reduce greenhouse gas (GHG) emissions. (The Paducah Site emissions are lower than threshold criteria; therefore, reporting is not required.) This EO requires DOE to calculate an emissions baseline and establish targets for reduction of GHG. The Paducah Site will support DOE's goals to achieve reduced GHG emissions. The SSP for PGDP was submitted in December 2013 (SST 2012). Figure 2.2 shows the site's GHG emissions by source. Additional details concerning the site's energy; transportation; environmental sustainability performance, including water conservation, energy efficiency, fleet management; and sustainable design/high performance building goals are in compliance with the DOE's sustainability goals. Details of the objectives of the SSP are outlined in Section 3.2.

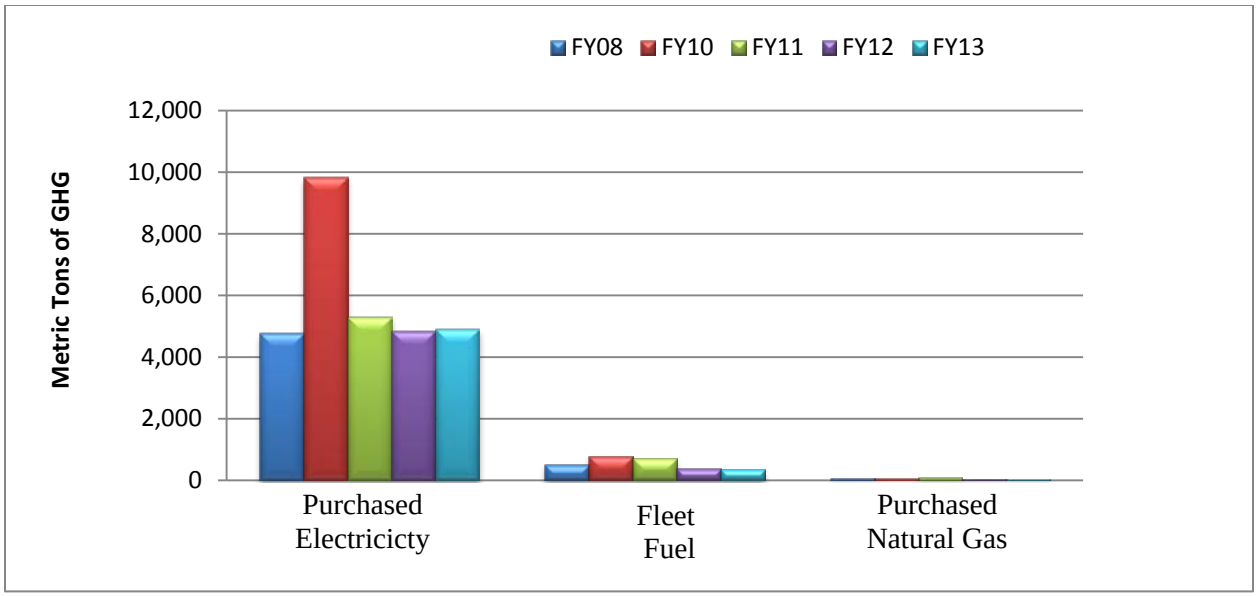

Figure 2.2. Greenhouse Gas Emissions by Source

2.7 EMERGENCY PLANNING AND COMMUNITY RIGHT TO KNOW ACT AND TITLE III OF SARA

Also referred to as Title III of SARA, the Emergency Planning and Community Right-to-Know Act (EPCRA) requires reporting of emergency planning information, hazardous chemical inventories, and releases to the environment, including GHGs.

EPCRA's primary purpose is to inform communities and citizens of chemical hazards in their areas. In order to ensure proper and immediate responses to potential chemical hazards, EPCRA Section 304 requires facilities to notify state emergency response commissions and local emergency planning committees of releases of hazardous substances and extremely hazardous substances when the release equals or exceeds the reportable quantity. Sections 311 and 312 of EPCRA require businesses to report the locations and quantities of chemicals stored on-site to state and local governments in order to help communities prepare to respond to chemical spills and similar emergencies (when chemicals exceed a 10,000 lb reporting threshold). EPCRA Section 313 requires EPA and the states to collect data annually on releases and transfers of certain toxic chemicals from industrial facilities and make the data available to the public.

The Paducah Site did not have any releases that were subject to EPCRA Section 304 notification requirements during 2013. In 2013, no EPCRA Section 311 notifications were sent for new chemicals at the Paducah Site. BWCS manufactured HF in 2013 and submitted a corresponding EPCRA 313 Report. DOE and LATA Kentucky also submitted EPCRA 313 Reports for HF.

The chemicals stored by all DOE contractors in 2013 were included in an EPCRA 312 Report. The chemicals reported were activated carbon, biodiesel fuel, diesel fuel, gasoline, hydrofluoric acid, compressed nitrogen, cryogenic nitrogen, potassium hydroxide, rock salt, sulfuric acid, uranium hexafluoride (UF_6), and uranium oxide. [UF_6 was reported though radioactive material is not subject to EPCRA Sections 311 and 312 (52 *FR* 38344-01).]

Federal facilities that use, produce, or store hazardous substances in quantities that exceed specific release thresholds are required to comply with EPCRA and Title III of SARA provisions to report these inventories and planned or accidental environmental releases to state, federal, and local emergency planning authorities. Table 2.4 lists the 2013 EPCRA reporting status for PGDP.

Table 2.4. Status of EPCRA Reporting

EPCRA Section	Description of Reporting	Status[a]
EPCRA Sec. 302–303	Planning Notification	No
EPCRA Sec. 304	Extremely Hazardous Substance Release Notification	No
EPCRA Sec. 311–312	Material Safety Data Sheet/Chemical Inventory	Yes
EPCRA Sec. 313	Toxic Release Inventory Reporting	Yes

[a] An entry of "yes," "no," or "not required" is sufficient for "Status."

2.8 OTHER MAJOR ENVIRONMENTAL ISSUES AND ACTIONS

2.8.1 Adapting to Climate Change

The Paducah Climate Change Adaptation Plan is in an exploratory phase as the site dynamics change with USEC departing. The Paducah Site has no unique way of affecting climate change directly. Normal power usage, fleet exhaust, and process power make up the majority of GHG emitted, and efforts are concentrated in those areas. There is an attempt by a local company to obtain a grant that would allow them to use an old, on-site capped landfill for a one-megawatt solar farm, which would tie in to the Tennessee Valley Authority electrical grid and supply renewable power to the local area.

The initiatives being taken at the Paducah Site for climate change adaptation are the same as the sustainability goals. This includes reduction in fleet and fuel usage, decrease in overall electrical and water consumption, and recycling for all waste and excess inventory.

Presently, the Paducah Site has made no local partnerships with federal agencies or local jurisdictions for collaboration or exploration of local climate change.

2.9 CONTINUOUS RELEASE REPORTING

Section 103(a) of CERCLA requires that hazardous substance releases in excess of a reportable quantity be reported immediately to the National Response Center. Section 103(f)(2) provides relief from the Section 103(a) reporting requirement for hazardous substance releases that are continuous, stable in quantity and rate, and already have been reported. For such releases, notice must be given annually or at such time there is any statistically significant increase in the quantity of hazardous substance released. Release reporting is discussed in Section 2.7.

2.10 UNPLANNED RELEASES

There were no reportable unplanned environmental releases for DOE operations at PGDP in CY 2013.

2.11 SUMMARY OF PERMITS

Table 2.5 provides a summary of the Paducah Site environmental permits maintained by DOE in CY 2013.

DOE, LATA Kentucky, and BWCS are co-permittees on the KPDES compliance permit. DOE is responsible for all outfalls addressed by this permit. BWCS is responsible for Outfall 017 only. LATA Kentucky is responsible for the remaining outfalls (001, 015, 019, and 020). USEC has a separate KPDES permit to address discharges from leased facilities. For the Conditional Major Operating Air Permit, BWCS is the sole permittee. DOE is the owner, and DOE and LATA Kentucky are co-operators for RCRA-permitted facilities and are responsible for compliance with the RCRA permits. DOE is the owner and LATA Kentucky the operator of the C-746-U Landfill and the closed C-746-S and C-746-T Landfills and is responsible for compliance with the Solid Waste Landfill Permit.

Table 2.5. Permits Maintained by DOE for the Paducah Site for CY 2013

Permit Type	Issued By	Permit Number	Issued To
State Agency Interest ID# 3059			
Clean Water Act			
Kentucky Pollutant Discharge Elimination System	KDOW	KY0004049	DOE/LATA Kentucky/BWCS
Clean Air Act			
Conditional Major Operating Air Permit	KDEP	F-10-035R1	BWCS
RCRA—Solid Waste			
Residential Landfill (closed) Inert Landfill (closed) Solid Waste Contained Landfill (construction/operation)	KDWM KDWM KDWM	SW07300014 SW07300015 SW07300045	DOE/LATA Kentucky DOE/LATA Kentucky DOE/LATA Kentucky
RCRA—Hazardous Waste			
Hazardous Waste Facility Permit	KDWM	KY8-890-008-982	DOE/LATA Kentucky

3. ENVIRONMENTAL MANAGEMENT SYSTEM

The EMS is designed to integrate environmental protection, environmental compliance, pollution prevention, and continual improvement into work planning and execution throughout all work areas. The Paducah Site EMS implements sound stewardship practices in the protection of land, air, water, and other natural or cultural resources potentially impacted by their operations. The EMS objectives are integrated into the Integrated Safety Management System (ISMS) established by the DOE Policy 450.4A, *Safety Management System Policy*. The EMS for two of DOE's contractors has been audited and found to satisfy DOE requirements. The EMS for the remaining contractor was under development in 2013.

Environmental protection programs at the Paducah Site conform to the five core elements of the International Organization for Standardization (ISO) EMS standard, ISO 14001. The major elements of an effective EMS include policy, planning, implementation and operation, checking, and management review. Through implementation of EMS, effective protection to workers, the surrounding communities, and the environment can be achieved while meeting operating objectives that comply with legal and other requirements. EMS feedback information is analyzed to determine the status of the EMS program relative to implementation, integration, and effectiveness.

During 2013, DOE contractors were responsible for compliance with all applicable laws, regulations, permit commitments, and other requirements, as defined in their respective contracts. Their Environmental Policy Statements emphasize conservation and protection of environmental resources by incorporating pollution prevention and environmental protection into the daily conduct of business. The DOE contractors implemented this policy through the programs described in this document, environmental cleanup, pollution prevention programs, and by integrating environmental protection, environmental regulatory compliance, and continual improvement into the daily planning and performance of work at PGDP. The environmental policies are communicated to employees through various methods. The DOE contractor project manager reviews and communicates the commitments in the policy with all of the other members of the DOE contractor management team. The policy is further communicated to employees and to subcontractors through sitewide communication, EMS awareness training, publications, and EMS brochures.

The EMS environmental stewardship scorecard assesses agency performance in environmentally preferable purchasing; environmental management system implementation; electronics stewardship; high performance sustainable buildings; and environmental compliance management improvement. The EMS environmental stewardship scorecard for PGDP in FY 2013 was green (which indicates standards for EMS implementation have been met).

DOE contractors at the Paducah Site are required to implement EMS requirements. The benefits of EMS to the facility include (1) reduced risk to the facility mission; (2) improved fiscal efficiency and/or cost avoidance; (3) heightened knowledge of environmental programs at all levels of the organization; (4) empowerment of individuals to contribute to the improved environmental conditions at the site; and (5) integration of the environment into organizational culture and operations. Employees have actively recommended work controls to be used to protect the environment.

3.1 ENVIRONMENTAL OPERATING EXPERIENCE AND PERFORMANCE MEASUREMENT

DOE and its contractors are committed to enhancing environmental stewardship and to reducing any impacts that site operations may cause to the environment. The Environmental Monitoring Program at

PGDP consists of effluent monitoring, environmental surveillance, and air monitoring around the plant. Requirements for routine environmental monitoring programs were established to measure and monitor effluents from DOE operations and maintain surveillance on the effects of those operations on the environment and public health through measurement, monitoring, and calculation. LATA Kentucky implements the Environmental Monitoring Program for the Paducah Site documented in the Environmental Monitoring Plan (EMP) (LATA Kentucky 2012; LATA Kentucky 2013a). These plans can be found at the following locations:

http://www.latakentucky.com/PublicDocuments/Environmental Monitoring Plan FY 2013/

http://www.latakentucky.com/PublicDocuments/Environmental Monitoring Plan FY 2014/

In addition to environmental monitoring documented in the EMP, BWCS also monitors radionuclide air emissions as required by their air permit. The results of these programs are discussed in detail in subsequent chapters of this ASER.

3.1.1 Site Sustainability Plan

In accordance with DOE Order 436.1 and EO 13514, this report provides information concerning the requirements and responsibilities of managing sustainability on the PGDP site including (1) to ensure DOE carries out its missions in a sustainable manner that addresses national energy security and global environmental challenges, while advancing sustainable, reliable and efficient energy for the future; (2) to initiate wholesale cultural change to factor sustainability and GHG reductions into all of DOE's corporate management decisions; and (3) to ensure that DOE achieves the sustainability goals established in its SSP pursuant to any applicable laws, regulations, EOs, sustainability initiatives, and related performance scorecards.

In addition to making physical changes at the facility to increase sustainability, another objective is to increase awareness of the sustainability opportunities in the workers and the surrounding community through public outreach and training. Table 3.1 contains a brief summary of FY 2013 performance and long-term planned actions to attain FY 2020 goals.

3.1.2 Waste Minimization/Pollution Prevention

The Waste Minimization/Pollution Prevention (WM/PP) Program at the Paducah Site provides guidance and objectives for minimizing waste generation. The program is set up to comply with RCRA and the Pollution Prevention Act, as well as applicable Commonwealth of Kentucky and EPA rules, DOE Orders, EOs, and the STP. All PGDP projects are evaluated for WM/PP opportunities.

WM/PP efforts for the site are reported in DOE's Consolidated Energy Data Report. During FY 2013, the Paducah Site recycled 882,289 lb of materials. Materials recycled included oils, antifreeze, paper, toner cartridges, scrap metal (nonradiological), batteries, tires, equipment, electronics, concrete, asphalt/rock, cardboard, vehicles, and plastics.

Table 3.1. DOE Goal Summary Table

DOE Goal	Site Performance Status	Site Planned Actions
GHG Reduction and Comprehensive GHG Inventory		
28% Scope 1 and 2 GHG reductions by FY 2020 from a FY 2008 baseline (related goals).	6.1% below FY 2008 baseline, strong progress toward "28% below baseline."	The Paducah Site is below the FY 2008 baseline for this goal for the second year in a row; continued vigilance with electrical consumption and fleet fuel consumption will be required to maintain and meet performance status.
13% Scope 3 GHG reduction by FY 2020 from the FY 2008 baseline.	21.7% reduction from FY 2008, exceeding 13% required reduction.	Personnel reduction has helped the site meet this goal.
Building, Energy Savings Performance Contracts Initiative Schedule, and Regional and Local Planning		
30% energy intensity reduction by FY 2015 from the FY 2003 baseline.	123.9% up from the 2003 baseline.	Energy consumption has decreased, however not to 2003 levels. The site has lost much of the gross square feet calculated in the original baseline due to the D&D operations. Small operational energy initiatives are acted upon as they arise; however, nothing large scale is planned.
EISA Section 432 energy and water evaluations.	100%	The Remediation and Infrastructure contractors performed 100% of the required EISA evaluations.
Individual buildings or processes metering for 90% of electricity (by October 1, 2012); for 90% of steam, natural gas, and chilled water (by October 1, 2015).	81% of electricity. 100% of natural gas (met). 0% of water [not applicable (N/A)]. Steam and chilled water (N/A).	The FY 2011 Metering Assessment details the metered consumption and steps required to achieve this goal. Natural gas already is metered, and steam is not being used by DOE contractors.
Cool roofs (when economical) for roof replacements unless project already has Critical Decision-2 approval. New roofs must have thermal resistance of at least R-30.	Work in progress.	Many facilities at the Paducah Site are trailers. Placement of cool roofs on trailers is uneconomical. A cool roof upgrade is being assessed for one of the buildings at the Paducah Site, C-103, because the life cycle for the building will require a replacement. The remaining facilities are being evaluated, but may not have the surface square footage or effective lifespan to achieve a return on investment.
15% of existing buildings larger than 5,000 gross ft^2 to be compliant with the five guiding principles of HPSB by FY 2015.	Initiated as life cycle allows.	The site is scheduled for D&D and investment in building upgrades is not fiscally responsible. As maintenance is performed at the C-103 Building, which is a building that has a continued, useful life, the HPSB standards are given consideration.
All new construction and major renovations greater than 5,000 gross ft^2 must comply with the guiding principles.	The Site currently has no projects planned that fit the requirements.	No new construction is planned for the Paducah Site; however, any upgrades to existing facilities are made with the HPSB principles in mind.

Table 3.1. DOE Goal Summary Table (Continued)

DOE Goal	Site Performance Status	Site Planned Actions
Fleet Management		
10% annual increase in fleet alternative fuel consumption by FY 2015 relative to the FY 2005 baseline.	41.3% increase from last year.	In FY 2005 there was no E85 present at the site, making the baseline 0. This year, the site was up 41.3% from FY 2012. The performance status should remain stable if fleet size/makeup does not change.
2% annual reduction in fleet petroleum consumption by FY 2020 relative to the FY 2005 baseline.	2,662% over FY 2005 baseline.	The recent fleet reduction plan and fuel saving practices have had a continued significant impact on the petroleum consumption. Historical data provided in the Consolidated Energy Data Report shows the Paducah Site having very low petroleum consumption in FY 2005. It will be extremely difficult to meet this goal with the return of the USEC fleet to DOE being a possibility.
100% of light-duty vehicle purchases must consist of alternative fuel vehicles (AFVs) by FY 2015 and thereafter.	AFVs currently make up 38%. Hybrid electric vehicles make up 25%.	The site has requested that General Services Administration send more AFVs/hybrids as other vehicles leave the site.
Reduce fleet inventory of non-mission critical vehicles by 35% by FY 2013 relative to a FY 2005 baseline.	Goal has been met.	The reduction in vehicle usage and total fleet numbers was completed in FY 2011.
Water Use Efficiency and Management		
26% potable water intensity reduction by FY 2020 from a FY 2007 baseline.	Goal is met.	To meet the standard, the contractors have installed low-flow systems and ceased all landscape watering. This site estimates this goal has been met.
20% water consumption reduction of industrial, landscaping, and agricultural (ILA) by FY 2020 from the FY 2010 baseline.	N/A	FY 2010 baseline is 0. The site still is not consuming water for ILA purposes; thus, there is no reduction to record.
Pollution Prevention and Waste Reduction		
Divert at least 50% of nonhazardous solid waste, excluding construction and demolition debris, by FY 2015.	Currently diverting 50.4%.	Estimates show the site at 50.4% diversion rate; the site intends to use best practices and innovation to continue to decrease municipal landfill waste.
Divert at least 50% of construction and demolition materials and debris by FY 2015.	Currently diverting 8.8%.	Noncontaminated waste is recycled and reused when applicable. The site historically recycles a large amount of D&D waste when it is not contaminated. This year, a portion of the old Waterworks Bridge abutment was recycled.
Sustainable Acquisition		
Procurements meet requirements by including necessary provisions and clauses.	Goal is met.	Environmentally Preferred Purchasing Program allows the subcontractors to monitor all purchase orders and make additions to the list for new products.

Table 3.1. DOE Goal Summary Table (Continued)

DOE Goal	Site Performance Status	Site Planned Actions
Electronic Stewardship and Data Centers		
All data centers are metered to measure monthly power usage effectiveness (PUE) of 100% by FY 2015.	N/A	The Paducah Site does not have any data centers.
Maximum annual weighted average PUE of 1.4 by FY 2015.	N/A	The Paducah Site does not have any data centers in which to monitor PUE.
Electronic Stewardship—100% of eligible personal computers, laptops, and monitors with power management actively implemented and in use by FY 2012.	Goal is met.	Power management is actively implemented on all computers.
Renewable Energy		
20% of annual electricity consumption from renewable sources by FY 2020.	Presently at 109.5% from renewable energy sources purchased.	PPPO purchases renewable energy certificates for the Paducah and Portsmouth sites. This year 7,500 MWh was purchased.
Climate Change Adaption		
Climate Change Adaption—Address DOE Climate Adaption Plan goals.		The initiatives being taken at the Paducah Site for climate change adaptation are the same as the sustainability goals. This includes reduction in fleet and fuel usage; overall electrical and water consumption decrease; and recycling for all waste and excess inventory.

The program strives to minimize waste using the following strategies: source reduction, segregation, reuse of materials, recycling, and procurement of recycled-content products.

The program has the following goals and objectives:

- Eliminate or reduce the amount and toxicity of all waste generated at the site;
- Comply with federal and state regulations and DOE requirements for waste minimization;
- Reuse or recycle materials when possible;
- Identify waste reduction opportunities;
- Integrate WM/PP technologies into ongoing projects;
- Coordinate recycling programs; and
- Track and report results.

Accomplishments of the WM/PP Program in 2013 include the following:

(1) Placed emphasis on using and/or recycling by-products.

(2) Drained filters, reused any gasoline products, and recycled oil.

(3) Handled light bulbs as universal waste and recycled them.

(4) Purchased green tip (low mercury) bulbs.

(5) Continued to review purchases for substitute products with lesser hazard concerns and maintained a minimum quantity of material on hand.

(6) Continued to reduce the amount of radioactive waste by the "Clean is Green" concept that is encouraged by DOE.

(7) Verified recyclables to be free of radiological contamination prior to off-site release.

3.1.3 Depleted Uranium Hexafluoride Cylinder Program

A product of the UE process, DUF_6 is a solid at ambient temperatures and is stored in large metal cylinders. At the end of 2013, the Paducah Site managed an inventory of approximately 46,068 cylinders stored in outdoor facilities, commonly referred to as cylinder storage yards. The inventory varies from time to time, as a result of DOE agreements to receive or market DUF_6.

Stored as a crystalline solid at less than atmospheric pressure, when DUF_6 is exposed to moisture in the atmosphere, HF and uranyl fluoride form. The uranium by-products form a hard crystalline solid that acts as a self-sealant within the storage cylinder. The acute hazard potential of DUF_6 primarily is chemical toxicity from any released HF.

The mission of the DUF_6 Cylinder Program is to safely store the DOE-owned DUF_6 inventory until its ultimate disposition. DOE has an active cylinder management program that includes cylinder and cylinder yard maintenance, routine inspections, and other programmatic activities such as cylinder corrosion studies. The program maintains a cylinder inventory database that serves as a systematic repository for all cylinder inspection data.

On April 15, 1999, DOE issued the *Final Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride* (DOE 1999). In 2002, DOE selected Uranium Disposition Services, LLC, (UDS) to design, build, and operate facilities at Paducah, Kentucky, and Portsmouth, Ohio. The facilities would convert the inventory of DUF_6 to triuranium octaoxide (U_3O_8), a more stable form of uranium that is suitable for disposal or reuse, and hydrofluoric acid that will be sold for commercial use.

Consistent with Public Law 107-206, construction began in July 2004 and continued through 2008. Physical construction of the facility was completed on December 19, 2008. On March 29, 2011, the contract transitioned from UDS to BWCS. BWCS announced full operational status in September 2011. During 2013, BWCS converted approximately 8,199 metric tons of DUF_6 to a more stable oxide and hydrofluoric acid. Off-site shipment is discussed in Section 4.2.

3.1.4 Environmental Restoration, Waste Disposition, and D&D

The environmental restoration program supports investigations and environmental response actions, D&D of facilities no longer in use, projects designed to demonstrate or test advancements in remedial technologies, and other projects related to action for the protection of human health and the environment.

Significant accomplishments in 2013 include the following:

- Completed D&D of C-340 Metals Plant;

- Completed installation of an electrical resistance heating system near the C-400 Cleaning Building to remove TCE from the subsurface; and

- Made significant progress in the D&D of the C-410 Feed Plant by stabilizing more than 9,000 ft of UF_6 piping; removing and neutralizing more than a ton of residual UF_6; removing asbestos wiring;

and removing and packaging 20 cold traps (used to "trap" and store UF_6), weighing more than 10,000 lb each.

3.1.5 Emergency Management

Emergency management is a systematic, integrated effort at the Paducah Site. Components of the PGDP Emergency Response Organization include the crisis manager and the Emergency Operations Center (EOC) cadre, an incident commander, the Emergency Squad, and the Joint Public Information Center. USEC, the PGDP plant operator, also maintains a fully staffed fire department along with protective force officers and a medical facility. As part of its lease agreement with DOE, USEC coordinates emergency response at PGDP.

DOE, USEC, and DOE's various contractors have separate emergency response procedures that they practice during training exercises to bolster their ability to work together. Those preparations were put to a real-life test on the afternoon of Sunday, November 17, 2013, when a tornado struck the plant site.

With wind speeds upward of 115 mph, the tornado carved a substantial path of destruction through western Kentucky and southern Illinois. The PGDP plant shift superintendent previously had directed all personnel to take cover when the National Weather Service issued a tornado warning for the immediate area earlier that day.

After the suspected presence of a tornado and resulting damage was confirmed, the plant shift superintendent declared an emergency according to established procedure and activated the Emergency Response Organization. The EOC, with its staff of about 60 people representing USEC, DOE, and DOE's prime contractors, was activated. No one at the plant was injured during the storm, and all safety systems functioned as designed. No production systems were affected, and there were no releases or off-site impacts.

Damage to DOE facilities involved the non-structural exterior of one of the four enrichment process buildings, the adjacent cooling towers and an electrical switchyard. Some power poles, wiring, and electrical circuitry around the site perimeter also were damaged. Figure 3.1 shows damage sustained during the tornado to the cooling towers, adjacent to a process building. Although the tornado passed near the DUF_6 conversion building and its adjacent inventory of DUF_6 cylinder containers, it did no damage to either. The twister did damage some of the other DUF_6 buildings and site equipment and moved a Jeep from the employee parking lot into a rainfall runoff ditch.

Figure 3.1. Cooling Tower Damage Sustained during 2013 Tornado

3.2 AWARDS AND RECOGNITION

3.2.1 Public Awareness Program

A comprehensive Community Relations and Public Participation Program exists for DOE activities at the Paducah Site. The purpose of the program is to provide the public with opportunities to become involved in decisions affecting environmental issues at the site.

3.2.2 Community/Educational Outreach

DOE supported several educational and community outreach activities during 2013.

Teams of Lone Oak Middle School students conducted research about the Paducah Site and, in February, presented ideas about cleanup and methods for reuse of the site and its facilities to DOE management and cleanup contractor, LATA Kentucky.

Also in February, DOE, along with several area and national businesses and entities, sponsored the Western Kentucky Regional Science Bowl for area high schools and middle schools.

In March, DOE held a meeting to inform the public that DOE was starting an environmental assessment to evaluate the environmental impacts of potential property transfers at the Paducah Site. DOE held an information session with follow-up questions and answers.

In April, Lone Oak and Heath Middle School students visited WKWMA to learn about the effects of chemical contamination on human health and the environment. Personnel from LATA Kentucky and teaming partner S.M. Stoller Corp. participated in the event with Kentucky Department of Fish and Wildlife Resources officers.

Three-dimensional models showing groundwater cleanup progress at the Paducah Site were displayed at the West Kentucky Community and Technical College Emerging Technology Center to help the public better understand the difficulty and complexity of the work. DOE, the University of Kentucky, and LATA Kentucky were involved in the exhibit.

In conjunction with the Kentucky Research Consortium for Energy and Environment, DOE began work in 2013 with area high school students to prepare a summary of the 2012 ASER.

3.2.3 Citizens Advisory Board

The PGDP Citizens Advisory Board (CAB), a site-specific advisory board chartered by DOE under the Federal Advisory Committees Act, completed its seventeenth full year of operation in September 2013. During the calendar year, the CAB held 6 regular board meetings and 22 subcommittee meetings.

The CAB includes six active subcommittees, which meet as necessary. The subcommittees review issues for the following areas:

- Burial Grounds
- Waste Disposal Options
- Historical Preservation
- Integrated Priority List
- Groundwater
- Future Use/Adaptive Reuse

All meetings are open to the public and all regular board meetings are publicly advertised. In addition to its voting members, the CAB also has liaison members representing EPA Region 4, KDWM, Kentucky Cabinet for Health and Family Services, and WKWMA.

The CAB is composed of up to 18 members, chosen to reflect the diversity of gender, race, occupation, views, and interests of persons living near the PGDP. The CAB is committed to reflecting the concerns of the communities impacted by environmental management of the plant site. It meets bimonthly to focus on early citizen participation in environmental cleanup priorities and related issues at the DOE facility. Additional information concerning the CAB may be obtained at www.pgdpcab.energy.gov.

In May, the CAB released a book to preserve the history and legacy of PGDP and pay tribute to the workers who made it successful. DOE infrastructure contractor SST sponsored the book, *The Story of the Paducah Gaseous Diffusion Plant, Megawatts to Megatons to Megawatts*.

3.2.4 Environmental Information Center

The public has access to the electronic version of the Administrative Records and programmatic documents at the DOE Environmental Information Center (EIC) in the Barkley Centre, 115 Memorial Drive, Paducah, Kentucky. The EIC is open Monday through Friday from 8 a.m. to 12 p.m. and by appointment. The EIC's phone number is (270) 554-3004.

Documents for public comment also are placed in the McCracken County Public Library (formerly the Paducah Public Library), 555 Washington Street, Paducah, Kentucky. The library is open Monday through Thursday from 9 a.m. to 9 p.m., Friday through Saturday from 9 a.m. to 6 p.m., and Sunday from 1 p.m. to 6 p.m.

The EIC and other public Web pages related to DOE work at the PGDP can be accessed at www.pppo.energy.gov/pad_eic.html and www.paducaheic.com.

THIS PAGE INTENTIONALLY LEFT BLANK

4. ENVIRONMENTAL RADIOLOGICAL PROTECTION PROGRAM AND DOSE ASSESSMENT

4.1 ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM

Routine DOE operations at PGDP result in releases of radioactive materials to the environment by atmospheric and liquid pathways. These releases potentially result in a radiation exposure to the public. In accordance with DOE Order 458.1, *Radiation Protection of the Public and the Environment*, DOE has an environmental surveillance program that includes radiological monitoring of pathways which may contribute to dose to the public. Surveillance includes analyses of surface water, groundwater, sediment, direct radiation, and ambient air (LATA Kentucky 2012; LATA Kentucky 2013a). DOE has established dose limits for the public and biota. The dose limit to the public is 100 millirem (mrem) per year summed over all exposure pathways resulting from routine DOE operations. Doses are to be minimized through the application of ALARA[3] principles. Doses to biota are constrained to 1 rad/day for aquatic organisms, 1 rad/day for terrestrial plants, and 0.1 rad/day for terrestrial animals. To confirm that doses are below public and biota dose limits, PGDP calculates annual dose estimates using effluent release data, environmental monitoring, and surveillance data combined with relevant site specific data (such as meteorological conditions, population characteristics, and stream flows).

Surface water, effluent water, and sediment monitoring programs have been impacted by the implementation of DOE Order 458.1. Modifications based on the order have been implemented to the sampling strategy for these programs. Sampling location changes include the addition of sampling surface water near the KPDES outfall locations. Sample parameter changes include the addition of radionuclide analysis at some surface water and sediment locations.

Surface water is not used as a source of public drinking water on the DOE reservation. Initiation of the NWPGS and the NEPCS resulted in an airborne pathway that is included in the dose calculations. The demolition of C-340 and DUF_6 conversion activities were included in 2013 airborne pathway dose calculations.

To assess fully the potential dose to the public, a hypothetical set of conservative characteristics were used to postulate an upper bound exposure scenario. This is referred to as the worst-case scenario. The actual dose received is considerably less than the hypothetical worse case calculated dose.

4.1.1 What is Dose?

Dose is the amount of energy absorbed by the human body as a result of a radioactive source; it is measured in rem [which equals 0.01 sievert (Sv)] or in mrem, which is one-thousandth of a rem. These exposures/intakes involve the transfer of energy from radiation to tissue and can result in tissue damage. Exposures to radiation from radionuclides outside the body are called external exposures; 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 radionuclide; simply leaving the

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

area of the source will stop the exposure. Internal exposure continues as long as the radionuclide remains inside the body.

Members of the public are routinely exposed to natural and man-made sources of ionizing radiation. An individual living in the U.S. is estimated to receive an average annual effective dose (ED) of about 620 mrem (6.2 mSv) (NCRP 2009). Half of the radiation dose to a member of the public, about 310 mrem/year, is from natural background sources of cosmic and terrestrial origin (Figure 4.1). The other half is from man-made sources, including diagnostic and therapeutic X-rays, tomography, and fluoroscopy; nuclear medicine; consumer products, such as cigarettes and smoke detectors; fallout from nuclear weapons tests; industrial, research, and educational applications; and effluents from nuclear facilities.

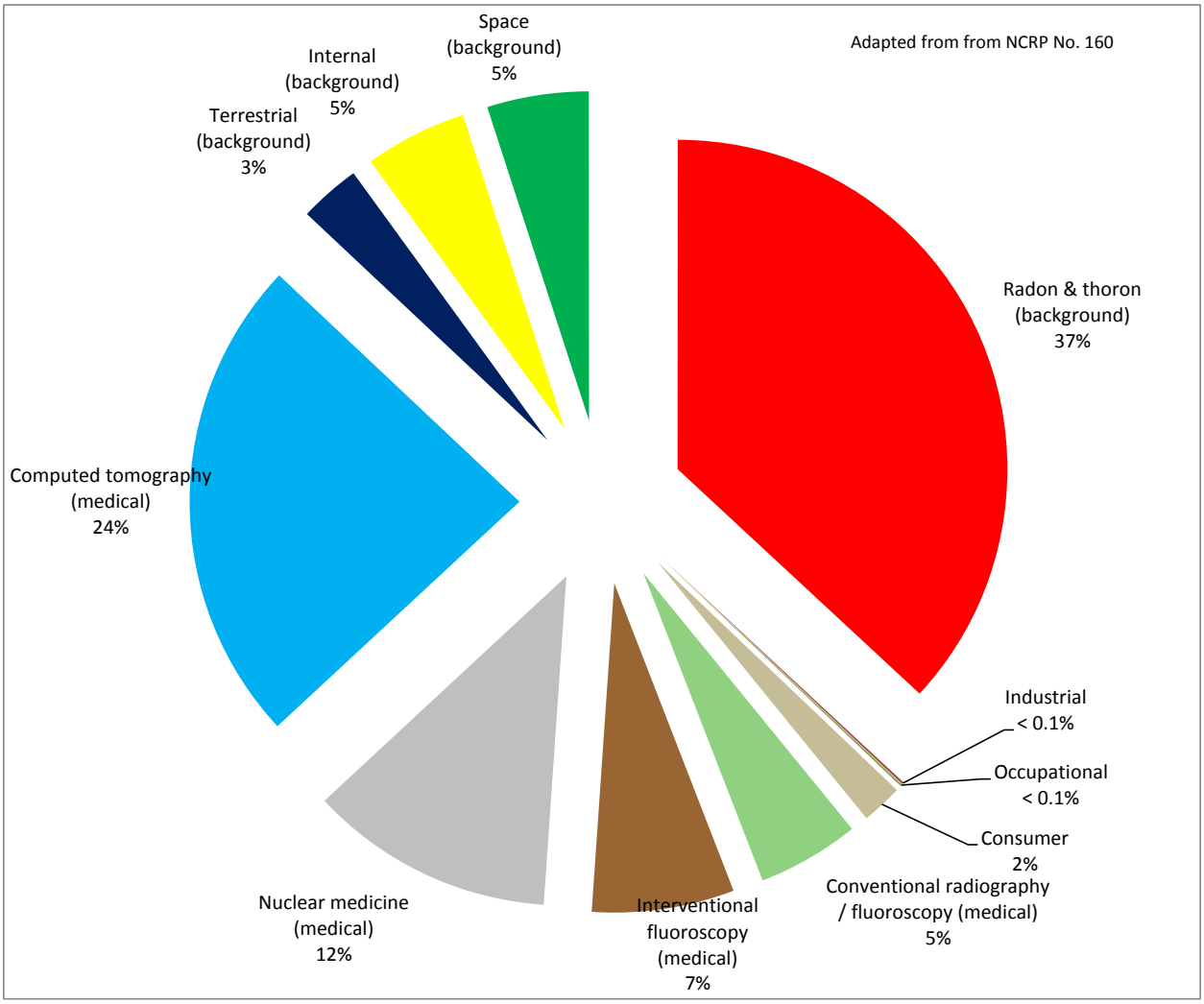

Figure 4.1. Sources of Radiation

Unless otherwise noted, the generic term “dose” used in this report is the total effective dose (TED) to a person, which includes both the committed effective dose (50-year committed dose) from internal deposition of radionuclides and the ED attributable to sources external to the body. Use of the TED allows doses from different types of radiation and to different parts of the body to be expressed on the same basis. National Council on Radiation Protection and Measurements Report No. 160 noted that the

average member of the U.S. population was exposed to significantly more radiation from medical procedures than from any other source. Approximately half of dose is attributed to natural sources (radon 37% and 13% is cosmic, terrestrial, and internal). Dose from nuclear power was grouped into a category comprising < 0.1%. The remaining dose was from medical exposures (approximately 48%).

DOE has established dose limits to the public so that DOE operations will not contribute significantly to this average annual exposure. DOE Order 458.1 establishes 100 mrem/yr (1 mSv/yr) as the total annual dose limit to a member of the public. Each year, DOE operations at the PGDP contribute to the public dose through radiological releases and direct radiation. Emissions and effluents are controlled so that releases are maintained ALARA. To confirm that doses to the public and biota are below established limits, PGDP calculates annual dose estimates using effluent release data, direct radiation monitoring data, and environmental monitoring data combined with relevant site specific data (such as meteorological conditions and population characteristics). These estimates are calculated using various computer codes that model the environmental dispersion of radionuclides that originate from on-site activities.

4.1.2 Radioactive Materials at PGDP

Radioactive materials present at PGDP are the result of processing raw and recycled uranium into nuclear materials. The PGDP associated radionuclides and their half-lives are listed below:

- Uranium-234 (245,000 year half-life)
- Uranium-235 (704,000,000 year half-life)
- Uranium-238 (4,470,000,000 year half-life)
- Thorium-230 (75,400 year half-life)
- Plutonium-238 (87.7 year half-life)
- Plutonium-239 (24,100 year half-life)
- Neptunium-237 (2,140,000 year half-life)
- Americium-241 (432 year half-life)
- Cesium-137 (30.2 year half-life)
- Technetium-99 (211,000 year half-life)

Daughter products for the radionuclides listed above also are present at PGDP in varying concentrations due to the multitude of chemical and physical separation processes historically used at the facility. The monitoring program for radioactivity in liquid and airborne effluents is described fully in the Paducah Site EMP (LATA Kentucky 2012; LATA Kentucky 2013a).

4.1.3 What is an Exposure Pathway?

An exposure pathway consists of a route for released radioactive material to be transported by an environmental medium from a source to a receptor (person, animal or plant) (Figure 4.2). Routine operations at PGDP release incidental radioactive materials into the environment through atmospheric and liquid discharges. These releases potentially result in a radiation dose to members of the public and environment. The principal pathways by which people potentially are exposed are the following:

- Inhalation of gases and particulates;
- Ingestion of vegetables, crops, venison, milk, and fish;
- Ingestion of surface and groundwater;
- Skin absorption; and
- External exposure.

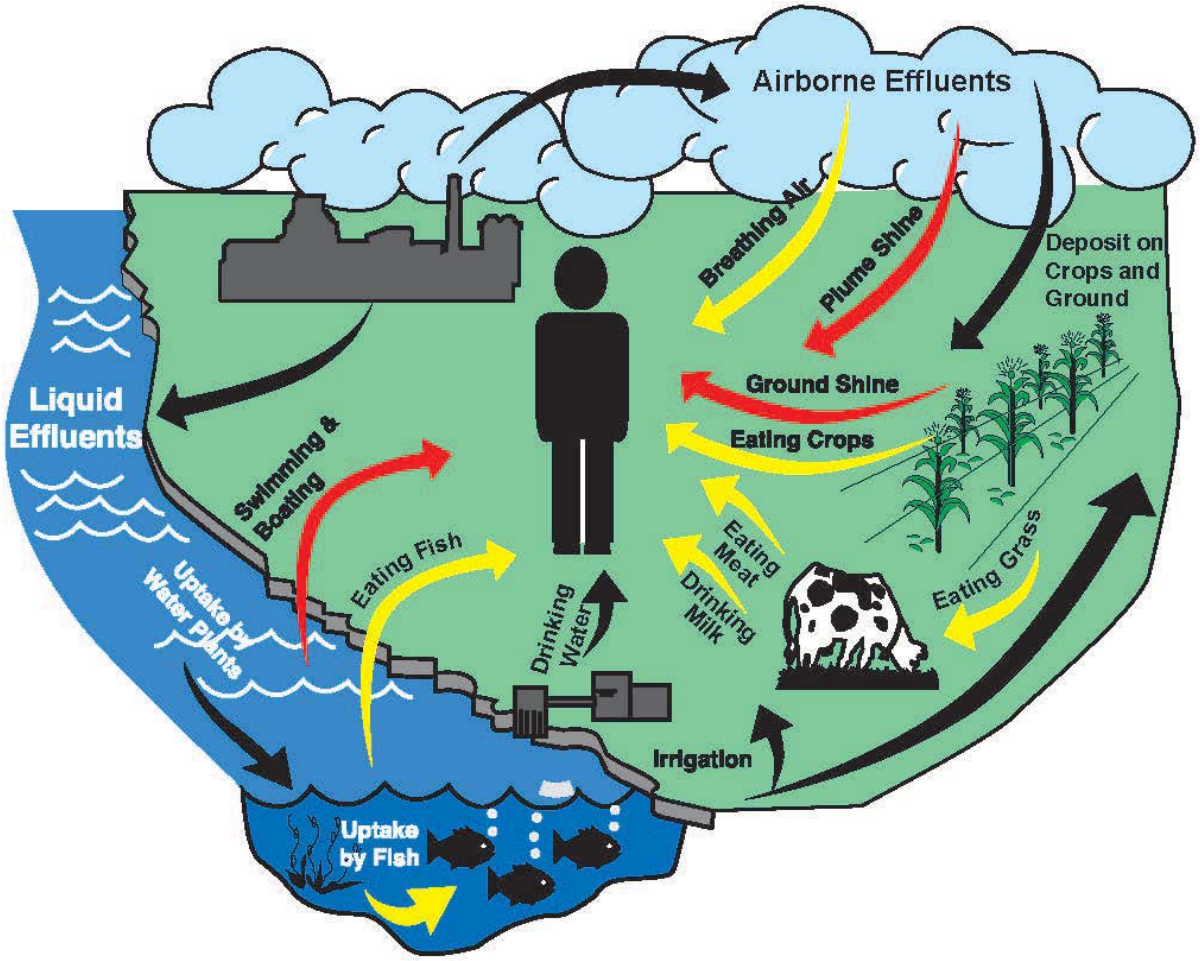

Figure 4.2. Potential Exposure Pathways

4.1.4 Dose Assessment Methodology

Radiological exposure assessments are modeled using exposure pathways applicable to the PGDP site utilizing methods consistent with the requirements of DOE Order 458.1. First, measurements (and/or estimates) of radionuclide concentrations in liquid and air released from the PGDP are assembled from the calendar year of interest. Then EPA- and DOE-approved models, or factors derived from those models, are used to estimate the TED to the maximally exposed individual (MEI) and the collective TED to the population within a 50-mile radius and estimated background dose.

For determining compliance with the DOE public dose requirements, PGDP calculates the potential off-site doses from PGDP effluent releases of radioactive materials (atmospheric and liquid) for a MEI and the population living within a 50-mile radius of PGDP. The MEI is the hypothetical resident who has the greatest probability of being affected by a radiological release. In accordance with DOE Order 458.1, the pathway and exposure assumptions for the MEI are to be reasonable and not underestimate the dose or substantially overestimate the dose. The MEI for PGDP is established based on conservative lifestyle assumptions for a hypothetical individual who lives outside the PGDP site at the location where the highest concentration of radionuclides in air have been modeled; consumes milk, meat, and vegetables produced at that location; spends time on or near Bayou or Little Bayou Creek; and hunts on the wildlife reservation (DOE 2013b). This person does not drink groundwater because all persons downgradient of

the PGDP are on public water. Surface water is not used for irrigation of crops based on survey data results (CH2M HILL 1991). Furthermore, Little Bayou Creek does not support aquatic life for consumption, and few game size fish could be caught from Bayou Creek, except when there is a major influx of fish from the Ohio River during a backwater event. Because of this, fish ingestion is not considered. Dose from surface water is calculated assuming ingestion at the nearest public withdrawal location, Cairo, Illinois. Dose from sediment ingestion and incidental contact with surface water is based on assumptions for recreational use of the Bayou and Little Bayou Creeks on the reservation. Dose associated with airborne releases are calculated for the hypothetical MEI located at the nearest plant neighbor.

4.1.5 Air Monitoring and Estimated Dose from Airborne Effluents

DOE operations may result in airborne releases from various sources including CERCLA remedial actions and fugitive emissions. Radionuclide sources at the Paducah Site evaluated in 2013 were the Northwest Plume Treatment Facility, the Northeast Plume Treatment Facility Cooling Tower, the Northeast Plume Treatment System Alternate Treatment Unit, the DUF_6 Conversion Facility, fugitive dust source emissions, and other miscellaneous sources. Specific activities that could generate fugitive emissions include transport and disposal of waste, demolition of contaminated facilities such as the C-340 Building (demolished in 2013), decontamination of contaminated equipment, and most environmental remediation activities. Ambient air monitoring, which monitors fugitive emissions from all Paducah Site operations (including USEC operations), is conducted using eight continuous air monitors located around the PGDP reservation. Data from a background location also is collected. See Figure 4.3 for air sampling locations. Radiological analytes are presented in the FY 2013 and FY 2014 EMP (LATA Kentucky 2012; LATA Kentucky 2013a).

Airborne radionuclide emissions are regulated by EPA under the Clean Air Act and its implementing regulations. DOE facilities are subject to 40 *CFR* Part 61, Subpart H, NESHAP, which contains the national emission standards for radionuclides other than radon from DOE facilities. The applicable standard is a maximum of 10 mrem (0.1 mSv) effective dose equivalent (EDE)[4] to any member of the public in any year.

Airborne radioactive materials released in 2013 from stacks and diffuse sources on the PGDP (Table 4.1) were modeled using the EPA-approved CAP88 computer code. This air dispersion code estimates EDEs based on the ingestion, inhalation, air immersion, and ground surface pathways. Site-specific data for CY 2013 (radionuclide releases in curies per year) were input into the CAP88 code, as were on-site meteorological data. Results are presented in Tables 4.1 to 4.3.

The hypothetical MEI was calculated to potentially receive an EDE of about 0.03 mrem, which is well below the NESHAP standard of 10 mrem. Based upon 2010 population census data, the collective ED to the entire population within 50 miles of PGDP was approximately 0.2 person-rem.

A complete summary of this emissions data can be found in the *National Emissions Standard for Hazardous Air Pollutants Annual Report for 2013* (LATA Kentucky 2014b).

[4] For radionuclides at PGDP, the EDE is equivalent to the ED.

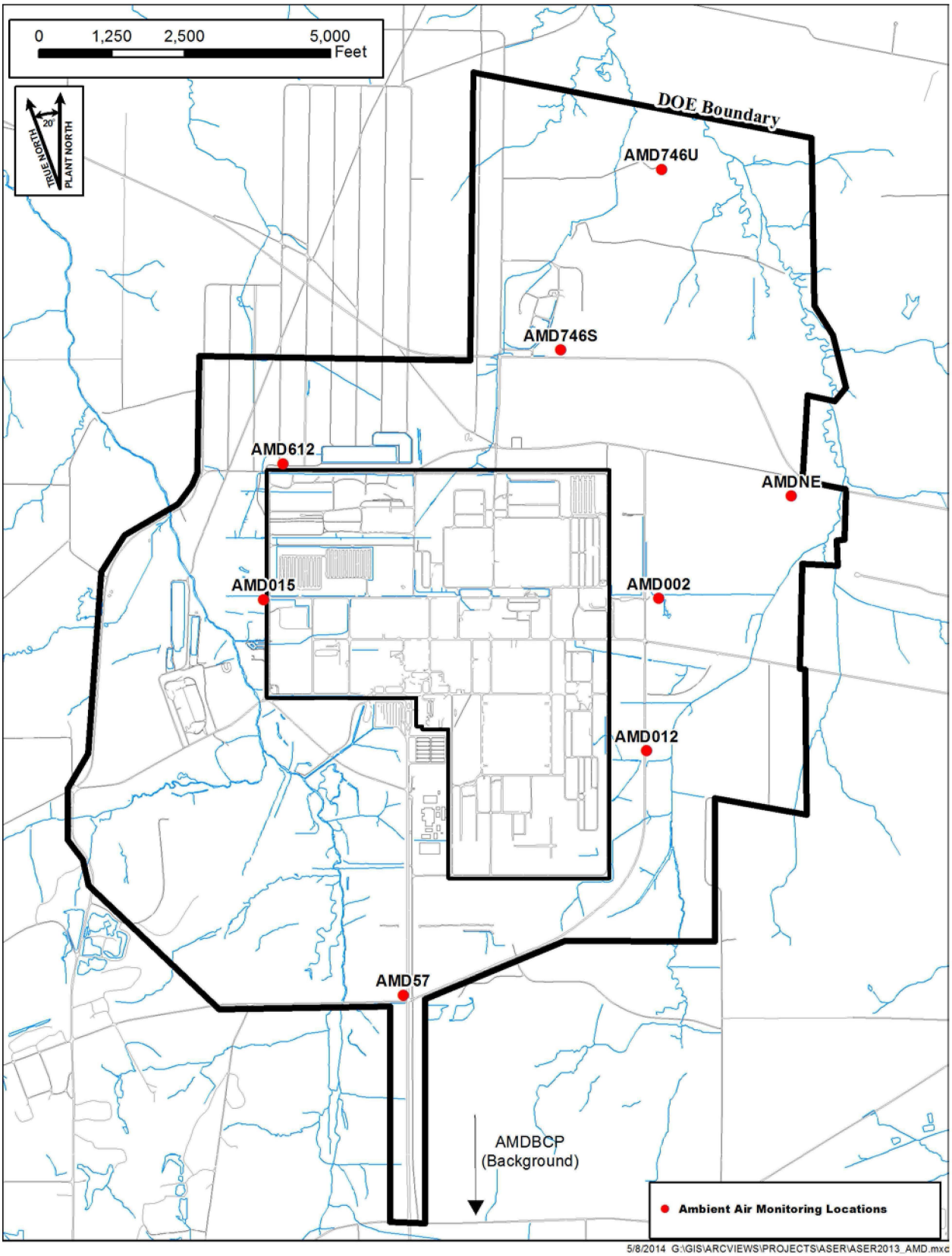

Figure 4.3. Air Monitoring Locations

Table 4.1. PGDP Radionuclide Atmospheric Releases for CY 2013 (in Curies)

Nuclide	Northwest Plume Treatment Facility	Northeast Plume Treatment Facility Cooling Tower	Northeast Plume Treatment System Alternate Treatment Unit	DUF_6 Conversion Facility	Total DOE Emissions	Total Site Emissions*
U-234	0	0	--	1.57E-07	1.57E-07	5.46E-03
U-235	0	0	--	7.19E-09	7.19E-09	1.90E-04
U-238	0	0	--	3.85E-07	3.85E-07	2.54E-03
Tc-99	1.27E-04	2.26E-06	1.28E-06	--	1.31E-04	4.60E-03
Th-230	0	0	--	--	--	5.84E-06
Th-231	0	0	--	2.80E-08	2.80E-08	2.80E-08
Th-234	0	0	--	2.56E-06	2.56E-06	2.56E-06
Np-237	0	0	--	--	--	6.18E-04
Pu-239	0	0	--	--	--	1.34E-06
Pa-234m	0	0	--	2.56E-06	2.56E-06	2.56E-06
Total Curies/Year	**1.27E-04**	**2.26E-06**	**1.28E-06**	**5.70E-06**	**1.36E-04**	**1.34E-02**

*The total site emissions reflect both USEC and DOE emissions; however, the source-specific columns show only DOE emissions. USEC emissions included in the calculated total DOE emissions, but are not discussed in this ASER.

Table 4.2. Dose Calculations for Airborne Releases

Emission Sources	Dose to the Maximum Exposed Individual for Each Source (mrem)	Dose to the Maximum Exposed Individual for the Plant (mrem)
DOE Emission Sources		
Northwest Plume Treatment Facility	2.5E-05	2.5E-05
Northeast Plume Treatment Facility Cooling Tower	1.7E-07	1.3E-07
Northeast Plume Treatment Facility Alternate Treatment Unit	1.9E-07	8.9E-08
DUF_6 Conversion Facility	2.5E-07	1.7E-07
Total from DOE Sources		**2.5E-05**
Total from USEC Sources*		**3.0E-02**
Total from All Sources		**3.0E-02**

*USEC sources included in the calculated total DOE emissions, but are not discussed in this ASER.

Table 4.3. Calculated Radiation Doses from Airborne Releases

	Effective Dose to MEI (mrem)	Percent of Standard (%)	Collective Effective Dose (person-rem)
PGDP	3.0E-02	0.3	0.2

4.1.6 Liquid Discharge Monitoring and Estimated Dose from Liquid Effluents

4.1.6.1 Surface water

Radioactive contaminants released to water may remain dissolved or suspended in surface water, deposited in sediment, deposited on ground or vegetation by irrigation, absorbed into plants and animals, or may infiltrate to the groundwater.

Surface water leaving PGDP includes rainfall runoff from cylinder yards and landfills and effluent from site processes (e.g., the C-612 NWPGS and the C-616 USEC Wastewater Treatment Facility). The discharges from PGDP flow into Bayou and Little Bayou Creeks, which then flow into the Ohio River.

DOE Order 458.1 requires the control and management of radionuclides from DOE activities in liquid discharges and sets guidelines for allowable concentrations of radionuclides in effluents to protect public health. This protection is achieved at PGDP by meeting DOE-STD-1196-2011, Derived Concentration Technical Standard (DCS), for ingestion limits (DOE 2011).

The DCS value for an isotope is the concentration of the isotope in drinking water that is calculated (derived) to result in an annual dose of 100 mrem to a person. That is, if the person's entire annual drinking water intake contained a radioactive isotope at the DCS level, that person would receive 100 mrem. In reality, people do not intentionally drink any water from surface streams in the area surrounding PGDP; therefore, the allowable concentrations for the DCSs are very conservative. The DCS is different for each isotope because of the differences in radiation type, radioactive energy, and half-life.

For environmental surveillance monitoring, surface water was sampled quarterly at four locations for radiological parameters (L10, L241, L5, and L11) in 2013 (see Figure 4.4). One background location (L1) is sampled annually. Additionally, a location near the nearest public water withdrawal location, Cairo, Illinois, (L306) was sampled. This sampling is performed to evaluate potential radiological effluents leaving the site and to evaluate the effectiveness of the outfall sampling program. Sampling locations were selected to support site-specific radiation exposure pathway analysis. Locations were prioritized for areas of public access, introduction of plant effluents to the environment, and verification of the effectiveness of PGDP effluent control and monitoring.

Isotopic analysis for multiple radionuclides is performed at each location unless the alpha and beta activity levels are below established threshold limits. The threshold limits were established by considering the isotopes that historically have been detected, identifying the two of those that have the lowest alpha and beta DCS values, respectively, and taking 10% of each of those values. The threshold limit established for alpha activity is 14 pCi/L (based on Th-232 and Pu-239) and the beta activity is 300 pCi/L (based on Cs-137). If, by the end of the calendar year, no threshold values have been exceeded at a location, then isotopic analysis for radionuclides is performed on the final sample to provide a data point for trending. Additional monitoring results are available through the PEGASIS Web site at http://padgis.latakentucky.com/padgis/.

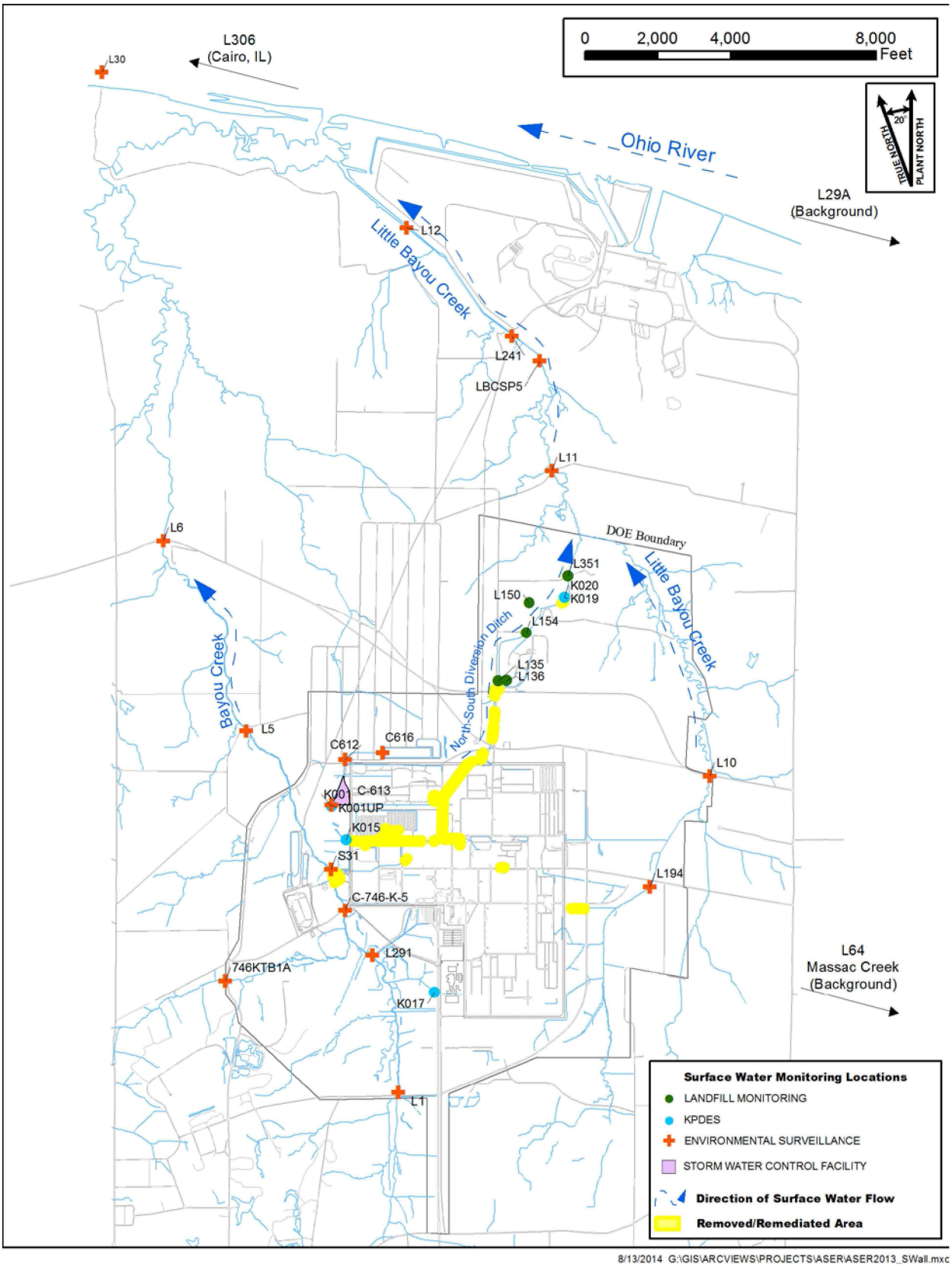

Figure 4.4. Surface Water Monitoring

In addition to the environmental surveillance, surface water locations, samples are taken at the five KPDES-permitted outfalls (001, 015, 017, 019, and 020). Table 4.4 lists the KPDES outfall, types of effluents, and type of flow. As with the environmental surveillance locations, isotopic analyses are not performed if the alpha and beta activity levels are below established threshold limits. If the threshold values are not exceeded at a location, then the dose calculated according to the pathway assumptions in the *Methods for Conducting Risk Assessments and Risk Evaluation* (DOE 2013b) will be less than 0.09 mrem/yr, and is assumed to pose minimal risk to the public or the environment. If, by the end of the calendar year, no threshold values have been exceeded at a location, then isotopic analysis for radionuclides is performed on the final sample to provide a data point for trending.

Table 4.4. KPDES Outfall Information

Outfall	Types of Liquid Effluent	Type of Flow
K001	USEC's C-616 Liquid Pollution Abatement Facility DOE NWPGS and NEPCS DOE's waste management activities, including routinely generated C-404 treated leachate, C-733 and C-612-A sump water, and other waste management activities DOE's discharge operations at the Northwest Storm Water Collection Basin (also referred to as the C-613 Sedimentation Basin) C-613 Sedimentation Basin	Continuous
K015	Surface water runoff from the east-central sections of the plant	Intermittent
K017	Surface water runoff from the southeast section of the plant (primarily the cylinder storage yards)	Continuous
K019	Surface water runoff from C-746-U (DOE's operational nonhazardous, solid waste landfill)	Intermittent
K020	Treated leachate from the C-746-S and C-746-U Landfills	Intermittent

Table 4.5 summarizes the isotopic detections of radionuclides at surface water sampling locations.

Table 4.5. Ranges of Detected Radionuclides in 2013 Surface Water Samples

Isotope	Range
Potassium-40 (pCi/L)	24.9–101
Technetium-99 (pCi/L)	15.3–49.9
Uranium-234 (pCi/L)	0.443–83.5*
Uranium-235 (pCi/L)	0.0513–10.5*
Uranium-238 (pCi/L)	0.541–642*

*Maximum results are from radiological monitoring locations near K020.

Additional monitoring results are available through the PEGASIS Web site at http://padgis.latakentucky.com/padgis/.

4.1.6.2 Drinking water

Surface water from the PGDP is not ingested; however, it eventually is discharged into the Ohio River, which is used as a public drinking water source. Cairo, Illinois, is the closest drinking water system (approximately 30 miles downstream) that uses water downstream of PGDP effluents. Cairo, Illinois, is located at the confluence of the Ohio and Mississippi Rivers. The average concentrations of radionuclides that were detected near the surface water collection inlet at Cairo during CY 2013 were used to calculate the dose to the MEI resulting from consumption of surface water. All radionuclides are assumed to come from PGDP in this calculation because radionuclides were not detected in background samples.

Surface water pathway dose was calculated where an MEI is assumed to consume water from the public drinking water supply at Cairo, Illinois (L306). Three aqueous samples were collected at L306 during 2013 and analyzed for radionuclides. Radiological results for all three sample events were nondetect except for Tc-99 in one sample (15.3 pCi/L, which is well below the DCS[5] of 44,000 pCi/L for ingestion of water). For the dose calculation, which was calculated using the average activities of the three L306 water samples, the MEI was assumed to consume all of his/her daily required water, 8 glasses, each containing 8 ounces (a total of approximately 2 liters), 365 days a year from the public drinking water supply. The maximum annual dose to an individual was calculated to be 0.012 mrem in 2013, which is significantly less than the 100 mrem/yr limit established by DOE Order 458.1.

Most of these individuals within a 50-mile radius of PGDP obtain their daily drinking water from sources other than those downgradient from PGDP. A bounding collective dose is calculated by multiplying the dose to the MEI from annual ingestion of drinking water from the Cairo supply by the number of residents in the 50-mile radius impacted area. The resulting collective dose from drinking water ingestion is 6.2 person-rem/year.

4.1.6.3 Incidental ingestion of surface water

Dose to the hypothetical MEI is calculated based on incidental ingestion of water due to wading or swimming in Bayou and Little Bayou Creeks and their tributaries. The assumptions from the *Methods for Conducting Risk Assessments and Risk Evaluation* are that a recreator may swim or wade 45 days a year, for 2.6 hours a day, with an incidental ingestion of 0.05 liters per hour and be in different locations throughout the wildlife management area (DOE 2013b). The highest monthly surface water results from the various sampling locations are utilized to calculate the bounding dose to the MEI. The annual dose to the MEI from incidental ingestion of surface water is 0.32 mrem/year.

Collective dose is not calculated for the incidental ingestion pathway due to the lack of a plausible exposure scenario. This pathway is more likely to involve individuals; therefore, it is more suited for MEI dose calculation.

4.1.6.4 Landfill leachate

During CY 2013, 810 tons of waste from 10 different waste streams was disposed of in the C-746-U Landfill. The waste included building demolition debris from the C-340 facility, soils, personal protective equipment, scrap metal, investigation derived wastes, and other various items. Authorized Limits have been established for the C-746-U Landfill and, as a result, contaminated material may be disposed of if it is below acceptable levels. DOE reviews and authorizes disposal of each waste stream that possesses residual radioactivity to ensure accurate inventory control is maintained. During routine sampling of the leachate the summer of 2013, an increase in radiological contaminants was noted. These levels were 15.2% above the 2012 discharge concentrations based on the time-weighted averages for 2013, but did not exceed the DCS set forth by DOE (DOE 2011). Subsequent sampling in 2014 has shown a reduction in contaminant concentrations.

4.1.6.5 Groundwater

DOE has numerous groundwater MWs more fully described in Chapter 6. Groundwater wells that supplied drinking water downgradient from PGDP have been replaced with public drinking water,

[5] DCSs are established in DOE 2011.

resulting in the loss of that exposure route. A drinking water pathway for consumption of surface water at the nearest public drinking water source [Ohio River at Cairo, Illinois (L306)] is included in dose calculations for surface water. Because groundwater is not used as a drinking water source (or for any other use by residents), it is not considered in the calculation of dose to the MEI. Similarly, it is not considered in the calculation of cumulative dose to the surrounding population.

4.1.7 Sediment Monitoring and Estimated Dose

Sediment is an important constituent of the aquatic environment. If a radionuclide is a suspended solid or is attached to suspended sediment, it can settle to the bottom, be taken up by certain organisms, or become attached to plant surfaces. Radionuclides transported by water can absorb on suspended organic and inorganic solids or be assimilated by plants and animals. Suspended solids, dead biota, and excreta settle to the bottom and become part of the organic substrata that support the bottom-dwelling community of organisms. Sediments can play a significant role in aquatic ecological impacts by serving as a repository for radioactive substances that pass via bottom-feeding biota to the higher trophic levels thus creating the need for sediment data.

A single sediment sample can represent information that would require a large number of water samples, spaced over a period of time, to reconstruct. Sediment acts to collect, concentrate, and store specific kinds of contaminants at specific locations. Concentrations of contaminants in sediments represent integrated measures of aqueous contaminant concentrations over some preceding period of time.

4.1.7.1 Sediment Surveillance Program

Radiological monitoring at sediment locations was not performed during CY 2011 and 2012. The reduction in sampling during these years was based on a thorough analysis of historical (pre-2011) radiological results in comparison to DOE standards. Historically, the maximum annual radiological dose to a member of the public from sediment exposure was less than 0.4 mrem, which is significantly less than the 100 mrem annual dose allowed by DOE Order 458.1.

Sediment sampling at the Paducah Site in CY 2013 included radiological and nonradiological constituents (LATA Kentucky 2012; LATA Kentucky 2013a). This sampling occurred in June 2013. Sampling locations have been selected to facilitate the site-specific radiation exposure pathway analysis and to provide an indication of the accumulation of undissolved radionuclides in the aquatic environment (Figure 4.5). Locations were prioritized for areas of public access, introduction of plant effluents to the environment, any unplanned release, and verification of the effectiveness of PGDP effluent monitoring.

During CY 2013, an unplanned release (see Section 4.3) occurred due to heavy rains during demolition of Building C-340. As a result, a follow-up sediment sampling event was performed during August 2013 at three locations: L194, S2, and S28. Location S2 was sampled before and after the unplanned release to allow for a comparison of sediment contaminant levels.

Sediment radiological analytical results are summarized in Table 4.6 and also may be found on the PEGASIS Web site at http://padgis.latakentucky.com/padgis/. The radiological results for CY 2013 are similar in magnitude to those measured during CY 2008–2010 [see the ASER for CY 2012 (LATA Kentucky 2014c)]. Overall, radiological concentrations in sediment are near background concentrations with the exception of locations S1, S2, and S27. Locations S1 and S27 historically exhibit the highest concentrations of analyzed radionuclides. Location S1, exhibiting elevated activity of Tc-99, is located on Bayou Creek within the DOE boundary surrounding PGDP. Location S27 is located within Little Bayou Creek just north of the DOE PGDP boundary. Overall, uranium activity is above background

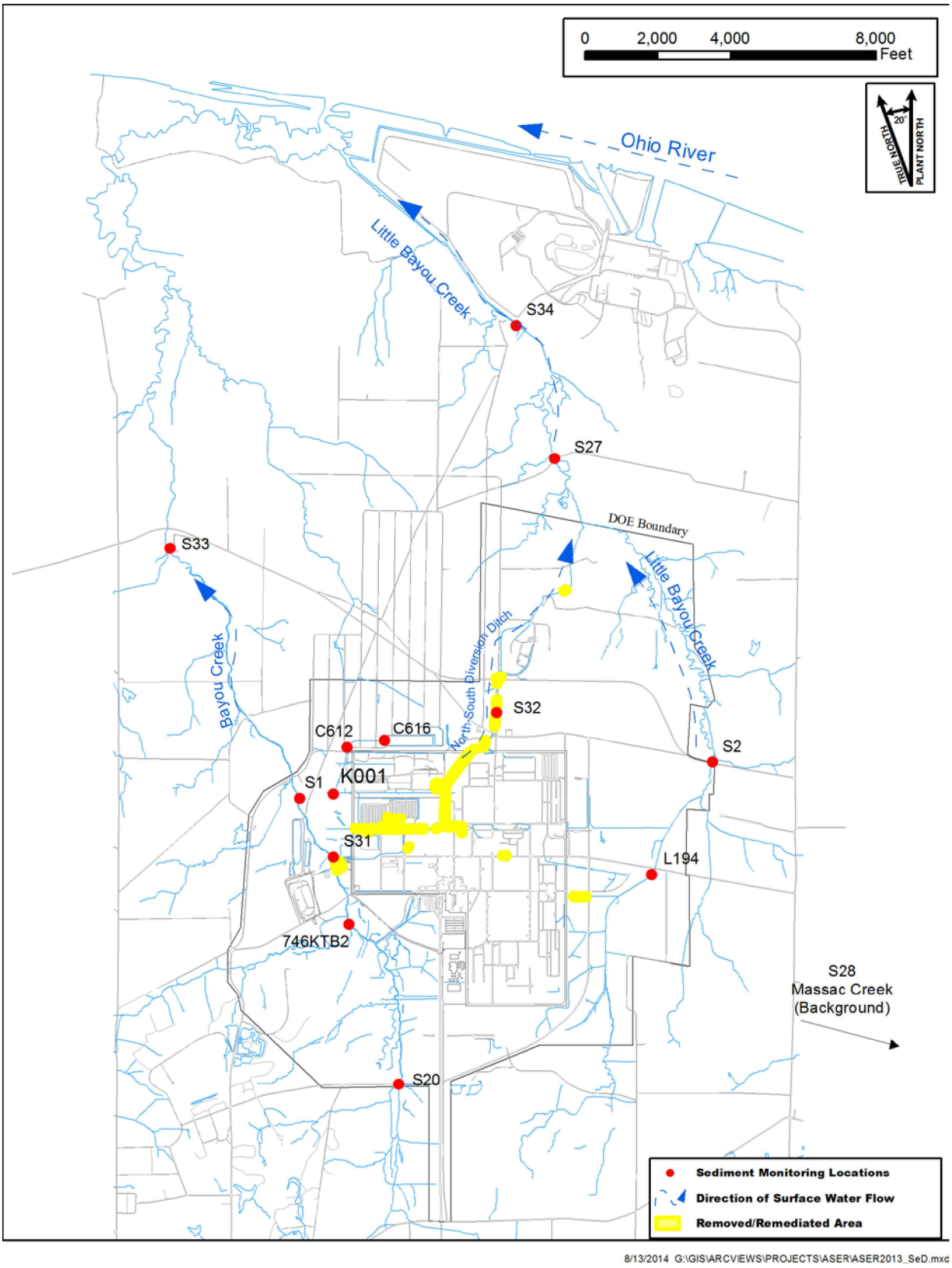

Figure 4.5. Sediment Monitoring Locations

in Little Bayou Creek and Bayou Creek near and downstream of the plant site. Other radionuclides, although present, are not significantly above background levels.

Table 4.6. Radiological Activities for Sediment Sampling[a]

Parameter	S1[b]	S1[b] (duplicate)	S2[b]	S2[c]	S20[b]	S27[b]	S33[b]	S34[b]	L194[c]	S28[c]
Alpha activity	8.64	12.7	13.5	not analyzed	2.95	21.6	3.35	3.45	not analyzed	not analyzed
Beta activity	20.4	25.4	16.5	not analyzed	3.75	106	4.14	2.78	not analyzed	not analyzed
Cesium-137	0.0519	0.0329	0.0275[d]	0.0266	0.026	0.044	0.0782	0.0156[d]	0.0319	0.009[d]
Neptunium-237	0.126	0.142	0.000[d]	0.000[d]	0.000[d]	0.434	0.000[d]	0.0108[d]	0.000[d]	0.004[d]
Plutonium-238	0.00251[d]	0.00338[d]	0.00443[d]	0.000[d]	0.00308[d]	0.0177[d]	0.0033[d]	0.00267[d]	0.000[d]	0.000[d]
Plutonium-239/240	0.0209[d]	0.0264[d]	0.00619[d]	0.000[d]	0.00179[d]	0.496	0.0167[d]	0.102	0.000[d]	0.000[d]
Potassium-40	5.85	5.07	6.67	5.79	2.62	4.63	4.46	3.21	7.15	4.43
Technetium-99	20	26.7	0.0632[d]	0.000[d]	0.000[d]	5.7	0.139[d]	0.737	0.00941[d]	1.8
Thorium-228	0.62	0.792	0.919	0.633	0.646	0.768	0.548	0.581	0.759	0.504
Thorium-230	0.799	1.01	0.948	0.724	0.604	5.36	0.703	1.4	1.38	1.03
Thorium-232	0.618	0.776	0.878	0.759	0.598	0.712	0.545	0.582	0.88	0.584
Thorium-234	9.23	4.85	7.74	6.47	0.763[d]	3.39	1.81	2.04	6.58	0.646
Total Uranium	7.61	9.57	7.46	7.32	0.777	13.5	2.73	2.53	4.91	0.613[d]
Uranium-234	2.7	3.21	0.959	1.01	0.358	4.56	1.12	0.749	0.975	0.291
Uranium-235	0.174	0.227	0.101	0.0856	0.0329	0.287	0.06	0.0467	0.0987	0.00869[d]
Uranium-238	4.73	6.13	6.4	6.22	0.387	8.65	1.55	1.73	3.83	0.314

[a] Units are in pCi/g.
[b] Sampling conducted before the unplanned release.
[c] Sampling conducted after the unplanned release.
[d] Result reported at concentrations less than the laboratory's reporting limit.
Note: Consistent with Nuclear Regulatory Commission guidance, 0.000 pCi/g is presented for results reported as less than zero.

When comparing the results from sampling at S2 before the unplanned release and after the unplanned release, the sediment results indicated lower concentrations of radionuclides after the release than before the release. This corresponds to a completion of C-340 demolition activities and also indicates that sediments in this location did not suffer a long term impact as a result of the unplanned release.

4.1.7.2 Sediment Dose

Areas that contain elevated radionuclide levels are located within the DOE property boundaries and are controlled for protection of the public. For purposes of calculating dose to the hypothetical MEI, it is postulated that exposure to contaminated sediment in Bayou Creek and Little Bayou Creek could occur during hunting or other recreational activities. Exposure is possible through incidental ingestion of contaminated sediment. The plausible worst-case ingestion assumption consists of an adult individual (i.e., an Adult Recreational User) who would wade around at one creek location every other day during the hunting season (104 days/year) and ingest a small amount of sediment during each visit (100 mg/day). A dose is then calculated based on the radionuclide activity and the amount of exposure via ingestion. Exposure is calculated using the methods presented in the *Methods for Conducting Risk Assessments and Risk Evaluation* (DOE 2013b), which conservatively includes the ingestion, inhalation, and external gamma pathways. Table A.8 of this document provides Site specific soil screening levels for receptors due to significant contaminants of concern. Samples from location S20 are assumed to be background and are subtracted from sample results to arrive at a dose associated with site releases. The downstream location with the maximum dose is assumed to represent the dose received from this pathway by the maximally exposed individual from the worst case exposure scenario.

Doses are calculated for ingestion of sediments for both Bayou Creek and Little Bayou Creek using the radiological results for sediment surveillance samples for CY 2013. The worst-case annual dose (including background) was calculated to be at location S27 (0.15 mrem); although this is an unlikely

scenario because the area currently is posted for contamination control in accordance with 10 *CFR* § 835 *Occupational Radiation Protection*. A comparison of sediment sampling data is provided in Table 4.6. The estimated worst-case annual dose above background from sediment was 0.077 mrem at downstream Little Bayou. This exposure pathway is the major contributor to the dose received by the MEI; however, it is significantly less than the DOE annual dose limit of 100 mrem per year. Dose results for sediment sample locations are provided in Table 4.7.

Table 4.7. Average Annual Dose Estimates for CY 2013 Incidental Ingestion of Sediment

	Committed Effective Dose Equivalent (mrem)—Sediment Ingestion									
Location	**Cs-137**	**Np-237**	**Pu-238**	**Pu-239/ Pu-240**	**Tc-99**	**Th-230**	**U-234**	**U-235**	**U-238**	**Total (mrem)**
Upstream Bayou[1]	4.21E-03	0.00E+00	2.14E-05	1.38E-05	0.00E+00	7.60E-04	2.28E-04	1.20E-03	4.07E-03	1.05E-02
Bayou Near Site[2]	2.66E-03	8.27E-03	0.00E+00	1.68E-04	2.14E-04	3.78E-04	1.65E-03	6.12E-03	5.31E-02	7.25E-02
Downstream Bayou[3]	8.46E-03	0.00E+00	1.53E-06	1.15E-04	1.28E-06	1.25E-04	4.85E-04	9.89E-04	1.22E-02	2.24E-02
Little Bayou near Site[4,d]	4.32E-04	0.00E+00	0.00E+00	2.10E-06	2.22E-07	5.20E-04	3.97E-04	2.27E-03	5.36E-02	5.73E-02
Downstream Little Bayou[5,d]	6.16E-04	1.37E-02	4.93E-05	2.29E-03	2.95E-05	3.49E-03	1.46E-03	4.89E-03	5.06E-02	7.71E-02
Massac Creek[6]	0.00E+00	2.47E-04	0.00E+00	0.00E+00	1.65E-05	5.36E-04	0.00E+00	0.00E+00	0.00E+00	7.99E-04
	Net Exposure from Paducah Site to maximally exposed individual [a,b,c,d] (Downstream Little Bayou) = 7.71E-02									

[a] Maximum allowable exposure is 100 mrem/year for all contributing pathways and 25 mrem/year from one source (DOE Order 458.1).
[b] Radionuclide dose from S20 is considered background and has been subtracted from PGDP-related doses. If location dose is less than background dose the dose is specified as 0.00E+0 mrem.
[c] Dose calculated as ratio of listed dose for Adult Recreator in Table A.8 in *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant* (DOE 2013b), which includes the ingestion, inhalation, and external gamma pathways.
[d] When more than one sample is present at the listed location, the doses of each sample are averaged.
The following footnotes correspond with row titles in this table. These are groupings of sample locations in the area described in the title and are shown on Figure 4.5.
1 = S20 (Background) 3 = S33 5 = S27, S34
2 = S1 4 = S2, L194 6 = S28

4.1.8 Terrestrial Environment Monitoring and Estimated Dose

Woodlands, meadows, and cultivated fields dominate the rural landscape around the DOE Reservation. Immediately adjacent to the DOE Reservation is WKWMA, which is used by a considerable number of hunters, trappers, and anglers each year. Hunting and trapping activities may include such wildlife as rabbit, deer, quail, raccoon, squirrel, dove, turkey, waterfowl, and beaver. Additionally, the Kentucky Department of Fish and Wildlife Resources sponsors field hunting trials for dogs within the WKWMA.

Farm-raised animal products, as well as local wildlife in the area, may be contaminated through water releases. Wildlife and animal products, including meat, eggs, and milk, may become contaminated through animal ingestion of contaminated water, sediment, other animals, or through direct contact with contaminated areas. The subsequent ingestion of these products can lead to public dose. As discussed earlier, a portion of the airborne radionuclides is estimated to be deposited in soil, ingested by animals, and uptaken by food crops. Irrigation and deposition through waterborne radionuclides is an incomplete pathway because municipal water is used at nearby residences for household purposes (including activities such as irrigation of crops and lawns). The estimated dose for these pathways is included with the calculations for airborne releases addressed in Section 4.1.1.

4.1.9 Wildlife

Deer monitoring has been eliminated from the Paducah Site monitoring program. During FY 2011, DOE performed an extensive review of data sets from 20 years of deer harvesting events. As a result of this review, DOE eliminated the deer monitoring because of a downward trend and a continued lack of detection in the results, as well as an overall downward trend in the concentration of contaminants found at the Paducah Site due to remediation efforts. This exposure route and associated dose has been captured in the food chain models associated with the CAP-88 air program. Doses from airborne releases are described in Section 4.1.1.

4.1.10 Direct Radiation Monitoring and Estimated Dose

4.1.10.1 Direct radiation surveillance

External radiation exposure from DOE's operations at the Paducah Site potentially contribute to the overall dose to the public. External radiation exposure is defined as exposure attributed to radioactive sources outside the body (e.g., cosmic gamma radiation). Sources of external radiation exposure at the Paducah Site include the cylinder storage yards, the operations inside the cascade building, and small items such as instrument calibration sources. Cylinder storage yards have the largest potential for a dose to the public because of their proximity to the PGDP security fence.

The external gamma and neutron radiation monitoring program is designed to provide data on external radiation exposure from DOE operations to members of the public. The primary factor in selecting the monitoring locations was the potential for a member of the public to be exposed to external radiation.

Secondary factors in selecting monitoring locations were accessibility and representative exposure potentially received by members of the public and area monitoring for individuals passing through the DOE site. Environmental thermoluminescent dosimeters (TLDs) with a calcium fluoride and lithium fluoride matrix were placed at the monitoring locations and collected and analyzed quarterly for a period of one year.

In 2013, direct radiation was monitored by quarterly placement, collection, and analysis of environmental TLDs. These monitoring locations are shown in Figure 4.6. Monitoring results indicate that 16 of 52 locations were consistently above background levels, as reported in the *Annual Report on External Gamma Radiation Monitoring for CY 2013, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (LATA Kentucky 2014d). Most of these locations were at or near the PGDP security fence in the vicinity of UF_6 cylinder storage yards in areas that until recently were not accessible to members of the public.[6]

4.1.10.2 Direct radiation dose

Due to PGDP security protocols in CY 2013, no members of the public routinely were allowed near the security fence. The external radiation doses measured by TLDs in areas accessible to the public were not statistically above background; therefore, the ED potentially received by a member of the public passing through accessible portions of the DOE Reservation are not statistically above background and, for the purposes of this report, are considered to be negligible. In 2013, TLD-14 and TLD-40 represented the closest locations that would be accessible to the public. TLD-14 is near Harmony Cemetery, located north of the plant security fence and south of Ogden Landing Road. Measurements at this location indicated external radiation doses statistically equivalent to the background radiation level. In 2013, TLD-40 located on the DOE Reservation boundary with the DOE-leased WKWMA area off of Dyke Road indicated external radiation dose measured to be at background levels. The MEI at the private residences also was calculated to be at background levels. Based on the results of the gamma and neutron radiation dose measurements made during CY 2013, the ED to the MEI member of the public from DOE operations was below the applicable DOE limit of 100 mrem within a year, in accordance with DOE Order 458.1.

[6] Recreational activities were expanded in the DOE-owned land in WKWMA in 2012. Expanded activities included youth turkey hunting, horseback riding, hiking, dog training and trials, gun hunting for small game, increased bow hunting for deer, mountain biking, and nature hiking. The expansion took effect January 1, 2012, after a new five-year license agreement was signed between the Kentucky Department of Fish and Wildlife Resources and DOE; however, most activities were not implemented until the fall 2012 hunting season.

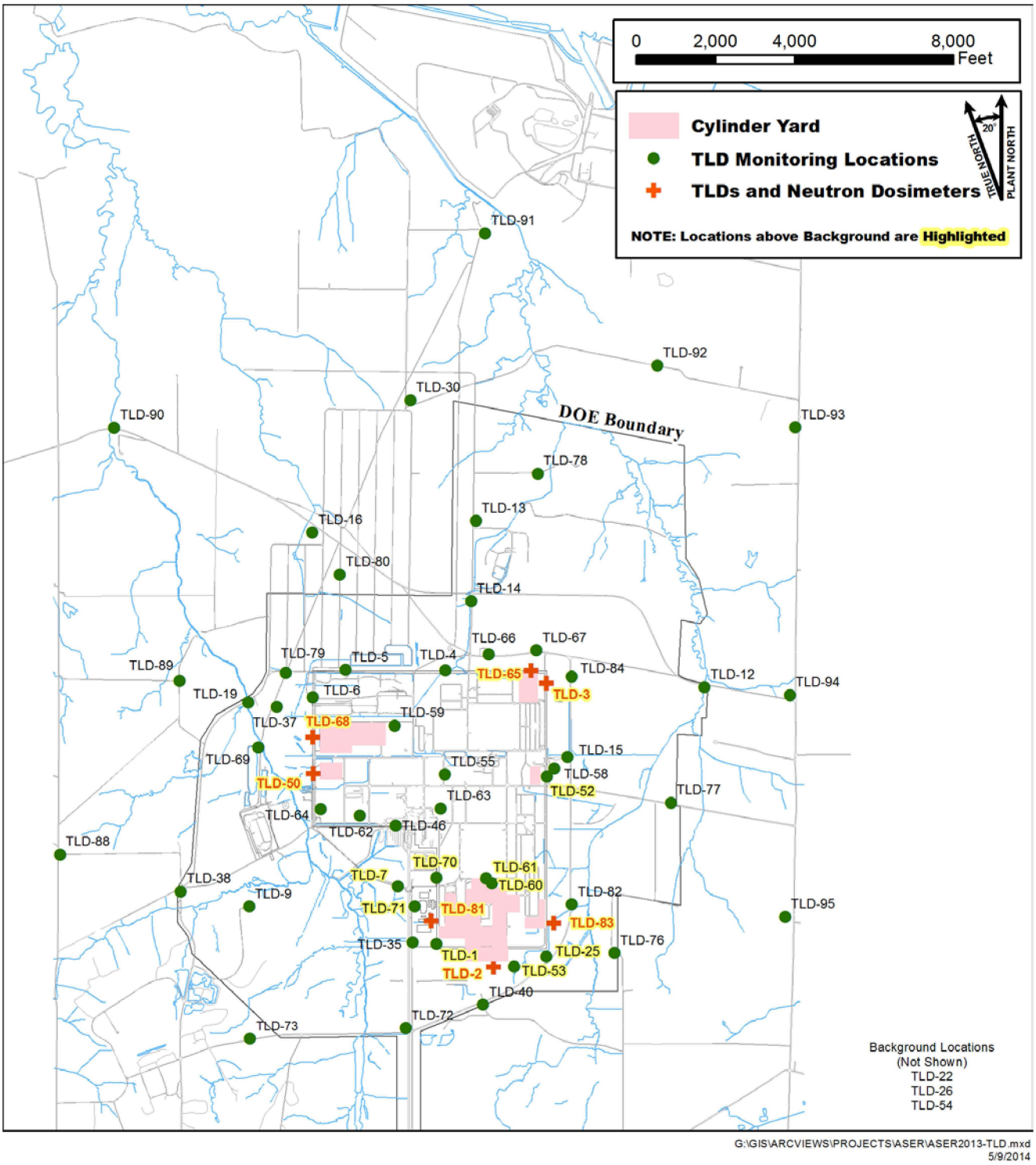

Figure 4.6. TLD Locations in the Vicinity of PGDP

4.1.10.3 Cumulative dose survey

This section presents the calculated radiological doses to individuals and the surrounding population from atmospheric and liquid releases from the Paducah Site, as well as from direct radiation. Table 4.8 provides a summary of the radiological dose for 2013 from the Paducah Site that could be received by a member of the public (i.e., the MEI) assuming worst-case exposure from all relevant pathways. The largest contributor to the calculated dose is from incidental ingestion of surface water. The groundwater pathway from DOE sources is assumed to contribute no dose to the population, because DOE has supplied all downgradient residents with public water. The worst-case combined (internal and external) dose to an individual member of the public was calculated at 0.44 mrem. This level is well below the DOE annual dose limit of 100 mrem/year to members of the public and below the EPA limit of 10 mrem airborne dose to the public.

Table 4.8. Summary of Potential Radiological Dose to the MEI from the Paducah Site for CY 2013[a]

Pathway	Dose to Maximally Exposed Individual[b] (mrem/year)	Percent of Total	Percent of DOE 100 mrem/yr Limit
Incidental ingestion of surface water	0.32	73	0.32
Ingestion of drinking water (Cairo, Illinois)	0.012	2.7	0.012
Incidental ingestion of sediments	0.077	18	0.077
Direct radiation	0.00	0.00	0.00
Atmospheric releases[c,d]	0.03	6.8	0.03
Ingestion of groundwater[e]	not applicable	not applicable	not applicable
Total annual dose above background (all relevant pathways)[a]	**0.44**	**100**	**0.44**

[a] Pathways defined in previous sections.
[b] Maximum allowable exposure from all sources is 100 mrem/year (DOE Order 458.1).
[c] DOE source emissions were from NWPGS, NEPCS, DUF_6 conversion activities and includes USEC emissions.
[d] Doses associated with atmospheric releases also include ingestion pathways considered in the AirDose EPA food chain modeling routines.
[e] Groundwater is not a viable pathway for the MEI due to DOE providing public water to downgradient residents.

Estimates of radiation doses presented in this report were calculated using the dose factors provided by DOE and EPA guidance documents and found within the *Methods for Conducting Risk Assessments and Risk Evaluation* (DOE 2013b). These dose factors are based on International Commission on Radiological Protection Publication 30 (ICRP 1980).

The cumulative dose to members of the public residing within 50 miles of the PGDP has also been determined. Population dose was calculated for each exposure pathway and is summed to determine the cumulative population dose from all relevant pathways. The annual cumulative population dose is 6.22 person-rem. Table 4.9 provides a summary of the population dose calculations.

Table 4.9. Summary of Potential Radiological Dose to the Population within 50 Miles of the Paducah Site for CY 2013[a]

Pathway	Population Dose (person-rem/year)	Percent of Total
Incidental ingestion of surface water[c]	not applicable	not applicable
Ingestion of drinking water (Cairo, Ill)	6.2	99.7
Incidental ingestion of sediments	not applicable	not applicable
Direct radiation	0.00	0
Atmospheric releases[b,e]	0.02	0.3
Ingestion of groundwater[d]	not applicable	not applicable
Total annual dose above background (all relevant pathways)[a]	**6.22**	**100**

[a] Pathways defined in previous sections.
[b] DOE source emissions were from NWPGS, NEPCS, DUF_6 conversion activities and includes USEC emissions.
[c] Incidental ingestion of surface water and sediment within plant creeks and ditches is not applicable for calculation of collective dose to residents who reside within 50 miles of PGDP.
[d] Groundwater is not a viable pathway for the calculation of collective dose due to DOE providing public water to downgradient residents.
[e] Doses associated with atmospheric releases also include ingestion pathways considered in the AirDose EPA food chain modeling routines.

4.1.11 Biota Monitoring and Estimated Dose

4.1.11.1 Biota surveillance

Radionuclides from both natural and man-made sources may be found in environmental media such as water, sediments, and soils. Contaminants may bioaccumulate in animals from eating contaminated feed, drinking contaminated water, and breathing contaminated air. Contaminants may accumulate in fish when they eat contaminated foods and equilibrate with surrounding contaminated waters. Because plant and animal populations residing in or near these media or taking food or water from these media may be exposed to a greater extent than humans, DOE prepared a technical standard, DOE-STD-1153-2002, that provides methods and guidance to be used to evaluate doses from ionizing radiation to populations of aquatic animals, riparian animals (i.e., those that live along banks of streams or rivers), terrestrial plants, and terrestrial animals.

Because both measured concentrations and bioconcentration factors associated with radionuclides of concern at the Paducah Site in animals and fish are low, routine site-specific pathway assessments, to include biota sampling, are not performed. Biota in the watersheds has been sampled extensively in the past, to the point that further collection of aquatic organisms could result in a deleterious effect on the aquatic community.

Sediment samples, as discussed in Section 4.1.3, are sampled annually for radionuclides. Surface water surveillance locations, as discussed in Section 4.1.2, are monitored quarterly.

4.1.11.2 Biota dose

Methods in the DOE Technical Standard, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE-STD-1153-2002, July 2002), were used to evaluate radiation doses to aquatic and terrestrial biota from CY 2013 operations. Doses were assessed for compliance with the limit in DOE Order 458.1 for native aquatic animal organisms (1 rad/day) and for compliance with the thresholds for terrestrial plants (1 rad/day), and for compliance with the thresholds for terrestrial animals (0.1 rad/day), as proposed in DOE-STD-1153-2002. The RESRAD-BIOTA computer model (November 2009) is a

calculation tool provided by DOE for implementing the technical standard and compares existing radionuclide concentration data from environmental sampling with biota concentration guideline (BCG) screening values and to estimate upper bounding doses to biota.

Dose to biota was evaluated for Bayou and Little Bayou Creeks. Sample locations L5 and S1 were used to represent sediment and water in Bayou Creek. Data obtained from sample location L11 and colocated sediment sample location S27 were used to represent sediment and water in Little Bayou Creek. Outfalls 019 and 020, which flow into Little Bayou Creek, were not considered due to their intermittent flow. Also, L11 and S27 represent a location on Little Bayou Creek that is downstream of the confluence with the North-South Diversion Ditch. The creek at this point is more substantial and more likely to support aquatic life than those areas upstream. Data from water and sediment sampling locations on Bayou and Little Bayou Creeks were entered into the RESRAD-BIOTA model to calculate dose to biota from PGDP operations. The value for each radionuclide was divided by its corresponding BCG to calculate a partial fraction for each nuclide in each medium. Partial fractions for each medium were added to produce a sum of fractions. Exposures from the aquatic pathway may be assumed to be less than the aquatic dose limit from DOE Order 458.1 if the sum of fractions for the water plus that for the sediment is less than 1.0.

In accordance with the graded approach described in DOE-STD-1153-2002, a screening was conducted using the maximum radionuclide concentrations from surface waters and sediments. Table 4.10 summarizes the radiological dose to aquatic and terrestrial biota for Bayou Creek. Table 4.11 summarizes the radiological dose to aquatic and terrestrial biota for Little Bayou Creek. The sum of fractions for each assessment was less than 1.0, indicating that the applicable BCGs were met for both the aquatic and terrestrial evaluations. Additional monitoring results are available through the PEGASIS Web site at http://padgis.latakentucky.com/padgis/.

Table 4.10. Bayou Creek 2013 Evaluation of Dose to Aquatic and Terrestrial Biota

Aquatic Animal						
	Water			Sediment		
Nuclide	Conc. (pCi/L)	BCG (pCi/L)	Ratio	Conc. (pCi/g)	BCG (pCi/g)	Ratio
Cs-137	0	1.05E+03	0.00E+00	0.0519	4.93E+04	1.05E-06
K-40	101	2.90E+03	3.48E-02	5.85	5.80E+04	1.01E-04
Np-237	0	6.85E+01	0.00E+00	0.126	7.86E+04	1.60E-06
Tc-99	0	2.47E+06	0.00E+00	20	4.69E+05	4.26E-05
Th-228	0	3.74E+02	0.00E+00	0.62	1.64E+04	3.77E-05
Th-230	0	2.57E+03	0.00E+00	0.799	2.74E+06	2.92E-07
Th-232	0	3.04E+02	0.00E+00	0.618	3.29E+06	1.88E-07
Th-234	0	2.67E+05	0.00E+00	9.23	4.33E+04	2.13E-04
U-234	0.882	2.02E+02	4.37E-03	2.7	3.08E+06	8.77E-07
U-235	0.0513	2.17E+02	2.36E-04	0.174	1.05E+05	1.66E-06
U-238	1.63	2.23E+02	7.30E-03	4.73	4.28E+04	1.10E-04
Summed	-	-	**4.67E-02**	-	-	**5.11E-04**

Table 4.10. Bayou Creek 2013 Evaluation of Dose to Aquatic and Terrestrial Biota (Continued)

Riparian Animal						
	Water			Sediment		
Nuclide	Conc. (pCi/L)	BCG (pCi/L)	Ratio	Conc. (pCi/g)	BCG (pCi/g)	Ratio
Cs-137	0	4.26E+01	0.00E+00	0.0519	3.12E+03	1.66E-05
K-40	101	2.50E+02	4.04E-01	5.85	4.43E+03	1.32E-03
Np-237	0	1.16E+04	0.00E+00	0.126	7.63E+03	1.65E-05
Tc-99	0	6.67E+05	0.00E+00	20	4.22E+04	4.73E-04
Th-228	0	2.04E+03	0.00E+00	0.62	8.05E+02	7.70E-04
Th-230	0	1.39E+04	0.00E+00	0.799	1.04E+04	7.66E-05
Th-232	0	1.68E+03	0.00E+00	0.618	1.30E+03	4.76E-04
Th-234	0	3.81E+06	0.00E+00	9.23	4.33E+03	2.13E-03
U-234	0.882	6.83E+02	1.29E-03	2.7	5.27E+03	5.13E-04
U-235	0.0513	7.36E+02	6.97E-05	0.174	3.73E+03	4.67E-05
U-238	1.63	7.56E+02	2.16E-03	4.73	2.49E+03	1.90E-03
Summed	-	-	**4.08E-01**	-	-	**7.74E-03**

Table 4.11. Little Bayou Creek 2013 Evaluation of Dose to Aquatic and Terrestrial Biota

Aquatic Animal						
	Water			Sediment		
Nuclide	Conc. (pCi/L)	BCG (pCi/L)	Ratio	Conc. (pCi/g)	BCG (pCi/g)	Ratio
Cs-137	0	1.05E+03	0.00E+00	0.044	4.93E+04	8.93E-07
K-40	0	2.90E+03	0.00E+00	4.63	5.80E+04	7.98E-05
Np-237	0	6.85E+01	0.00E+00	0.434	7.86E+04	5.52E-06
Pu-239	0	1.87E+02	0.00E+00	0.496	7.04E+06	7.05E-08
Tc-99	0	2.47E+06	0.00E+00	5.7	4.69E+05	1.21E-05
Th-228	0	3.74E+02	0.00E+00	0.768	1.64E+04	4.67E-05
Th-230	0	2.57E+03	0.00E+00	5.36	2.74E+06	1.96E-06
Th-232	0	3.04E+02	0.00E+00	0.712	3.29E+06	2.17E-07
Th-234	0	2.67E+05	0.00E+00	3.39	4.33E+04	7.84E-05
U-234	0	2.02E+02	0.00E+00	4.56	3.08E+06	1.48E-06
U-235	0	2.17E+02	0.00E+00	0.287	1.05E+05	2.74E-06
U-238	10.8	2.23E+02	4.84E-02	8.65	4.28E+04	2.02E-04
Summed	-	-	**4.84E-02**	-	-	**4.32E-04**
Riparian Animal						
	Water			Sediment		
Nuclide	Conc. (pCi/L)	BCG (pCi/L)	Ratio	Conc. (pCi/g)	BCG (pCi/g)	Ratio
Cs-137	0	4.26E+01	0.00E+00	0.044	3.12E+03	1.41E-05
K-40	0	2.50E+02	0.00E+00	4.63	4.43E+03	1.04E-03
Np-237	0	1.16E+04	0.00E+00	0.434	7.63E+03	5.69E-05
Pu-239	0	6.22E+02	0.00E+00	0.496	5.86E+03	8.46E-05
Tc-99	0	6.67E+05	0.00E+00	5.7	4.22E+04	1.35E-04
Th-228	0	2.04E+03	0.00E+00	0.768	8.05E+02	9.54E-04
Th-230	0	1.39E+04	0.00E+00	5.36	1.04E+04	5.14E-04
Th-232	0	1.68E+03	0.00E+00	0.712	1.30E+03	5.48E-04
Th-234	0	3.81E+06	0.00E+00	3.39	4.33E+03	7.84E-04
U-234	0	6.83E+02	0.00E+00	4.56	5.27E+03	8.66E-04
U-235	0	7.36E+02	0.00E+00	0.287	3.73E+03	7.70E-05
U-238	10.8	7.56E+02	1.43E-02	8.65	2.49E+03	3.48E-03
Summed	-	-	**1.43E-02**	-	-	**8.55E-03**

4.2 CLEARANCE OF PROPERTY CONTAINING RESIDUAL RADIOACTIVE MATERIAL

DOE contractors use the processes, guidelines, and limits found in DOE Order 458.1 and associated guidance (such as the surface activity guidelines) for the clearance of residual radioactive material. 10 *CFR* 835 Surface Contaminated Object Limits are used for clearance of objects with the potential for surficial contamination, while specific Authorized Limits have been derived to control the release of items with potential volumetric contamination. In those cases where volumetric Authorized Limits have not been established, release is determined based on a comparison to established background radionuclide concentrations approved in the *Methods for Conducting Risk Assessments and Risk Evaluation* (DOE 2013b), where appropriate. Property potentially containing residual radioactive material will not be cleared from PGDP unless the property is demonstrated not to contain residual radioactive material or the property is evaluated and appropriately monitored or surveyed to determine that any residual radioactive material levels are within acceptable limits. Property clearance requirements are governed by procedures established by each DOE contractor.

In 2013, LATA Kentucky authorized 115 releases of non-real property that were assessed for contamination. Several of these releases were in support of reuse and recycling efforts. Multiple radiological surveys were performed to measure and assess the radiological status of the property. Items released included, but were not limited to, heavy equipment, vehicles, containers, tanks, monitoring equipment, activated carbon, batteries, recovered Freon, transformers, light ballasts, unused chemicals, and mobile offices. Items with the potential for volumetric contamination were assessed to determine if sampling was necessary to support the release. The results of volumetric samples were compared to established background concentrations.

In 2013, BWCS continued off-site shipment of hydrofluoric acid produced by the DUF_6 Conversion Facility, which converts DUF_6 into uranium oxide and hydrofluoric acid. Each shipment must meet the release limit of less than 3 pCi/mL of total uranium activity. During 2013, 1,318,813 gal of hydrofluoric acid were shipped off-site, and the total uranium activity of each shipment was < 1.06 pCi/mL.

All SST release surveys are for items that never were in a contaminated area.

In addition to off-site releases, DOE also placed some 810 tons of waste with residual radioactive contamination into the on-site C-746-U Landfill during 2013. The C-746-U Landfill waste acceptance criteria includes established volumetric and surficial Authorized Limits that govern disposal. Authorized Limits for the C-746-U Landfill initially were established in 2003 and have been maintained since that time. The latest revision was approved by DOE in 2011. Waste streams disposed of within the C-746-U Landfill during CY 2013 include, but are not limited to, building demolition debris, scrap metals, soils, personal protective clothing, investigation derived wastes, and concrete. Table 4.12 provides a summary of Authorized Limit disposals at the C-746-U Landfill during CY 2013 and the cumulative totals since Authorized Limit inception in May 2003.

Table 4.12. C-746-U Landfill Authorized Limit Disposals at C-746-U Landfill

Cumulative Activity from 2013 Disposals			Total Activity from Disposals 5/21/03 to 12/31/13			
Isotope	**Activity (Curies)**		**Isotope**	**Activity (Curies)**	**Inventory Limit (Curies)**	**Percent Utilized**
Am-241	0.000086974		Am-241	0.00616688	79	0.01%
Cs-137	0.000062775		Cs-137	0.01013736	43	0.02%
Np-237	0.000078427		Np-237	0.01141782	12	0.10%
Pu-238	0.000043004		Pu-238	0.00186785	88	0.00%
Pu-239/240	0.000086858		Pu-239/240	0.01376221	162	0.01%
Tc-99	0.005990041		Tc-99	1.01231318	117	0.87%
Th-228	0.000307886		Th-228	0.33676058	9	3.74%
Th-230	0.000475479		Th-230	0.58066208	230	0.25%
Th-232	0.000336776		Th-232	0.00055218	9	0.01%
U-234	0.003997262		U-234	0.00421266	360	0.00%
U-235	0.000247034		U-235	0.00046244	15	0.00%
U-238	0.008818624		U-238	0.00903403	360	0.00%
Waste Streams Disposed of (2013)	10		Waste Streams Disposed of (2003–2013)	250		
Mass Disposed of (2013)	810 tons		Mass Disposed (2003–2013)	121,000 tons		
			Volume of Current Cells	386,169 yd^3		
			Remaining Cell Volume	68,680 yd^3		

4.3 UNPLANNED RADIOLOGICAL RELEASES

During the winter and spring of 2013, an unplanned radiological release occurred as a result of high amounts of rainfall onto the C-340 demolition project. The C-340 facility was used to produce uranium tetrafluoride and uranium metal. In the fall of 2012, DOE began demolition of the facility as part of its EM mission. Demolition activities were undertaken using heavy equipment to disassemble and downsize the building structure and internal components. While predemolition decontamination activities significantly reduced the overall uranium holdup and contamination levels within the facility, considerable amounts of uranium remained in the facility as surface contamination and residue trapped within inaccessible spaces. Uranium residues from piles of demolition debris located on the C-340 footprint were mobilized by multiple rain events in the spring and summer. Despite efforts to mitigate the release of uranium into the stormwater runoff system, uranium was detected at increased levels in Outfalls 010 and 011. Upon notification of the uranium results, the project undertook corrective actions in an attempt to further mitigate the release by increasing the use of sediment controls, fixatives, and improved housekeeping; these corrective actions were effective in reducing future releases, but did not reduce concentrations already released.

The impacts of the unplanned release on the dose received by the MEI and biota have been discussed in previous sections. Outfalls 010 and 011 drain to Little Bayou Creek. Little Bayou Creek is not a source of drinking water; dose to the MEI was calculated assuming only incidental ingestion during recreational activities. Further, Little Bayou Creek is posted and controlled in accordance with 10 *CFR* § 835, which further limits public access. Due to these considerations, the resultant dose to the MEI from incidental surface water ingestion was found to be insignificant at 0.32 mrem/year.

THIS PAGE INTENTIONALLY LEFT BLANK

5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

5.1 AIR MONITORING

USEC steam plant emissions are the largest monitored nonradiological point source at the site. Responsibility for this and other USEC emission points was turned over to USEC as a result of the 1993 lease agreement. The only DOE point source required to perform monitoring is the DUF_6 Conversion Facility. During 2013, the total estimated HF emission for emission points U001 and U002 was approximately 61.7 lb. Additional remediation sources of air emissions other than radionuclides (see Chapter 4) for the Paducah Site in 2013 were the NWPGS and the NEPCS.

5.2 SURFACE WATER MONITORING

At the Paducah Site, the CWA regulations were applied through issuance of a KPDES permit for effluent discharges to Bayou Creek and Little Bayou Creek. The KDOW issued KPDES Permit No. KY0004049 to the Paducah Site. This permit applies to the following five DOE outfalls: 001, 015, 017, 019, and 020. Further, KDWM specifies in landfill permits SW07300014, SW07300015, and SW07300045 that surface runoff will be analyzed to ensure that landfill constituents are not discharging into nearby receiving streams. Sampling was performed in compliance with the KDWM requirements for operation of the contained landfill.

Surface water monitoring locations and the monitoring program under which they are sampled at the Paducah Site are shown in Figure 4.4 and in Table 5.1. Table 5.1 also shows the reporting requirements for each of these programs. Permit exceedances are described in Section 2. Monitoring results are available through the PEGASIS Web site at http://padgis.latakentucky.com/padgis/ and are summarized in Table 5.2.

5.3 SEDIMENT MONITORING

Sediment monitoring locations are shown in Figure 4.5. PCBs were detected in sediment during 2013 ranging from 110 µg/kg to 2,250 µg/kg. According to *Methods for Conducting Risk Assessments and Risk Evaluation*, the no action level[7] for PCBs is 284 µg/kg for the teen recreational user and the action level[8] is 28,400 µg/kg (DOE 2013b). Additional monitoring results are available through the PEGASIS Web site at http://padgis.latakentucky.com/padgis/.

[7] The no action level is the concentration that represents the lesser of an excess lifetime cancer risk of 10^{-6} and a hazard index of 0.1.
[8] The action level is the concentration that represents the lesser of an excess lifetime cancer risk of 10^{-4} and a hazard index of 3.

Table 5.1. Summary of Surface Water Monitoring at PGDP

Program	Number of Locations
Effluent Watershed Monitoring Program	
C-746-S and C-746-T Landfill Surface Water *Quarterly Compliance Monitoring Reports*: http://paducaheic.com/Search.aspx?accession=env 1.J.1-00224 http://paducaheic.com/Search.aspx?accession=env 1.J.1-00357 http://paducaheic.com/Search.aspx?accession=env 1.J.1-00374	3*
C-746-U Landfill Surface Water *Quarterly Compliance Monitoring Reports*: http://paducaheic.com/Search.aspx?accession=env 1.J.1-00320 http://paducaheic.com/Search.aspx?accession=env 1.J.1-00356 http://paducaheic.com/Search.aspx?accession=env 1.J.1-00375	3*
KPDES Monthly Discharge Monitoring Reports	5
C-613 Northwest Storm Water Control Facility Reported to KDWM via electronic mail	1
Environmental Surveillance Watershed Monitoring Program	
Surface Water	19
Seep	1

*One location is listed for both C-746-S and C-746-T and for C-746-U.

Table 5.2. Ranges of Detected Analytes in 2013 Surface Water Samples

Analyte	Range
Anions	
Chloride (mg/L)	2.3–35
Nitrate as Nitrogen (mg/L)	1.7–2.6
Sulfate (mg/L)	4–46
Wetchemistry Parameters	
Carbonaceous Biochemical Oxygen Demand (mg/L)	5–9
Chemical Oxygen Demand (mg/L)	26–76
Dissolved Solids (mg/L)	40–1970
Hardness—Total as $CaCO_3$ (mg/L)	16–560
Suspended Solids (mg/L)	8–492
Total Organic Carbon (mg/L)	1.3–24.8
Total Organic Halides (µg/L)	7.4–97
Total Solids (mg/L)	104–762
Semivolatile Organic Compounds	
Benz(a)anthracene (µg/L)	0.0025–0.009
Benzo(k)fluoranthene (µg/L)	0.006–0.0069
Volatile Organic Compounds	
Trichloroethene (µg/L)	1.7–41
Pesticides/PCBs	
Heptachlor (µg/L)	0.0088–0.0088
PCB-1248 (µg/L)	0.16–0.69
PCB-1254 (µg/L)	0.13–0.13
PCB-1260 (µg/L)	0.06–0.07
Polychlorinated biphenyl (µg/L)	0.26–0.69
Metals	
Arsenic (mg/L)	0.00106–0.00481
Barium (mg/L)	0.0118–0.131
Iron (mg/L)	0.0094–5.9

Table 5.2. Ranges of Detected Analytes in 2013 Surface Water Samples (Continued)

Analyte	Range
Lead (mg/L)	0.00282–0.00282
Nickel (mg/L)	0.00584–0.00933
Phosphorous (mg/L)	0.09–0.76
Selenium (mg/L)	0.00545–0.021
Sodium (mg/L)	0.971–8.57
Uranium (mg/L)	0.00101–1.74
Zinc (mg/L)	0.0207–2.81

5.4 BIOTA MONITORING

The KPDES permit calls for chemical monitoring and toxicity monitoring as an indicator of discharge-related effects in the receiving streams. Biological monitoring (i.e., fish or benthic macroinvertebrate sampling) was not required under the specifications listed in the renewed KPDES permit. Additionally, the watershed monitoring plan was revised to reflect the changes in the renewed permit due to extensive sampling campaigns conducted in the past.

5.4.1 Aquatic Life

Starting in 1987, aquatic or biological monitoring of Bayou Creek and Little Bayou Creek had been conducted following guidelines set forth in the Watershed Monitoring Plan (WMP). Requirements set forth in the WMP followed conditions in the KPDES permit and best management practices. Initially, those conditions required fish and benthic macroinvertebrate in the receiving creeks, as well as chronic and acute toxicity sampling at the KPDES outfalls. After years of collecting fish and benthic macroinvertebrate samples, KDOW issued a new KPDES permit eliminating the requirements for the fish and benthic macroinvertebrate sampling; however, the chronic and acute toxicity sampling remained a KPDES permit condition. Using a conservative approach, DOE continued the benthic macroinvertebrate sampling efforts through 2010. Benthic macroinvertebrate sampling was eliminated in 2011. Chronic and acute toxicity sampling remain in the KPDES permit and in the WMP.

Warning signs along Bayou and Little Bayou Creeks remain to warn members of the public about the possible risks posed by recreational contact with these waters, stream sediments, and fish caught in the creeks.

5.5 GROUNDWATER MONITORING

Monitoring and protection of groundwater resources at the Paducah Site are required by federal and Commonwealth of Kentucky regulations and by DOE Orders. Groundwater is not used for on-site purposes and when off-site contamination from the Paducah Site was discovered in 1988, DOE provided an alternate water supply to affected residences. Additional information regarding groundwater monitoring is provided in Section 6.

THIS PAGE INTENTIONALLY LEFT BLANK

6. GROUNDWATER PROTECTION PROGRAM

The *Results of the Site Investigation Phase 1* (CH2M HILL 1991) determined the primary off-site contaminants in the Regional Gravel Aquifer (RGA) to be TCE and Tc-99. TCE was used until 1993 as an industrial degreasing solvent and Tc-99 is a fission by-product contained in nuclear power reactor returns that were brought on-site through 1976 for reenrichment of U-235 (DOE 2001). Such reactor returns no longer are used in the enrichment process; however, Tc-99 still is present in the system. Known or potential sources of TCE and Tc-99 include former test areas, spills, leaks, buried waste, and leachate derived from contaminated scrap metal.

Investigations of the on-site source areas of TCE at the Paducah Site are ongoing. The main source of TCE contamination in the groundwater is near the C-400 Cleaning Building. TCE has a low solubility and a higher density than water, which are common characteristics of dense nonaqueous-phase liquids (DNAPLs). DNAPLs typically sink through the subsurface and may form pools in less permeable layers of the subsurface, as well as the base of the aquifer. This physical nature of DNAPLs makes treatment difficult because these pools constitute a continuous source of dissolved-phase contamination (i.e., plumes) deep within the aquifer. The highest concentration of DNAPL at the Paducah Site is associated with past activities at C-400.

Groundwater monitoring serves to detect the nature and extent of contamination (i.e., types of contaminants, concentration of contaminants) and to determine the movement of groundwater near the plant. Data obtained from the monitoring supports the decision making process for the ultimate disposition of the contaminants. Figure 6.1 presents monitoring wells sampled in CY 2013 and shows the 2012 TCE plume associated with PGDP (LATA Kentucky 2013e). The TCE plume map is revised every two years; therefore, the 2012 map is the most recent representation of the TCE plume. See Section 6.4 for additional information about the plumes associated with PGDP.

For access to historical groundwater data, visit the PEGASIS Web site at http://padgis.latakentucky.com/padgis/ to view data for over 150 MWs and groundwater locations at PGDP.

6.1 GEOLOGIC AND HYDROGEOLOGIC SETTING

The local groundwater flow systems at the Paducah Site include the following (from shallowest to deepest): (1) the Terrace Gravel flow system, (2) Upper Continental Recharge System (UCRS), (3) RGA, and (4) the McNairy flow system. Additional water-bearing zones monitored at the Paducah Site are the Eocene Sands and the Rubble Zone (i.e., the weathered upper portion of the Mississippian bedrock). These components are illustrated on Figure 6.2.

Groundwater flow originates south of the Paducah Site within Eocene Sands and the Terrace Gravel. Groundwater within the Terrace Gravel discharges to local streams and recharges the RGA. Groundwater flow through the UCRS predominantly is downward, also recharging the RGA. From the plant site, groundwater generally flows northward in the RGA toward the Ohio River, which is the local base level for the system. Flow in the McNairy beneath PGDP also is northward to discharge into the Ohio River.

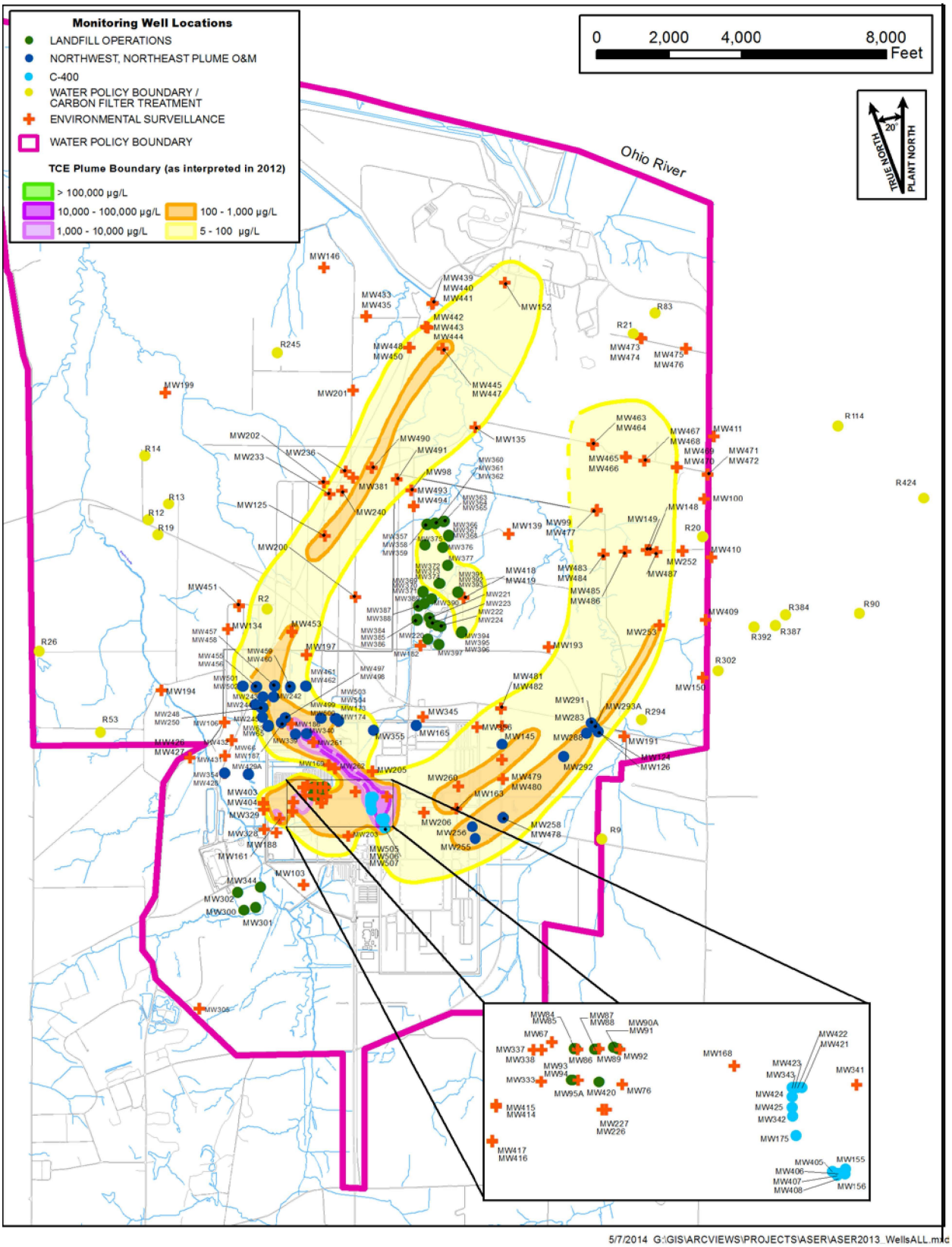

Figure 6.1. Monitoring Wells Sampled in CY 2013

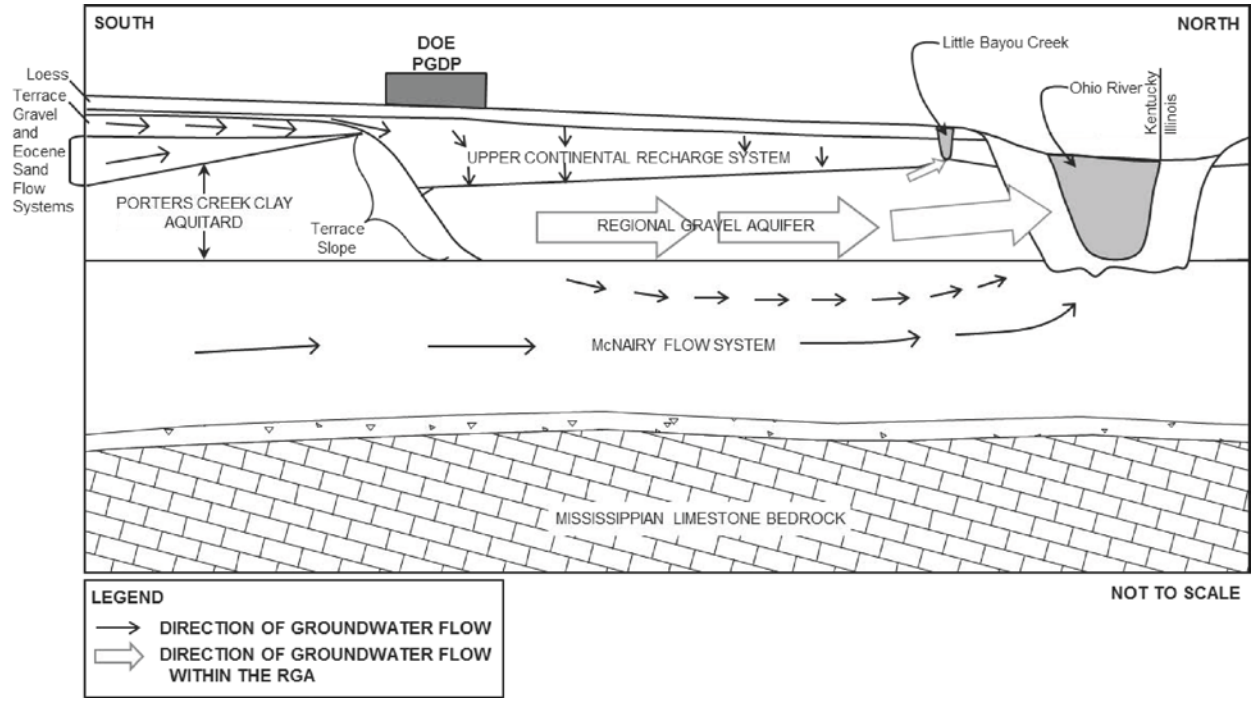

Figure 6.2. Paducah Site Groundwater Flow System

Additional information regarding the geology and hydrogeology of PGDP can be found in the *Report of the Paducah Gaseous Diffusion Plant Groundwater Investigation Phase III* (available at http://paducaheic.com/Search.aspx?accession=I-02500-0030) (MMES 1992).

6.2 USES OF GROUNDWATER IN THE VICINITY

The WKWMA and some lightly populated farmlands are in the immediate vicinity of the Paducah Site. Homes are sparsely located along rural roads in the vicinity of the site. Two communities, Grahamville and Heath, lie within 2 miles east of the plant.

Historically, groundwater was the primary source of drinking water for residents and industries in the vicinity of the plant area. In areas where the groundwater either is known to be contaminated or is suspected of becoming contaminated in the future, DOE has provided water hookups to the West McCracken County Water District and pays water bills for affected residences and businesses. Residential wells have been capped and locked except for those that are used by DOE for monitoring (per license agreement between DOE and each resident; renewed every five years).

PGDP uses surface water from the Ohio River for process waters and on-site drinking water. The nearest community downstream of Paducah using surface water for drinking water is Cairo, Illinois, which is located at the confluence of the Mississippi and Ohio Rivers.

6.3 GROUNDWATER MONITORING PROGRAM

MWs are used extensively at the Paducah Site to assess the effect of plant operations on groundwater quality. The primary objectives of groundwater monitoring at the Paducah Site are early detection of any contamination resulting from past and/or present land disposal of wastes and provision of data that can be used for decision documents, if contamination is detected.

The sitewide approach is outlined in the following two documents related to groundwater monitoring: (1) Groundwater Protection Plan (LATA Kentucky 2010); and (2) and the Paducah Site EMP (LATA Kentucky 2012; LATA Kentucky 2013a). Over 300 MWs and residential wells were sampled in accordance with DOE Orders and federal, state, and local requirements during 2013. Well sampling is included in several different monitoring programs, as shown in Table 6.1. Shown also in Table 6.1 are the reporting locations for each of these programs. Monitoring results are available through the PEGASIS Web site at http://padgis.latakentucky.com/padgis/.

Table 6.1. Summary of Groundwater Monitoring at PGDP

Program	Number of Wells				
	Terrace Gravel[a]	RGA	UCRS	Rubble Zone	Total
Groundwater Monitoring Program for Landfill Operations					
C-746-S and C-746-T Landfill Wells *Quarterly Compliance Monitoring Reports*: http://paducaheic.com/Search.aspx?accession=env 1.J.1-00224 http://paducaheic.com/Search.aspx?accession=env 1.J.1-00357 http://paducaheic.com/Search.aspx?accession=env 1.J.1-00374	0	18	5	0	23[b]
C-746-U Landfill Wells *Quarterly Compliance Monitoring Reports*: http://paducaheic.com/Search.aspx?accession=env 1.J.1-00320 http://paducaheic.com/Search.aspx?accession=env 1.J.1-00356 http://paducaheic.com/Search.aspx?accession=env 1.J.1-00375	0	13	8	0	21
C-404 Landfill Wells (required by permit) Semiannual C-404 Groundwater Monitoring Reports: http://paducaheic.com/Search.aspx?accession=env 1.J.1-00223 http://paducaheic.com/Search.aspx?accession=env 1.J.1-00358	0	5	4	0	9
C-404 Landfill Wells (noncommitted)	0	11	0	0	11[c]
C-746-K Landfill Wells Semiannual FFA Progress Reports: http://paducaheic.com/Search.aspx?accession=env 1.A-00527	4	0	0	0	4
Northeast Plume Operations and Maintenance Program Semiannual FFA Progress Reports (see above for links)					
Semiannual Wells	0	11	0	0	11[d]
Quarterly Wells	0	5	0	0	5
Northwest Plume Operations and Maintenance Program Semiannual FFA Progress Reports (see above for links)					
Semiannual Wells	0	33	0	0	33
C-400 Monitoring Wells Semiannual FFA Progress Reports (see above for links)					
Semiannual Wells	0	8	0	0	8
Quarterly Wells	0	9	0	0	9
Water Policy Boundary Monitoring Program ASER					
Northwestern Wells	0	22	0	0	22
Northeastern Wells	0	11	0	0	11

Table 6.1. Summary of Groundwater Monitoring at PGDP (Continued)

Program	Number of Wells				
	Terrace Gravel[a]	RGA	UCRS	Rubble Zone	Total
Carbon Filter Treatment System ASER	0	1	0	0	1
Environmental Surveillance Groundwater Monitoring Program ASER					
Biennial Wells	1	96	4	0	101
Annual Wells	0	26	1	1	28[d]
Geochemical Environmental Surveillance	0	39	0	0	39[e]

[a] Includes Eocene Sands.
[b] The total number of wells where sampling is required by the permit associated with the C-746-S&T Landfills is 25; however, 2 of these wells are required by the permit only for water level measurement. The total number of analytically measured wells, therefore, is 23.
[c] The total number of wells associated with the C-404 Landfill noncommitted wells is 11; however, these wells also are included in the Environmental Surveillance Groundwater Monitoring Program.
[d] Three wells were revised mid-CY 2013 from sampling under the Environmental Surveillance Program to the Northeast Plume Operations and Maintenance Program. At the end of CY 2013, the number of total wells under the Northeast Plume Operations and Maintenance Program was 14 and the Environmental Surveillance Groundwater Monitoring Annual Wells was 25.
[e] The total number of wells associated with the Geochemical Environmental Surveillance monitoring is 39; however, these wells also are monitored in other programs.

6.4 GROUNDWATER MONITORING RESULTS

Groundwater monitoring at the Paducah Site addresses general environmental surveillance, current and inactive landfills, groundwater plume pump-and-treat operations, the C-400 Cleaning Building, and area residential wells. The Environmental Surveillance Groundwater Monitoring Program is reviewed each year and modified as appropriate to continue to delineate the boundaries of the contaminant plumes over time. Groundwater monitoring results from all sampling efforts conducted by the Paducah Site are compiled in the Paducah Oak Ridge Environmental Information System (OREIS) database. A complete listing of analytical results is available upon request or by visiting the PEGASIS Web site at http://padgis.latakentucky.com/padgis/ to view data. A summary of detected analytes in 2013 are shown in Table 6.2.

The PGDP groundwater plume maps are revised every two years to provide a basis for timely incorporation of routine groundwater monitoring and characterization data, demonstrate the progress of groundwater cleanup to date, and facilitate planning to optimize the site groundwater cleanup. These maps depict the general footprint of the TCE and Tc-99 contamination in the RGA and convey the general magnitude and distribution of contamination within the plumes. For additional description of the PGDP plumes, please see *Trichloroethene and Technetium-99 Groundwater Contamination in the Regional Gravel Aquifer for Calendar Year 2012 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (LATA Kentucky 2013d). This document is available from the EIC and at the following link: http://paducaheic.com/Search.aspx?accession=ENV 1.J.1-00382.

Table 6.2. Ranges of Detected Analytes in 2013 Monitoring Well Groundwater Samples

Analyte	Range
Anions	
Chloride (mg/L)	5.1–190*
Fluoride (mg/L)	0.11–0.72
Nitrate as Nitrogen (mg/L)	1–4.5
Sulfate (mg/L)	4.9–1,740
Wet Chemistry Parameters	
Alkalinity (mg/L)	78–382
Chemical Oxygen Demand (mg/L)	26–38
Dissolved Solids (mg/L)	140–618
Iodide (mg/L)	2.6–2.6
Total Organic Carbon (mg/L)	1–12.9
Total Organic Halides (µg/L)	7–290
Radionuclides	
Alpha activity (pCi/L)	3.98–45.2
Beta activity (pCi/L)	4.27–999
Technetium-99 (pCi/L)	16.2–14,900*
Tritium (pCi/L)	572–707
Uranium-234 (pCi/L)	0.301–0.9
Uranium-238 (pCi/L)	0.067–1.01
Volatile Organic Compounds	
1,1-Dichloroethane (µg/L)	1.4–73
1,1-Dichloroethene (µg/L)	1–110
1,2,3-Trichloropropane (µg/L)	16-16
Carbon tetrachloride (µg/L)	28–28
Chloroform (µg/L)	1.2–73
cis-1,2-Dichloroethene (µg/L)	1.1–75,000*
trans-1,2-Dichloroethene (µg/L)	2.2–2.2
Trichloroethene (µg/L)	1–480,000*
Vinyl chloride (µg/L)	5.2–290
PCBs	
PCB-1242 (µg/L)	0.11–0.31
PCB-1248 (µg/L)	0.57–0.57
PCB-1254 (µg/L)	4.74–5.76
Polychlorinated biphenyl (µg/L)	0.18–5.76
Metals	
Aluminum (mg/L)	0.201–10.9
Arsenic (mg/L)	0.00101–0.0135
Barium (mg/L)	0.0144–0.418
Beryllium (mg/L)	0.00102–0.00102
Boron (mg/L)	0.222–2.02
Cadmium (mg/L)	0.00112–0.00112
Calcium (mg/L)	8.21–512
Chromium (mg/L)	0.0109–2.12
Cobalt (mg/L)	0.00105–0.0404
Iron (mg/L)	0.103–292
Iron (2+) (mg/L)	130–300
Lead (mg/L)	0.00132–0.0142
Magnesium (mg/L)	2.86–120
Manganese (mg/L)	0.00541–23.6
Molybdenum (mg/L)	0.0011–0.00686
Nickel (mg/L)	0.00503–0.406
Potassium (mg/L)	0.233–47.9
Selenium (mg/L)	0.00504–0.0274
Sodium (mg/L)	16.6–154
Uranium (mg/L)	0.00145–0.0135
Zinc (mg/L)	0.0215–0.0215
Arsenic, Dissolved (mg/L)	0.00126–0.0135
Barium, Dissolved (mg/L)	0.0141–0.434
Chromium, Dissolved (mg/L)	0.0107–0.0162
Lead, Dissolved (mg/L)	0.00253–0.00253
Selenium, Dissolved (mg/L)	0.00674–0.00674
Uranium, Dissolved (mg/L)	0.00131–0.0063

*Maximum results are from C-400 MWs.

Records of decision have been put in place to clean up the Northwest Plume (DOE 1993), the Northeast Plume (DOE 1995b), the C-400 Cleaning Building source area (DOE 2005), and sources to the Southwest Plume (DOE 2012). The locations where the actions defined in these records of decision have been put in place are shown in Figure 6.3. These documents can be found in the EIC. Table 6.3 lists the cumulative TCE removed through these projects. The graphs shown in Figures 6.4 and 6.5 illustrate the cumulative TCE removed by the NWPGS and the NEPCS.

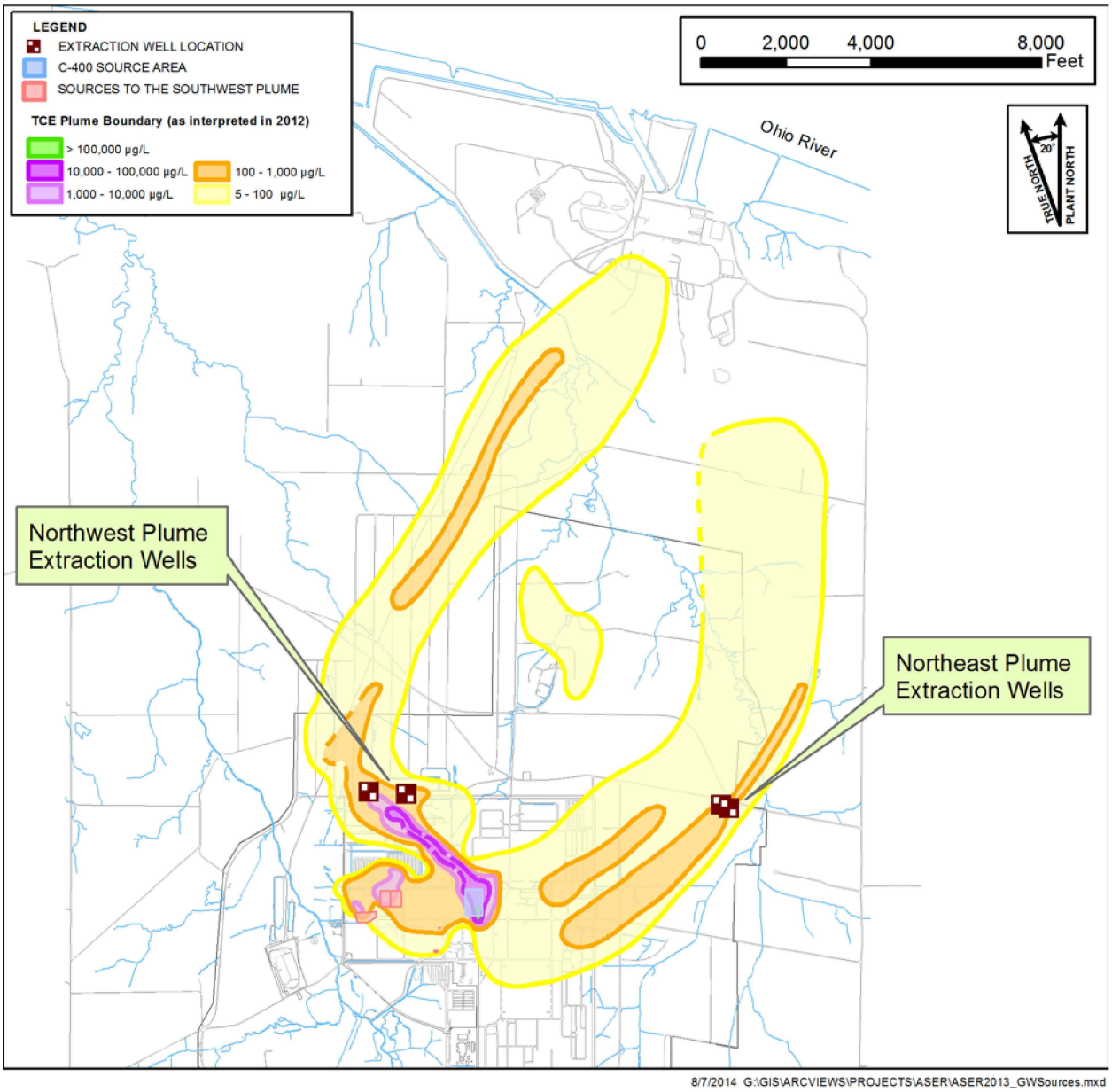

Figure 6.3. Locations of Groundwater Sources

Table 6.3. Cumulative TCE Removed at Paducah

Source Area	Cumulative TCE Removed (gal)
Northwest Plume Groundwater System	3,250
Northeast Plume Containment System	284
C-400 (including treatability study)	2,545[a]
Southwest Plume[b]	0
Other sources (i.e., SWMU 91, LASAGNA™)	246

[a] Cumulative through September 30, 2013.
[b] No remedial action implemented to date.

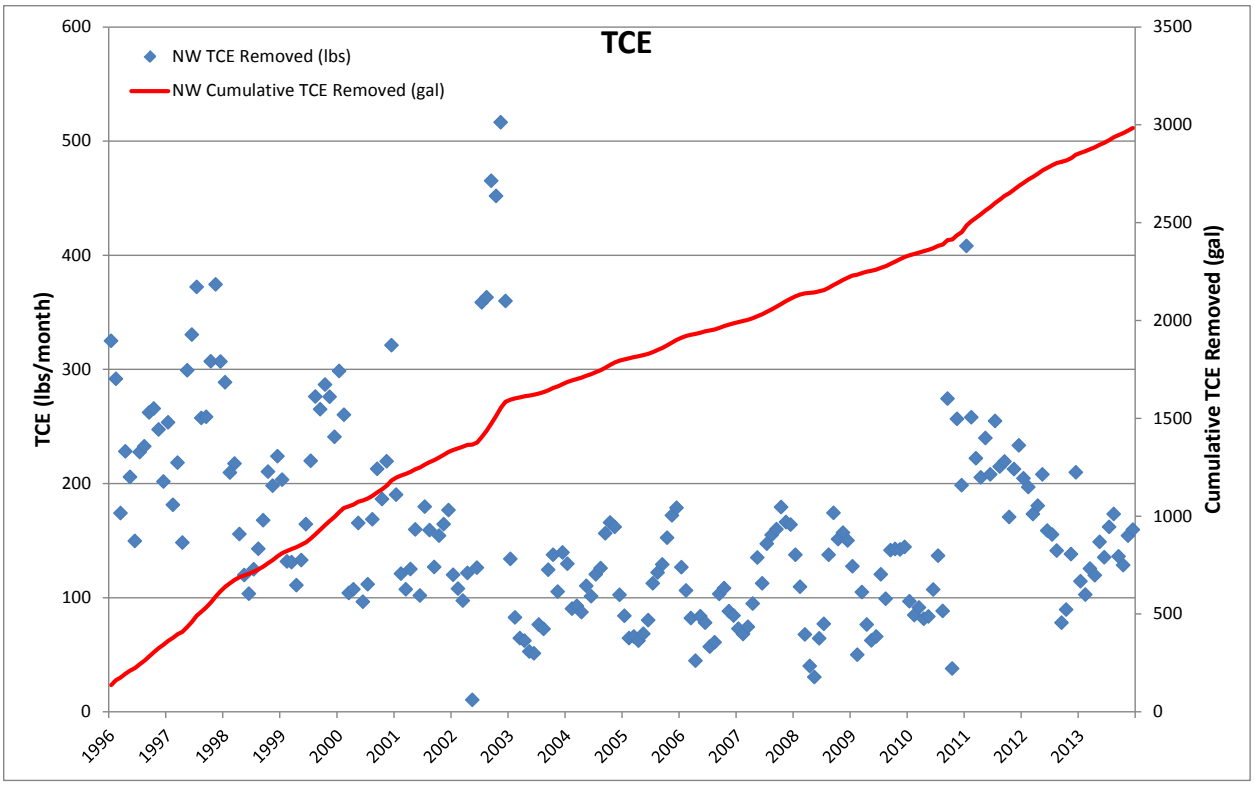

Figure 6.4. Northwest Plume Groundwater System TCE Removed

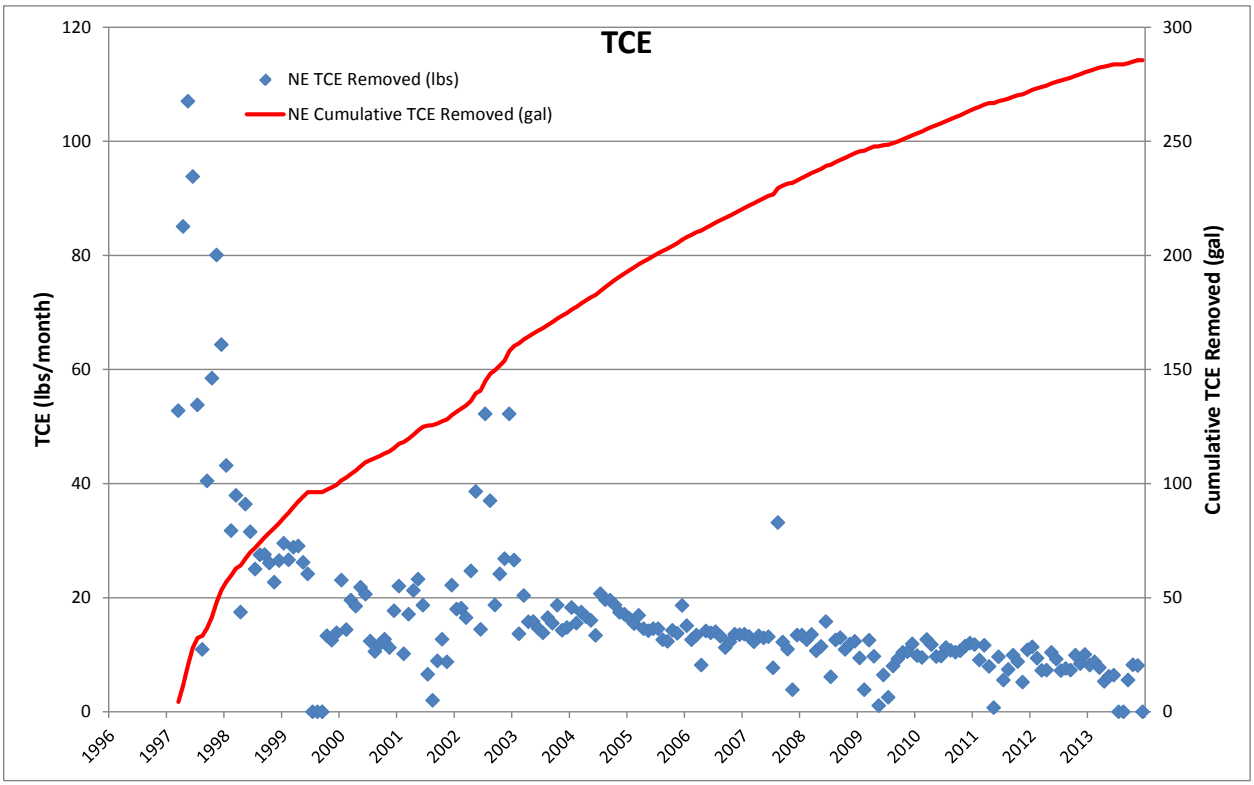

Figure 6.5. Northeast Plume Containment System TCE Removed

Groundwater monitoring at the compliance locations at C-746-S and C-746-T Landfill Wells, C-746-U Landfill Wells showed the Kentucky Solid Waste Facility (401 *KAR* 47:030 § 6) maximum contaminant level (MCL) exceedances listed in Table 6.4. Additional information, including a Groundwater Assessment Report that determined that there was no evidence indicating a release from the C-746-U Landfill, is found in Section 2.5.9. The report found that the beta activity and TCE in the wells were sourced from upgradient of the landfill and associated with migration of historical plumes (LATA Kentucky 2013d).

Table 6.4. Summary of MCL Exceedances for C-746-S & -T and C-746-U in 2013

C-746-S and C-746-T Landfills		
UCRS	**Upper RGA**	**Lower RGA**
None	MW372: beta activity, trichloroethene MW384: beta activity MW387: beta activity MW39l: trichloroethene MW394: trichloroethene	MW373: beta activity, trichloroethene MW385: beta activity MW388: beta activity MW392: trichloroethene
C-746-U Landfill		
UCRS	**Upper RGA**	**Lower RGA**
None	MW357: trichloroethene MW372: beta activity, trichloroethene	MW358: trichloroethene MW361: trichloroethene MW373: beta activity, trichloroethene

Shading indicates a background MW.

In addition to Kentucky Solid Waste Facility MCL exceedances, requirements at the C-746-S and C-746-T Landfill and C-746-U Landfill include evaluation of whether statistically significant increases in compounds other than those set forth in 401 *KAR* 47:030 § 6 have occurred at the landfills.

The C-404 Landfill groundwater monitoring requirements use four tiers of statistical analysis to evaluate compliance MWs. Results of the statistical analyses indicate an increased concentration of dissolved arsenic in MW84 as compared to background wells; however, this increase was discounted primarily due to the nature of the statistical analysis. Further, the dissolved arsenic concentration was below the MCL.

THIS PAGE INTENTIONALLY LEFT BLANK

7. QUALITY ASSURANCE

The Paducah Site maintains a QA/Quality Control (QC) Program to verify the integrity of data generated within the Environmental Monitoring Program. Each aspect of the monitoring program, from sample collection to data reporting, must comply with quality requirements and assessment standards. Requirements and guidelines for the QA/QC Program at the Paducah Site are established by the following:

- DOE Order 414.1D, *Quality Assurance*;
- *Quality Assurance Program and Implementation Plan*, PAD-PLA-QM-001 (LATA Kentucky 2013f);
- Commonwealth of Kentucky and federal regulations and guidance from EPA;
- American National Standards Institute;
- American Society of Mechanical Engineers;
- American Society for Testing and Materials (ASTM); and
- American Society for Quality Control.

The QA/QC Program specifies organizational and programmatic elements to control equipment, design, documents, data, nonconformances, and records. Emphasis is placed on planning, implementing, and assessing activities and implementing effective corrective actions, as necessary. Program requirements are specified in project and subcontract documents to ensure that requirements are included in project-specific QA plans and other planning documents. PGDP uses DOE Consolidated Audit Program (DOECAP)-audited laboratories. DOECAP implements annual performance qualification audits of environmental analytical laboratories and commercial waste treatment, storage, and disposal facilities to support complex-wide DOE mission activities.

In 2013, the EMP defined the relationship of each element of the Environmental Monitoring Program. The *Environmental Monitoring Quality Assurance Project Plan* (QA Plan) defined the relationship of each element of the Environmental Monitoring Program to key quality and data management requirements. The QA Plan is an appendix to the EMP (LATA Kentucky 2012; LATA Kentucky 2013a). A programmatic QA Plan was implemented in 2013. Additionally, the following procedures further ensure quality:

- Field forms are maintained in accordance with PAD-RM-1009, *Records Management, Administrative Record, and Document Control.*

- Communication and documentation between the sample and data management organization and field sampling personnel are conducted in accordance with PAD-ENM-5007, *Data Management Coordination.*

- Sample labels and chains-of-custody are completed according to PAD-ENM-2708, *Chain-of-Custody Forms, Field Sample Logs, Sample Labels, and Custody Seals*.

- Data assessment is conducted by a technical reviewer or their designee according to PAD-ENM-5003, *Quality Assured Data*.

- Logbooks and data forms are prepared in accordance with PAD-ENM-2700, *Logbooks and Data Forms*.

The QA Plan and the procedures cited above were in effect and covered data collected during the time frame of January through December 2013. Training requirements, sample custody, procedures, instrument calibration and maintenance, and data review are a few of the subjects discussed in the QA Plan and above procedures.

7.1 FIELD SAMPLING QUALITY CONTROL

7.1.1 Data Quality Objectives and Sample Planning

From the start of any sampling program, data quality objectives (DQOs) play an important role in setting the number of samples, location of sampling sites, sampling methods, sampling schedules, and coordination of sampling and analytical resources to meet critical completion times. These sampling program criteria are documented in the Paducah Site EMP (LATA Kentucky 2012; LATA Kentucky 2013a).

Each sampling location and sample collected is assigned a unique identification number. Each segment of the identification number sequence is used to designate information concerning the location from which a sample is collected. To progress from planning to implementing the DQOs, an analytical statement of work (SOW) for the analytical laboratory was generated from a system within the Paducah Integrated Data System. From this system, the Project Environmental Measurements System (PEMS), an electronic database used for managing and streamlining field-generated and laboratory-generated data, is populated with sample identification numbers, sampling locations, sampling methods, analytical parameters, analytical methods, and sample container and preservative requirements. This information is used to produce sample bottle labels and chain-of-custody forms for each sampling event.

7.1.2 Field Measurements

Field measurements for the groundwater and surface water monitoring program are collected in the field and include water level measurements, pH, conductivity, flow rate, turbidity, temperature, dissolved oxygen, total residual chlorine, ORP (oxidation/reduction potential) and barometric pressure. Environmental conditions, such as ambient temperature and weather, also are recorded. Field measurements are collected, downloaded electronically, recorded on appropriate field forms or recorded in logbooks, and input into PEMS.

7.1.3 Sampling Procedures

Samples are collected using media-specific procedures, which are written according to EPA-approved sampling methods. Sample media consist of surface water, groundwater, and sediment. Sample information recorded during a sampling event consists of the sample identification number, station (or location), date collected, time collected, and person who performed the sampling. This information, which is documented in a logbook or data form, on a chain-of-custody form, and on the sample container label, then is input directly into PEMS. Chain-of-custody forms are maintained from the point of sampling, and the samples are protected properly until they are placed in the custody of an analytical laboratory.

7.1.4 Field Quality Control Samples

The QC program for both groundwater and environmental monitoring activities specifies a minimum target rate of 5%, or 1 per 20 environmental samples, for field QC samples. Table 7.1 shows the types of field QC samples collected and analyzed. Analytical results of field QC samples are evaluated to determine if the sampling event biased the sample results.

Table 7.1. Types of QC Samples

Field QC Samples	Laboratory QC Samples
Field blanks[a]	Laboratory duplicates
Field duplicates	Reagent blanks
Trip blanks[a]	Matrix spikes[b]
Equipment rinseates[c]	Matrix spike duplicates
	Performance evaluations
	Laboratory control samples

[a] Blanks = Samples of deionized water used to assess potential contamination from a source other than the media being sampled.
[b] Spikes = Samples that have been mixed with a known quantity of a chemical to measure overall method effectiveness during the analysis process, as well as possible sample/matrix interferences.
[c] Rinseates = Samples of deionized water that have been used to rinse the sampling equipment. It is collected after completion of decontamination and prior to sampling. It is used to assess adequate decontamination of sampling equipment.

7.2 ANALYTICAL LABORATORY QUALITY CONTROL

7.2.1 Analytical Procedures

When available and appropriate for the sample matrix, EPA-approved SW-846 methods are used for sample analysis. When SW-846 methods are not available, other nationally recognized methods, such as those developed by DOE and ASTM, are used. Analytical methods are identified in a SOW for laboratory services. Using guidance from EPA, laboratories document the steps in sample handling, analysis, reporting results, and follow chain-of-custody procedures.

7.2.2 Laboratory Quality Control Samples

Laboratory QC samples are prepared and analyzed as required by the analytical methods used. Typical laboratory QC samples are identified in Table 7.1. If QC acceptance criteria are not met, then appropriate action, as denoted by the analytical method, is taken or the analytical data are qualified appropriately.

7.2.3 Independent Quality Control

The Paducah Site is required by DOE and EPA to participate in independent QC programs. The site also participates in voluntary independent programs to improve analytical QC. These programs generate data that readily are recognized as objective measures that provide participating laboratories and government agencies a periodic review of their performance. Results that exceed acceptable limits are investigated and documented according to formal procedures. Although participation in certain programs is mandatory, the degree of participation is voluntary, so that each laboratory can select parameters of particular interest to that facility. These programs are conducted by EPA, DOE, and commercial laboratories.

The EPA and KDOW require, as part of their QA program, a laboratory QA study. Each laboratory performing analyses to demonstrate KPDES permit compliance is required to participate. Three laboratories and one sampling organization participated in the study in 2013. Final results for the Discharge Monitoring Report QA Study Number 33 were “acceptable.” Discharge Monitoring Report QA Study results were provided to KDOW and EPA, as required.

7.2.4 Laboratory Audits/Sample and Data Management Organization

Laboratory audits are performed annually by DOECAP to ensure that the laboratories are in compliance with regulations, methods, and procedures. The audited laboratories are included on the DOECAP-audited listing for use by the sample and data management organization. Findings are documented and addressed by the audited laboratory through corrective actions. LATA Kentucky reviews DOECAP audit reports and laboratory corrective action plans for compliance with LATA Kentucky requirements on an annual basis.

7.3 DATA MANAGEMENT

7.3.1 Project Environmental Measurements System

The data generated from sampling events are stored in PEMS, a consolidated site data system for tracking and managing data. The system is used to manage field-generated data, import laboratory-generated data, input data qualifiers identified during the data review process, and transfer data to the Paducah OREIS database for reporting. PEMS uses a variety of references and code lists to ensure consistency and standardization of the data.

7.3.2 Paducah OREIS

Paducah OREIS is the database used to consolidate data generated by the Environmental Monitoring Program. Data consolidation consists of the activities necessary to prepare the evaluated data for the users. The PEMS files containing the assessed data are transferred from PEMS to Paducah OREIS for future use. The data manager is responsible for notifying the project team and other data users of the available data. Data used in reports distributed to external agencies (e.g., the quarterly landfill reports and the ASER) are obtained from Paducah OREIS and have been through the data review process. [The data review process is documented in *Data and Documents Management and Quality Assurance Plan for Paducah Environmental Management and Enrichment Facilities*, Section 8.4 (DOE 1998)].

7.3.3 PEGASIS

PEGASIS allows access to environmental sampling data and site-specific geographic information system features through the Internet. PEGASIS includes analytical sample results from various environmental studies, restoration reports and supporting documents, and maps. Environmental data loaded to Paducah OREIS has been assessed, verified, and validated (if applicable), as specified in PAD-ENM-5003, *Quality Assured Data*. Environmental data from Paducah OREIS is loaded into PEGASIS on a monthly basis. PEGASIS does not contain data related to waste or facility characterization. Access to PEGASIS is available at http://padgis.latakentucky.com/padgis/.

7.3.4 Electronic Data Deliverables

A “results only” electronic data deliverable (EDD) is requested for all samples analyzed by each laboratory. The results and qualifier information from the EDD are checked in addition to the format of all fields provided. Discrepancies are reported immediately to the laboratory so corrections can be made or new EDDs can be issued. Approximately 10% of the EDDs are checked randomly to verify that the laboratory continues to provide adequate EDDs.

7.3.5 Data Packages

A “forms only” Level III data package is requested from the laboratory when data validation is to be performed on a specific sampling event or media. All data packages received from the fixed-base laboratory are tracked, reviewed, and maintained in a secure environment. The following information is tracked: sample delivery group number, date received, receipt of any EDD, and comments. The contents of the data package and the chain-of-custody forms are compared and discrepancies identified. Discrepancies are reported immediately to the laboratory and data validators. All data packages are forwarded to the Document Management Center for permanent storage.

7.3.6 Laboratory Contractual Screening

Laboratory contractual screening is the process of evaluating a set of data against the requirements specified in the analytical SOW to ensure that all requested information is received. The contractual screening includes, but is not limited to, the chain-of-custody form, analytes requested, method used, units, holding times, and reporting limits achieved. The contractual screening is conducted electronically upon receipt of data from the analytical laboratory. Any exception to the SOW is identified and documented.

7.3.7 Data Verification, Validation, and Assessment

Data verification is the process for comparing a data set against a set standard or contractual requirement. Verification is performed electronically, manually, or by a combination of both. Data verification includes contractual screening and other criteria specific to the data. Data are flagged as necessary. Verification qualifiers are stored in PEMS and transferred with the data to Paducah OREIS.

Data validation is the process performed by a qualified individual for a data set, independent from sampling, laboratory, project management, or other decision making personnel. Data validation evaluates laboratory adherence to analytical method requirements. Validation qualifiers are stored in PEMS and transferred with the data to Paducah OREIS. Data from routine sampling events are validated programmatically at a frequency of 5% of the total data packages. Each of the selected data packages, which make up 5% of the total number of data packages, is validated 100%. From the environmental monitoring data, 12 packages were validated in CY 2013.

Data assessment is the process for assuring that the type, quality, and quantity of data are appropriate for its intended use based on the DQOs. It allows for the determination that a decision (or estimate) can be made with the desired level of confidence, given the quality of the data set. Data assessment follows data verification and data validation (if applicable) and must be performed at a rate of 100% to ensure data are useable. The data assessment is conducted by trained technical personnel in conjunction with other project team members. Assessment qualifiers are stored in PEMS and transferred with the data to Paducah OREIS. Data are made available for reporting from Paducah OREIS upon completion of the data assessment, and associated documentation is filed with the project files. Rejected data identified in the verification or validation process are noted as rejected in OREIS.

THIS PAGE INTENTIONALLY LEFT BLANK

8. REFERENCES

BJC (Bechtel Jacobs Company LLC) 1998. *The Polychlorinated Biphenyl Annual Compliance Agreement Report for the Paducah Gaseous Diffusion Plant, January 1 – December 31, 1997*, BJC/PAD-10, Bechtel Jacobs Company LLC, Paducah, KY, June.

BJC 2006. *Cultural Resources Survey for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, BJC/PAD-688/R1, Bechtel Jacobs Company LLC, Paducah, KY, March.

BWCS (B&W Conversion Services, LLC) 2014. Letter to Ms. Sara Beard, Division of Water, Commonwealth of Kentucky, from John D. Wollery, President and Project Manager, "Contract No. DE-AC30-11CC40015, DUF_6 Conversion Project Paducah Gaseous Diffusion Plant, Toxicity Reduction Evaluation (TRE) Second Quarter 2014 Progress Report Agency Interest Number 3059, Kentucky Pollutant Discharge Elimination System Permit No: KY0004049," July 30.

CH2M HILL 1991. *Results of the Site Investigation Phase I, at the Paducah Gaseous Diffusion Plant*, Paducah, Kentucky, KY/ER-4, CH2M HILL, Paducah, KY.

CH2M HILL 1992. *Results of the Site Investigation, Phase II, at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/SUB/13B-97777C P-03/1991/1, CH2M HILL, Paducah, KY.

COE (U.S. Army Corps of Engineers) 1994. *Environmental Investigations at the Paducah Gaseous Diffusion Plant and Surrounding Area, McCracken County, Kentucky*, Five Volumes, U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

DOC (U.S. Department of Commerce) 2013. McCracken County Quick Facts from the U.S. Census Bureau, http://quickfacts.census.gov/gfd/states/21/21145.html (accessed March 14, 2013).

DOE (U.S. Department of Energy) 1993. *Record of Decision for Interim Remedial Action at the Northwest Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/06-1143&D4, Science Applications International Corporation, Paducah, KY, July.

DOE 1995a. *Environmental Assessment for the Construction, Operation, and Closure of the Solid Waste Landfill at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/EA-1046, U.S. Department of Energy, Oak Ridge, TN.

DOE 1995b. *Record of Decision for Interim Remedial Action at the Northeast Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/06-1356&D2, Jacobs Engineering Group, Inc., Paducah, KY, June.

DOE 1998. *Data and Documents Management and Quality Assurance Plan for Paducah Environmental Management and Enrichment Facilities*, DOE/OR/07-1595&D2, Bechtel Jacobs Company LLC, Kevil, KY.

DOE 1999. *Final Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride*, DOE/EIS-0269, Office of Nuclear Energy, Science and Technology, April.

DOE 2001. *Feasibility Study for the Groundwater Operable Unit at Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1857&D2, U.S. Department of Energy, Paducah, KY, August.

DOE 2005. *Record of Decision for Interim Remedial Action for the Groundwater Operable Unit for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/OR/07-2150&D2/R2, Bechtel Jacobs Company LLC, Paducah, KY, July.

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

DOE 2012. *Record of Decision for Solid Waste Management Units 1, 211-A, 211-B, and Part of 102 Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0365&D2/R1, U.S. Department of Energy, Paducah, KY, March.

DOE 2013a. *Site Management Plan Paducah Gaseous Diffusion Plant, Paducah, Kentucky, Annual Revision—FY 2013*, DOE/LX/07-1284&D2/R1, U.S. Department of Energy, Paducah, KY, July.

DOE 2013b. *Methods for Conducting Risk Assessments and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0107&D2/R2, Volume 1, *Human Health*, U.S. Department of Energy, Paducah, KY, June.

DOE 2014. *Removal Action Report for the C-340 Metals Reduction Plant at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-1286&D2, U.S. Department of Energy, Paducah, KY, April.

EPA (U.S. Environmental Protection Agency) 1992. *Compliance Agreement between the United States Department of Energy and the United States Environmental Protection Agency, Washington, D.C.*, U.S. Environmental Protection Agency, Washington, DC, February.

EPA 1998. *Federal Facility Agreement for the Paducah Gaseous Diffusion Plant*, U.S. Environmental Protection Agency, Atlanta, GA, February 13.

ESRI (Environmental Systems Research Institute, Inc.) 2012. Population layer by zip code created in conjunction with Tom-Tom from 2010 census data.

FEMA (Federal Emergence Management Agency) 2013. Flood Insurance Rate Map, http://map1.msc.fema.gov/idms/IntraView.cgi?KEY=36310734&IFIT=1 (accessed March 18, 2013).

Garland, Jennifer M. June 5, 2008. U.S. Department of the Interior, Fish and Wildlife Service. Frankfort, KY. "Final Biological Opinion: Proposed Participation In and Approval of Conservation Memoranda of Agreement for the Indiana Bat (Myotis sodalis)," memorandum to Field Supervisor, Frankfort, KY.

ICRP (International Commission on Radiological Protection) 1980. Annals of the ICRP, Parts I and II, "Limits for Intakes of Radionuclides by Workers, International Commission on Radiological Protection," Publication 30, Elmsford, NY.

LATA Kentucky (LATA Environmental Services of Kentucky, LLC) 2010. *Groundwater Protection Plan for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, PAD-PROJ-0018, LATA Environmental Services of Kentucky, LLC, Kevil, KY, August.

LATA Kentucky 2012. *Environmental Monitoring Plan, Fiscal Year 2013, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, PAD-ENM-0055/R2, LATA Environmental Services of Kentucky, LLC, Kevil, KY, December.

LATA Kentucky 2013a. *Environmental Monitoring Plan, Fiscal Year 2014, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, PAD-ENM-0055/R3, LATA Environmental Services of Kentucky, LLC, Kevil, KY, November.

LATA Kentucky 2013b. *LATA Environmental Services of Kentucky, LLC, Environmental Radiation Protection Program at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, PAD-PROG-0055, LATA Environmental Services of Kentucky, LLC, Kevil, KY, November.

LATA Kentucky 2013c. *National Emission Standards for Hazardous Air Pollutants Management Plan for Emission of Radionuclides for the U.S. Department of Energy Operations at the Paducah Site, Paducah, Kentucky*, PAD-REG-1017, LATA Environmental Services of Kentucky, LLC, Kevil, KY, November.

LATA Kentucky 2013d. *Groundwater Assessment Report for the C-746-U Solid Waste Landfill at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, PAD-ENM-0064/R1, LATA Environmental Services of Kentucky, LLC, Kevil, KY, May.

LATA Kentucky 2013e. *Trichloroethene and Technetium-99 Groundwater Contamination in the Regional Gravel Aquifer for Calendar Year 2012 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, PAD-ENR-0136, LATA Environmental Services of Kentucky, LLC, Kevil, KY, June.

LATA Kentucky 2013f. *Quality Assurance Program and Implementation Plan for the Paducah Environmental Remediation Project*, PAD-PLA-QM-001/R4AC1, LATA Environmental Services of Kentucky, LLC, Kevil, KY, October.

LATA Kentucky 2014a. *Annual Document of Polychlorinated Biphenyls at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, for January 1, 2013–December 31, 2013*, PAD-SO-0054, LATA Environmental Services of Kentucky, LLC, Kevil, KY, June.

LATA Kentucky 2014b. *National Emissions Standards for Hazardous Air Pollutants Annual Report for 2013 U.S. Department of Energy Emissions at the Paducah Gaseous Diffusion Plant*, PAD-REG-1022, LATA Environmental Services of Kentucky, LLC, Kevil, KY, June.

LATA Kentucky 2014c. *Paducah Site Annual Site Environmental Report for Calendar Year 2012*, PAD-REG-1018, LATA Environmental Services of Kentucky, LLC, Kevil, KY, June.

LATA Kentucky 2014d. *Annual Report on External Gamma Radiation Monitoring for CY 2013, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, PAD-RAD-0621, LATA Environmental Services of Kentucky, LLC, Kevil, KY, March.

MMES (Martin Marietta Energy Systems, Inc.) 1992. *Report of the Paducah Gaseous Diffusion Plant Groundwater Investigation, Phase III*, KY/E-150, Martin Marietta Energy Systems, Inc., Paducah, KY, November 25.

NCRP (National Council on Radiation Protection and Measurements) 2009. "Ionizing Radiation Exposure of the Population of the United States," *NCRP Report No. 160*, National Council on Radiation Protection and Measurements, Washington, DC.

SST (Swift & Staley Team) 2012. *Fiscal Year 2013 Site Sustainability Plan, Paducah Gaseous Diffusion Plant,* SST.SSP-0001/R3, Swift & Staley Team, Paducah, KY, December.

Glossary

absorption—The process by which the number and energy of particles or photons entering a body of matter are reduced by interaction with the matter.

adsorption—The accumulation of gases, liquids, or solutes on the surface of a solid or liquid.

activity—See radioactivity.

air stripping—The process of bubbling air through water to remove volatile organic compounds from the water.

alpha particle—A positively charged particle emitted from the nucleus of an atom having the same charge and mass as that of a helium nucleus (two protons and two neutrons).

ambient air—The atmosphere around people, plants, and structures.

analyte—A constituent or parameter being analyzed.

aquifer—A geologic formation, group of formations, or part of a formation capable of yielding a significant amount of groundwater to wells or springs.

aquitard—A geologic unit that inhibits the flow of water.

assimilate—To take up or absorb.

atom—Smallest particle of an element capable of entering into a chemical reaction.

authorized limit—A limit on the concentration or quantity of residual radioactive material on the surfaces or within property that has been derived consistent with DOE directives including the as low as reasonably achievable (ALARA) process requirements. An authorized limit also may include conditions or measures that limit or control the disposition of property.

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

biota—The animal and plant life of a particular region considered as a total ecological entity.

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

chain-of-custody form—A form that documents sample collection, transport, analysis, and disposal.

closure—Formal shutdown of a hazardous waste management facility under Resource Conservation and Recovery Act requirements.

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

composite sample—A single sample that is representative of a continuous event or multiple increments over a designated period of time at a particular location.

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

conductivity—A measure of a material's capacity to convey an electric current. For water, this property is related to the total concentration of the ionized substances in water and the temperature at which the measurement is made.

confluence—The point at which two or more streams meet; the point where a tributary joins the main stream.

congener—Any particular member of a class of chemical substances. A specific congener is denoted by a unique chemical structure.

contained landfill—A solid waste site or facility that accepts disposal of solid waste. The technical requirements for contained landfills are found in 401 *KAR* 47:080, 48:050, and 48:070 to 48:090.

contamination—Deposition of radioactive material on the surfaces of structures, areas, objects, or personnel; or introduction of microorganisms, chemicals, toxic substances, wastes, or wastewater into water, air, and soil in a concentration greater than that found naturally.

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

curie (Ci)—A unit of radioactivity. One curie is defined as 3.7×10^{10} (37 billion) disintegrations per second. Several fractions and multiples of the curie are used commonly:

- **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; 3.7×10^{-2} disintegrations per second.

daughter—A nuclide formed by the radioactive decay of a parent nuclide.

decay, radioactive—The spontaneous transformation of one radionuclide into a different radioactive or nonradioactive nuclide or into a different energy state of the same radionuclide.

dense nonaqueous-phase liquid (DNAPL)—The liquid phase of chlorinated organic solvents. These liquids are denser than water and include commonly used industrial compounds such as tetrachloroethene and trichloroethene.

derived concentration technical standard (DCS)—A DOE technical standard that documents the derived concentration value for a radionuclide in water that would result in a dose of 100 mrem in a year to a gender- and age-weighted reference person using DOE-approved dose conversion factors and assuming continuous exposure. The standard is established in DOE Order 458.1, *Radiation Protection of the Public and the Environment.*

disintegration, nuclear—A spontaneous nuclear transformation (radioactivity) characterized by the emission of energy and/or mass from the nucleus of an atom.

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

- **absorbed dose**—The quantity of 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 Gy).

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

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

- **committed effective dose equivalent/committed effective dose**—The sum of total absorbed dose (measured in mrem) to a tissue or organ received over a 50-year period resulting from the intake of radionuclides, multiplied by the appropriate weighting factor. The committed effective dose equivalent is the product of the annual intake (pCi) and the dose conversion factor for each radionuclide (mrem/pCi). Committed effective dose equivalent is expressed in units of rem (or sievert).

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

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

downgradient—In the direction of decreasing hydrostatic head.

downgradient well—A well that is installed hydraulically downgradient of a site and that may be capable of detecting migration of contaminants from a site.

drinking water standards (DWS)—Federal primary drinking water standards, both proposed and final, as set forth by the EPA in 40 *CFR* § 141 and 40 *CFR* § 143.

effluent—A liquid or gaseous waste discharge to the environment.

effluent monitoring—The collection and analysis of samples or measurements of liquid and gaseous effluents for purposes of characterizing and quantifying the release of contaminants, assessing radiation exposures to members of the public, and demonstrating 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 that exposure to ionizing radiation received at a person's workplace. Population exposure is the exposure to the total number of persons who inhabit an area.

external radiation—Exposure to ionizing radiation when the radiation source is located outside the body.

formation—A mappable unit of consolidated or unconsolidated geologic material of a characteristic lithology or assemblage of lithologies.

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.

grab sample—An individual sample collected within a short period of time at a particular location.

groundwater, unconfined—Water that is in direct contact with the atmosphere through open spaces in permeable material.

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.

hardness—The amount of calcium carbonate dissolved in water, usually expressed as part of calcium carbonate per million parts of water.

high-level waste—High-level radioactive waste or HLW means: (1) irradiated reactor fuel; (2) liquid wastes resulting from the operation of the first cycle solvent extraction system, or equivalent, and the concentrated wastes from subsequent extraction cycles, or equivalent, in a facility for reprocessing irradiated reactor fuel; and (3) solids into which such liquid wastes have been converted.

hydrogeology—Hydraulic aspects of site geology.

hydrology—The science dealing with the properties, distribution, and circulation of natural water systems.

in situ—In its original place; field measurements taken without removing the sample from its origin; remediation performed while groundwater remains below the surface.

internal dose factor—A factor used to convert intakes of radionuclides to dose equivalents.

internal radiation—Occurs when natural radionuclides enter the body by ingestion of foods or liquids or by inhalation. Radon is the major contributor to the annual dose equivalent for internal radionuclides.

ion—An atom or compound that carries an electrical charge.

irradiation—Exposure to radiation.

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

- **long-lived isotope**—A radionuclide that decays at such a slow rate that a quantity of it will exist for an extended period (half-life is greater than three years).

- **short-lived isotope**—A radionuclide that decays so rapidly that a given quantity is transformed almost completely into decay products within a short period (half-life is two days or less).

laboratory detection limit—The lowest reasonably accurate concentration of an analyte that can be detected; this value varies depending on the method, instrument, and dilution used.

lower limit of detection—The smallest concentration or amount of analyte that can be reliably detected in a sample at a 95% confidence level.

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

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

milliroentgen (mR)—A measure of X-ray or gamma radiation. The unit is one-thousandth of a roentgen.

minimum detectable concentration—The smallest amount or concentration of a radionuclide that can be distinguished in a sample by a given measurement system at a preselected counting time and at a given confidence level.

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.

mrem—The dose equivalent that is one-thousandth of a rem.

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

nuclide—An atom specified by its atomic weight, atomic number, and energy state. A radionuclide is a radioactive nuclide.

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

part per billion (ppb)—A unit measure of concentration equivalent to the weight/volume ratio expressed as µg/L or mg/mL.

part per million (ppm)—A unit measure of concentration equivalent to the weight/volume ratio expressed as mg/L.

pathogen—A disease-producing agent; usually refers to living organisms.

person-rem—Collective dose to a population group. For example, a dose of 1 rem to 10 individuals results in a collective dose of 10 person-rem.

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

piezometer—An instrument used to measure the hydraulic potential of groundwater at a given point; also, a well designed for this purpose.

polychlorinated biphenyl (PCB)—Any chemical substance that is limited to the biphenyl molecule and that has been chlorinated to varying degrees.

polycyclic aromatic hydrocarbon (PAH)—Any organic compound composed of more than one benzene ring.

process water—Water used within a system process.

purge—To remove water before sampling, generally by pumping or bailing.

quality assurance (QA)—Any action in environmental monitoring to ensure the reliability of monitoring and measurement data.

quality control (QC)—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 the absorbed dose (rad) is multiplied to obtain a quantity that expresses, on a common scale for all ionizing radiation, the biological damage to exposed persons. A quality factor is used because some types of radiation, such as alpha particles, are more biologically damaging than others.

rad—An acronym for radiation absorbed dose. The rad is a basic unit of absorbed radiation dose. (This is being replaced by the "gray," which is equivalent to 100 rad.)

radiation detection instruments—Devices that detect and record the characteristics of ionizing radiation.

radioactivity—The spontaneous discharge of radiation from atomic nuclei. This is usually in the form of beta or alpha radiation, together with gamma radiation. Beta or alpha emission results in transformation of the atom into a different element, changing the atomic number by +1 or -2 respectively.

radioisotope—Radioactive isotope. An unstable isotope of an element that decays or disintegrates spontaneously, emitting radiation. More than 1,300 natural and artificial radioisotopes have been identified.

radionuclide—An unstable nuclide capable of spontaneous transformation into other nuclides by changing its nuclear configuration or energy level. This transformation is accompanied by the emission of photons or particles.

reference material—A material or substance with one or more properties that is sufficiently well established and used to calibrate an apparatus, to assess a measurement method, or to assign values to materials.

release—Any discharge to the environment. Environment is broadly defined as any water, land, or ambient air.

rem—The unit of dose equivalent (absorbed dose in rads multiplied by the radiation quality factor). Dose equivalent is frequently reported in units of millirem (mrem), which is one-thousandth of a rem.

remediation—The correction of a problem. See Environmental Restoration.

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

RFI Program—RCRA Facility Investigation Program; EPA-regulated investigation of a solid waste management unit with regard to its potential impact on the environment.

roentgen—A unit of exposure from X-rays or gamma rays. One roentgen equals 2.58×10^4 coulombs per kilogram of air.

screen zone—In well construction, the section of a formation that contains the screen, or perforated pipe, that allows water to enter the well.

sievert (Sv)—The SI (International System of Units) unit of dose equivalent; 1 Sv = 100 rem.

slurry—A suspension of solid particles (sludge) in water.

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

specific conductance—The ability of water to conduct electricity; this ability varies in proportion to the amount of ionized minerals in the water.

stable—Not radioactive or not easily decomposed or otherwise modified chemically.

storm-water runoff—Surface streams that appear after precipitation.

strata—Beds, layers, or zones of rocks.

substrate—The substance, base, surface, or medium in which an organism lives and grows.

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, primarily K-40, thorium, and uranium, in the earth's soils. Terrestrial radiation contributes to natural background radiation.

thermoluminescent dosimeter (TLD)—A device used to measure external gamma radiation.

total activity—The total quantity of radioactive decay particles that are emitted from a sample.

total solids—The sum of total dissolved solids and suspended solids.

total suspended particulates—Refers to the concentration of particulates in suspension in the air irrespective of the nature, source, or size of the particulates.

transuranic element—An element above uranium in the Periodic Table, that is, with an atomic number greater than 92. All 11 TRUs are produced artificially and are radioactive. They are neptunium, plutonium, americium, curium, berkelium, californium, einsteinium, fermium, mendelevium, nobelium, and lawrencium.

troughing system—A collection and containment system designed to collect leaks of oil that have been contaminated with PCBs.

turbidity—A measure of the concentration of sediment or suspended particles in solution.

upgradient—In the direction of increasing hydrostatic head.

vadose zone—Soil zone located above the water table.

volatile organic compound—Any organic compound that has a low boiling point and readily volatilizes into air (e.g., trichloroethane, tetrachloroethene, and trichloroethene).

watershed—The region draining into a river, river system, or body of water.

wetland—A lowland area, such as a marsh or swamp, inundated or saturated by surface or groundwater sufficiently to support hydrophytic vegetation typically adapted to life in saturated soils.