2015 Paducah Site
Annual Site Environmental Report

FPDP–RPT–0020

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 2015a; FPDP 2016a) 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.

FPDP-RPT-0020

Paducah Site
Annual Site Environmental Report
for Calendar Year 2015

September 2016

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

Prepared by
FLUOR FEDERAL SERVICES, INC.,
Paducah Deactivation Project
managing the
Deactivation Project at the
Paducah Gaseous Diffusion Plant
under Task Order DE-DT0007774

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CONTENTS

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FIGURES

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TABLES

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ACRONYMS

ACO	Administrative Consent Order
AFV	alternative fuel vehicle
ALARA	as low as reasonably achievable
ASER	Annual Site Environmental Report
ASTM	American Society for Testing and Materials
ATU	alternate treatment unit
BMP	Best Management Practices
BCG	biota concentration guideline
BWCS	BWXT 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
DCS	derived concentration technical standard
DOE	U.S. Department of Energy
DOECAP	U.S. Department of Energy Consolidated Audit Program
DQO	data quality objective
DUF_6	depleted uranium hexafluoride
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
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ER	Environmental Restoration
ERPP	Environmental Radiation Protection Program
FFA	Federal Facility Agreement
FFC Act	Federal Facility Compliance Act
FFCA	Federal Facilities Compliance Agreement
FFS	Fluor Federal Services, Inc.
FPDP	Fluor Federal Services, Inc., Paducah Deactivation Project
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
HSWA	Hazardous and Solid Waste Amendments
HWFP	hazardous waste facility permit
ISO	International Organization for Standardization
KAR	*Kentucky Administrative Regulations*
KDAQ	Kentucky Division for Air Quality
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
NOV	Notice of Violation
NPL	National Priorities List
NRC	National Response Center
NRHP	National Register of Historic Places
NTNCWS	non-transient non-community water system
NWPGS	Northwest Plume Groundwater System
OREIS	Oak Ridge Environmental Information System
PEGASIS	PPPO Environmental Geographic Analytical Spatial Information System
PEMS	Project Environmental Measurements System
PGDP	Paducah Gaseous Diffusion Plant
PPPO	Portsmouth/Paducah Project Office
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 Inc.
STP	Site Treatment Plan
SWMU	solid waste management unit
TED	total effective dose
TLD	thermoluminescent dosimeter
TSCA	Toxic Substances Control Act
TSS	total suspended solids
UCRS	Upper Continental Recharge System
UDS	Uranium Disposition Services, LLC
UE	uranium enrichment
USEC	United States Enrichment Corporation
UST	underground storage tank
VOC	volatile organic compound

WKWMA	West Kentucky Wildlife Management Area
WM/PP	waste minimization/pollution prevention
WMP	Watershed Monitoring Plan

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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 2015* 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
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EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE) manages work at the Paducah Site to comply with and adhere to 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 current environmental regulations.

The purpose of this Annual Site Environmental Report is to summarize calendar year (CY) 2015 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 at the Paducah Site 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 the Paducah Site in fiscal year 2015 was green (which indicates standards for the Environmental Management System implementation have been met).

Groundwater programs continue to remediate contamination in off-site groundwater plumes and on-site source areas. Ambient air monitoring contaminant levels continue either to be not detected or below permitted limits. The internal/external dose of radiation (based on calculations) from the plant that could be received by a member of the public is nearly 20 times lower than the acceptable DOE annual dose limit (the DOE annual dose limit is 100 millirem/year).

DOE continues to implement the environmental cleanup program at the Paducah Gaseous Diffusion Plant. Highlights of accomplishments through 2015 include the following: removed approximately 606 gal of trichloroethene from contaminant source areas at Paducah; completed demolition of the C-410/C-420 Feed Plant Complex; continued to optimize the Paducah Site's infrastructure to conserve energy/water and reduce utility costs; converted approximately 5,542 metric tons of depleted uranium hexafluoride to a more stable oxide and hydrofluoric acid; and reused or recycled 89 metric tons of materials.

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1. INTRODUCTION

The U.S. Department of Energy (DOE) requires that environmental monitoring be conducted and documented for 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) 2015 environmental management (EM) activities at the Paducah Site, including effluent monitoring and environmental surveillance, 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: (1) effluent monitoring and (2) 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. 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 the environment to harmful chemicals and radiation.

Prime contractors performing work to support DOE missions at the Paducah Site are the following: BWXT Conversion Services, LLC (BWCS); Swift & Staley Inc. (SST);[1] LATA Environmental Services of Kentucky, LLC (LATA Kentucky);[2] and Fluor Federal Services, Inc., (FFS) Paducah Deactivation Project (FPDP).

1.1 SITE LOCATION

The Paducah Site is located in a generally rural area of McCracken County, Kentucky, 10 miles west of Paducah, Kentucky, and 3.5 miles south of the Ohio River (Figure 1.1). Until 2013, the Paducah Site was an active uranium enrichment (UE) facility with extensive support facilities. The UE process was housed in several large buildings. The plant is on a 3,556-acre DOE site comprised of the following: 837 acres within a fenced security area, 600 acres located outside the security fence, 133 acres in acquired easements, and the remaining 1,986 acres licensed to the Commonwealth of Kentucky as part of the West Kentucky Wildlife Management Area (WKWMA).

[1] Swift & Staley Inc. is known as SST at the Paducah Site.
[2] LATA Kentucky's contract with DOE expired in July 2015.

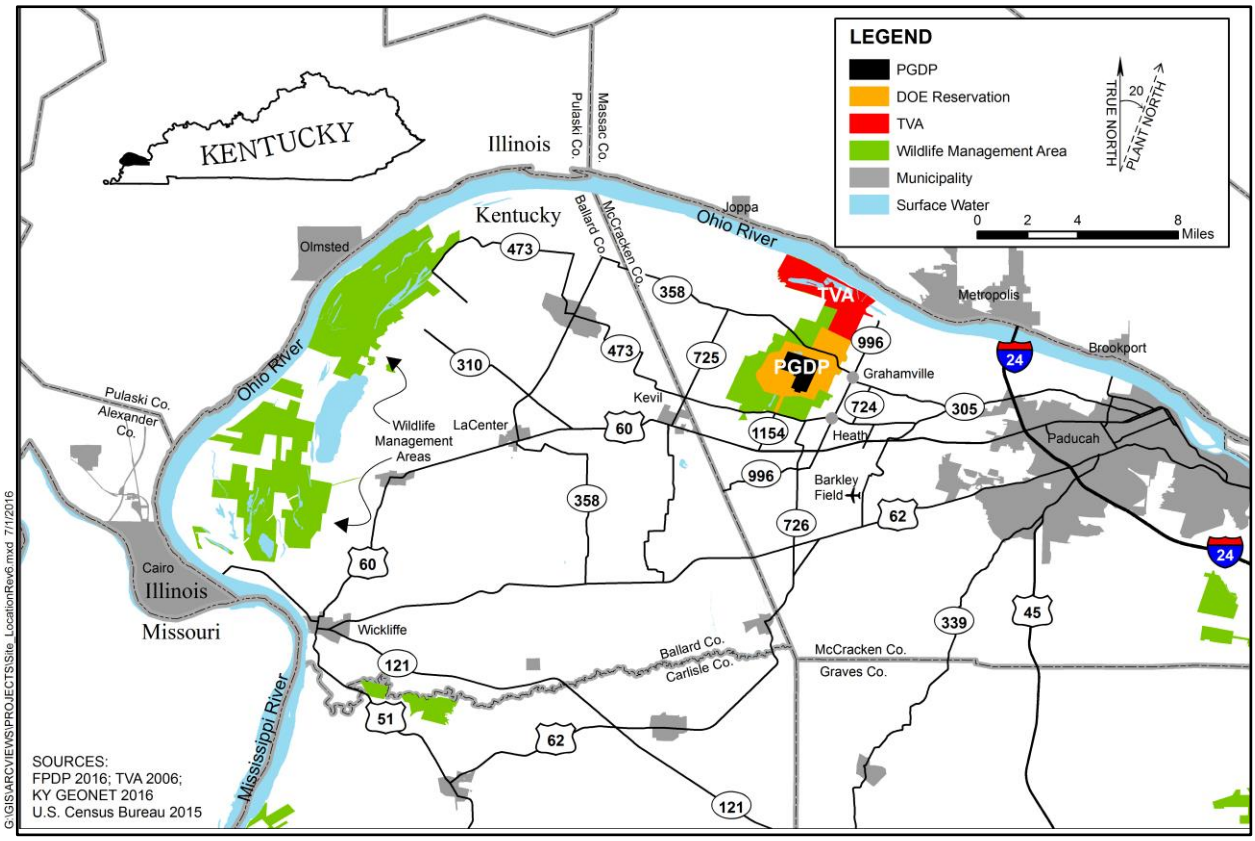

Figure 1.1. Location of the Paducah Site

WKWMA consists of woodlands, meadows, and cultivated fields and 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.

During World War II, Kentucky Ordnance Works was operated in an area southwest and west of the plant on what is now WKWMA.

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. The Paducah Site 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 developed in support of the Federal Flood Risk Management Standard show flood hazard located within the DOE boundary at the Paducah Site, but only slightly within the industrialized area of the Paducah Site (FEMA 2015).

1.2.3 Wetlands

Approximately 1,100 separate wetlands, totaling over 1,500 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 Section 6.1.

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 hardwood communities 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. Some areas near the Paducah Site are frequented by rabbits, mice, opossum, vole, mole, raccoon, and deer. Birds include red-winged blackbirds, quail, sparrows, shrikes, mourning doves, turkeys, cardinals, meadowlarks, hawks, and owls. Several groups of coyotes also reside in these areas around the Paducah Site. Aquatic habitats are used by muskrat and beaver in the study area. 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). Harvestable fish populations exist in Bayou Creek, especially near the mouth of the creek at the Ohio River. Fish populations in Little Bayou Creek are in the minnow category (DOE 2015c).

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, and two are "threatened" (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, gaseous diffusion plants (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. 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.

In addition to GDP stabilization, deactivation, and infrastructure optimization, DOE's PPPO mission is to accomplish the following at the Portsmouth and Paducah Sites (http://energy.gov/pppo/pppo-mission).

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

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 Program. Environmental Restoration (ER); Facility Stabilization, Deactivation, and Infrastructure Optimization; and Waste Management are projects under the EM Program. The mission of the ER 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 Facility Stabilization, Deactivation, and Infrastructure Optimization is to remove radioactive and hazardous materials from the facility, safely shut down facility systems, and optimize infrastructure that will continue to support the site. The mission of the Waste Management Project is to characterize and dispose of waste stored and generated on-site in compliance with regulatory requirements and DOE Orders. 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 (HF), and to manage associated facilities and grounds. The environmental monitoring summarized in this report supports 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 United States Enrichment Corporation (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. Until 2013, USEC enriched uranium at the Paducah Site to supply nuclear fuel to electric utilities worldwide. In 2014, USEC returned Paducah leased facilities to DOE control, and the DOE Deactivation Contractor began management of the facilities for DOE. These returned facilities are undergoing deactivation in preparation for decommissioning. Deactivation and decommissioning work continued in 2015 for one Paducah facility that already was under DOE control.

1.5 DEMOGRAPHIC INFORMATION

The population of McCracken County, Kentucky is approximately 65,000 (DOC 2016). The major city in McCracken County is Paducah, Kentucky, whose population is approximately 25,000 (DOC 2016). Three small communities are located within 3 miles of the DOE property boundary at the Paducah Site: 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 the Paducah Site is about 534,000 according to the 2010 census.

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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 that DOE submit an annual Site Management Plan (SMP) that summarizes remediation work completed to date, outlines remedial priorities, and contains schedules for completing future work. The fiscal year (FY) 2015 SMP was approved in April 2015 and May 2015 by KDEP and EPA, respectively (DOE 2015a).

Significant enforceable milestones required under CERCLA and the FFA for CY 2015 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 FFA Significant Milestones Scheduled for Completion in CY 2015

Milestone	Date Completed
C-400 Phase IIb Treatability Study Construction Start/Field Start[a]	12/19/2014
Burial Grounds Operable Unit Solid Waste Management Units (SWMUs) 5 and 6 Remedial Action Record of Decision—D1	Postponed[b]
Burial Grounds Operable Unit SWMUs 5 and 6 Remedial Action Remedial Design Work Plan—D1	Postponed[b]
Disposition of Inactive Facilities Decontamination and Decommissioning Operable Unit Completion Notification Letter (C-410)	Postponed[c]
Soils Operable Unit Remedial Investigation 2 Report—D1[a]	7/2/2015
C-400 Phase IIb Revised Treatability Study Report—D1[a]	12/21/2015

[a] Milestone was an enforceable milestone included in the SMP (DOE 2015a).
[b] Project milestone date was revised beyond 2015. New dates for completion followed resolution of dispute and will be established using FFA schedule.
[c] Project milestone date was revised beyond 2015 to align with completion of the C-410/C-420 Removal Action. The C-410/C-420 Complex was the last inactive facility targeted for completion under the Decontamination and Decommissioning Operable Unit.

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). In October 2015, FPDP began partial closure of C-733 by removing four 3,000-gal tanks, as described in Part I (Closure Plan), Section 4.1, of the Hazardous Waste Facility Permit Application. 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. EPA has authorized the Commonwealth of Kentucky to administer 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 facility permit (HWFP) was issued by Kentucky Division of Waste Management (KDWM) to DOE on July 24, 2015. The HWFP became effective on August 23, 2015. The federal portion of the HWFP is known as a Hazardous and Solid Waste Amendments (HSWA) Permit. In March 2016, DOE revised the HWFP Application to address EPA feedback concerning applicability of RCRA air emission standards. EPA currently is evaluating the revised application. Pending issuance of the renewal for the HSWA Permit, the Paducah Site continues operating in compliance with the existing HSWA permit issued on April 24, 2006, in accordance with 40 *CFR* § 270.51(a). For CY 2015, there were no Notices of Violation (NOVs) issued for the HWFP or HSWA Permits (KY8-890-008-982).

2.1.5 Federal Facility Compliance Act—Site Treatment Plan

The Federal Facility 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/STP on September 10, 1997. The STP facilitates compliance with the FFC Act. For the reporting period January 1 to December 31, 2015, no addition of mixed low-level waste was added to the STP. An inventory of mixed waste that remained in storage at the end of December 2014 was shipped off-site in February 2015 (DOE 2016a).

The Agreed Order requires that DOE implement a Waste Minimization and Pollution Prevention (WM/PP) Awareness Program to minimize the amount of new wastes added to the STP each year. All PGDP projects are evaluated for WM/PP opportunities. WM/PP activities at PGDP related to the STP WM/PP goals include the following:

- Reducing the quantity of wastes generated at their sources;
- Treating wastewaters on-site to meet discharge limitations;
- Draining, decanting, drying, dewatering, evaporating, and otherwise removing liquid from wastes when possible;
- Segregating, sorting, consolidating, and reducing the volume of like wastes; and
- Reusing or recycling materials.

WM/PP activities at PGDP are listed in Chapter 3.

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 the Paducah Site real property to third parties for possible economic development. A public comment meeting was held in July 2015 to present the conclusions of the EA. On December 14, 2015, DOE issued a Finding of No Significant Impact. A link to the final EA and finding is found below.[3]

A CX was approved for demolition of support buildings. Numerous minor activities conducted in 2015, such as routine maintenance, small-scale facility modifications, site characterization, facility deactivation, and utility consolidation, were within the scope of an approved EIS, EA, or CXs. The DOE Paducah Site

[3] http://www.energy.gov/pppo/downloads/paducah-gaseous-diffusion-plant-final-environmental-assessment-potential-land-and

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 encompass 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 (with respect to Environmental Restoration, Waste Disposition, and Deactivation and Decommissioning) 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].

The Paducah Site complies with PCB regulations (40 *CFR* § 761) and the TSCA UE Federal Facilities Compliance Agreement (FFCA). The TSCA UE 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 2015 are documented in the PCB Annual Document (FPDP 2016b).

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),[4] that groundwater is protected, that future remediation would not be needed, and that no radiological protection requirements are violated.

The Paducah Site complies with DOE Order 435.1 and DOE Order 458.1. The programs described below outline ways the Paducah Site complies with these DOE Orders.

[4] 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.

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 Paducah Site, FPDP implements an Environmental Radiation Protection Program (ERPP) (FPDP 2014a). 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;

(2) To control the radiological clearance of real and personal property (see "clearance of property" in glossary);

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

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

(5) To protect 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 Chapter 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 (KDAQ). The Paducah Site complies with federal and Commonwealth of Kentucky rules by implementing the CAA and its amendments. Air emissions at the Paducah Site fall under one of three authorities: the DUF_6 Conversion Facility Conditional Major Air Permit, the FFS Title V Air Permit, or CERCLA.

The DUF_6 Conversion Facility operated under KDAQ Conditional Major Operating Air Permit No. F-10-035 R1 throughout CY 2015. Because the existing permit was set to expire February 21, 2016, a renewal application was submitted to KDAQ on August 21, 2015.

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. This is accomplished by reacting DUF_6 gas with steam, nitrogen, and hydrogen that produces HF. The oxide powder is collected and packaged for reuse or disposal, while HF is a saleable end product. Low levels of HF off-gassed from the conversion process are captured by a primary and secondary caustic scrubber system. Emissions from oxide handling are controlled by a high-efficiency particulate air filter system. Air that is displaced during filling and emptying of HF storage tanks at the HF storage and load-out area is vented through a dedicated scrubber system. The facility has two emission points. Emission point U001 is the stack for the Conversion Building. Emission point U002 is the stack for HF storage and load-out area.

Any stationary source with the potential to emit more than 100 tons per year of any regulated air pollutant other than a hazardous air pollutant (HAP), 10 tons per year of any HAP, or 25 tons per year of any combination of HAPs is considered a major source under Title V of the CAA. Title V major sources are subject to Title V permitting requirements. During USEC's leasehold, USEC operations were considered a Title V major source. Accordingly, USEC operated under a Title V permit. On February 4, 2014, USEC applied for a renewal of its Title V permit. This permit application added 21 emergency motor emission units, under 40 *CFR* Part 63, Subpart ZZZZ, *National Emissions Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines.* On October 21, 2014, at the termination of USEC's lease and prior to issuance of a renewed permit, USEC transferred its Title V Air Permit to FFS. On February 23, 2015, KDAQ issued Title V Permit V-14-012 to FFS.

On February 10, 2015, FFS applied to KDAQ for a significant revision to the Title V permit that proposed adding five new low and ultra-low emission package boilers to replace three existing boilers. The Title V permit revision, V-14-012 R1, was issued on August 14, 2015.

CERCLA response actions also were a source of air pollutants in 2015. These sources include the Northwest Plume Groundwater System (NWPGS), the Northeast Plume Containment System (NEPCS) alternate treatment unit (ATU), and the Southwest Plume Sources Remedial Action. 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 applicable or relevant and appropriate. 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 carbon adsorption system to remove the TCE prior to atmospheric discharge. At the NEPCS, the system includes pretreatment filtration and removal of TCE via air stripping technology. 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. The Southwest Plume Sources Remedial Action volatilized TCE and other VOCs through deep soil mixing, supplemented by steam/hot air injection with vapor extraction. The vapor extraction then was passed through activated carbon to remove the volatile organic compounds (VOCs).

For CY 2015, 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 2013a). Potential radionuclide sources at the Paducah Site in 2015 were from deactivation of PGDP, DUF_6 Conversion Facility, NEPCS, NWPGS, and fugitive and diffuse sources. DOE utilized ambient air monitoring data to verify a low emission rate of radionuclides in off-site ambient air in accordance with the NESHAP Management Plan. The fugitive and diffuse sources include building ventilation, uranium transfers, transport and disposal of waste, demolition of contaminated facilities such as the C-410/C-420 Feed Plant Complex, decontamination of contaminated equipment, and environmental remediation activities. Ambient air data were collected at nine locations surrounding the Paducah Site in order to measure radionuclides emitted from Paducah Site sources, including fugitive emissions. All of the DOE air monitors utilized are solar powered. These solar powered air monitors are environmentally friendlier, more dependable, and less energy-consuming than the non-solar powered models they replaced. The ambient air results are discussed in further detail in Chapter 4.

2.3.3 Pollutants and Sources Subject to Regulation

Any stationary source with the potential to emit more than 100 tons per year of any regulated air pollutant other than a HAP, 10 tons per year of any HAP, or 25 tons per year of any combination of HAPs is considered a major source under Title V of the CAA. The Deactivation Project is considered a major source because it has identified potential emissions of carbon monoxide, nitrogen oxides, and sulfur oxides greater than 100 tons per year, as well as potential emission of HF, a HAP, in excess of 10 tons per year. Potential emissions of carbon monoxide, sulfur oxides and nitrogen oxides are related primarily to coal-fired boilers that were replaced in 2015 by a combination of five natural gas and natural gas/fuel-oil-fired boilers. Without potential emissions from the coal-fired boilers, which no longer are operational, potential HF emissions from the Deactivation Project still would exceed 10 tons per year, with potential emissions being primarily related to cascade operations associated with deactivation activities.

KDAQ considers the DUF_6 facility to be a separate source from the Deactivation Project and, therefore, has issued DUF_6 a separate permit. The DUF_6 facility has the potential to emit more than 10 tons per year of HF, but the DUF_6 air permit limits potential HF emissions to less than 10 tons per year. As such, KDAQ considers DUF_6 facility to be a conditional major source (in Kentucky, a conditional major source whose potential emissions exceed a Title V major source threshold, but which accepts permit conditions that are legally and practically enforceable to limit the source's potential to emit below major source thresholds).

2.3.4 Stratospheric Ozone Protection

DOE operates several refrigeration units that contain less than 50 lb of ozone-depleting substances. The Paducah Site also has a very large R-114 cooling system. This system currently holds approximately 6.3 million lb of R-114 refrigerant. Releases from the system are tracked and repaired in accordance with 40 *CFR* Part 82 requirements and the Title V Permit. In addition to the 6.3 million lb of R-114 refrigerant in the cooling systems, approximately 2.2 million lb of R-114 is stored in railcars at the Paducah Site. In 2015, FPDP moved some R-114 from the cooling system into railcars and began procurement of containers to store more R-114. In 2015, FPDP also began soliciting industries interested in the resale, reuse, recycle, or conversion of the R-114 currently stored on-site.

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 and storm water 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.

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 KPDES permits for effluent discharges to

Bayou Creek and Little Bayou Creek. The Kentucky Division of Water (KDOW) issued KPDES Permit Number KY0004049 to DOE and FFS for Outfalls 001, 015, 017,[5] 019, and 020, and KPDES Permit KY0102083 to DOE and FFS for Outfalls 002, 004, 006, 008, 009, 010, 011, 012, 013, and 016. The KPDES permits call for monitoring as an indicator of discharge-related effects in the receiving streams. Discharge monitoring reports are issued monthly and quarterly. Additionally, the KPDES permits require the development and implementation of a Best Management Practices (BMP) Plan to prevent or minimize the potential for the release of pollutants. These BMPs have requirements for all operations and are implemented through the site Environmental Management System (EMS) and work control.

Two NOVs were received during CY 2015 for alleged exceedances related to the KPDES permit, though one of them was for alleged exceedances that occurred in 2014. Each NOV was for allegedly failing to comply with the total suspended solids (TSS) discharge limit set forth in KPDES Permit No. KY0004049. The permitted limits for TSS concentration are a monthly average of 30 mg/L and a daily maximum of 60 mg/L. During the month of November 2014, reported results at Outfall 020 were a monthly average of 94 mg/L and a daily maximum of 94 mg/L. This exceedance, together with a similar permit exceedance in 2013 resulted in a civil penalty of $4,000 paid by LATA Kentucky. During the month of September 2015, reported TSS results at Outfall 001 were a monthly average of 45 mg/L and a daily maximum of 137 mg/L, resulting in the second NOV. The second NOV did not result in a penalty.

A summary of the CY 2015 KPDES permit exceedances or noncompliances and solutions is provided in Table 2.2.

Table 2.2. KPDES Noncompliances in CY 2015[a]

Permit Type	Outfall	Parameter	Number of Permit Exceedances	Number of Samples Taken	Number of Compliant Samples	Percent Compliance	Month of Exceedance	Description/ Solution
KPDES[b]	001	Total Suspended Solids	1	57	56	98%	September	A beaver dam was causing the additional suspended solids in the outfall. The dam has been removed.
KPDES[c]	006	pH	1	82	80	98%	September	A tank of carbon dioxide that was used to reduce pH ran dry, and the supplier was unable to deliver replacement. Two samples were collected at that time. The maximum pH result was 9.13; the permit limit is 9. An NOV for this exceedance was not received in 2015.

[5] Permit Number KY0004049 also includes BWCS as a permittee for Outfall 017.

Table 2.2. KPDES Noncompliances in CY 2015[a] (Continued)

Permit Type	Outfall	Parameter	Number of Permit Exceedances	Number of Samples Taken	Number of Compliant Samples	Percent Compliance	Month of Exceedance	Description/ Solution
KPDES[b]	017	Toxicity	4	34	30	88%	June, October (2), and November	A toxicity reduction evaluation plan has been submitted. NOVs for these exceedances were not received in 2015.

[a] Table 2.2 lists exceedances that occurred in CY 2015. The table does not include NOVs received in 2015 for exceedances in 2014.
[b] The permit type is KPDES (KY0004049).
[c] The permit type is KPDES (KY0102083).

2.4.3 Storm Water 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 2015).

2.4.4 Safe Drinking Water Act

The Paducah Site supplies on-site drinking water from the Ohio River to its facilities. The drinking water system was operated and managed by FPDP in accordance with the Safe Drinking Water Act (SDWA) regulations for CY 2015. FPDP maintains a water withdrawal permit from KDOW for up to 30 mgd. Water is pumped from the Ohio River and treated for on-site distribution. Remote facilities use bottled water.

FPDP operates a non-transient non-community water system (NTNCWS), regulated by KDOW, using lime softening, coagulation, sedimentation, filtering, and disinfection for water treatment. KDOW's requirement for surface water systems serving populations less than 10,000 to submit monitoring plans to demonstrate compliance with regulations is applicable to the FPDP NTNCWS. Various sampling locations in the FPDP treatment and distribution system are monitored in accordance with these plans, and the monitoring results are submitted to KDOW. Sanitary water system monitoring results in 2015 were below state and federal maximum contaminant levels established under the SDWA. An NOV was issued to FFS under the SDWA in June 2015, for failing to submit the results from the April 2015 total organic carbon sample. The NOV was later rescinded when information was provided that the sample results had been received by KDOW within the required compliance reporting period.

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. In November 2015, the Paducah Site informally consulted with the U.S. Fish and Wildlife Service regarding removal of a tree that was a potential roost area for the Indiana bat and the northern long-eared bat. The Fish and Wildlife Service agreed that removal of the tree at the time proposed would not affect the bat habitat adversely.

Table 2.3 includes 13 federally listed species that have been identified as potentially occurring at or near the Paducah Site. No proposed or candidate species have been identified in the area. 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 2015 adversely 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[b]	Indiana Bat	*Myotis sodalis*	Endangered
	Northern Long-eared Bat	*Myotis septentrionalis*	Threatened
Clams	Clubshell	*Pleurobema clava*	Endangered
	Fanshell	*Cyprogenia stegaria*	Endangered
	Fat Pocketbook	*Potamilus capax*	Endangered
	Orangefoot Pimpleback	*Plethobasus cooperianus*	Endangered
	Pink Mucket	*Lampsilis abrupta*	Endangered
	Rabbitsfoot	*Quadrula cylindrica cylindrica*	Threatened
	Ring Pink	*Obovaria retusa*	Endangered
	Rough Pigtoe	*Pleurobema plenum*	Endangered
	Sheepnose Mussel	*Plethobasus cyphyus*	Endangered
	Spectaclecase	*Cumberlandia monodonta*	Endangered
Birds	Least Tern	*Sterna antillarum*	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 (FWS 2016).
[b] Although Gray Bat appears to be included as an endangered species in McCracken County, further information available for counties within Kentucky in which the Gray Bat is known to or is believed to occur does not include McCracken.

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

The Memorandum of Understanding on Migratory Birds (2013) between DOE and the U.S. Fish and Wildlife Service 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 the Paducah Site. 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.

2.5.5 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 2015.

2.5.6 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 KDWM under the UST Program, 16 have been closed in accordance with approved closure plans (the last closed in March 2015), and 2 were determined not to exist. No USTs remained in service at the Paducah Site at the end of 2015.

2.5.7 Solid Waste Management

The Paducah Site disposes of a portion of its solid waste at its contained landfill facility, C-746-U Solid Waste Contained Landfill under Solid Waste Permit, SW07300045. 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.

During 2015, the office waste generated by DOE and its contractors at the plant site was taken off-site for disposal. Office waste generated at the C-746-U Landfill itself is disposed of at the landfill. A commercial waste company 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 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 currently 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. This EO requires DOE to calculate an emissions baseline and establish targets for reduction of GHG. On March 19, 2015, the President signed EO 13693, *Planning for Federal Sustainability in the Next Decade*, which replaced EO 13514. EO 13693 requires federal agencies to establish GHG reduction targets and achieve sustainability goals to reach those targets. This EO includes and expands upon prior EO goals and requirements, as well as climate preparedness and resilience planning for the impacts of climate change. In support of DOE's goals to reduce GHG emissions, SST submitted an SSP in December 2015 (SST 2015), and FPDP submitted an SSP in December 2014 (FPDP 2014b). Details of the objectives of the SSP are outlined in Chapter 3 of this report.

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. The Paducah Site, as a federal facility, is subject to these reporting requirements.

EPCRA's primary purpose is to increase the public's knowledge and access to information of chemical hazards in their communities. 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, in April 2015, notified KDEP, the National Response Center (NRC), and the Kentucky Emergency Response Team of a sulfuric acid leak from a storage tank. The entire amount of sulfuric acid that had leaked was contained within the secondary containment, and there was no threat of release to the environment.

In 2015, no EPCRA Section 311 notifications were sent for new chemicals at the Paducah Site. BWCS manufactured HF in 2015 and submitted a corresponding EPCRA 313 Report. DOE also submitted an EPCRA 313 Report for HF as well as a report for chlorine used for water sanitization.

The chemicals stored by all DOE contractors in 2015 (including FPDP) were included in an EPCRA 312 Report. The chemicals reported were activated carbon, argon, biodiesel fuel, diesel fuel, gasoline, coagulant, calcium hydroxide, calcium oxide, carbon dioxide, chlorine, chlorine trifluoride, coal, dichlorotetrafluoroethane (R-114), ferric sulfate, ferrous sulfate, fluorine, cooling water treatment, HF, lead acid batteries, nitric acid, compressed nitrogen, cryogenic nitrogen, oil, PCBs, potassium hydroxide, propane, rock salt, sodium carbonate, sodium thiosulfate, 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).]

Table 2.4 lists the 2015 EPCRA reporting status for the Paducah Site.

Table 2.4. Status of EPCRA Reporting

EPCRA Section	Description of Reporting	Status[a]
EPCRA Sec. 302–303	Planning Notification	Yes
EPCRA Sec. 304	Extremely Hazardous Substance Release Notification	Yes
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 Green and Sustainable Remediation

Green and sustainable remediation (GSR) is the practice of using sustainable methods to reduce environmental and social impacts of remedial cleanup and closure activities in a cost effective way. GSR also offers opportunities to meet compliance obligations at lower overall cost and environmental impact.

2.8.2 Adapting to Climate Change

Normal power usage, fleet exhaust, and process power account for the majority of GHG emitted, and efforts for reductions in these areas are being made. There is an attempt by a local company to obtain a grant that would allow them to use an old, closed and capped on-site 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.

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

2.8.3 Additional NOVs

An inspection of a waste shipment to Energy*Solutions* of Utah was conducted in September 2015 and found freestanding aqueous liquid inside a waste container. The waste shipped to Energy*Solutions* allegedly failed to conform to the Utah Administrative Code, which states that solid waste containing liquid shall contain as little freestanding and noncorrosive liquid as is reasonably achievable, but in no case shall the liquid exceed one percent of the volume. The state of Utah issued an NOV to FPDP for the alleged violation.

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. Releases of this nature typically are included in the SARA Title III reports and notifications listed in Section 2.7.

2.10 UNPLANNED RELEASES

There were three unplanned releases at the Paducah Site that are discussed below. Small leaks and spills are cleaned and have no potential impacts on the environment.

On April 6, 2015, operators at the C-616 plant were conducting a routine inspection when they noted a slow leak of sulfuric acid into the open air, but within secondary containment. The total acid leaked was estimated at 857 gal, which was fully contained in the acid neutralization pit. As a result, this spill was reported to KDEP, NRC, and the Kentucky Emergency Response Team on April 6, 2015. The acid collected in the neutralization pit was neutralized with soda ash and discharged after verification of pH to a settling pond that flows to Outfall 001. This sulfuric acid tank, along with others in the same area, was removed from service, emptied, and dismantled for disposal.

On April 9, 2015, inspections of discharges to Outfall 001 found that the water was significantly discolored. Investigation of the source, found that the failure of the ash silo secondary separator was the direct cause of discolored water. Failure of the separator resulted in pulverized coal that had not fully combusted being discharged. Once it was confirmed that the discolored water was discharged from the steam plant, the steam plan was shut down, straw bales were installed in the ditches from the steam plant to the outfall, and flocculants were added to the C-616-F lagoon to support settling of suspended solids. As a result of the discharge, KDEP issued a letter of warning to LATA Kentucky. In July 2015, the coal fire boiler was replaced permanently with newer natural gas boilers.

On May 27, 2015, a PCB transformer leak was noticed, and the area was secured. Initial walk down visually determined that approximately 2 gal of PCB oil had leaked from one of the transformers. Following discovery, an additional 0.3-0.5 gal of oil leaked for a total PCB leak of 15 lb. The spill location was well inside a large process building with no potential off-site or environmental consequences. To prevent further leaks, the PCB transformer was drained to below the insulator housing. The spill site was cleaned in accordance with 40 *CFR* § 761 requirements. The PCB transformer subsequently was removed from service, drained, and flushed along with all remaining PCB transformers at the Paducah Site.

2.11 SUMMARY OF PERMITS

Table 2.5 provides a summary of the Paducah Site environmental permits maintained by DOE in CY 2015.

Table 2.5. Permits Maintained by DOE for the Paducah Site for CY 2015

Permit Type	Issued By	Permit Number	Issued To
State Agency Interest ID No. 3059			
Clean Water Act			
Kentucky Pollutant Discharge Elimination System	KDOW	KY0004049	DOE/FFS/BWCS
		KY0102083	DOE/FFS
Permit to Withdraw Public Water	KDOW	0900	FFS
Water Treatment Registration	KDOW	Public Water System KY0732457	FFS
Clean Air Act			
Conditional Major Operating Air Permit	KDAQ	F-10-035 R1	BWCS
Title V Air Permit	KDAQ	V-14-012 R1	FFS
RCRA—Solid Waste			
Residential Landfill (closed)	KDWM	SW07300014	DOE/FFS
Inert Landfill (closed)	KDWM	SW07300015	DOE/FFS
Solid Waste Contained Landfill (construction/operation)	KDWM	SW07300045	DOE/FFS
RCRA—Hazardous Waste			
Hazardous Waste Facility Permit	KDWM	KY8-890-008-982	DOE/FFS
Underground Storage Tank Registration	KDWM	6319-073	DOE
Hazardous and Solid Waste Amendments Portion of the RCRA Permit	EPA	KY8-890-008-982	DOE/FFS

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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 site operations. The EMS objectives are integrated into the Integrated Safety Management System established by the DOE Policy 450.4A, *Safety Management System Policy*. The EMS for DOE's contractor, SST, was audited and found to satisfy DOE requirements. The EMS for the two remaining contractors was under development in 2015.

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 2015, 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 the Paducah Site. 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 the Paducah Site in FY 2015 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.

Within this section, the following are summarized.

- Environmental operating experience and performance measurement
    - — Site sustainability plan
    - — WM/PP

- DUF_6 cylinder program
- Environmental restoration, waste disposition, and deactivation and decommissioning
- Emergency management

- Facility stabilization, deactivation, and infrastructure optimization

- Accomplishments, awards, and recognition
- Public awareness program
- Community/educational outreach
- Citizens Advisory Board
- Environmental Information Center
- Additional awards

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 the Paducah Site 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. FPDP implements the Environmental Monitoring Program for the Paducah Site documented in the Environmental Monitoring Plan (EMP) (LATA Kentucky 2015a; FPDP 2016a). These plans can be found at the following location: http://ffspaducah.com/public-documents/all.

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.

Environmental operating experience and performance measurement is an integral component of an EMS. This section discussed the site's progress on meeting these goals with respect to site sustainability and WM/PP. Additionally, achievements and descriptions are provided for DOE programs.

3.1.1 Site Sustainability Plan

In accordance with DOE Order 436.1 and EO 13693, this report provides information concerning the requirements and responsibilities of managing sustainability on the Paducah 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 in workers and the surrounding community about sustainability opportunities through public outreach and training. Table 3.1 is adapted from the *Fiscal Year 2016 Site Sustainability Plan, Paducah Gaseous Diffusion Plant* and contains a brief summary of FY 2015 performance and long-term planned actions to attain future goals (SST 2015). Additionally, the site has implemented the following:

- Use of direct push technology rigs instead of conventional rigs to limit production of IDW;
- Zero-valent iron incorporated into SWMU 1 Soil Mixing to passively remediate groundwater;
- Sealing the slab at C-410/420 to minimize impact to storm water runoff;
- Utilizing the on-site landfill as much as possible to minimize GHG production associated with off-site transport; and
- Using 113,000 gal of oil on-site from obsolete production facilities to rinse PCB transformers.

3.1.2 Waste Minimization/Pollution Prevention

The 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 of the Paducah Site projects are evaluated for WM/PP opportunities. Materials recycled included oils, paper, toner cartridges, scrap metal (nonradiological), aluminum cans, batteries, tires, electronics, cardboard, and plastics.

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.

Table 3.1. DOE Goal Summary Table

DOE Goal	Site Performance
GHG Reduction	
Reduce GHG emissions by FY 2025 from a FY 2008 baseline.	Overall consumption has increased drastically since the 2008 baseline due to USEC-leased facilities returning to DOE control, making achievement of the goal very challenging.
Sustainable Buildings	
Reduce energy intensity.	Energy initiatives are challenging due to the age of the facilities.
Metering of all individual buildings for electricity, natural gas, steam, and water, where cost-effective and appropriate.	There are no plans to add meters for these utilities on-site because the site is in the deactivation phase.
Increase regional and local planning coordination and involvement.	The site currently is involved in deactivation. As projects arise, there will be more opportunity for involvement.

Table 3.1. DOE Goal Summary Table (Continued)

Clean and Renewable Energy	
Work toward a percentage of total electric and thermal energy accounted for by renewable and alternative energy.	Presently, the site has no on-site renewable energy generation capability.
Water Use Efficiency and Management	
Reduce potable water intensity. Reduce water consumption of industrial, landscaping, and agricultural.	Site numbers have increased due to the plant footprint increasing in the past FY. The plant footprint increased because USEC-leased facilities were returned to DOE.
Fleet Management	
Reduce annual petroleum consumption.	Sitewide fleet totals have increased with the addition of the Deactivation contractor and its fleet vehicles, making the goal difficult to achieve.
Increase annual alternative fuel consumption.	Alternative fuel consumption has increased. Plant personnel are encouraged to utilize alternative fuel vehicles (AFVs), and the contractors are promoting E-85 use within plant communication mediums.
Reduce fleet-wide, per-mile GHG emissions.	Not met due to plant fleet increasing. The plant fleet increased to accommodate additional DOE contractors now managing returned USEC-leased facilities. Communication tools are being utilized to encourage smarter travel and vehicle usage.
Purchase AFVs for light-duty vehicles.	The majority of the site's fleet consists of AFVs.
Acquire passenger vehicles that consist of zero emission or plug-in hybrid electric vehicles.	No vehicles on-site meet criteria, at this time.
Sustainable Acquisition	
Promote sustainable acquisition and procurement to the maximum extent practicable ensuring bio-preferred and bio-based provisions and clauses in applicable contracts.	All applicable contracts contain sustainable acquisition clauses.
Pollution Prevention and Waste Reduction	
Divert from landfills nonhazardous solid waste, excluding construction and demolition debris through recycling and waste minimization.	The site diverts as much waste as possible, unless it is contaminated and ineligible.
Divert from landfills construction and demolition materials and debris through recycling and waste minimization.	The site diverts as much waste as possible, unless it is contaminated and ineligible.
Electronic Stewardship	
Purchase Electronic Product Environmental Assessment Tool-registered products.	All electronic acquisitions currently meet standards.
Enable eligible personal computers, laptops, and monitors with power management.	Power management is implemented actively on all computers.
Enable eligible computers and imaging equipment with automatic duplexing.	All eligible computers and printers have duplexing capabilities.
Reuse or recycle used electronics using environmentally sound disposition options each year.	Twenty-five pallets of miscellaneous electronics were recently shipped in FY 2015 to an off-site, environmentally-approved vendor.

Table 3.1. DOE Goal Summary Table (Continued)

Climate Change Resilience	
Update policies to incentivize planning for and addressing the impacts of climate change. Update emergency response procedures and protocols to account for projected climate change, including extreme weather events. Ensure workforce protocols and policies reflect projected human health and safety impacts of climate change. Ensure site/laboratory management demonstrates commitment to adaptation efforts through internal communication and policies. Ensure that site/laboratory climate adaptation and resilience policies and programs reflect best available current climate change science, updated as necessary.	Paducah has no specific actions for climate change resilience.
Sustainable Remediation	
Integrate Sustainability into Remediation Activities.	Integration of these activities is not applicable at this time.

NOTE: Information is adapted from Table 1 of the *Fiscal Year 2016 Site Sustainability Plan, Paducah Gaseous Diffusion Plant* (SST 2015).

WM/PP efforts for the site are reported in DOE's Consolidated Energy Data Report. During FY 2015, the Paducah Site reused or recycled 89 metric tons of materials that were diverted from landfill disposal.

WM/PP accomplishments at PGDP related to the STP WM/PP in 2015 were the following:

- Regenerated 26,626 lb of activated carbon averting disposal;
- Recycled 1,545 lb of various light bulbs; and
- Shipped 3,807 lb of miscellaneous liquids from radiological areas to be burned for energy recovery.

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 2015, the Paducah Site managed an inventory of approximately 52,700 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 HF 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 2015, BWCS converted approximately 5,542 metric tons of DUF_6 to a more stable oxide and HF. Off-site shipment is discussed in Section 4.2.

3.1.4 Environmental Restoration, Waste Disposition, and Deactivation and Decommissioning

The environmental restoration program supports investigations and environmental response actions, deactivation and decommissioning 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.

The following are Paducah Site significant accomplishments in 2015.

- Completed Phase IIb treatability study to evaluate steam-enhanced remediation for the Regional Gravel Aquifer (RGA) under the C-400 Cleaning Building.
- Completed deep soil mixing at the Oil Landfarm (SWMU 1) for the Southwest Plume Sources Remedial Action (Figure 3.1).
- Began Southwest Plume Sources (SWMUs 211-A and 211-B at the C-720 Maintenance Building) final characterization field work.
- Completed supplemental sampling fieldwork at one historical burial ground (SWMU 4).
- Completed additional sampling at various soil areas (Soils Operable Unit RI 2).
- Completed Soils Operable Unit Sitewide Evaluation Report (Sitewide Walkover).
- Completed vapor intrusion study for private residences in the Water Policy Area and completed screening study report.
- Modernized C-612 NWPGS equipment.
- Completed Northeast Plume Optimization Explanation of Significant Differences.
- Completed decontamination and decommissioning of the C-410/C-420 Feed Plant Complex.

Figure 3.1. Deep Soil Mixing

- Completed demolition of the C-746-B Warehouse.

- Designed and fabricated portable equipment to allow removal of uranium deposits, which is key to making former production buildings inherently safe and ready for demolition.

3.1.5 Emergency Management

Emergency management is a systematic, integrated effort at the Paducah Site. Members of the Paducah Site Emergency Response Organization include the crisis manager and the Emergency Operations Center cadre, an incident commander, and the Emergency Squad. The Joint Public Information Center provides timely and accurate information to the community during emergency situations.

The Paducah Site also maintains a fully staffed fire department along with protective force officers and a medical facility. DOE's various contractors have separate emergency response procedures that they practice during training exercises to bolster their ability to work together. Under contracts to DOE, emergency responses are coordinated at the Paducah Site through the Emergency Operations Center.

3.1.6 Facility Stabilization, Deactivation, and Infrastructure Optimization

GDP was transferred from USEC to DOE on October 21, 2014. Since that time, the U.S. Nuclear Regulatory Commission has terminated its certificate of compliance for PGDP, and the facilities now are regulated under DOE authority. Several modifications have occurred to support the transition during 2015. DOE continued to optimize the Paducah Site's infrastructure to conserve energy/water and reduce utility costs. The following are significant Paducah Site accomplishments in 2015.

- Four oversized and outdated electrical switchyards were consolidated into a single switchyard, improving the efficiency of the electricity distribution system that will result in cost savings over time.

- The site's coal-fired steam plant was replaced with five new natural gas package boilers to save energy costs and provide environmental benefits.

- More than 52 of over 74 acres of roofs were replaced, reducing hazards and avoiding future costs of heating and piecemeal repairs, while improving worker safety (http://energy.gov/em/articles/doe-office-environmental-management-2015-year-review).

- Nearly 100,000 gal of PCB-contaminated transformer oil and 113,000 gal of the rinsing agent were safely drained, shipped, and dispositioned (http://energy.gov/em/articles/innovative-approach-reduces-costs-removing-contaminated-oil-paducah-site).

3.2 ACCOMPLISHMENTS, AWARDS, AND RECOGNITION

DOE and its contractors are committed to enhancing public awareness and community/educational outreach. The Paducah Citizens Advisory Board (CAB) and the DOE Environmental Information Center (EIC) are both avenues through which DOE interacts with the public. In addition to public outreach, DOE's contractors have received recognition for their work.

3.2.1 Public Awareness Program

A comprehensive Community Relations and Public Participation Program exists for DOE activities at the Paducah Site (DOE 2015b). The purpose of the program is to provide the public with opportunities to become involved in decisions relating to environmental issues at the site.

3.2.2 Community/Educational Outreach

DOE supported several educational and community outreach activities during 2015.

DOE and its contractors reached out to public middle schools in the City of Paducah and McCracken and Ballard counties to encourage local students to study science, technology, engineering, and math during 2015 (Figure 3.2).

Volunteers from FPDP, in cooperation with PPPO, gave local sixth-grade classes a practical science lesson on groundwater, sampling, and aquifers, and discussed possible future careers with them.

Figure 3.2. DOE Contractor Personnel Give Area Middle School Students Science Lesson and Discuss Possible Future Careers

Students viewed an aquifer model that illustrated the underground layers of water-bearing, permeable rock, gravel, sand, or silt from which groundwater can be extracted.

DOE and its contractors also engaged students through other educational outreach programs such as the annual DOE National Science Bowl, for which regional competitions were held in February for Western Kentucky middle and high schools. DOE and its contractors also supported the Western Kentucky Regional Science Fair, local school career fairs, and a summer internship program for college students.

FPDP sponsored Forward Paducah, a six-month strategic planning process initiated by Paducah Economic Development in September 2015. The process was aimed at assessing the area's strengths and challenges as well as targeting industries to help grow the local economy.

In a joint project between DOE and the Kentucky Research Consortium for Energy and Environment, administered by the University of Kentucky Center for Applied Energy Research, students from Marshall County High School summarized a previous year's ASER. Additional information is available at the following link: http://www.ukrcee.org/Marshall/Edu.aspx.

3.2.3 Citizens Advisory Board

The Paducah CAB is a site-specific advisory board chartered by DOE under the Federal Advisory Committees Act. During the CY, the CAB held several regular board meetings and additional subcommittee meetings.

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

- Decontamination and Decommissioning/Facilities
- Environmental Restoration
- Community Engagement
- Integrated Priority List

All regular board meetings are open to the public and 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, representing business, academia, labor, local government, environmentalists, special interest groups, and the general public from Western Kentucky and surrounding areas. 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.

3.2.4 Environmental Information Center

The public has access to the electronic version of the Administrative Records and programmatic documents at the 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, 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 Paducah Site can be accessed at www.paducaheic.com and http://energy.gov/pppo/paducah-site.

3.2.5 Additional Awards

In May of 2015, SST was presented with the Governor's Safety and Health Award for achieving 1,633,686 hours worked without a lost time injury or illness.

In January 2015, SST received recognition as a DOE Voluntary Protection Program Star Status (Figure 3.3). SST was the first contractor in the history of the Paducah site to achieve this recognition.

Figure 3.3. Paducah Site Contractor Receives DOE Voluntary Protection Program Star Status

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4. ENVIRONMENTAL RADIOLOGICAL PROTECTION PROGRAM AND DOSE ASSESSMENT

4.1 ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM

Routine DOE operations at the Paducah Site may 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 2015a; FPDP 2016a). 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 sources of ionizing radiation and exposure pathways. Doses are to be optimized through the application of ALARA principles so that DOE operations will not contribute significantly to the average annual exposure. 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, the Paducah Site calculates annual dose estimates using effluent release data, environmental monitoring data, and surveillance data combined with relevant site specific data (such as meteorological conditions, population characteristics, and stream flows).

Surface water is not used as a source of public drinking water on the DOE Reservation; however, data from these outfalls are included as part the incidental surface water ingestion pathway. To assess fully the potential dose to the public, a hypothetical set of characteristics was used to postulate an upper bound exposure 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 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.

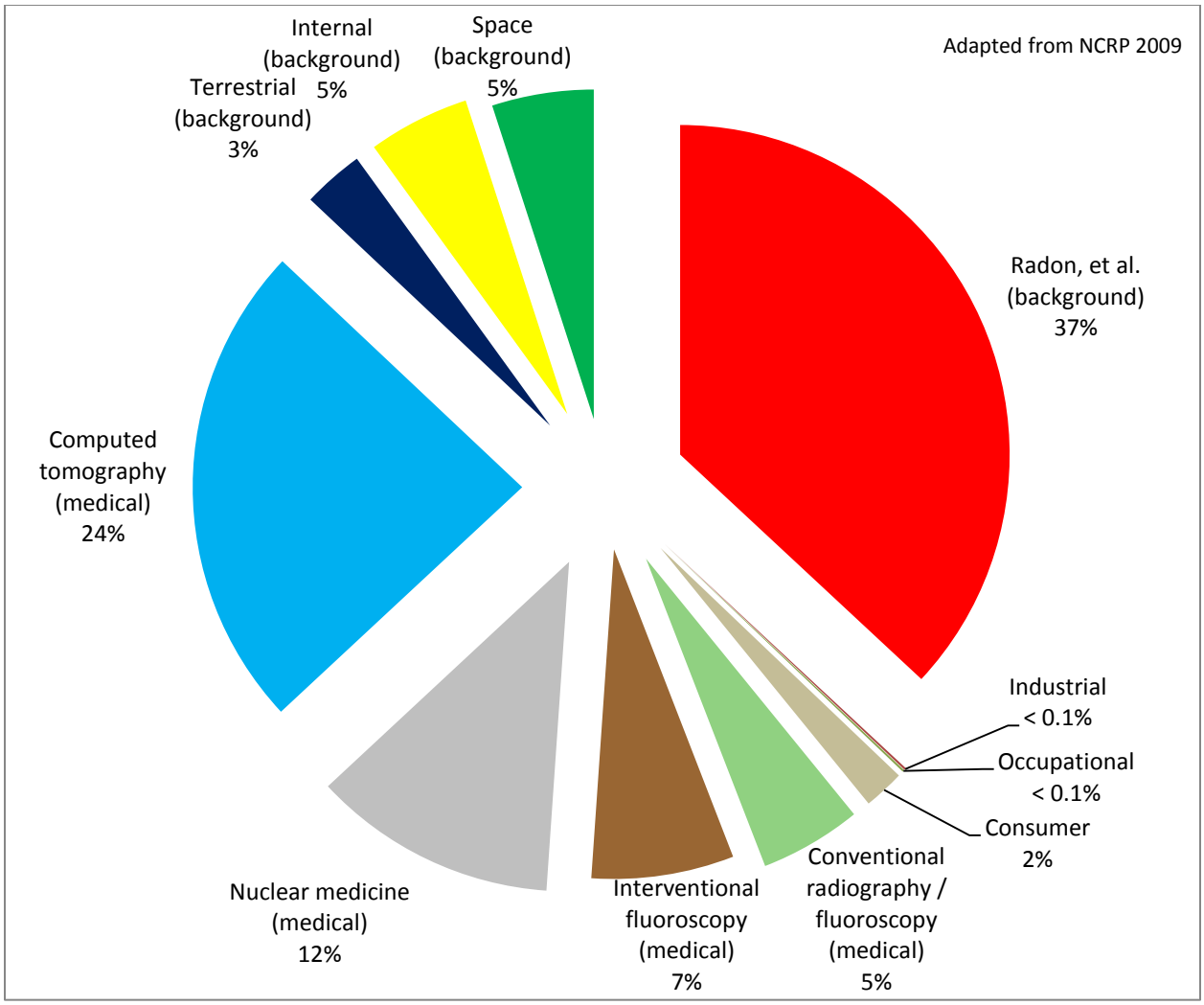

Figure 4.1. Sources of Radiation

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 an average individual's 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% of the total dose).

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 Paducah Site may 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, the Paducah Site 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 dose calculations use various computer codes that model the environmental dispersion of radionuclides that originate from on-site activities.

4.1.2 Radioactive Materials at the Paducah Site

Radioactive materials present at the Paducah Site are the result of processing raw and recycled uranium into nuclear materials. The Paducah Site 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)
- Technetium-99 (211,000 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)

Daughter products for the radionuclides listed above also are present at the Paducah Site 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 2015a; FPDP 2016a).

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 the Paducah Site may release incidental radioactive materials into the environment through atmospheric and liquid discharges. The principal routes 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 water and groundwater;
- Skin absorption (also called dermal absorption); and
- External exposure to ionizing radiation.

4.1.4 Dose Assessment Methodology

Radiological exposure assessments are modeled using exposure pathways applicable to the Paducah Site utilizing methods consistent with the requirements of DOE Order 458.1 and various guidance, including the *Methods for Conducting Risk Assessments and Risk Evaluations* (DOE 2015c). First, measurements (and/or estimates) of radionuclide concentrations in liquid and air released from the Paducah Site are assembled from the CY 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. The MEI is the hypothetical resident who has the greatest probability of being affected by a radiological release.

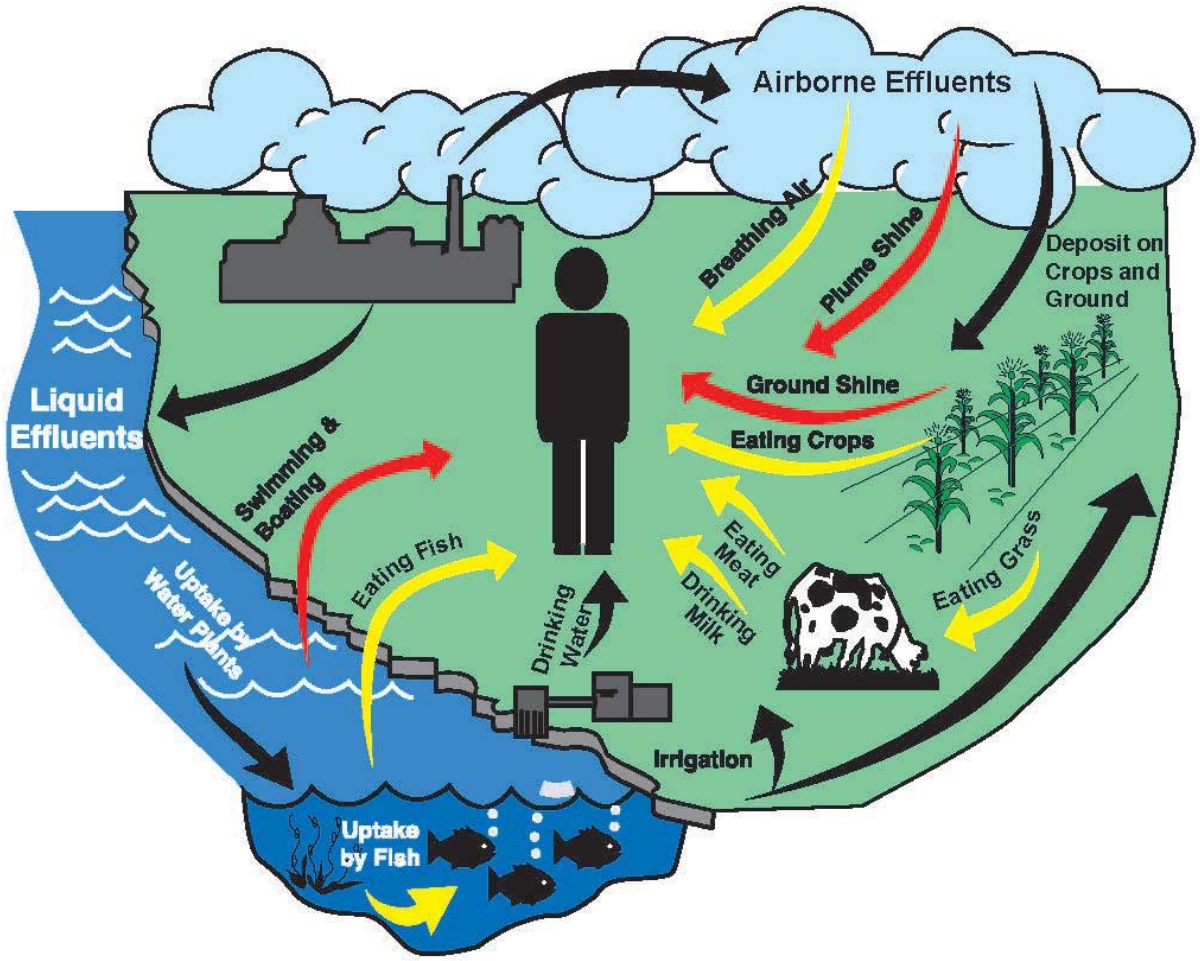

Figure 4.2. Potential Exposure Pathways

For determining compliance with the DOE public dose requirements, the Paducah Site calculates the potential off-site doses from the Paducah Site effluent releases of radioactive materials (atmospheric and liquid) for the MEI and the population living within a 50-mile radius of the Paducah Site. 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 the Paducah Site is established based on lifestyle assumptions for radiological exposure that would yield an overestimation of dose for a hypothetical individual who lives near the Paducah Site at the location where the highest concentration of radionuclides in air has been modeled; consumes milk, meat, and vegetables produced at that location; spends time on or near Bayou or Little Bayou Creeks; and hunts on the wildlife reservation (DOE 2015c). This person does not drink groundwater because all persons potentially impacted by the Paducah Site have access to 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, dose from fish ingestion is not included. Dose from surface water is calculated assuming ingestion at the nearest public withdrawal location, Cairo, Illinois. Dose from incidental sediment and surface water ingestion 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 2015 were the following:

- NWPGS;
- NEPCS ATU;
- DUF_6 Conversion Facility;
- C-400 Group (which includes the following C-400 Cleaning Building sources: the C-400 decontamination spray booth, the C-400 No. 5 dissolver/rotary vacuum filter, and the C-400 laundry);
- C-709/C-710 Laboratory Hoods;
- Seal Exhaust/Wet Air Group (which includes the seal exhaust systems in the C-310 Product Withdrawal Building; C-315 Tails Withdrawal Building; C-331, C-333, C-335, and C-337 Process Buildings; wet air exhaust systems in the C-310 Product Withdrawal Building; and the C-331, C-333, C-335, and C-337 Process Buildings); and
- Fugitive dust source emissions.

Specific activities that could generate fugitive emissions include transport and disposal of waste, decontamination of contaminated equipment, and most environmental remediation activities. Ambient air monitoring, which monitors fugitive emissions from all Paducah Site operations (including DUF_6 Conversion Facility operations), is conducted using nine continuous air monitors surrounding the Paducah Site reservation. One of these air monitors collects data from a background location. See Figure 4.3 for air sampling locations. Radiological analytes are presented in the FY 2015 and FY 2016 EMP (LATA Kentucky 2015a; FPDP 2016a).

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)[6] to any member of the public in any year.

Airborne radioactive materials released in 2015 from stacks and diffuse sources on the Paducah Site (Table 4.1) were modeled using the EPA-approved CAP-88 computer program. This air dispersion model estimates EDEs based on the ingestion, inhalation, air immersion, and ground surface pathways. Site-specific data for CY 2015 (radionuclide releases in curies per year) were input into the CAP-88 program, as were on-site meteorological data.

[6] For radionuclides at the Paducah Site, the EDE is equivalent to the ED.

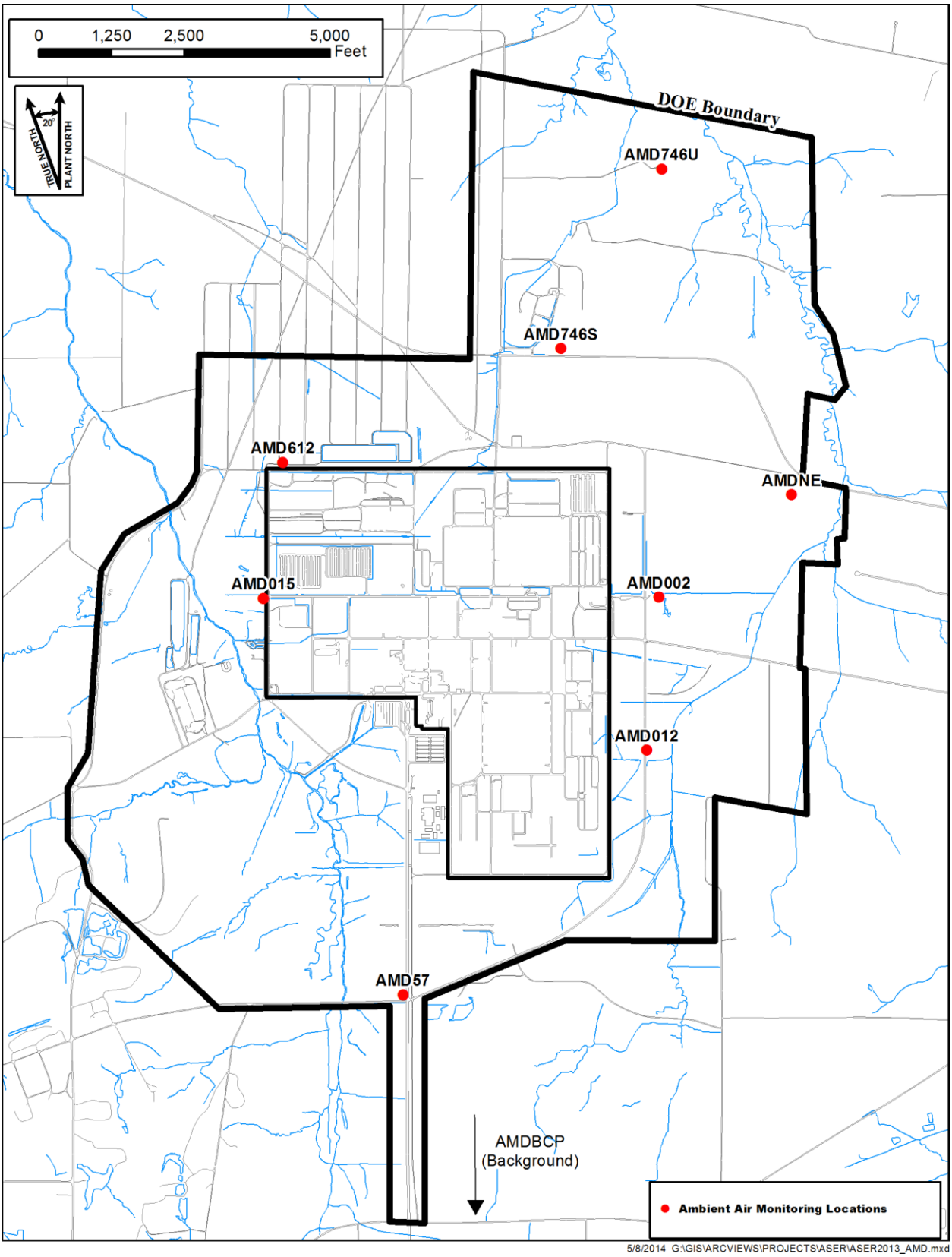

Figure 4.3. Air Monitoring Locations

Table 4.1 shows the estimates of radionuclide atmospheric releases in curies (i.e., units of radioactivity), Table 4.2 provides the EDE to the MEI for each individual point source.

Table 4.1. Radionuclide Atmospheric Releases for CY 2015 (in Curies) for the Paducah Site*

Nuclide	NWPGS	NEPCS ATU	DUF_6 Conversion Facility	C-400 Group	C-709 & C-710	Seal Exhaust/ Wet Air Group	Total Site Emissions
U-234	0	0	2.27E-07	0	6.50E-05	3.37E-06	6.86E-05
U-235	0	0	1.04E-08	0	2.60E-06	1.17E-06	3.78E-06
U-238	0	0	5.57E-07	2.60E-07	6.03E-06	3.49E-07	7.20E-06
Tc-99	8.32E-05	7.45E-06	0	5.94E-06	0	1.38E-06	9.80E-05
Th-230	0	0	0	0	0	0	0
Th-231	0	0	3.35E-08	0	0	0	3.35E-08
Th-234	0	0	3.06E-06	0	0	0	3.06E-06
Np-237	0	0	0	2.89E-08	0	0	2.89E-08
Pu-239	0	0	0	0	0	0	0
Pa-234m	0	0	3.06E-06	0	0	0	3.06E-06
Total Curies/Year	**8.32E-05**	**7.45E-06**	**6.95E-06**	**6.23E-06**	**7.36E-05**	**6.27E-06**	**1.84E-04**

*Values are taken from *National Emissions Standard for Hazardous Air Pollutants Annual Report for 2015* (FPDP 2016c).

Table 4.2. Dose Calculations for Airborne Releases

Emission Sources	Dose to the MEI for the Plant (mrem)
DOE Emission Sources	
NWPGS	6.0E-05
NEPCS ATU	1.7E-06
DUF_6 Conversion Facility	2.4E-07
C-400 Group	2.0E-06
C-709 & C-710	2.1E-05
Seal Exhaust/Wet Air Group	2.0E-06
Total from All Sources	8.7E-05

The hypothetical MEI was calculated to potentially receive an EDE of 0.000087 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 the Paducah Site is shown in Table 4.3, as estimated by the CAP-88 program.

Table 4.3. Calculated Radiation Doses from Airborne Releases for the Paducah Site

Effective Dose to MEI (mrem)	Percent of Standard (%)	Collective Effective Dose (person-rem)
8.7E-05	0.00087	5.0E-04

A complete summary of this emissions data can be found in the *National Emissions Standard for Hazardous Air Pollutants Annual Report for 2015* (FPDP 2016c).

4.1.6 Liquid Discharge Monitoring and Estimated Dose from Liquid Effluents

4.1.6.1 Surface water

In general, radioactive contaminants released to surface 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 the Paducah Site includes rainfall runoff from cylinder yards and landfills and effluent from site processes [e.g., the C-612 NWPGS and the C-616 Wastewater Treatment Facility (Figure 4.4)]. The discharges from the Paducah Site 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.

Figure 4.4. C-616 Wastewater Treatment Facility Lagoon

This protection is achieved at the Paducah Site by meeting DOE-STD-1196-2011, Derived Concentration Technical Standard (DCS), for ingestion limits (DOE 2011a).

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 the Paducah Site; therefore, the allowable concentrations for the DCSs result in a dose that is higher than a person would actually receive. 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 2015 (see Figure 4.5). One background location (L1) is sampled annually. Additionally, a location near the nearest public water withdrawal location, Cairo, Illinois, (L306) was sampled. 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 the Paducah Site effluent control and monitoring. Areas removed/remediated as part of a 2010 removal action for contaminated sediment associated with the Surface Water Operable Unit are denoted on the figure (DOE 2011b).

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

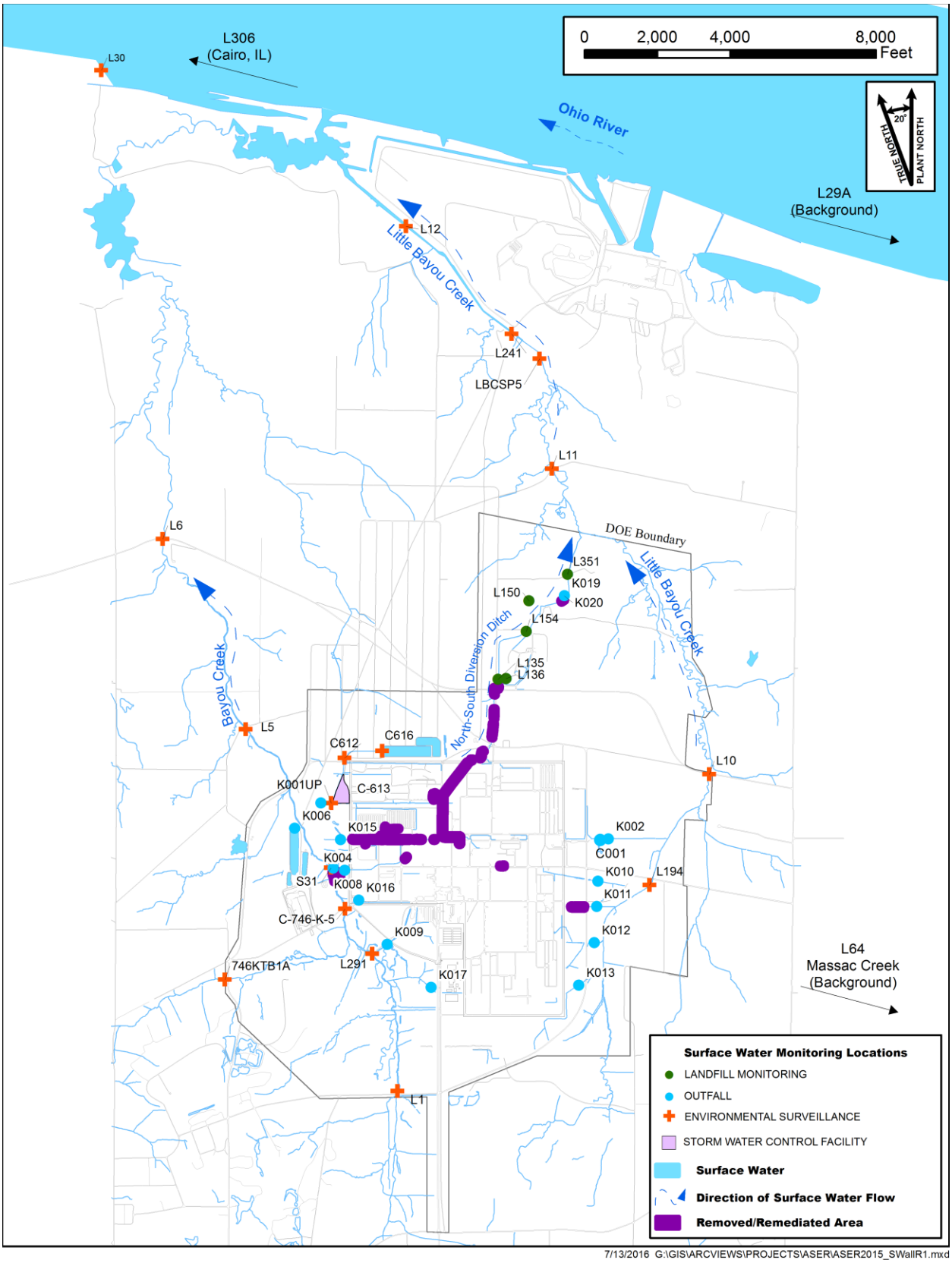

Figure 4.5. Surface Water Monitoring

limit established for alpha activity is 14 pCi/L (based on thorium-232 and plutonium-239) and the beta activity is 300 pCi/L (based on cesium-137). If, by the end of the CY, 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 PPPO Environmental Geographic Analytical Spatial Information System (PEGASIS) Web site at http://padgis.latakentucky.com/padgis/.

In addition to the environmental surveillance surface water locations, samples were taken near the KPDES-permitted outfalls (001, 002, 004, 006, 008, 009, 010, 011, 012, 013, 015, 016, 017, 019, and 020) throughout the year. As with the environmental surveillance locations, isotopic analyses are not performed if the alpha and beta activity levels are below established threshold limits. If, by the end of the CY, 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 summarizes the isotopic detections of radionuclides at the surface water sampling locations and KPDES-permitted outfalls described. See Section 5.2 for discussion related to nonradiological surface water sampling.

Table 4.4. Ranges of Detected Radionuclides in 2015 Surface Water Samples

Isotope	Range
Technetium-99 (pCi/L)	1.82E+01–3.80E+01
Uranium-234 (pCi/L)	1.18E+00–2.70E+01
Uranium-235 (pCi/L)	1.33E+00–2.51E+00
Uranium-238 (pCi/L)	1.04E+00–1.28E+02

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 Paducah Site is not consumed by persons as a drinking water source; 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 the Paducah Site effluents. Cairo, Illinois, is located at the confluence of the Ohio and Mississippi Rivers. No radionuclide isotopes were detected near the surface water collection inlet at Cairo during CY 2015. Only one dissolved beta result was detected (at 3.21 pCi/L).

The drinking water pathway dose was calculated where an MEI is assumed to consume water from the public drinking water supply at Cairo, Illinois (L306). For the dose estimate, because no radionuclide isotopes were detected, a default value of less than 0.09 mrem/yr was used, as specified in the EMP (FPDP 2016a).

In previous years, collective dose for annual ingestion of drinking water was estimating using the entire population within a 50-mile radius of the Paducah Site; however, most of these individuals within a 50-mile radius of the Paducah Site obtain their daily drinking water from sources other than those downgradient of the Paducah Site (see Sections 4.1.4 and 6.2). For 2015, an estimated collective dose has been calculated by multiplying the dose to the MEI from annual ingestion of drinking water from the Cairo supply (prior to treatment) by the estimated number of residents of Cairo in 2010 (2,830 persons) (Moonshadow Mobile 2015), which resulted in a representative collective dose of 0.25 person-rem.

4.1.6.3 Incidental ingestion of surface water

Dose to the hypothetical MEI is calculated based on incidental ingestion of surface water due to wading or swimming in Bayou and Little Bayou Creeks and their tributaries. The assumptions based on *Methods for Conducting Risk Assessments and Risk Evaluations* 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 2015c). 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 0.17 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

Leachate from the C-746-U Landfill is sampled routinely and compared to the DCSs set forth by DOE (DOE 2011a). Summaries of detected radiological results are included in Table 4.4. Additional monitoring results are available through the PEGASIS Web site at http://padgis.latakentucky.com/padgis/.

4.1.6.5 Groundwater

DOE has numerous groundwater monitoring wells (MWs), which are more fully described in Chapter 6. Groundwater wells that supplied drinking water to residents in the water policy area downgradient of the Paducah Site have been replaced with public drinking water, resulting in the loss of groundwater as a drinking water source as an 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, it is not considered in the calculation of dose to the MEI. Similarly, groundwater as a drinking water source 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. Radionuclides transported by water can adsorb onto 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. Thus, 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 and by 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

Sediment sampling at the Paducah Site in CY 2015 included radiological and nonradiological constituents (LATA Kentucky 2015a; FPDP 2016a). This sampling occurred in June 2015. 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 4.6).

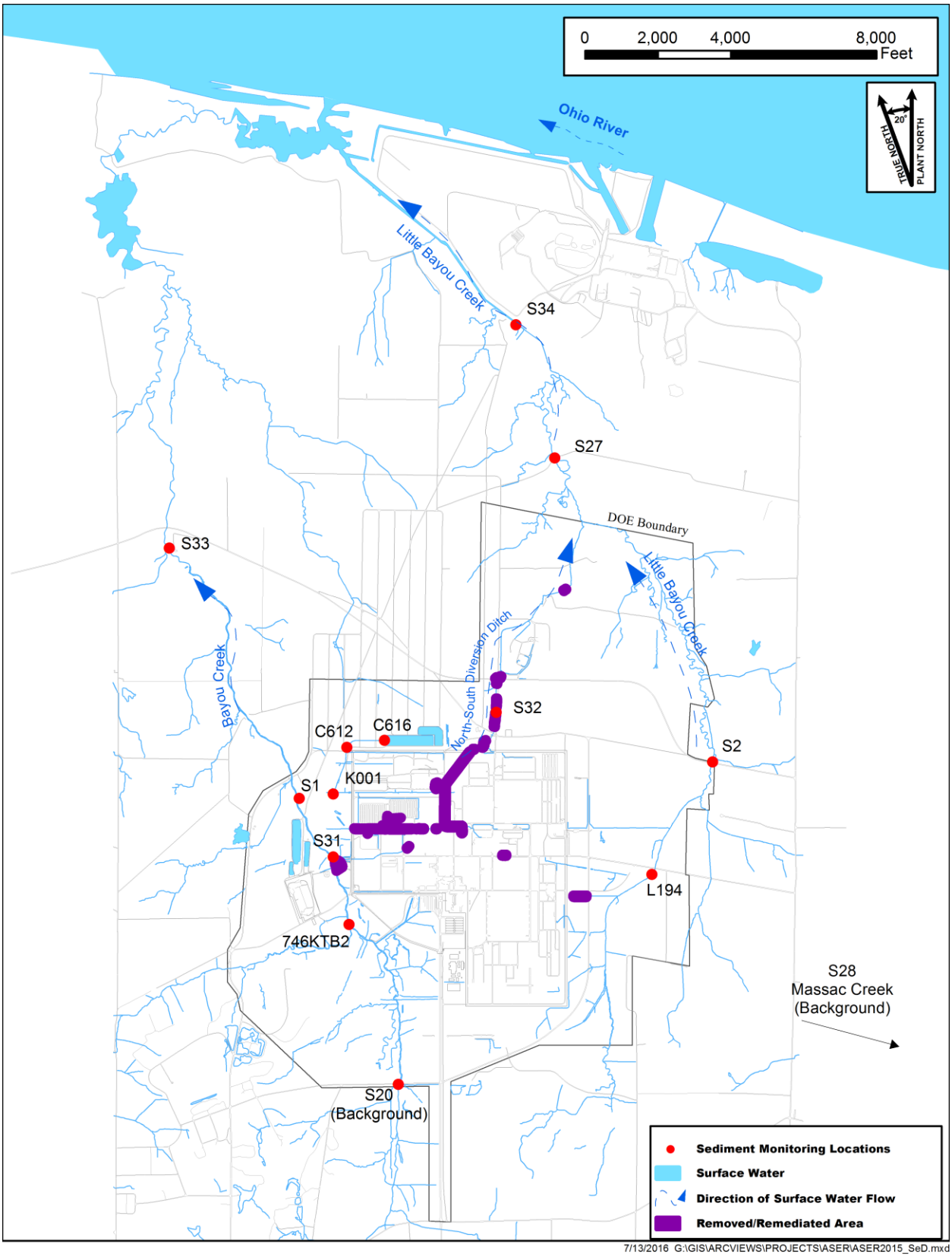

Figure 4.6. Sediment Monitoring Locations

Locations were prioritized for areas of public access, introduction of plant effluents to the environment, any unplanned release, and verification of the effectiveness of the Paducah Site effluent monitoring. Areas removed/remediated as part of a 2010 removal action for contaminated sediment associated with the Surface Water Operable Unit are denoted on the figure (DOE 2011b).

Sediment radiological analytical results are summarized in Table 4.5 (see Section 5.3 for discussion related to nonradiological sediment sampling) and also may be found on the PEGASIS Web site at http://padgis.latakentucky.com/padgis/. The radiological results for CY 2015 are similar in magnitude to those measured during previous years. Overall, radiological concentrations in sediment are near background concentrations, but have exhibited concentrations of analyzed radionuclides above background. Figure 4.6 shows the sampling locations. Location S28 provides background concentrations for nonradiological sediment sampling; Location S20 provides background concentrations for radiological sediment sampling. Location S1 is located on Bayou Creek within the DOE boundary surrounding the Paducah Site. Location S2 is located downstream at Little Bayou Creek near the DOE boundary. Location S27 is located within Little Bayou Creek just north of the DOE Paducah Site boundary. Location S33 is located within Bayou Creek north of the DOE boundary. Overall, uranium activity is above background in Little Bayou Creek and Bayou Creek near and downstream of the plant site. Other radionuclides, although present, are not of concern because they are not significantly above background values presented in *Methods for Conducting Risk Assessments and Risk Evaluations* (DOE 2015c).

Table 4.5. Radiological Activities for Sediment Sampling[a]

Parameter	S1	S1 (duplicate)	S2	S20 (background)	S27	S33	S34
Alpha activity	1.28E+01	9.23E+00	4.56E+00	2.01E+00[b]	1.38E+01	1.80E+01	1.49E+01
Beta activity	2.16E+01	1.39E+01	5.59E+00	-3.61E-01[b]	2.52E+01	1.81E+01	1.23E+01
Cesium-137	1.58E-02[b]	4.87E-02[b]	1.38E-02[b]	-2.47E-02[b]	3.66E-02[b]	1.29E-01	-6.14E-03[b]
Neptunium-237	8.92E-02[b]	3.94E-01[b]	-2.23E-01[b]	-2.41E-01[b]	-1.34E-01[b]	-9.57E-02[b]	1.61E-01[b]
Plutonium-238	1.10E-01[b]	-4.11E-02[b]	-1.20E-02[b]	4.49E-02[b]	1.04E-01[b]	-1.35E-01[b]	-8.33E-02[b]
Plutonium-239/240	2.53E-01[b]	9.58E-02[b]	9.11E-02[b]	2.05E-01[b]	1.04E-01[b]	-1.68E-01[b]	4.85E-02[b]
Potassium-40	2.26E+00	2.34E+00	3.28E+00	1.51E+00	2.96E+00	8.03E+00	3.16E+00
Technetium-99	2.14E+01[b]	3.52E+00[b]	1.10E+01[b]	2.17E+01[b]	1.38E+00[b]	8.66E+00[b]	1.38E+01[b]
Thorium-228	2.82E-01[b]	4.47E-01	2.15E-01[b]	2.95E-01[b]	2.11E-01[b]	8.76E-01	2.08E-01[b]
Thorium-230	1.18E+00	6.52E-01	7.53E-01	2.01E-01[b]	1.25E+00	2.07E+00	4.70E-01[b]
Thorium-232	4.71E-01	2.29E-01[b]	2.22E-01[b]	2.06E-01[b]	4.31E-01	1.38E+00	5.25E-01
Thorium-234	1.72E+00[b]	3.71E+00	4.71E+00	3.18E-01[b]	5.24E+00	2.47E+00	1.53E+00
Total Uranium	5.63E+00	5.56E+00	3.66E+00	1.93E+00	5.18E+00	4.75E+00	3.19E+00
Uranium-234	2.23E+00	2.05E+00	7.81E-01	7.70E-01[b]	1.71E+00	2.29E+00	9.73E-01
Uranium-235	5.98E-01[b]	3.99E-01[b]	1.30E-01[b]	4.58E-01[b]	9.09E-01	2.97E-01[b]	8.32E-02[b]
Uranium-238	2.81E+00	3.10E+00	2.75E+00	7.02E-01	2.56E+00	2.17E+00	2.14E+00

[a] Units are in pCi/g.
[b] Result reported at concentrations less than the laboratory's reporting limit.

4.1.7.2 Sediment dose

For the purpose 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 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 Evaluations* (DOE 2015c), which includes the ingestion, inhalation, and external gamma pathways. Table A.8 of that document provides site-specific soil screening levels for receptors due to site-related radionuclides. Results 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 MEI from the 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 2015. The highest annual dose was calculated to be at location S27 (0.043 mrem/yr), downstream at Little Bayou Creek, near the Little Bayou Creek/North-South Diversion Ditch confluence. This dose calculation is based on the assumption that a person continually returns to the same location (i.e., S27). A comparison of sediment sampling data is provided in Table 4.5. This exposure pathway is the major contributor to the dose received by the MEI. Dose results for sediment sample locations are provided in Table 4.6.

Table 4.6. Average Annual Dose Estimates for CY 2015 Incidental Ingestion of Sediment

	Committed Effective Dose Equivalent (mrem/year)—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)**
S20 (background) [b]	0.00E+00	0.00E+00	1.09E-04	5.41E-04	2.53E-04	4.55E-04	3.55E-04	1.90E-02	5.32E-03	2.60E-02
S1 [b]	6.48E-03	1.47E-02	0.00E+00	0.00E+00	0.00E+00	1.62E-03	6.31E-04	1.68E-03	1.71E-02	4.21E-02
S2 [b]	2.77E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.25E-03	5.07E-06	0.00E+00	1.55E-02	1.95E-02
S27 [b]	7.35E-03	0.00E+00	1.43E-04	0.00E+00	0.00E+00	2.37E-03	4.33E-04	1.87E-02	1.41E-02	***4.31E-02***
S33 [b]	2.59E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.23E-03	7.00E-04	0.00E+00	1.11E-02	4.20E-02
S34 [b]	0.00E+00	9.82E-03	0.00E+00	0.00E+00	0.00E+00	6.09E-04	9.35E-05	0.00E+00	1.09E-02	2.14E-02
									Net Exposure from Paducah Site to the MEI[a,b,c,d] (Downstream Little Bayou) =	**4.3E-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 Paducah Site-related doses. If location dose is less than background dose or less than zero, the dose is specified as 0.00E+00 mrem/year.
[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 2015c), 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.

4.1.8 Terrestrial Environment Monitoring and Estimated Dose

Wildlife and farm-raised 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).

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.

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 contributes 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 Paducah Site 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. In 2015, 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. These monitoring locations are shown in Figure 4.7. Monitoring results indicate that 12 of 51 locations were consistently above background levels, as reported in the *Annual Report on External Radiation Monitoring for Calendar Year 2015, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (FPDP 2016d). These locations were adjacent to or in close proximity to the Paducah Site security fence in the vicinity of UF_6 cylinder storage yards. Because security protocols prohibited the public from gaining prolonged access to the PGDP boundary fence in CY 2015, the potential radiation doses calculated at or in close proximity to the fence are not realistic.

4.1.10.2 Direct radiation dose

Due to Paducah Site security protocols in CY 2015, 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; however, the ED potentially received by a member of the public passing through accessible portions of the DOE Reservation would receive 5.1 mrem/yr in a worst case scenario (visiting the areas of highest exposure 80 hours/yr). In 2015, TLD-14 and TLD-40 represented the closest locations that would be accessible to the public. TLD-14, which is near Harmony Cemetery, located north of the plant security fence and south of Ogden Landing Road, represents the nearest location routinely accessible by the public. Measurements at this location indicated external radiation doses statistically equivalent to the background radiation level. In 2015, TLD-40 located on the DOE Reservation boundary with the DOE-leased WKWMA area off of Dyke Road also 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 2015, 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.

For 2015, an estimated collective dose has been calculated by multiplying the dose to the MEI from direct radiation by a total estimated number of visitors hiking within the WKWMA annually (150 persons) (DOE 2015c), which resulted in a representative collective dose of 0.77 person-rem.

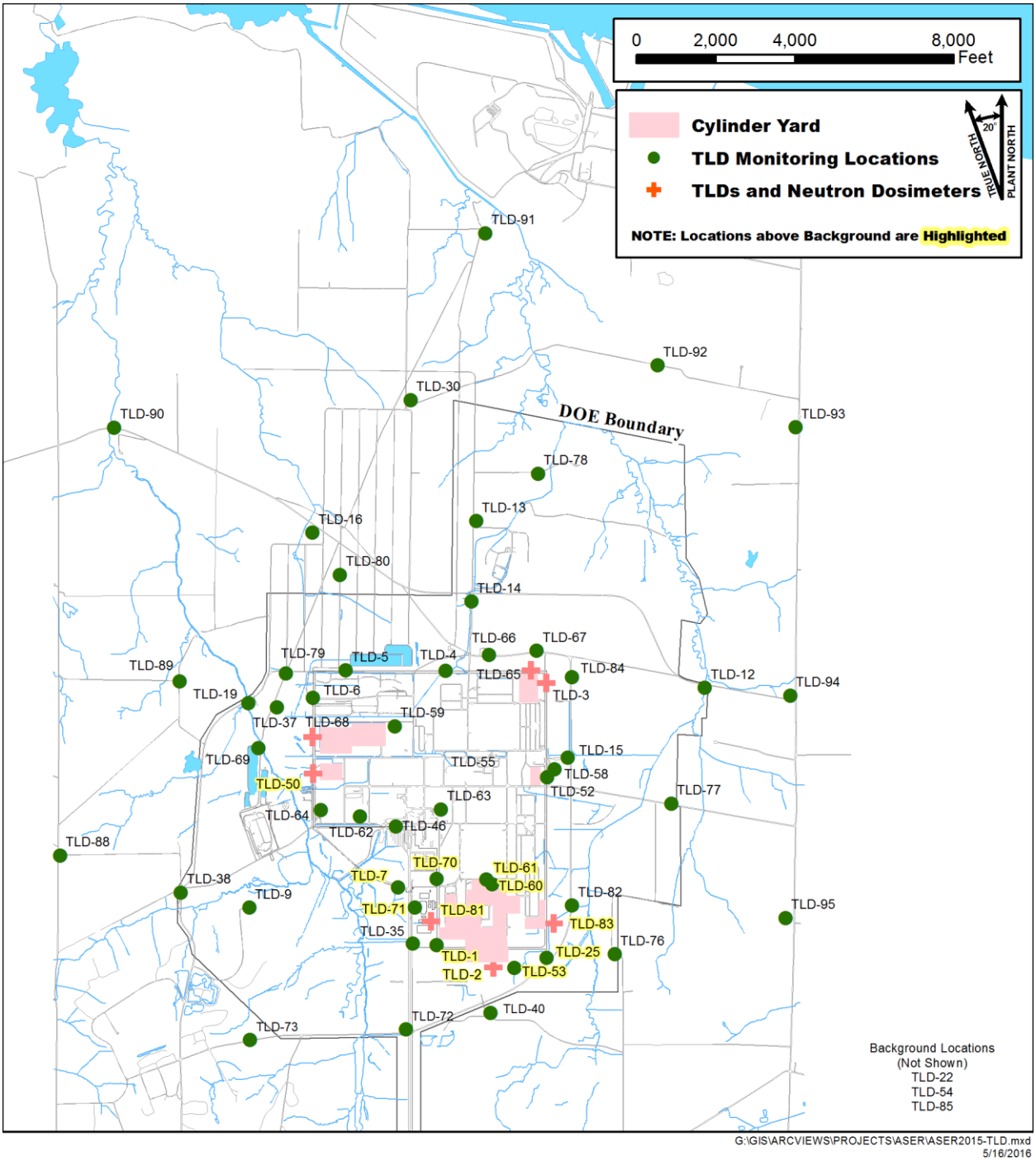

Figure 4.7. TLD Locations in the Vicinity of the Paducah Site

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 4.7 provides a summary of the radiological dose for 2015 from the Paducah Site that could be received by a member of the public (i.e., the MEI) assuming exposure from all relevant pathways. The largest contributor to the calculated dose is from direct radiation. Also contributing to the dose that could be received by the MEI are atmospheric releases, incidental ingestion of surface water, ingestion of drinking

water (in Cairo, Illinois), and incidental ingestion of sediments. The groundwater pathway from DOE sources is assumed to contribute no dose to the population, because DOE has supplied all potentially impacted residents with access to public water. The combined (internal and external) dose to an individual member of the public was calculated at 5.4 mrem/year. This level is well below the DOE annual dose limit of 100 mrem/year to members of the public and the EPA limit of 10 mrem airborne dose to the public. Table 4.7 also shows the percent of the DOE annual dose limit that is received by the MEI.

Table 4.7. Summary of Potential Radiological Dose to the MEI from the Paducah Site for CY 2015[a]

Pathway[a]	Dose to MEI[b] (mrem/year)	Percent of Total	Percent of DOE 100 mrem/yr Limit
Atmospheric releases[c]	8.7E-05	0.0016%	0.000087%
Ingestion of drinking water (Cairo, Illinois)	9.0E-02	1.7%	0.09%
Incidental ingestion of surface water	1.7E-01	3.1%	0.17%
Ingestion of groundwater[d]	not applicable	not applicable	not applicable
Incidental ingestion of sediments	4.3E-02	0.80%	0.043%
Direct radiation	5.1E+00	93%	5.1%
Total annual dose above background (all relevant pathways)[a]	**5.4E+00**	**100%**	**5.4%**

[a] Pathways defined in previous sections.
[b] Maximum allowable exposure from all sources is 100 mrem/year (DOE Order 458.1).
[c] Doses associated with atmospheric releases also include ingestion pathways considered in the AirDose EPA food chain modeling routines.
[d] 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 dose-based screening levels found within the *Methods for Conducting Risk Assessments and Risk Evaluations* (DOE 2015c).

The cumulative dose to members of the public residing within 50 miles of the Paducah Site 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, based on representative assumptions is 1.02 person-rem. Table 4.8 provides a summary of the representative population dose calculations.

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 bioaccumulate 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.

Table 4.8. Summary of Potential Radiological Dose to the Population within 50 Miles of the Paducah Site for CY 2015[a]

Pathway	Population Dose (person-rem/year)	Percent of Total
Atmospheric releases[b,e]	5.2E-04	0.051%
Ingestion of drinking water (Cairo, Ill)	2.5E-01[f]	25%
Incidental ingestion of surface water[c]	not applicable	not applicable
Ingestion of groundwater[d]	not applicable	not applicable
Incidental ingestion of sediments[c]	not applicable	not applicable
Direct radiation	7.7E-01[g]	75%
Total annual dose above background (all relevant pathways)[a]	**1.02E+00**	**100%**

[a] Pathways defined in previous sections.
[b] DOE source emissions were from NWPGS, NEPCS ATU, DUF_6 conversion activities, C-400 Group, and C-709 & C-710 Seal Exhaust/Wet Air Group.
[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 the Paducah Site.
[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.
[f] Population dose for ingestion of drinking water from Cairo, Illinois, is based on a representative assumption using the estimated population of Cairo, Illinois, only.
[g] Population dose for direct radiation is based on a representative assumption using the estimated visitors hiking in WKWMA only.

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 4.1.7, are sampled annually for radionuclides. Surface water surveillance locations, as discussed in Section 4.1.6, 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 2015 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 discussed in DOE-STD-1153-2002. The RESRAD-BIOTA computer model (version 1.8) 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 water and sediment, respectively, in Bayou Creek. Data obtained from water sample location L11 and collocated sediment sample location S27 were used to represent water and sediment, respectively, 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 Paducah Site 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 4.9 summarizes the radiological dose to aquatic and terrestrial biota for Bayou Creek. Table 4.10 summarizes the radiological dose to aquatic and terrestrial biota for Little Bayou Creek. For each assessment, the limiting organism (i.e., the organism that is most sensitive to the potential radiological dose) is identified. The sum of fractions (or ratios) for each assessment and for the limiting organism was less than 1.0, indicating that the applicable BCGs were met for both the aquatic and terrestrial evaluations. These summed values are presented in the footnotes of each table. Additional monitoring results are available through the PEGASIS Web site at http://padgis.latakentucky.com/padgis/.

Table 4.9. Bayou Creek 2015 Evaluation of Dose to Aquatic and Terrestrial Biota[a]

	Aquatic Animal								
	Water				Sediment				Total
Radionuclide	Concentration (pCi/L)	BCG (pCi/L)	Ratio	Limiting Organism	Concentration (pCi/g)	BCG (pCi/g)	Ratio	Limiting Organism	Ratio
Cs-137	1.94E+00[b]	1.05E+03	1.85E-03	No	4.87E-02[b]	4.93E+04	9.87E-07	No	1.85E-03
K-40	1.34E+01[b]	2.90E+03	4.63E-03	No	2.34E+00	5.79E+04	4.04E-05	No	4.67E-03
Np-237	1.18E+00[b]	6.85E+01	1.72E-02	Yes	3.94E-01[b]	7.86E+04	5.01E-06	No	1.72E-02
Pu-238	-7.84E-02[b]	1.76E+02	-4.45E-04	Yes	1.10E-01[b]	3.95E+06	2.79E-08	No	-4.45E-04
Pu-239	-1.57E-01[b]	1.87E+02	-8.40E-04	Yes	2.53E-01[b]	7.05E+06	3.59E-08	No	-8.40E-04
Tc-99	2.43E+02[b]	2.47E+06	9.85E-05	No	2.14E+01[b]	4.59E+05	4.66E-05	No	1.45E-04
Th-228	N/A	3.74E+02	N/A	Yes	4.47E-01	1.64E+04	2.72E-05	No	2.72E-05
Th-230	N/A	2.57E+03	N/A	Yes	1.18E+00	2.74E+06	4.30E-07	No	4.30E-07
Th-232	N/A	3.07E+02	N/A	Yes	4.71E-01	3.23E+06	1.46E-07	No	1.46E-07
Th-234	3.27E+01[b]	2.66E+05	1.23E-04	Yes	3.71E+00	4.32E+04	8.59E-05	No	2.09E-04
U-234	1.03E+01	2.02E+02	5.10E-02	Yes	2.23E+00	3.03E+06	7.36E-07	No	5.10E-02
U-235	9.09E-01[b]	2.18E+02	4.18E-03	Yes	5.98E-01[b]	1.10E+05	5.46E-06	No	4.18E-03
U-238	2.06E+01	2.24E+02	9.22E-02	Yes	3.10E+00	4.29E+04	7.23E-05	No	9.22E-02
Summed	-	-	1.70E-01	-	-	-	2.85E-04	-	1.70E-01
	Riparian Animal								
	Water				Sediment				Total
Radionuclide	Concentration (pCi/L)	BCG (pCi/L)	Ratio	Limiting Organism	Concentration (pCi/g)	BCG (pCi/g)	Ratio	Limiting Organism	Ratio
Cs-137	1.94E+00[b]	4.27E+01	4.54E-02	Yes	4.87E-02[b]	3.13E+03	1.56E-05	Yes	4.55E-02
K-40	1.34E+01[b]	2.49E+02	5.37E-02	Yes	2.34E+00	4.42E+03	5.29E-04	Yes	5.43E-02
Np-237	1.18E+00[b]	1.16E+04	1.02E-04	No	3.94E-01[b]	7.63E+03	5.16E-05	Yes	1.54E-04
Pu-238	-7.84E-02[b]	5.51E+02	-1.42E-04	No	1.10E-01[b]	5.73E+03	1.92E-05	Yes	-1.23E-04
Pu-239	-1.57E-01[b]	6.22E+02	-2.52E-04	No	2.53E-01[b]	5.87E+03	4.31E-05	Yes	-2.09E-04
Tc-99	2.43E+02[b]	6.67E+05	3.64E-04	Yes	2.14E+01[b]	4.14E+04	5.17E-04	Yes	8.81E-04
Th-228	N/A	2.04E+03	N/A	No	4.47E-01	8.05E+02	5.55E-04	Yes	5.55E-04
Th-230	N/A	1.39E+04	N/A	No	1.18E+00	1.04E+04	1.13E-04	Yes	1.13E-04
Th-232	N/A	1.69E+03	N/A	No	4.71E-01	1.22E+03	3.85E-04	Yes	3.85E-04
Th-234	3.27E+01[b]	3.80E+06	8.61E-06	No	3.71E+00	4.32E+03	8.59E-04	Yes	8.68E-04
U-234	1.03E+01	6.84E+02	1.51E-02	No	2.23E+00	5.27E+03	4.23E-04	Yes	1.55E-02
U-235	9.09E-01[b]	7.37E+02	1.23E-03	No	5.98E-01[b]	3.79E+03	1.58E-04	Yes	1.39E-03
U-238	2.06E+01	7.57E+02	2.72E-02	No	3.10E+00	2.49E+03	1.24E-03	Yes	2.85E-02
Summed	-	-	1.43E-01	-	-	-	4.91E-03	-	1.48E-01

Table 4.9. Bayou Creek 2015 Evaluation of Dose to Aquatic and Terrestrial Biota[a] (Continued)

	Terrestrial Animal								
	Water				Sediment				Total
Radionuclide	Concentration (pCi/L)	BCG (pCi/L)	Ratio	Limiting Organism	Concentration (pCi/g)	BCG (pCi/g)	Ratio	Limiting Organism	Ratio
Cs-137	1.94E+00[b]	5.99E+05	3.24E-06	No	4.87E-02[b]	3.65E+25	1.33E-27	No	3.24E-06
K-40	1.34E+01[b]	1.93E+06	6.94E-06	No	2.34E+00	3.65E+25	6.41E-26	No	6.94E-06
Np-237	1.18E+00[b]	6.49E+06	1.82E-07	No	3.94E-01[b]	3.65E+25	1.08E-26	No	1.82E-07
Pu-238	-7.84E-02[b]	1.89E+05	-4.15E-07	No	1.10E-01[b]	3.65E+25	3.01E-27	No	-4.15E-07
Pu-239	-1.57E-01[b]	2.01E+05	-7.83E-07	No	2.53E-01[b]	3.65E+25	6.93E-27	No	-7.83E-07
Tc-99	2.43E+02[b]	1.54E+07	1.58E-05	No	2.14E+01[b]	3.65E+25	5.86E-25	No	1.58E-05
Th-228	N/A	6.34E+04	N/A	No	4.47E-01	3.65E+25	1.22E-26	No	1.22E-26
Th-230	N/A	4.52E+05	N/A	No	1.18E+00	3.65E+25	3.23E-26	No	3.23E-26
Th-232	N/A	5.41E+04	N/A	No	4.71E-01	3.65E+25	1.29E-26	No	1.29E-26
Th-234	3.27E+01[b]	4.31E+06	7.58E-06	No	3.71E+00	3.65E+25	1.02E-25	No	7.58E-06
U-234	1.03E+01	4.05E+05	2.54E-05	No	2.23E+00	3.65E+25	6.11E-26	No	2.54E-05
U-235	9.09E-01[b]	4.20E+05	2.16E-06	No	5.98E-01[b]	3.65E+25	1.64E-26	No	2.16E-06
U-238	2.06E+01	4.06E+05	5.07E-05	No	3.10E+00	3.65E+25	8.49E-26	No	5.07E-05
Summed	-	-	1.11E-04	-	-	-	9.94E-25	-	1.11E-04
	Terrestrial Plant								
	Water				Sediment				Total
Radionuclide	Concentration (pCi/L)	BCG (pCi/L)	Ratio	Limiting Organism	Concentration (pCi/g)	BCG (pCi/g)	Ratio	Limiting Organism	Ratio
Cs-137	1.94E+00[b]	4.93E+07	3.93E-08	No	4.87E-02[b]	3.65E+26	1.33E-28	No	3.93E-08
K-40	1.34E+01[b]	5.79E+07	2.31E-07	No	2.34E+00	3.65E+26	6.41E-27	No	2.31E-07
Np-237	1.18E+00[b]	7.86E+07	1.50E-08	No	3.94E-01[b]	3.65E+26	1.08E-27	No	1.50E-08
Pu-238	-7.84E-02[b]	3.95E+09	-1.99E-11	No	1.10E-01[b]	3.65E+26	3.01E-28	No	-1.99E-11
Pu-239	-1.57E-01[b]	7.05E+09	-2.23E-11	No	2.53E-01[b]	3.65E+26	6.93E-28	No	-2.23E-11
Tc-99	2.43E+02[b]	4.59E+08	5.30E-07	No	2.14E+01[b]	3.65E+26	5.86E-26	No	5.30E-07
Th-228	N/A	1.64E+07	N/A	No	4.47E-01	3.65E+26	1.22E-27	No	1.22E-27
Th-230	N/A	2.74E+09	N/A	No	1.18E+00	3.65E+26	3.23E-27	No	3.23E-27
Th-232	N/A	3.23E+09	N/A	No	4.71E-01	3.65E+26	1.29E-27	No	1.29E-27
Th-234	3.27E+01[b]	4.32E+07	7.57E-07	No	3.71E+00	3.65E+26	1.02E-26	No	7.57E-07
U-234	1.03E+01	3.03E+09	3.40E-09	No	2.23E+00	3.65E+26	6.11E-27	No	3.40E-09
U-235	9.09E-01[b]	1.10E+08	8.29E-09	No	5.98E-01[b]	3.65E+26	1.64E-27	No	8.29E-09
U-238	2.06E+01	4.29E+07	4.80E-07	No	3.10E+00	3.65E+26	8.49E-27	No	4.80E-07
Summed	-	-	2.06E-06	-	-	-	9.94E-26	-	2.06E-06

(Summed) total ratio for limiting organism: 2.69E-01.
(Summed) water ratio for limiting organism: 2.64E-01.
(Summed) sediment ratio for limiting organism: 4.91E-03.
N/A in this table indicates radionuclide was not analyzed. Ratios were not included and not summed for radionuclides that were not analyzed.
[a] Bayou Creek evaluated based on 2015 maximum results for L5 and S1.
[b] Result was reported at concentrations less than the laboratory's reporting limit.

Table 4.10. Little Bayou Creek 2015 Evaluation of Dose to Aquatic and Terrestrial Biota[a]

	Aquatic Animal								
	Water				Sediment				Total
Radionuclide	Concentration (pCi/L)	BCG (pCi/L)	Ratio	Limiting Organism	Concentration (pCi/g)	BCG (pCi/g)	Ratio	Limiting Organism	Ratio
Cs-137	N/A	1.05E+03	N/A	No	3.66E-02[b]	4.93E+04	7.42E-07	No	7.42E-07
K-40	N/A	2.90E+03	N/A	No	2.96E+00	5.79E+04	5.11E-05	No	5.11E-05
Np-237	N/A	6.85E+01	N/A	Yes	-1.34E-01[b]	7.86E+04	-1.71E-06	No	-1.71E-06
Pu-238	N/A	1.76E+02	N/A	Yes	1.04E-01[b]	3.95E+06	2.64E-08	No	2.64E-08
Pu-239	N/A	1.87E+02	N/A	Yes	1.04E-01[b]	7.05E+06	1.48E-08	No	1.48E-08
Tc-99	3.68E+01[b]	2.47E+06	1.49E-05	No	1.38E+00[b]	4.59E+05	3.01E-06	No	1.79E-05
Th-228	N/A	3.74E+02	N/A	Yes	2.11E-01[b]	1.64E+04	1.28E-05	No	1.28E-05
Th-230	1.41E-01[b]	2.57E+03	5.49E-05	Yes	1.25E+00	2.74E+06	4.55E-07	No	5.53E-05
Th-232	N/A	3.07E+02	N/A	Yes	4.31E-01	3.23E+06	1.33E-07	No	1.33E-07
Th-234	N/A	2.66E+05	N/A	Yes	5.24E+00	4.32E+04	1.21E-04	No	1.21E-04
U-234	1.10E-01[b]	2.02E+02	5.45E-04	Yes	1.71E+00	3.03E+06	5.64E-07	No	5.45E-04
U-235	1.50E+00[b]	2.18E+02	6.89E-03	Yes	9.09E-01	1.10E+05	8.29E-06	No	6.90E-03
U-238	5.22E-01[b]	2.24E+02	2.34E-03	Yes	2.56E+00	4.29E+04	5.97E-05	No	2.39E-03
Summed	-	-	9.84E-03	-	-	-	2.56E-04	-	1.01E-02
	Riparian Animal								
	Water				Sediment				Total
Radionuclide	Concentration (pCi/L)	BCG (pCi/L)	Ratio	Limiting Organism	Concentration (pCi/g)	BCG (pCi/g)	Ratio	Limiting Organism	Ratio
Cs-137	N/A	4.27E+01	N/A	Yes	3.66E-02[b]	3.13E+03	1.17E-05	Yes	1.17E-05
K-40	N/A	2.49E+02	N/A	Yes	2.96E+00	4.42E+03	6.69E-04	Yes	6.69E-04
Np-237	N/A	1.16E+04	N/A	No	-1.34E-01[b]	7.63E+03	-1.76E-05	Yes	-1.76E-05
Pu-238	N/A	5.51E+02	N/A	No	1.04E-01[b]	5.73E+03	1.82E-05	Yes	1.82E-05
Pu-239	N/A	6.22E+02	N/A	No	1.04E-01[b]	5.87E+03	1.77E-05	Yes	1.77E-05
Tc-99	3.68E+01[b]	6.67E+05	5.52E-05	Yes	1.38E+00[b]	4.14E+04	3.33E-05	Yes	8.85E-05
Th-228	N/A	2.04E+03	N/A	No	2.11E-01[b]	8.05E+02	2.62E-04	Yes	2.62E-04
Th-230	1.41E-01[b]	1.39E+04	1.02E-05	No	1.25E+00	1.04E+04	1.20E-04	Yes	1.30E-04
Th-232	N/A	1.69E+03	N/A	No	4.31E-01	1.22E+03	3.53E-04	Yes	3.53E-04
Th-234	N/A	3.80E+06	N/A	No	5.24E+00	4.32E+03	1.21E-03	Yes	1.21E-03
U-234	1.10E-01[b]	6.84E+02	1.61E-04	No	1.71E+00	5.27E+03	3.24E-04	Yes	4.85E-04
U-235	1.50E+00[b]	7.37E+02	2.04E-03	No	9.09E-01	3.79E+03	2.40E-04	Yes	2.28E-03
U-238	5.22E-01[b]	7.57E+02	6.90E-04	No	2.56E+00	2.49E+03	1.03E-03	Yes	1.72E-03
Summed	-	-	2.95E-03	-	-	-	4.27E-03	-	7.22E-03
	Terrestrial Animal								
	Water				Sediment				Total
Radionuclide	Concentration (pCi/L)	BCG (pCi/L)	Ratio	Limiting Organism	Concentration (pCi/g)	BCG (pCi/g)	Ratio	Limiting Organism	Ratio
Cs-137	N/A	5.99E+05	N/A	No	3.66E-02[b]	3.65E+25	1.00E-27	No	1.00E-27
K-40	N/A	1.93E+06	N/A	No	2.96E+00	3.65E+25	8.11E-26	No	8.11E-26
Np-237	N/A	6.49E+06	N/A	No	-1.34E-01[b]	3.65E+25	-3.67E-27	No	-3.67E-27
Pu-238	N/A	1.89E+05	N/A	No	1.04E-01[b]	3.65E+25	2.85E-27	No	2.85E-27
Pu-239	N/A	2.01E+05	N/A	No	1.04E-01[b]	3.65E+25	2.85E-27	No	2.85E-27
Tc-99	3.68E+01[b]	1.54E+07	2.39E-06	No	1.38E+00[b]	3.65E+25	3.78E-26	No	2.39E-06
Th-228	N/A	6.34E+04	N/A	No	2.11E-01[b]	3.65E+25	5.78E-27	No	5.78E-27
Th-230	1.41E-01[b]	4.52E+05	3.12E-07	No	1.25E+00	3.65E+25	3.42E-26	No	3.12E-07
Th-232	N/A	5.41E+04	N/A	No	4.31E-01	3.65E+25	1.18E-26	No	1.18E-26
Th-234	N/A	4.31E+06	N/A	No	5.24E+00	3.65E+25	1.44E-25	No	1.44E-25
U-234	1.10E-01[b]	4.05E+05	2.72E-07	No	1.71E+00	3.65E+25	4.68E-26	No	2.72E-07
U-235	1.50E+00[b]	4.20E+05	3.57E-06	No	9.09E-01	3.65E+25	2.49E-26	No	3.57E-06
U-238	5.22E-01[b]	4.06E+05	1.28E-06	No	2.56E+00	3.65E+25	7.01E-26	No	1.28E-06
Summed	-	-	7.83E-06	-	-	-	4.59E-25	-	7.83E-06

Table 4.10. Little Bayou Creek 2015 Evaluation of Dose to Aquatic and Terrestrial Biota[a] (Continued)

	Terrestrial Plant								
	Water				Sediment				Total
Radionuclide	Concentration (pCi/L)	BCG (pCi/L)	Ratio	Limiting Organism	Concentration (pCi/g)	BCG (pCi/g)	Ratio	Limiting Organism	Ratio
Cs-137	N/A	4.93E+07	N/A	No	3.66E-02[b]	3.65E+26	1.00E-28	No	1.00E-28
K-40	N/A	5.79E+07	N/A	No	2.96E+00	3.65E+26	8.11E-27	No	8.11E-27
Np-237	N/A	7.86E+07	N/A	No	-1.34E-01[b]	3.65E+26	-3.67E-28	No	-3.67E-28
Pu-238	N/A	3.95E+09	N/A	No	1.04E-01[b]	3.65E+26	2.85E-28	No	2.85E-28
Pu-239	N/A	7.05E+09	N/A	No	1.04E-01[b]	3.65E+26	2.85E-28	No	2.85E-28
Tc-99	3.68E+01[b]	4.59E+08	8.02E-08	No	1.38E+00[b]	3.65E+26	3.78E-27	No	8.02E-08
Th-228	N/A	1.64E+07	N/A	No	2.11E-01[b]	3.65E+26	5.78E-28	No	5.78E-28
Th-230	1.41E-01[b]	2.74E+09	5.14E-11	No	1.25E+00	3.65E+26	3.42E-27	No	5.14E-11
Th-232	N/A	3.23E+09	N/A	No	4.31E-01	3.65E+26	1.18E-27	No	1.18E-27
Th-234	N/A	4.32E+07	N/A	No	5.24E+00	3.65E+26	1.44E-26	No	1.44E-26
U-234	1.10E-01[b]	3.03E+09	3.63E-11	No	1.71E+00	3.65E+26	4.68E-27	No	3.63E-11
U-235	1.50E+00[b]	1.10E+08	1.37E-08	No	9.09E-01	3.65E+26	2.49E-27	No	1.37E-08
U-238	5.22E-01[b]	4.29E+07	1.22E-08	No	2.56E+00	3.65E+26	7.01E-27	No	1.22E-08
Summed	-	-	1.06E-07	-	-	-	4.59E-26	-	1.06E-07

(Summed) total ratio for limiting organism: 1.42E-02.
(Summed) water ratio for limiting organism: 9.88E-03.
(Summed) sediment ratio for limiting organism: 4.29E-03.
N/A in this table indicates radionuclide was not analyzed. Ratios were not included and not summed for radionuclides that were not analyzed.
[a] Little Bayou Creek evaluated based on 2015 maximum results for L11 and S27.
[b] Result was reported at concentrations less than the laboratory's reporting limit.

4.2 CLEARANCE OF PROPERTY CONTAINING RESIDUAL RADIOACTIVE MATERIAL

This section addresses clearance of personal property (see glossary) containing residual radioactive material. The Paducah Site has begun efforts to transfer real property (see glossary), but clearance of real property has not yet taken place.

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 property with residual radioactive material (see glossary). 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 whether items with potential volumetric contamination are released. In those cases where volumetric Authorized Limits have not been established, release is determined based on a comparison to established background radionuclide concentrations. These background radionuclide concentrations are documented in the *Methods for Conducting Risk Assessments and Risk Evaluations* (DOE 2015c), where appropriate.

Property potentially containing residual radioactive material will not be cleared from the Paducah Site unless the property is demonstrated to be within acceptable limits. Property clearance requirements are governed by procedures established by each DOE contractor.

In 2015, LATA Kentucky authorized 181 and FPDP authorized 232 releases of personal property that were surveyed for contamination. Several of these releases were in support of reuse and recycling efforts and deactivation operations. Multiple radiological surveys were performed to measure the radiological status of the property. Items released included, but were not limited to, heavy equipment, vehicles, containers, tanks, monitoring equipment, activated carbon, and batteries. 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 2015, SST authorized, with concurrence from DOE, 175 releases of personal property that were surveyed for surface contamination. Most of these were in support of SST operations including, but not limited to, vehicles, mowers, miscellaneous equipment and parts, furniture, electronics, and fire extinguishers.

In 2015, BWCS continued off-site shipment of HF produced by the DUF_6 Conversion Facility, which converts DUF_6 into uranium oxide and HF. Each shipment must meet the release limit of less than 3 pCi/mL of total uranium activity. During 2015, 800,592 gal of HF were shipped off-site, and the total uranium activity of each shipment was below the detection limit of 1.06 pCi/mL.

In addition to off-site releases, DOE placed 832 tons of waste into the C-746-U Landfill using the C-746-U Authorized Limits. 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 2015 include, but are not limited to, building demolition and asbestos removal debris from the C-410/C-420 Feed Plant Complex, debris from the demolition of the C-746-B warehouse and the C-746-M waste storage facility, the decommissioning of the C-746-A warehouse, and removal of two USTs. Table 4.11 provides a summary of Authorized Limit disposal at the C-746-U Landfill during CY 2015 and the cumulative totals since Authorized Limit disposal began in May 2003.

Table 4.11. C-746-U Landfill Authorized Limit Disposal

Cumulative Activity from 2015 Disposal			Total Activity from Disposal 5/21/03 to 12/31/15			
Isotope	**Activity (Curies)**		**Isotope**	**Activity (Curies)**	**Inventory Limit (Curies)**	**Percent Utilized ***
Am-241	3.28E-03		Am-241	1.09E-02	79	0.01%
Cs-137	1.70E-04		Cs-137	1.19E-02	43	0.03%
Np-237	1.08E-03		Np-237	1.32E-02	12	0.11%
Pu-238	1.46E-04		Pu-238	4.54E-03	88	0.01%
Pu-239/240	9.13E-03		Pu-239/240	2.39E-02	162	0.01%
Tc-99	1.84E-01		Tc-99	1.29E+00	117	1.10%
Th-228	1.75E-04		Th-228	7.49E-02	9	0.83%
Th-230	2.70E-02		Th-230	2.37E-01	230	0.10%
Th-232	9.23E-05		Th-232	7.54E-02	9	0.84%
U-234	2.99E-02		U-234	3.86E-01	360	0.11%
U-235	1.43E-03		U-235	1.80E-02	15	0.12%
U-238	2.94E-02		U-238	4.07E-01	360	0.11%

Waste streams disposed of (2015)	14	Waste streams disposed of (2003–2015)	254
Mass disposed of (2015)	832 tons	Mass disposed of (2003–2015)	121,000 tons
		Volume of current cells	386,169 yd^3
		Remaining cell volume	68,680 yd^3

*Percent utilized is the percentage of total activity disposed of divided by the disposal inventory limit, per isotope.

4.3 UNPLANNED RADIOLOGICAL RELEASES

There were no unplanned radiological releases in 2015.

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5. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

5.1 AIR MONITORING

Air emissions from the Oil Landfarm (SWMU 1) for the Southwest Plume Sources Remedial Action (a CERCLA project) were monitored for VOCs as part of operational controls for the remediation. No other active emission points at the Paducah Site require nonradiological air monitoring. The aging steam plant boilers that required emission monitoring no longer are used as of May 2015, and have been replaced with new efficient natural gas fired package boilers. The new boilers do not require emission monitoring. The C-310 Product Withdrawal Building stack was in stand-by in 2015, pending potential operations to evacuate fluorine compounds from the process buildings. If operations/emissions resume, the stack will be monitored, as required.

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 Nos. KY0004049 and KY0102083 to the Paducah Site. KPDES Permit KY0004049 applies to Outfalls 001, 015, 017, 019, and 020. KPDES Permit KY0102083 applies to Outfalls 002, 004, 006, 008, 009, 010, 011, 012, 013, and 016. 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.

Surface water monitoring locations and the monitoring program under which they are sampled routinely at the Paducah Site are shown in Figure 4.5 and in Table 5.1, respectively. Table 5.1 also shows the reporting for each of these programs, with hyperlinks to the reports, if available. Permit exceedances are described in Chapter 2. Monitoring results are available through the PEGASIS Web site at http://padgis.latakentucky.com/padgis/ and are summarized in Table 5.2.

Project-specific surface water sampling for decommissioning and ER projects is not summarized within this report. Results for C-410/C-420 Feed Plant Complex demolition storm water sampling are available upon request.

5.3 SEDIMENT MONITORING

Sediment monitoring locations are shown in Figure 4.6. Total PCBs (also listed as polychlorinated biphenyls in laboratory reports) were detected in sediment during 2015 ranging from 1.42 µg/kg to 222 µg/kg, within the acceptable risk range. According to *Methods for Conducting Risk Assessments and Risk Evaluations*, the no action level[7] for Total PCBs is 189 µg/kg, and the action level[8] is 18,900 µg/kg for the recreational user (DOE 2015c). The recreational user is used for comparison because it is the most reasonably anticipated scenario. 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 the Paducah Site

Program and Reporting Location	Number of Locations
Effluent Watershed Monitoring Program	
C-746-S and C-746-T Landfill Surface Water *Quarterly Compliance Monitoring Reports*: First Quarter CY 2015 (January—March) Second Quarter CY 2015 (April—June) Third Quarter CY 2015 (July—September) Fourth Quarter CY 2015 (October—December)	3*
C-746-U Landfill Surface Water *Quarterly Compliance Monitoring Reports*: First Quarter CY 2015 (January—March) Second Quarter CY 2015 (April—June) Third Quarter CY 2015 (July—September) Fourth Quarter CY 2015 (October—December)	3*
KPDES Monthly Discharge Monitoring Reports	15
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 2015 Surface Water Samples

Analyte	Range
Anions	
Chloride (mg/L)	0.353–91.7
Nitrate as Nitrogen (mg/L)	2.23–3.92
Sulfate (mg/L)	1.76–46.6
Wet Chemistry Parameters	
Carbonaceous Biochemical Oxygen Demand (mg/L)	1.13–32.9
Chemical Oxygen Demand (mg/L)	10–85.4
Dissolved Solids (mg/L)	58.6–234
Fecal Coliform (CFU/100 mL)	1–23
Hardness—Total as $CaCO_3$ (mg/L)	37.8–547
Suspended Solids (mg/L)	0.7–242
Total Organic Carbon (mg/L)	4.87–21
Total Solids (mg/L)	100–296
Volatile Organic Compounds	
Trichloroethene (µg/L)	0.3–112
Pesticides/PCBs	
PCB-1248 (µg/L)	0.0434–0.0434
PCB-1254 (µg/L)	0.081–0.154
PCB-1260 (µg/L)	0.0321–0.222
Total PCBs (µg/L)	0.0321–0.376
Other Organics	
Oil and Grease (mg/L)	1.1–5.73

Table 5.2. Ranges of Detected Analytes in 2015 Surface Water Samples (Continued)

Analyte	Range
Metals	
Antimony (mg/L)	0.00255–0.00255
Arsenic (mg/L)	0.0017–0.00312
Cadmium (mg/L)	0.00011–0.00011
Chromium (mg/L)	0.00266–0.00353
Copper (mg/L)	0.000592–0.0051
Iron (mg/L)	0.0853–2.66
Lead (mg/L)	0.0005–0.00175
Nickel (mg/L)	0.00051–0.00722
Phosphorous (mg/L)	0.0201–0.539
Selenium (mg/L)	0.00219–0.00219
Sodium (mg/L)	0.651–13.1
Uranium (mg/L)	0.000252–0.361
Zinc (mg/L)	0.00369–0.107

5.4 BIOTA MONITORING

Biological monitoring (i.e., fish or benthic macroinvertebrate sampling) was not required under the specifications listed in the KPDES permits. 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) (LATA Kentucky 2011). Requirements set forth in the WMP followed conditions in the KPDES permit (KY0004049) and best management practices. Initially, the permit required sampling of 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 in 2009, eliminating the requirements for the fish and benthic macroinvertebrate sampling; however, the chronic and acute toxicity sampling remained a KPDES permit condition. In order to provide data for future ecological assessments, 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. Sampling under the WMP now is described in the BMP Plan (LATA Kentucky 2014).

Warning signs are posted along Bayou and Little Bayou Creeks 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.

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6. GROUNDWATER PROTECTION PROGRAM

The Results of the Site Investigation Phase 1 (CH2M HILL 1991) determined the primary off-site contaminants in the RGA, the primary aquifer for local groundwater users, to be TCE and technetium-99. TCE was used until 1993 as an industrial degreasing solvent and technetium-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). Known or potential sources of TCE and technetium-99 include former test areas, spills, leaks, buried waste, and leachate derived from contaminated scrap metal previously stored on-site.

Investigations of the on-site source areas of TCE at the Paducah Site are ongoing. The main source and highest concentration of TCE contamination in the groundwater is near the C-400 Cleaning Building. TCE has a low solubility and a higher density than water and is included in a chemical group referred to as dense nonaqueous-phase liquids. As a result of these characteristics, TCE typically sinks through the subsurface and may form pools in less permeable layers of the subsurface, as well as the base of the aquifer. This makes treatment difficult because these pools constitute a continuous source of dissolved-phase contamination (i.e., plumes) deep within the aquifer.

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 groundwater monitoring supports the decision making process for the ultimate disposition of the contaminants. Figure 6.1 presents monitoring wells sampled in CY 2015 and shows the 2014 TCE plume associated with the Paducah Site (LATA Kentucky 2015b). The TCE plume map is revised every two years. See Section 6.4 for additional information about the plumes associated with the Paducah Site.

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 the Paducah Site.

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 the Paducah Site also is northward to discharge into the Ohio River.

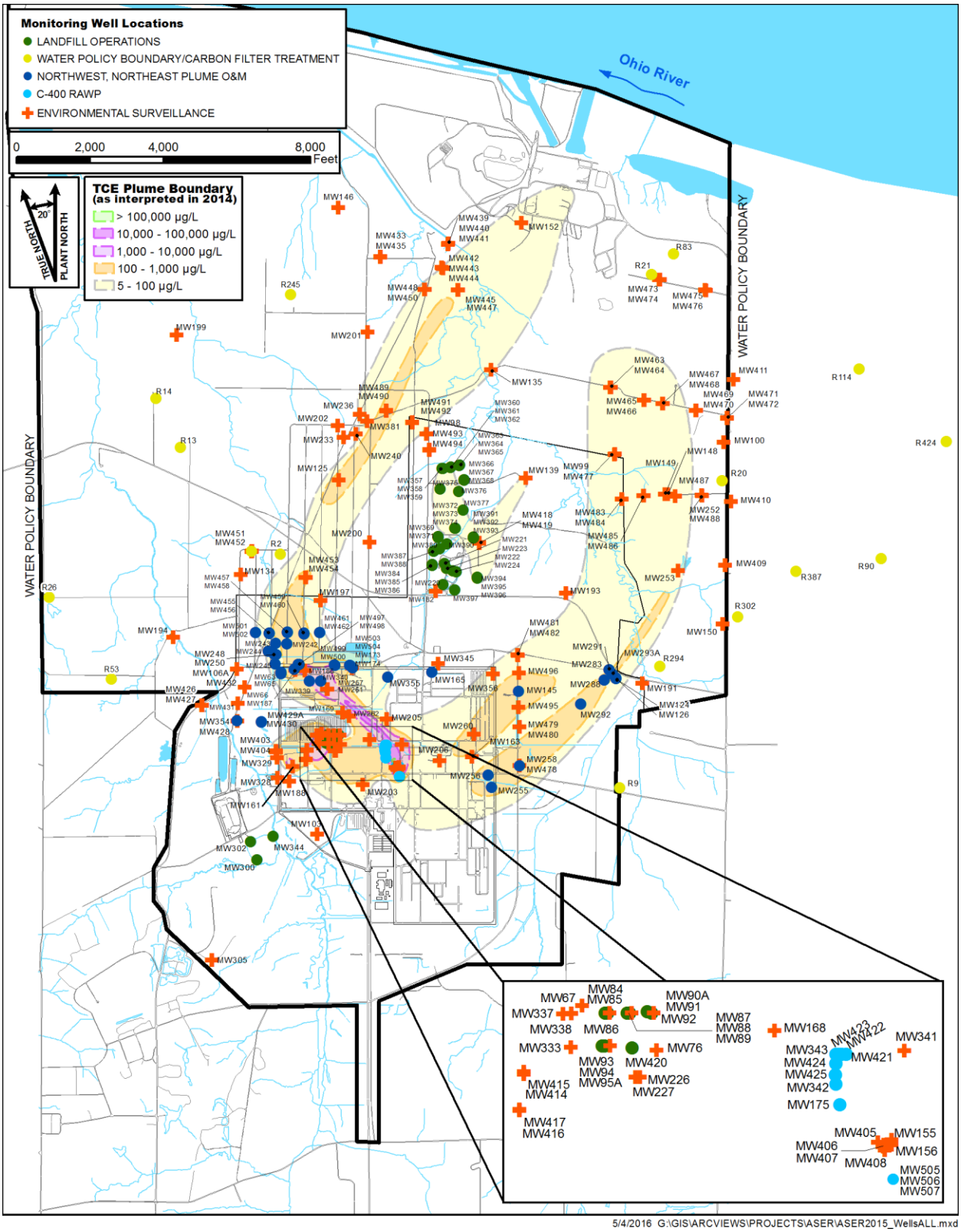


Figure 6.1. Monitoring Wells Sampled in CY 2015

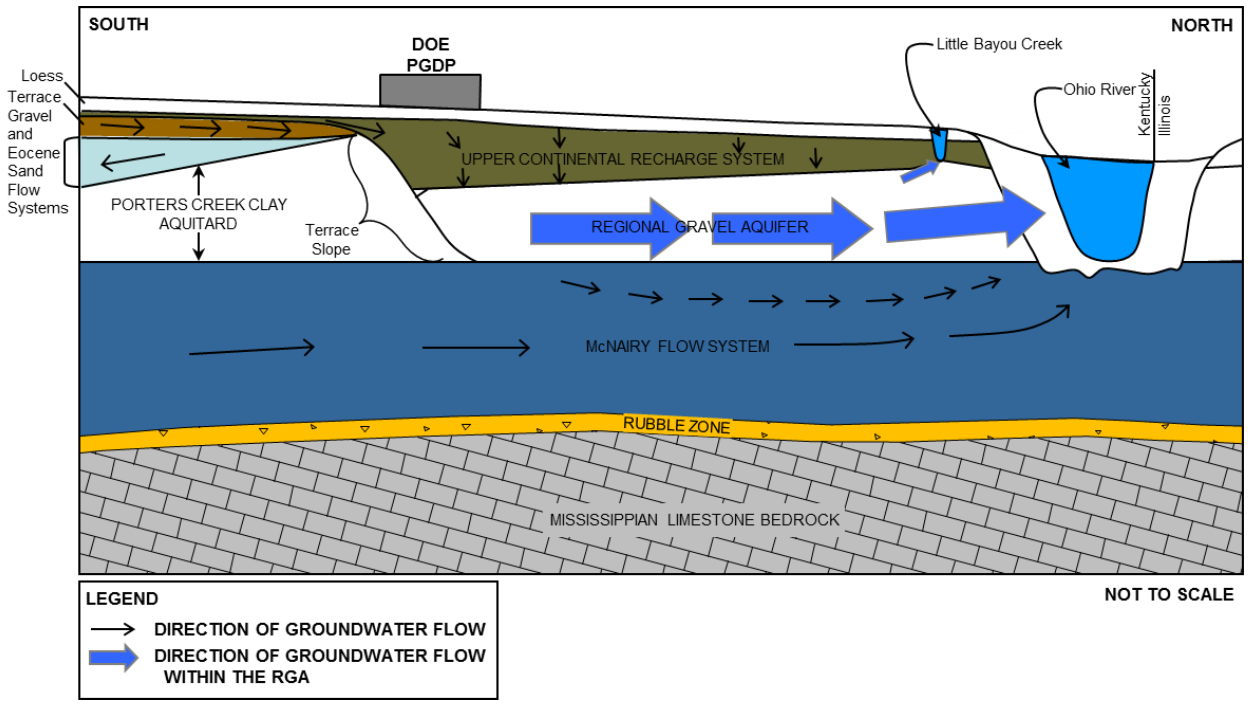


Figure 6.2. Paducah Site Groundwater Flow System and Water-Bearing Zones

Additional information regarding the geology and hydrogeology of the Paducah Site 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). In 2015, revision of the sitewide groundwater flow model was initiated. The revision is expected to be complete in CY 2016.

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 businesses in the vicinity of the plant area. In areas where the groundwater either is known to be contaminated or has the potential to become 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).

The Paducah Site 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 the groundwater monitoring program at the Paducah Site are obtaining

data to determine baseline conditions of groundwater quality and quantity; demonstrating compliance with and implementation of all applicable regulations and DOE Orders; providing data to allow early detection of groundwater pollution or contamination; identifying existing and potential groundwater contamination sources and maintaining surveillance of these sources; and providing data for making decisions about waste disposal on land-based units and the management and protections of groundwater resources. The groundwater monitoring program consists of routine compliance and facility monitoring designed to ensure protection of public health and the environment.

The sitewide approach is outlined in the following two documents related to groundwater monitoring: (1) Groundwater Protection Plan (LATA Kentucky 2015c); and (2) and the Paducah Site EMP (LATA Kentucky 2015a; FPDP 2016a). Nearly 300 MWs and residential wells were sampled in accordance with DOE Orders and federal, state, and local requirements during 2015. Well sampling is included in several different monitoring programs, as shown in Table 6.1. Shown also in Table 6.1 are the number of wells sampled in each flow system and each program (note that some wells are sampled under more than one program) and the reporting locations for each of these programs, with hyperlinks to the reports, if available. Monitoring results are available through the PEGASIS Web site at http://padgis.latakentucky.com/padgis/.

Table 6.1. Summary of Groundwater Monitoring at the Paducah Site

Program and Reporting Location	Number of Wells[a]				
	Terrace Gravel/ Eocene Sands	RGA	UCRS	Rubble Zone	Total
Groundwater Monitoring Program for Landfill Operations					
C-746-S and C-746-T Landfill Wells *Quarterly Compliance Monitoring Reports*: First Quarter CY 2015 (January—March) Second Quarter CY 2015 (April—June) Third Quarter CY 2015 (July—September) Fourth Quarter CY 2015 (October—December)	0	18	5[b]	0	23[c]
C-746-U Landfill Wells *Quarterly Compliance Monitoring Reports*: First Quarter CY 2015 (January—March) Second Quarter CY 2015 (April—June) Third Quarter CY 2015 (July—September) Fourth Quarter CY 2015 (October—December)	0	12	9[b]	0	21
C-404 Landfill Wells (required by permit) *Semiannual C-404 Groundwater Monitoring Reports:* C-404 Hazardous Waste Landfill May 2015 Semiannual Groundwater Report (October 2014—March 2015) C-404 Hazardous Waste Landfill November 2015 Semiannual Groundwater Report (April 2015—September 2015)	0	5	4	0	9
C-404 Landfill Wells (noncommitted)	0	11	0	0	11
C-746-K Landfill Wells *Semiannual FFA Progress Reports:* Second Half of FY 2015 (Data reported January—June 2015) First Half of FY 2016 (Data reported July—December 2015)	3	0	0	0	3

Table 6.1. Summary of Groundwater Monitoring at the Paducah Site (Continued)

Program and Reporting Location	Number of Wells[a]				
	Terrace Gravel/ Eocene Sands	RGA	UCRS	Rubble Zone	Total
Northeast Plume Operations and Maintenance Program *Semiannual FFA Progress Reports:* (see links above)					
Semiannual Wells	0	9	0	0	9
Quarterly Wells	0	5	0	0	5
Northwest Plume Operations and Maintenance Program *Semiannual FFA Progress Reports:* (see links above)					
Semiannual Wells	0	33	0	0	33
C-400 Cleaning Building Interim Remedial Action Monitoring Wells *Semiannual FFA Progress Reports:* (see links above)					
Semiannual Wells	0	8	0	0	8
Quarterly Wells	0	9	0	0	9
Water Policy Boundary Monitoring Program *ASER*					
Northwestern Wells	0	20	0	0	20
Northeastern Wells	0	9	0	0	9
Carbon Filter Treatment System *ASER*	0	1	0	0	1
Environmental Surveillance Groundwater Monitoring Program *ASER*					
Annual Wells	0	22[d]	1	1	24[d]
Biennial Wells	1	96	4	0	101
Geochemical Environmental Surveillance	0	38	0	0	38

[a] Some wells are sampled under more than one program.
[b] Not all wells had a sufficient amount of water to obtain samples.
[c] 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.
[d] Not all wells were sampled due to well being inoperable or inaccessible.

6.4 GROUNDWATER MONITORING RESULTS

Groundwater monitoring at the Paducah Site addresses programs including general environmental surveillance, current and inactive landfills, groundwater plume pump-and-treat operations, the C-400 Cleaning Building Interim Remedial Action monitoring, 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. Analytical results of interest are available upon request (by e-mailing PegasisAdmin@ffspaducah.com) or by visiting the PEGASIS Web site at http://padgis.latakentucky.com/padgis/ to view data. A summary of detected analytes from monitoring well groundwater samples (i.e., typically station names that begin with "MW") in 2015 are shown in Table 6.2.

The Paducah Site 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 technetium-99 contamination in the RGA and convey

Table 6.2. Ranges of Detected Analytes in 2015 Monitoring Well Groundwater Samples

Analyte	Range
Anions	
Bromide (mg/L)	0.0764–1.25
Chloride (mg/L)	0.417–114
Fluoride (mg/L)	0.035–0.706
Nitrate as Nitrogen (mg/L)	0.0332–9.59
Sulfate (mg/L)	0.422–1,500
Wet Chemistry Parameters	
Alkalinity (mg/L)	81.2–192
Alkalinity as $CaCO_3$ (mg/L)	26.3–167
Chemical Oxygen Demand (mg/L)	6.77–120
Cyanide (mg/L)	0.00189–0.003
Dissolved Solids (mg/L)	77.1–503
Iodide (mg/L)	0.257–0.8
Phosphate as Phosphorous (mg/L)	0.0756–0.348
Silica (mg/L)	7.97–28.8
Sulfide (mg/L)	0.0935–0.0935
Sulfite (mg/L)	0.5–0.5
Total Organic Carbon (mg/L)	0.36–11.2
Total Organic Halides (µg/L)	3.42–226
Volatile Organic Compounds	
1,1,1-Trichloroethane (µg/L)	0.31–0.31
1,1,2-Trichloroethane (µg/L)	0.38–2.73
1,1-Dichloroethane (µg/L)	0.33–35.9
1,1-Dichloroethene (µg/L)	0.33–78.3
1,2-Dichloroethane (µg/L)	0.32–0.48
Benzene (µg/L)	5.32–5.32
Carbon tetrachloride (µg/L)	0.32–166
Chloroform (µg/L)	0.33–468
cis-1,2-Dichloroethene (µg/L)	0.3–38,000*
Methane (mg/L)	0.0125–0.497
Tetrachloroethene (µg/L)	0.3–21.8
Toluene (µg/L)	0.4–0.99
trans-1,2-Dichloroethene (µg/L)	0.51–6.1*
Trichloroethene (µg/L)	0.3–55,900*
Vinyl chloride (µg/L)	0.69–233
Xylene (µg/L)	1.02–1.02
PCBs	
PCB-1242 (µg/L)	0.0511–0.182
Total PCBs (µg/L)	0.0511–0.182

*Maximum results are from C-400 Cleaning Building Interim Remedial Action MWs.

Analyte	Range
Metals	
Aluminum (mg/L)	0.0151–3.20
Arsenic (mg/L)	0.00173–0.0118
Barium (mg/L)	0.0173–0.521
Boron (mg/L)	0.00459–1.77
Cadmium (mg/L)	0.000118–0.00284
Calcium (mg/L)	5.05–368
Chromium (mg/L)	0.00247–2.99
Cobalt (mg/L)	0.0001–0.0324
Copper (mg/L)	0.00035–0.0124
Iron (mg/L)	0.0341–192
Lead (mg/L)	0.00055–0.00897
Magnesium (mg/L)	1.24–85.6
Manganese (mg/L)	0.00105–16.8
Mercury (mg/L)	0.000095–0.00017
Molybdenum (mg/L)	0.00017–0.0308
Nickel (mg/L)	0.00052–1.81
Potassium (mg/L)	0.0838–26.4
Selenium (mg/L)	0.0015–0.00523
Silver (mg/L)	0.000103–0.00126
Sodium (mg/L)	0.688–176
Tantalum (mg/L)	0.0013–0.00158
Uranium (mg/L)	0.000072–0.00647
Vanadium (mg/L)	0.00134–0.0168
Zinc (mg/L)	0.00353–5.85
Arsenic, Dissolved (mg/L)	0.00176–0.00823
Barium, Dissolved (mg/L)	0.0097–0.518
Cadmium, Dissolved (mg/L)	0.00019–0.00019
Chromium, Dissolved (mg/L)	0.00208–0.0238
Lead, Dissolved (mg/L)	0.00091–0.00091
Selenium, Dissolved (mg/L)	0.00165–0.00318
Uranium, Dissolved (mg/L)	0.00071–0.00617
Radionuclides	
Alpha activity (pCi/L)	585–21
Beta activity (pCi/L)	8.87–717
Radium-226 (pCi/L)	0.413–2.04
Radium-228 (pCi/L)	4.55–5.6
Technetium-99 (pCi/L)	19.5–8,220*
Thorium-230 (pCi/L)	0.421–1.03
Thorium-232 (pCi/L)	0.201–0.512
Uranium-234 (pCi/L)	1.97–1.99
Uranium-238 (pCi/L)	0.9.91–1.61

the general magnitude and distribution of contamination within the plumes. For additional description of the Paducah Site plumes, please see *Trichloroethene and Technetium-99 Groundwater Contamination in the Regional Gravel Aquifer for Calendar Year 2014 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (LATA Kentucky 2015b). This document is available from the EIC and at the following link: http://paducaheic.com/Search.aspx?accession=ENV 1.J.1-00789.

Records of decision have been put in place under the Groundwater Operable Unit for the following Projects:

- Northwest Plume (DOE 1993; DOE 2010),
- Northeast Plume (DOE 1995b; DOE 2015d),
- C-400 Cleaning Building source area (DOE 2005), and
- Southwest Plume (DOE 2012).

These documents can be found in the EIC (www.paducaheic.com). The locations of groundwater contamination sources are shown in Figure 6.3. Table 6.3 lists the cumulative TCE removed from liquid VOCs and VOCs on carbon recovered through CY 2015. The graphs shown in Figures 6.4 and 6.5 illustrate the cumulative TCE removed from liquid by the NWPGS and the NEPCS through CY 2015.

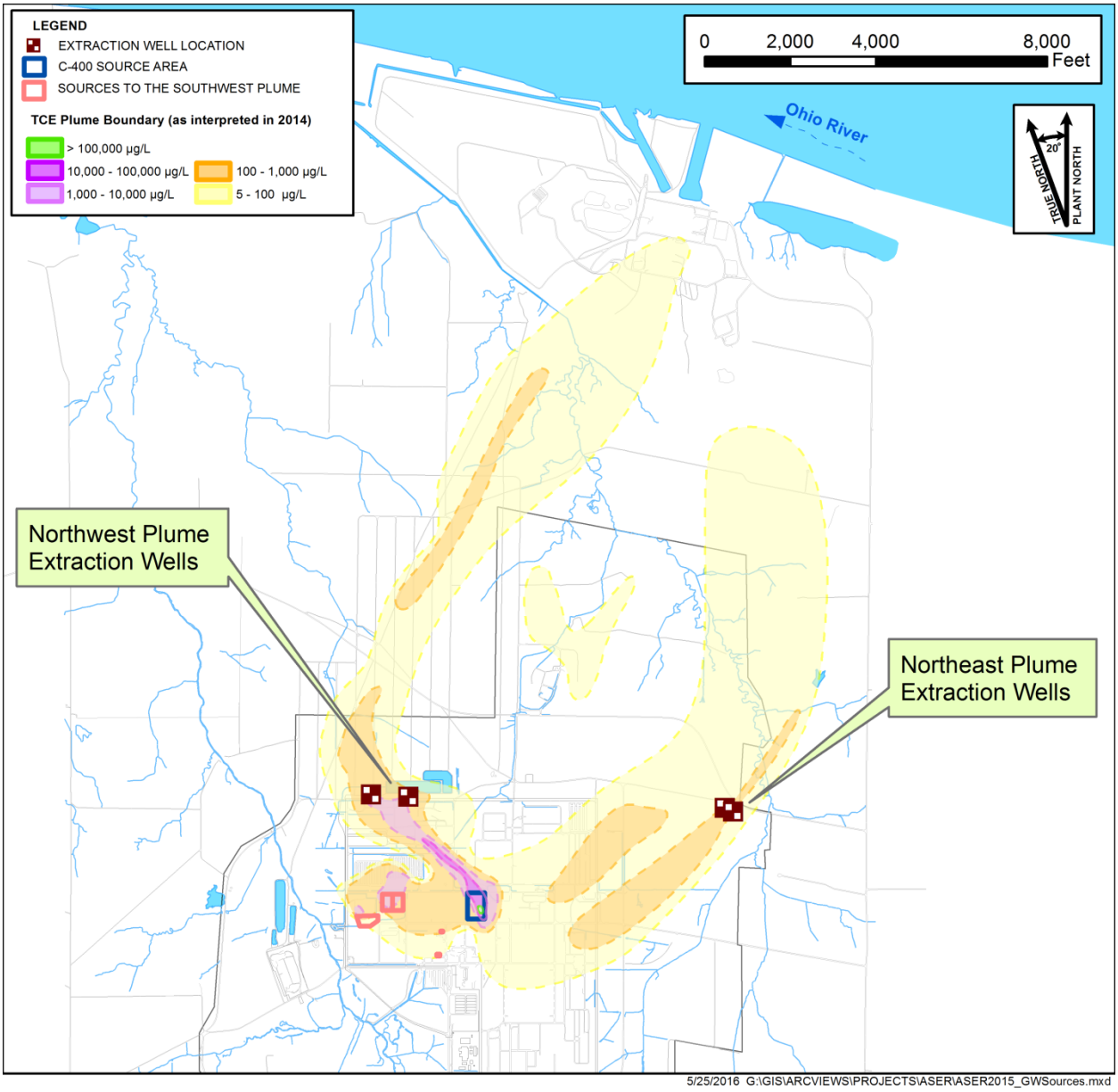
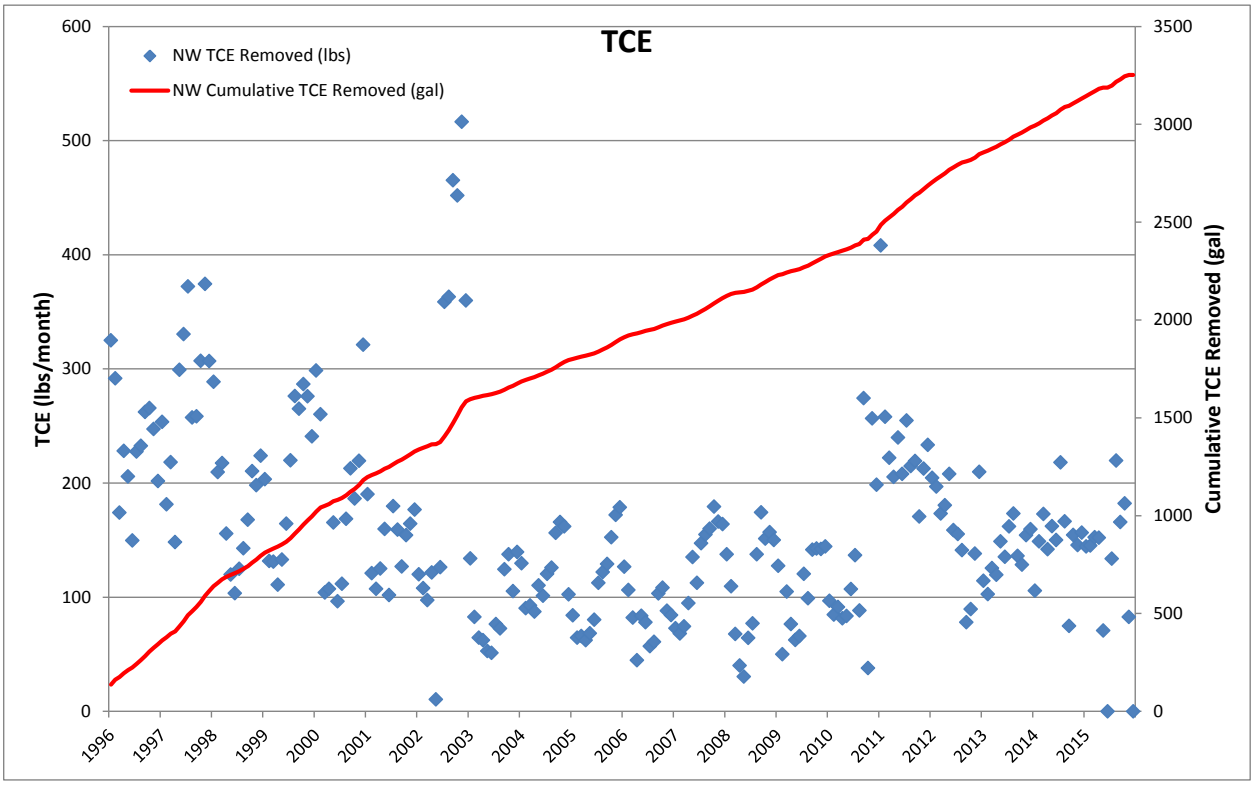


Figure 6.3. Locations of Groundwater Contamination Sources

Table 6.3. Cumulative TCE Removed at Paducah

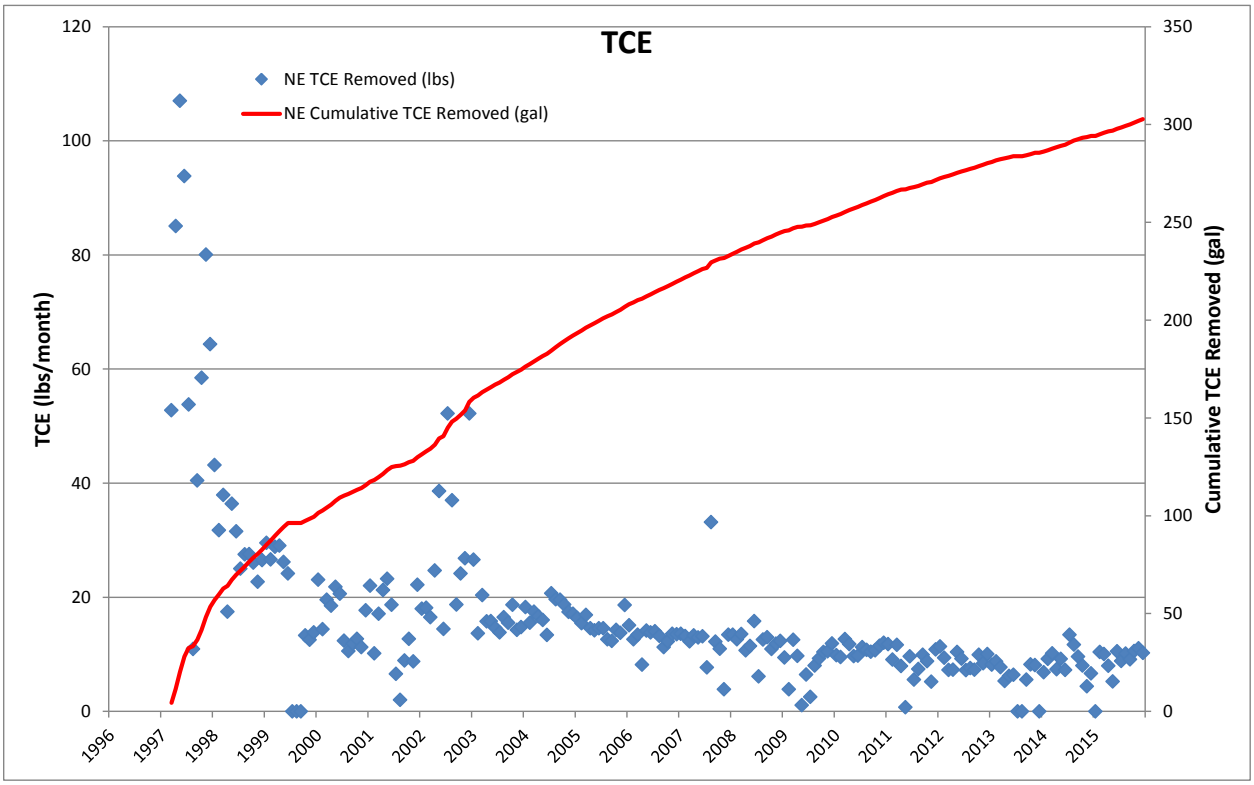
Source Area	Cumulative TCE Removed (gal) [a]
NWPGS	3,893[b]
NEPCS	330[b]
C-400 Cleaning Building Interim Remedial Action (including treatability study)	3,572[b]
Other sources (i.e., SWMU 91, LASAGNA™)	246

[a] TCE values include liquid VOCs and VOCs on carbon recovered.
[b] Cumulative through December 31, 2015. Value taken from DOE 2016b.



Source: DOE 2016b

Figure 6.4. Northwest Plume Groundwater System TCE Removed



Source: DOE 2016b

Figure 6.5. Northeast Plume Containment System TCE Removed

A Groundwater Assessment Report documented that there was no evidence indicating a release from the C-746-U Landfill (LATA Kentucky 2013b). The data used to support this assessment were groundwater analyses of quarterly and semiannual monitoring for the period 2002 through 2012 and the focused sampling of October 2006. The report found that the beta activity (associated with technetium-99) and TCE in the wells were sourced from upgradient of the C-746-U Landfill and associated with migration of historical plumes. The Kentucky Solid Waste Facility (401 *KAR* 47:030 § 6) maximum contaminant level (MCL) exceedances are listed in Table 6.4.

Table 6.4. Summary of MCL Exceedances for C-746-S & -T and C-746-U in 2015

C-746-S and C-746-T Landfills		
UCRS	**Upper RGA**	**Lower RGA**
None	MW220: trichloroethene MW372: beta activity, trichloroethene MW384: beta activity MW387: beta activity MW39l: trichloroethene MW394: trichloroethene	MW373: trichloroethene MW385: beta activity MW388: beta activity MW392: trichloroethene
C-746-U Landfill		
UCRS	**Upper RGA**	**Lower RGA**
MW359: trichloroethene	MW357: trichloroethene MW372: beta activity, trichloroethene	MW358: beta activity, trichloroethene MW361: trichloroethene MW367: beta activity MW373: trichloroethene

Shading indicates a background MW.

Statistical analyses also are used to evaluate compliance MWs at the C-746-S and C-746-T Landfill, the C-746-U Landfill, and the C-404 Landfill. Each report (see Table 6.1) lists any statistical exceedance that is found.

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 Description for the Fluor Federal Services, Inc., Paducah Deactivation Project, Paducah, Kentucky*, CP2-QA-1000;
- 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. The Paducah Site 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 2015, 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 2015a; FPDP 2016a).

The Paducah Programmatic Quality Assurance Project Plan was implemented in 2013 and was updated in 2015 (DOE 2015e). This plan is based on the Uniform Federal Policy for Quality Assurance Project Plans. Additionally, the following procedures further ensure quality:

- Field forms are maintained in accordance with CP3-RD-0010, *Records Management Process*.
- Communication and documentation between the sample and data management organization and field sampling personnel are conducted in accordance with CP3-ES-5007, *Data Management Coordination*.
- Sample labels and chains-of-custody are completed according to CP4-ES-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 CP3-ES-5003, *Quality Assured Data*.

- Logbooks and data forms are prepared in accordance with CP4-ES-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 2015. Additional subjects included in the QA Plan are training requirements, sample custody, procedures, and instrument calibration and maintenance.

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 2015a; FPDP 2016a). The Paducah Site EMP is evaluated and modified, as appropriate, using the DQO methodology on an FY basis (i.e., October 1 through September 30) following EPA DQO guidance (EPA QA/G-4).

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 is 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, sediment, and air filters. 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 activities 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. These programs are conducted by EPA, DOE, and commercial laboratories. Data that do not meet acceptable criteria 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.

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 the LATA Kentucky sampling organization participated in the study in 2015. Final results for the Discharge Monitoring Report QA Study Number 35 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. FPDP reviews DOECAP audit reports and laboratory corrective action plans for compliance with FPDP 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)]. Environmental data loaded to Paducah OREIS have been assessed, verified, and validated (if applicable), as specified in CP3-ES-5003, *Quality Assured Data*.

7.3.3 PEGASIS

PEGASIS allows public 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 from Paducah OREIS is loaded into PEGASIS on a monthly basis. PEGASIS does not contain data related to waste, deactivation, demolition, 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 electronically 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, 60 packages were validated in CY 2015.

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.

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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 activity—A measure of the emission of alpha particles during radioactive decay. Alpha particles are positively charged particles 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.

assimilate—To take up or absorb.

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 activity—A measure of the emission of beta particles during radioactive decay. Beta particles are negatively charged particles 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.

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

clearance of property—The removal of property that contains residual radioactive material from DOE radiological control under 10 *CFR* § 835 and DOE Order 458.1.

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.

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.

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.

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.

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 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.

internal exposure—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.

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.

limited area—The industrial area at PGDP, comprising approximately 644 acres.

low-level waste—Low-level waste is radioactive waste that is not high-level waste; spent nuclear fuel; transuranic waste; byproduct material (as defined in Section 11e.(2) of the *Atomic Energy Act of 1954*, as amended); or naturally occurring radioactive material.

maximally exposed individual (MEI)—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.

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.

personal property—Property of any kind, except for real property.

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.

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

process water—Water used within a system process.

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.

real property—Land and anything permanently affixed to the land such as buildings, fences, and those things attached to the buildings, such as light fixtures, plumbing, and heating fixtures, or other such items, that would be personal property, if not attached.

record of decision—A public document that explains which cleanup alternatives will be used to clean up a Superfund site.

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.

reportable quantity—An amount set by a regulation in which release to the environment must be reported to regulatory agencies.

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

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

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

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.

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.

transuranic (TRU) 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.

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

upgradient—In the direction of increasing hydrostatic head.

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.

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