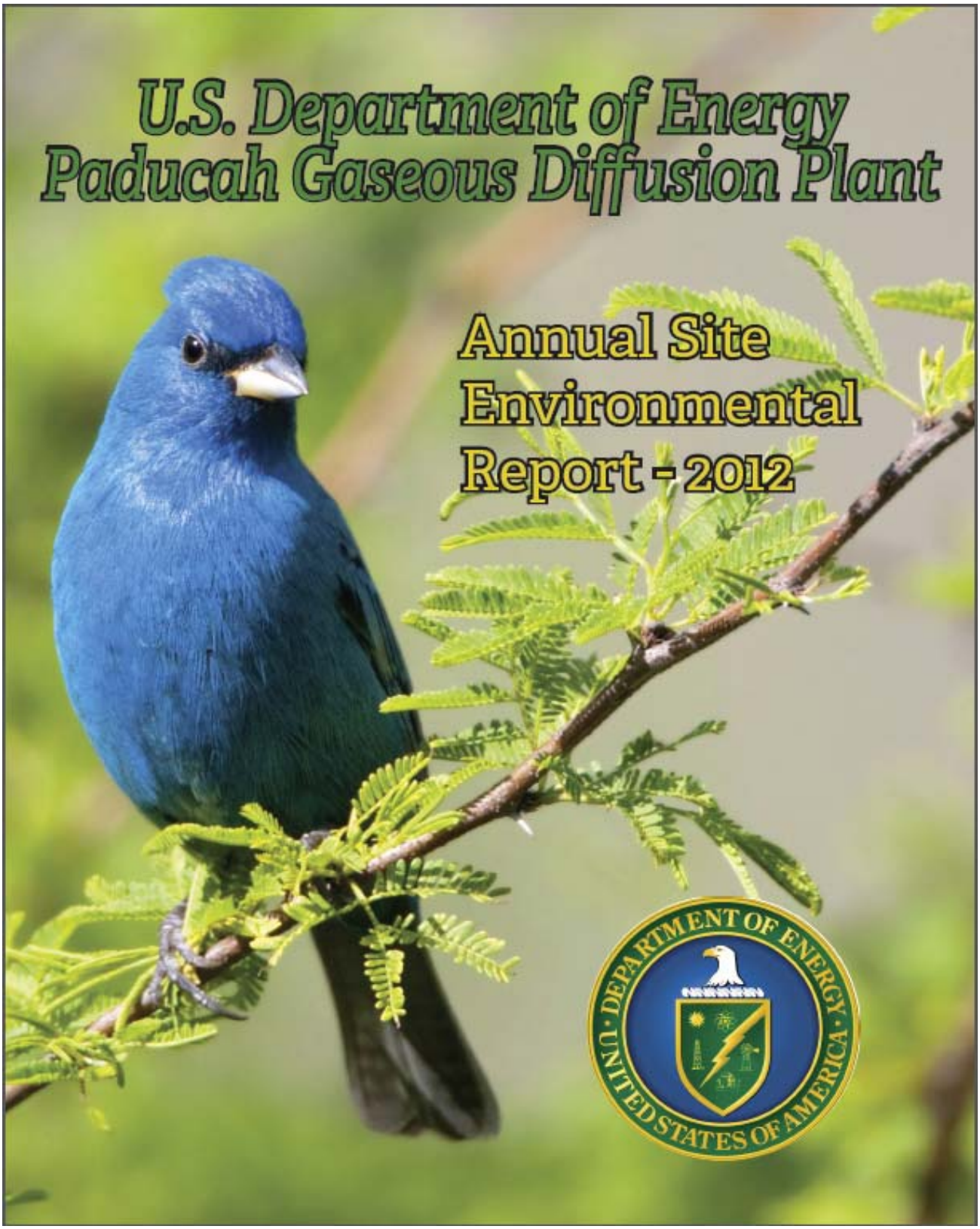

U.S. Department of Energy Paducah Gaseous Diffusion Plant
2012 Annual Site Environmental Report (ASER): Student Summary

U.S. DEPARTMENT OF ENERGY PADUCAH PLANT

2012 ANNUAL SITE ENVIRONMENTAL REPORT (ASER):

Student Summary

Marshall County High School

AP Chemistry Environmental Science Classes

December 2015

Prepared by
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Prepared for
United States Department of Energy
Portsmouth/Paducah Project Office

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2 MESSAGE FROM THE DEPARTMENT OF ENERGY

The U.S. Department of Energy (DOE) conducts comprehensive environmental monitoring at the Paducah Gaseous Diffusion Plant (PGDP) site and nearby areas to ensure protection of human health and the environment. Annual environmental monitoring data is summarized and presented by the PGDP site in an Annual Site Environmental Report. This year Marshall County (Kentucky) High School AP Environmental Science and AP Physics students participated in classroom and field activities related to the *PGDP 2012 Annual Site Environmental Report (ASER)*. The students compiled the results of their participation and understanding of information in the document *U.S. DEPARTMENT OF ENERGY PADUCAH PLANT 2012 ANNUAL SITE ENVIRONMENTAL REPORT (ASER): Student Summary*.

Environmental work at DOE's facilities is technically complex and challenging. The scale of the PGDP industrial complex, immensity of its infrastructure and impacts on the surface and subsurface environment magnify the technical complexities faced by the DOE in its management and cleanup. The Annual Student Summary Report is important to DOE as a tool to clearly and concisely explain the comprehensive PGDP environmental monitoring and remediation programs to stakeholders. PGDP environmental data collected from soil, surface water, sediment, air, and groundwater during 2012 indicate that the site is in compliance with regulatory and human health standards and actively pursuing the remediation of on-site sources of potential ongoing contamination.

The PGDP site sincerely appreciates the work of the students, teacher, and staff at Marshall County High School in the production of the 2012 Annual Site Environmental Report Student: *Student Summary* document. On behalf of the entire Department of Energy, we congratulate each of you for your effort, enthusiasm, and willingness to support DOE with this project. We hope that you enjoy reading the *PGDP 2012 Annual Site Environmental Report: Student Summary.*

Production Team:

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Special Thanks to:

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Dr. Steve Price, UK Dept. of Agriculture Assistant Professor
Dr. Richard Halbrook, SIU emeritus, Ecological Sciences
Tim Kreher, West Kentucky Wildlife Management Area Manager

3 MESSAGE FROM THE STUDENTS

Dear Reader,

We hope that our summary environmental report, *U.S. DEPARTMENT OF ENERGY PADUCAH PLANT 2012 ANNUAL SITE ENVIRONMENTAL REPORT (ASER): Student Summary* helps you understand what industrial operations related to uranium enrichment occurred at the U.S. Department of Energy's (DOE) Gaseous Diffusion Plant (PGDP), how past operations impacted the environment, what the DOE does to address environmental impacts, and what current environmental monitoring indicates about current environmental conditions.

Our AP Environmental Science and Physics classes are thankful to have been chosen to learn about the history of the PGDP, uranium enrichment as a large-scale industrial operation, Western Kentucky's history and the Cold War, historical environmental impacts at the PGDP, and work being conducted to remediate environmental impacts that have occurred during the plant's operations.

Sincerely,

Figure 3-1. Class Photo

4 ACRONYMS

AEA	Atomic Energy Act
AEC	Atomic Energy Commission
AIP	Agreement in Principle
ALARA	As Low As Reasonably Achievable
ARRA	American Reinvestment and Recovery Act
ASER	Annual Site Environmental Report
BGOU	Burial Grounds Operable Unit
BGS	below ground surface
BWCS	B&W Conversion Services, LLC
CAA	Clean Air Act
CAB	Paducah Citizens Advisory Board
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
CHS	Cabinet for Health Services
CSOU	Comprehensive Site Operable Unit
CSWOU	Comprehensive Site Wide Operable Unit
CWA	Clean Water Act
CY	calendar year
D&D	decontamination and decommissioning
DNAPL	dense non-aqueous-phase liquid
DOE	U.S. Department of Energy
DQO	data quality objective
EA	Environmental Assessment
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
EPS	Environmental Policy Statement
ERP	Environmental Restoration Program
FFA	Federal Facility Agreement
FFCA	Federal Facilities Compliance Act
FFS	focused feasibility study
FS	feasibility study
FY	fiscal year
GDP	gaseous diffusion plant
GHG	greenhouse gas
GP	guiding principle

GWOU	Groundwater Operable Unit
GW	Groundwater
IRA	interim remedial action
KAR	*Kentucky Administrative Regulations*
KCHFS	Kentucky Cabinet for Health and Family Services
KDAQ	Kentucky Division for Air Quality
KDENF	Kentucky Division of Enforcement
KDEP	Kentucky Department for Environmental Protection
KDOW	Kentucky Division of Water
KDWM	Kentucky Division of Waste Management
KOW	Kentucky Ordinance Works
KPDES	Kentucky Pollutant Discharge Elimination System
LATAKY	Los Alamos Technical Associates Environmental Services of Kentucky, LLC
LLW	low-level radioactive waste
LPAF	Liquid Pollution Abatement Facility
LUC	land use control
MCL	maximum contaminant level
MLLW	mixed low-level waste
MW	monitoring well
N/A	not applicable
ND	not detected
NEPA	National Environmental Policy Act
NEPCS	Northeast Plume Containment System
NESHAP	National Emission Standards for Hazardous Air Pollutants
NFA	no further action
NOV	Notice of Violation
NPL	National Priorities List
NR	not reported/collected
NRC	U.S. Nuclear Regulatory Commission
NRHP	National Register of Historic Places
NSDD	North-South Diversion Ditch
NWPGS	Northwest Plume Groundwater System
OREIS	Oak Ridge Environmental Information System
ORISE	Oak Ridge Institute for Science and Education
OU	operable unit
PCB	Polychlorinated Biphenyls
PEMS	Project Environmental Measurement System
PGDP	Paducah Gaseous Diffusion Plant
PEGASIS	Paducah Environmental Geographic And Spatial Information System
PPPO	Portsmouth/Paducah Project Office
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act

FFCA	Federal Facilities Compliance Agreement
RGA	Regional Gravel Aquifer
RI	remedial investigation
ROD	record of decision
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SMP	Site Management Plan
SOU	Soils Operable Unit
SOW	statement of work
SSP	Site Sustainability Plan
SST	Swift & Staley Team
SWMU	solid waste management unit
SWOU	Surface Water Operable Unit
TCE	trichloroethylene
TLD	thermoluminescent dosimeter
TNT	trinitrotoluene
TSCA	Toxic Substances Control Act
TSS	total suspended solids
TVA	Tennessee Valley Authority
UCRS	Upper Continental Recharge System
UDS	Uranium Disposition Services, LLC
UE	uranium enrichment
UK	University of Kentucky
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

5 EXECUTIVE SUMMARY

The Paducah Gaseous Diffusion Plant (PGDP) is a uranium enrichment facility located near Paducah, Kentucky that is owned by the United States Department of Energy (DOE) and operated by DOE contractors ***(Figure 6-1)*** The PGDP enrichment plant was constructed and began operations in the early 1950's to support the nation's Cold War nuclear efforts. Industrial enrichment operations at PGDP occupy an industrial site of more than one square mile which contains facilities required for material preparation, material storage, enrichment process components, water treatment, process system cooling, fire suppression, steam generation, sanitary and industrial waste disposal ***(Figure 6-2 and Figure*** 6-3***)***. The power-hungry enrichment process required its own source of electrical power that was supplied through construction and operation of the Tennessee Valley Authority's Shawnee Steam Plant located immediately north of the PGDP on the Ohio River.

Under AEA management, historical industrial operations at the PGDP created industrial process waste that contained radioactive and hazardous materials. Over the course of PGDP operations, the handling, storage and disposal of radioactive and hazardous materials resulted in contamination of soil, surface water and groundwater which DOE now actively remediates and monitors.

Since 1988 and the discovery of the radionuclide technetium-99 (Tc-99) in residential water wells near the site, DOE has been investigating, monitoring, and remediating the origin, extent and impacts of uranium enrichment operations on workers, the public and the environment. DOE is responsible for publishing an Annual Site Environmental Report (ASER) for the PGDP that identifies the activities undertaken in a calendar year to address environmental issues and comply with environmental regulations. DOE manages work at the Paducah site to comply with and adhere to applicable laws, regulations, and site-specific regulatory permits that protect plant personnel, the environment and the public.

In 2012, DOE continued to conduct monitoring programs to measure the PGDP's impact on the environment which includes the West Kentucky Wildlife Management Area (WKWMA) and privately owned property around the site. Over the years monitoring programs have shown a decrease in contamination levels of surface water, sediment, and ambient air. Historical analyses of groundwater indicated the presence of trichloroethylene (TCE) in three large contaminant plumes and Tc-99 in one plume. Comparison of current analyses to historical analyses indicates that the concentrations of TCE and Tc-99 in the plumes are decreasing ***(Figure 6-4)***.

In 2012, the DOE expanded recreational access to areas on the DOE Reservation outside of the fenced industrial area. This allowed the public closer contact with the cylinder yards than ever before. With closer access to radioactive material in the cylinders, the DOE had to take into account the potential radiological exposure to the public. The 2012 Site ASER (DOE, 2014) report shows a slight increase in exposure over previous years. The increase is not of concern because the current exposure it is less than 2% of the allowable DOE annual dose limit of 100 millirems per year for members of the public.

At the PGDP, DOE has implemented measures to reduce the contamination on the industrial site, DOE Reservation and surrounding areas. With the depleted uranium hexafluoride conversion facility at full operational status, nearly 4,500 metric tons of depleted uranium has been transformed into a more stable form of uranium oxide.

The DOE and its contractors are in charge of reducing contamination while deactivating the PGDP enrichment process from full operations and operating the uranium hexafluoride conversion facility. During the Decontamination and Decommissioning (D & D), the enrichment systems and the buildings that house them will be dismantled, and infrastructure will be decontaminated and disposed. During D & D of the plant, DOE will continue to conduct environmental monitoring and operate the groundwater pump and treatment systems. As of 2012, thirty facilities have been demolished.

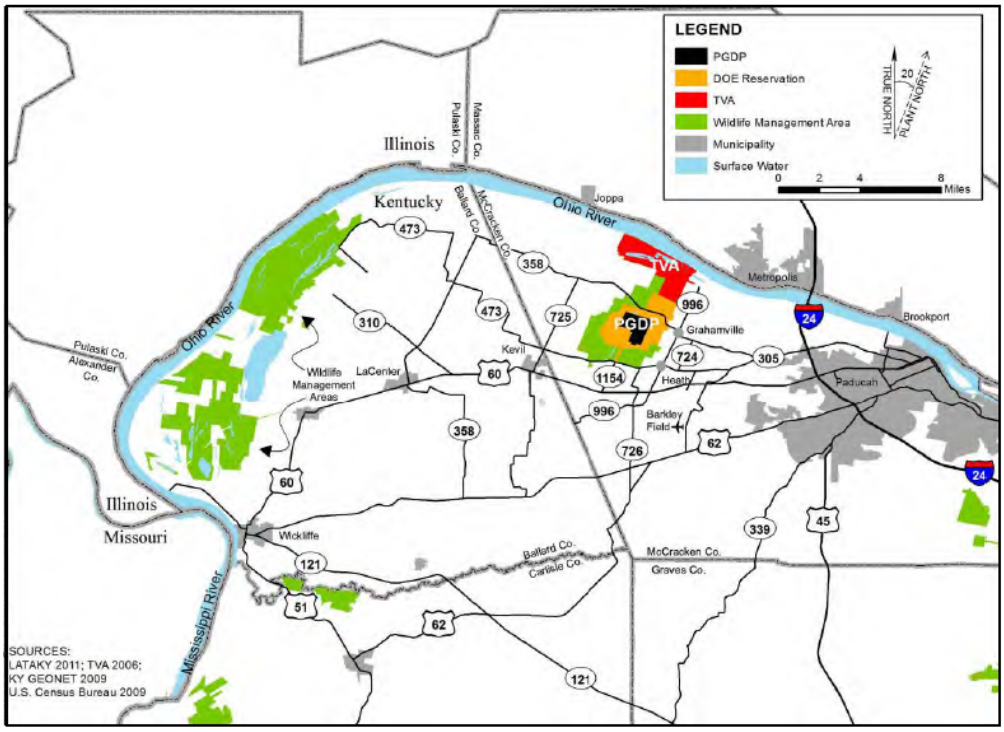


Figure 5-1. Paducah Gaseous Diffusion Plant Location Map.

The DOE oversees two primary programs at the PGDP, 1) Environmental Management (EM) and 2) the Uranium Program. The EM program is conducted to minimize or eliminate the hazards associated with the past operation of the PGDP. The Uranium Program oversees enrichment operations and maintains safe, controlled storage of the enriched uranium. The EM Program oversees the reclamation of depleted uranium hexafluoride through separation of hexafluoride gas from uranium metal. The reclaimed fluoride gas is recycled for industry re-use and spent uranium is converted into a stable uranium oxide material for disposal or reuse.

The United States Enrichment Corporation (USEC) operates the industrial enrichment processes at the PGDP and in 2012 was in the planning process for shutting down uranium enrichment operations during 2013-14. Los Alamos Technical Associates Environmental Services of Kentucky (LATAKY) is responsible for environmental remediation and environmental compliance work at PGDP including monitoring and improving conditions of groundwater and soil. Environmental Management Systems (EMS) are designed to integrate environmental protection with effective execution at all work areas. An effective EMS includes policy, planning, implementation, and operation, checking, and management review.

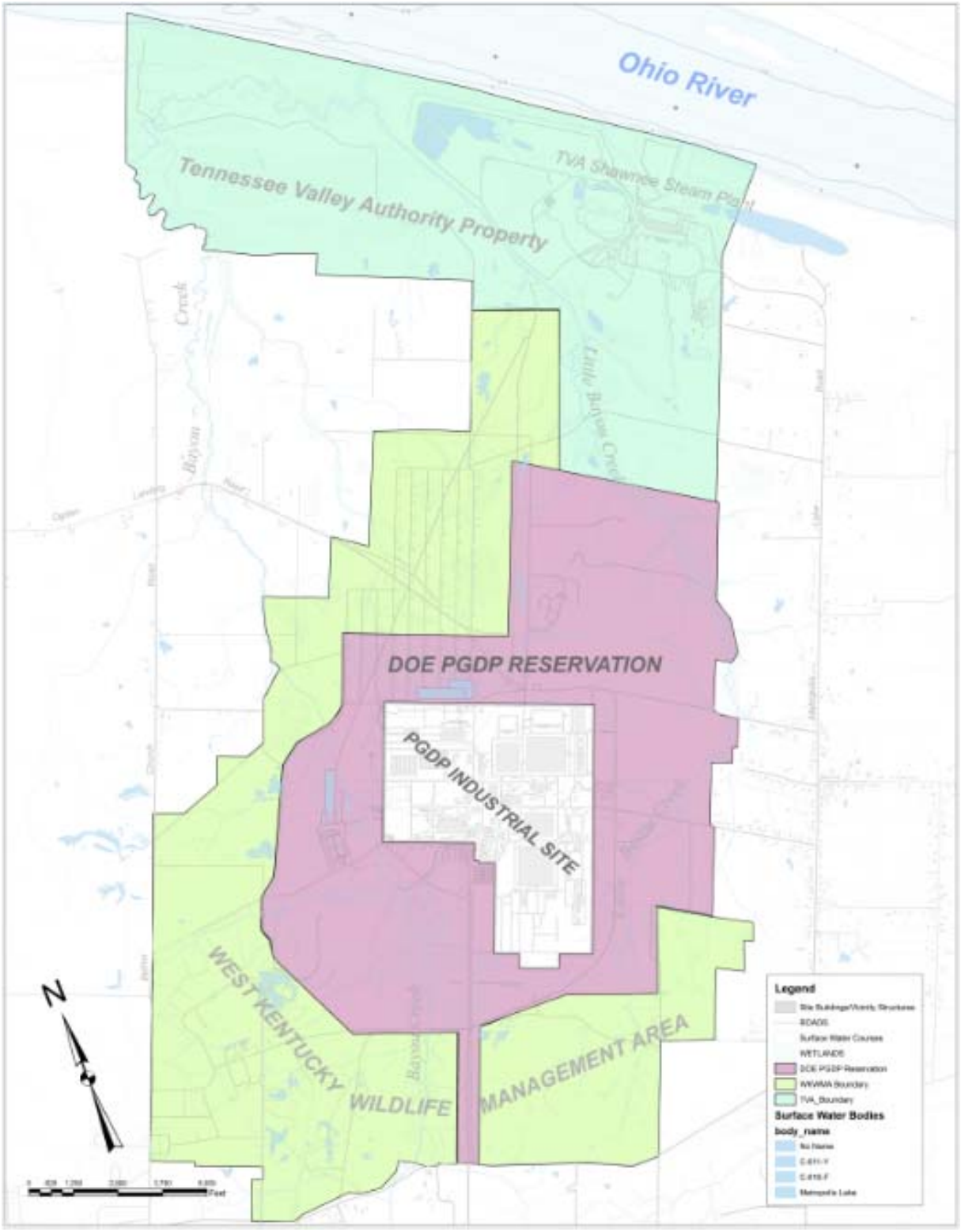


Figure 5-2. The Paducah Gaseous Diffusion Plant and Surrounding Area.

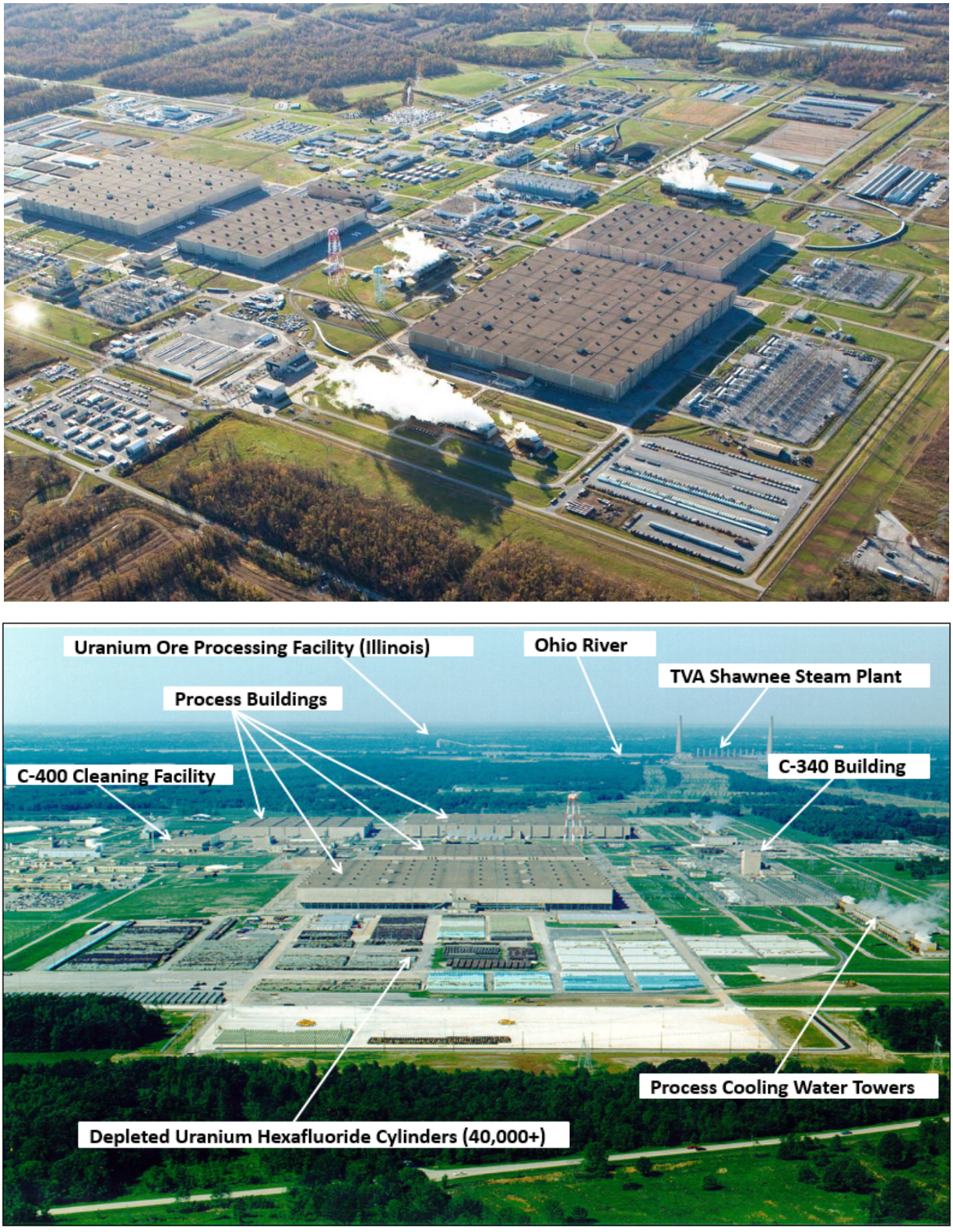


Figure 5-3. Aerial View of the Paducah Gaseous Diffusion Plant (top) and DOE PGDP Facilities and Surrounding Areas (bottom).

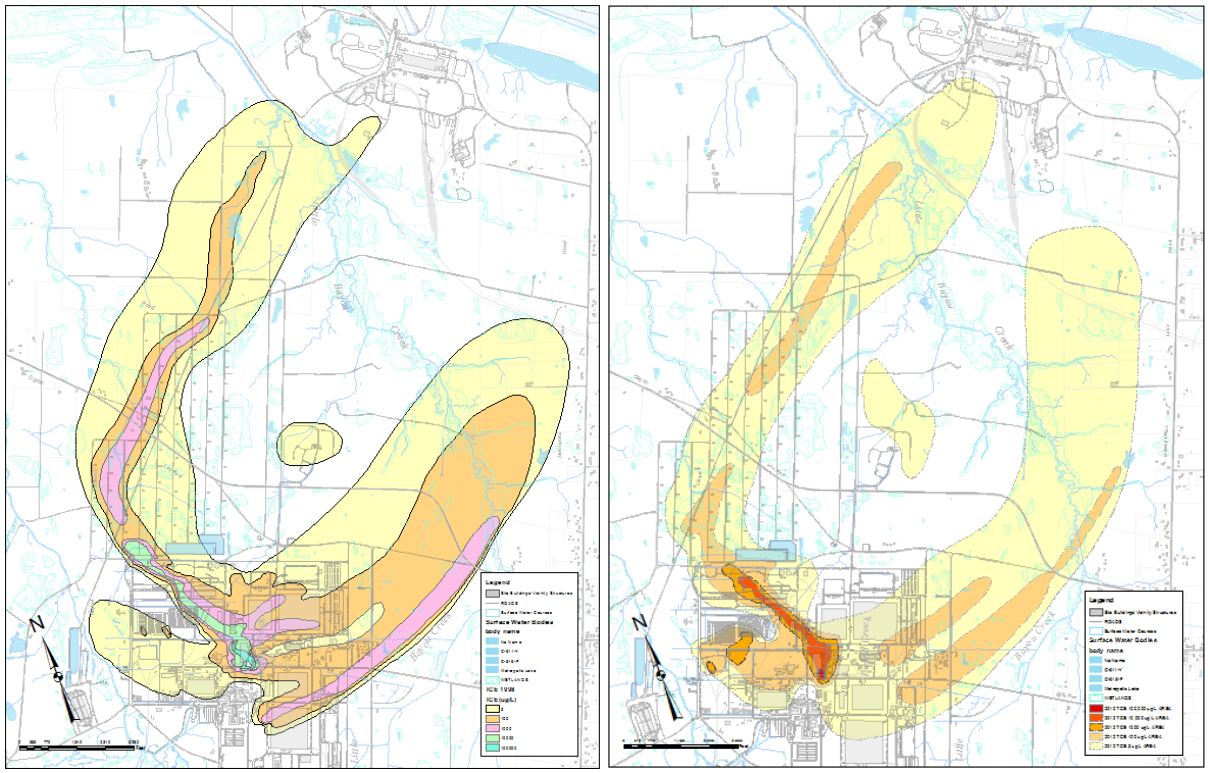


Figure 5-4. PGDP Trichloroethene Groundwater Contaminant Plumes 1998 and 2012.

The Environmental Protection Agency (EPA), and the KY Department for Environmental Protection are the two main regulatory agencies that issue permits, review compliance reports, oversee monitoring programs, issue inspections, and supervise the execution of applicable laws at the PGDP.

The EM program includes a Paducah Site Waste Disposition Program that directs the safe treatment, storage, and disposal of waste generated from DOE activities. Guidance for minimizing generated waste is provided by the site's Waste Minimization/Pollution Prevention Program (WM/PP). The WM/PP sets objectives to minimize waste using the following strategies: source reduction, segregation, and reuse of materials.

Decontamination and decommissioning (D&D) is conducted for inactive facilities and structures contaminated with radiological and hazardous material. D&D waste disposal was packaged for off-site shipment, disposed in the on-site C-746-U Landfill, or recycled.

Extensive monitoring of the PGDP's impacts on the environment is conducted through the EM program. All impacted or potentially impacted environmental media is monitored including: soil, sediment, surface water, air, and groundwater.

Wildlife monitoring at and in the vicinity of the PGDP has been conducted since the early 1990's although fish and benthic macroinvertebrate sampling and deer harvesting has been discontinued due to contaminants being reduced to well below regulatory, health and ecological protection levels in deer and a new permit being issued that eliminated requirement for fish and macroinvertebrate sampling.

Because of small amounts of non-radiological airborne emissions, the Paducah Site is considered a minor air emissions source.

Groundwater is monitored and protected as required by state and federal law and is not used for on-site purposes, local agricultural use, or residential consumption. On- and off-site groundwater impacted by organic and radioactive contaminants is being treated to remove contaminants. Areas that act as sources to surface water and groundwater contamination are being addressed through remedial actions.

Figure 5-5. Surface-water sampling for contaminant testing.

6 THE PADUCH SITE, BACKGROUND AND HISTORY

6.1 GEOGRAPHICAL FEATURES

The PGDP site is located approximately 13 miles west of the City of Paducah Kentucky and three miles south of the Ohio River. The Tennessee River, which flows into the Ohio River, is located 15 miles upstream of the site. The Ohio-Mississippi River confluence is located about 35 miles downstream of the site (*Figure 6-1*).

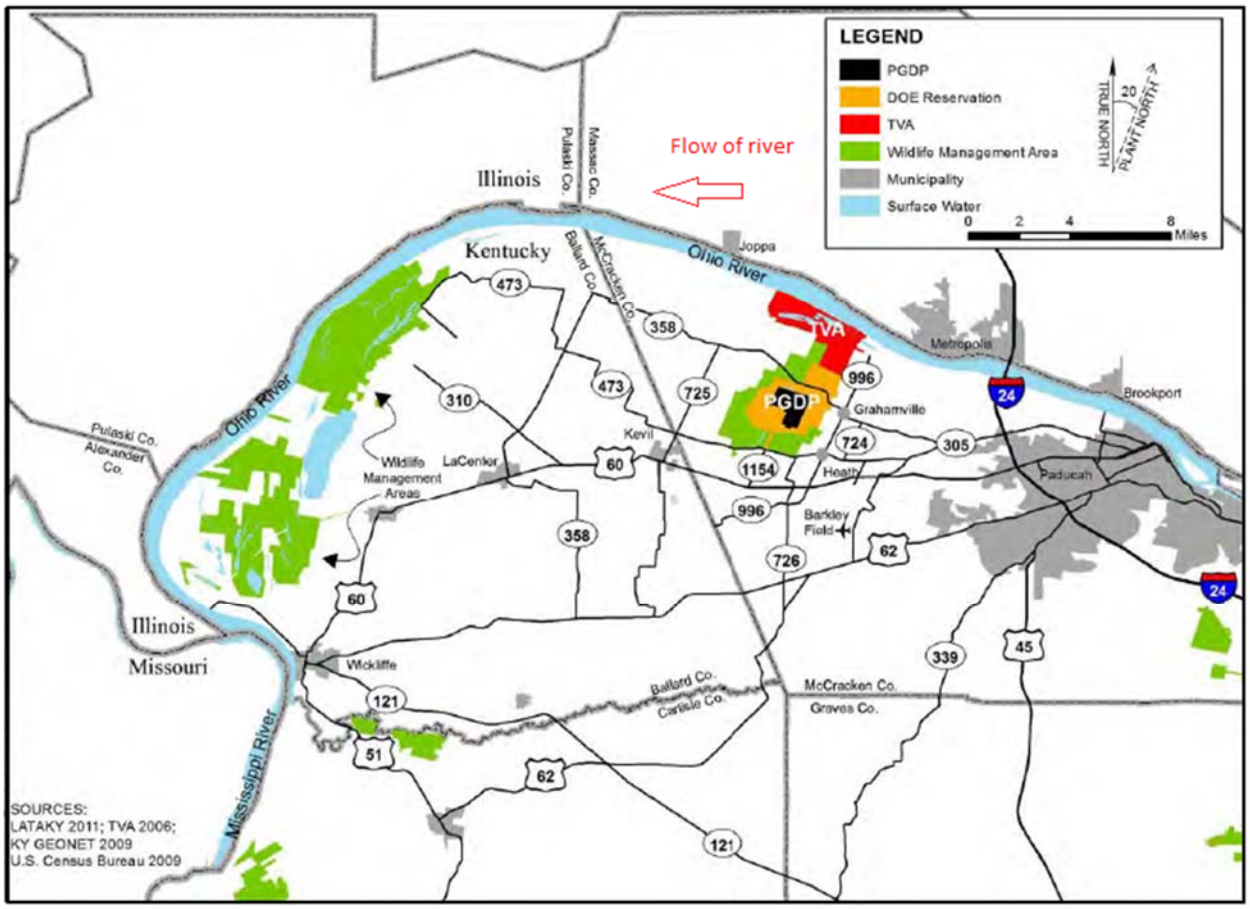


Figure 6-1. PGDP Location Map (DOE, 2014).

The DOE PGDP Reservation encompasses approximately 3500 acres. Approximately one square mile of the Reservation contains a secure industrial complex where uranium enrichment operations are conducted. Within the restricted industrial area are the enrichment process facilities and many additional industrial support facilities ***(Figure 5-3)***.

The PGDP property occupies portions of the watersheds of two streams that flow into the Ohio River. Little Bayou Creek is east of DOE property and flows intermittently along a 7 mile course to join Bayou Creek several miles north of the PGDP industrial site. Bayou Creek is a perennial stream bounding the west side of the DOE property that discharges to the Ohio at the northern extent of its nine mile course.

Little Bayou Creek and Bayou Creek converge about three miles north of the plant before emptying into the Ohio River. The Ohio River, Bayou Creek and Little Bayou Creek are associated with flooding around the plant. Maps show that all three drainage systems have 100-year floodplains within the DOE Property boundary, but not the industrialized area of PGDP.

There are more than 1,100 separate wetlands, totaling over 1,600 acres, found in a study area of about 12,000 acres in and around the PGDP with more than 60% of the area forested ***(Figure 6-4)***. The soils in the area are mainly silty, acidic, poorly drained, and have little organic content.

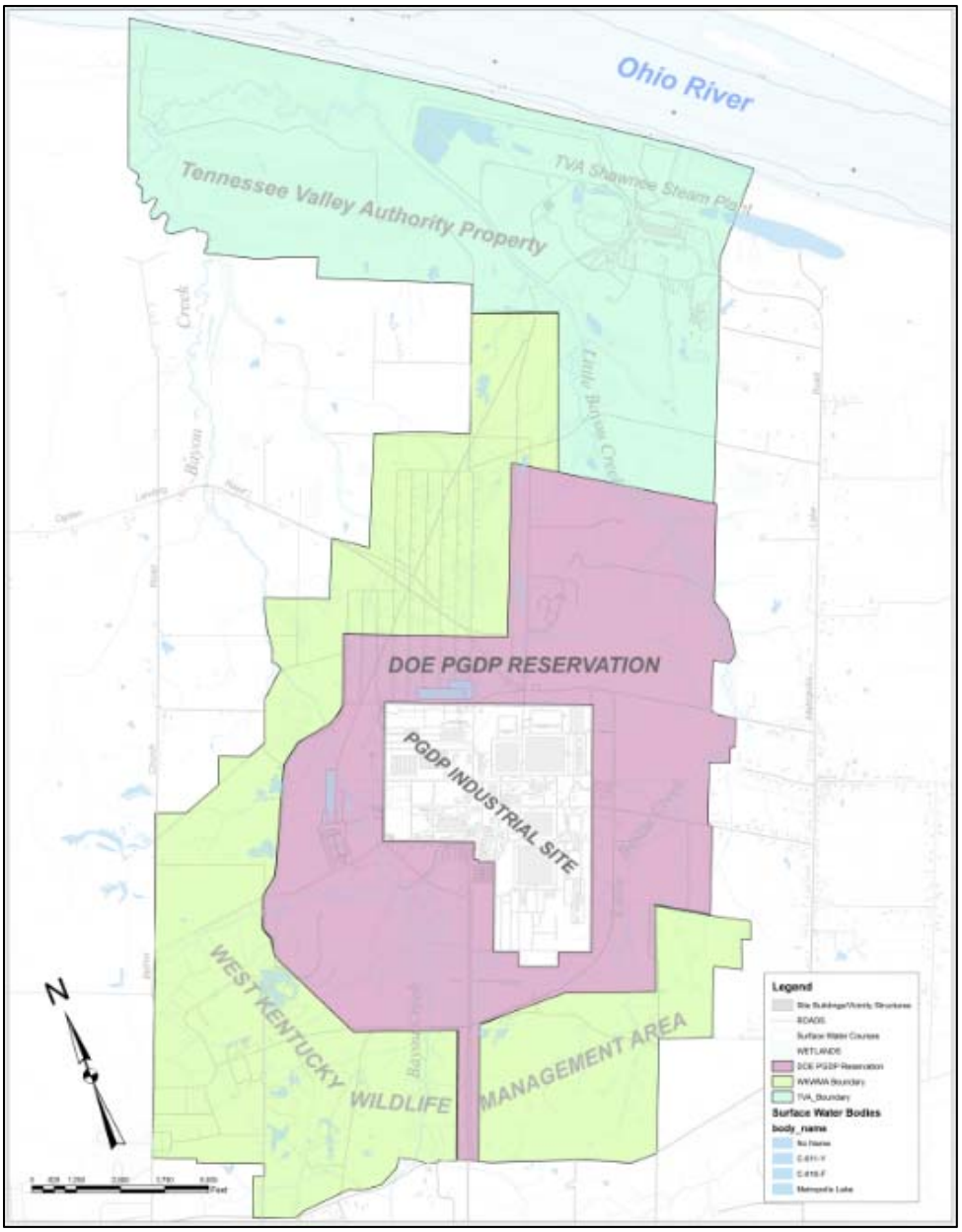


Figure 6-2. DOE PGDP Reservation and Surrounding Areas.

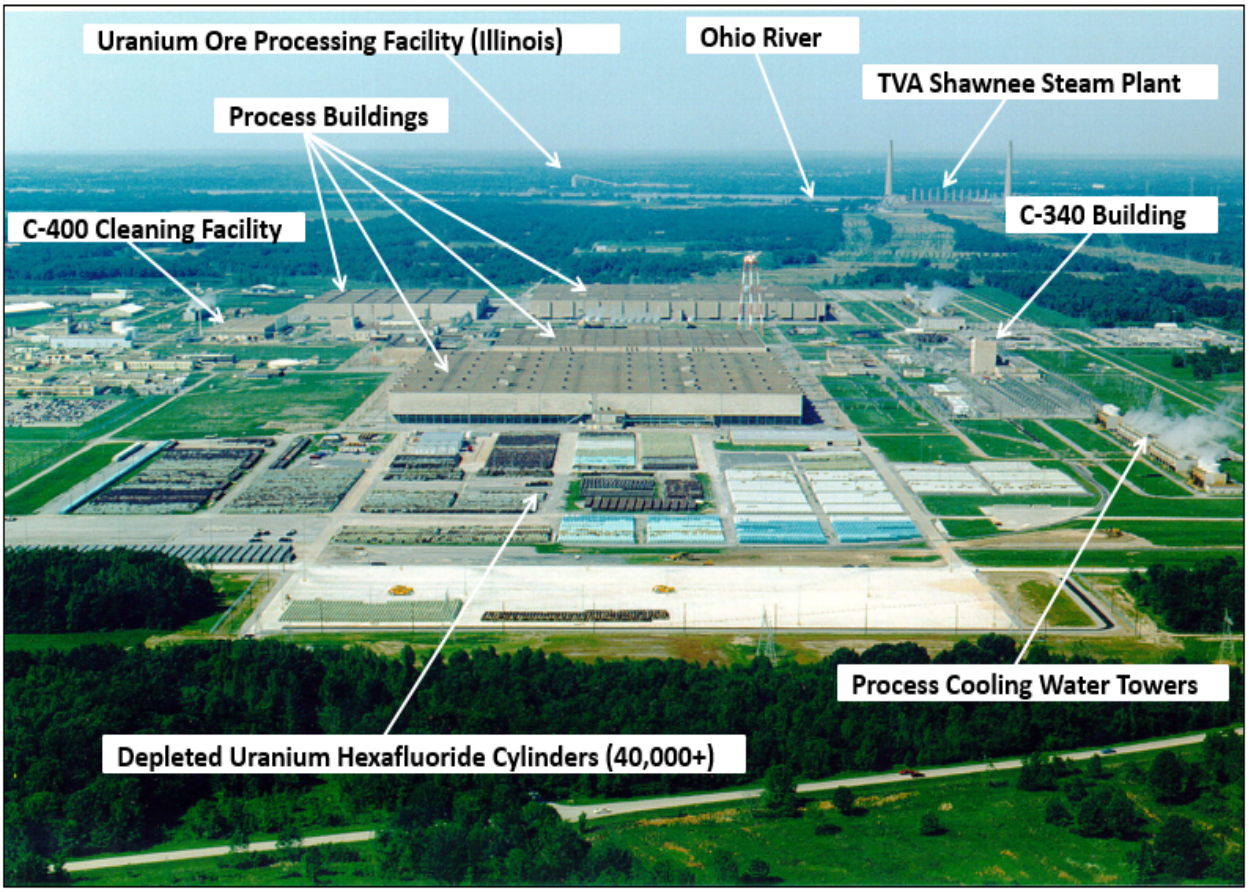


Figure 6-3. DOE PGDP Facilities and Surrounding Areas.

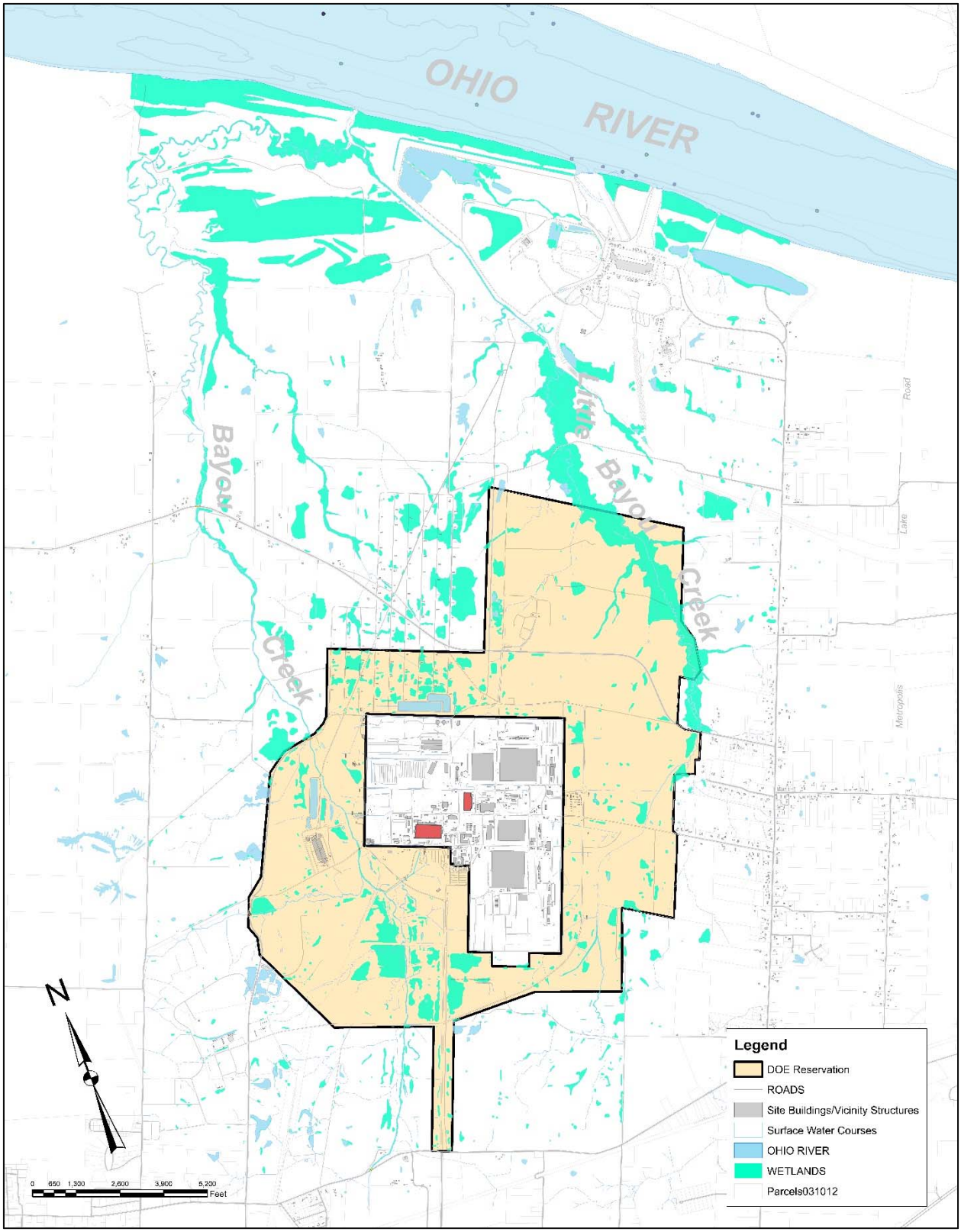


Figure 6-4. Wetlands and surface water in the vicinity of the PGDP.

6.2 HISTORY

Construction of the Paducah Gaseous Diffusion Pant (PGDP) began in 1950 as a large-scale building effort in sparsely populated rural Western Kentucky. At the time of construction, one of the uranium enrichment process buildings was one the largest man-made structures in the world. The PGDP was in operation and began enriching uranium in 1952 and it continued to enrich uranium in 2012.

In July of 1993, the United States Enrichment Corporation (USEC), a private company, leased the production areas of the PGDP. DOE remained responsible for the maintenance of the environment, waste management, non-leased facilities management, uranium hexafluoride (UF_6) cylinder management, and the decontamination and decommissioning (D&D) of facilities. DOE also implements environmental monitoring and management programs to ensure protection of human health and the environment and compliance with all applicable regulatory requirements. Three key (prime) contractors perform work supporting the DOE missions at the PGDP:

i. United States Enrichment Corporation (**USEC**)- operates the enrichment process and facilities
ii. Los Alamos Technical Associates of Kentucky (**LATAKY**)- manages environmental compliance and implementation of remedial activities
iii. Swift and Staley Team (SST) – Data Management and Security.

DOE requires that environmental monitoring be conducted and documented for all the facilities. There are numerous laws and regulations that DOE has to comply with. The PGDP ASER is published yearly to summarize activities at the Paducah site, including environmental surveillance, monitoring and compliance with Federal and State guidelines, DOE Orders, and environmental regulations. The types of monitoring at the site address potential impacts to the environment and humans. The overall goals of the DOE/EM are to protect the site, personnel on and around the site, and neighboring communities.

6.3 BACKGROUND

After the December 1941 attack on Pearl Harbor, the U.S. Army Corps of Engineers acquired 16,126 acres of farm land in McCracken County, Kentucky to construct and operate a trinitrotoluene (TNT) production facility. Two-hundred and fifty (250) families living on the land were given 10 days to move for the construction of the Kentucky Ordnance Works (KOW). The KOW was completed within in a year and in the spring of 1943 had its own power plant, hospital, cafeteria, water and sewer systems, roads and railroads. It was the largest of eleven TNT plants in the U.S and produced approximately 196,000 tons of TNT that was used as explosives in bombs, mines, torpedoes, and other munitions during WWII. In the fall of 1945, the end of WWII, the KOW plant was shut down.

Figure 6-5. Workers at the Kentucky Ordnance Works during WW-II.

Following shutdown of TNT production, KOW property was turned over to the Federal Farm Mortgage Corporation and then to the General Services Administration. Only part of the original KOW property acquisition was safe enough for public use and sold. The TNT production sites remained under the control of the Army Corps of Engineers.

Remnants of the KOW still remain, including large concrete TNT storage bunkers. These bunkers were evenly spaced about 425 feet apart with thick concrete walls to direct any accidental explosion out the roof and into the air as opposed to exploding laterally and detonating adjacent bunkers. Remaining bunkers are now part of the West Kentucky Wildlife Management Area (WKWMA - *Figure 6-6*).

Figure 6-6. Abandoned KOW TNT storage bunkers on the DOE PGDP Reservation

Figure 6-7. Home fallout (bomb) shelters under construction in the 1950's.

Following World War II and the Manhattan Project's advancements in physics and nuclear fission, efforts to expand the production, military and non-military uses of fissionable material were initiated by the Atomic Energy Commission (AEC). In 1950, while homes across the country were installing fallout shelters for protection from the nuclear threat **(Figure 6-7)**, Paducah was selected as the site for a gaseous diffusion plant. The land, which was already owned by the federal government (historical KOW property), was located adjacent to the Ohio River bulk transportation waterway, and promoted by Vice President Alben Barkley, a Paducah native.

Even though the plant was not complete until 1954, production of enriched uranium began in 1952. The feedstock for the gaseous diffusion uranium enrichment process is made by the mixing (complexing) fluoride gas with uranium to make gaseous uranium hexafluoride (UF_6). The increase or enrichment of U-

235 from the feedstock is done by separating the uranium isotope U-235 from U-238. The gaseous UF_6 mixture is pushed through miles of process piping and physical filtration under high pressure and temperature to separate the U-235 from U-238. Each cylinder of gaseous UF6 goes thru more than 1700 cycles of enrichment to accomplish the desired enrichment level. In 1965, the PGDP switched from enriching uranium for military purposes to enriching uranium for nuclear reactors.

Throughout operations the original PGDP facilities have been upgraded and refurbished, but the process of enriching uranium continued unchanged through 2012 and continued until plant enrichment facilities were stopped (in the spring of 2013). Significant upgrades to PGDP enrichment operations included the retrofit of enrichment process components to withstand seismic impacts because of the site's proximity to the New Madrid Seismic Zone.

Of the 7,566 acres originally acquired, the Department of Energy currently only owns 3,556 acres (including 133 acres in easements). 1,361 acres were transferred to Tennessee Valley Authority which is where the Shawnee Fossil Plant is located. 2,781 acres were conveyed to the Commonwealth of Kentucky for conservation and recreational purposes as part of the West Kentucky Wildlife Management Area (WKWMA). Of the 3,556 acres currently owned or controlled by the DOE, approximately 650 acres are within the fenced security area, 800 acres are located outside the secured area and 133 acres are in easements. The remaining 1,976 acres are licensed to the Commonwealth of Kentucky as part of the WKWMA.

6.4 ECOLOGICAL RESOURCES

6.4.1 Vegetation

Human activity had great impact on the PGDP industrial site. However, much of the land surrounding the DOE PGDP Reservation and industrial site is managed as the WKWMA by Kentucky Department of Fish and Wildlife personnel.

The vegetation that grows on and around the site is indicative of old field succession related to historical and current farming activities. Within the WKWMA management efforts are deployed to restore the natural pre-farming habitat to the area as well as to provide food and habitat for local terrestrial, amphibian, aquatic, and avian species. Specific species habitats in the vicinity of the PGDP are identified in ***Figure 6-10***.

Management techniques are implemented at WKWMA to maintain or return to early "native" successional vegetation. Those techniques include mowing and/or burning. Plants are cultivated on the WKWMA for wildlife forage and include corn, millet, milo, and soybean. There is young woody-stemmed vegetation, with sun tolerant wooded species emerging as successional growth. Grasses may accompany young and transitional woodlands and vary depending on the location and age of the woodlands. Established woodland areas contain thick undergrowth of grape, honeysuckle, blackberry, and associated species.

Figure 6-8. Students Observing Native Succession Habitat.

In the wooded areas, there are mixes of a variety of hardwood species. Species include Oaks, shagbark and shellback hickory, and water-dependent Tupelo trees in several wetland areas. The undergrowth in established heavily forested areas is limited due to the forest being as mature as it is, however the undergrowth is dense and generally referred to as scrub-shrub community.

6.4.2 Wildlife

Due to the variety of ecosystems and local ecosystem communities, the species of wildlife at and around the PGDP site is very diverse, ranging from waterfowl to grazing mammals. The Ohio River serves as both a drinking water source and habitat for the species of waterfowl and mammals that graze the area.

In the vicinity of the PGDP and WKWMA there are potentially 12 species of federal concern. Eleven of those species are considered "endangered" under the Endangered Species Act of 1973 and the twelfth has been proposed for classification as an endangered species. Even though potential habitat for the endangered Indiana Bat species is on DOE property, no endangered individuals have been found on the property.

Figure 6-9. The WKWMA is a popular spot for sportsmen

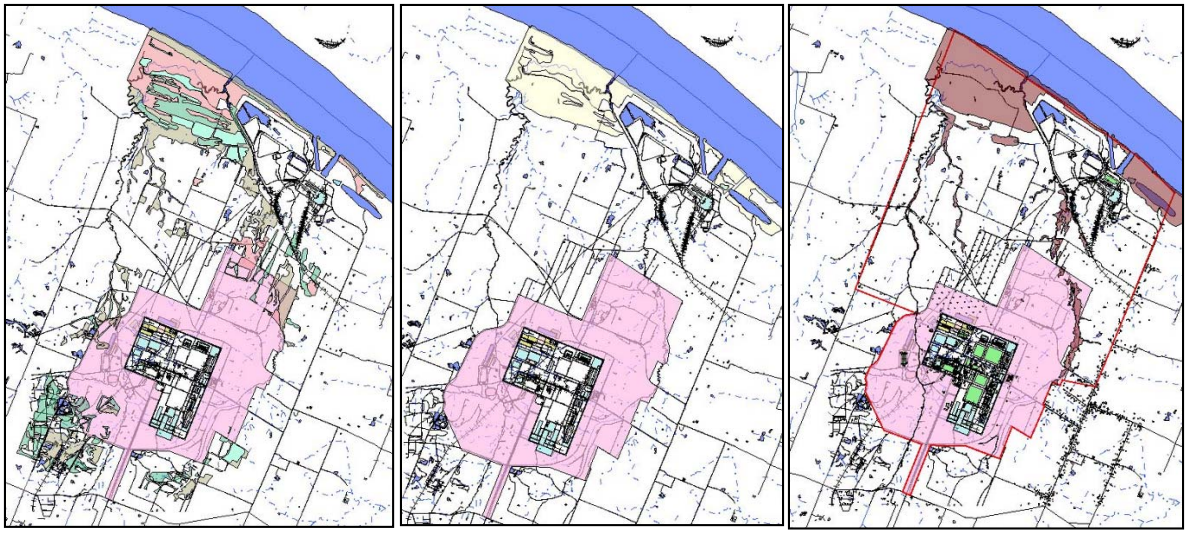


Figure 6-10. Bat Habitat, Bald Eagle Habitat and Snake Habitat in the vicinity of PGDP.

Bat Habitat	Bald Eagle Habitat	Snake Habitat
Salmon, Green & Gray Shading	Yellow Shading	Brown Shading

6.5 SITE PROGRAMS & MISSIONS

Two programs are operated by DOE at the PGDP site: (1) Environmental Management (EM) and (2) the Uranium Program. The projects done under the EM include monitoring, waste disposition, restoration, decontamination and decommissioning and the conversion of depleted uranium hexafluoride (DUF6) into fluorine gas and uranium oxide. These programs are done to help decommission unused infrastructure at the site as well as restore the land for future use.

Currently, the Uranium Enrichment program's main purposes are to: 1) maintain safe compliant storage of the depleted uranium inventory until its final deposition and 2) manage the cessation of uranium enrichment process activities as well as the decommissioning of uranium enrichment infrastructure. The environmental monitoring summarized in this report is in compliance with all DOE programs/projects and regulatory requirements.

Figure 6-11. A specialized hoist is used to move one of the approximately 46,000 canisters containing depleted uranium hexafluoride (DUF6) stored at the PDGP.

7 COMPLIANCE PROGRAM

7.1 INTRODUCTION

In 1988 the Kentucky Department of Public Health's -Radiation Control Program and the McCracken County Health Department identified the radionuclide Tc-99 in off-site drinking water wells in the vicinity of the PGDP. The finding prompted DOE, U.S. EPA, the Kentucky Radiation Control Program and the Kentucky Department for Environmental Protection to begin investigating the PGDP and surrounding areas for radioactive and hazardous materials in air, soil, sediment, surface water, and groundwater.

As a result of the initial environmental investigations the PGDP site was placed on the National Priorities List (NPL) in 1994 and became a Superfund site under the Comprehensive Environmental Response and Liability Act (CERCLA). CERCLA is administered by the U.S. Environmental Protection Agency (EPA). Additionally, hazardous materials became subject to management under Resource Conservation and Recovery Act (RCRA) regulations administered by the Commonwealth of Kentucky. RCRA requires the management of hazardous materials from cradle to grave. The PGDP handles hazardous waste under a RCRA hazardous waste permit.

Because of the multiple regulatory agencies involved in managing the hazardous and radioactive materials at the site, a Federal Facilities Agreement (FFA) was implemented in 1998. The FFA integrated the management of the many environmental and health regulations that DOE is required to comply with. In addition to CERCLA and RCRA, DOE operates under the following regulations and requirements:

1. DOE Orders - set of internal DOE requirements that address the handling and storage of radioactive materials and also address dose to workers and the public.
2. Solid Waste Permit - DOE manages its non-hazardous solid waste under waste disposal permits issued by the Kentucky Division of Waste Management.
3. The National Environmental Policy Act (NEPA) – evaluates the environmental impact of site activities through the development of NEPA environmental assessment documents that include Environmental Impact Statements (EIS) and Environmental Assessments (EA).
4. Federal Facilities Compliance Act (FFCA) – requires that DOE develop plans to address hazardous, mixed, and radioactive waste with oversight and agreement from the Commonwealth of Kentucky.
5. Toxic Substances Control Act (TSCA) – provides EPA with information on the use, environmental and health effects of hazardous substances at the PGDP.
6. Polychlorinated Biphenyls (PCB's) – Documents PGDP compliance with 40 CFR Part 761 which addresses PCBs and reports annually on PGDP PCB Compliance relative to the FFCA (above).
7. The Emergency Planning and Community Right-to-Know Act (EPCRA) is in place to notify or warn the public of threats originating from the PGDP.
8. Superfund Amendments and Reauthorization Act (SARA) – reauthorized CERCLA with increased emphasis on citizen involvement and human health impacts

7.2 ENVIRONMENTAL RESTORATION AND WASTE MANAGEMENT

During 2012 modifications were made to the waste disposal permit issued by the State of Kentucky. The modifications included: improving the cover material on one of the site landfills, updating working procedures of the landfill, and revising the groundwater monitoring parameters required by the solid waste disposal permit.

The solid waste for the site is disposed in an on-site contained landfill. Disposal of waste in the landfill began in 1997. The trash from the offices and buildings on the site is disposed of off-site at Calvert City, KY and Kevil, KY. In 2012 Paducah was issued a violation for storing hazardous sample waste in a unit that wasn't specified in its solid waste permit.

The Federal Facility Compliance Act (FFCA) was enacted in 1992 under which the Paducah site became subject to fines and penalties for the mistreatment or mishandling of waste that they were not subject to before.

The Paducah site conducts reviews of the environmental impacts at the site based on the National Environmental Policy Act (NEPA).

To ensure the safety of the chemical substances at the site, the Toxic Substances Control Act (TSCA) was put into place in 1976.

The PGDP is required to submit an annual PCB document that accounts for the management of PCB wastes on the site.

7.3 RADIATION PROTECTION

The Atomic Energy Act of 1954 (AEA) provided the regulatory authority for the Department of Energy and the Nuclear Regulatory Commission (NRC) to address the development and regulation of radioactive materials for the government, energy industry and private industry. The AEA provides authority to DOE to implement self-imposed regulations for the handling and disposal of radioactive materials. The self-imposed regulations for the handling and disposal of radioactive materials are DOE Orders.

The PGDP site manages radioactive materials under DOE Order 458.1, *Radiation Protection of the Public and the Environment,* and DOE Order 435.1, *Radioactive Waste Management.* These DOE Orders prevent undue risk from radiation and radiological activities to workers and the public by implementing dose standards for radiation exposures. Order 435.1 also sets the procedures utilized for the short- and long-term management of radioactive wastes.

Figure 7-1. Nuclear power plants (above), nuclear medicine, production of nuclear material for the military and medical industries require regulations for protection of human health and the environment.

7.4 AIR QUALITY AND PROTECTION

DOE manages and attempts to reduce its emissions of greenhouse gases (GHG) through compliance with the National Emission Standards for Hazardous Air Pollutants (NESHAPs) program. The PGDP has also taken steps to ensure it controls the potential for exposure to airborne radiation through NESHAPS compliance under Kentucky Division of Air Quality and EPA oversight.

DOE operates a system of air monitors in the immediate vicinity of the PGDP and also monitors air emissions from specific site activities including waste management and remediation activities. The Kentucky Cabinet for Health and Family Services (KCHFS) Radiation Control Program conducts off-site radiation air monitoring.

The PGDP Site follows the Clean Air Act to maintain their air monitoring records. The site only has one major building that has qualified as first priority in pollution. There are numerous buildings with asbestos at the site with care taken to maintain compliance with EPA, Occupational Safety and Health Administration, and Kentucky regulatory requirements, as applicable.

7.5 WATER QUALITY AND PROTECTION

7.5.1 Surface Water – The Clean Water Act

The Clean Water Act (CWA) was put into place in 1972. The CWA requires the site to manage its point source (surface water) discharges into waters of the United States. The sites discharges are regulated by the Kentucky Pollutant Discharge Elimination System (KPDES) which requires a permit for surface water discharges from the site to local waterways.

There are 14 outfall ditches that discharge PGDP (industrial site) effluent (surface water and runoff) into Bayou Creek and Little Bayou Creek. Each outfall is monitored for toxicity and permitted chemical and radioactive material discharges. Bayou Creek and Little Bayou Creek are being monitored for contamination because they receive water discharged from the PGDP.

The PGDP received notices of violation for water standards in two of its outfalls, KPDES 001 and KPDES 017. Both outfalls discharge effluent to Bayou Creek. Excessive zinc concentrations violated permit standards at KPDES 017 on two test dates while low PH and total suspended solids exceeded permit levels at KPDES 001 on two separate dates.

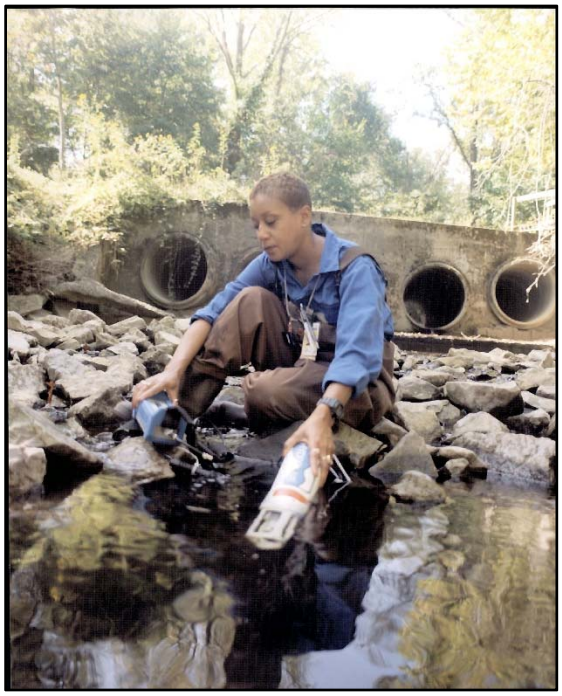


Figure 7-2. Water sampling on Bayou Creek

7.5.2 Drinking Water – The Safe Drinking Water Act

The PGDP withdraws water for industrial and domestic use from the Ohio River. Intake of Ohio River water is located at the TVA Shawnee Steam Plant and two supply pipelines run from the TVA facility to the PGDP water treatment facility. The PGDP water treatment facility is operated under the regulations in the Safe Drinking Water Act.

7.6 OTHER ENVIRONMENTAL STATUTES

The Paducah Site follows the Endangered Species Act of 1973 which provides for the designation and protection of endangered and threatened animals and plants. The Act also protects ecosystems on which endangered or threatened species depend. At the Paducah Site, all projects are considered and reviewed in conjunction with the EMS and CERCLA to determine if activities have any potential to impact these species or ecosystems.

7.7 OTHER MAJOR ENVIRONMENTAL REGULATIONS

7.7.1 Underground Storage Tanks

Eighteen Underground Storage Tank (UST) systems at PGDP have been used to store products such as gasoline, diesel fuel, and waste oil. Fourteen of those systems have been closed in accordance with approved closure plans. Two UST systems were determined not to exist.

7.7.2 Endangered Species Act

On the PGDP Reservation, the West Kentucky Wildlife Management Area, TVA Property, and surrounding areas, 12 endangered or potentially endangered species have been identified as potentially occurring based on local habitat suitability ***(Table 7-1)***. While the endangered Indiana bat has potential habitat on the PGDP Reservation, this species has not actually been observed.

Ecological impacts are considered relative to CERCLA activities and routine site activities. If necessary, project-specific surveys are performed to identify impacts to threatened or endangered species. Since the early 1990's DOE has consulted with the U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, Oak Ridge National Laboratory and many academic institutions to identify species, habitat, and impacts at the PGDP and surrounding areas. The Department of Energy's Agreement in Principle with various agencies in Kentucky has a goal to maintain an independent, impartial, and qualified assessment of environmental impacts associated with DOE's PGDP facility.

7.7.3 National Historic Preservation Act

The National Historic Preservation Act requires the PGDP to identify and protect historic properties that qualify for inclusion on the National Register of Historic Places (NRHP). An NRHP district that includes more than 100 PGDP properties and/or buildings was identified to be eligible for inclusion under NRHP Register Criterion A - military significance during the Cold War.

7.8 CONTINUOUS RELEASE REPORTING

The Paducah Site is required to report their Chemical Inventory and their Toxic Release Inventory which include planned and accidental releases under the EPCRA.

Table 7-1. Federally Listed, Proposed, and Candidate Species Potentially Occurring within the Paducah Site Study Area[a]

Common Name	Scientific Name	Endangered Species Act Status
Indiana Bat[b]	*Myotis sodalist*	Listed Endangered
Fanshell	*Cyprogenia stegaria*	Listed Endangered
Pink Mucket	*Lampsilis abrupta*	Listed Endangered
Ring Pink	*Obovaria retusa*	Listed Endangered
Orangefoot Pimpleback	*Plethobasus cooperianus*	Listed Endangered
Clubshell	*Pleurobema clava*	Listed Endangered
Rough Pigtoe	*Pleurobema plenum*	Listed Endangered
Fat Pocketbook	*Potamilus capax*	Listed Endangered
Spectaclecase	*Cumberlandia monodonta*	Listed Endangered
Sheepnose	*Plethobasus cyphyus*	Listed Endangered
Rabbitsfoot	*Quadrula c. cylindrical*	Proposed
Interior Least Tern	*Sterna antillarum athalassos*	Listed Endangered

[a]The listed species are identified as an Endangered, Threatened, or Candidate Species known or with the potential to be located within McCracken County, KY, by the U.S. Fish and Wildlife Service (April 10, 2013). Note that the area encompasses all of McCracken County not just the DOE Reservation. None of these species have been reported as sighted on the DOE Reservation, although potential summer habitat exists there for the Indiana bat.

[b] Specimens of the Indiana bat were netted, identified, measured, and released on WKWMA property in 1991 and 1999.

7.9 UNPLANNED RELEASES

There were no unplanned environmental releases in 2012.

7.10 SUMMARY OF PERMITS

Even though USEC runs the enrichment process, the DOE retains all responsibility for the Environmental Restoration Program, the Enrichment Facilities Program, and the Legacy Waste Management Program. ***Table 7-2*** provides a summary of the Paducah Site environmental permits maintained by DOE in 2012 During 2012 permit inspections were conducted by the Kentucky Division of Waste Management, EPA, and the Kentucky Division of Air Quality. Three observations from a hazardous waste facility compliance inspection were corrected: training, open containers, and excessive waste storage time.

Table 7-2. Regulatory Permits in place for the PGDP.

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

8 ENVIRONMENTAL MONITORING AND WASTE MANAGEMENT PROGRAM

8.1 ENVIRONMENTAL MANAGEMENT SYSTEM

The Environmental Management System (EMS) includes environmental protection, environmental compliance, pollution prevention, and continual improvement in all PGDP work planning and execution. At the Paducah site, the DOE is responsible for implementation of the EMS and an EMS environmental stewardship scorecard is used to assess annual performance. The 2012 PGDP stewardship scorecard was green.

During 2012, two of DOE's contractors were audited and found to comply with the EMS based on their performance on the EMS scorecard. The EMS reduces risk to the facility mission, improves fiscal efficiency and cost, heightens knowledge of environmental programs, and enables improvement of environmental conditions at the site.

DOE and its contractors are responsible for compliance with all laws, regulations, and other requirements related to the environment. Their Environmental Policy Statements (EPS) emphasize that conservation and protection are part of all aspects of daily site conduct. Environmental policies are communicated through site-wide communication, EMS awareness training, publications, and EMS brochures.

Figure 8-1. Maintenance and decommissioning work on electrical systems at the PGDP.

8.2 ENVIRONMENTAL MONITORING PROGRAM

Prior to 1993, DOE's primary mission at Paducah Gaseous Diffusion Plant was the enrichment of uranium. Since July 1st 1993, DOE's responsibilities at the PGDP have switched to environmental restoration and monitoring, depleted uranium (DUF6) cylinder management, and waste management. Changes to the site mission in 1995 included an emphasis on the Environmental Monitoring Plan (EMP) which is reviewed annually and updated every three years.

Figure 8-2. Management and storage of hazardous material at the PGDP.

DOE and its contractors are committed to environmental betterment through effluent monitoring, environmental surveillance, and air monitoring. Air emissions monitoring is required during site construction, demolition, and remediation activities. Groundwater, surface water, waste water, landfills, sediment, soil, air, and waste disposal areas are all monitored to help reduce the impacts the PGDP has on the environment. Environmental monitoring is conducted in cooperation with the Kentucky Department of Environmental Protection, the Kentucky Radiation Control Program and the EPA.

LATAKY is responsible for the collection and assessment of data generated though the PGDP Environmental Monitoring Plan. BWCS monitors its radiation releases from the DUF6 Conversion Facility in addition to the Environmental Monitoring Plan activities conducted by LATAKY.

8.3 ENVIRONMENTAL RESTORATION PROGRAM

The Environmental Restoration Program was created to ensure that releases from the past are investigated and that appropriate responses are made to protect human health and the environment. Federal laws guide this process. The ERP encompasses previous hazardous material and waste disposal areas at the PGDP, the D&D, and disposal of buildings and facilities that are no longer in use. A table of the current goals of the ERP are in ***Attachment 2***. A timeline of response event completions from the ERP is in ***Attachment 3***.

In response to solvent (TCE) and radioactive contamination in the environment, the Department of Energy identified the character and extent of contamination and provided alternative drinking water to residents in areas that were impacted by contamination from the site or could possibly be impacted in the future ***(Figure 8-3*** *Water Policy Boundary****)***. Monitoring of the contamination included routine water sampling and included the implementation of groundwater pump and treat measures to minimize the release of contaminated groundwater from the industrial site to off-site areas.

Under the Environmental Monitoring Plan, goals were set to aid DOE, its contractors and regulators in their efforts to characterize the sources and extent of contamination in all media at the site and to provide target levels for remediation of all environmental media. Sources as well as extents of environmental contamination were identified through DOE Orders, CERCLA, RCRA and other regulatory programs.

Following identification of sources and extents, the site was divided into smaller areas to help manage response actions. Areas with source, media, and contaminant similarities were grouped into operable units (OU's) for efficient management. The OUs include Surface Water (SWOU), Groundwater (GWOU), Burial Grounds Operable Unit (BGOU), Soils Operable Unit (SOU), and Comprehensive Site Operable Unit (CSOU). Detailed investigations of OU contamination were implemented by parties to the Federal Facilities Agreement to address RCRA, CERCLA, and DOE Orders.

Response actions conducted for operable unit contamination have included the removal of above ground waste disposal areas, removal of contaminated soil, removal of contaminated sediment. Ongoing remedial activities include electrical resistance heating and removal (vaporization) of TCE from shallow subsurface soils at the C-400 Cleaning Facility, the removal of various radioactive and hazardous waste contaminated surface soils and spoil piles, the excavation and disposal of contaminated ditch soil and the removal of contaminated sediment loads from site surface water. Plans for steam injection into Regional Gravel Aquifer TCE source areas at the C-400 cleaning facility were finalized in 2012

Groundwater contamination associated with the GWOU is unique in its required action. It requires reducing human exposure, segregation, isolation and if practical, cleaning extremely large volumes of contaminated groundwater. Reduction or removal of groundwater contamination also requires that soil, sediment and surface water sources to groundwater contamination be addressed.

Three plumes of dissolved TCE groundwater contamination originate on the PGDP industrial site: the Southwest Plume, the Northeast Plume, and the Northwest Plume ***(Figure 8-4)***.

The Southwest Plume is generally confined to the PGDP industrial site while the Northeast and Northwest Plumes have migrated nearly three miles toward the TVA Shawnee Steam Plant, Metropolis Lake and Ohio River. A small, low concentration TCE groundwater plume occurs at PGDP landfills located north of the industrial site. In addition to TCE, Tc-99 is a contaminant in the Southwest Plume, Northwest Plume and a small portion of the Northeast Plume. Onsite concentrations in the on-site and near-site Northwest Plume have continued to decrease since CY 2000 ***(Figure 8-5)***.

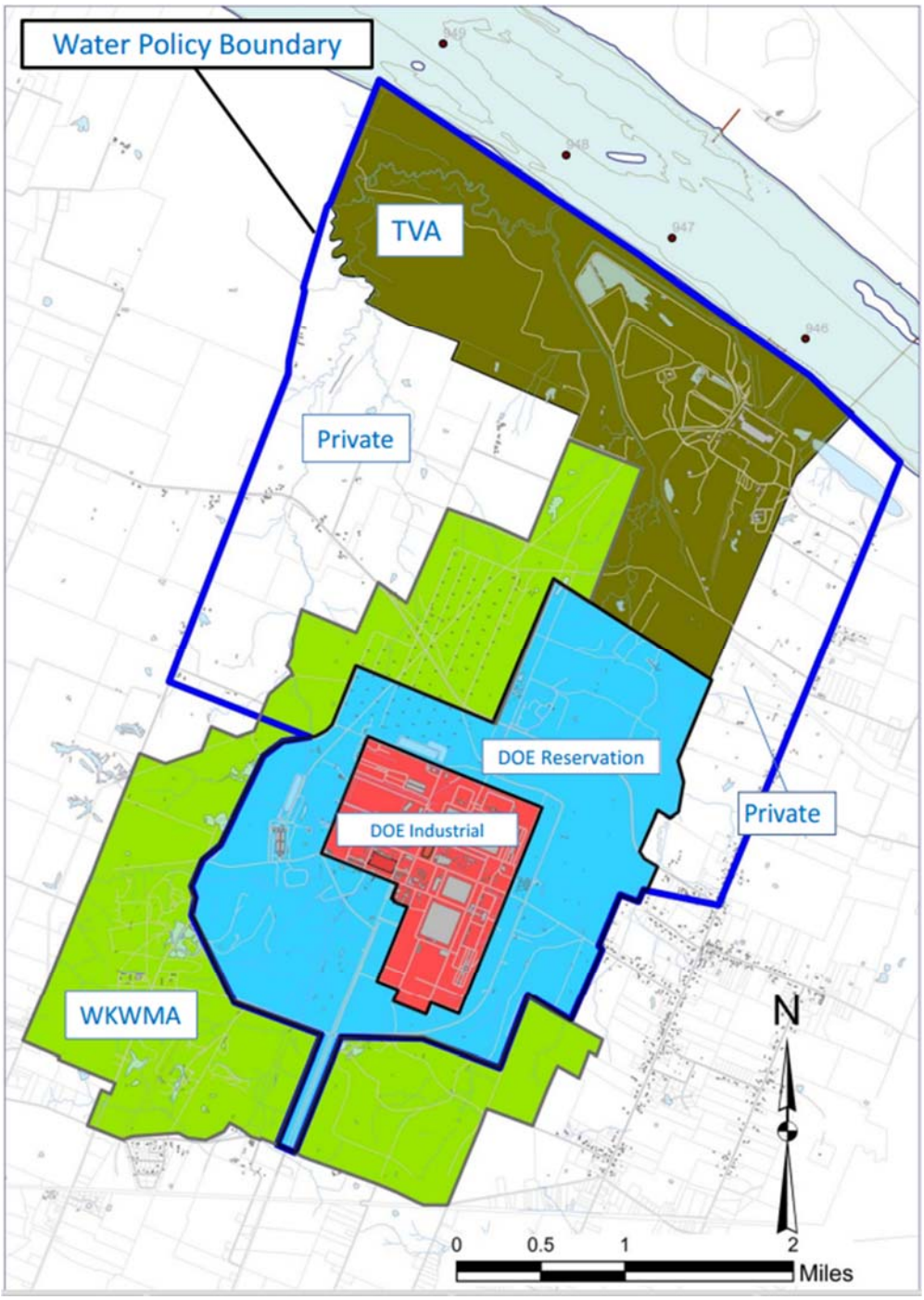


Figure 8-3. Water Policy Boundary around PGDP

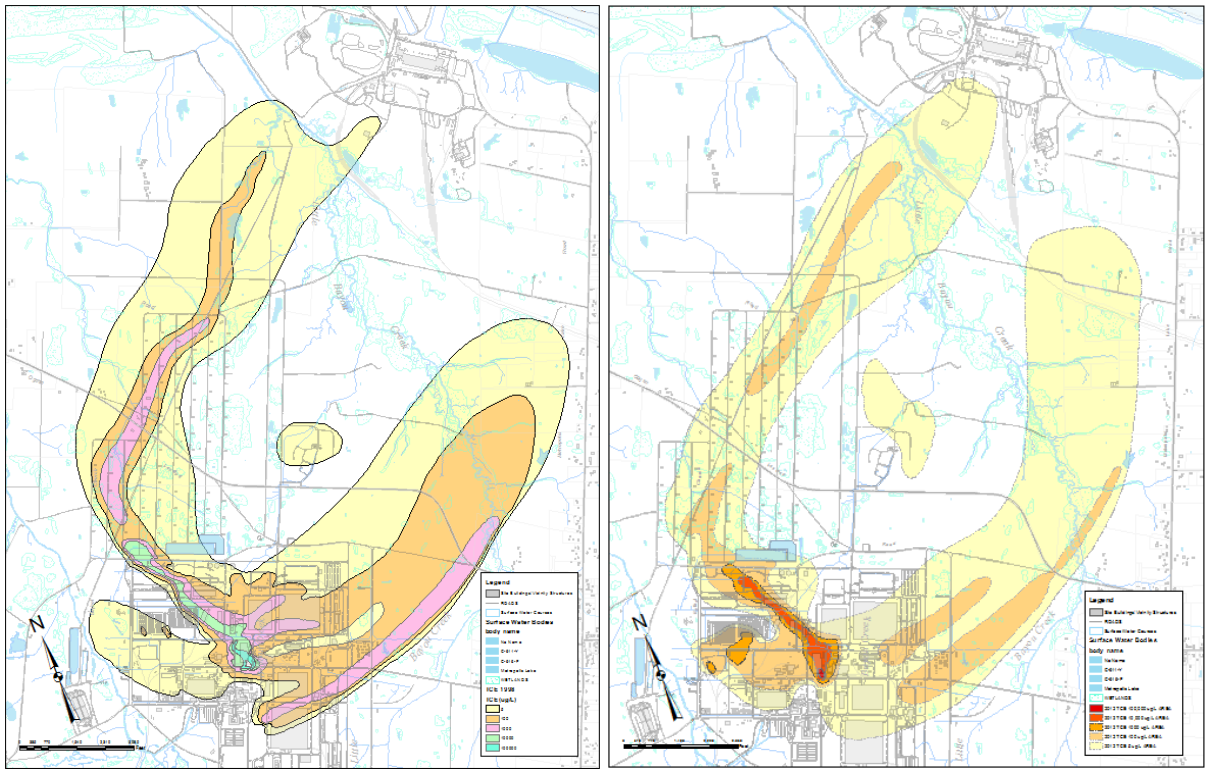


Figure 8-4. PGDP Trichloroethene Groundwater Contaminant Plumes 1998 and 2012.

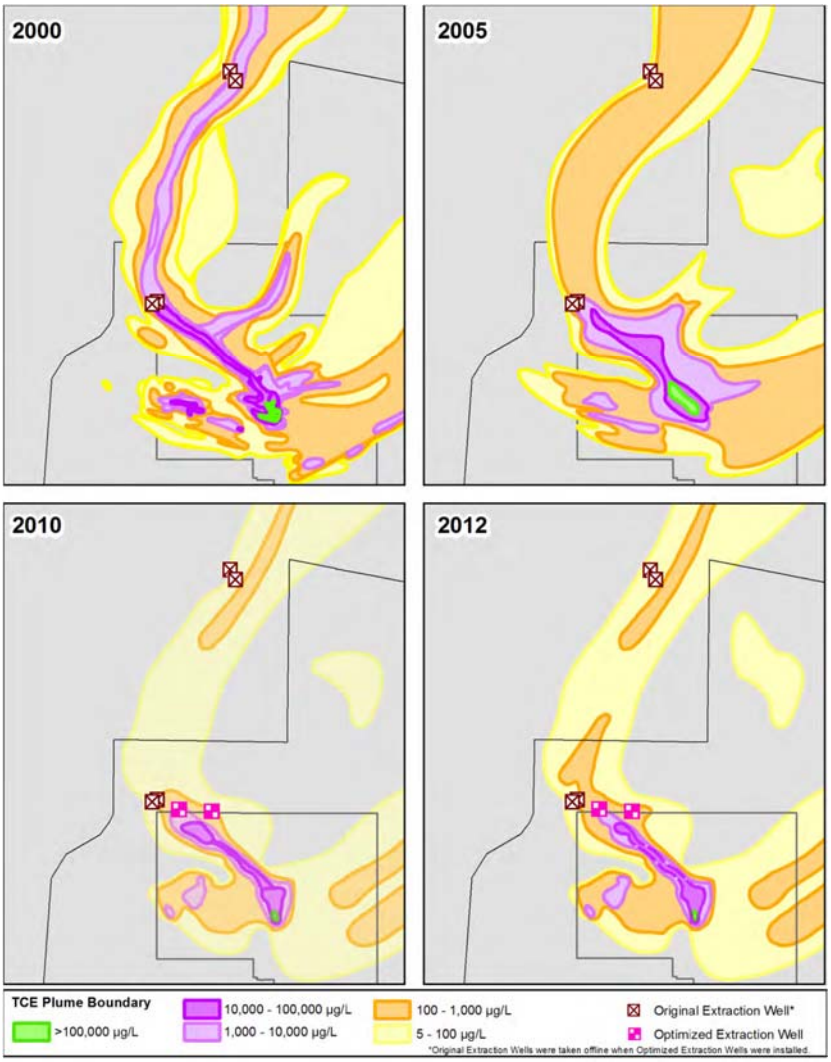


Figure 8-5. CY 2000 thru 2012 Decrease in Northwest Plume onsite TCE Concentrations.

Several sources of TCE and PCB contamination were found for the Southwest Plume. They are being addressed through field investigations supporting potential remediation actions at three areas: Solid Waste Management Unit 1 (SWMU 1), which is an abandoned waste-oil landfarm; 2) the C-720 Maintenance Building; and 3) SWMU 4, an abandoned shallow waste burial area.

The Northwest Plume groundwater treatment system has removed 1.7 billion gallons of TCE and Tc-99 contaminated groundwater in its 17 years of use. Concentrations of TCE and Tc-99 have decreased to levels which are now, in some areas of the plume, ten times less than levels before pump and treat operations began.

The Northeast Plume groundwater treatment system has removed 1.3 billion gallons of TCE-contaminated groundwater and reduced plume TCE concentrations which are now, in some areas of the plume, up to ten times less than levels before pump and treat operations began.

Figure 8-6. Monitoring of surface water as it leaves the DOE industrial site.

The goals of the SWOU are to characterize contamination, find the extent of contamination in the soil, determine the level of soil contamination relative to environmental regulations and health standards, and identify the human risk as well as ecological risk. Once data is assessed, DOE identifies the best methods to reduce any excessive impacts and tries to find better alternatives to manage excessive contaminants.

Tests to determine the extent of shallow soil contamination have been routinely conducted as part of specific projects in the Soils Operable Unit (SOU). The Burial Grounds Operable Unit (BGOU) has large areas of soil contamination where waste contaminated with hazardous and radioactive materials were purposely buried. In general, burial grounds are associated with large volumes of soil contamination. PGDP burial grounds have been analyzed and sampled since 1990. A fifth and final phase of burial ground investigation will be completed in 2014.

8.3.1 CY 2012 Response Activities

During calendar year 2012 the DOE and its contractors accomplished the following tasks related to the Environmental Restoration Program.

- Continued operation of the Northwest and Northeast Plume groundwater treatment (pump and treat) systems (GWOU, CSWOU)
- Optimized operation of the Northwest Plume groundwater pump and treat system to remove more contamination from on-site sources and block on-site contamination from flowing off of the industrial site and the DOE Reservation. (GWOU, CSWOU)

- Received approval for the Soils OU Remedial Investigation (RI) Report from EPA and Kentucky. (SOILS OU)
- Submitted a Feasibility Study (FS) for SWMUs 2, 3, 7, and 30 of BGOU at PGDP. (BGOU)
- Submitted CERCLA Waste Disposal Alternatives Evaluation RI/FS Report. (D&D, CSWOU)
- Submitted an FS for BGOU SWMUs 5 and 6. (BGOU)
- Began installation of Phase IIa of the C-400 Phase II Project. (SOU, GWOU)
- Signed Final Record of Decision (ROD) for Southwest Plume sources (GWOU)
- Conducted additional source characterization for the Southwest Plume sources (GWOU)
- Received approval for the SWOU RI/FS Work Plan. (SWOU)

8.4 WASTE DISPOSITION PROGRAM

Contamination (waste) is characterized by its radioactivity, concentration, chemical properties, physical properties, and toxicity. Specific laws govern how specific types and combinations of waste types are handled and disposed. Approximately 3 million ft^3 of waste has been displaced to date at the PGDP. Some of the displaced waste was shipped offsite and some was disposed of in onsite landfill(s). The various waste types handled at the PGDP fall into the eight categories below.

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

(2) *Mixed waste*—Waste containing both a hazardous component regulated under RCRA and a radioactive component regulated under the Atomic Energy Act.

(3) *Transuranic waste*—Waste that contains more than 100 nanocuries of alpha emitting transuranic isotopes with half-lives greater than 20 years per gram of waste.

(4) *Low-level radioactive waste*—radioactive waste not classified as high-level or transuranic waste.

(5) *PCB-containing and PCB-contaminated waste*—Waste containing or contaminated with PCBs.

(6) *Asbestos waste*—Asbestos-containing materials from renovation and demolition activities.

(7) *Solid waste*—Solid sanitary/industrial waste basically is refuse or industrial/construction debris and is disposed of in landfills.

(8) *PCB radioactive waste*—PCB waste or PCB items mixed with radioactive materials.

Waste management and disposition includes recycling. Large-scale recycling occurred with the separation of fluoride gas from depleted uranium hexafluoride feedstock at PGDP's DUF6 conversion facility ***(Figure 8-7)***. Hydrofluoric acid is recovered fluorine gas and recycled for sale. Uranium is converted to uranium oxide that is stable and safe for storage, disposal or re-use. Approximately 45 tons of other materials right down to office supplies were recycled for 2012. Additional examples of PGDP recycling activities include reusing gasoline products, recycling light bulbs, purchasing low mercury bulbs, and verifying that all recycled materials are below acceptable release limits.

Figure 8-7. The depleted uranium hexafluoride (DUF6) Conversion Facility at the PGDP.

Depleted uranium hexafluoride (DUF6) is transported and stored in large metal cylinders ***(Figure 8-8)***. In 2012 the number of DUF6 cylinders at the PGDP reached 46,000 as cylinders of DUF6 from other DOE sites were shipped to PGDP for eventual conversion and future use ***(Figure 8-9).*** The DUF6 cylinders are kept in outdoor cylinder storage yards. One of the hazards of outdoor DUF6 cylinder storage is the potential to release of UF6 which reacts with air to form uranium and HF gas. The condition of the DUF6 cylinders is addressed by regular maintenance and inspections.

Figure 8-8. Uranium hexafluoride (UF6) cylinders (for scale).

Figure 8-9. Depleted Uranium hexafluoride (DUF6) cylinders in outdoor storage yards at PGDP.

8.5 DECONTAMINATION AND DECOMMISSIONING (D&D)

Buildings that lose their usefulness and contain or are contaminated with hazardous or radioactive material must be decontaminated and decommissioned (D&D). Buildings that have been subject to D&D are demolished and disposed. By 2012, 30 out of the 37 targeted facilities at PGDP were successfully decontaminated and decommissioned.

Contaminants encountered during D&D include depleted uranium, natural uranium, transuranic radionuclides, uranium tetrafluoride, PCBs, asbestos, and lead paint. D&D requires coordination with waste treatment and management at the PGDP.

Three (3) buildings received stimulus (American Reinvestment and Recovery Act (ARRA)) funding to undergo D&D; C-340 D&E, C-746 East End Smelter, and the C-400 Feed Plant complex.

The following are significant D&D accomplishments in 2012:

- Continued deactivation of C-410 Building and completed deactivation of C-340 Building.
- Completed stabilization and removal of 9,000 linear feet of UF6 piping in the C-410 Complex.
- Completed stabilization of 8 UF6 production reactors and filters, 24 UF6 ash receivers, the 1,000 gallon UF6 surge tank, and over 1,800 ft. of ash conveyor used in the UF6 production system.
- Continued asbestos abatement in the C-410 Complex.
- Initiated and completed transite removal from the C-340 Complex.
- Mobilized subcontractor and initiated structural demolition of the C-340 Complex (see Figure 3.4).
- Completed over 50% of C-340 Building demolition in 2012.

- Packaged over 700 tons of PCB remediation debris in gondolas from C-340 D&D for off-site shipment.
- Disposed over 700 tons of demolition debris from C-340 D&D in the C-746-U Landfill.

Most notable of these facilities are the C-410 complex buildings where uranium was processed to produce enrichment process feed material and the C-340 building where uranium metal and other metals were milled and processed (***Figure 8-10*** and Figure 8-11). The green colored wall in Figure 8-10 throughFigure 8-12 is transite fixative which ensures that contamination on the wall surface stays in place.

Figure 8-10. Demolition of C-340 building where Uranium and other metals were milled and processed

Figure 8-11. Demolition of the C-410 Building where uranium was blended to produce feed material for the enrichment process.

Figure 8-12. C-410 demolition workers in personal protective gear.

8.6 AWARDS AND RECOGNITIONS

The PGDP Plant has operated over 2 million employee hours without an OSHA recordable occupational injury. It also won the Governor's Health and Safety Award, the highest safety honor given by the Commonwealth. The company actively works to keep the community aware of their decisions.

Two and three-dimensional models were created by University of Kentucky College of Design students to show the sources and extents of groundwater impacts and groundwater cleanup progress. This was displayed at West Kentucky Community and Technical College. The Department of Energy also did various community activities to raise awareness.

The Citizens Advisory Board was organized under the Federal Advisory Committees Act and completed its 16th full year of operation in 2012. All meetings are open to the public and publically advertised. The board has 18 members that reflect the demographics of the area.

The End State Vision Document was created and issued in 2005 to outline DOE's plans for future environmental activities at the PGDP. It was revised in 2008 and will be updated in 2013.

The public has access to administrative records and programmable documents at the DOE PGDP Environmental Information Center (EIC) in the Barkley Center, 115 Memorial Drive, Paducah Kentucky (http://paducaheic.com/). It is open Monday through Friday from 8:00 am to 12:00 pm and appointments are available by phone. The phone number is (270) 554-3004. Documents are also placed in the McCracken County Public Library, 555 Washington Street, Paducah, Kentucky.

The Paducah Environmental Geographic And Spatial Information System (PEGASIS) project provides an external geographic information system data viewer to the public. PEGASIS data and GIS information for the PGDP can be accessed at: (http://padgis.latakentucky.com/padgis/PAD_Homepage.aspx)

The DOE Portsmouth Paducah Office (PPPO) manages the Paducah Gaseous Diffusion Plant and the Portsmouth Gaseous Diffusion Plant in Portsmouth, Ohio. Web pages for more PGDP information can be found at www.energy.gov/pppo.

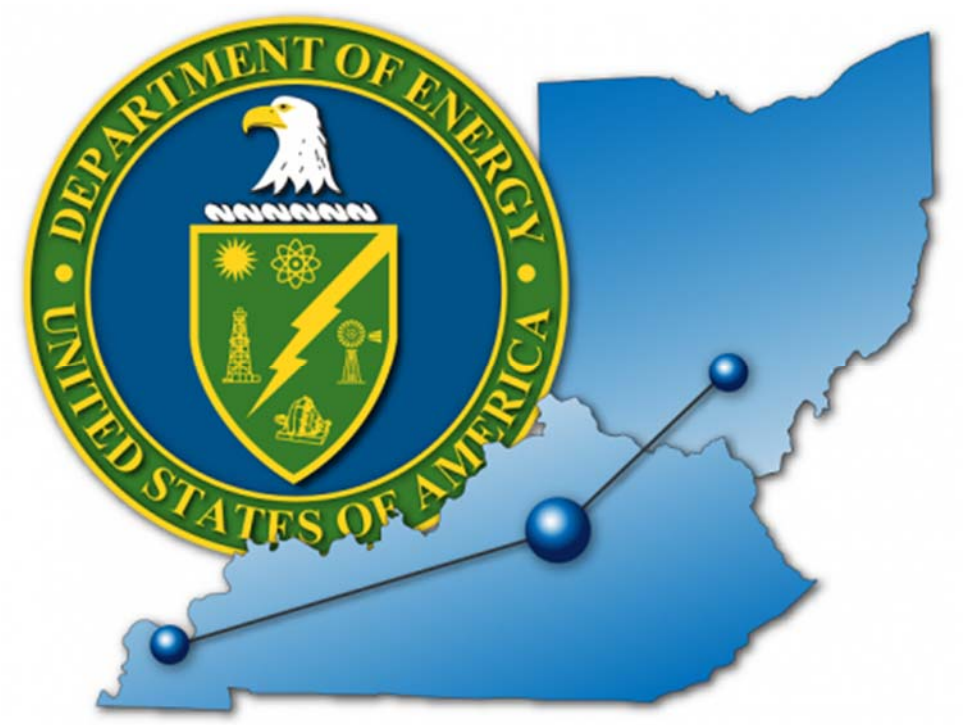


Figure 8-13. DOE Portsmouth-Paducah Project Office banner.

9 ENVIRONMENTAL RADIOLOGICAL PROGRAM

9.1 INTRODUCTION

Radionuclides are the unstable forms of a chemical element that radioactively decay and release radiation. DOE Orders require the PGDP to monitor airborne and waterborne releases of radionuclides and radioactive materials. The monitoring is part of the PGDP Environmental Monitoring Plan.

Uranium and technetium are elements introduced into the environment from the PGDP enrichment process. Uranium and technetium are also two of the many elements that consist of radioactive isotopes or radioisotopes. The radioisotopes of an element have different numbers of neutrons in the nucleus but all isotopes of an element have the same number of protons in the nucleus of each atom. The atomic number of an element indicates the number of protons in its nucleus.

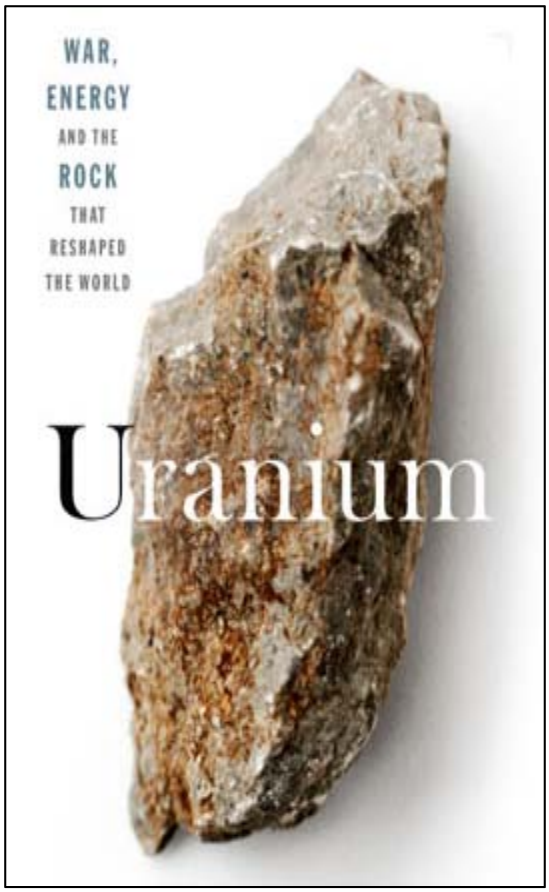


Figure 9-1. Uranium bearing ore.

When the nucleus of an isotope breaks down, it releases excess energy as either particles or as radiation. This material or isotope is radioactive material. The transformation of one isotope into another isotope of the same element or to a different element altogether is the process of nuclear decay. When an isotope does not undergo nuclear decay, the isotope is stable. When decay does occur, the isotope is referred to as unstable. The rate of decay for unstable isotope material is measured in Curies (Ci) which represent the number of decays per second. Subatomic particles or radiation from radioactive decay include alpha particles (2 protons plus 2 neutrons), beta particles (an electron or positron) and gamma rays (a neutron).

Each isotope has a very specific energy that is released during radioactive decay. That energy can be used to identify and quantify radioactive material. The energy releases are measured by detectors used in the field or by radiochemistry laboratory instruments.

The following radionuclides are present at the PGDP as part of the uranium enrichment process:

- Uranium-238, Uranium-234, Uranium-235
- Plutonium-239, Plutonium-238
- Thorium-234, Thorium-230
- Americium-241
- Cesium-137
- Neptunium-237
- Technetium-99

When radioactive particles, i.e. ionizing radiation, interact with the human body, the energy from the radiation may be transferred to body tissue. The amount of radiation energy passed to the body per unit weight of organ or tissue is referred to as dose. Dose may be measured in millirems (mrem) and is expressed relative to varying units of time, mrem/yr. Different types of radiation exposure can affect the human body in different ways by interacting with tissue in different ways. DOE Order 458.1 sets dose limits of 100 mrem per year through all exposure pathways from DOE operations.

9.2 RADIOLOGICAL EFFLUENT MONITORING

DOE monitors the release of radioactivity to water, sediment and air. In accordance with DOE Order 450.1A (Environmental Protection Program), effluent monitoring is conducted as part of the EMS. DOE Order 458.1, *Radiation Protection of the Public and the Environment*, sets dose limits for members of the public at 100 mrem per year through all exposure pathways. DOE requires that the dose be as low as reasonably achievable (ALARA). Radiological airborne releases from DOE activities are regulated under 40 CFR 61, Subpart H, which governs radionuclide emissions (except Radon). 10 mrem/yr is the limit set to any individual in the public from airborne emissions. All DOE sites must conduct radiological surveillance monitoring of all media and populations in surrounding areas.

Releases of radionuclides to water, soil, and the atmosphere have occurred during historical operations and continue to occur from a few current activities at the PGDP. Those activities include operation of: 1) Northwest Plume Groundwater Treatment System; 2) The Northeast Plume Groundwater Treatment System; and 3) the Depleted Uranium Hexafluoride System. Analyses of air and liquid effluent samples from PGDP indicate that levels of uranium and Tc-99 are at levels that are not considered harmful to human health.

Most human health problems associated with radionuclides are caused by external gamma radiation or radioactive material entering the body. Health problems may result from the transfer of energy from radiation to tissue which results in tissue damage. Radiation either comes from internal or sources external. The difference is important since external radiation stops once the person is away from the source, while internal continues as long as the source is inside the body.

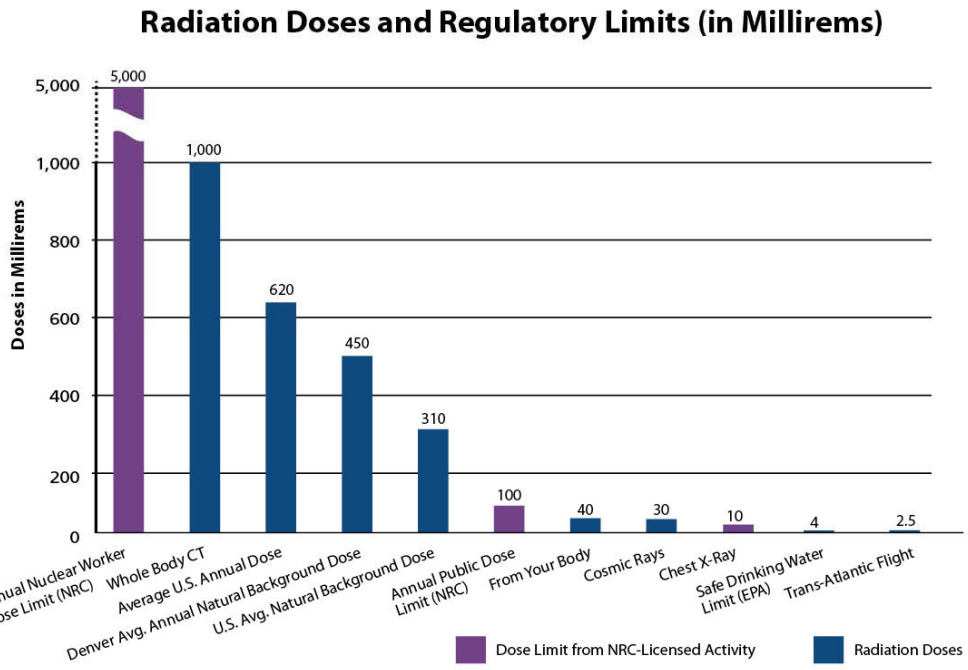


Figure 9-2. Radiation Dose and Regulatory Limits (Millirems).

Historical monitoring at the PGDP reveals less than a 1 mrem/yr dose of radiation from radionuclides in sediments. In October 2010, the revised PGDP Environmental Monitoring Plan changed sampling requirements, so sediments were only tested for non-radiological materials. The change was implemented because there had not been noticeable increases in the radioactivity of sediment samples. Data from 2008-2010 has been recently reviewed. Table 4.7 shows the radiological analysis parameters from 2008-2010, while ***Figure 4.4*** shows where the sediment samples came from.

9.3 RADIOLOGICAL ENVIRONMENTAL SURVEILLANCE

9.3.1 Air

DOE, the Kentucky Cabinet for Health Services Radiation and Environmental Monitoring Section, and USEC all monitor airborne releases of radioactivity. The results of 2012 ambient air monitoring ***(****Figure 9-3****)*** indicated that the Paducah Site is in compliance with the regulatory standards for radioactive air emissions. Computer modeling is used to predict and evaluate airborne releases of radioactivity from the PGDP and impacts from the releases.

9.3.2 Materials Releases

During 2012 BWCS shipped anhydrous HF (hydrogen fluoride) recovered from the DUF6 conversion facility. Because of the potential for radiation exposure DOE Order 458.1, Change 2, *Radiation Protection of the Public and the Environment* limits are set on the activity of HF released from the conversion facility. In 2012, shipments were below the release limits for uranium activity. Thirteen (13) TLD locations in the vicinity of the UF6 cylinder yard measured local radiation above background.

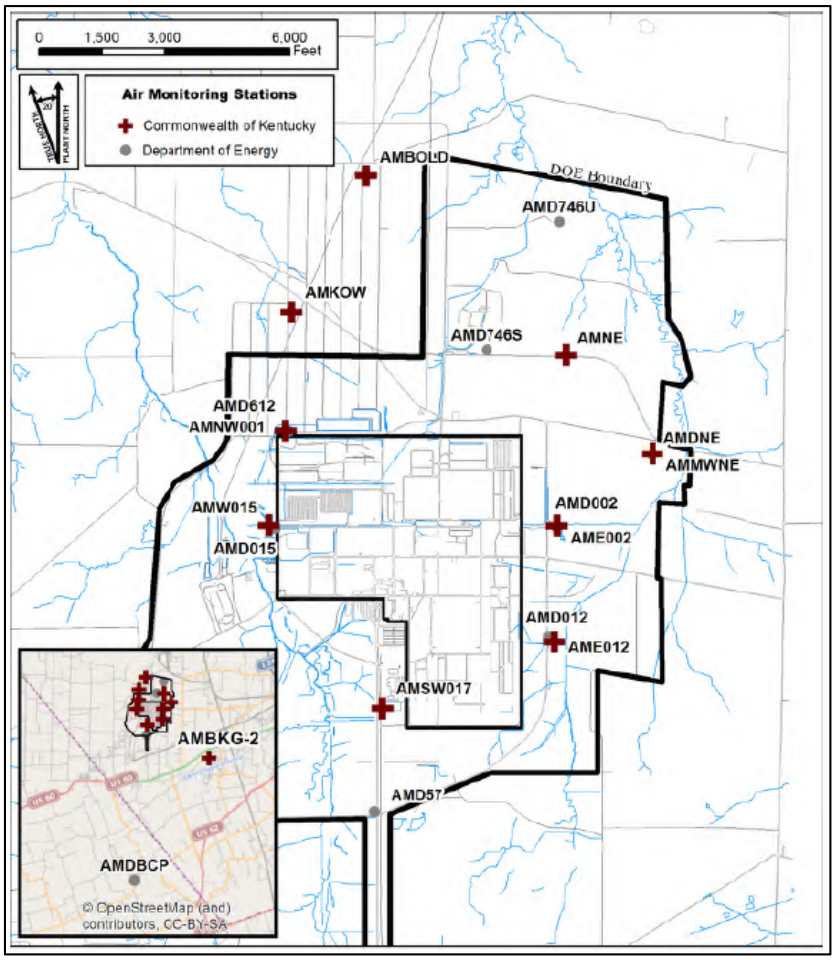


Figure 9-3. Airborne Radiation Surveillance Monitoring Locations.

9.3.3 Surface Water

Radionuclides released in surface water through PGDP outfalls are monitored upstream and downstream of the PGDP. ***(***Figure 4.2.***)*** Comparisons are made between the upstream and downstream radionuclide activities to determine if PGDP discharges are impacting water quality in Bayou and Little Bayou Creeks. Seeps located near the TVA Shawnee Steam Plant are also monitored for radioactivity. Historical and recent sampling indicates that surface water radionuclide activities are protective.

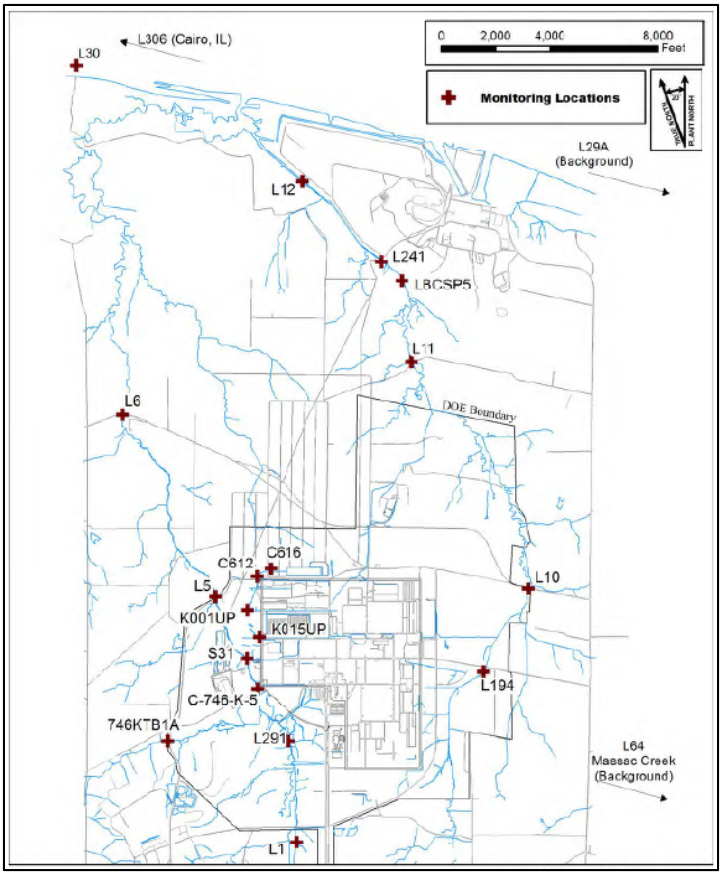


Figure 9-4. Surface Water Surveillance Monitoring Locations.

9.3.4 Sediment

If radioactive materials are pollutants, they can be transported in solution, as sediment, or by sediment and smaller particles. Once transported they can be deposited in or along a water courses or water bodies. Radioactive pollutants can be absorbed by organic solids, inorganic solids and taken up by plants or animals. Solids, dead organisms, and waste settle at the bottom of the water and support the bottom-dwelling community of the water passing to higher levels of the food chain through smaller organisms.

The average concentration (activity) of radionuclides in the sediments upstream and downstream of PGDP Industrial Site is shown in ***Figure 9-5***. Location S32, located within the PGDP buffer area with limited public access, has the highest levels of radionuclides. Uranium was also detectable in Little Bayou Creek and Bayou Creek near the plant site downstream ***(Table 9-1)***. Other radionuclides were present, but not significantly so. Areas with high radionuclides are within DOE boundaries and are posted for protection.

DOE sampled sediments through a radiological environmental surveillance program. Historical sediment sampling indicated that dose from sediments would be less than 1 mrem/yr and that the dose is protective.

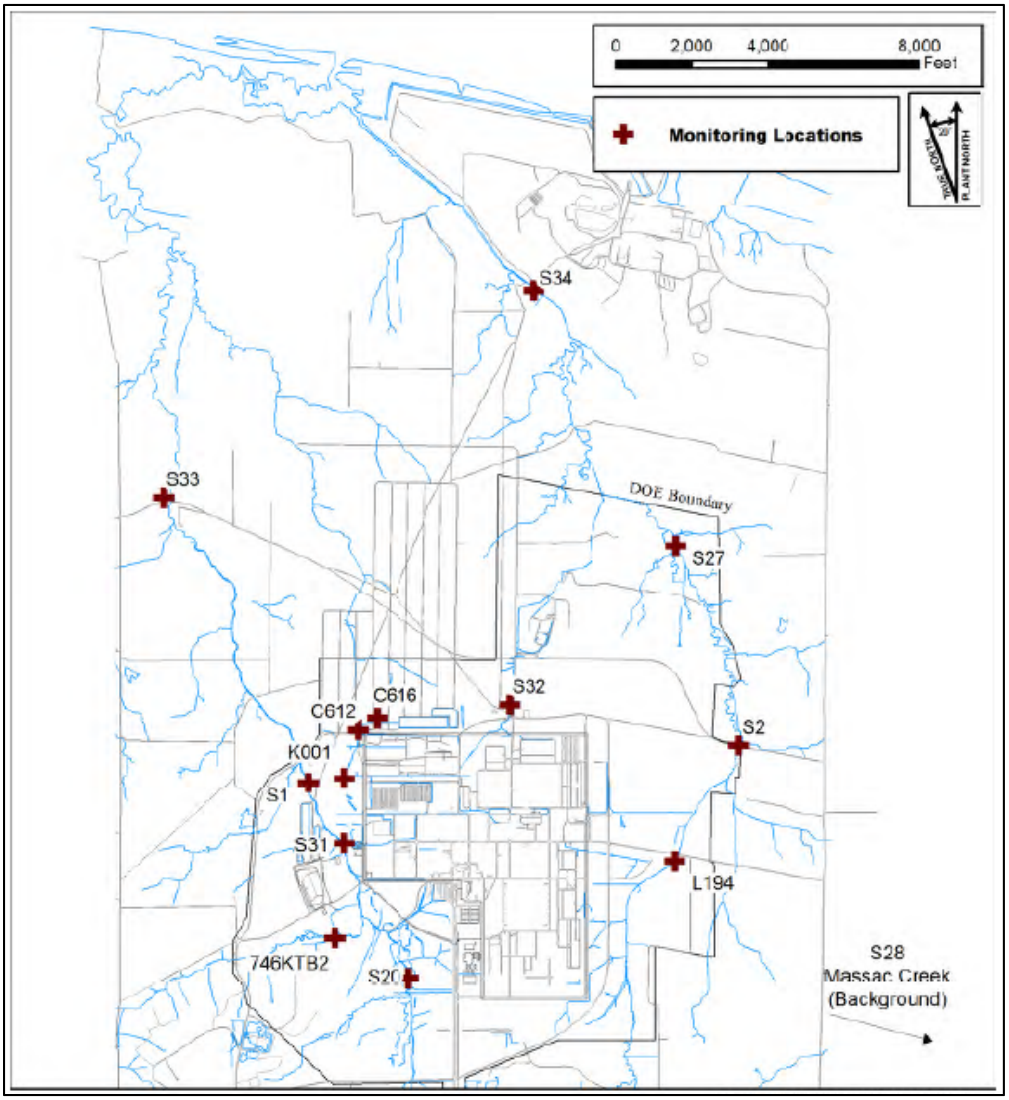


Figure 9-5. Sediment Surveillance Monitoring Locations.

Table 9-1. Radioacitivity of sediment samples collected at the PGDP.

Parameter (pCi/g, except where noted)	Upstream Bayou[1]	Bayou Near Site[2]	Down-stream Bayou[3]	Little Bayou Near Site[4]	Down-stream Little Bayou[5]	C-746-K Area[6]	NSDD[7]	Massac Creek[8]
Alpha Activity	4.58	18.2	6.71	10.98	10.31	5.46	43.2	4.47
Americium-241	0.00570[b]	0.0203	0.00816[b]	0.00467[b]	0.0278	0.00739[b]	0.420	0.00265[b]
Beta Activity	4.03	31.9	8.74	17.9	9.93	5.44	49.4	2.10
Cesium-137	0.0282[b]	0.0964	0.0766	0.0289	0.0639	0.0216[b]	0.373	0.0049[b]
Cobalt-60	0.0193[b]	0.00912[b]	0.0253[b]	0.0130[b]	0.0102[b]	0.0107[b]	0.000[d]	0.00460[b]
Neptunium-237	0.00357[b]	0.167	0.0115[b]	0.0112	0.0117	0.0150[b]	0.448	0.00175[b]
Plutonium-239/240	0.00338[b]	0.0899	0.0125	0.00277[b]	0.0959	0.0322	1.41	0.00143[b]
Potassium-40	8.54	7.67	7.82	4.88	4.70	4.13	6.67	7.46
Technetium-99	3.41	9.49	7.74	0.571	1.90	0.460	18.8	0.654
Thorium-230	0.341	1.04	0.585	0.294	1.87	0.253	21.1	0.257
Uranium (mg/kg)	99.8[c]	96.6[c]	97.8[c]	96.2[c]	96.1[c]	98.8[c]	95.8[c]	96.9[c]
Uranium	0.333[b]	10.6	1.61	13.0	3.47	2.09	5.11	0.310
Uranium-234	0.168	5.29	0.734	1.40	0.709	0.852	2.24	0.149
Uranium-235	0.00583[b]	0.250	0.0394	0.164	0.0627	0.0457	0.118	0.0143
Uranium-235 (wt.%)	N/A	1.06	0.803	0.346	0.395	0.591	0.662	1.49
Uranium-238	0.163	5.33	0.832	11.4	2.70	1.20	2.76	0.147

[a] The results presented in the table are the averages of the highest reported result within the area groupings over a three-year time span.
[b] Results for this location all are reported at activities less than the laboratory's minimum detectable activity and/or radiological uncertainty.
[c] Results for this location all are reported at concentrations less than the laboratory's reporting limit.
[d] Consistent with NRC guidance, 0.000 is presented for results reported less than zero.
N/A = result not available.

9.3.5 Ecological Monitoring

DOE Orders requires that DOE must consider protection of biota, both aquatic and terrestrial systems. DOE Order 458.1 requires that populations of aquatic animals and terrestrial plants be protected at a dose rate limit of 1 rad/day. A dose rate limit of 0.1 rad/day is recommended for terrestrial animals in the evaluation of the terrestrial systems.

9.3.6 Direct Exposure

A potential concern at the PGDP is direct external radiation exposure. Direct external radiation exposure is exposure caused by radioactive sources outside of the body. Sources of this exposure include the cylinder storage yards, enrichment process buildings, and smaller sources such as instrument check locations. Cylinder storage yards pose the most threat to the public since they are the closest to the PGDP security fence. The PGDP External Radiation Monitoring Program places thermoluminescent dosimeters (TLDs) at 42 locations around the PGDP to measure direct radiation exposure. Thirteen TLD locations in the vicinity of the UF6 cylinder yard indicated local radiation above background.

In 2012, DOE expanded recreational use access to areas on DOE Reservation outside of the fenced industrial area. This allowed the public to come into closer contact with the UF6 cylinder yards than ever before. With closer contact to radiation from radioactive material in the cylinders, potential radiological exposure to the public was evaluated. The 2012 Site ASER (DOE, 2014) report shows a slight increase in exposure over previous years. The increase is not of concern because it is less than 2% of the allowable DOE annual dose limit.

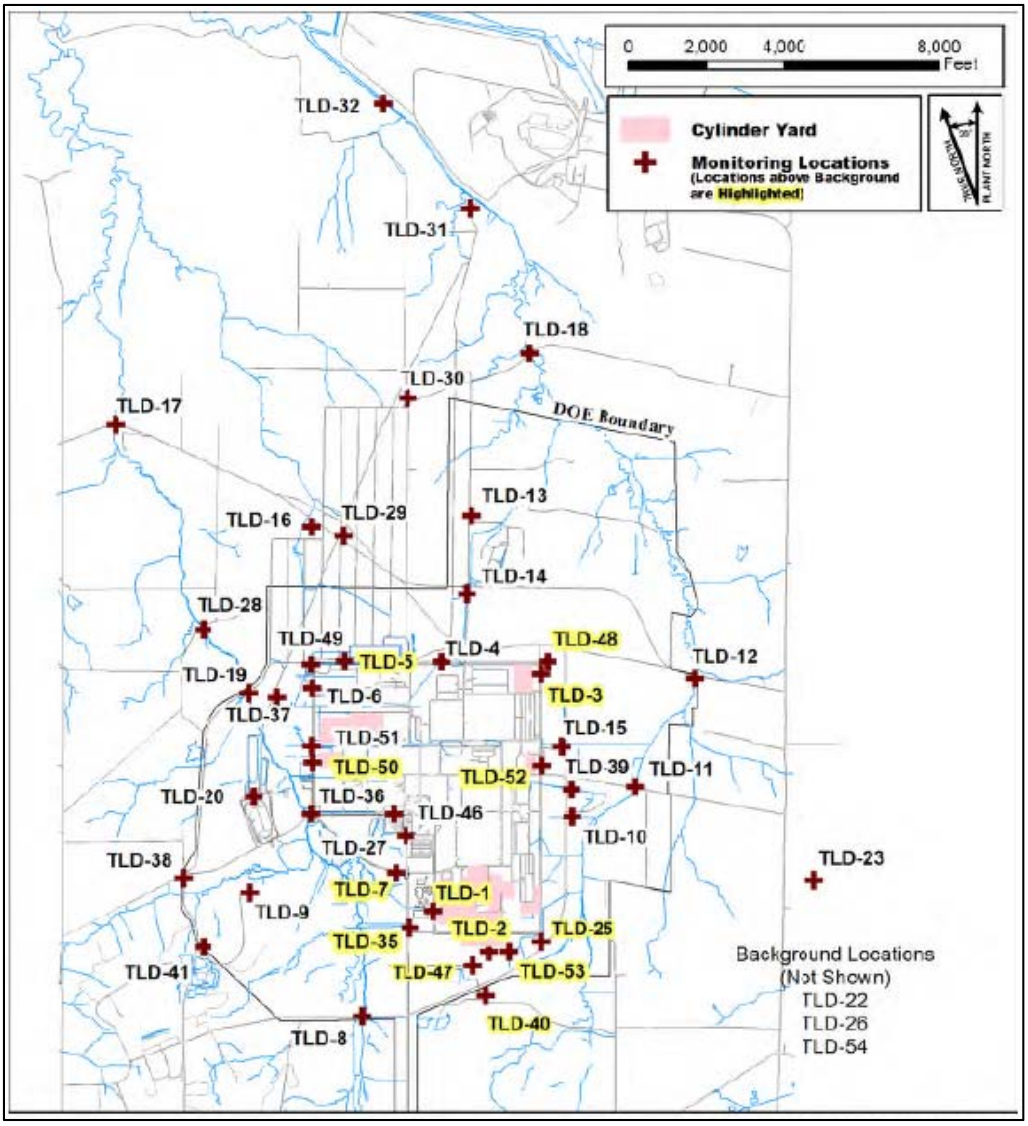


Figure 9-6. Thermoluminescent Detector Direct Exposure Surveillance Monitoring Locations.

Only 13 of the 42 TLD locations were consistently above levels considered to be above background. Most of the locations were near the PGDP security fence near cylinder storage yards the public did not have access to until recently. DOE limit for dose is established as 25 mrem/yr from any single source.

9.4 RADIOLOGICAL DOSE CALCULATIONS

Dose calculations for the PGDP considered three primary radiation exposure routes that would add to an off-site receptors dose: 1) inhalation, 2) ingestion, and 3) direct radiation exposure. For ingestion, modeled exposure pathways include, incidental drinking of surface water, incidental ingestion of sediment, and consumption of wildlife that had ingested and/or inhaled radioactive materials.

The following considerations were included in the dose calculations:

Exposure to contaminated sediment is possible during fishing, hunting, swimming, or other recreational activities in Bayou Creek or Little Bayou Creek. However, testing showed that radiation levels were below background, despite this pathway contributing the most to the worst-case scenario.

The public does not have access to the PGDP inside the industrial area boundary fence, thus, doses are calculated at the closest point the public is allowed. Any place identified to have radiation levels above legal limits is restricted from the public. The highest dose of an individual was estimated to be 1.6 mrem per year, far below the limit of 25 mrem per year for an average member of the public specified by the NRC.

The most common surface water pathway is through drinking water that contains radionuclides. Testing revealed that the closest public water supply source, Cairo, Illinois, did not have radiation levels above background.

Four airborne sources contributed to public radiation dose in 2012: 1) the Northwest Plume Groundwater System, 2) the Northeast Plume Containment System, 3) C-340 demolition, 4) and DUF6 conversion operations. All of these sources were analyzed and tested for possible risk to an individual and the public. The estimated amount was well below the established limits.

The USEC facility may have some contaminants in the area but they are still well below the safety limits set by regulatory agencies. Despite compliance with regulatory standards, DOE is currently conducting many projects to help lower doses at all locations which is consistent with ALARA. It may take decades to minimize site contamination and exposures but in the meantime there are no unacceptable health risk dangers to the public from any normal site activities.

The highest estimated dose that an exposed person may have received from all DOE exposure pathways was 1.902 mrem/year. This was created from a worst-case scenario and is below the Federal standard of 100 mrem/year.

The dose calculation can be summarized as follows:

1. The largest contributor to the calculated dose is from direct radiation.
2. The groundwater pathway has been replaced and contributed nothing to the dose
3. All levels were below established limits.
4. Any increase in potential dose was from recent allowance of public access to areas closer to the cylinder yards in the facility.

9.5 UNPLANNED RADIOLOGICAL RELEASES

There were no unplanned radiological releases at PGDP in 2012.

10 ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

10.1 NONRADIOLOGICAL POINT SOURCE EFFLUENT MONITORING

A point source is a specific location where media contamination is released. Airborne, wastewater and effluent point sources are monitored at the PGDP.

USEC steam plant emissions are the largest monitored point source at the site. During 2012, hydrogen fluoride stack testing protocol was used to perform continuous monitoring on the DUF6 Conversion Building Stack. The results indicated no detection of hydrogen fluoride emissions while operating one conversion line. The Kentucky Department for Environmental Protection declared an end to the continuous monitoring of hydrogen fluoride (HF) at the DUF6 Conversion Facility. An estimated 34 lbs. of hydrogen fluoride were release from the facility in 2012.

The Northeast Plume Containment System (NEPCS) and the Northwest Plume Groundwater System (NPGS) have removed 3 billion gallons of groundwater containing approximately 1,930 lbs. of TCE. The Northwest Plume treatment facility uses active carbon and ion exchange to remove Tc-99 and TCE. The NEPCS uses the existing cooling tower at Paducah Gaseous Diffusion Plant for stripping TCE from groundwater. Contaminated groundwater enters the cooling towers with water used to cool the enrichment process equipment. TCE is a volatile substance and is vaporized and released from the steam in the cooling towers. In the atmosphere, any remaining TCE naturally breaks down. During 2012 a total 169 gallons of TCE was removed from the subsurface.

The Kentucky Division of Waste Management specifies in landfill permits that “surface runoff will be analyzed to ensure that landfill constituents are not discharging into nearby receiving streams.” Analytical results from the five DOE outfalls are reported to Kentucky Division of Water in monthly and quarterly discharge monitoring reports.

10.2 NONRADIOLOGICAL ENVIRONMENTAL SURVEILLANCE

Air, surface water, ground water, soil and sediment are monitored as part of the PGDP’s nonradiological surveillance. As a result of the transfer of the operations of the plant to USEC in 1993, major air emission sources were transferred to USEC. In 2012 DOE did not conduct ambient air monitoring for radiological parameters at the PGDP.

Sediment is an important constituent of the aquatic environment that can redistribute contamination in surface water courses and water bodies. Contaminated suspended solids can settle to the bottom of water bodies and low energy areas in and adjacent to water courses. Suspended solids, dead biota, and excreta settle to the bottom and become part of the organic substrate that supports the bottom dwelling community of organisms. Contaminants enter the food web when they are consumed by bottom dwelling organisms.

Creek and ditch sediments are sampled semiannually as part of environmental surveillance activities. The results were that the PCB-contaminated areas either are within DOE-controlled area or are posted for protection of the public. With no anticipation of an increase in metal contaminants originating from site operations, the metals analysis was removed from the Environmental Monitoring Plan program.

The major source of soil contamination is deposition from air pathways. Because DOE no longer operates any major air emission sources, routine soil surveillance is not performed. However, surface soil contamination associated with point sources is being addressed across the PGDP by the Soils Operable Unit investigations.

Because DOE no longer operates any major air emission sources, routine vegetation surveillance activities are not performed.

DOE notified the Kentucky Department of Fish and Wildlife in July 2011 that it was ceasing deer harvesting from the Paducah site. The lack of detection of contaminants was the basis for the elimination.

Figure 10-1. Habitats at the PGDP, the WKWMA, and vicinity host numerous deer.

11 GROUNDWATER PROTECTION PROGRAM

11.1 INTRODUCTION

DOE Orders require the PGDP to monitor and protect the groundwater resources around the PGDP Site. DOE is concerned about the on-site sources of groundwater contamination and the groundwater off-site, which has two primary contaminants, TCE (trichloroethene) and Tc-99. TCE was used as a degreaser at the PGDP for routine cleaning of enrichment process and industrial equipment. Tc-99 was a by-product of the nuclear fission process and was introduced to the PGDP in spent nuclear fuel rods. The known sources of TCE and Tc-99 groundwater contaminants are the C-400 Cleaning Facility, the C-720 Maintenance Facility, Solid Waste Management Unit (SWMU) 001 Oil Landfarm, SWMU 4 Shallow Land Burial area, test areas, spills, leaks, buried waste, and scrap metal.

The contaminant TCE was found at its highest concentrations in groundwater around the C-400 cleaning building. TCE is a widely used industrial degreaser and a common contaminant at many industrial sites worldwide. TCE's low solubility trait makes TCE hard to dissolve. TCE's density, which is greater than the density of water, causes the TCE to move vertically downward through groundwater. TCE is a dense non-aqueous phase liquid (DNAPL). When DNAPL encounters an impermeable material like clay, the vertical migration of the TCE stops and the TCE accumulates and may pool on the clay surface. The pooled TCE dissolves very slowly making it a long-term source for downgradient groundwater contamination. To date the environmental industry has not been very successful removing DNAPL source areas from the saturated or unsaturated subsurface.

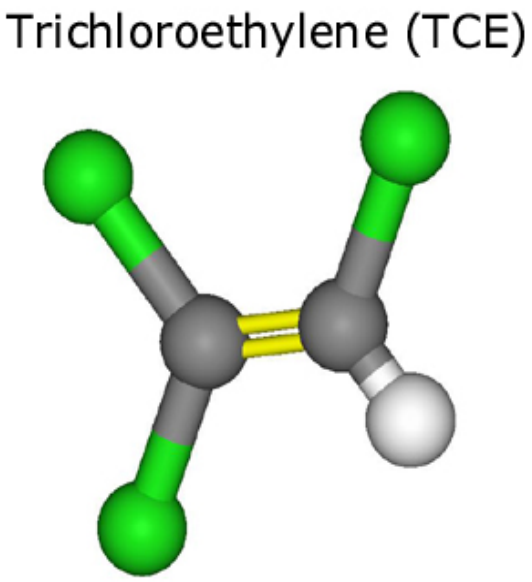


Figure 11-1. TCE Molecule. Green = Chlorine atoms, Gray = Carbon atoms, and silver-white = Hydrogen atoms.

11.2 GROUNDWATER HYDROLOGY

While most rainfall finds its way to lakes or streams as runoff, the rest of the precipitation infiltrates into the ground. When the ground contains contaminants like TCE and Tc-99, infiltrating water becomes contaminated. Although most people are not aware of groundwater contamination, contaminated groundwater resides in aquifers which are large areas of water contained underground, and poses a hazard if consumed by humans or wildlife.

To monitor groundwater, drills are used to advance a borehole from the surface. Once the borehole reaches its intended groundwater target, a steel, stainless steel or polyvinyl chloride casing is inserted. Slots are placed in the casing at the target depth to allow targeted water to flow into and out of the casing. Using pumps, water samples are extracted from the ground. Some groundwater data is collected at the well and then samples are sent to laboratories for analysis.

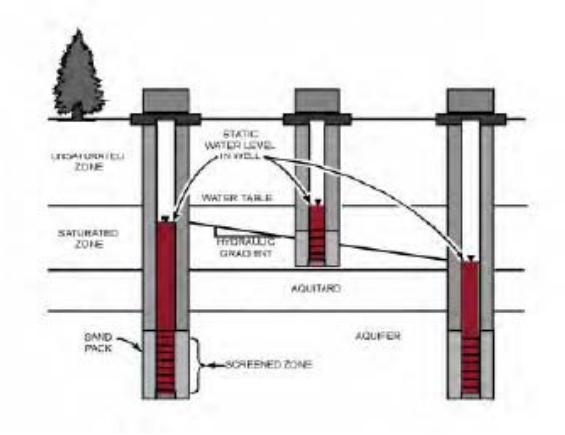


Figure 11-2. Groundwater monitoring well construction relative to the UCRS, RGA and Aquitards.

Many landfills at the PGDP, where waste was buried, are monitored by the DOE in order to provide early ground or surface water contamination detection. Many residential wells in the near vicinity of the landfills and burial grounds are also monitored in order to provide groundwater contamination data and residential wells away from known areas of PGDP groundwater contamination are also monitored.

11.3 GEOLOGIC AND HYDROGEOLOGIC SETTING

The Paducah area is considered part of the Mississippi Embayment of the Gulf Coastal Plain Province. The Mississippian Embayment is composed of sand, silt, and clay deposits ***(Figure 11-4)***. The four main local portions of the groundwater system (in order from shallowest to deepest) are the Loess & UCRS (shallow soil to the top of the local aquifer), the Terrace Gravel flow system (south of PGDP), the RGA (Regional Gravel Aquifer), and the underlying McNairy flow system. Most of the groundwater flow in the RGA originates on the southern part of the Paducah site with some contribution from the Terrace Gravel flow system. Groundwater under the Paducah site flows north to the Ohio River.

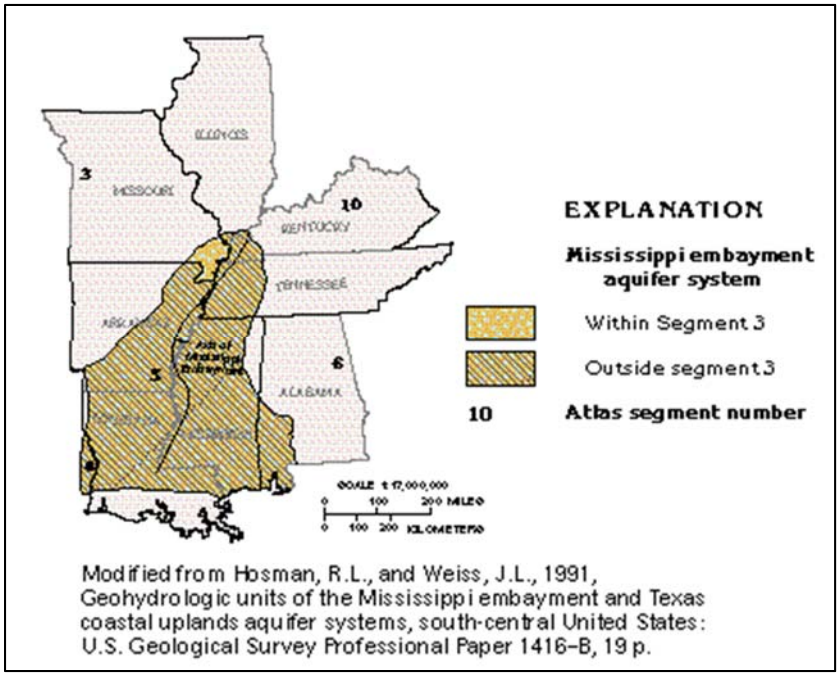


Figure 11-3. Map illustrating the extent of the Mississippian Embayment.

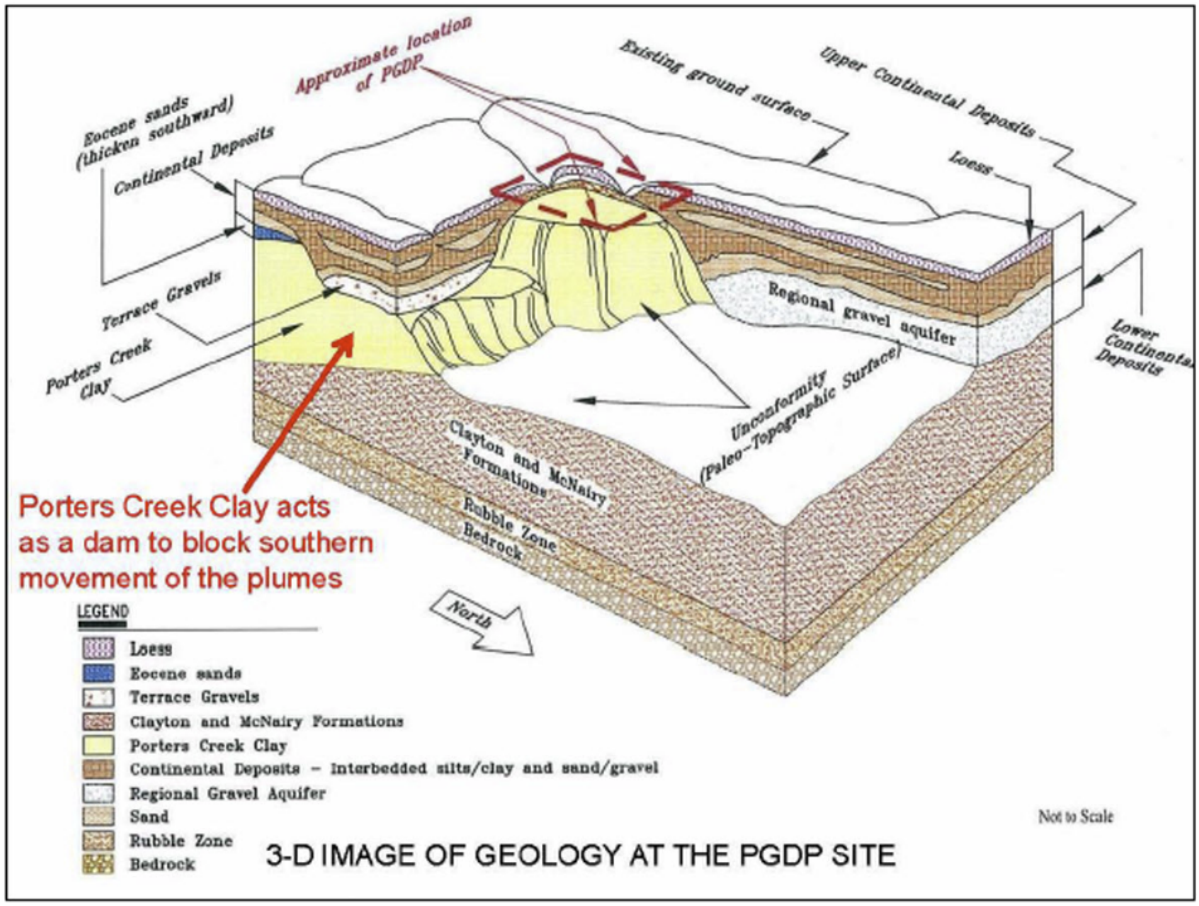


Figure 11-4. Block Diagram of the PGDP Geology.

11.4 USES OF GROUNDWATER IN THE VICINITY

Keeping the local groundwater free from PGDP impacts is a very important and essential objective of DOE and its contractors. A primary concern for the cleanup at the Paducah site is the protection of human health and wildlife in the surrounding area. Lightly populated farmland and homes sparsely located along rural roads are common in the area. Prior to the operation of the PGDP, local groundwater was used for domestic and agricultural consumption. Local groundwater is the drinking water source for the towns of Heath and Grahamville.

Along with the human population, there is an abundant amount of wildlife that lives in this area that utilizes local surface water and groundwater as a water source. Groundwater from the RGA discharges to the surface in local surface water bodies like Metropolis Lake and abundant wetlands within a mile of the Ohio River. Currently, contaminated groundwater discharge is observed along a stretch of Little Bayou Creek near the TVA Steam Plant. Concentrations of TCE and Tc-99 in the Little Bayou Creek seeps have decreased tenfold from 2000 thru 2012.

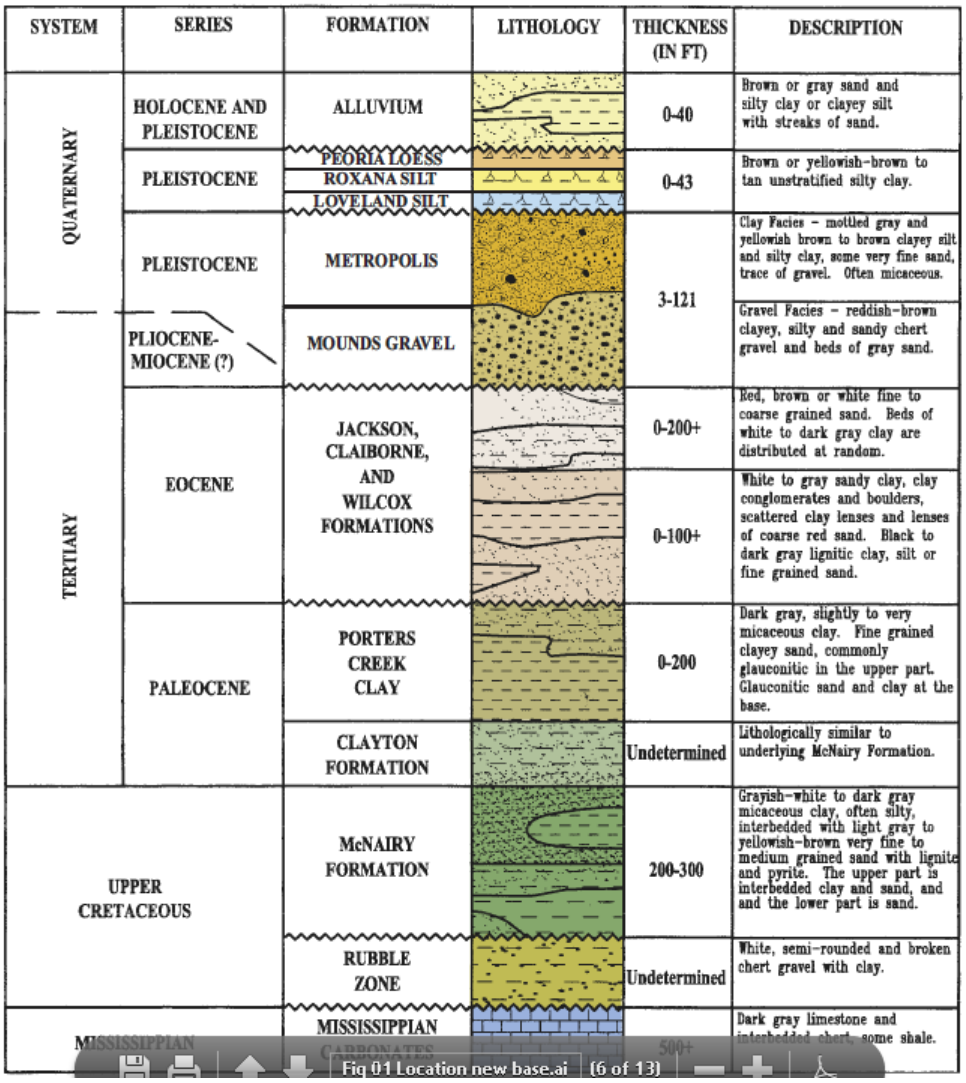


Figure 11-5. PGDP Lithologic Column.

11.5 GROUNDWATER MONITORING PROGRAM

The goal of the groundwater monitoring program is early detection of contamination, monitoring of contaminant trends and the prevention of contamination in the future. Over the course of PGDP operations, DOE and its contractors installed a network of 500+ groundwater monitoring wells in the UCRS and the RGA ***(Figure 11-7)***. There are several dozen additional monitoring wells at the TVA Shawnee Steam Facility near the Ohio River and south of the PGDP industrial site on KOW property. Over the course of PGDP operations DOE has collected and analyzed more 300 drinking water wells in the immediate vicinity of the site ***(Figure 11-8)***.

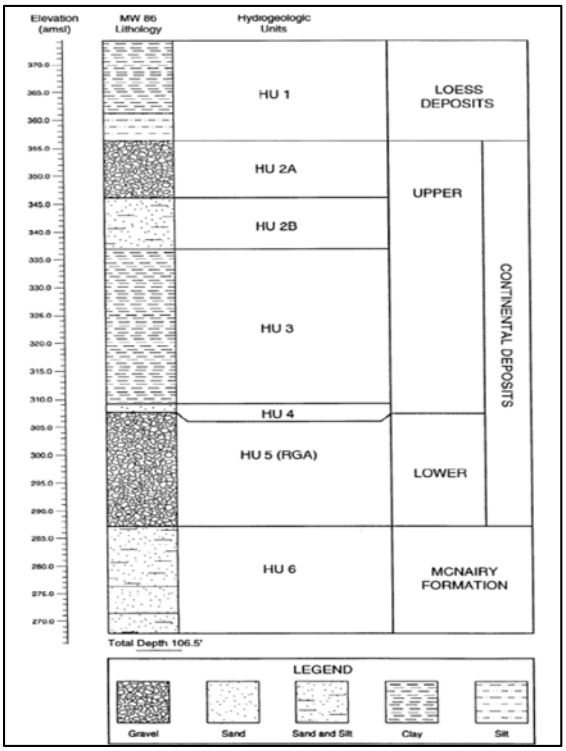


Figure 11-6. Hydrogeologic Framework.

Thirty wells were rehabilitated in 2013. Rehabilitation consists of removing the biofilm and blocking materials within the well and surrounding aquifer so that the data collected at the well remains reliable.

11.6 ENVIRONMENTAL RESTORATION ACTIVITIES

One of the PGDP environmental restoration activities is the mapping of data routinely collected from the groundwater (plume and source area) monitoring system. Data from the monitoring system supports the process of mapping TCE and Tc-99 contaminant plumes. Site wide groundwater plume maps are revised every two years to increase their accuracy and to provide regular information about the plumes.

The northwest plume recovery began in 1995 with four extraction wells and continues today with thirty-three. Since 2010, the contamination zone of the Northwest plume has significantly decreased. The northeast plume recovery began in 1995 as well with two extraction wells and continues today with several more wells. Contamination in the southwest plume is mainly within the PGDP industrial site and

adjacent DOE reservation. Investigations to help identify the appropriate responses to address point sources for the southwest plume began in 2012.

2012 Plume monitoring indicated there were no advances in the extent of groundwater contamination (LATAKY, 2014). The concentrations of TCE and Tc-99 were stable or decreasing onsite and across the extents of the plumes. The plume containment system is working, the NW Plume containment System (Pump and Treat) has been optimized, and the Northeast Plume pump and treat system will be optimized to reduce or eliminate groundwater contamination originating on the PGDP site.

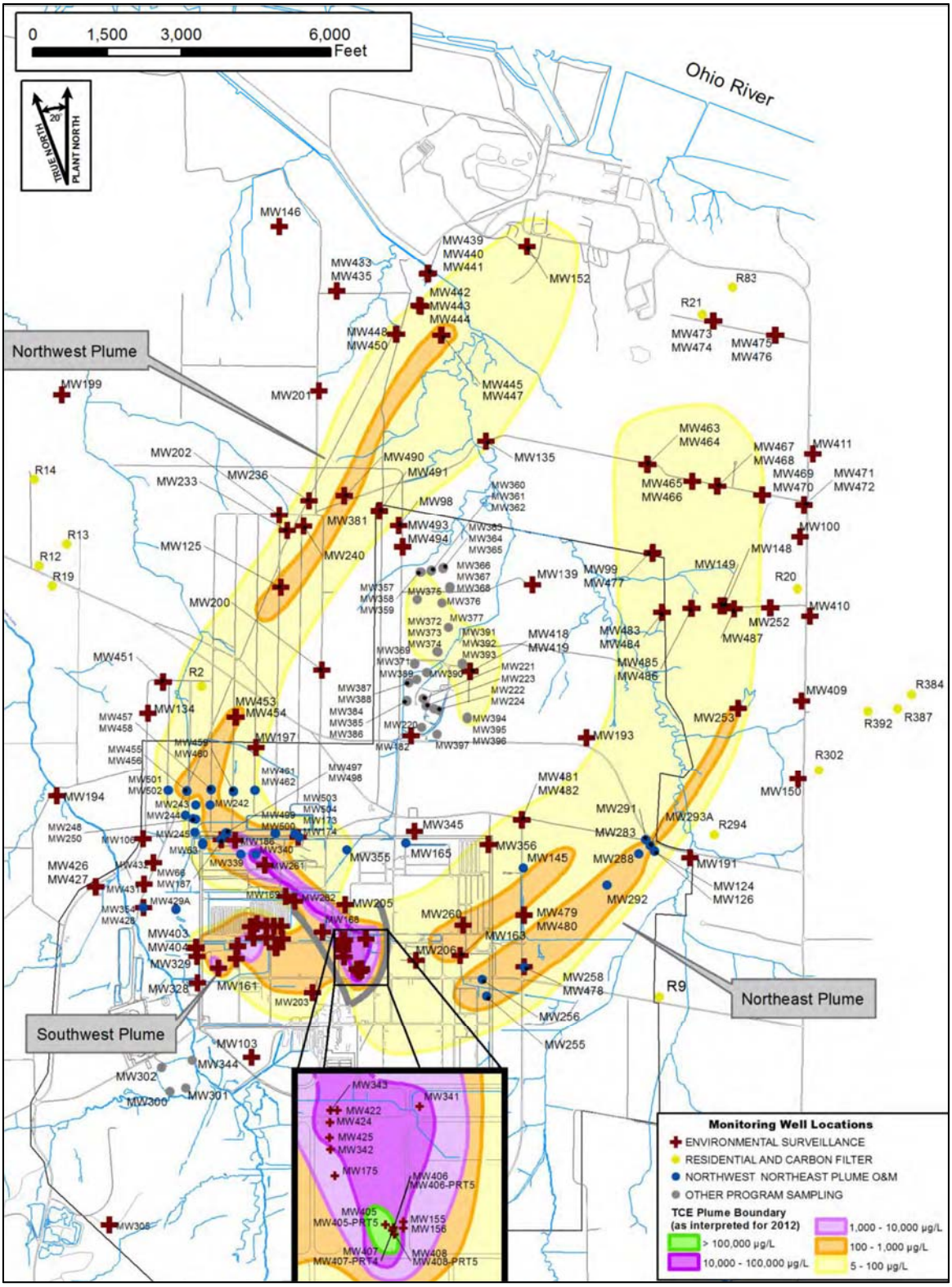


Figure 11-7. PGDP and TVA Groundwater Monitoring Wells.

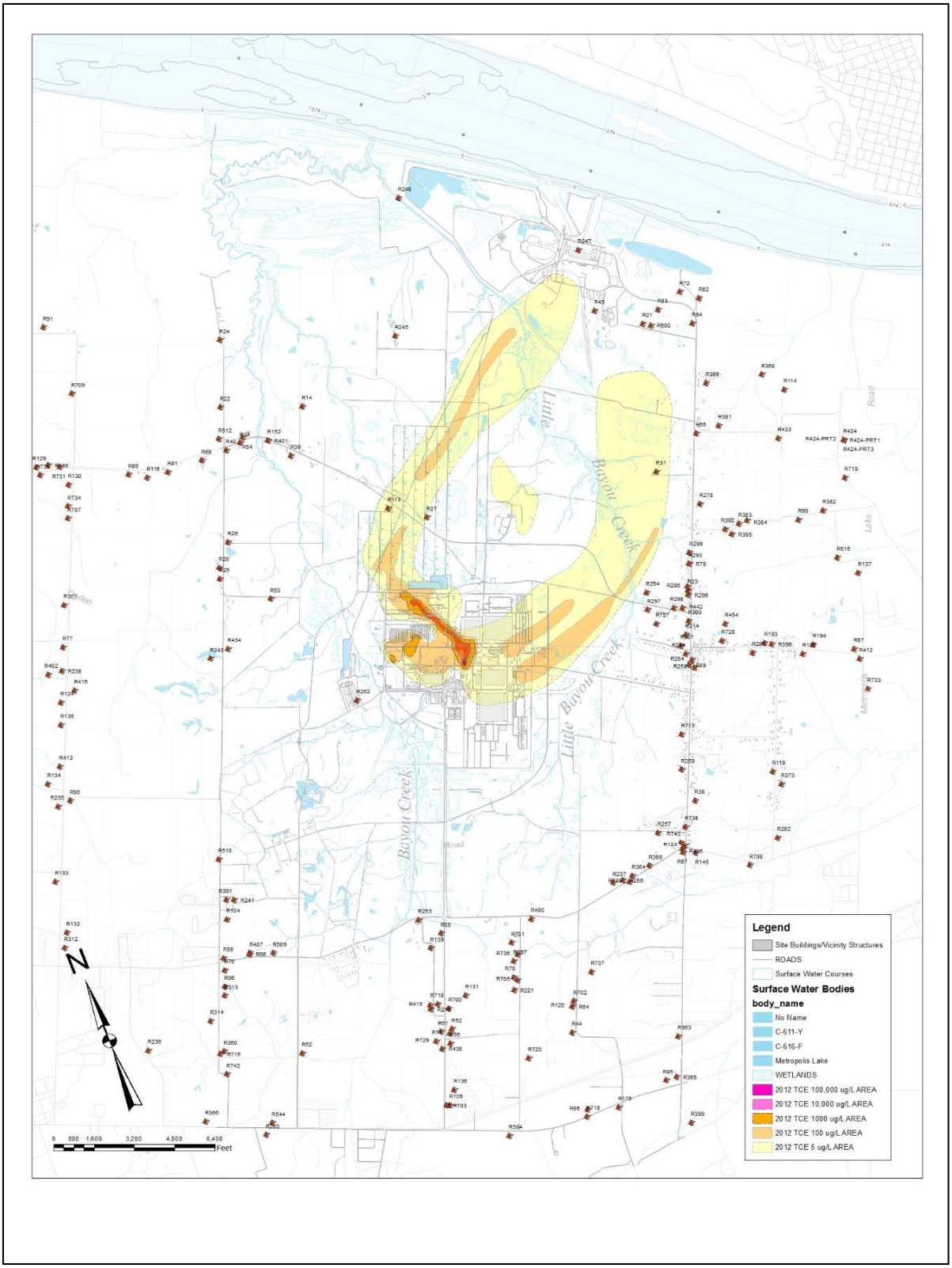


Figure 11-8. PGDP Vicinity Residential and Agricultural Well Monitoring Locations.

During 2012 the following general groundwater characteristics were obtained from groundwater monitoring network data:

- Depths to water at the PGDP site ranged from 39.95 ft. to 63.54 ft. below ground surface (bgs)
- pH ranged from 6.01 to 6.55 Std. Units
- Redox ranged from -144 mV to 866 mV
- Temperature ranged from 55.3 degrees Fahrenheit to 72.5 degrees Fahrenheit

11.7 GROUNDWATER MONITORING RESULTS

Groundwater monitoring at the Paducah site addresses environmental surveillance, landfill release surveillance, plume pump and treat performance, C-400 building groundwater and source treatments, and provides assurance that site contamination does not impact residential well water supplies.

12 QUALITY ASSURANCE

12.1 INTRODUCTION

The DOE and its contractors utilize a Quality Assurance and Quality Control Program (QA/QC) to ensure that data from environmental monitoring activities accurately and repeatedly reflects conditions in the vicinity of the PGDP. Each aspect of the monitoring program must follow the quality requirements and assessment standards. Extra attention is given to the planning, execution, and analyzing activities and putting into effect effective actions to correct what is necessary. In order to support complex-wide DOE mission activities, annual performance qualification audits are made of environmental analytical laboratories and commercial waste treatment, storage, and disposal facilities.

QA/QC standards are set by these following organizations:

1. DOE Order 414.1c
2. PGDP Quality Assurance Program and Implementation Plan (PAD-PLA-QM-001/RT)
3. Commonwealth of Kentucky and Federal regulations
4. Guidelines from EPA
5. American National Standards Institute (ANSI);
6. American Society of Mechanical Engineering (ASME);
7. American Society for Testing and Materials (ASTM);
8. American Society for Quality Control

The Quality Assurance and Quality Control Program cites organizations and programmatic elements in order to control their equipment, design, documents, data, nonconformances, and records. Extra attention is given to the planning, execution, and analyzing of activities. The QA/QC procedures are in effect to prompt necessary actions to correct identified problems. The QA identifies the relationships of each element of the Environmental Monitoring Plan to improve data quality and data management requirements. The QA plan is important to the Environmental Monitoring Plan.

The following procedures further ensure quality of PGDP data:

Field forms are maintained in accordance with PAD-RM-1009;
Communications and documentations between the sample and data management organization and field sampling personnel are conducted in accordance with PAD-ENM-5007, data management coordination
Sample labels and chains of custody are completed according to PAD-ENM-2708, Chain-of-custody forms
Data assessment is conducted by a technical reviewer or their designee according to PAD-ENM-5003, Quality assured data
Logbooks and data forms are prepared in accordance with PAD-ENM-2700, Logbooks and data forms.

12.2 FIELD SAMPLING QUALITY CONTROL

12.2.1 Data Quality Objectives and Sample Planning

When beginning any sample program, data quality objectives (DQO) are used to determine the number of samples needed, location of sampling sites, sampling methods, schedules, and analytical data needs. DQOs all help to meet critical completion times and ensure that appropriate data is collected. When takings samples, collection and location are given I.D. numbers. Location and sample results data are stored in the project environmental measurements systems (PEMS), a huge data base.

12.2.2 Field measurements

Field measurements for the groundwater and surface water include the following

- Level measurements
- pH
- conductivity
- flow rate
- turbidity
- temperature
- dissolved oxygen
- total residual chlorine
- oxidation/reduction potential
- barometric pressure

12.2.3 Sampling Procedures

Samples are:

- collected according to EPA-approved sampling methods
- include surface water, ground water, sediment, and biota
- consists of ID #, location, data, time, initial of person who collected the sample
- put into PEMS

12.2.4 Field Quality Control Samples

Quality control samples include split samples, duplicate samples, and blank samples. They are collected and analyzed to make sure field measurements are accurate, reliable, and reproducible.

Quality Control groundwater and environmental monitoring activities specifies a minimum target rate of 5% or 1% per 20 environmental samples.

12.3 ANALYTICAL LABORATORY QUALITY CONTROL

EPA approved methods are used for sample analysis, when available. Otherwise, ASTM or other methods may be used. Analytical methods are identified in Statement of Work (SOW) for lab services. Part of the SOW outlines how the laboratory documents the steps in sample handling, analysis, reporting results, and how it follows a chain-of-custody procedure.

12.3.1 Lab Audits/ Samples

Lab audits are performed annually in order to verify that laboratories are:

- Following regulations
- Following prescribed methods and procedures

Findings are documented and assessed.

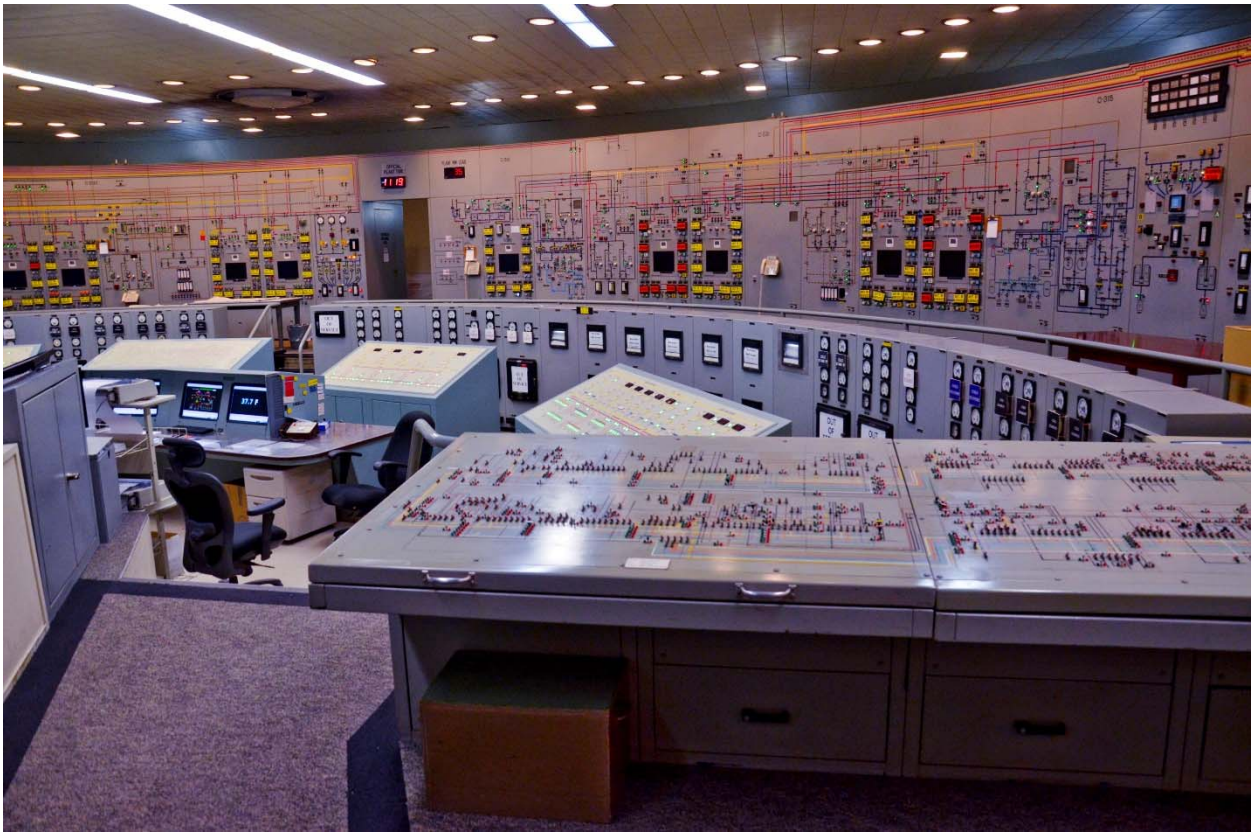


Figure 12-1. The PDGP industrial enrichment processes control room.

12.4 DATA MANAGEMENT

The PGDP uses a site electronic data system for tracking and managing environmental data, the Paducah Environmental Monitoring System (PEMS). PEMS uses a variety of references and codes lists to ensure consistency and standardization of the data.

- Manages field generated data
- Imports lab generated data
- Transfers data to the Paducah OREIS

The Oak Ridge Environmental Information System (OREIS) is a database used to consolidate data generated by the environmental monitoring program. OREIS environmental sampling data can be accessed through the worldwide web by data query or by spatial query using the Paducah Environmental Geographic and Spatial Information System (PEGASIS).

PEGASIS allows access to environmental sampling data. Data assessment is the process for assuring that the type, quality, and quantity of data are appropriate for their intended use based on the DQOs. It allows the determination that a decision can be made with the desired level of confidence, given the quality of the data set. 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.

12.5 DATA, VERIFICATION, VALIDATION, AND ASSESSMENT

Data verification is the process for comparing data against standards or contractual requirements. Verification is: electronic, manual, or both. Includes screening and other data. Stored in PEMS, transferred to OREIS. Validation is the process performed independently by a qualified individual for a data set. Data assessment is the process for assuring that the type, quality, and quantity of data are appropriate for their intended use based on the DQOs. It allows that a decision can be made with the desired level of confidence, given the quality of the data set. Data assessment follows verification and validation. It must preformed at 100% to make sure it's usable. If rejected it is noted in OREIS.

13 ATTACHMENT 1. DOE EM NEWSLETTER HIGHLIGHTS

Following the October 2014 project kickoff, students found and shared the article below when browsing the web for Paducah Gaseous Diffusion Plant environmental information.

EM Update | Vol. 4, Issue 6 | June 2012

Paducah Site Undergoing Steady Groundwater Cleanup with Variety of Methods

PADUCAH, Ky. – A multifaceted approach and focused application of technologies are paying dividends toward cleaning up about 2,100 acres of groundwater extending northeasterly from the Paducah site.

Past disposal practices and releases of the degreaser trichloroethene (TCE) due to spills and leaks have resulted in the formation of three main plumes of contaminated groundwater. The two largest plumes extend in a horseshoe configuration toward the Ohio River.

Since the contamination was discovered in a few residential wells north of the plant in 1988, the Department has provided city water to affected or potentially affected properties. Ninety-one homes and businesses currently receive city water.

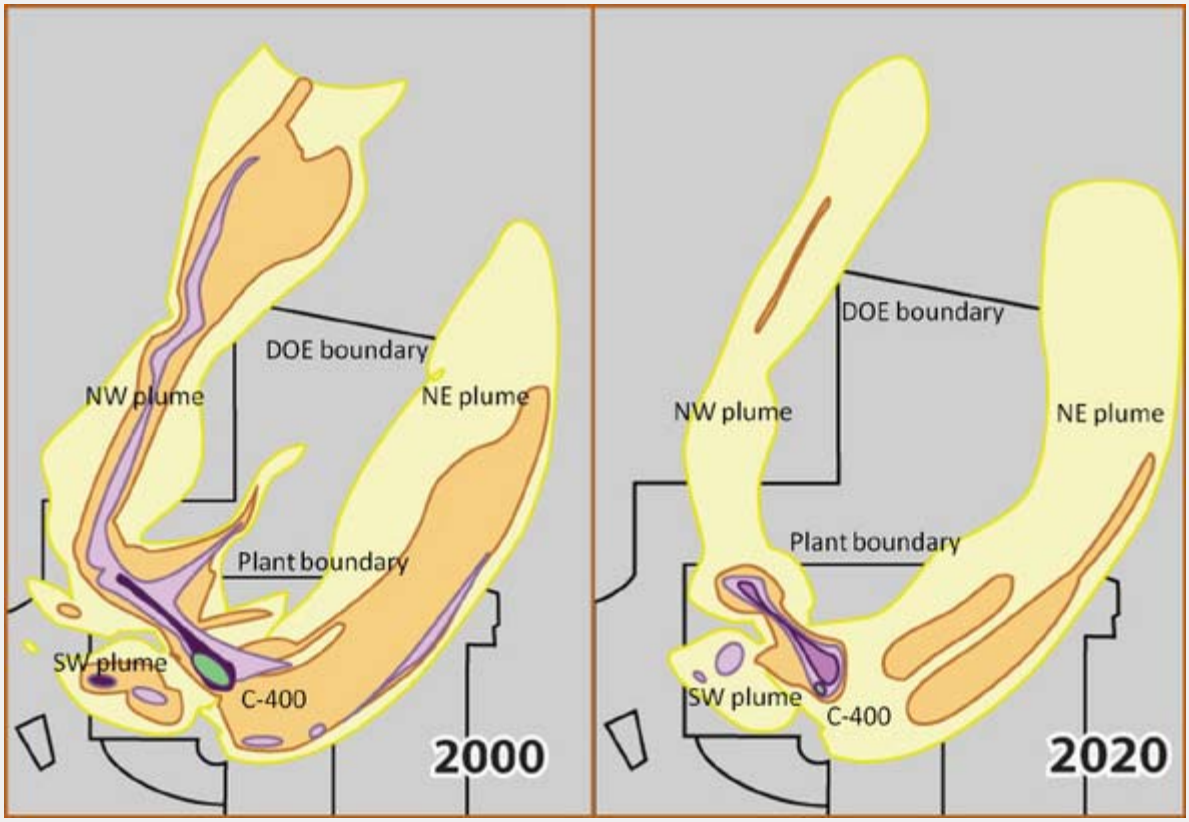
The yellow outline depicts an area southeast of the C-400 Cleaning Building, background, where electrical resistance heating will be used to remove trichloroethene (TCE) down to 60 feet below ground. Electrodes will heat the chemical into a vapor that can be pumped to the surface and treated in the white structure, center.

TCE is one of the nation's most prevalent groundwater contaminants, present in one-third to one-half of all Superfund sites, according to the National Institutes of Health. DOE banned the use of TCE at the Paducah plant in 1993.

Paducah is among the nation's Superfund sites, which the U.S. Environmental Protection Agency prioritizes for cleanup of hazardous waste that could affect local ecosystems or people.

Pump-and-treat systems northwest and northeast of the site have cleansed nearly 3 billion gallons of groundwater since the mid-1990s. Two new wells in 2010 greatly increased the capture rate of TCE in the northwest plume to nearly 100 percent. Later this year, DOE cleanup contractor LATA Environmental Services of Kentucky will start designing a similar pump-and-treat system to optimize TCE removal in the northeast plume, with implementation planned for 2013.

"We believe that optimizing the existing pump-and-treat systems, which capture the chief sources of off-site groundwater contamination, will result in continued dissipation of the plumes through 2020 and beyond," said Reinhard Knerr, DOE Paducah Site Lead.



Computer modeling depicts how improved pumping and treating will lessen the presence of TCE in the aquifer at the Paducah Site through 2020. The tiny green oval near a cleaning building in the middle of the site shows heaviest concentrations of TCE. Next-highest concentrations are shown respectively in dark and light purple, and dark yellow. Light yellow depicts areas where TCE concentrations are above federal drinking water standards.

Past leaks and spills of TCE at an equipment cleaning building in the center of the site are the chief source of groundwater contamination. In 2010, electrical resistance heating (ERH) helped evaporate and remove TCE from as deep as 60 feet below ground in areas southwest and east of the building. By late September, LATA Kentucky will start installing an ERH system to remove TCE from as deep as 60 feet, southeast of the building.

The 2010 project showed that ERH did not reach target temperatures to remove TCE from the deeper aquifer, 60 to 100 feet below ground near the cleaning building. Pending regulatory approval, LATA Kentucky anticipates starting work in 2014 on a chemical-treatment system to remove TCE from the deeper aquifer.

A third area of groundwater contamination, known as the southwest plume, is largely confined to the plant's southwestern fenced area. The primary source is a 2.2-acre oil landfarm, where waste oils containing TCE were biodegraded from 1973 to 1979 using lime and fertilizer.

Starting in July 2013, large-diameter augers will be used with steam to mix the soil and evaporate TCE for treatment using activated carbon. Reactive iron will also be injected into the ground during mixing in areas requiring secondary treatment. Soil mixing will be performed as deep as 50 feet.

Additional testing this summer will determine whether bioremediation or long-term monitoring will be implemented for two other sites of southwest plume contamination. Those sites, northeast and southeast of a large maintenance building, have TCE contamination in the upper 50 feet of soil.

Citizens Advisory Board's Eco Fair Blends Fun and Facts for Schoolchildren near Paducah Site

PADUCAH, Ky. – Nearly 500 sixth-graders from three Paducah area middle schools participated in the third annual Eco Fair this past spring.

The event near the Paducah site, sponsored by the Paducah Citizens Advisory Board (CAB) and DOE, took place near a small lake in West Kentucky Wildlife Management Area just west of the site. The management area includes nearly 2,000 acres of DOE-owned land licensed to the Kentucky Department of Fish & Wildlife Resources (KDFWR).

Lone Oak Middle School student Trevor Tilley was impressed with a demonstration about how the nation's landfills are swelling with waste that takes nearly an eternity to biodegrade.

Lone Oak Middle School sixth-graders pet a mallard hen at the third annual Eco Fair May 15 in West Kentucky Wildlife Management Area.

"It surprised me that Styrofoam didn't take the longest to decompose," Tilley said. "It was glass bottles."

Glass bottles and jars take about 1 million years to break down, according to the Recycle Now! exhibit. Recycle Now! is a recycling facility that is part of the Greater Paducah Sustainability Project, a Paducah nonprofit organization that CAB Chairman Ralph Young supports.

The CAB is an independent group that advises the Department on cleanup issues.

Eco Fair attendees learned at the Recycle Now! demonstration that people throw out enough glass bottles and jars every month to fill a giant skyscraper.

"Our exhibit was a little more hands-on this year," Young said. "They had to use their brains and rank which waste breaks down the fastest."

Ralph Young of Recycle Now! explains to Eco Fair attendees the value of recycling. Young is chairman of the Paducah Citizens Advisory Board, which advises the Department of Energy regarding cleanup issues at the Paducah site.

Other Eco Fair activities were fish and waterfowl monitoring, water filtration, tree sustainability, cooking with solar heat, and radiation in everyday life. Students also heard about the history of the Paducah Gaseous Diffusion Plant and the Department's role in overseeing environmental cleanup.

KDFWR personnel showed students how waterfowl are banded and tracked with transmitters, and how fish are stunned with mild electrical charges so they can be examined to monitor their population.

Other Eco Fair participants included the CAB and DOE cleanup contractor LATA Environmental Services of Kentucky.

DOE Honors WIPP Representative for Cutting Travel Costs, Greenhouse Gas Emissions

WASHINGTON, D.C. – A representative of the Waste Isolation Pilot Plant (WIPP) near Carlsbad, N.M., on Tuesday received the Secretary of Energy's Appreciation Award for her efforts to improve sustainability and reduce travel costs and the number of fleet vehicles.

Judy A. McLemore, who works for URS Regulatory and Environmental Services, based in Carlsbad, was honored for helping advance DOE's management and operational excellence at WIPP. URS Regulatory and Environmental Services is a subcontractor to URS Washington TRU Solutions, WIPP's management and operating contractor.

Secretary Chu presents the Secretary of Energy's Appreciation Award to Judy A. McLemore.

McLemore implemented travel restrictions and challenged WIPP departments to meet a DOE requirement to improve sustainability performance. Under her leadership, greenhouse gas emissions associated with business travel at WIPP dropped by 63 percent compared to the fiscal year 2008 baseline. WIPP departments also delivered a 63 percent reduction in business ground travel in fiscal year 2011. Those costs dropped by $20,000 in fiscal year 2011 and they are projected to decrease by $140,000, a reduction of 50 percent, in fiscal year 2012. McLemore also contributed to WIPP's achievement of a 20 percent reduction in its vehicle fleet over the past two years.

The reductions at WIPP work toward a larger goal being pursued across DOE. In January 2011, Secretary Chu issued a memorandum calling for a 35 percent reduction of the DOE vehicle fleet.

Despite WIPP's remote location — the nearest large airport is more than 150 miles away — each department helped achieve the decrease in travel costs. Workers shared vehicles more often and increased the use of technology options. For example, personnel at the Central Characterization Project (CCP), which saw a 75 percent drop in its business trips, conducted more meetings through

conference calls and video conferencing. CCP personnel also conducted interactive electronic document reviews with regulators instead of meeting in person and reduced rental car usage by standardizing travel arrangements so that only one rental car is necessary per trip. CCP is responsible for characterization and shipment of virtually all the DOE transuranic waste across the DOE complex for safe and expeditious disposal at the WIPP site.

New Resin Increases Efficiencies in Groundwater Treatment along Columbia River at Hanford Site

RICHLAND, Wash. – The Richland Operations Office and contractor CH2M HILL Plateau Remediation Company are using a new treatment material that is expected to increase treatment efficiency and reduce annual operating costs at treatment facilities by $1 million per year at the Hanford site in southeast Washington State.

Along the Columbia River, CH2M HILL manages five groundwater treatment systems that pump and treat contaminated groundwater from the aquifer. The systems use an ion exchange resin that essentially strips specific contaminants from the water before it is pumped back into the ground. The new resin material is being used in all five treatment systems, replacing an older resin.

Dean Neshem, a pump-and-treat operations and maintenance engineer, observes operations at one of the Hanford site's five groundwater treatment facilities. Based on technical recommendations from DOE, CH2M HILL engineers tested and compared multiple resins to determine the products capable of removing contaminants from the groundwater.

The new treatment resin retains more than 15 times as much contaminant than previous resins. This means it does not have to be changed out as often, which reduces worker handling and material costs.

The new resin can be disposed of on the Hanford site, eliminating costs and energy use associated with shipping the old resin several thousand miles for recharging at an off-site facility.

The anticipated cost savings are the result of effective materials selection. Based on technical recommendations from DOE, CH2M HILL engineers tested and compared multiple resins to determine which product was capable of removing contaminants from the groundwater. The primary contaminant of concern, hexavalent chromium, resulted from discharges to the soil made during Hanford's plutonium production days.

A new treatment material is expected to increase groundwater treatment efficiency and reduce annual operating costs at treatment facilities by $1 million per year at the Hanford site.

The resin was originally installed at the 100-DX Groundwater Treatment Facility in 2010, and the facility operated over one year without a single resin change. With approximately 100 resin change-outs avoided and each change-out of the old resin costing approximately $10,000, that is an annual savings of at least $1.2 to 1.6 million.

CH2M HILL changed over all of the remaining treatment systems along the river to the new resin. Together, these facilities are helping DOE contain chromium contamination and prevent it from reaching the Columbia River.

DOE Joins Federal Agencies in Summer Food Drive

WASHINGTON, D.C. – The DOE is working with the Chief Human Capital Officers Council, Office of Personnel Management and other federal agencies to help stock area food banks as part of the fourth annual Feds Feed Families campaign that runs June through August this year.

The DOE Feeds Families drive, which is part of the greater federal effort, hopes to alleviate the severe shortage food banks in the Washington, D.C. region and U.S. face during the summer months. DOE hopes to collect at least 230,000 pounds of food this summer.

Last year, DOE and other participants in the Feds Feed Families campaign donated a record 5,793,446 pounds of nonperishable food items to local area food banks, far outpacing the goal to gather 2 million pounds. The campaign is challenging participants to exceed their campaign collection goals this year.

Employees from EM at DOE headquarters are pitching in to help along with employees at field sites around the DOE complex. Designated collection boxes for non-perishable goods are located throughout federal workplaces. Most-needed items include canned fruits and vegetables, multigrain cereals, grains, soups, 100 percent juice drinks, condiments, snacks, and baking goods.

Additional information on this year's campaign is available here.

Contributors Box

Jillian Carter, Office of EM Principal Deputy Assistant Secretary

Maren Disney, Hanford site

Mark McKenna, Hanford site

Susan Scott, Waste Isolation Pilot Plant

David Sheeley, EM Office of External Affairs

Joe Walker, Paducah site

Visit Us on the Web: www.em.doe.gov

U.S. DEPARTMENT OF ENERGY | Office of Environmental Management

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14 ATTACHMENT 2. ENVIRONMENTAL RESTORATION PROJECT GOALS

DOE Goal	Site Performance Status	Site Planned Actions
28% Scope 1 and 2 GHG reductions by fiscal year (FY) 2020 from a FY 2008 baseline (related goals).	6.6% below FY 2008 baseline, strong progress toward "28% below baseline."	The Site is below the FY 2008 baseline for this goal for the first time since inception, continued vigilance with electrical consumption and fleet fuel consumption will be required to maintain and meet performance status.
13% Scope 3 GHG reduction by FY 2020 from the FY 2008 baseline.	91.4% reduction from FY 2008, exceeding 13% required reduction.	Personnel reduction, along with a suspected high estimate for FY 2008's baseline currently has the site meeting this goal.
30% energy intensity reduction by FY 2015 from the FY 2003 baseline.	147% up from the 2003 baseline, but 26% down from FY 2011.	High energy consumption remediation projects and start-up of the DUF_6 project have greatly increased power needs for the EM Projects at Paducah. Small energy saving initiatives have been implemented with success. In light of this, Paducah continues to implement small operational type energy initiatives as life cycle analysis allows. An example of this is the new high efficiency HVAC unit on the C-103 Building.
Energy Independence and Security Act (EISA) Section 432 energy and water evaluations.	100%	The Remediation and Infrastructure contractors performed 100% of the required EISA evaluations.
Individual buildings or processes metering for 90% of electricity (by October 1, 2012); for 90% of steam, natural gas, and chilled water (by October 1, 2015).	81% of electricity. 100% of natural gas (met). 0% of water [not applicable (N/A)]. Steam and chilled water (N/A).	The FY 2011 Metering Assessment details the metered consumption and steps required to achieve this goal. Natural gas already is metered, and steam is not being used by DOE contractors. Adding meters to two of the DUF_6 facilities would allow the Site to meet this goal for electrical consumption.
Cool roofs (when economical) for roof replacements unless project already has Critical Decision-2 approval. New roofs must have thermal resistance of at least R-30.	Work in progress.	Trailers are an uneconomical place for cool roofs; however, a cool roof upgrade is being assessed for C-103 as the life cycle will require a replacement. The remaining facilities are being evaluated, but may not have the surface square footage or effective lifespan to achieve a return on investment.
15% of existing buildings larger than 5,000 gross ft^2 to be compliant with the five guiding principles (GPs) of high performance and sustainable buildings (HPSB) by FY 2015.	Initiated as life cycle allows.	As maintenance is performed at the C-103 building, the HPSB standards are given consideration.
All new construction and major renovations greater than $5 million to be Leadership in Energy and Environmental Design® Gold certified. Meet high performance and HPSB GPs if less than or equal to $5 million.	The Site currently has no projects planned that fit the requirements.	No new construction is planned for the Paducah Site; however, any upgrades to existing facilities are made with the HPSB principles in mind.
7.5% of a site's annual electricity consumption from renewable sources by FY 2010 (2x credit if the energy is produced on-site).	185% of the goal currently exceeding the requirement.	PPPO purchases and will continue to purchase Renewable Energy Certificates for Paducah and Portsmouth.

DOE Goal	Site Performance Status	Site Planned Actions
10% annual increase in fleet alternative fuel consumption by FY 2015 relative to the FY 2005 baseline.	13% decrease from FY 2010 due to fleet reduction. Goal not met.	In FY 2005 there was no E85 present at the Site, making the baseline 0. In 2012 the site was 13% down from FY 2010. The recent fleet reduction and fuel saving practices hurt this goal.
2% annual reduction in fleet petroleum consumption by FY 2015 relative to the FY 2005 baseline.	4,855% over FY 2005 baseline. 23% reduction from FY 2011.	The recent fleet reduction plan and fuel saving practices have had a continued significant impact on the petroleum consumption. Historical data provided in the Consolidated Energy Data Report shows the Paducah Site having very low petroleum consumption in FY 2005. The increased fuel consumption reflects a ramp up in manpower and vehicle usage to support the remediation mission in years subsequent to 2005.
100% of light-duty vehicle purchases must consist of alternative fuel vehicles (AFVs) by FY 2015 and thereafter. (The goal for FY 2000–2015 has been 75%.)	AFVs currently make up 36%. Hybrid electric vehicles make up 25%.	The site has requested that General Services Administration send more AFVs/hybrids as other vehicles leave the site.
Reduce fleet inventory by 35% within the next three years relative to a FY 2005 baseline.	Goal has been met.	The reduction in vehicle usage and total fleet numbers was completed in FY 2011.
26% water intensity reduction by FY 2020 from a FY 2007 baseline.	Goal met.	To meet the standard, the contractors have installed low-flow systems and ceased all landscape watering.
20% water consumption reduction of industrial, landscaping, and agricultural (ILA) by FY 2020 from the FY 2010 baseline.	N/A	FY 2010 baseline is 0. The site still is not consuming water for ILA purposes; thus, there is no reduction to record.
Divert at least 50% of nonhazardous solid waste, excluding construction and demolition debris, by FY 2015.	Currently diverting 33%.	Estimates show the Site at 33% diversion rate, the site intends to use best practices and innovation to continue to decrease municipal landfill waste.
Divert at least 50% of construction and demolition materials and debris by FY 2015.	Currently diverting 8.5%.	Non contaminated waste is recycled and reused when applicable. The site historically recycles a large amount of D&D waste when it is not contaminated.
Procurements meet sustainability requirements and include sustainable acquisition clause (95% each year).	Goal met.	Environmentally Preferred Purchasing Program allows the subcontractors to monitor all purchase orders and make additions to the list for new products.
All data centers are metered to measure monthly power usage effectiveness (PUE) (100% by FY 2015).	N/A	The Paducah Site does not have any data centers.
Maximum annual weighted average PUE of 1.4 by FY 2015.	N/A	The Paducah Site does not have any data centers in which to monitor PUE.
Electronic Stewardship—100% of eligible personal computers, laptops, and monitors with power management actively implemented and in use by FY 2012.	Goal met.	Power management is actively implemented on all computers.

15 ATTACHMENT 3. 1990 TO 2012 SIGNIFICANT RESPONSE ACTION SUMMARY TIMELINE

1993

- Imposed land use controls (LUCs) (fencing and posting) to restrict public access to contaminated areas in certain outfall ditches and surface water areas (1993).

1995

- Extended municipal water lines as a source of drinking water to affected residents to eliminate exposure to contaminated groundwater (1995).
- Constructed and implemented groundwater treatment system for the Northwest Plume to reduce contaminant migration (1995).
- Rerouted surface runoff away from highly contaminated portions of the North-South Diversion Ditch (NSDD) to reduce potential migration of surface contamination (1995).

1997

- Constructed and implemented groundwater treatment system for the Northeast Plume to reduce contaminant migration (1997).

1998

- Excavated soil with high concentrations of PCBs in on-site areas to reduce off-site migration and potential direct-contact risks to plant workers (1998).

2000

- Removed and disposed of "Drum Mountain," a contaminated scrap pile potentially contributing to surface water contamination so that a potential direct-contact risk to plant workers would be eliminated and an off-site migration risk would be reduced (2000).

2002

- Applied *in situ* treatment of TCE-contaminated soil at the cylinder drop test site using innovative technology (i.e., the Lasagna™ technology) to eliminate a potential source of groundwater contamination (2002).
- Removed petroleum-contaminated soil from SWMU 193, the former McGraw Construction Yards, now the Southside Cylinder Yards, to eliminate a potential source of groundwater contamination (2002).
- Completed installation of a sediment control basin at Outfall 001 to control the potential migration of contaminated sediment (2002).

2003

- Completed a treatability study that demonstrated the effectiveness of the six-phase heating technology for *in situ* treatment of dense nonaqueous-phase liquid (DNAPL) at C-400 (2003).

2004

- Completed installation of a retention basin and excavation of the on-site portions of the NSDD, which removed a source of direct-contact risk to plant workers and a potential source of surface water contamination (2004).

2005

- Investigated potential source areas contributing to the Southwest Plume, remedial actions were evaluated (2005).
- Completed D&D of the C-603 Nitrogen Facility to the slab (2005).

2006

- Performed a site investigation (SI) near the C-746-S&T Landfills and determined that TCE groundwater contamination is from SWMU 145, the Residential/Inert Landfill and Borrow Area (2006).
- Disposed of approximately 30,500 tons of scrap metal, which eliminated a potential direct-contact risk to plant workers and a source of surface water contamination (2006).
- Completed D&D of the C-402 Lime House to the slab (2006).
- Initiated remedial design/action for volatile organic contamination in soil and groundwater at the C-400 Cleaning Building (2006).

2007

- Completed D&D of the C-405 Incinerator to the slab (2007).
- Completed remedial action field investigation for the Burial Grounds Operable Unit (BGOU) (2007).

2008

- Completed D&D of the C-746-A West End Smelter to the slab (2008).
- Completed D&D of the C-342 Ammonia Disassociation Facility to the slab (2008).

2009

- Recycled tanks from C-342 for the Leachate Collection System at C-746-U Landfill (2009).
- Demolished two 66-year-old KOW concrete water towers built for a World War II-era munitions plant. Concrete was recycled as aggregate, and most was returned to the site for use as backfill. (2009).

2010

- Signed an action memorandum (AM), completed the removal action work plan, and completed fieldwork for the removal for the Soils Inactive Facilities (C-218 Firing Range and the C-410-B Holding Pond) (2010).
- Completed installation and initiated operations of the Northwest Plume optimization wells for enhanced groundwater capture (2010).
- Completed D&D of the C-746-A East End Smelter to the slab (2010).
- Completed the Soils OU remedial investigation fieldwork (2010).
- Sampled Soils OU SWMUs (2010).
- Completed C-400 Electrical Resistance Heating (ERH) Phase I for treatment of soil and groundwater contaminated with volatile organic compounds (VOCs) removing 550 gal of TCE (2010).

2011

- Completed D&D of the C-411 and east expansion of the C-410 Building to the slab (2011).
- Completed systems removal and declared C-340 Building demolition ready (2011).
- Completed Surface Water OU Removal Action by obtaining regulatory approvals for the Removal Action Report (2011).
- Obtained regulatory approvals for the Soils Inactive Facilities Removal Action Report (2,700 yd3 of contaminated soil removed from C-410-B Neutralization Pit and C-218 Firing Range) (2011).
- Completed the Soils OU RI for 86 SWMUs totaling ~ 200 acres; analyzed over 3,000 samples for various parameters (2011).
- Completed SWMU 13 Site Evaluation (SE) of a 294,000-ft2 area formerly used for storage of clean scrap metal. The SE Report was submitted to EPA and Kentucky. Elements of the SE Report will be incorporated into a subsequent Soils OU RI. (2011).
- Shipped all transuranic waste off-site, completing the last inventory of waste stored on-site under the STP (2011).

2012

- Dismantled and removed C-720-N Scale House and five C-615 trailers (2012).
- Completed removal of UF6 piping from the C-410 Building (2012) (see Figure 3.1).
- Completed SWMU 4 Phase 1 sampling (2012).
- Finished Southwest Plume Remedial Design Support Investigation fieldwork (2012).

16 ATTACHMENT 4. MCHS 2014-15 CLASS ACTIVITIES

Figure 16-1. (Top) Steve Hampson introduces ASER to MCHS Class (October 2014). (Bottom) Don Dihel introduces site health and safety at the PGDP DOE Site Office.

Figure 16-2. Lunch and Habitat Discussion with Dr. Steven Price at WKWMA

Figure 16-3. Hands-on Wetland Habitat Field Research at WKWMA (May 20115).

Figure 16-4. Tim Kreher, KY Fish and Wildlife discusses Grassland Habitats at the WKWMA (May 2015).

Figure 16-5. Dr. Price demonstrates the use of a water quality measurement instrument at the iron bridge on Bayou Creek.

Figure 16-6. A visit to the Tupelo Swamp (May 2015).

Figure 16-7. Dr. Halbrook presents PGDP and WKWMA historical ecological monitoring and more recent studies elsewhere (photo from 2013-2014 class presentation, February 2014).

Figure 16-8. Students handle amphibians and reptiles during wildlife presentation at WKWMA.

Figure 16-9. Student & matching reptile during wildlife presentation at WKWMA.

Figure 16-10. Student ASER writing workshops at MCHS (December 2014).

17 ATTACHMENT 5.

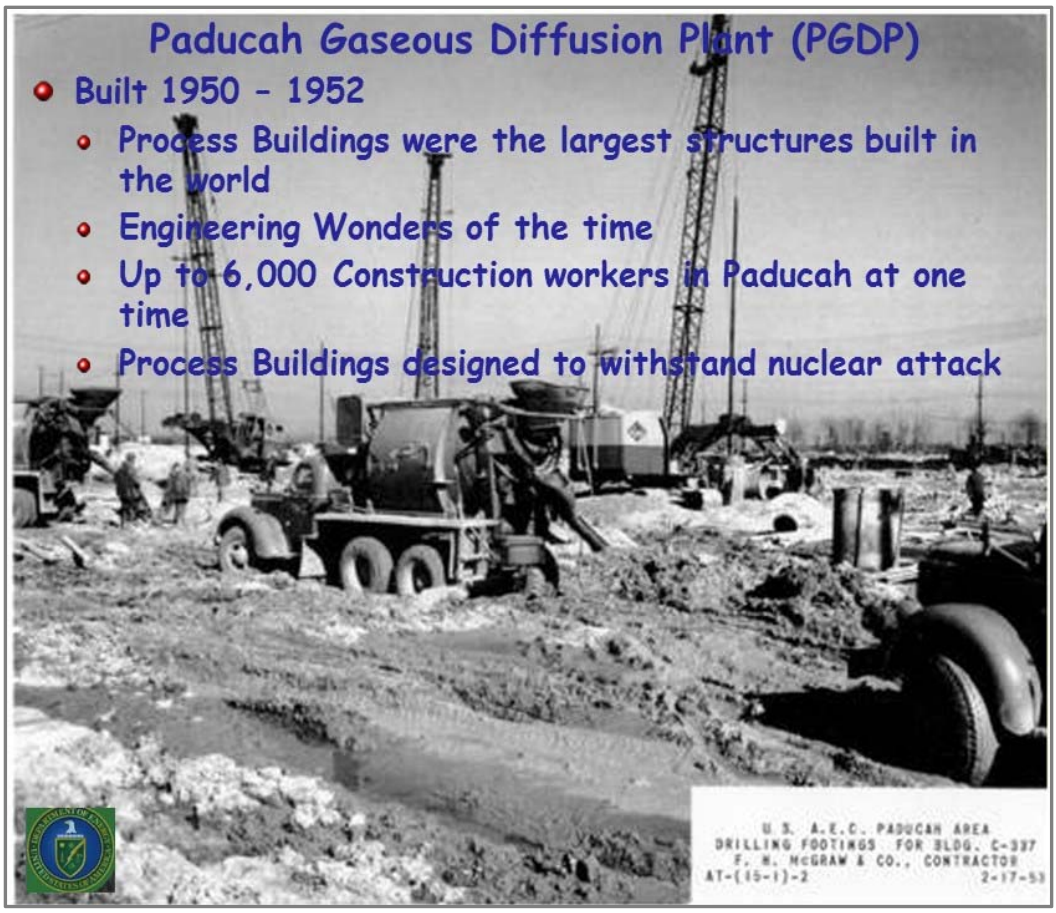
MCHS 2014-15 PROJECT KICKOFF PRESENTATION

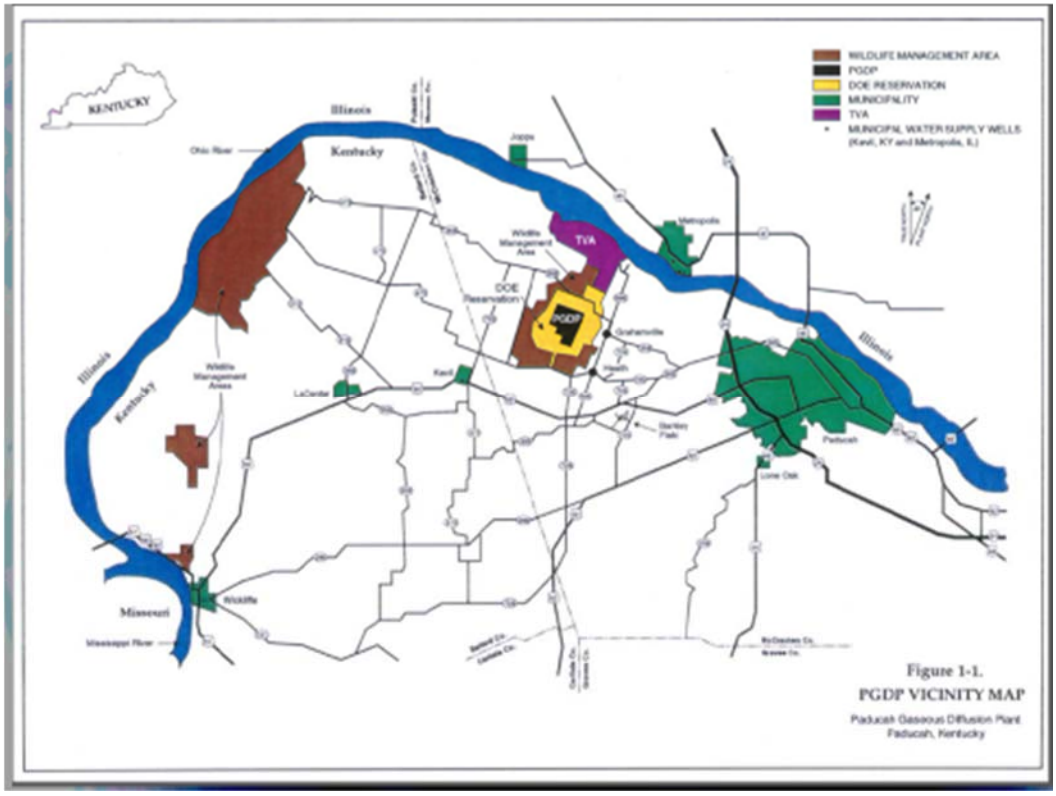

the PADUCAH GASEOUS DIFFUSION PLANT
AP Environmental Science ASER PROJCET
Marshall County High School
October 2nd, 2014
UK
UNIVERSITY OF KENTUCKY
CAER KRCEE

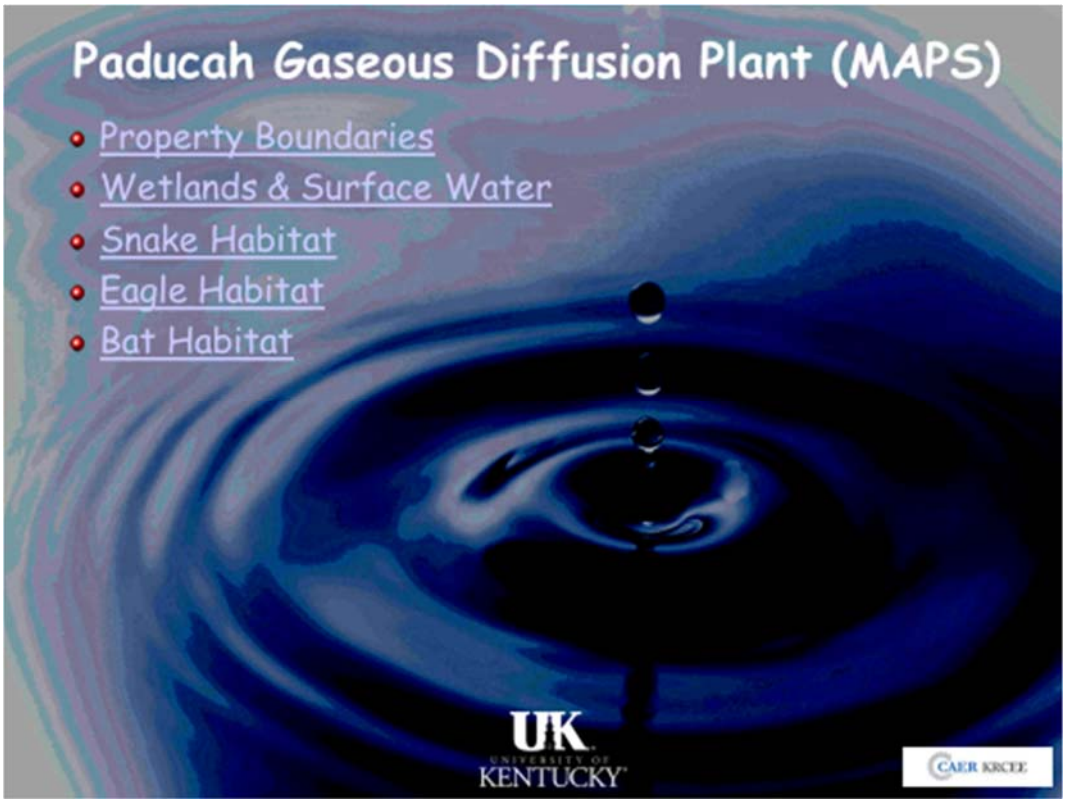

An Introduction to
the PADUCAH GASEOUS DIFFUSION PLANT
Outline
Brief History
Plant Purpose
Plant Significance
Location & Surroundings
Uranium Enrichment primer
The Facility
PGDP & the Environment
Trichloroethylene (TCE); Technetium-99; Uranium +d, Site Environmental Management
Environmental Impact = Regulatory Compliance
ASER
Next
What's to be done?
UK
UNIVERSITY OF KENTUCKY


Paducah Gaseous Diffusion Plant (PGDP)
URANIUM ENRICHMENT FACILITY
Owned by United States Government
Department of Energy (DOE)
United States Enrichment Corp. (USEC) operated facility for DOE
Was last operating government enrichment facility
Began Shutdown of Enrichment Operations April, 2013
Enriched uranium for military, weapons, and nuclear energy industry
A COLD WAR Military-Industrial Facility
Nuclear high tech originating in Manhattan Project
High Security (No Fly Zone after 9/11)
Largest industrial complex in W. Kentucky
Largest employer in W. Kentucky (past)
Largest stockpile of mined uranium in world
Very skilled workforce
UK
UNIVERSITY OF KENTUCKY
CAER KRCEE


WELCOME
to the
ATOMIC CITY
1950's Paducah-PGDP Post Card
CAER KRCEE


Paducah Gaseous Diffusion Plant (PGDP)
Built 1950 – 1952
Process Buildings were the largest structures built in the world
Engineering Wonders of the time
Up to 6,000 Construction workers in Paducah at one time
Process Buildings designed to withstand nuclear attack
U. S. A.E.C. PADUCAH AREA
DRILLING FOOTINGS FOR BLDG. C-337
F. H. McGRAW & CO., CONTRACTOR
AT-(15-1)-2
2-17-53


WILDLIFE MANAGEMENT AREA
PGDP
DOE RESERVATION
MUNICIPALITY
TVA
KENTUCKY
Illinois
Kentucky
Missouri
TVA
PGDP
Figure 1-1.
PGDP VICINITY MAP
Paducah Gaseous Diffusion Plant
Paducah, Kentucky


Paducah Gaseous Diffusion Plant (MAPS)
Property Boundaries
Wetlands & Surface Water
Snake Habitat
Eagle Habitat
Bat Habitat
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Paducah Gaseous Diffusion Plant (PGDP)
Heavy Industrial Plant Complex (1 square mile)
Process Buildings (where uranium enrichment process occurs)
Preparation & Maintenance Buildings
Cleaning Facilities
Water Treatment (11 -22 million gallons per day)
Process Cooling Water, Fire Water, Storm Water, & Sanitary Water Systems
Sewage & Wastewater Treatment Systems
Landfills
Burial Grounds
Electrical Power Facilities (electric use/day = St. Louis)
TVA Shawnee Steam Plant built to supply PGDP electricity
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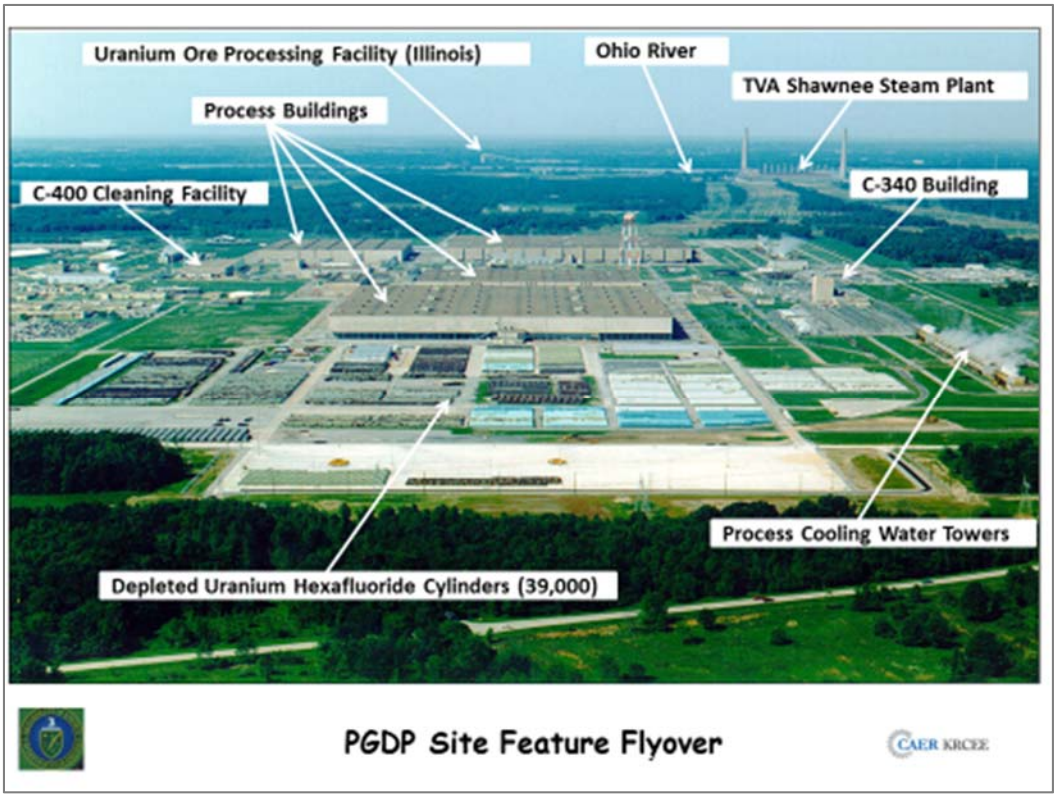
Uranium Ore Processing Facility (Illinois)
Ohio River
TVA Shawnee Steam Plant
Process Buildings
C-400 Cleaning Facility
C-340 Building
Process Cooling Water Towers
Depleted Uranium Hexafluoride Cylinders (39,000)
PGDP Site Feature Flyover
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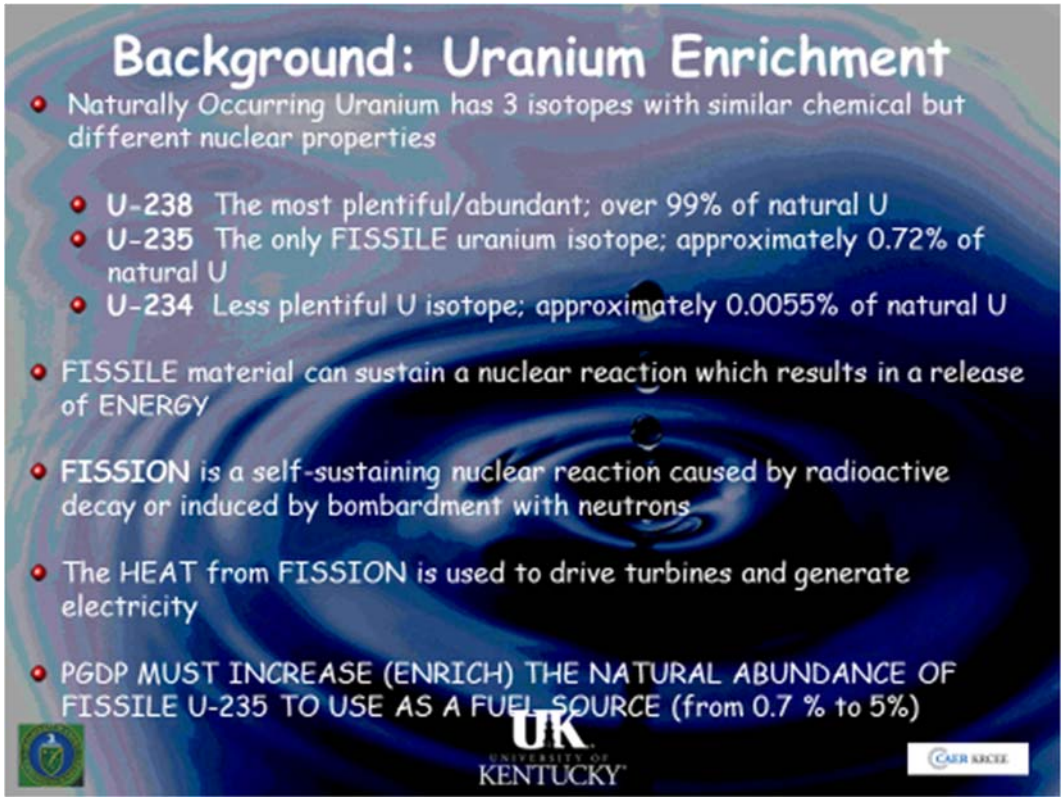
Background: Uranium Enrichment
Naturally Occurring Uranium has 3 isotopes with similar chemical but different nuclear properties
U-238 The most plentiful/abundant; over 99% of natural U
U-235 The only FISSILE uranium isotope; approximately 0.72% of natural U
U-234 Less plentiful U isotope; approximately 0.0055% of natural U
FISSILE material can sustain a nuclear reaction which results in a release of ENERGY
FISSION is a self-sustaining nuclear reaction caused by radioactive decay or induced by bombardment with neutrons
The HEAT from FISSION is used to drive turbines and generate electricity
PGDP MUST INCREASE (ENRICH) THE NATURAL ABUNDANCE OF FISSILE U-235 TO USE AS A FUEL SOURCE (from 0.7 % to 5%)
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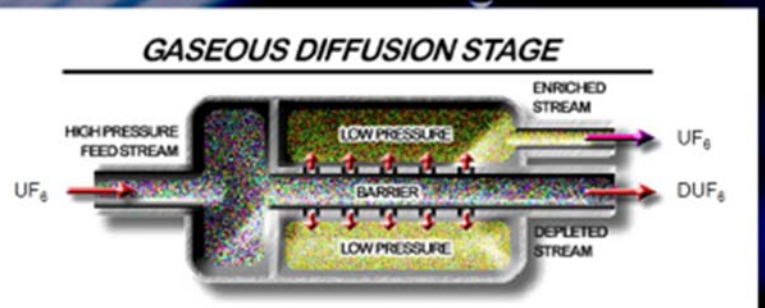
Background: Uranium Enrichment

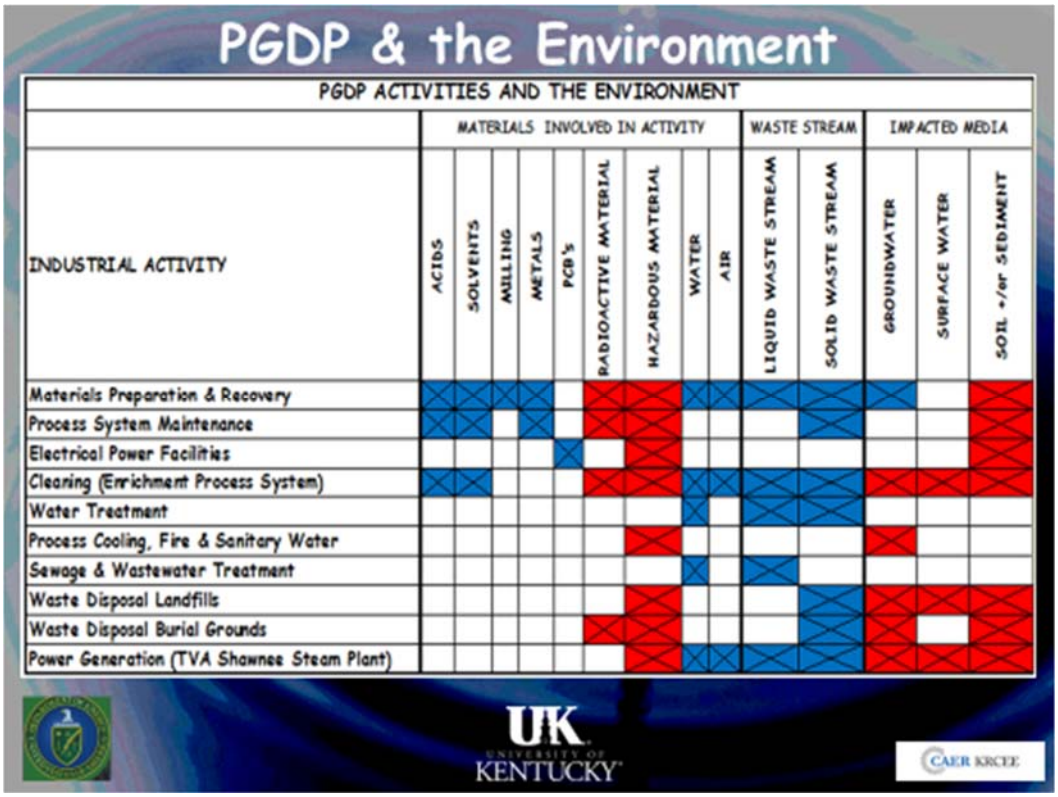
- The GASEOUS DIFFUSION PROCESS was used at PGDP to increase the abundance of U-235
- URANIUM is blended with FLUORINE GAS at high temperature and pressure to produce URANIUM HEXAFLUORIDE GAS (UF_6)
- U-235 separated from U-238 by molecular DIFFUSION thru membrane (a STAGE)
- A volume of UF_6 gas is passed thru 1,760 STAGES to complete enrichment



This process of uranium enrichment increases the concentration of U-235 from 0.7% up to 5.0%

Background: Uranium Enrichment

The 8th Stage Compressor (of 1,760) from PGDP's diffusion process


PGDP & the Environment
PGDP ACTIVITIES AND THE ENVIRONMENT
MATERIALS INVOLVED IN ACTIVITY
WASTE STREAM
IMPACTED MEDIA
INDUSTRIAL ACTIVITY
ACIDS
SOLVENTS
MILLING
METALS
PCB's
RADIOACTIVE MATERIAL
HAZARDOUS MATERIAL
WATER
AIR
LIQUID WASTE STREAM
SOLID WASTE STREAM
GROUNDWATER
SURFACE WATER
SOIL +/or SEDIMENT
Materials Preparation & Recovery
Process System Maintenance
Electrical Power Facilities
Cleaning (Enrichment Process System)
Water Treatment
Process Cooling, Fire & Sanitary Water
Sewage & Wastewater Treatment
Waste Disposal Landfills
Waste Disposal Burial Grounds
Power Generation (TVA Shawnee Steam Plant)
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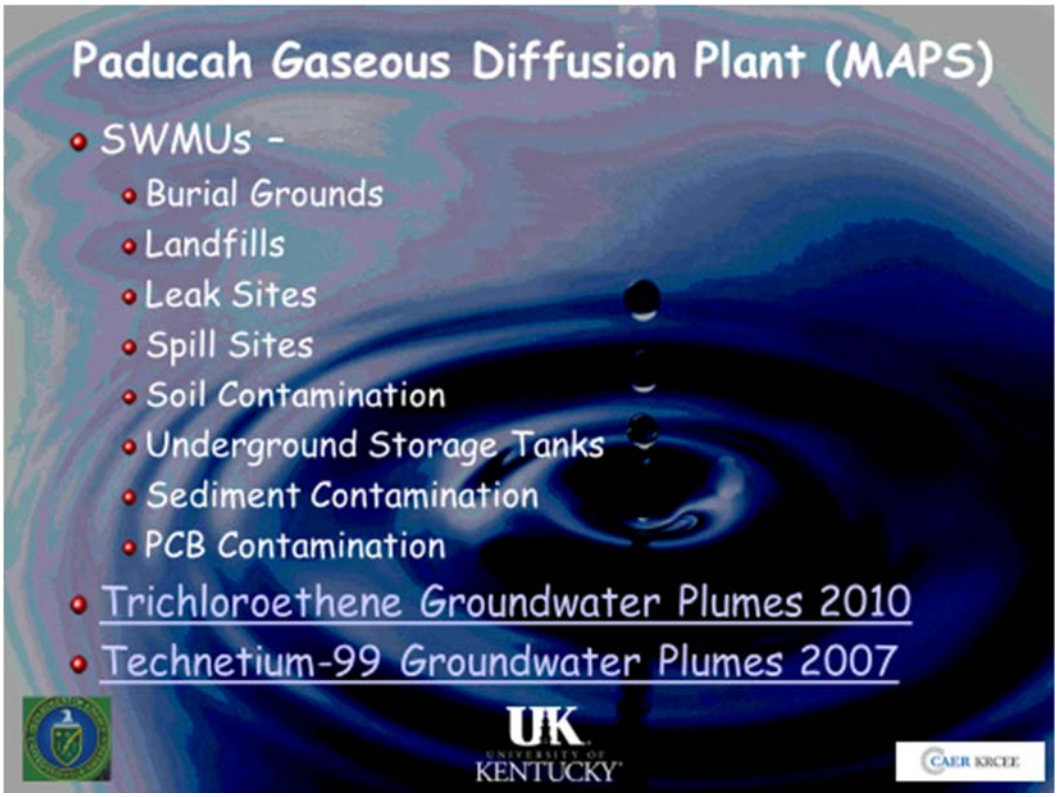
Paducah Gaseous Diffusion Plant (MAPS)
SWMUs –
Burial Grounds
Landfills
Leak Sites
Spill Sites
Soil Contamination
Underground Storage Tanks
Sediment Contamination
PCB Contamination
Trichloroethene Groundwater Plumes 2010
Technetium-99 Groundwater Plumes 2007
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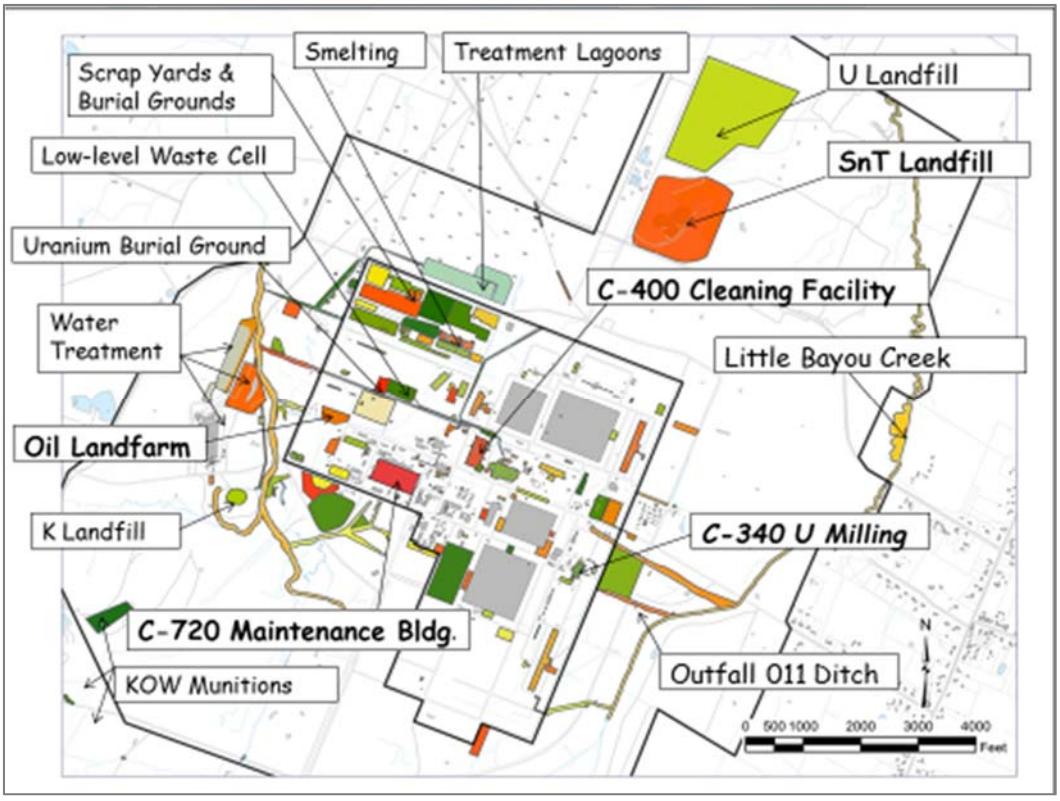
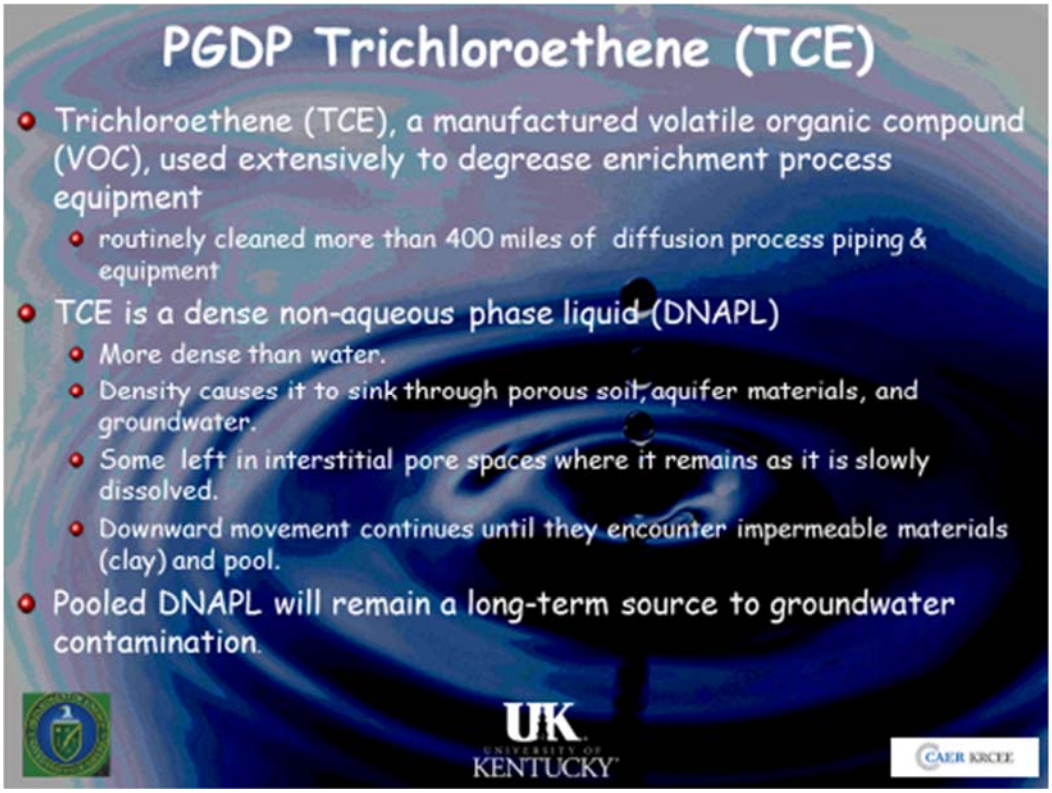

Smelting
Treatment Lagoons
Scrap Yards & Burial Grounds
U Landfill
Low-level Waste Cell
SnT Landfill
Uranium Burial Ground
C-400 Cleaning Facility
Water Treatment
Little Bayou Creek
Oil Landfarm
K Landfill
C-340 U Milling
C-720 Maintenance Bldg.
KOW Munitions
Outfall 011 Ditch
N
0 500 1000 2000 3000 4000
Feet


PGDP Trichloroethene (TCE)
Trichloroethene (TCE), a manufactured volatile organic compound (VOC), used extensively to degrease enrichment process equipment
routinely cleaned more than 400 miles of diffusion process piping & equipment
TCE is a dense non-aqueous phase liquid (DNAPL)
More dense than water.
Density causes it to sink through porous soil, aquifer materials, and groundwater.
Some left in interstitial pore spaces where it remains as it is slowly dissolved.
Downward movement continues until they encounter impermeable materials (clay) and pool.
Pooled DNAPL will remain a long-term source to groundwater contamination.
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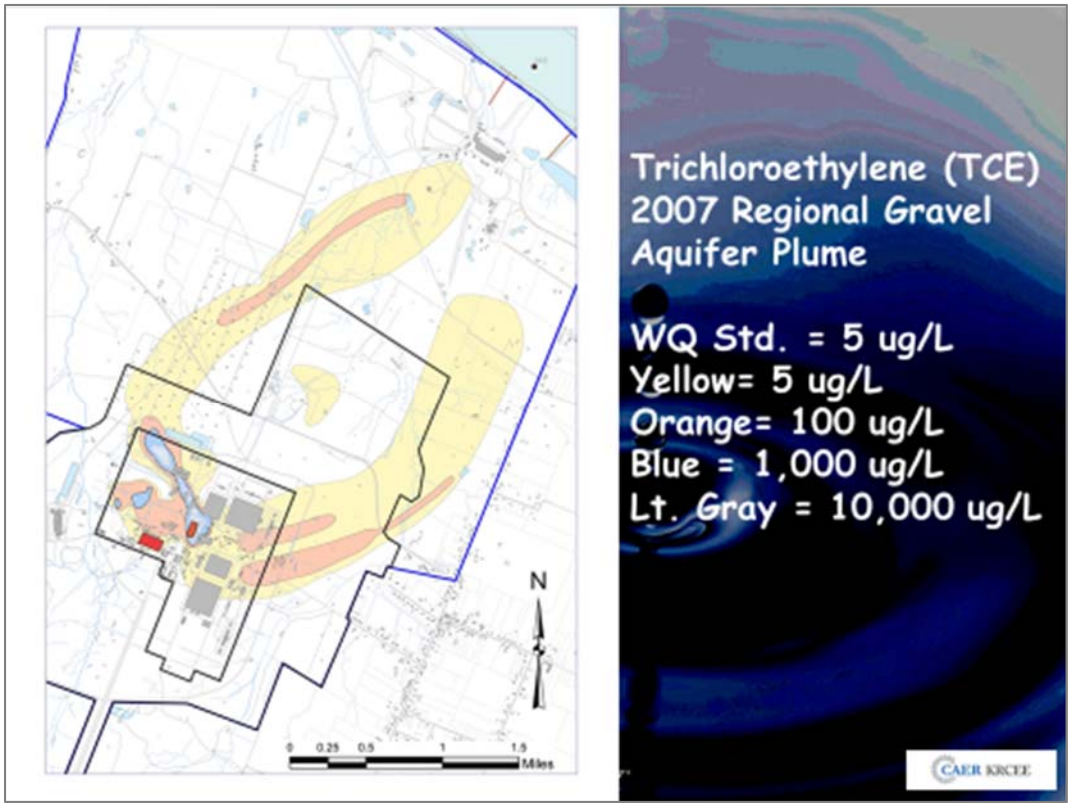
N
0 0.25 0.5 1 1.5
Miles
Trichloroethylene (TCE)
2007 Regional Gravel
Aquifer Plume
WQ Std. = 5 ug/L
Yellow= 5 ug/L
Orange= 100 ug/L
Blue = 1,000 ug/L
Lt. Gray = 10,000 ug/L
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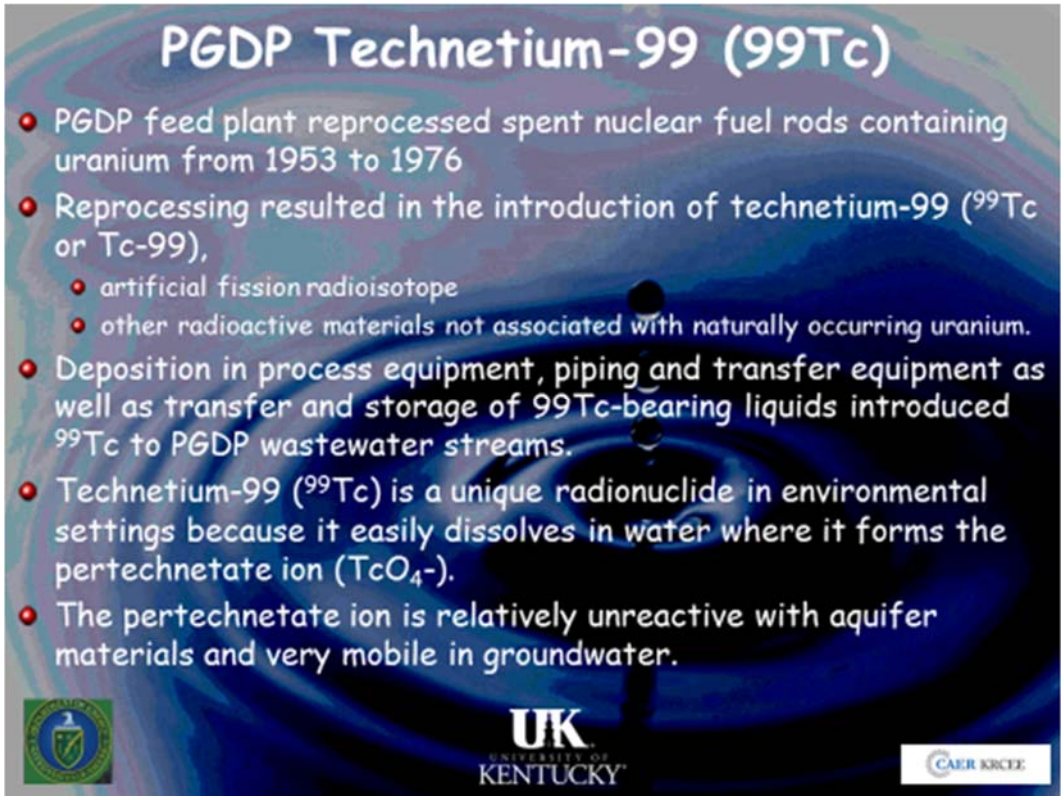
PGDP Technetium-99 (99Tc)
PGDP feed plant reprocessed spent nuclear fuel rods containing uranium from 1953 to 1976
Reprocessing resulted in the introduction of technetium-99 (99Tc or Tc-99),
artificial fission radioisotope
other radioactive materials not associated with naturally occurring uranium.
Deposition in process equipment, piping and transfer equipment as well as transfer and storage of 99Tc-bearing liquids introduced 99Tc to PGDP wastewater streams.
Technetium-99 (99Tc) is a unique radionuclide in environmental settings because it easily dissolves in water where it forms the pertechnetate ion (TcO4-).
The pertechnetate ion is relatively unreactive with aquifer materials and very mobile in groundwater.
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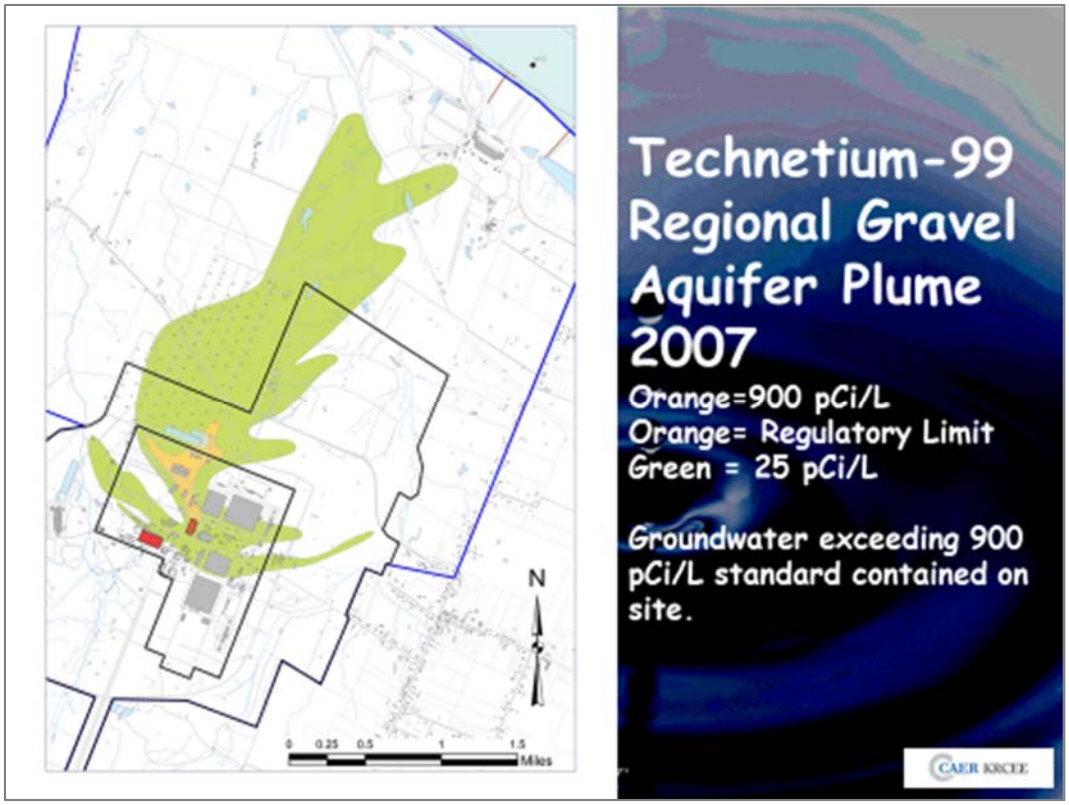
Technetium-99
Regional Gravel
Aquifer Plume
2007
Orange=900 pCi/L
Orange= Regulatory Limit
Green = 25 pCi/L
Groundwater exceeding 900 pCi/L standard contained on site.
N
0 0.25 0.5 1 1.5
Miles
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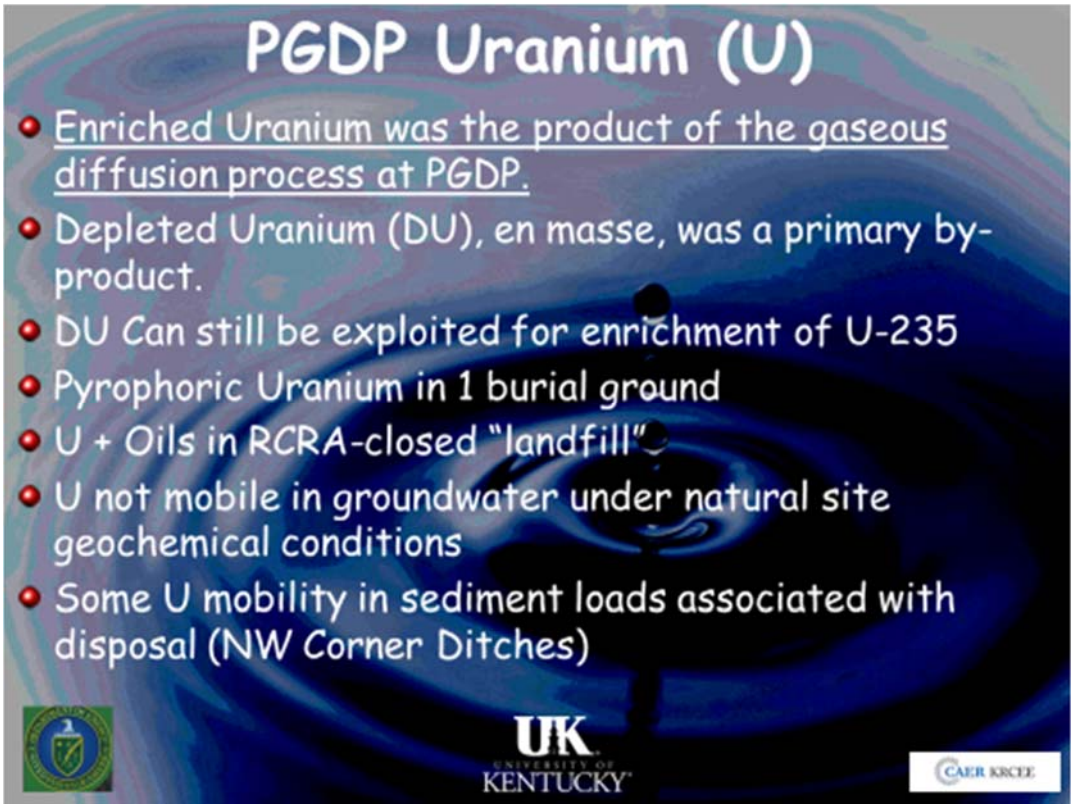
PGDP Uranium (U)
Enriched Uranium was the product of the gaseous diffusion process at PGDP.
Depleted Uranium (DU), en masse, was a primary by-product.
DU Can still be exploited for enrichment of U-235
Pyrophoric Uranium in 1 burial ground
U + Oils in RCRA-closed "landfill"
U not mobile in groundwater under natural site geochemical conditions
Some U mobility in sediment loads associated with disposal (NW Corner Ditches)
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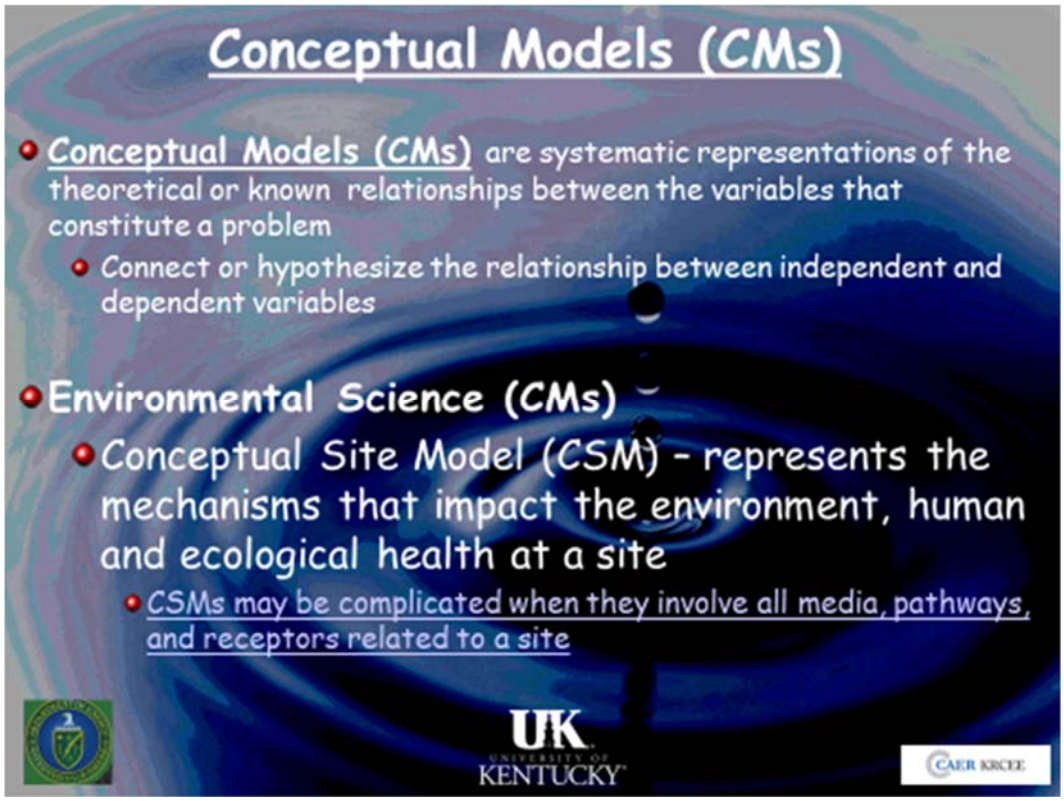
Conceptual Models (CMs)
Conceptual Models (CMs) are systematic representations of the theoretical or known relationships between the variables that constitute a problem
Connect or hypothesize the relationship between independent and dependent variables
Environmental Science (CMs)
Conceptual Site Model (CSM) - represents the mechanisms that impact the environment, human and ecological health at a site
CSMs may be complicated when they involve all media, pathways, and receptors related to a site
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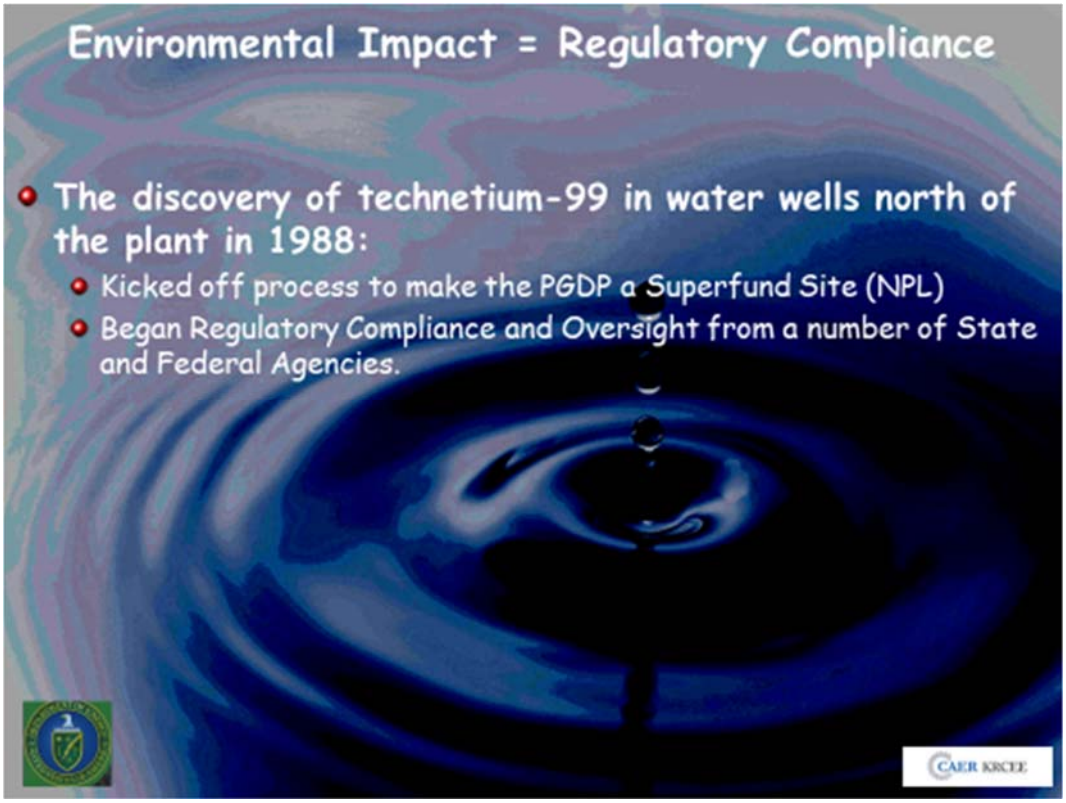
Environmental Impact = Regulatory Compliance
The discovery of technetium-99 in water wells north of the plant in 1988:
Kicked off process to make the PGDP a Superfund Site (NPL)
Began Regulatory Compliance and Oversight from a number of State and Federal Agencies.
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Environmental Impact = Regulatory Compliance
Ky. Environmental Protection Cabinet – RCRA
Hazardous Waste Branch-Federal Facilities Section
Solid Waste Branch – waste disposal/landfills
Division of Water – groundwater & surface water
Division of Air – air quality
U.S. Environmental Protection Agency – CERCLA
Region IV Federal Facilities
AEC eventually became DOE + NRC
NRC has regulatory responsibility for enrichment operations (USEC)
DOE retains responsibility for legacy waste and environmental cleanup.
DOE sets standards for Operations, Cleanup, H & S and nuclear safety under DOE Orders.
Ky. Radiation Control Program – Off-site Radiation Impacts (NRC)
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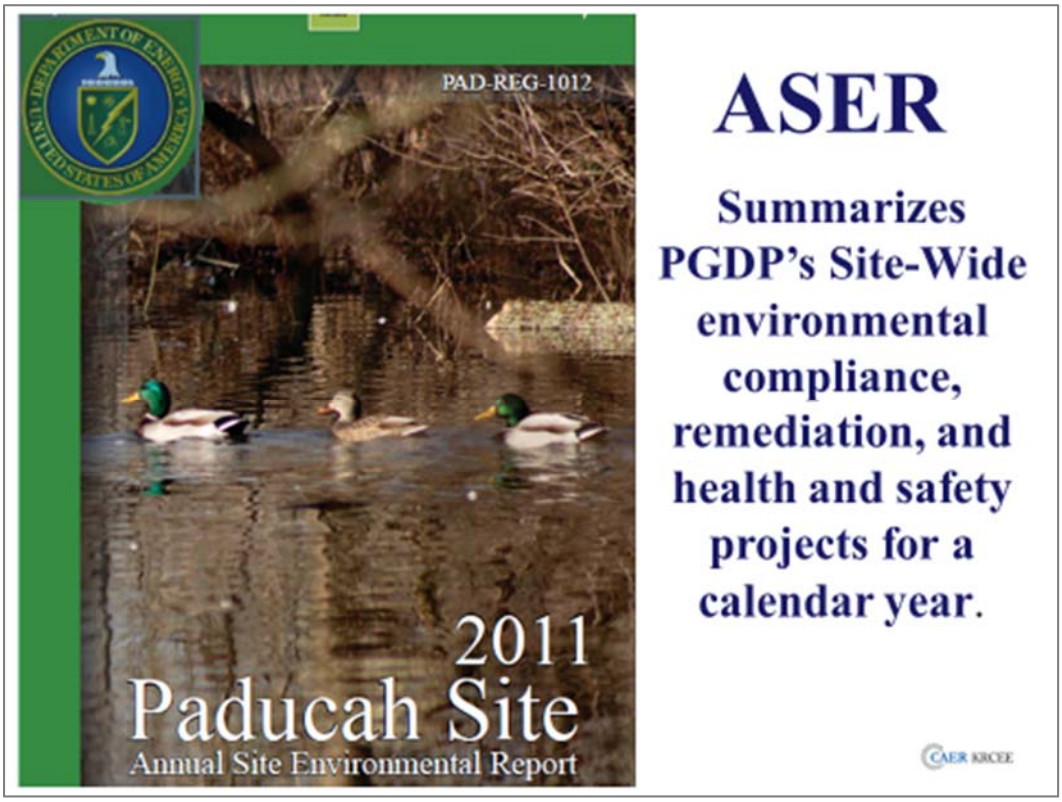
PAD-REG-1012
2011
Paducah Site
Annual Site Environmental Report
ASER
Summarizes PGDP's Site-Wide environmental compliance, remediation, and health and safety projects for a calendar year.
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PGDP ASER
Calendar Year 2011
COMPLIANCE SUMMARY
ENVIRONMENTAL PROGRAM
ENVIRONMENTAL RADIOLOGICAL PROTECTION PROGRAM
ENVIRONMENTAL NONRADIOLOGICAL PROGRAM
GROUNDWATER PROTECTION PROGRAM
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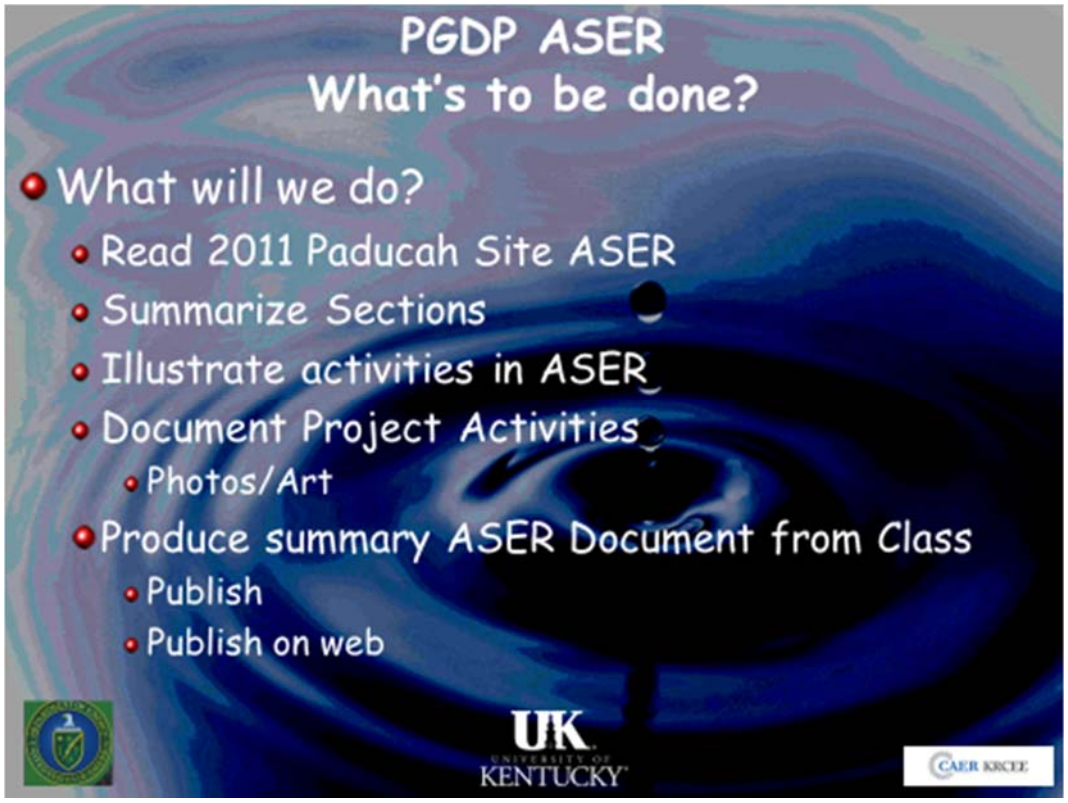
PGDP ASER
What's to be done?
What will we do?
Read 2011 Paducah Site ASER
Summarize Sections
Illustrate activities in ASER
Document Project Activities
Photos/Art
Produce summary ASER Document from Class
Publish
Publish on web
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NEXT
ASER & SITE TOPICS PRESENTATIONS
TOPICS
Site Regulatory/Environmental Management/DOE Science/ Opportunities
Site Radiation Health and Safety
Health Physicist (HP) or Site HP Program
Groundwater Protection Program
Physical System/Sources/Monitoring/Remediation
Site GW Lead Scientist/Program Manager)
Ecological Monitoring (Field Trip)
Field Studies Summary
UK Research Faculty/Emeritus SIU Faculty
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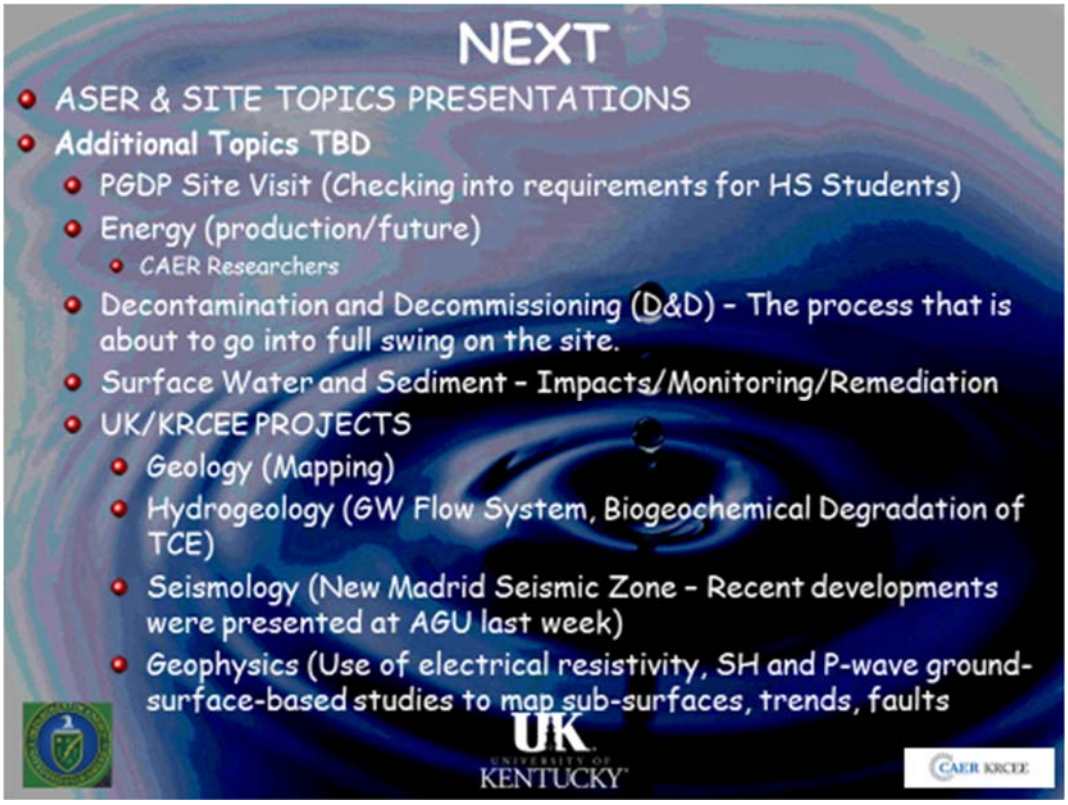
NEXT
ASER & SITE TOPICS PRESENTATIONS
Additional Topics TBD
PGDP Site Visit (Checking into requirements for HS Students)
Energy (production/future)
CAER Researchers
Decontamination and Decommissioning (D&D) – The process that is about to go into full swing on the site.
Surface Water and Sediment – Impacts/Monitoring/Remediation
UK/KRCEE PROJECTS
Geology (Mapping)
Hydrogeology (GW Flow System, Biogeochemical Degradation of TCE)
Seismology (New Madrid Seismic Zone – Recent developments were presented at AGU last week)
Geophysics (Use of electrical resistivity, SH and P-wave ground-surface-based studies to map sub-surfaces, trends, faults
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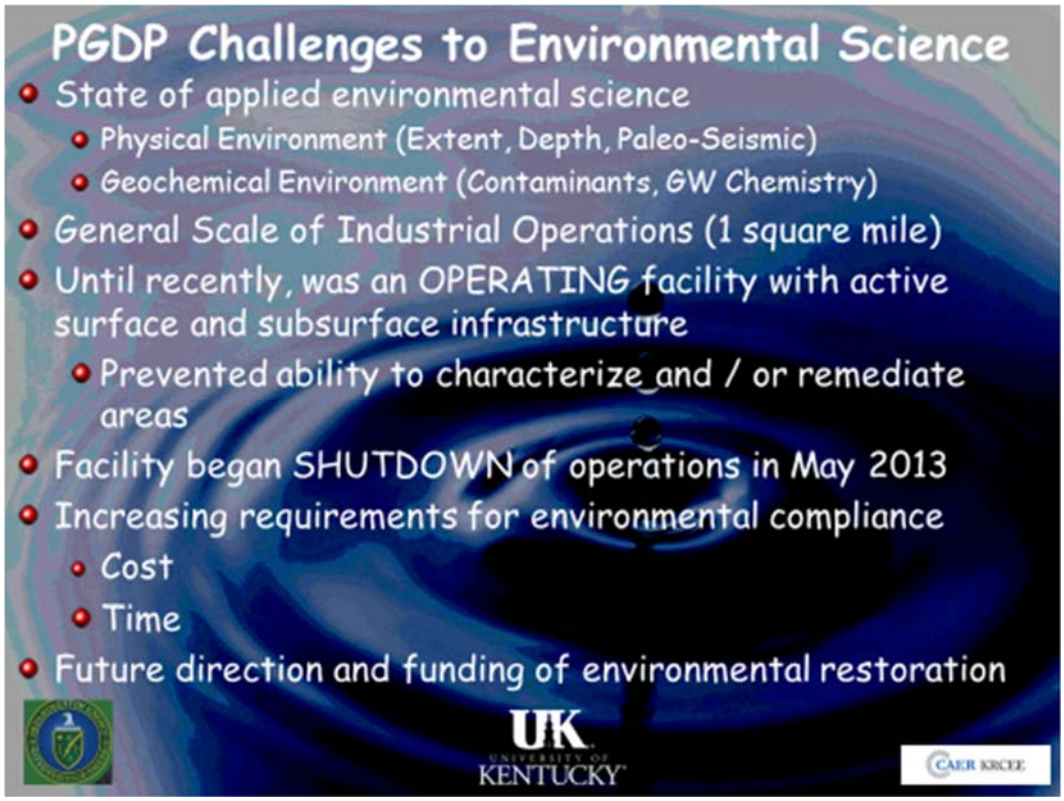
PGDP Challenges to Environmental Science
State of applied environmental science
Physical Environment (Extent, Depth, Paleo-Seismic)
Geochemical Environment (Contaminants, GW Chemistry)
General Scale of Industrial Operations (1 square mile)
Until recently, was an OPERATING facility with active surface and subsurface infrastructure
Prevented ability to characterize and / or remediate areas
Facility began SHUTDOWN of operations in May 2013
Increasing requirements for environmental compliance
Cost
Time
Future direction and funding of environmental restoration
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Ask Questions
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UK/KRCEE Website
http://www.ukrcee.org/
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to the
ATOMIC CITY
1950's Paducah-PGDP Post Card
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