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Environmental Site Description for a Uranium Atomic Vapor Laser Isotope Separation (U-AVLIS) Production Plant at the Paducah Gaseous Diffusion Plant Site

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Notation

Acronyms, Initialisms, and Chemical Names

AEC	Atomic Energy Commission
ANL	Argonne National Laboratory
BN	Burlington Northern Railroad
BREC	Big Rivers Electric Corp.
CDR	Conceptual Design Report
CIPS	Central Illinois Public Service
CO	carbon monoxide
CPPCD	City of Paducah, Planning and Community Development
DOE	U.S. Department of Energy
EDGe	Engineering, Design, and Geosciences Group, Inc.
EEC	Egyptian Electric Co-Op
EEI	Electric Energy, Inc.
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
EPGA	estimated peak ground acceleration
ERCE	ERC Environmental and Energy Services Co., Inc.
ERP	Environmental Restoration Program
ESD	environmental site description
ESP	electrostatic precipitator
FEMA	Federal Emergency Management Agency
HF	hydrogen fluoride
ICBO	International Conference of Building Officials
ICR	Illinois Central Railroad
IDENR	Illinois Department of Energy and Natural Resources
JPEC	Jackson Purchase Electric Cooperative
KAR	Kentucky Administrative Regulations
KCED	Kentucky Cabinet for Economic Development
KCHR	Kentucky Cabinet for Human Resources
KDAQ	Kentucky Department of Air Quality
KDFWR	Kentucky Department of Fish and Wildlife Resources
KGS	Kentucky Geological Survey
KOW	Kentucky Ordnance Works
KPDES	Kentucky Pollutant Discharge Elimination System
KSNPC	Kentucky State Nature Preserves Commission
LBL	Land Between the Lakes
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MSL	mean sea level
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NO_x	nitrogen oxides
NRHP	National Register of Historic Places
O_3	ozone

ORGDP	Oak Ridge Gaseous Diffusion Plant
PADD	Purchase Area Development District
P&L	Paducah and Louisville Railroad
PATS	Paducah Area Transit System
Pb	lead
PCB	polychlorinated biphenyl
PDMC	Planning and Development, McCracken County
PGA	peak ground acceleration
PGDP	Paducah Gaseous Diffusion Plant
PM_{10}	particulate matter less than 10 microns in diameter
PMF	probable maximum flood
PORTS	Portsmouth Gaseous Diffusion Plant
PSD	Prevention of Significant Deterioration
RCRA	Resource Conservation and Recovery Act
SARA	Superfund Amendments and Reauthorization Act
SEC	Southeastern Electric Co-op
SFRPDDC	Southern Five Regional Planning District and Development Commission
SHPO	State Historic Preservation Officer
SIEC	Southern Illinois Electric Co-Op
SIPC	Southern Illinois Power Co-Op
SO_2	sulfur dioxide
SSHD	Southern Seven Health Department
TCE	trichloroethylene
TLV	threshold limit value
TSCA	Toxic Substance Control Act
TSP	total suspended particulates
TVA	Tennessee Valley Authority
U-AVLIS	Uranium Atomic Vapor Laser Isotope Separation
UF_6	uranium hexafluoride
USBC	U.S. Bureau of the Census
USDOE	U.S. Department of Energy
USGS	U.S. Geological Survey
WKWMA	West Kentucky Wildlife Management Area

Units of Measure

°C	degrees Centigrade
Btu	British thermal unit
cfs	cubic feet per second
dBA	A-weighted decibel(s)
°F	degrees Fahrenheit
ft	foot (feet)
ft/d	feet per day
g	acceleration of gravity
g	gram(s)
gpm	gallons per minute

h	hour(s)
Hz	hertz
I_{MM}	modified Mercalli (seismic) intensity
in.	inch(es)
kg	kilogram(s)
kHz	kilohertz
L	liter
lb	pound(s)
m	meter(s)
m_b	(seismic) magnitude
mCi	millicurie(s)
µCi	microcurie(s)
µCi/mL	microcuries per milliliter
µg/L	micrograms per liter
$\mu g/m^3$	micrograms per cubic meter
mg	milligram(s)
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mgd	million gallons per day
mg/m^3	milligrams per cubic meter
mi	mile(s)
mi^2	square mile(s)
min	minute(s)
mo	month(s)
mrem	millirem(s)
MW	megawatt(s)
pCi/g	picocuries per gram
pCi/L	picocuries per liter
ppb	parts per billion
ppm	parts per million
s	second(s)
w/w	weight of fluoride ion per weight of forage unit
wk	week(s)
yr	year(s)

Environmental Site Description for a Uranium Atomic Vapor Laser Isotope Separation (U-AVLIS) Production Plant at the Paducah Gaseous Diffusion Plant Site

1 Introduction

1.1 Context of This Document

Uranium enrichment in the United States has utilized a diffusion process to preferentially enrich the U-235 isotope in the uranium product. In the 1970s, the U.S. Department of Energy (DOE) began investigating more efficient and cost-effective enrichment technologies. In January 1990, the Secretary of Energy approved a plan for the demonstration and deployment of the Uranium Atomic Vapor Laser Isotope Separation (U-AVLIS) technology, with the near-term goal to provide the necessary information to make a deployment decision by November 1992. Initial facility operation is anticipated for 1999.

The U-AVLIS process is based on electrostatic extraction of photoionized U-235 atoms from an atomic vapor stream created by electron-beam vaporization of uranium metal alloy. The U-235 atoms are ionized when precisely tuned laser light -- of appropriate power, spectral, and temporal characteristics -- illuminates the uranium vapor and selectively photoionizes the U-235 isotope. The electron energy states of each uranium isotope are unique to that isotope, and isotopic enrichment exploits the small spectral shift in the absorptivity of the different uranium isotopes. The enriched uranium product is collected on negatively charged product collector plates, and depleted uranium is collected on a neutral surface. During U-AVLIS enrichment, a feedstock of approximately 0.7% U-235 isotopic assay is converted to a product of 3-5% U-235 isotopic assay.

A programmatic document for use in screening DOE sites to locate a U-AVLIS production plant was developed and implemented in two parts (Wolsko et al. 1991). The first part consisted of a series of screening analyses, based on exclusionary and other criteria, that identified a reasonable number of candidate sites. These sites were subjected to a more rigorous and detailed comparative analysis for the purpose of developing a short list of reasonable alternative sites for later environmental examination. The final evaluation, which included sensitivity studies, identified the Oak Ridge Gaseous Diffusion Plant (ORGDP) site, the Paducah Gaseous Diffusion Plant (PGDP) site, and the Portsmouth Gaseous Diffusion Plant (PORTS) site as having significant advantages over the other sites considered.

On April 10, 1991, DOE announced the results of the final programmatic study. The locations of the three sites are shown in Fig. 1.

This environmental site description (ESD) provides a detailed description of the PGDP site and vicinity suitable for use in an environmental impact statement (EIS). The report is based on existing literature, data collected at the site, and information collected by Argonne National Laboratory (ANL) staff during a site visit.

FIGURE 1 Locations of Three Alternative Sites for a U-AVLIS Production Plant

The organization of the ESD is as follows. Topics addressed in Sec. 2 include a general site description and the disciplines of geology, water resources, biotic resources, air resources, noise, cultural resources, land use, socioeconomics, and waste management. Identification of any additional data that would be required for an EIS is presented in Sec. 3.

Following the site description and additional data requirements, Sec. 4 provides a short, qualitative assessment of potential environmental issues. These issues are based on best available knowledge of the conceptual design as presented in the site data package (Martin Marietta 1990). The brief assessments relate to constructing and operating a U-AVLIS production plant.

This document was prepared even though details of the conceptual design of the U-AVLIS facility are not yet available. The absence of these details, which will be provided at a future date in the Conceptual Design Report (CDR), is not expected to greatly affect the descriptions presented in this document. Such information will be required, however, for the comprehensive environmental analysis required in an EIS.

1.2 History of the Paducah Facility

The 3,423-acre reservation that contains the PGDP was originally part of a 16,126-acre parcel of land in rural McCracken County, Kentucky, a parcel that was purchased by the federal government at the beginning of World War II for the construction of the Kentucky Ordnance Works (KOW). The KOW, located approximately 10 miles (mi) west of Paducah and just south of the Ohio River, was operated by the Atlas Powder Co. until the war ended (Martin Marietta 1991). Prior to the war, the area within the KOW boundaries consisted of farms and scattered woodland tracts.

In 1950, the Atomic Energy Commission (AEC), a predecessor of the DOE, acquired 7,565 acres of the former KOW site for a large-scale gaseous diffusion plant similar to the one operating at Oak Ridge, Tennessee. Construction of the PGDP lasted from 1950 until 1954, with actual operations beginning in 1952. During the same time period, construction of the Shawnee Steam Plant, owned by the Tennessee Valley Authority (TVA), began just north of the PGDP. The Union Carbide Corp. was the PGDP operating contractor from March 1952 until April 1984. Martin Marietta Energy Systems has operated the plant since 1984. The PGDP originally employed approximately 1,600 workers.

In 1953, the AEC granted the state of Kentucky permission to transform a 2,080-acre parcel surrounding the PGDP into a wildlife management area. The DOE reservation currently consists of the 2,080-acre wildlife management area and a 1,343-acre site managed by Martin Marietta Energy Systems.

2 Affected Environment

This section describes the environment of the Paducah Gaseous Diffusion Plant site that could be affected by the siting, construction, and operation of the U-AVLIS production plant. The PDGP is located in McCracken County in northwestern Kentucky, about 10 mi west of the city of Paducah (Fig. 2). The PDGP reservation consists of 3,423 acres of land, of which 748 acres are fenced, and is operated as a uranium enrichment facility (Fig. 3) (Martin Marietta 1990). Support operations include feed and withdrawal of uranium hexafluoride (UF_6) from the gaseous diffusion process; recovery of uranium-bearing compounds from various waste materials and from equipment removed for maintenance; and also normal operations of waste management, maintenance, engineering, security, and other business-related activities required by uranium enrichment.

The proposed U-AVLIS site is located in an undeveloped, mowed, and graded area southwest of the existing C-333 gaseous diffusion building (Fig. 3).

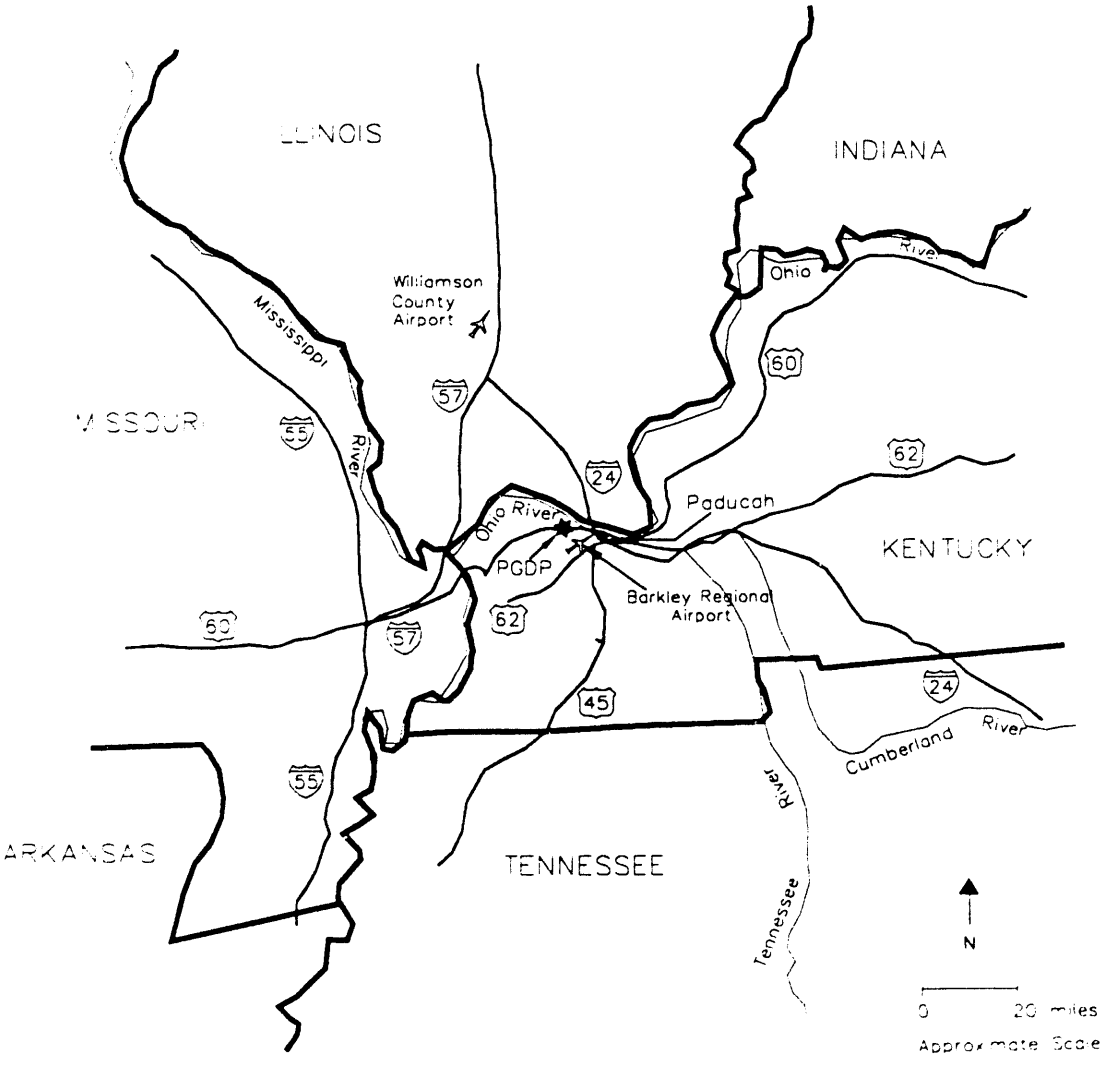


FIGURE 2 Location of the PGDP Site in Northwestern Kentucky (Source: Adapted from ERCE 1990a)

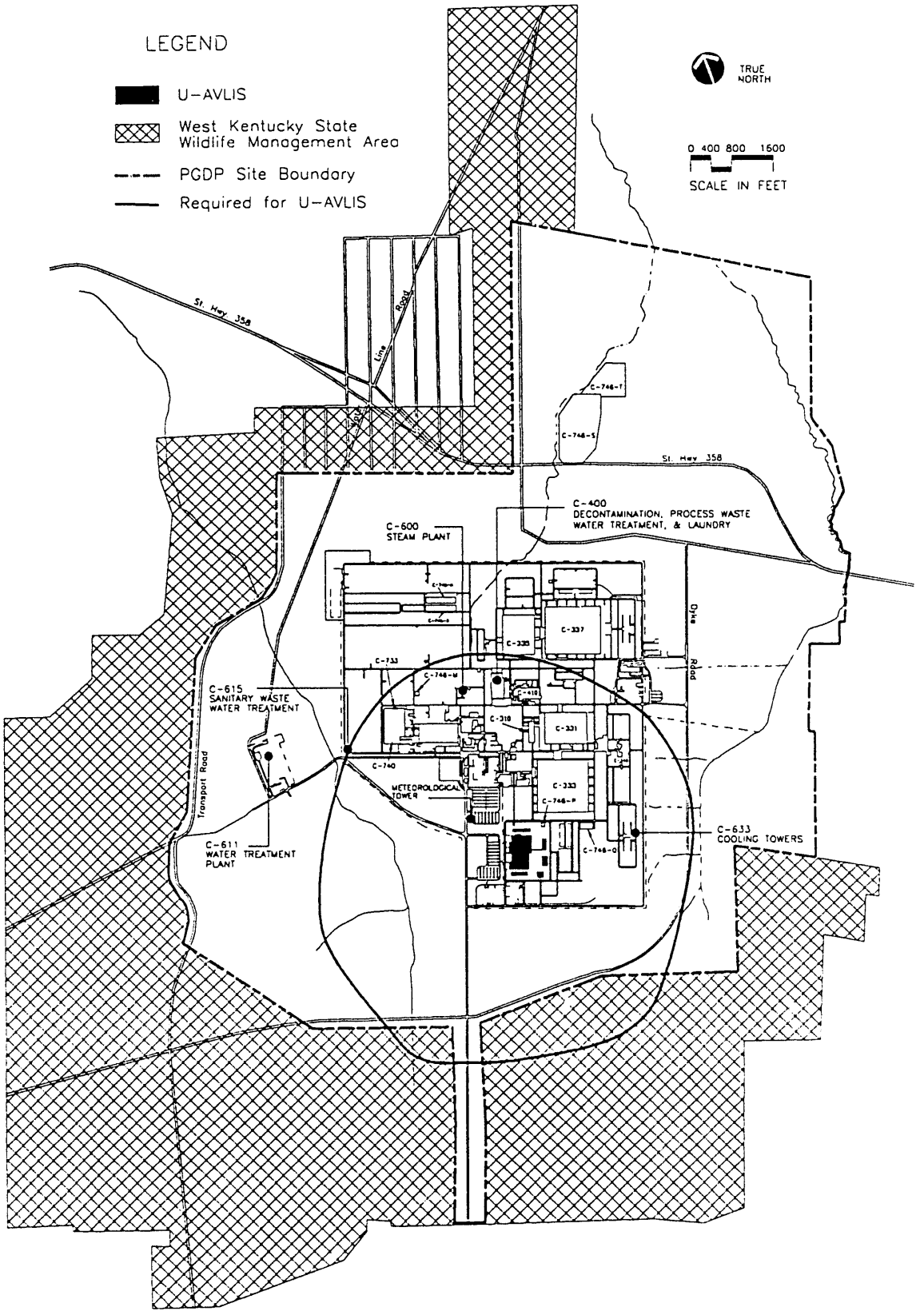


FIGURE 3 Paducah Gaseous Diffusion Plant Site

2.1 Geology

2.1.1 Location and Physiography

The PGDP site is situated on a relatively flat upland in the northern Mississippi Embayment portion of the Atlantic and Gulf Coastal Plain physiographic province (Saylor et al. 1990). The site slopes slightly from more than 450 feet (ft) above mean sea level (MSL) south of the plant to 300 ft MSL near the Ohio River, which is located about 3.6 mi to the north. The elevations within the plant site range from 350 to 380 ft MSL (CH_2M HILL 1991), well above the 100-year (yr) floodplain of the Ohio River (Saylor et al. 1990).

Two tributaries of the Ohio River drain the PGDP site. The smaller one, Little Bayou Creek, flows near the eastern boundary of the site, while the Big Bayou Creek, a perennial stream, runs across the southwestern part of the site. The two streams are fed by a few smaller intermittent brooks and receive discharge from the PGDP. The two streams join together northwest of the plant before entering into the Ohio River.

2.1.2 Regional Geology

The PGDP is located near the northern terminus of the Mississippi Embayment. The embayment is a gently warped basin, oriented nearly north-south, and is surrounded by highlands of relatively resistant Paleozoic sedimentary rocks. During Cretaceous, Tertiary, and Quaternary times, the embayment received sediments from the surrounding highlands. Clastic materials were accumulated on the top of the Paleozoic bedrock, which was primarily composed of northward-dipping limestones and shales (Saylor et al. 1990). The stratigraphic sequence of the geologic formations and their lithologic descriptions are shown in Fig. 4. The geological formations above the Paleozoic limestone, in ascending order, are the Tuscaloosa Formation (or the Little Bear Soil), the Clayton and McNairy formations (Cretaceous), the Porters Creek Clay (Paleocene), the undifferentiated Eocene Sands (Eocene), the Continental Deposits (Pliocene-Pleistocene), loess (Pleistocene), and the most recent alluvium deposits. The Continental Deposits lie on an ancient erosional surface, which truncates several older bedrock units. A schematic north-south cross section in the PGDP area is provided in Fig. 5. Detailed descriptions of the geologic formations have been published (Saylor et al. 1990; ERC/EDGe 1989).

2.1.3 Local Geology

The geology in the vicinity of PGDP is conceptualized as shown in Fig. 6 (CH_2M HILL 1991). After deposition of the Eocene Sands in the Mississippi Embayment, uplift occurred and an erosional surface developed that truncated the southwest-dipping Eocene Sands, Porters Creek Clay, and the Clayton and McNairy formations. The subsurface contact of these formations is shown in Fig. 7. During late Tertiary and Quaternary times, the Continental Deposits (Fig. 6) were laid down over the erosional surface. Lithologically, the deposits can be separated into a

System	Series	Formation	Thickness (ft)		Lithology	Topography and Geologic Setting
Quaternary	Pleistocene and Recent	Alluvium	0-40		Brown or gray sandy and silty clay or clayey silt with streaks of sand. Some brown sand with streaks of clay and silt.	Recent floodplain deposits in the valleys of the Ohio River and its larger tributaries.
	Pleistocene	Loess	0-43		Brown or yellowish-brown to tan to gray unstratified silty clay	Wind-laid deposits covering all upland areas and sloping sides of streams.
	Pleistocene ----------	Continental Deposits	3-121		Clay Facies (Upper Continental Deposits) Orange to yellowish-brown to brown clayey silt. Some fine sand and gravel. Often micaceous.	Underlies loess or alluvium throughout the area. A thick silt deposit blankets the lower levels of the Plio-Pleistocene gravel.
----------	---------- Pliocene (?)				Gravel Facies (Lower Continental Deposits) Reddish-brown silty and sandy chert gravel and beds of gray sandy gravel, silt, and clay.	Terrace deposits lying on an irregular surface cut at different levels into sediments of Eocene, Paleocene, and Cretaceous age. The pre-Pliocene surface consists of channels and terraces cut by an intricate drainage system at an altitude of about 280 ft above sea level.
Tertiary	Eocene, Undifferentiated	Eocene Sands	0-200+	0-300+	Red, brown, or white fine- to coarse-grained sand. Beds of white to dark-gray clay are distributed at random.	Become thin and difficult to differentiate from the lower Eocene unit north of Childress Road. Generally not present north of U.S. Highway 60. Underlies Plio-Pleistocene gravel and younger deposits where present. Exposed in creek beds and railroad cut in the southern half of the Health Quadrangle.
			0-100+		White to gray sandy clay, clay conglomerate and boulders, scattered clay lenses, and lenses of coarse red sand. Black to dark-gray lignitic clay, silt, or fine-grained sand. A bed of coarse sand at the base of the Eocene sequence is apparently discontinuous.	Underlies the main body of Eocene sediments in the southern part of the Heath Quadrangle. May be exposed in creeks north of U.S. Highway 60.

FIGURE 4 Stratigraphic Sequence of the Study Area, in Descending Order (Source: Adapted from CH_2M HILL 1991)

System	Series	Formation	Thickness (ft)	Lithology	Topography and Geologic Setting
	Paleocene	Porters Creek Clay	0-200	Dark gray, slightly to very micaceous clay. Fine-grained clayey sand, commonly glauconitic in the upper part. Glauconitic sand and clay at the base.	Underlies the entire Heath Quadrangle except north of Grahamville. Pinches out at the steep slope of the erosional Plio-Pleistocene surface and thickens quickly southward.
Cretaceous		Clayton and McNairy Formations	200-300	Grayish-white to dark gray micaceous clay, often silty, interbedded with light gray to yellowish-brown very fine- to medium-grained sand. The upper part is mostly clay; the lower part is predominantly micaceous fine sand.	Underlies the Plio-Pleistocene gravel north of Grahamville and Porters Creek Clay south of Grahamville.
		Tuscaloosa Formation	?	White, well-rounded or broken chert gravel with clay.	May occur in pockets in the eroded surface of the Paleozoic rocks.
Mississippian		Mississippian Carbonates	500+	Dark gray limestone and interbedded chert, some shale.	Underlies the entire area at approximately sea level.

FIGURE 4 (Cont'd)

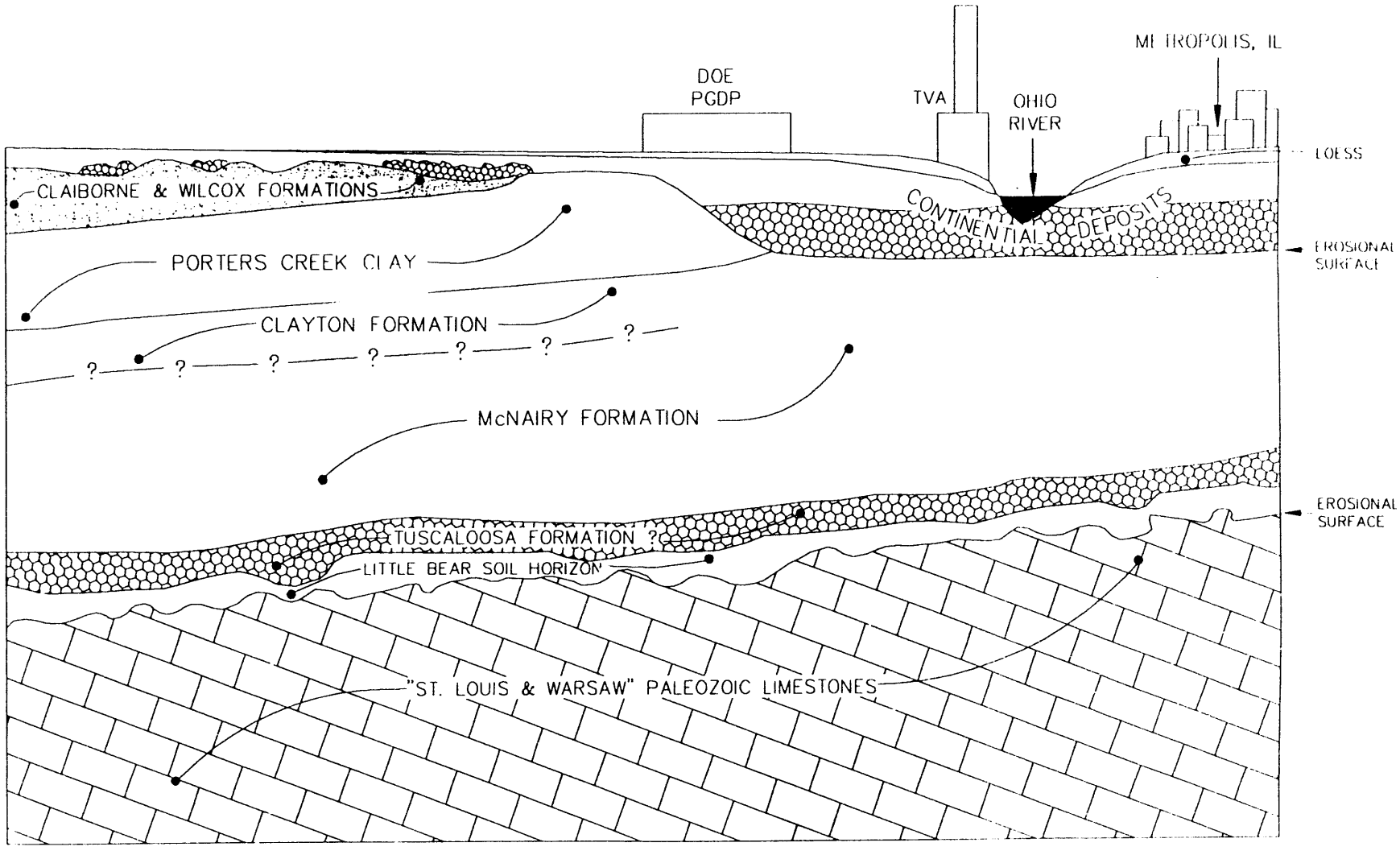


FIGURE 5 Schematic Diagram of a North-South Section, Showing the Stratigraphic Relationships in the PGDP Area (Source: ERC/EDGe 1989)

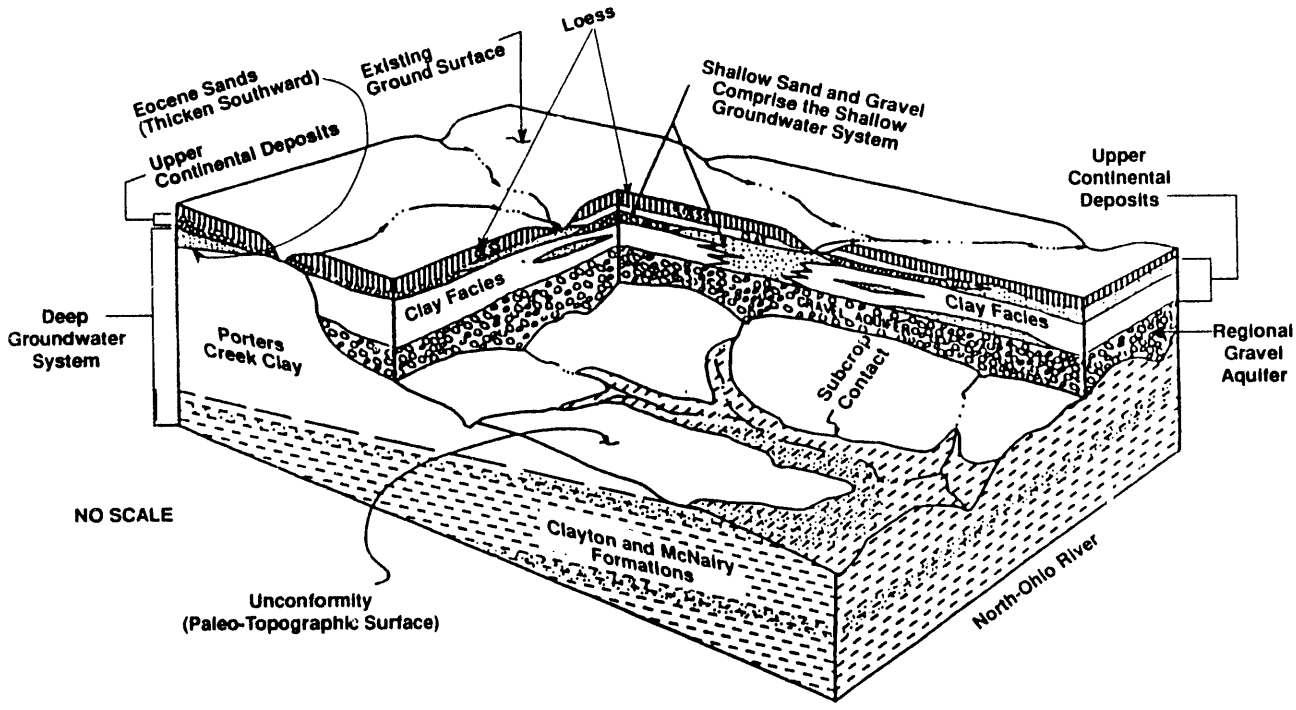


FIGURE 6 Conceptual Stratigraphy in the Vicinity of the PGDP (Source: CH_2M HILL 1991)

gravel facies (Lower Continental Deposits) and a clay facies (Upper Continental Deposits). On the top of the Continental Deposits is windblown material (loess) of variable thickness.

The Lower Continental Deposits unit is primarily composed of gravel or sandy gravel, with beds of sandy silt and clay. It ranges from 0 to 106 ft thick (Saylor et al. 1990) and is a major aquifer in the PGDP area.

The Upper Continental Deposits unit overlying the gravel unit is dominated by fine-grained materials, with lenses of fine sands (Early et al. 1989). Available exploratory boring data show that this unit is laterally and vertically heterogeneous in terms of lithologic texture and varies from 45 to 60 ft thick.

Above the Continental Deposits and near the surface is a layer of loess, which typically extends to a depth of about 25 ft (CH_2M HILL 1990), varies in thickness, and consists of clayey silt and silty clay. Adjacent to creeks and the Ohio River, the loess may be covered by alluvial sediment.

2.1.4 Soils

The soil at the PGDP site is mostly derived from the loess deposit and is primarily silt loam and silty clay loam (CH_2M HILL 1991). The thickness of the soil horizon in the region is typically 5 ft. The soil mainly belongs to the Calloway-Henry association, which consists of medium textured and poorly to somewhat poorly drained soils. Undisturbed soils found on the uplands

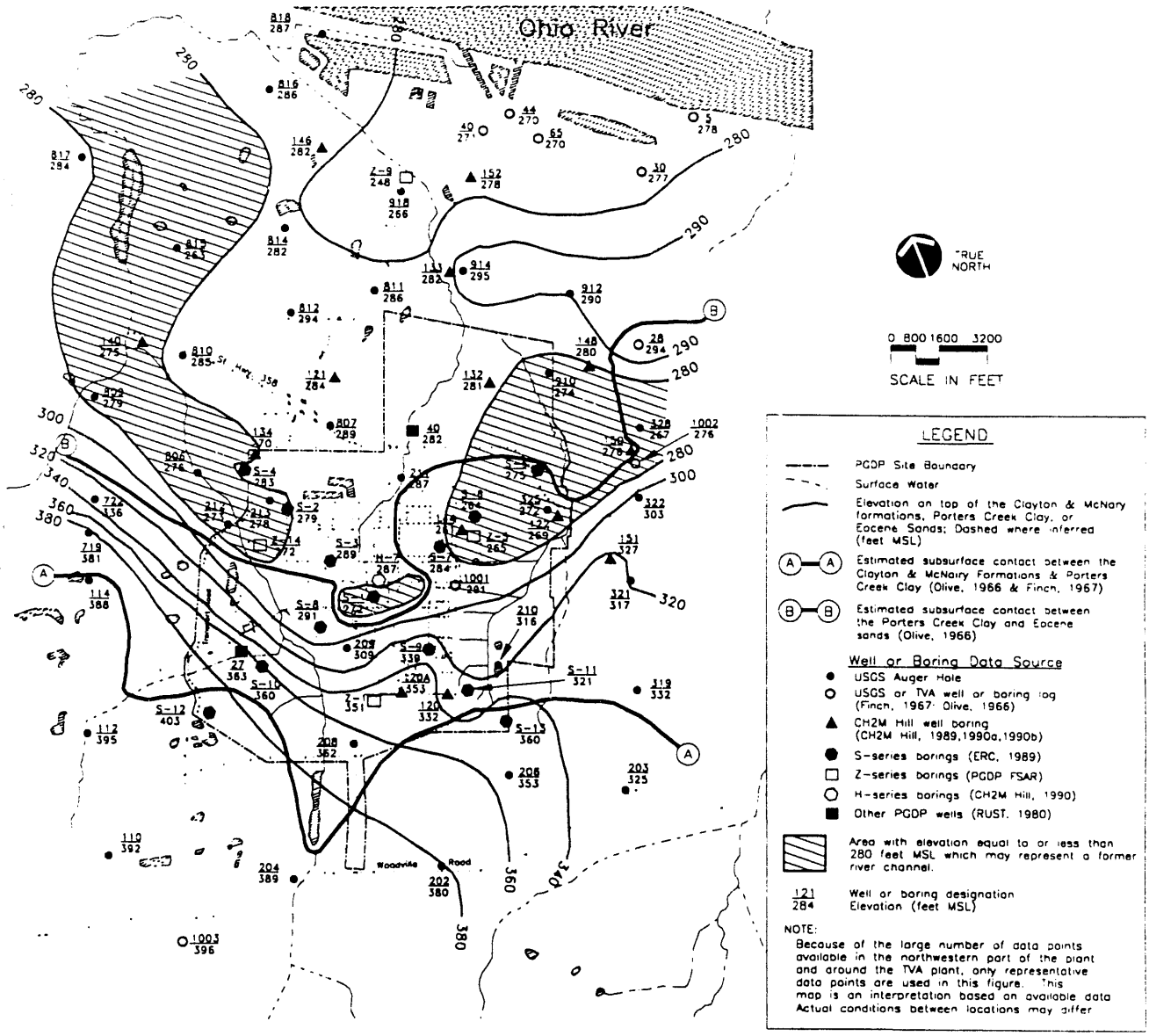


FIGURE 7 Contour Map of the Elevation of the Top of the Clayton and McNairy Formations, Porters Creek Clay, and Eocene Sands (Source: Adapted from CH_2M HILL 1991)

typically contain a low-permeability layer (fragipan), with a thickness of 1-2 ft at depths ranging from 1 to 4 ft. Within most areas of the plant, the fragipan has been destroyed by development of the site. In areas where the fragipan is present, it may create a perched water table during the winter and spring (CH_2M HILL 1991).

2.1.5 Seismicity

Regionally, the PGDP is located near the northeastern end of the New Madrid fault zone (Reelfoot Rift). Within a 200-mi radius, six additional major fault zones are recognized (ERCE 1990b; Saylor et al. 1990): the Rough Creek fault zone, the Saint Genevieve fault zone, the Cottage Grove fault zone, the Shawneetown fault zone, the Wabash Valley fault zone, and the

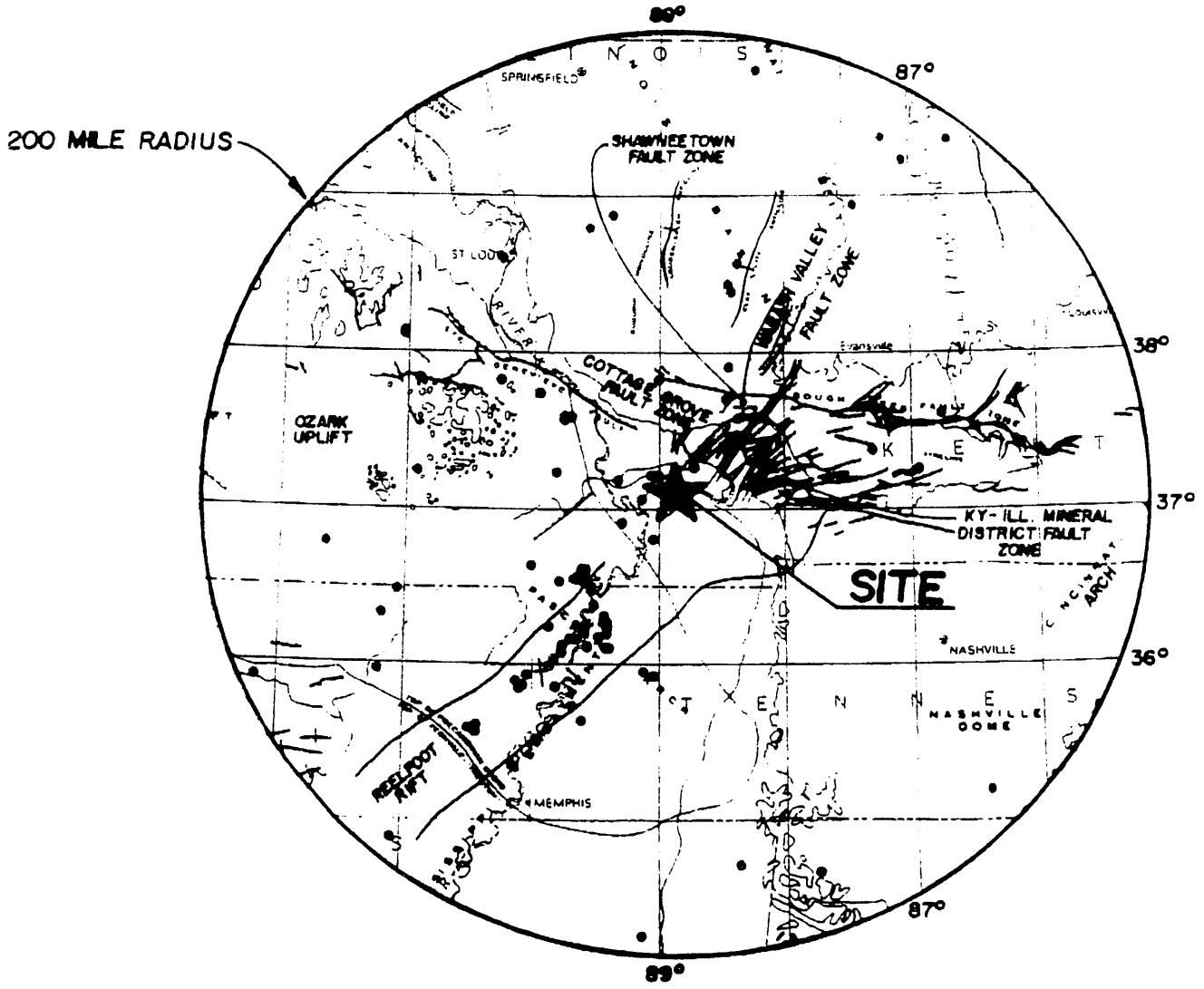
Illinois-Kentucky Mineral District fault zone (Fig. 8). The New Madrid fault zone may extend beyond Paducah along the Shawneetown fault zone and even to the Wabash Valley fault zone (Saylor et al. 1990).

A fault starting less than 3 mi east of the site has been identified from boring data. It trends northeast under the Ohio River (ERCE 1990b). Six other faults whose existence is also based on boring data are defined in neighboring townships. Two small surface faults are shown on the Paducah West Geologic Quadrangle and apparently predate the Pleistocene series (ERCE 1990b).

Surface rupture caused by strong-motion earthquakes is rare in the central or eastern United States (Saylor et al. 1990). As a result, the degree to which faulting has occurred in post-Paleocene sediment is unclear (ERCE 1990b). There is no clear evidence to support post-Paleocene faulting in the Mississippi Embayment in southern Illinois, but it is proposed that faults found in the Paleozoic strata may remain active to the present (ERCE 1990b).

Most strong-motion earthquakes (with a magnitude of $m_b > 5.5$ and a modified Mercalli intensity of $I_{MM} > VII$) within a 400-mi radius of the site are centered in two active zones (Saylor et al. 1990). This conclusion is based on data provided by the NOAA Geophysical Data Center in Boulder, Colorado. The most active zone is the New Madrid rift zone, located immediately to the south-southwest of Paducah in southeastern Missouri, southern Illinois, western parts of Kentucky and Tennessee, and northeastern Arkansas. The other active zone is the Wabash Valley fault zone, located immediately northeast of Paducah in southeastern Illinois and southwestern Indiana. The largest earthquake in the region centered in the New Madrid rift zone; on February 7, 1812, a magnitude of 7.3 m_b was recorded. The epicenter of the earthquake was approximately 60 mi southwest of PGDP at 36.5°N latitude and 89.6°W longitude (ERCE 1990b). The intensity of this earthquake in McCracken County, where Paducah is located, was estimated to be $I_{MM} = X$ (Saylor et al. 1990).

All earthquakes occurring since 1776 that have epicenters within 200 mi of the site have been compiled by the U.S. Geological Survey (ERCE 1990b). According to the Uniform Building Code of the International Conference of Building Officials (ICBO), the PGDP is located in Seismic Zone 2A and near the boundary of Seismic Zone 3 (ERCE 1990b). At the boundary, the estimated peak ground acceleration (EPGA) of the 500-yr return period provided by the Federal Emergency Management Agency (FEMA) is 0.20 of the acceleration of gravity (g) (Saylor et al. 1990). Several studies (including Dames and Moore 1973; TERA Corp. 1981; Beavers 1974) have also provided the probabilistic risk assessment for ground motion at the PGDP, and their various results are summarized in Saylor et al. (1990). For example, the peak ground acceleration (PGA) of the 500-yr nominal return period ranges from 0.07 to 0.32 g, and the 1000-yr nominal return period ranges from 0.09 to 0.40 g. Kennedy et al. (1990) give the maximum horizontal ground surface acceleration at the PGDP as 0.45 g, for an annual probability of exceedance of 1×10^{-3} (or a 1000-yr return period). Another study gives a maximum horizontal ground surface acceleration of 0.25 g at the PGDP for the same annual probability of exceedance (Martin Marietta 1990).



EXPLANATION

- • EARTHQUAKE EPICENTER (2.5 < RICHTER MAGNITUDE < 5.5)
- GEOLOGIC BOUNDARY
- NORMAL FAULT
- THRUST FAULT
- ANTICLINE
- SYNCLINE

NOTE: NO EARTHQUAKES WITH MAGNITUDES > 5.5 OCCURRED WITHIN THE 200 MILE RADIUS FROM 1975-1984.

FIGURE 8 Regional Tectonic Structures and Seismicity,1975-1984 (Source: ERCE 1990b)

2.2 Air Resources

2.2.1 Climate and Local Meteorology

The climate of Paducah, Kentucky, is moderate but humid. Summers are generally dry; precipitation occurs mainly in the spring and fall. Winters are characterized by moderately cold days. The average temperature during the coldest month, January, averages about 1.7°C (35°F). Summers are warm and humid; the average temperature in July is about 26°C (79°F). Yearly precipitation averages about 44 inches (in.). On the basis of data from 1983 to 1988, the relative humidity is estimated to be approximately 83% at 6 a.m. and 61% at noon.

A meteorological monitoring system was installed at the PGDP in 1987. This 60-meter (m) tower is located south of the Administration Building (C-100) and contains instrumentation at 10-m and 60-m heights. Meteorological parameters measured include wind speed and direction at both levels; standard deviation of wind direction at the 60-m level (for estimate of stability class); temperature at both levels; barometric pressure and relative humidity at the 10-m level; and rainfall. Data are summarized in Fig. 9, which presents wind roses for the 10- and 60-m levels based on 3.5 yr of data from January 1988 through May 1991. The prevailing wind direction at Paducah is from the south and southwest.

2.2.2 Air Quality

2.2.2.1 Air Emissions

There are 27 air-pollutant emission sources at the PGDP site with permits to operate from the Kentucky Department of Air Quality (KDAQ). Table 1 lists the permitted pollution sources. However, not all of the emission points were active in 1989; the four major sources then in operation (Fig. 10) were as follows.

1. *Three boilers in the C-600 steam plant.*

Two coal- and oil-fired boilers and one gas- and oil-fired boiler in the C-600 steam plant provide energy used in operation of the site. The main C-600 steam plant emissions are sulfur dioxide (SO_2) and nitrogen oxides (NO_x); these pollutants are routinely monitored. The SO_2 emissions are continuously monitored in the stack as pounds of SO_2 per million British thermal units (Btu) input to the boiler. Combined with information on fuel usage, estimates are made of monthly and annual emissions. The NO_x emissions are calculated from fuel usage by using handbook values of NO_x produced per pound of fuel for each type of fuel burned in this boiler. Total suspended particulates (TSP) are normally not monitored. The steam plant is currently in compliance. The KDAQ permit limit of 20% opacity is achieved with electrostatic precipitators (ESPs) operating at 99% efficiency for particulate removal. Past tests have shown emission levels of less than 0.1 pound (lb) of TSP per million Btu boiler input.

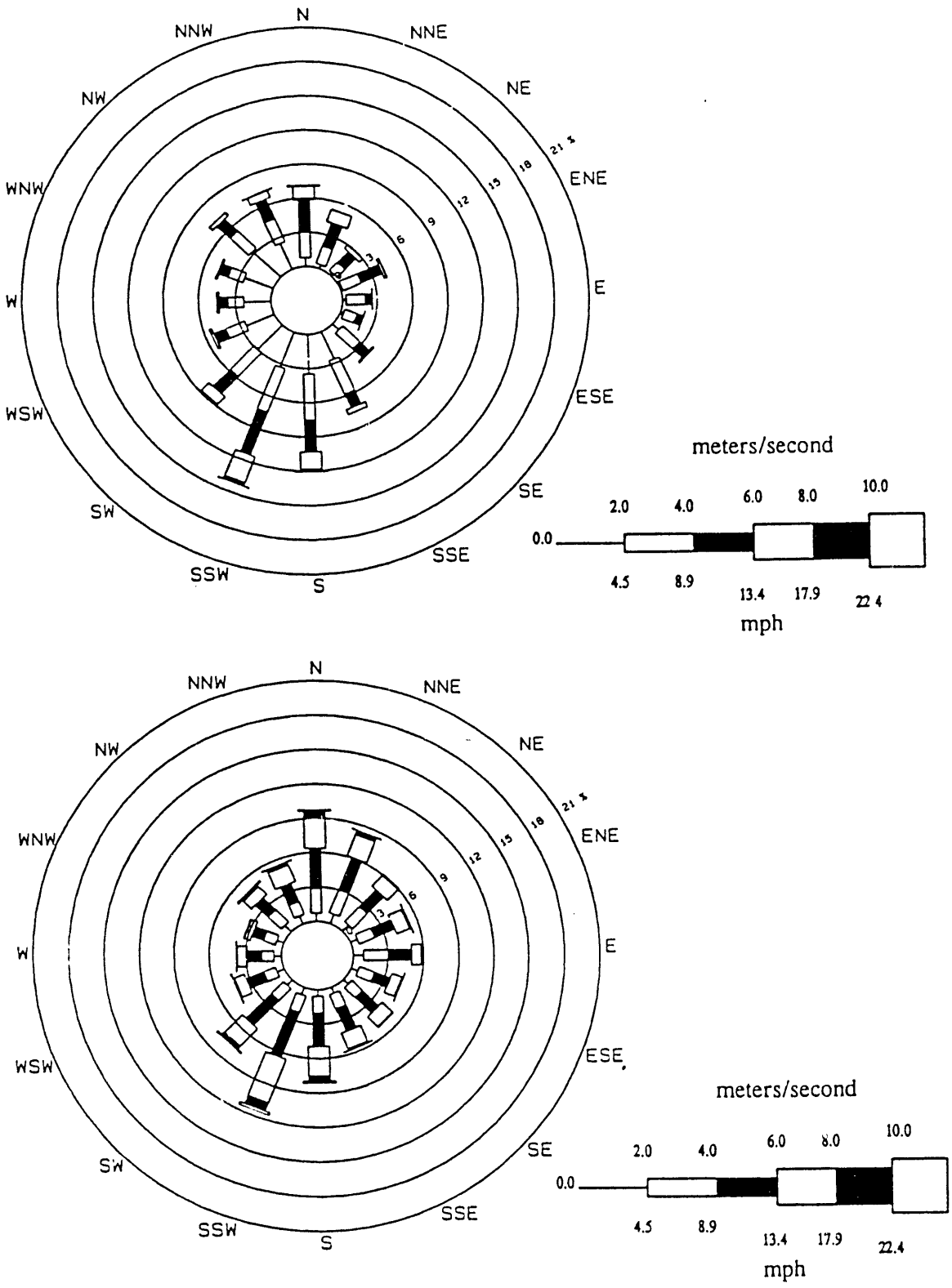


FIGURE 9 Wind Roses for the 10-m Level (Top) and 60-m Level (Bottom) for PGDP, 1988 through May 1991

TABLE 1 Air Pollutant Emission Sources at PGDP with Permits to Operate

Permit No.	Location	Control Equipment
1	C-600 No. 2 boiler	Electrostatic precipitators and low-sulfur coal
2	C-600 No. 3 boiler	Electrostatic precipitators and low-sulfur coal
4	C-405 incinerator (north)[a]	Venturi scrubber
5	C-405 incinerator (south)[a]	Venturi scrubber
7	C-310 purge vent	Sodium fluoride traps, high-speed centrifuge
8	C-410 fluorine production	Cold condensers
15	C-400 UF_4 pulverizer	Filters
26	C-746 reverberatory furnace[a]	
27	C-746 aluminum sweat furnace[a]	
29	C-400 gold recovery[a]	
31	C-724 paint spray booth	Water wash scrubber
32	C-725 paint spray booth	Water wash scrubber
33	C-746-A rotary calciner[a]	Calcium carbonate traps
34(a)	Smelter - central dust collector	Filters
35	C-600 No. 1 boiler	
36	Smelter-induction furnace[a]	Filters
37	C-600 coal-handling equipment	Water sprays
38	C-400 Detrex open-top vapor degreaser	Covered systems and condensing coils
39	C-400 Blakeslee open-top vapor degreaser	Covered systems and condensing coils
40	C-720 Branson open-top vapor degreaser (trichloroethylene)	
41	C-720 cold cleaning degreaser[a]	
42	Chemical unloading	Wet cyclone scrubber
41	C-340 uranium alloy remelting operation[a]	Filters

[a]Shut down with no plans to restart.

Source: Kornegay et al. 1990.

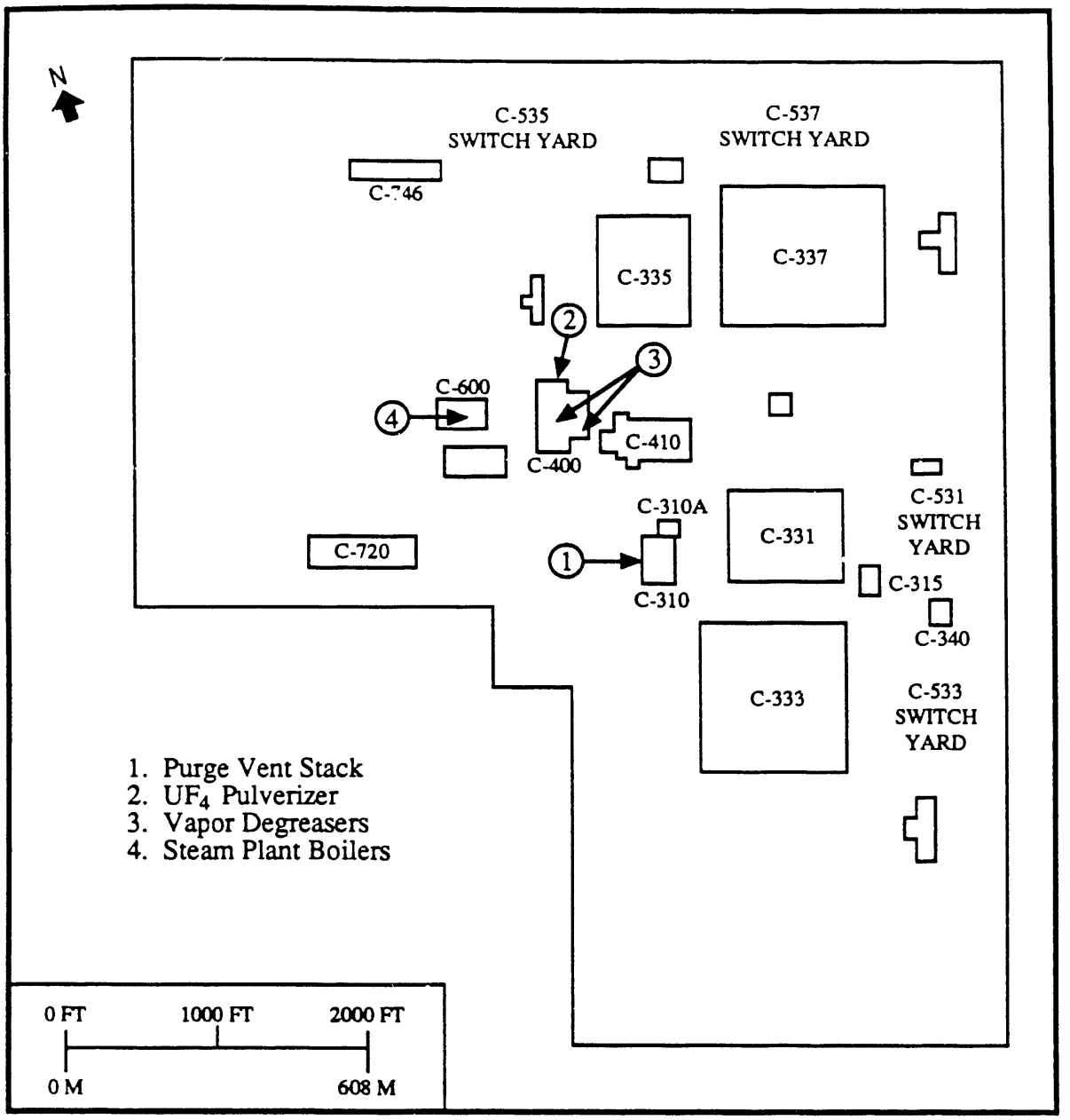


FIGURE 10 Location of Major Stationary Air-Emission Sources at PGDP (Source: Kornegay et al. 1990)

The ESPs provide clear stack emissions while the boilers are operating, but visible emissions occur during startup, shutdown, and some maintenance activities. These periods are brief and infrequent. Table 2 quantitatively summarizes PGDP chemical releases, including the steam plant emissions, in both pounds and kilograms (kg).

2. *The cascade purge vent stack at C-310.*

The C-310 stack is used as the vent for the cascade system (series of diffusion stages). Low-molecular-weight gases travel up the cascade and are released from the C-310 stack.

TABLE 2 PGDP 1989 Chemical Release Information

Chemical Name	Type of Release	Quantity (lb [kg])	Major Release Source	Basis of Estimate
SARA 313 INVENTORY CHEMICALS[a]				
Chromium[b]	Fugitive emissions	3,300 [1,500]	Cooling tower system	Material balance
Trichloro-ethylene[c]	Point source	90,000 [41,000]	C-400 degreaser/ storage tanks	Material balance
Sulfuric acid	Fugitive emissions	750 [340]	Cooling tower system	Engineering calculations
Chlorine	Fugitive emissions	7,300 [3,300]	Cooling tower system	Engineering calculations
Nitric acid	Point source	2 [1]	C-400 storage tank	Engineering calculations
OTHER LARGE INVENTORY CHEMICALS				
Fluorides	Stack emissions	15,000 [6,800]	C-310 stack emissions	Engineering calculations/ continuous stack sampling
Nitrogen	Fugitive emissions	1,700,000 [770,000]	General plant cooling	Material balance
Freon 114	Fugitive emissions	470,000 [210,000]	Process cooling	Engineering calculations
Ammonia	Fugitive emissions	450 [200]	Blueprint machines	Material balance
Freon 11	Fugitive emissions	2,600 [1,200]	Air-conditioning systems	Material balance
Freon 22	Fugitive emissions	1,000 [450]	Air-conditioning systems	Material balance
Freon 113	Fugitive emissions	1,400 [640]	C-360 flush solution for sample cool-down	Material balance
STEAM PLANT EMISSIONS				
SO_2	Stack emissions	640,000 [290,000]	Fossil fuels combustion	Emission factors[d]
NO_x	Stack emissions	620,000 [280,000]	Fossil fuels combustion	Emission factors[d]
Particulates	Stack emissions	25,000 [11,000]	Fossil fuels combustion	Emission factors[d]
Carbon monoxide (CO)	Stack emissions	18,000 [8,200]	Fossil fuels combustion	Emission factors[d]

[a]These chemicals are summarized from information compiled as required by the Superfund Amendments and Reauthorization Act (SARA) Title III, Sec. 313.

[b]Quantity calculated as chromium; chemical compound is sodium bichromate.

[c]Trichlorethylene and 1,1,1-trichloroethane.

[d]In U.S. EPA, 1986, *Compilation of Air Pollutant Emission Factors,* Vol. 1 (Suppl. A), Oct.

Source: Kornegay et al. 1990.

Released are gaseous fluorides and traces of uranium and technetium. These stack emissions are controlled by using high-speed centrifugal separation and chemical traps. The stack gases are continuously sampled, with daily analysis of the samples.

3. *Two vapor degreasers in the C-400 cleaning building.*

The two degreasers are used to clean component equipment used in the diffusion process. The larger degreaser (1.5 m × 6.9 m × 5.4 m) is large enough to accommodate the largest components of gaseous diffusion process equipment. This degreaser uses trichloroethylene (TCE) as a cleaning agent. The TCE is contained in troughs at the north and south ends of the degreaser. Steam coils in the troughs vaporize the chemical. The TCE vapor then moves to the center of the degreaser (between the troughs), where the equipment to be cleaned is positioned. Condensing coils are located near the top of the degreaser to condense and recycle the vaporized TCE after it has been used to degrease the equipment.

The second and smaller degreaser (1.5 m × 1.8 m × 1.5 m) uses 1,1,1-trichloroethane as the degreasing agent. Steam coils that vaporize the 1,1,1-trichloroethane are located in the bottom of the degreaser. Condensing coils are also used to vaporize the 1,1,1-trichloroethane after use.

The use of movable covers in both degreasers minimizes the degreasing agent losses except during equipment insertion or removal. Losses cannot be completely controlled because of the high volatility of the agents and the large area exposed. These losses are calculated by assuming that 90% of the agents is lost to the atmosphere. A project is underway to test various alternative chemicals at various locations in the plant to study the feasibility of replacing TCE and 1,1,1-trichloroethane.

4. *The UF_4 pulverizers in C-400.*

The UF_4 pulverizer stack in Building C-400 employs a high-efficiency cartridge filter as control equipment. That stack emits U-234, U-235, and U-238 as effluent. Radionuclide emissions from the stack are included in Table 3. It should be noted that potential radionuclide emissions come from only two sources, the C-310 cascade vent and the C-400 UF_4 pulverizers. Although the UF_4 pulverizers have been used in the past, they are no longer in operation and will not be restarted as operating units.

. Other air emissions not included in the tables and considered small and infrequent result from asbestos removal, boiler startup and shutdown, fire-training exercises, chemical spills, process leaks, or emissions above normal levels.

The three categories of chemical releases presented in Table 2 are amplified below.

1. Under the requirements of SARA Title III, Sec. 313 ("community right-to-know" law), a total of 309 specific chemicals and 20 chemical categories could be listed. Only chemicals that were manufactured/processed in excess of 12.5 tons or otherwise used in excess of 5 tons at the PDGP are listed in

TABLE 3 1989 PGDP Stack Emissions Summary

Stack	Control Equipment	Emissions		
		Effluent	kg/year	Curies
C-310 -- cascade vent	Chemical traps	U-234	3.4×10^{-5}	2.12×10^{-4}
		U-235	3.7×10^{-3}	8.0×10^{-6}
		U-238	2.0×10^{-1}	6.7×10^{-5}
		Tc-99	2.1×10^{-4}	3.6×10^{-3}
C-400 -- UF_4 pulverizers[a]	High-efficiency cartridge filter	U-234	0	0
		U-235	0	0
		U-238	0	0
C-600 -- steam plant	Use of low-sulfur coal, control of excess air	SO_2	292,309	
		NO_x	282,380	
		Particulates	11,272	
		CO	8,179	

[a]Did not operate in 1989 and will not be restarted.

Source: Kornegay et al. 1990.

Table 2 as "SARA 313" chemicals. Emission totals for such chemicals are often estimated quantities obtained through material balance calculations, monitoring data, or engineering calculations. In some cases, when quantitative monitoring data, inventory estimates, or emission factors were not readily available, release estimates were principally based on "best engineering judgment." Information obtained from air permits, rate of operation, quantities used, and known treatment efficiencies was also used to estimate quantities released into the environment. Assumptions based on best engineering judgment were required, in short, to perform the calculations when all variables were not known.

2. The list of "other large inventory chemicals" provides additional chemical information (not reportable under SARA 313). This category of Table 2 is not a complete list of chemicals released at the PGDP site; this list was added to include more chemicals that might be of interest to the public (such as ozone-[O_3-] depleting gases).

3. The "steam plant emissions" represent release estimates of certain chemicals from the coal- and gas-fired steam boilers at the site.

Updates and additional refinements of PGDP chemical releases are being prepared by site personnel. The three stack sources discussed in the text above -- both radioactive and nonradioactive -- are shown in Table 3. Stack emissions are shown by month for 1989 (Table 4a) and for years 1985-1989 (Table 4b).

TABLE 4a 1989 PGDP Monthly Stack Effluent Pollutant Emissions[a]

Emission Type/Source	January	February	March	April	May	June	July	August	September	October	November	December
Uranium												
C-310 purge vent stack (g)	2	2	3	2	2	2	1	3	2	182	2	2
C-400 pulverizer (g)[b]	0	0	0	0	0	0	0	0	0	0	0	0
Technetium												
C-310 purge vent stack (mg)	8	2	<1	8	5	1	116	48	5	13	3	1
C-310 purge vent stack (μCi)	135.2	33.8	<16.9	135.2	84.5	16.9	1,960.4	811.2	84.5	219.7	50.7	16.9
Nitrogen oxide												
C-600 stack (kg)	25,960	25,633	26,061	26,173	20,736	19,085	19,450	19,431	19,579	23,327	25,455	31,490
Sulfur dioxide												
C-600 stack (kg)	26,970	26,414	26,805	27,189	21,517	19,786	20,190	20,177	20,262	24,174	26,390	32,435
Particulates												
C-600 stack (kg)	1,039	1,021	1,037	1,046	829	762	777	777	781	932	1,017	1,254
Carbon monoxide												
C-600 stack (kg)	744	753	769	750	596	550	559	558	567	674	734	925

[a]Units used are grams (g), milligrams (mg), microcuries (μCi), and kilograms (kg).

[b]Includes data only for the period the process was in operation. This unit was not in operation in 1989 and will not be restarted.

Source: Kornegay et al. 1990.

TABLE 4b 1985-1989 Total Annual Stack Effluent Pollutant Emissions

Emission Type/Source	1989	1988	1987	1986	1985
Uranium					
C-310 purge vent stack (g)	205	16	34	46	2,900
C-400 pulverizer (g)[a]	0	119	529	636	1,332
Technetium					
C-310 purge vent stack (mg)	211	221	56	520	600
C-310 purge vent stack (μCi)	3,565.9	3,732	890	8,956	10,250
Nitrogen oxides					
C-600 stack (kg)	282,380	256,800	252,900	262,900	314,400
Sulfur dioxide					
C-600 stack (kg)	292,309	188,000	178,700	176,400	212,400
Particulates					
C-600 stack (kg)	11,272				
Carbon monoxide					
C-600 stack (kg)	8,179				

[a]Includes data only for the period the process was in operation. This unit was not in operation in 1989 and will not be restarted.

Source: Kornegay et al. 1990.

Uranium effluent released at the PGDP (Table 4b) during those five years amounted to 0.29 millicuries (mCi) (205 g). This value is an increase from 0.06 mCi of uranium emitted in 1988. The increase was due to a malfunction of the uranium effluent detector, which, if operating correctly, would have set off chemical traps that control the uranium effluent concentrations. This malfunction accounted for 88.8% of the uranium emitted from the C-310 stack in 1989. Corrective actions have been taken to lessen the possibility of uranium effluent increases above normal levels and to provide a quick indication of any upset that may occur. It is not expected that amounts of radioactivity this large would be emitted in future years.

Also during 1989, 3.6 mCi (211 mg) of technetium was released (Table 4b). This number is down from the 3.7 mCi released in 1988. There has been no new introduction of Tc-99 into the cascade and no increase of Tc-99 in product withdrawal.

2.2.2.2 Ambient Air Quality

There are two categories of air quality monitors in the vicinity of the PGDP site. The first set is operated and maintained by PGDP to assess the impact on the ambient air of various air contaminants emitted from the site. The results of these measurements are also used to demonstrate compliance with the ambient air quality standards for gaseous fluorides established by the KDAQ. The second set of monitoring stations is run by the state of Kentucky over the entire state, and these stations measure particulate matter (both TSP and particulates with an aerodynamic diameter of 10 microns or less [PM_{10}]), SO_2, CO, O_3, NO_x, and lead (Pb). Each set of monitoring stations will be discussed in turn.

1. *PGDP Site Monitors.*

Ambient air is sampled continuously for gaseous fluorides and radioactive particulates at four locations monitored by the PGDP (Fig. 11):

- Plant North (PN), Plant South (PS), Plant East (PE), and Plant West (PW) within the plant fence;
- Boundary North (BN) and Boundary East (BE) at the plant boundary;
- One North (1N), One South (1S), One West (1W), One East (1E), and One Southeast (1SE) at 1 mi from the fence; and
- Grahamville (GR), the nearest community.

Air-sampling equipment consists of filters treated with sodium carbonate for ambient collection of fluorides. These filters are exchanged and analyzed each week for alpha and beta activity and fluoride concentrations. The results of the analyses are used to evaluate compliance with KDAQ air-quality standards for gaseous fluoride ambient. Ambient air measurements for 1989 are summarized for fluorides (Table 5a) and radioactivity (Table 5b). The average concentration of fluoride is between 4% and 7% of the maximum weekly average of 2 parts per billion (ppb). Therefore, compliance with Kentucky Secondary Ambient Air Quality Standards (401 Kentucky Administrative Regulations [KAR] 53:010) is continuously achieved. Regulations for airborne radionuclide emissions under the limits of total plant off-site radiological dosages to the public as specified by the National Emissions Standards for Hazardous Air Pollutants (NESHAP). The maximum off-site radiological dose attributable to 1989 PGDP emissions is a 50-yr committed effective dose equivalent of 1×10^{-4} millirems (mrem). The dose is a small fraction of the limit imposed by the regulations. The radioactivity air-sampling results in Table 5b are expressed as microcuries per milliliter (μCi/mL).

2. *State of Kentucky Monitors.*

Monitoring stations operated by the state of Kentucky provide estimates of the criteria pollutant concentrations and other relevant air pollutants that may be used as baseline values for the PGDP vicinity. Criteria pollutants are particulate matter (measured as PM_{10}), SO_2, CO, O_3, NO_x,

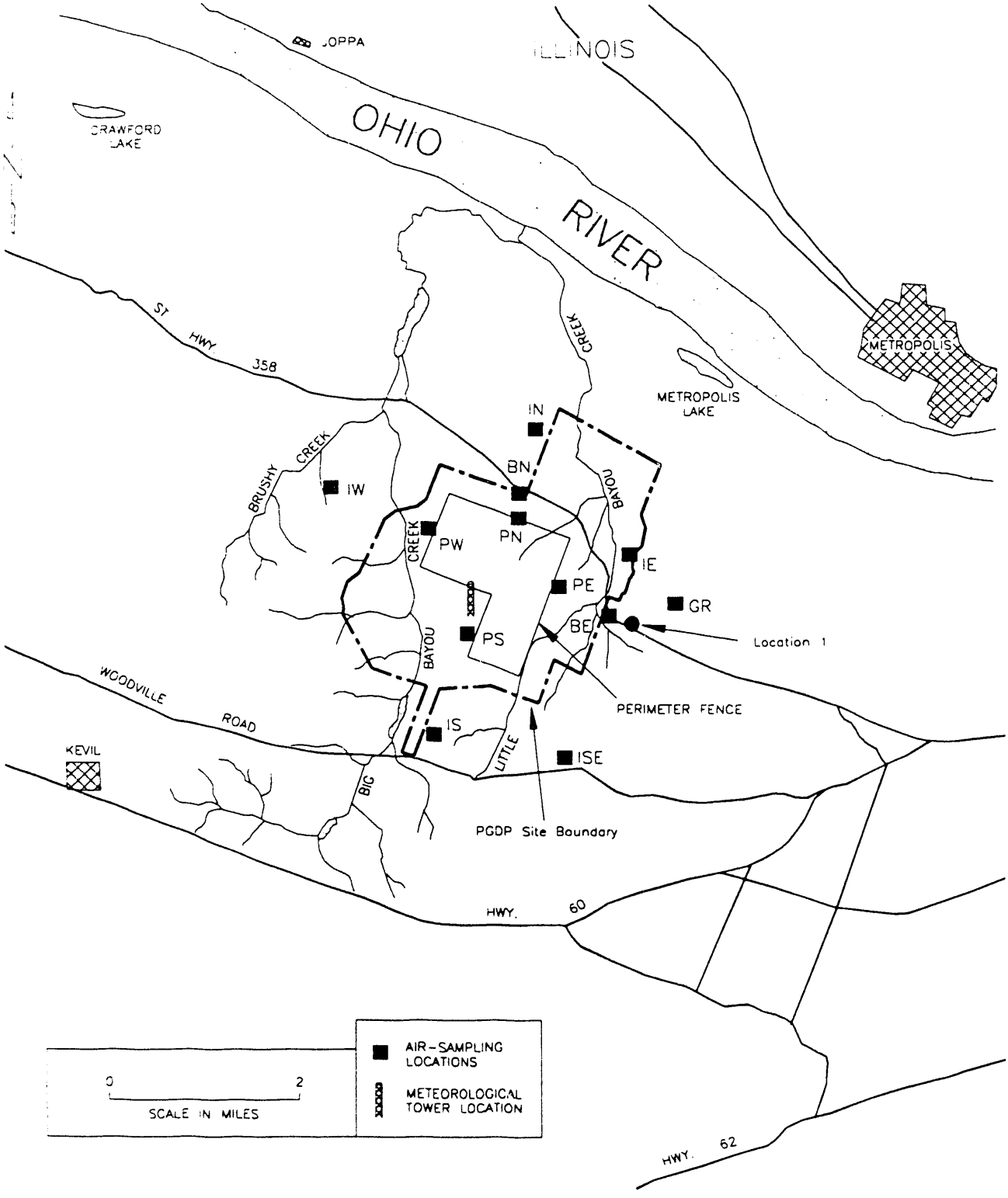


FIGURE 11 Location of Air-Sampling and Meteorological Monitoring Stations at PGDP (Source: Adapted from Kornegay et al. 1990)

TABLE 5a 1989 PGDP Air Sampling for Fluorides[a]

Sampling Point[b]	No. of Samples	Concentration (ppb HF)			Percent of 1-Week Average
		Min.	Max.	Avg.[c]	
PN[d]	51	0.07	0.615	0.206	d
PE[d]	49	0.056	0.184	0.118	d
PS[d]	50	0.058	0.207	0.105	d
PW[d]	51	0.078	0.215	0.123	d
BN	51	0.068	0.312	0.138	7
BE	52	0.061	0.126	0.089	4
1N	49	0.061	0.147	0.093	5
1E	46	0.049	0.125	0.081	4
1SE	48	0.049	0.137	0.077	4
1S	49	0.053	0.188	0.081	4
1W	50	0.054	0.124	0.077	4
GR	47	0.026	0.149	0.083	4

[a]Gaseous fluorides expressed as hydrogen fluoride (HF).

[b]Located in Fig. 11, with abbreviations defined in text above under "PGDP Site Monitors."

[c]Kentucky Secondary Ambient Air Quality Standards (401 KAR 53.010); maximum 24-hour (h) average is 3.5 ppb as HF; maximum 1-week (wk) average is 2.0 ppb as HF; monthly average is 1.0 ppb as HF.

[d]Sampling locations are on government property inside the plant perimeter fence; therefore, results were not presented. For comparison, the 40-h occupational threshold limit value (TLV) for HF is 3000 ppb.

Source: Kornegay et al. 1990.

and Pb. Table 6 presents Kentucky air quality regulations and the estimates of ambient levels of the relevant pollutants that may be seen at the PGDP site. Monitoring stations in Paducah function as part of the Paducah-Cairo Interstate Air Quality Control Region for most pollutants (PM_{10}, TSP, SO_2, CO, and O_3). Estimates of fluoride concentrations were obtained from data measured by PGDP personnel within the site boundary. Kentucky has no monitoring system for fluorides. As Table 6 indicates, the Paducah area is in attainment for all air pollutants.

The Paducah area is not heavily industrialized. Only a few important sources of air pollution exist: an Allied Signal Corp. UF_6 conversion plant a few miles north of the PGDP at Metropolis, Illinois; the coal-fired TVA Shawnee plant, about 15 mi north of Paducah; and a Calvert City industrial complex, 15-20 mi east-northeast of Paducah.

TABLE 5b 1989 PGDP Air Sampling for Radioactivity (μCi/mL)

Sampling Point[a]	Gross Alpha (μCi/mL × 10^{-14}) Min.	Max.	Avg.	Gross Beta (μCi/mL × 10^{-13}) Min.	Max.	Avg.	No. of Samples
PN	-0.32[b]	5.12	0.36	0.00	1.18	0.36	51
PE	-0.26	1.00	0.24	0.00	1.00	0.31	49
PS	-0.24	0.72	0.25	0.00	0.78	0.32	50
PW	-0.26	1.36	0.29	0.00	1.36	0.35	51
BN	-0.14	4.82	0.29	0.09	1.11	0.34	51
BE	-0.23	1.18	0.27	0.00	2.29	0.34	52
1N	-0.25	1.48	0.22	0.10	0.62	0.32	49
1E	-0.20	5.07	0.33	0.00	0.86	0.30	46
1SE	-0.34	0.79	0.21	0.08	0.60	0.31	48
1S	-0.11	4.77	0.32	0.00	0.78	0.32	49
1W	-0.20	0.72	0.24	0.06	0.91	0.31	50
GR	-0.41	5.40	0.33	0.00	0.66	0.31	47

[a]For locations and the meaning of the sampling point abbreviations, see footnote b, Table 5a.

[b]Because of fluctuations in the instrument used to analyze for radioactivity, the background count is higher than that for the sample; this explains the negative count.

Source: Kornegay et al. 1990.

2.3 Noise

The ambient noise levels in the area of the PGDP are low for two reasons: the rural location of the site and the relatively distant locations of the nearest residences to the noise sources. The residence nearest to the proposed location of the U-AVLIS plant borders Route 358, which runs from the east side of the plant through Grahamville (about 0.5 mi from the site boundary). In Fig. 11, the location of this residence is identified as Location 1. During a field measurement survey taken on July 2, 1991, at 8:30 a.m., it was not possible to hear the noise from the plant at this residence, even though the plant was then in full operation.

Measured ambient noise levels at Location 1 were as follows:

31 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	16 kHz	A-weighted decibels (dBA)
56	50	45	41	40	30	35	45	42	26	44

TABLE 6 State of Kentucky Air Quality Regulations and Estimates of PGDP Background Ambient Levels

Contaminant[a]	Primary Standard[a]	Secondary Standard[a]	Estimated PGDP Background Level
Sulfur oxides (sulfur dioxide) ($\mu g/m^3$)			
Annual arithmetic mean	80 (0.03 ppm)	–	16[c]
Maximum 24-hour average	365 (0.14 ppm)[b]	–	83[c]
Maximum 3-hour average	–	1300 (0.50 ppm)[b]	302[c]
Particulate matter, measured as PM_{10} ($\mu g/m^3$)			
Annual arithmetic mean	50[d]	50[d]	39[c]
Maximum 24-h average	150[e]	150[e]	135[c]
Carbon monoxide (mg/m^3)			
Maximum 8-h average	10 (9 ppm)[b]	Same as primary	3.7[c]
Maximum 1-h average	40 (35 ppm)[b]	Same as primary	6.1[c]
Ozone ($\mu g/m^3$)			
Maximum average	235 (0.12 ppm)[f]	Same as primary	200[c]
Nitrogen dioxide ($\mu g/m^3$)			
Annual arithmetic mean	100 (0.05 ppm)	Same as primary	32[c]
Lead ($\mu g/m^3$)			
Maximum arithmetic mean averaged over a calendar quarter	1.5	Same as primary	0.05 g[f]
Hydrogen sulfide ($\mu g/m^3$)			
Maximum 1-h average	–	14 (0.01 ppm)[b]	h
Gaseous fluorides, expressed as HF ($\mu g/m^3$)			
Annual arithmetic mean	400 (0.5 ppm)	–	0.16[i]
Maximum 1-month (mo) average	–	0.82 (1.00 ppb)[b]	–
Maximum 1-wk average	–	1.64 (2.00 ppb)[b]	0.615[i]
Maximum 24-h average	800 (1.0 ppm)[b]	2.86 (3.5 ppb)[b]	–
Maximum 12-h average	–	3.68 (4.50 ppb)[b]	–

TABLE 6 (Cont'd)

Contaminant[a]	Primary Standard[a]	Secondary Standard[a]	Estimated PGDP Background Level
Total fluorides (ppm) Dry weight basis (as fluoride ion) in and on forage for consumption by grazing ruminants. The following concentrations are not to be exceeded:			
Average concentration of monthly samples over growing season (not to exceed 6 consecutive months)	-	40 ppm (w/w[j])	-
2-mo average	-	60 ppm (w/w[j])	-
1-mo average	-	80 ppm (w/w[j])	-
Odors		At any time when 1 volume unit of ambient air is mixed with 7 volume units of odorless air, the mixture must have no detectable odor.	Not available

[a]Units are micrograms per cubic meter (μ/m^3) and milligrams per cubic meter (mg/m^3). In primary and secondary Kentucky standards, parts per million (ppm) values are alternative ways of expressing the units.

[b]This average is not to be exceeded more than once per year.

[c]Paducah, McCracken County (1390 Irvin Cobb Drive).

[d]The standard is attained when the expected annual arithmetic mean concentration is less than or equal to 50 $\mu g/m^3$.

[e]The standard is attained when the expected number of days per calendar year with a 24-h average concentration above 150 $\mu g/m^3$ is equal to or less than 1.

[f]The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm (235 $\mu g/m^3$) is equal to or less than 1.

[g]Highest value measured in state of Kentucky, at Louisville, in Jefferson County.

[h]Not measured in state of Kentucky monitoring system.

[i]Based on PGDP date obtained on site.

[j]Weight of fluoride ion per weight of forage unit.

Source: Kentucky 1991.

These measurements represent 10-second (s) averages when cars could not be heard. Automobile traffic is the main source of noise at this residence during the day, but the measurements made were aimed at eliminating those transient passbys and obtaining residual background levels. Background noise levels presented above did include noise made by birds and background mass transportation noise far off in the distance. These measured noise levels are low and representative of a rural environment.

2.4 Water Resources

2.4.1 Regional Surface Water

The PGDP is situated in the western part of the Ohio River Basin. About 4 mi north of the site, the Ohio River flows west to the Mississippi River, about 34 mi distant. Two creeks drain across the site (Fig. 12). Little Bayou Creek, an intermittent creek, drains the eastern boundary of PGDP, and has a drainage area of 8.5 square miles (mi^2). The other is Big Bayou Creek, which drains the southwestern part of the site. The latter has a drainage area of 18.6 mi^2. These two creeks join together and discharge to the Ohio River.

The Ohio River has a drainage area of about 203,000 mi^2. At Metropolis, Illinois, about 4 mi upstream from the confluence of the Big Bayou and Little Bayou creeks, the Ohio River has a 61-yr average discharge of 270,000 cubic feet per second (cfs) (USGS 1990). The maximum discharge of 1,780,000 cfs occurred on February 1, 1937. The recorded minimum daily discharge of 15,000 cfs occurred on July 30, 1930. The flow in the Ohio River is regulated through several dams (CH_2M HILL 1991). The downstream dam nearest to the site is about 12 mi from the confluence of the two creeks upstream of the Ohio River (the confluence is located about 3 mi north of PGDP). The nearest upstream dam is about 11 mi above the confluence. The level of the Ohio River in the PGDP area is controlled by the downstream dam.

The record flood of the Ohio River for this area occurred in January 1937, with a high-water mark of 347.0 ft MSL or 28 ft below the lowest elevation of the PGDP site (Martin Marietta 1991). Preliminary assessment of the probable maximum flood (PMF) level on the Ohio River shows that the PGDP site is 10 to 20 ft above the PMF level on the basis of 10^{-6} to 10^{-8} annual probability of occurrence (Martin Marietta 1990). A comprehensive flood hazard assessment is being prepared (Martin Marietta 1990).

2.4.2 Local Surface Water

The PGDP is located on a local drainage divide. Surface runoff from the eastern part of the site flows to Little Bayou Creek, while runoff from the western part flows to Big Bayou Creek. The flow of both creeks responds rapidly to precipitation (Saylor et al. 1990). During dry weather, discharge from the PGDP contributes almost 100% of the normal flow in Little Bayou Creek and 85% of the normal flow in Big Bayou Creek. Over the 1-yr period from October 1987

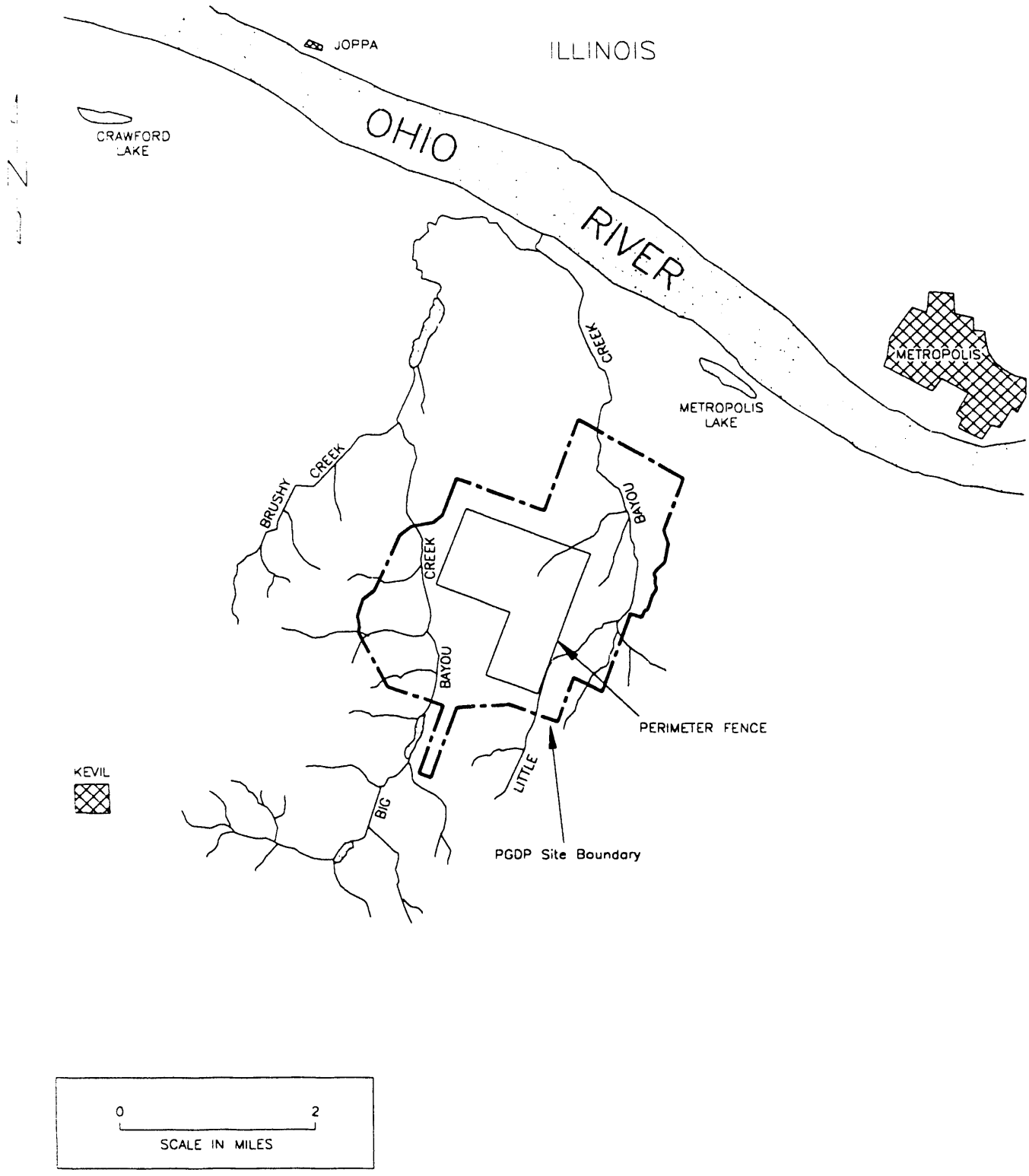


FIGURE 12 Surface Water Bodies in the Vicinity of PGDP (Source: Adapted from Saylor et al. 1990)

to November 1988, the average discharge to Big Bayou Creek was approximately 4 million gallons/day (mgd), and the average discharge to Little Bayou Creek was about 0.7 mgd (CH_2M HILL 1991).

The water quality of Big Bayou and Little Bayou creeks is heavily influenced by the quality of the PGDP effluent discharges. Since 1958, the site has monitored surface water for contamination, primarily radionuclides. A review of the historical monitoring program has been published (CH_2M HILL 1991). In October 1989 and August 1990, surface waters were sampled in the two creeks and their tributaries at locations upstream and downstream of the site -- as well as at Kentucky Pollutant Discharge Elimination System (KPDES) outfalls at the PGDP -- and chemically analyzed for volatile and semivolatile organic constituents, pesticides, polychlorinated biphenyls (PCBs), metals, and radionuclides (CH_2M HILL 1991). The 1990 data indicate that the calcium, magnesium, potassium, and sodium ion concentrations of the two creeks downstream of the site are 25 milligrams per liter (mg/L), 60 mg/L, 21-32 mg/L, and 25-32 mg/L, respectively. The chloride, nitrogen, and sulfate concentrations are 21-27 mg/L, 0.23-0.60 mg/L, and 59-88 mg/L, respectively (CH_2M HILL 1991). Technetium-99 was detected at low levels (up to 37 picocuries per liter [pCi/L]) in both creeks. Uranium-234 and -238 are also reported in Little Bayou Creek. Chloroform at low concentrations (about 1 and 2 micrograms per liter [µg/L]) is the only organic chemical found in Big Bayou Creek. Detailed information on the water quality is provided in CH_2M HILL (1991).

Technetium-99, thorium-230, and uranium -- ranging up to 744 picocuries per gram (pCi/g), 346 pCi/g, and 70 pCi/g, respectively -- were present in sediments at nearly all of the ditch outfalls of the PGDP site. High levels of mixed hydrocarbons were present at outfalls that are tributaries of Big Bayou and Little Bayou creeks. Dioxins in low concentrations were detected at outfalls leading to Big Bayou Creek. PCBs were present in sediments at one outfall leading to Little Bayou Creek. Anomalous concentrations of a variety of metals, such as arsenic (5.2 milligrams per kilogram [mg/kg]), aluminum (7,300 mg/kg), chromium (25.2 mg/kg), lead (11 mg/kg), vanadium (24.9 mg/kg), and zinc (18.11 mg/kg), were reported at one outfall leading to Little Bayou Creek. A detailed description of sediment contaminations at the outfalls is provided in CH_2M Hill (1991).

2.4.3 Regional Groundwater

The Gravel Facies of the Continental Deposits is the major aquifer of regional importance in the vicinity of the PGDP. The gravel is saturated over most of its areal extent in the region and is capable of yielding up to 1,000 gallons per minute (gpm) in wells (Early et al. 1989). In general, the groundwater flow direction of the aquifer is north toward the Ohio River (Hansen 1966; Lambert 1966; CH_2M HILL 1991). Figure 13 shows the potentiometric surface for the gravel aquifer.

The water levels of the aquifer typically were on the order of 40 to 50 ft below the ground surface (CH_2M HILL 1991). Based on field and laboratory data, the hydraulic conductivities of the aquifer are estimated to range from 0.28 to 2,800 feet per day [ft/d] (Early et al. 1989). The average saturated thickness of the aquifer is estimated to be 25 ft (CH_2M HILL 1991).

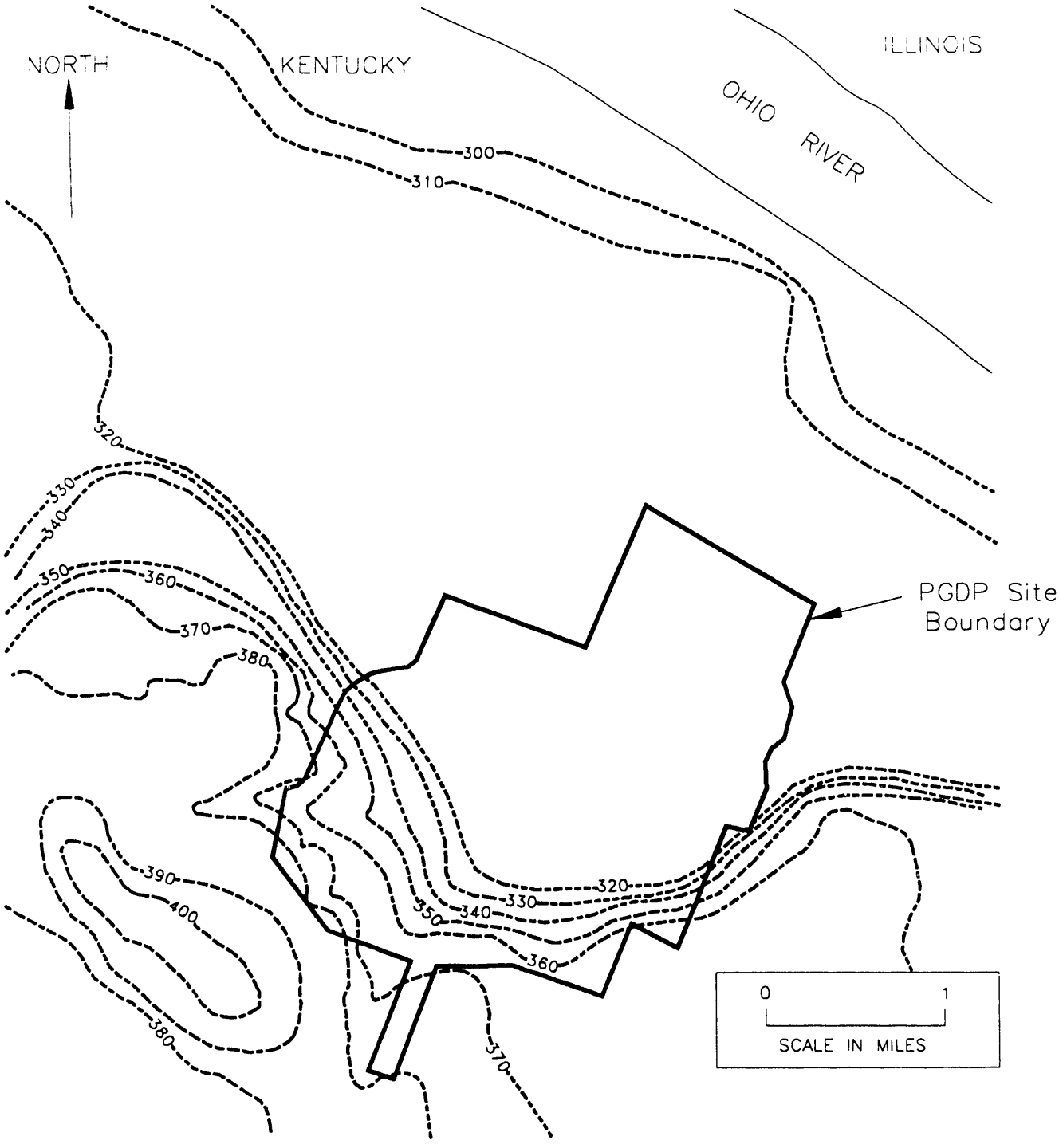


FIGURE 13 Regional Potentiometric Surface for the Regional Gravel Aquifer (Source: Adapted from CH_2M HILL 1991)

In addition to the gravel aquifer of the Lower Continental Deposits, the sand lenses in the Upper Continental Deposits and that unit's overlying loess constitute a shallow aquifer; the hydraulic conductivities of the sand lenses range from 0.028 to 28 ft/d (CH_2M HILL 1991). The Eocene Sands, Porters Creek Clay, and Clayton and McNairy formations form a deep groundwater system; typically, the system has a water level on the order of 40 to 60 ft below the ground surface. The groundwater of this system flows toward the Ohio River (CH_2M HILL 1991).

2.4.4 Local Groundwater

Two groundwater systems and one major aquifer have been classified in the PGDP area (CH_2M HILL 1991). Surficial loess and the Upper Continental Deposits unit form the shallow groundwater system. The Lower Continental Deposits unit forms the regional gravel aquifer. Bedrock below the Continental Deposits forms the deep groundwater system.

2.4.4.1 Shallow Groundwater System

Groundwater in the shallow groundwater system moves primarily by means of vertical infiltration, through sand lenses and layers in the Upper Continental Deposits. Interpretation of potential groundwater movement is complicated by the heterogeneity of the geologic materials and the assumptions used in geologic interpretation. For example, if the loess deposits in the southern part of the plant area are considered as part of the shallow groundwater system, the groundwater in this part of the plant area probably moves to the north, while the groundwater in the western part of the plant area probably moves to the east (Fig. 14). The hydraulic conductivities of the sand lenses in the Upper Continental Deposits range from 0.028 to 28 ft/d; the conductivities in the loess range from 0.00028 to 0.28 ft/d (Early et al. 1989).

2.4.4.2 Regional Gravel Aquifer

The regional gravel aquifer is continuous from the southern part of the plant to the floodplain of the Ohio River. The water levels of this aquifer are on the order of 40 to 50 ft below the ground surface. Groundwater predominantly flows to the north (Fig. 15). The hydraulic conductivities of the aquifer range from 0.28 to 2800 ft/d (Early et al. 1989).

2.4.4.3 Deep Groundwater System

The deep groundwater system is contained in the Eocene Sands and older bedrock. Because of the shortage of data and also the many layers of bedrock involved, properties of this groundwater system are not clearly known. A more detailed discussion of this system is provided in CH_2M HILL (1991).

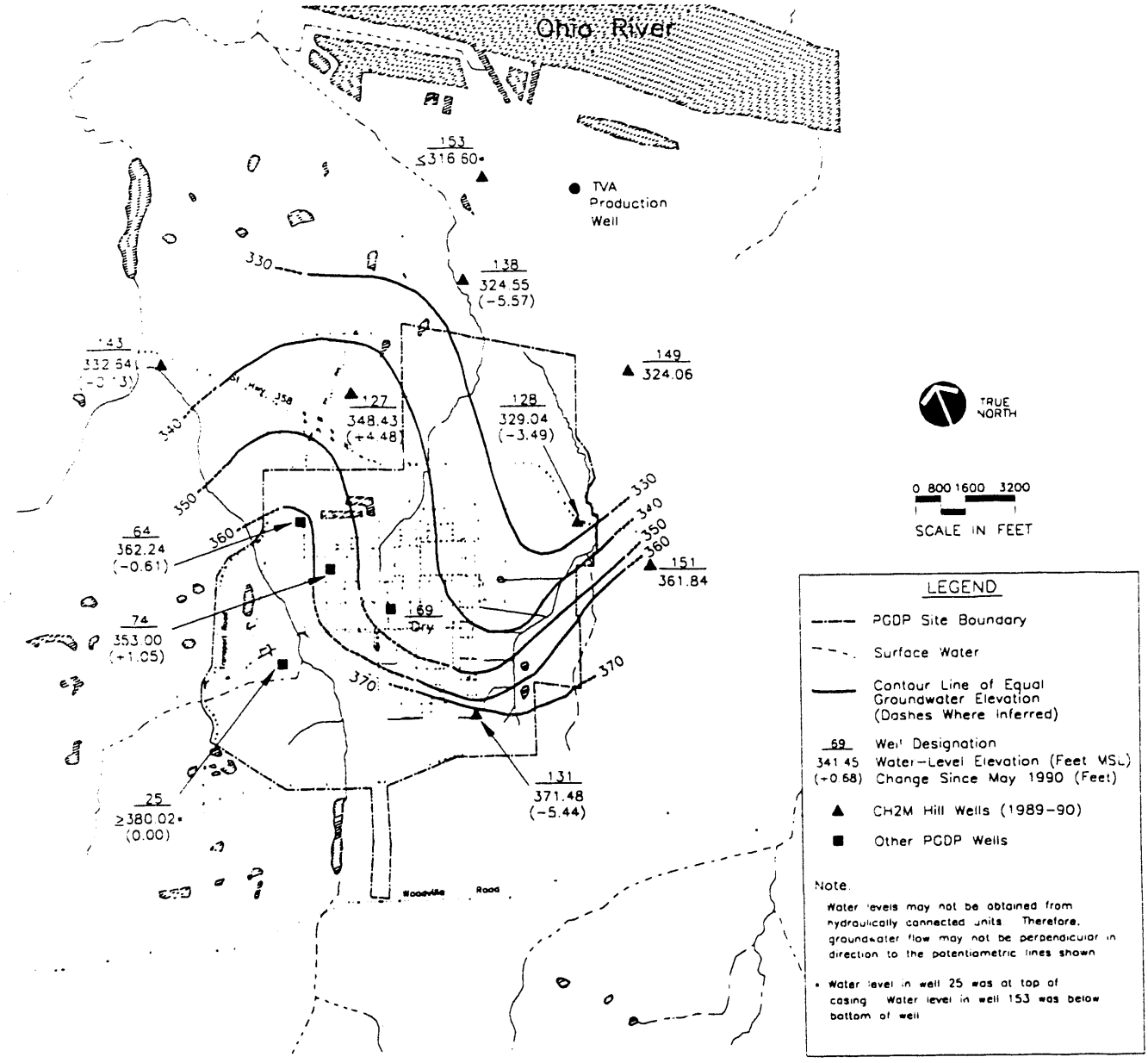


FIGURE 14 Water-Level Elevations and Changes in the Shallow Groundwater System, October 1990 (Source: Adapted from CH_2M HILL 1991)

2.4.4.4 Groundwater Quality

In the two groundwater systems and the major aquifer, calcium in groundwater typically varied between 15 and 50 mg/L. Sodium was typically found at similar or higher concentrations. Concentrations may vary over a factor of two between two sampling rounds or between two adjacent wells. The pH values typically ranged from 6.0 to 7.5 (CH_2M HILL 1991).

Groundwater contamination has occurred at many of the PGDP waste management units. Various levels and types of contamination were found in the shallow groundwater system and the regional gravel aquifer both on-site and off-site (CH_2M HILL 1991). The deep groundwater

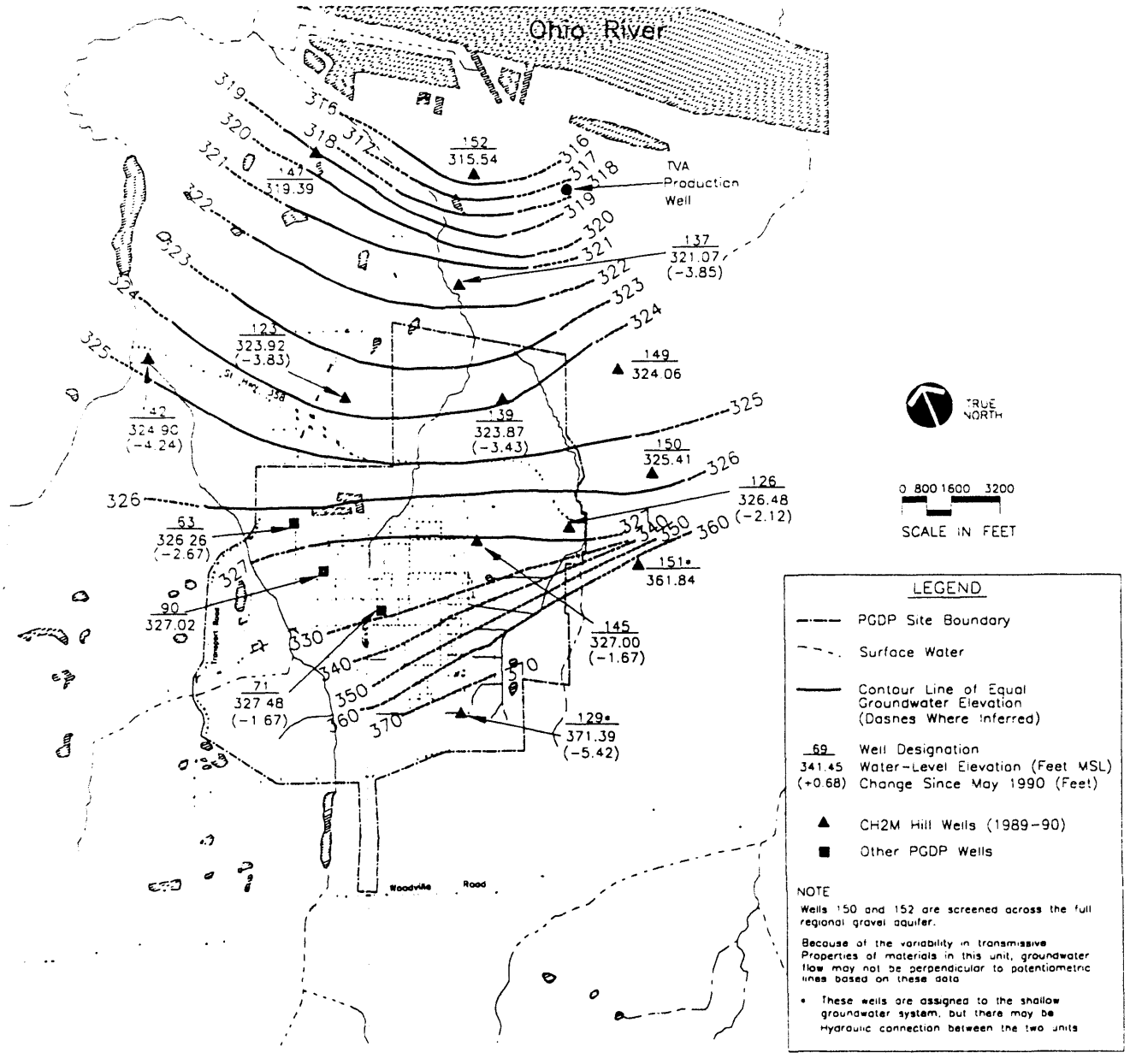


FIGURE 15 Potentiometric Surface and Changes for the Regional Gravel Aquifer (Upper Part) at the PGDP Site, October 1990 (Source: Adapted from CH_2M HILL 1991)

system does not seem to be significantly contaminated. In Figs. 16 and 17, the extents of the TCE and Tc-99 plumes in the regional gravel aquifer at the PGDP are shown. The major route of contaminant transport appears to be through the regional gravel aquifer (CH_2M HILL 1991). Currently, an investigative program (CH_2M HILL 1990) is pursuing three objectives: (1) to identify and characterize on-site sources of contaminants, (2) to characterize the nature and extent of off-site contamination caused by the plant, and (3) to evaluate appropriate alternatives for remediation of off-site contamination. Other current monitoring programs include the Groundwater-Monitoring Program of the Environmental Restoration Program (ERP), and the Ambient Environmental Monitoring Program (CH_2M HILL 1990).

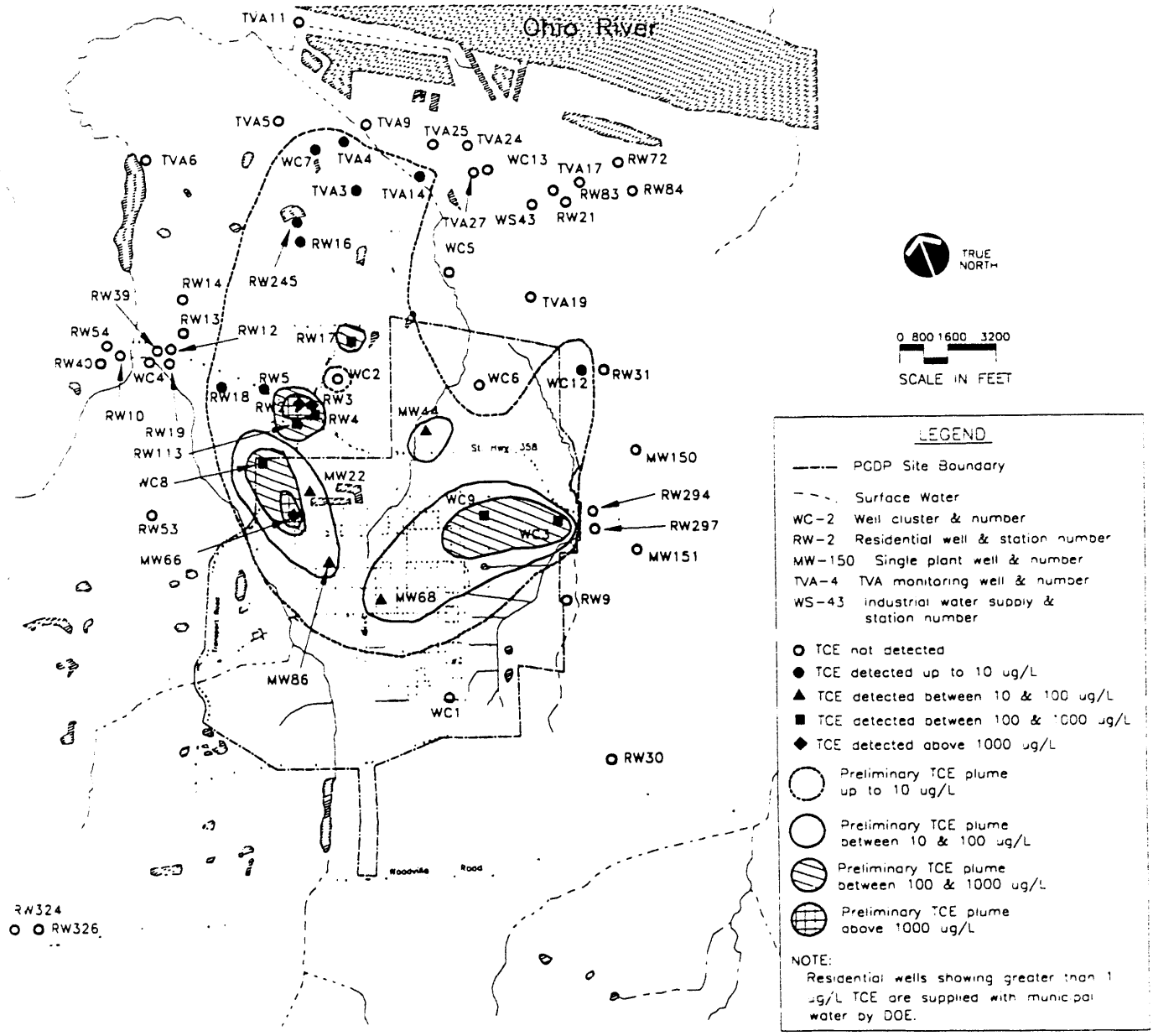


FIGURE 16 Preliminary Delineation of Off-Site TCE Plume in Regional Gravel Aquifer (Source: Adapted from CH_2M HILL 1991)

2.4.4.5 Water Use

Local residents within 1 km of the eastern site boundary use groundwater for domestic needs. However, the PGDP does not use groundwater (USDOE 1989). Instead, the plant obtains its water supply from the Ohio River through an intake structure near the Shawnee Power Plant of the TVA. The volume of water withdrawn ranges from 4 cfs at zero power production to about 45 cfs at maximum power production, with an average withdrawal of 19 cfs (Saylor et al. 1990). The Ohio River also provides water for the Shawnee Power Plant (averaging about 2406 cfs) and municipalities. The average PGDP discharge to the Ohio River through Big Bayou and Little

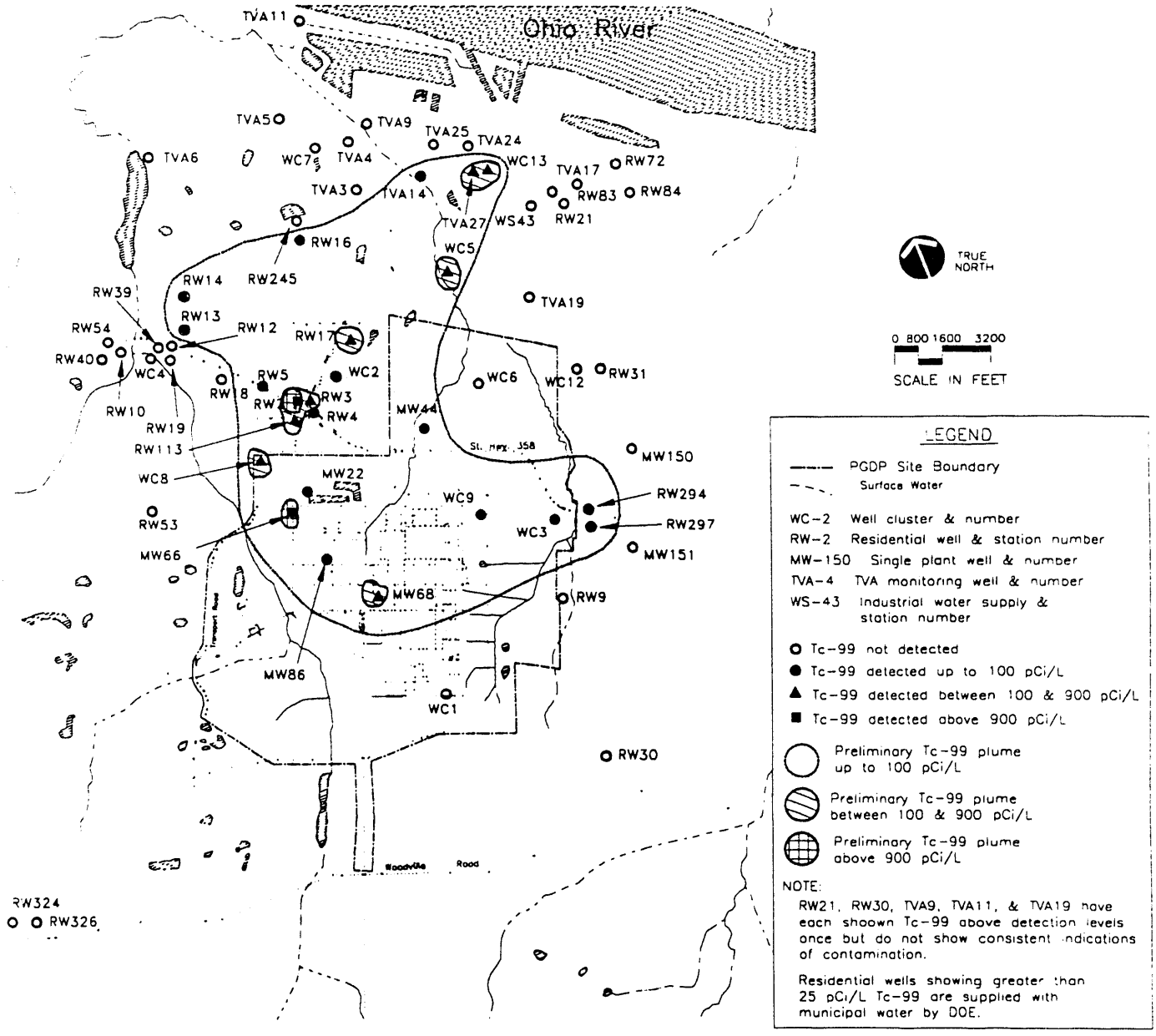


FIGURE 17 Preliminary Delineation of Off-Site Tc-99 Plume in Regional Gravel Aquifer (Source: Adapted from CH_2M HILL 1991)

Bayou creeks is about 6.3 cfs, including blowdown from cooling towers, sewage discharge, once-through cooling, and stormwater runoff (Saylor et al. 1990).

2.4.5 Water Regulations

2.4.5.1 Federal Regulations

DOE Order 5400.1 specifies that DOE facilities comply with all applicable environmental statutes, regulations, and standards, and DOE Order 5480.1 requires monitoring of effluent to the

environment, including groundwater, to ensure that radiation doses to the public are maintained as low as reasonably achievable and are consistent with prescribed dose standards (Douthitt 1990).

The Safe Drinking Water Act and the Clean Water Act provide the criteria for federal ambient water quality regulation. The former provides certain maximum contaminant level (MCL) values as part of the national primary drinking water regulations (40 CFR 141). The MCLs apply to both surface and underground public drinking water supplies and are enforceable federal standards that apply to remedial action alternatives. Recommended values that are not legally enforceable should also be considered in an analysis of remedial action alternatives. These included the maximum contaminant level goals (MCLGs) and the water quality criteria in the Clean Water Act.

2.4.5.2 State of Kentucky Regulations

The Commonwealth of Kentucky has U.S. Environmental Protection Agency (EPA) authorization for administering the monitoring and protection of water resources. State regulations are promulgated and enforced by the Kentucky Department of Environment Protection, Division of Air Quality, Water Quality and Waste Management. Kentucky water pollution control and groundwater protection programs are described in the KAR and include the following regulations: 401 KAR 5:005, 010 (waste discharge); 401 KAR 5:50, 55, 60, 65, 70, 75, 80, 85, 90 (Pollution Discharge Elimination System permitting program); 401 KAR 5:026, 029, 031, 035 (water quality standards); 401 KAR 34:060 (groundwater protection); and 401 KAR 35:060 (groundwater monitoring).

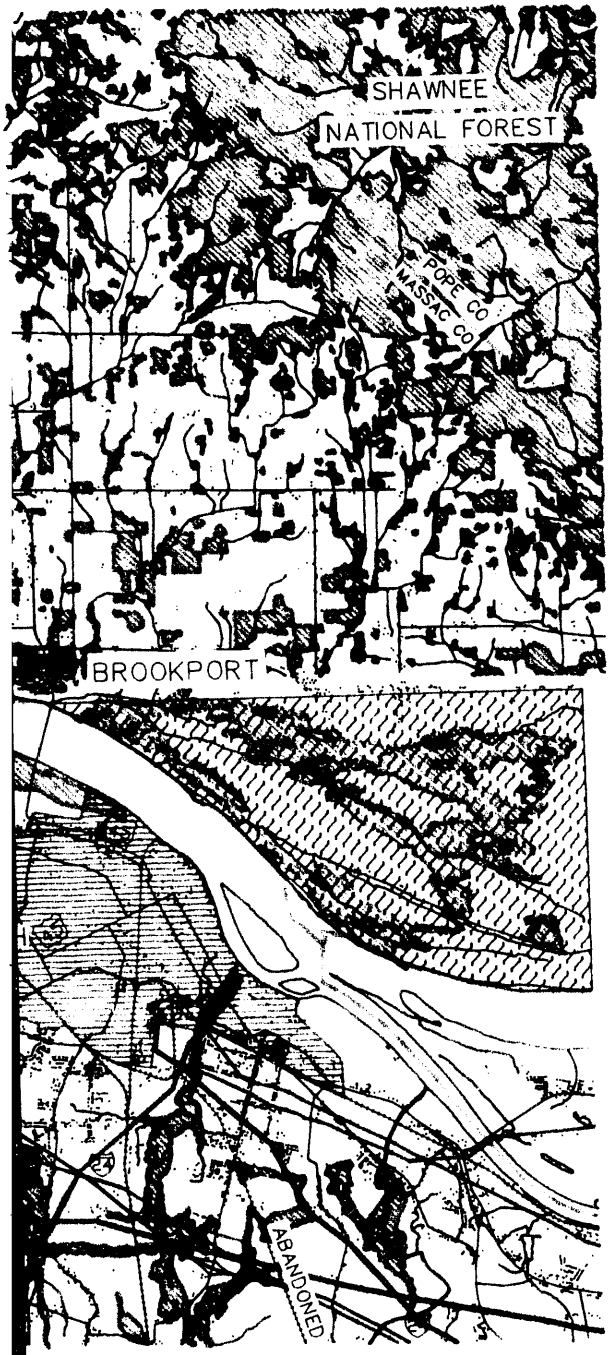
2.5 Land Use, Recreation, and Visual Resources

2.5.1 Land Use (Fig. 18)

The proposed U-AVLIS production plant site is located in rural northwest McCracken County, Kentucky, approximately 12 mi west of Paducah and 3.6 mi south of the Ohio River, within the confines of a 3,423-acre reservation containing the PGDP. The DOE has turned over 2,080 acres of the reservation to the Kentucky Department of Fish and Wildlife Resources (KDFWR), which administers it as a wildlife management area. However, a stipulation in the 1953 agreement granting the land to KDFWR allows the DOE to utilize any or all of the KDFWR land whenever the need arises (Martin Marietta 1991). The TVA owns most of the land north of the PGDP (south of the Ohio River), and approximately 75% of the land within a 5-mi radius of the PGDP is in agricultural use or dedicated to open space (Saylor et al. 1990). The nearest population concentration to PGDP is in the unincorporated community of Grahamville, about 2 mi east, with an estimated 1990 population of 1,404 (PDMC 1991).

The study area for this section's analysis consists of Ballard, Graves, and McCracken counties in Kentucky, and the southern Illinois counties of Johnson, Massac, and Pulaski.

igure 18 Land Use in the Study Area



LEGEND

- Agricultural
- Bottom Land
- Parks
- Urban
- Woodlands
- County Borders
- Pipelines
- Railroads
- Transmission Lines

Agricultural land uses account for approximately 60% of total land in the study area, although the number of farms in the study area has steadily decreased since World War II. Almost 25% of the remaining land in the study area is forest land. McCracken County, which includes the study area's largest city (Paducah), has a greater percentage of land area dedicated to residential land uses than any of the other counties in the study area. The PGDP accounts for approximately 2% of McCracken County's total land area. Industrial uses account for less than 5% of the land within the study area. Table 7 depicts farm and forest land acreage for each county in the study area.

Massac and Pulaski counties, both in Illinois, led the study area in land dedicated to agricultural uses (68%). In 1987, corn and soybeans were the primary crops grown in Massac County, but the county contained four fruit orchards and several livestock farms as well. Almost 21% of the county was in forest land. The primary crops grown in Pulaski County in 1987 were corn and sorghum (CPPCD 1991). Johnson County, which had 49% of its land dedicated to agriculture in 1987, produced mainly soybeans and corn. Forest land accounted for 38% of the county's land.

In Kentucky, McCracken County had the smallest percentage (44%) of land area dedicated to agricultural uses. Ballard County had 65% of its land dedicated to agriculture in 1987;

TABLE 7 Selected Land Uses in the Study Area, 1987

County, by State	Total Land Area (acres)	Land in Farms (acres)	Number of Farms	Forest (acres)
KENTUCKY				
Ballard	162,560	105,236	433	-
McCracken	160,640	70,148	434	98,600[a]
Graves	356,480	220,710	1,213	76,400
ILLINOIS				
Johnson	221,440	108,505	574	84,900
Massac	154,240	104,883	744	31,700
Pulaski	129,920	88,345	465	N/A[b]

[a]This figure represents the combined total for Ballard and McCracken counties.

[b]Not available.

Sources: Kentucky data and Illinois forest land data provided by City of Paducah, Planning and Community Development (CPPCD), Paducah, Kentucky; Illinois farm data provided by Southern Five Regional Planning District and Development Commission, Ullin, Illinois.

soybeans, corn, and wheat were its principal crops, and the county had several hog/pig farms operating in the same year. In Graves County, 62% of the land was used for agricultural purposes in 1987; in addition to soybeans and corn, this county produced pimentos, strawberries, milk, and beef.

Several TVA and Electric Energy, Inc. (EEI), transmission lines run through the Kentucky portions of the study area, particularly south of the PGDP. Two pipelines, one belonging to the Trunkline Gas Co. and the other owned by Shell Oil, run north-south through Ballard County, between Kevil and LaCenter. In Illinois, a natural gas pipeline owned by Central Illinois Public Service (CIPS) runs through a section of Johnson County near Vienna.

There are no military bases in the study area. However, Paducah contains a National Guard armory, a U.S. Army Reserve unit, and a U.S. Coast Guard marine safety office.

Massac County's land use plan, adopted in 1980, is the only county plan of its kind in the study area. However, the Southern Five Regional Planning District and Development Commission (SFRPDDC), made up of the five southernmost counties in Illinois, drew up a regional land use plan in 1977 (SFRPDDC 1991). The city of Paducah developed a comprehensive plan in 1988 (Talbert 1988).

2.5.2 Minerals and Mining Activity

While several coal fields and mines are located in Illinois counties just north of the study area, sand, gravel, stone, and clay are the principal minerals found within the six-county region.

In the three Kentucky counties of the study area, sand, gravel, ceramic clay, and ball clay are extracted (KGS 1991). Sand and gravel are dredged from beds along the Ohio River in McCracken County. In Graves County, ball and ceramic clays are taken from several pit operations. Gravel is produced from a pit operation near Hickory. Currently, no mineral extraction operations are in progress in Ballard County, but that county does contain reserves of gravel, ceramic clay, and lignite.

Stone aggregate, sand, and gravel are extracted from the three Illinois counties of the study area. Pulaski County has five sand and gravel pits, as well as a stone quarry located near Ullin (IDENR 1991). Five sand and gravel pits operate in Massac County, including a dredging operation on the Ohio River. A single stone quarry operates in Johnson County.

2.5.3 Recreational Resources

Numerous recreational opportunities are available within the study area and surrounding region. The West Kentucky Wildlife Management Area that borders the PGDP is a popular hunting spot for quail and deer. Land Between the Lakes (LBL), a 170,000-acre peninsula nestled between Kentucky Lake and Lake Barkley, is located approximately 35 mi southeast of Paducah. It is a major recreation and outdoor environmental education area that offers camping, fishing, swimming, boating, and more than 200 mi of designated trails (PADD 1990). The Kentucky Lake

State Resort Park, located approximately 25 mi east of Paducah, features a 72-room lodge and 221 campsites. Lake Barkley State Resort Park, near Cadiz, is approximately 50 mi southeast of Paducah. The Columbus-Belmont Battlefield State Park, located in Columbus, approximately 25 mi southwest of PGDP, has a historical hiking trail, 38 campsites, a picnic area, and a museum containing Civil War artifacts (KCED 1990).

Recreational resources in Paducah include 15 municipal parks, 13 playgrounds, 12 soccer fields, 20 tennis courts, 8 baseball diamonds, 4 lighted softball fields, 3 public swimming pools, and several picnic shelters (Martin Marietta 1990). Bob Noble Park, Paducah's largest park, features an amusement park, a 5-acre lake, 10 lighted tennis courts, an outdoor amphitheater, athletic fields, and a fitness trail. Brooks Stadium, a baseball field used for American Legion games, has a seating capacity of 3,000.

Recreational opportunities in Ballard County include Wickliffe Mounds, a Mississippian period (800-1350 A.D.) village, and hunting on any of the county's three wildlife management areas. A community park in LaCenter offers tennis courts, ballfields, a picnic area, and a playground. LaCenter also has a nine-hole public golf course. The city of Mayfield, in Graves County, has four municipal parks, five playgrounds, several baseball diamonds and tennis courts, a public swimming pool, a football stadium, and the county fairgrounds. A new YMCA facility that would include a swimming pool, racquetball courts, gymnasium, and fitness center has been proposed for the city.

Southern Illinois offers several attractions within a 90-minute (min) ride of Paducah. Cave-in-Rock, an 18th and early 19th century haven for river pirates, is located along the Ohio River in Hardin County. Fort Massac State Park contains 1,450 acres outside of Metropolis, across the Ohio River from Paducah. Fern Clyffe State Park, which offers camping, hiking, nature trails, and scenic views, occupies 1,075 acres of Johnson County. Giant City State Park, located 10 mi south of Carbondale, Illinois, and approximately 45 mi northwest of Paducah, offers camping, horseback riding, rapelling, hiking trails, and a lodge constructed by the Civilian Conservation Corps during the 1930s. The Shawnee National Forest, which consists of approximately 250,000 acres of forest land and lakes scattered across 10 southern Illinois counties, has 24 developed recreation sites that offer hiking, swimming, horseback riding, camping, boating, fishing, and scenic vistas (Martin Marietta 1990). The 11,000-acre LaRue Pine Hills Ecological Area is located in Union County, approximately 30 mi northwest of Paducah. The Illinois General Assembly recently passed riverboat gambling legislation, and the Illinois Gaming Board is expected to grant a gambling license for a riverboat casino in Metropolis in the near future (SFRPDDC 1991).

2.5.4 Transportation Network

There is a well-developed transportation network serving the study area and surrounding region. It includes two interstate highways, several U.S. highways, two major rail lines, and a regional airport (Fig. 19). Water transportation is available, with the PGDP located within 30 mi of several major rivers.

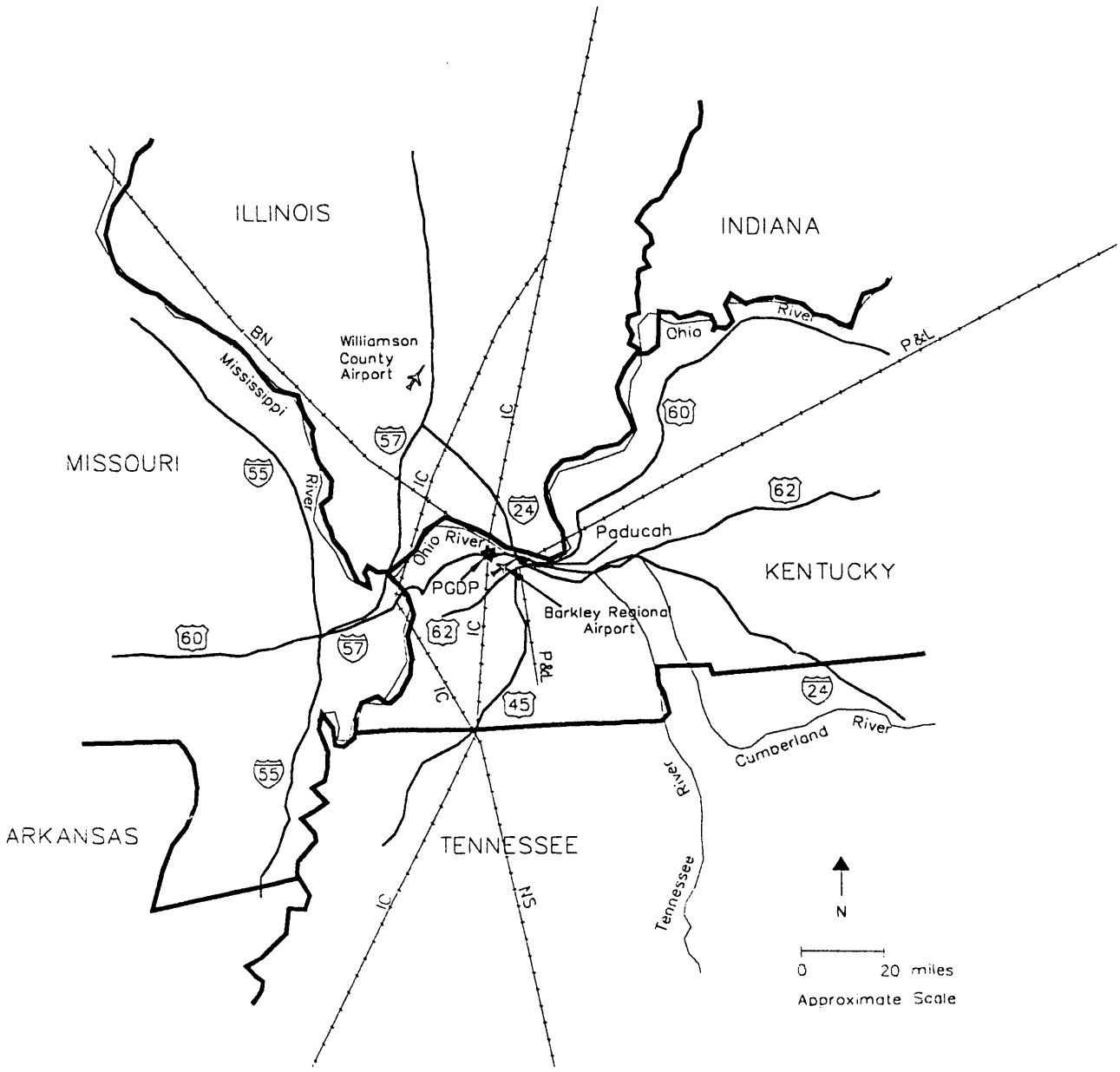


FIGURE 19 Regional Transportation Network

Interstate 24, which links the study area to Chattanooga and Interstate 75 to the south, and to Interstate 57 approximately 30 mi to the north, passes through Paducah 12 mi east of the PGDP. Interstate 24 intersects with I-40 and I-65 in Nashville.

The principal U.S. highways that serve the study area are U.S. 45, running north and south out of Paducah; U.S. 62, an east-west artery that runs south of the PGDP; and U.S. 60, which runs parallel to the Ohio River, passes through Paducah, and continues southwest approximately 2 mi south of the PGDP. State Highway 1154, which provides main access into the PGDP, runs north from U.S. 60 directly into the reservation. A traffic-count analysis of public roads surrounding the site was performed in 1989 and indicated traffic flows below capacity and minimal congestion at peak thresholds (Saylor et al. 1990).

Barkley Regional Airport, located approximately 10 mi west of Paducah, provides commercial air service through American Eagle, Northwest Airlink, and Trans World Express and charter service through Midwest Aviation and Ohio Valley Aviation. Williamson County Airport, located in southern Illinois approximately 55 mi from Paducah, offers commercial service as well.

Rail service is provided by two major lines, the Burlington Northern Railroad (BN) and the Paducah and Louisville Railroad (P&L). The BN line runs north out of Paducah into Centralia, Illinois. The PGDP is served by a branch of the P&L, which has links in the area to the Illinois Central Railroad (ICR), the BN, and CSX Transportation (Martin Marietta 1991).

The study area is well suited for water transportation, with the Ohio, Tennessee, and Cumberland rivers located within 15 mi of the PGDP. The Mississippi River flows approximately 30 mi to the west. The port of Paducah, located near the confluence of the Ohio and Tennessee rivers, is a chief distribution terminal for petroleum products, scrap metal, coal, and cement. St. Louis, New Orleans, and Pittsburgh can be easily accessed by river from Paducah.

Mass transportation is available in Paducah through the Paducah Area Transit System (PATS), which offers bus service from 6 a.m. to 6 p.m on weekdays, and from 9 a.m. until 6 p.m. on Saturdays. Recent estimates indicate that approximately 90% of the urban population of McCracken county resides within 0.5 mi of a PATS bus route (Martin Marietta 1991).

2.5.5 Visual Resources

A complete inventory of visual resources around the proposed site does not exist. However, the PGDP is located in a rural setting and is surrounded primarily by farmland and scattered woods. A TVA-owned power generating facility is located directly north of PGDP, on the south side of the Ohio River. The immediate vicinity of the PGDP has a relatively flat topography, with a few low ridges and hills to the west, south, and east. No significant viewsheds have been identified at this point.

2.6 Biotic Resources

This section describes the biotic resources of the DOE property and the fenced PGDP site (see Appendix A for species list), with emphasis on those resources that might be affected by construction and operation of the U-AVLIS facility. Additional descriptions of the ecological resources of the PGDP site have been published (USDOE 1982; Oakes et al. 1987).

2.6.1 Terrestrial Resources

The PGDP site lies within the Oak-Hickory Forest Section (Galvin 1979). Major tree species of this forest type include several species of oak (e.g., white, black, scarlet, shingle, post, and chestnut) and of hickory (e.g., shagbark, bitternut, and mockernut). Common understory

trees and shrubs include pawpaw, witch-hazel, flowering dogwood, hop-hornbeam, hawthorn, serviceberry, and sumacs (Galvin 1979).

The fenced PGDP site is surrounded by an additional 2,675 acres of DOE property. Most of the PGDP site is nonforested, consisting of mowed grass and developed areas (Saylor et al. 1990). The few upland woody areas on the site are small patches of mature and immature hardwood forest. The former are dominated by southern red oak, shagbark hickory, and post oak. The latter occur mostly within power line rights-of-way and along railroad cuts and are dominated by saplings of oak and hickory and by early to mid-successional trees such as sassafras, black cherry, red maple, and sumac.

Mature riparian forest occurs along Little Bayou and Big Bayou creeks. These stands are dominated by river birch, black willow, and cottonwood (Saylor et al. 1990) and extend along the entire lengths of both streams, including their off-site portions.

Most undeveloped nonforested areas within the DOE reservation (but outside the fenced PGDP site) are leased by the West Kentucky Wildlife Management Area (WKWMA) and are managed for wildlife habitat and food supply through mowing, plantings, and controlled burns, which curtails the natural succession of fields to forest (Saylor et al. 1990). In areas not mowed by the WKWMA, the early to mid-successional woody species listed above are among the initial woody invader species. Although hunting is not permitted on the site, bobwhite and mourning doves (the major game species in the area) occur in adjacent hunting areas.

Common amphibians include American and Woodhouse's toads, which are found throughout the PGDP site. Southern leopard and green frogs are most common in streams and ponds. Slimy salamanders are most common in forested areas. The most abundant reptile on the site is the eastern box turtle. Other common species include the red-eared turtle and snapping turtle, especially in water bodies. The most abundant snake is the black racer (Saylor et al. 1990).

Commonly encountered bird species include the red-bellied woodpecker, wood thrush, red-eyed vireo, Kentucky warbler, and rufous-sided towhee. A roadside bird survey conducted during the 1977 breeding season identified the bobwhite, cardinal, indigo bunting, rufous-sided towhee, and common grackle as the most common species on the PGDP site. Water birds do not frequent the small ponds located on the site because of lack of appropriate habitat, but rather rest and/or overwinter at the Ballard County Wildlife Management area, located 25 mi west of the site (Saylor et al. 1990). Similarly, raptors are not numerous on the PGDP site.

The most abundant mammal species on the PGDP site is the house mouse. As a result of game management activities, white-tailed deer and eastern cottontail rabbits are common throughout the site. Raccoons and foxes forage and den throughout the site. In forested areas, common mammal species include the white-footed mouse, meadow jumping mouse, and eastern gray and eastern fox squirrels. The southeastern shrew is common in fields and along fencerows and forest edges. The eastern mole is abundant in drier areas with loose soils. Along Little Bayou and Big Bayou creeks, muskrat, mink, and beaver can be found occasionally (Saylor et al. 1990). Muskrats are more common in the off-site wildlife management areas than on-site.

The proposed U-AVLIS site is an undeveloped green-field site southwest of the existing C-333 gaseous diffusion cascade building (Fig. 3). The site is mowed and has been graded flat (Martin Marietta 1990). Common plant species on the proposed U-AVLIS site include grasses, plantain, and Queen Anne's lace. The 017 KPDES outfall crosses the field from east to west and drains into Big Bayou Creek. This drainage channel supports mostly rushes and bulrushes. Less than 100 m south of this channel is an old railroad bed that supports sedges, spike-rush, and knotweed. A mature hardwood forest lies immediately to the south of the proposed U-AVLIS site. This large stand of trees includes shagbark hickory, southern red oak, post oak, red maple, sweetgum, American and red elm, and blackgum. Some trees, especially the southern red oak and blackgum, exceed 30 in. in diameter. Understory species include wild raspberry, poison ivy, stinging nettle, and touch-me-not.

Uranium tails from the proposed U-AVLIS facility would be stored in a new facility at the northwest corner of the PGDP site, outside the present security fence. This area is currently a mixture of open mowed grass (with clumps of hackberry and wild plum), wooded streams bordered by cherry, oak, cottonwood, willow, and sumac, and second-growth woods. Common herbaceous plants along these streams channels include butterfly weed, pokeweed, and water hemlock.

2.6.2 Wetlands

According to the National Wetlands Inventory Map, no wetlands occur on the PGDP site. However, as described above, forested wetlands (riparian hardwood forests) do occur along the banks of Little Bayou and Big Bayou creeks. These stands are dominated by river birch, black willow, and cottonwood. Both creeks are adjacent to the U-AVLIS site: Big Bayou to the west and Little Bayou to the east. Other wetlands near the PGDP site occur along stream corridors and along the Ohio River (north of the PGDP site).

2.6.3 Aquatic Resources

No natural ponds or lakes occur on the PGDP site; however, there are numerous permanently flooded excavated pits throughout the site. These pits do not provide much useful habitat for aquatic plant or animal species. As discussed above, most waterfowl in the region use other resources.

Little Bayou and Big Bayou creeks provide the only natural aquatic habitat on the PGDP site. Surface drainage from the PGDP is to Big Bayou Creek on the west and to Little Bayou Creek on the east. The confluence of Big and Little Bayou creeks is about 0.5 mi from the Ohio River, about 2.5 mi north of the PGDP site. Both streams receive discharges from the site (see Sec. 2.4.2).

Surveys of the streams were conducted upstream and downstream of PGDP discharge points in 1977, 1979, and 1982. In 1982, monitoring in Big Bayou Creek upstream of PGDP discharge points showed an aquatic fauna indicative of oxygen-rich, clean-water streams. Twelve fish species (153 individuals) were found, the most common being bluegill (67% of total), creek

chub (18%), and green sunfish (10%). A rich benthic fauna was also found, including mayflies, dragonflies, and damselflies (Saylor et al. 1990). Below the discharge points (about 2 mi downstream), only 15 fish of 6 species were encountered, the most common species being gizzard shad and longear sunfish. The most common member of the periphyton community downstream of the discharges was *Nitzschia palea*, a species indicative of polluted waters (Saylor et al. 1990).

The portion of Little Bayou Creek upstream of PGDP outfalls supports an aquatic biota typical of streams with intermittent flow and indicative of generally good water quality (Saylor et al. 1990). Below the discharge, benthic species were indicative of polluted waters (Saylor et al. 1990).

The Ohio River receives discharges from the PGDP site (via Little and Big Bayou creeks) and from other point and nonpoint sources in several states. Thus, the water quality of the river is poor and the biota are typical of eutrophication (Saylor et al. 1990). The gaseous diffusion plant withdraws cooling water from the Ohio River at the rate of about 18.5 mgd (Martin Marietta 1990). No data on impingement and entrainment (current and projected) of fish and other aquatic organisms are available.

2.6.4 Threatened and Endangered Species

No federally listed plant species have been identified as occurring or potentially occurring in the vicinity of the PGDP site (Winford 1991), although no systematic survey has been conducted. One state-listed threatened species, compass plant, occurs on the north side of State Highway 60, about 1 mi south of the PGDP site (Saylor et al. 1990; KSNPC 1991). Two species of special concern, water hickory and hair grass, occur in the vicinity. The former occurs in the Metropolis Lake State Nature Preserve on the Ohio River, about 1 mi north of the DOE property (Saylor et al. 1990). The location of the latter was not specified in Saylor et al. (1990).

The Indiana bat is the only federally listed threatened or endangered mammal that potentially occurs on the site (Winford 1991). This species has been observed recently (Hendricks 1991; Schaaf 1991) north of the PGDP site, near the Ohio River, where suitable summer habitat (large hickory trees) exists. Suitable winter habitat for the Indiana bat does not occur on the site (Saylor et al. 1990). The evening bat has been observed recently near the Ohio River (Hendricks 1991; Schaaf 1991). The southeastern myotis, a state species of special concern, probably forages on the PGDP site (Saylor et al. 1990). Another state species of special concern, the northern long-eared bat, has also been observed near the Ohio River (Hendricks 1991; Schaaf 1991).

On the basis of species ranges, several federally and state-listed bird species could occur on or near the PGDP site and on surrounding DOE property (Saylor et al. 1990; Winford 1991) -- see Table 8. Three federally endangered species (bald eagle, Arctic peregrine falcon, and interior least tern) could occur in the vicinity of the PGDP site, although none has been observed. Bald eagles have been known to spend part of the winter at the Ballard County Wildlife Management Area (25 mi west of the PGDP site) and at the LBL (35 mi southeast of the PGDP site) (Saylor et al. 1990). The number of eagles at each site is not known. Bachman's sparrow, a federal Category 2 species, could occur on DOE property and on the PGDP site (Saylor et al. 1990; Winford 1991)

because of the presence of suitable habitat (old-field areas and other open areas with tall grass and scattered pines) (Saylor et al. 1990). The hooded merganser, a state endangered bird, has been seen within 5 mi of the PGDP site. Bell's vireo, a state species of special concern, has been observed in the WKWMA on DOE property (Saylor et al. 1990). The great blue heron, also a state species of special concern, has been observed near the Ohio River.

No federally listed threatened or endangered fish are known to occur on the PGDP site. Blue sucker, a Category 2 species, has been collected nearby from the Ohio River (Saylor et al. 1990). The lake sturgeon (a federal Category 2 and state endangered species) could be present in the vicinity of the proposed action (Winford 1991) if suitable feeding and spawning habitat occurs in the Ohio River (Trautman 1981).

The alligator snapping turtle (a federal Category 2 species and a state threatened species) could occur in the vicinity of the PGDP site (KSNPC 1991; Schaaf 1991), where suitable habitat exists. This turtle prefers the deep muddy pools of large rivers (such as the Ohio River) and deep sloughs (Carr 1952; Johnson 1987). The copperbelly water snake could also occur in the vicinity of the PGDP site (Winford 1991), especially in quiet bodies of water (Johnson 1987) such as occur in portions of the WKWMA and in some areas adjacent to the Ohio River. This reptile is a federal Category 2 species and is a state species of special concern.

Five federally endangered mussels potentially occur in the vicinity of the PGDP site (including in the Ohio River) (Winford 1991). Four of these are also state endangered species (Saylor et al. 1990; KSNPC 1991) -- see Table 8. Three snails that potentially occur on or near the site are federal Category 2 species (Winford 1991) -- see Table 8.

2.7 Cultural Resources

2.7.1 Regional Prehistory and History

The prehistory and history of a region provide the requisite context for evaluation of its archaeological sites and historic structures. The following is a description of the prehistory and history of the Ohio River Valley in southern Illinois and northwestern Kentucky, the location of the PGDP.

Archaeological research has revealed evidence of early prehistoric settlement in this area assigned to the Paleo-Indian period (9,000-8,000 B.C.). This period is characterized by small, highly mobile human populations that subsisted primarily on the hunting of post-glacial big game animals and some gathering of wild plant foods. The archaeological record of this period is primarily confined to isolated artifacts (Funk 1978).

The Paleo-Indian period is followed by the Archaic period (8,000-1,500 B.C.), represented by a gradual shift from big-game hunting to smaller-scale hunting, fishing, and seasonal cycles of gathering a variety of wild plant foods within the expanding mixed forests.

TABLE 8 Threatened, Endangered, or Special-Interest Species that Occur or Potentially Occur in the Vicinity of the PGDP

Species	Status[a] Federal	State
PLANTS		
Compass plant (*Silphium laciniatum*)		T
Hair grass (*Muhlenbergia glabriflora*)		S
Sweet coneflower (*Rudbeckia subtomentosa*)		T
Water hickory (*Carya aquatica*)		S
MAMMALS		
Evening bat (*Nycticeius humeralis*)	T	
Indiana bat (*Myotis sodalis*)	E	E
Northern long-eared bat (*Myotis septentrionalis*)		S
Southeastern myotis (*Myotis austroriparius*)		S
BIRDS		
Arctic peregrine falcon (*Falco peregrinus tundrius*)	E	
Bachman's sparrow (*Aimophila aestivalis*)[b]	C2	E
Bald eagle (*Haliaeetus leucocephalus*)	E	E
Bell's vireo (*Vireo bellii*)[b]		S
Great blue heron (*Ardea herodias*)		S
Hooded merganser (*Lophodytes cucullatus*)		E
Interior least tern (*Sterna antillarum athalassos*)	E	E
AMPHIBIANS AND REPTILES		
Alligator snapping turtle (*Macroclemys temminckii*)	C2	T
Copperbelly water snake (*Nerodia erythrogaster neglecta*)	C2	S
Green treefrog (*Hyla cinerea cinerea*)		S
FISH		
Blue sucker (*Cycleptus elongatus*)	C2	
Lake sturgeon (*Acipenser fulvescens*)	C2	E
AQUATIC		
Armigerous river snail (*Lithasia armigera*)	C2	I
Fat pocketbook pearly mussel (*Potamilus capax*)	E	E
Orange-footed pearly mussel (*Plethobasus cooperianus*)	E	E
Ornate rocksnail (*Lithasia geniculata*)	C2	I
Pink mucket pearly mussel (*Lampsilis orbiculata*)	E	E
Ring pink (*Obovaria retusa*)	E	E
Tuberculed-blossom pearly mussel (*Epioblasma torulosa torulosa*)	E	
Varicose rocksnail (*Lithasia verrucosa*)	C2	I

[a]E = endangered; T = threatened; PT = proposed for threatened status; C2 = Category 2, status under review; S = special concern; I = state species for which more information is needed to determine their status (KSNPC 1991)

[b]Observed on DOE property surrounding the PGDP site.

Sources: Saylor et al. 1990; KSNPC 1991; Schaaf 1991; Winford 1991.

Populations grew rapidly during this period and became more diverse, especially during the Late Archaic (4,000-1,500 B.C.), as resources became more abundant and reliable with the shifting climatic conditions (Tuck 1978).

The subsequent Woodland period is divided into the Early (2,000-300 B.C.), Middle (300 B.C.-A.D. 400), and Late (A.D. 400-900) Woodland phases. The Adena culture of the Early Woodland period is characterized by a horticulture subsistence and the presence of pottery, in addition to a more intensive Archaic type of subsistence pattern. Archaeological evidence also suggests a ceremonial florescence during this period, which includes elaborate mortuary practices, such as the introduction of mound building (Tuck 1978).

In the Middle Woodland period, the Adena culture coexists with the Crab Orchard Hopewellian culture. The Crab Orchard culture is similar to, but more complex and elaborate than, the Adena culture, especially in terms of the ceremonial and mortuary practices. There is an abundance of earthen mounds constructed during this period, and a number of distinct types of ceramics appear in the archaeological record for this particular region of the Midwest. Maize cultivation and long-distance trading were also prevalent in the culture (Fitting 1978).

The Mississippian culture (A.D. 900-1500) was developed gradually out of the Late Woodland Crab Orchard Hopewellian culture. The Ohio River Valley of southern Illinois and northwestern Kentucky contains the Tennessee and Cumberland variants of the Mississippian culture. Populations had continued to grow throughout the Woodland periods and were now at their height. Large villages, long-distance trade networks, and subsistence based on the intensive agriculture of maize, beans, and squash were characteristic of this cultural period. Earthen mounds were no longer primarily for burial use, but were temple mounds. Temple mounds were large, flat-topped platform mounds, usually situated around a central plaza. The Mississippian period is dominated by the Cahokia site in southwestern Illinois. This site was the largest prehistoric settlement in North America during this time; its ceremonial, socioeconomic, and political influence extended all over the Midwest region (Fowler and Hall 1978).

The Mississippian period is followed by the Protohistoric period (A.D. 1500-1700). There is little in the archaeological record after A.D. 1500. The Kincaid site, located near the present-day Pope and Massac county line in Illinois, suggests Mississippian occupation until 1612 in the Ohio Valley. However, at the time of contact with the first French explorers, most Mississippian villages were abandoned, perhaps because of earlier pressure from other Native American groups that had been forced west by the encroachment of European settlers (Fowler and Hall 1978). In the mid to late 1600s, the French encountered the Dhegiha Sioux in Illinois and Kentucky; however, the tribe soon abandoned the area. The northern Algonquian-speaking tribes of the Illinois Confederacy (Kaskaskia, Maroa, Tamaroa, Peoria, Tapouaro, Coiracoentanon, Moingwena, Espominkia, Chinkoa, Michigamea, and Chepoussa) moved south into the Ohio Valley at this time. In the late 1600s, the Shawnee and Delaware, forced east from their native lands on the Upper Ohio, moved and settled into the Ohio Valley in Illinois and Kentucky. The Shawnee passed through and settled periodically in this region throughout the eighteenth century, but did not lay claim to any of the land (Bauxer 1978).

Defending their homelands, the Illinois Confederate tribes fought throughout the 1700s. In 1832, the last of the Illinois ceded their land to the federal government. At this time, the nearly

disintegrated Illinois moved to a reservation in eastern Kentucky. While there, a regenerative movement united them under the name of the Peoria. Today, a small number of Peoria reside on a reservation in northeast Oklahoma (Callender 1978).

Historically, the area referred to as the Kentucky Ordnance Works, located west-northwest of the PGDP, was used to produce ammunition during World War II. Trinitrotoluene and sulfur used at the munitions plant were stored in a number of bunkers. Today, 3,423 acres of this land is owned by DOE, which leases 2,080 acres to the state of Kentucky as a wildlife management area. Shortly after the end of World War II, the munitions plant was shut down and construction of the current gaseous diffusion plant began.

2.7.2 Archaeological Sites and Historic Structures

The proposed U-AVLIS production plant is located in the southernmost portion of the plant area, directly east of Hobbs Road (Fig. 3). The area appears to have been subject to prior disturbance, probably associated with the construction of the plant, which began in 1950.

More than 200 archaeological sites have been recorded for McCracken County alone, reflecting the high archaeological site density of the region (Saylor et al. 1990). A number of Indian mounds have been recorded north of the plant, near the Ohio River. Archaeological and historic sites in the area that are currently in the National Register of Historic Places (NRHP) are listed in Appendix B.

No archaeological surveys have been conducted on the PGDP, nor has there been an inventory of historic structures. Structures associated with the Kentucky Ordnance Works are west and northwest of the PGDP; the majority of these structures are bunkers used in the mid-1940s. West of the plant is the abandoned munitions plant and two large water storage silos. Most of the roads running through this area were constructed during this period.

The PGDP was constructed in the early 1950s. The earliest structures are therefore approaching 40 years of age and will need to be evaluated for NRHP eligibility in about 10 years.

North of the plant is the Homestead site and two cemeteries. Harmony Cemetery is right outside of the security fence, near the landfill. A smaller cemetery, which is no longer maintained, is northeast of the site.

2.7.3 Native American Concerns

At present, there are no Native American reservations or federally recognized tribes in Kentucky. Native American religious and cultural sites (including those for burials) are protected under the American Indian Religious Freedom Act. To date, no burial sites have been encountered within the Paducah reservation. No religious or sacred sites in current or recent use by Native American groups have been identified.

2.8 Socioeconomic Factors

2.8.1 Population

The proposed site is located in McCracken County, which borders the Ohio River in northern Kentucky. The county's 1990 population was 62,079 (USBC 1991). The study area consists of McCracken, Ballard, and Graves counties in Kentucky, and the southern Illinois counties of Massac, Johnson, and Pulaski. The six-county study area had a total population of 137,153 in 1990. Paducah, approximately 12 mi east of the proposed site, is the largest city in the study area with a 1990 population of 27,256. The nearest cities with populations exceeding 5,000 in 1990 include the southern Illinois town of Metropolis (population 6,734), 6.2 mi northwest, and the Graves County city of Mayfield (population 9,935), approximately 28 mi southeast. Several small and unincorporated communities lie within 5 mi of PGDP. These include Grahamville (population 1,404), 1.5 mi east; Rossington, 2.7 mi north, and Woodville, 4.5 mi southwest (Saylor et al. 1990). Kevil, which is incorporated, lies 4.7 mi west of the PGDP and had a population in 1990 of 336.

Population increases were recorded in all six counties of the study area between 1970 and 1980. Johnson County, in southern Illinois, experienced an increase of 27% during the decade, while the smallest increase of the decade occurred in the southern Illinois county of Pulaski, where the population grew by only 0.5%. During the 1980s, the population declined in four of the six counties. Only Johnson County experienced substantial growth (17.9%) during the decade. Conversely, Pulaski County lost 14.8% of its 1980 population by 1990 (USBC 1991). Of the three Kentucky counties in the study area, Ballard experienced the largest population decline (10.2%) during the 1980s.

Historical and current population data for the study area and for major urban centers within each county are presented in Table 9.

A discussion of population distribution and population projections for a 50-mi radius around the proposed site has been published (Martin Marietta 1990).

2.8.2 Housing

The study area had almost 60,000 housing units in 1990 (USBC 1991). Approximately 73% (54,783) of these units were occupied by the owner in the same year. Renter vacancy rates in the six counties ranged from 5% in Pulaski County to 10.3% in Ballard County (see Table 10).

McCracken County, in Kentucky, had the most available housing units in the study area in 1990, with 110 vacant rental units and 600 owner-occupied units for sale (Saylor et al. 1990). Owner-occupied housing had a median value of $48,500 in 1990, the highest in the study area (USBC 1991). Pulaski County, in southern Illinois, had the lowest renter vacancy rate (5%), median rent ($133), and median owner-occupied housing value ($24,000) in the study area.

TABLE 9 Current and Historical Population Data for the Study Area

County/City, by State	Population 1970[a]	1980[b]	1990[c]
KENTUCKY			
Ballard	8,243	8,798	7,902
LaCenter	1,044	1,044	1,040
Graves	33,708	34,049	33,550
Mayfield	10,724	10,705	9,935
McCracken	58,121	61,310	62,079
Paducah	31,627	29,315	27,256
ILLINOIS			
Johnson	7,550	9,624	11,347
Vienna	1,325	1,420	1,446
Massac	13,889	14,990	14,752
Metropolis	6,940	7,171	6,734
Pulaski	8,791	8,840	7,523
Mounds	1,177	1,669	1,407

[a]SFRPDDC 1991.

[b]USBC 1988.

[c]USBC 1991.

The Kentucky counties of Ballard and Graves had median monthly rents of $136 and $166, respectively, in 1990. Ballard County had the highest 1990 owner-occupancy rate (82.3%) in the study area, and the median price of an owner-occupied house was $33,000 in 1990. Graves County had 65 rental units available in 1990 and 240 owner-occupied homes were for sale. The median price of a home occupied by its owner was $38,500 in 1990.

The rental vacancy rate was 8.6% in Massac County during 1990, and 77.6% of all occupied housing units were occupied by owners. Owner-occupied housing had a median value of $35,700 in 1990, and the median rental payment for the same year was $157. Johnson County had 912 vacant rental units in 1990, and a median rental payment of $150. Owners lived in 81.7% of the county's occupied housing in 1990, and the median value of a home occupied by its owner that year was $36,800.

TABLE 10 Housing Units and Rental Vacancy Rates in the Study Area, 1990

County, by State	Total	Total Occupied	Owner-Occupied	Renter-Occupied	Rental Vacancy Rate (%)
KENTUCKY					
Ballard	3,351	3,191	2,626	565	10.3
Graves	14,528	13,377	10,425	2,952	9.1
McCracken	27,581	25,625	17,470	8,155	8.6
ILLINOIS					
Johnson	4,671	3,725	3,043	682	8.7
Massac	6,446	5,908	4,582	1,326	8.6
Pulaski	3,410	2,957	2,242	715	5.0

Source: USBC 1991.

2.8.3 Labor, Employment, and Income

The six-county study area had 66,714 people in the labor force in 1990. Kentucky's McCracken County, with a 1990 labor force of 29,339 people, accounted for more than 40% of the study area's total available work force. The county also had the study area's lowest unemployment rate (5.1%) in 1990 (see Table 11). The unemployment rate for the state of Kentucky in 1990 was 6.1%. The major employers in McCracken County in 1990 were Martin Marietta Energy Systems (1,600 employees), Lourdes Hospital (1,550 employees), Baptist Hospital (1,190 employees), and the Walker Boat Yard (335 employees). Ballard County had an unemployment rate of 9% in 1990. The major employers in the county in 1990 were Westvaco (550 employees), a printing company, and Credence Speakers, Inc. (70 employees). The 1990 unemployment rate was also 9.3% in Graves County, which had a labor force of 15,950 in 1990. General Tire, with 2,500 employees, was the major employer in the county in 1990.

The study area's three Illinois counties experienced double-digit unemployment rates in 1990. Pulaski County had both the smallest labor force (3,182) and the highest unemployment rate (13.7%) in the study area. The major employer in the county in 1990 was the Shawnee Development Council, with 450 employees (SFRPDDC 1991). Johnson County experienced an unemployment rate of 11.4% in 1990, when 7,353 people were in the labor force. The state of Illinois prison system was the major employer in the county for 1990, with approximately 900 employees. The 1990 unemployment rate was 10.1% in Massac County, which had a labor force of 7,376 in that year. Allied Signal Corp. (400 employees) and Electric Energy's Joppa generating station (335 employees) were the county's major employers in 1990. Allied Signal, formerly the Allied Chemical Corp., operates the largest privately owned UF_6 conversion plant.

TABLE 11 Employment and Income in the Study Area

County, by State	1990 Labor Force	1990 Unemployment Rate	Income ($)
KENTUCKY			
Ballard	3,514	9.0%	11,408
Graves	15,950	9.3%	12,078
McCracken	29,339	5.1%	14,728
ILLINOIS			
Johnson	7,353	11.4%	7,835
Massac	7,376	10.1%	11,152
Pulaski	3,182	13.7%	7,148

Sources: Illinois employment and per-capita income data provided by Southern Five Regional Planning District and Development Commission; Kentucky employment data provided by the Purchase Area Development District, Paducah, Kentucky; Kentucky per-capita income data taken from Saylor et al. 1990.

Data for 1987 indicate that McCracken and Graves counties in Kentucky were the only counties in the study area, with per-capita income levels that exceeded their respective state average for that year. The 1987 per-capita income for the state of Kentucky was $11,997, while Illinois had a 1987 per capita income of $12,437. The Illinois counties of Johnson and Pulaski had 1987 per-capita income levels that were substantially lower than the state average, while Ballard County, in Kentucky, had a 1987 per-capita income level that was slightly below the state average.

2.8.4 Public and Community Services

2.8.4.1 Education

The study area is served by 11 public school districts and 2 community colleges. McCracken County has 2 public school districts, 16 elementary schools, 4 high schools, 8 private schools, and Paducah Community College. The county's public school system, the largest in the study area, employed 616 teachers and enrolled 10,440 students in grades K-12 for the 1991-92 school year (see Table 12). The Graves County Public School System currently consists of 2 districts, 6 elementary schools, 1 high school, 324 teachers, and 5,631 K-12 students. There are no middle (grades 7 and 8) schools in the county (Saylor et al. 1990). Ballard

TABLE 12 County Public School Statistics for the Study Area, Scholastic Year 1991-92

County, by State	Enrollment	Number of Teachers	Number of Districts
KENTUCKY			
Ballard	1,431	111	1
Graves	5,631	324	2
McCracken	10,440	616	2
ILLINOIS			
Johnson	1,765	129	2
Massac	2,643	206	2
Pulaski	1,732	158	2

Source: Kentucky data provided by the City of Paducah, Planning and Community Development; Illinois data provided by Darren V. Gerard of the Southern Five Regional Planning District and Development Commission.

County has a single public school district that has 6 elementary schools, 1 high school, 111 teachers and 1,431 K-12 students for the 1991-92 school year.

Public school enrollment figures for 1991-92 in the three Illinois counties indicate a K-12 population of 6,140. Massac County has 2 school districts, 8 elementary schools, a middle school, 2 high schools, and 206 teachers serving 2,643 K-12 students in 1991. The Johnson County Public School System currently has 129 teachers instructing 1,765 K-12 students in 7 elementary schools and 1 high school. In Pulaski County, 1,732 K-12 students attend 5 public schools in 2 school districts staffed by 158 teachers. Shawnee Junior College, located in the Pulaski County community of Ullin, has branch campuses in Cairo and Metropolis. The current enrollment at the Ullin campus is approximately 2,100.

2.8.4.2 Police

Police protection in the study area is provided by local city police forces, county sheriff's departments, and the state police forces of Illinois and Kentucky. The city of Paducah, in McCracken County, has the largest police department in the study area, with 73 officers (CPPCD 1991). The McCracken County Sheriff's Department employs 17 officers. In Graves County, the city of Mayfield employs 30 police officers, and the County Sheriff's Department has 7 officers. The Kentucky State Police outpost in Mayfield has 38 officers. The Ballard County Sheriff's Police Department has 7 officers.

Metropolis, in Massac County, employs 14 officers and has the largest city police department of the three Illinois counties in the study area. The Massac County Sheriff's Police, with 21 officers, has the largest county police force in the study area. In Johnson County, five officers are employed by the Sheriff's Police Department. The city of Vienna has 2 full-time police officers. The Pulaski County Sheriff's Police Department has the smallest county police force in the study area with 4 members. However, the Illinois State Police has 38 officers operating out of the Ullin outpost in Pulaski County.

2.8.4.3 Fire

Most of the fire protection in the study area consists of volunteer departments. In the three Kentucky counties, only Paducah and Mayfield feature large, full-time fire departments. The Paducah Fire Department is the largest in both McCracken County and the study area, with 91 full-time fire fighters (Saylor et al. 1990); the rest of the county is served by 129 volunteer fire fighters serving in 9 departments (CPPCD 1991). McCracken County also has a hazardous materials team consisting of approximately 25 trained fire fighters who serve various fire departments within the county. The team holds regular training exercises and coordinates its efforts with two similar teams operating out of the PGDP. Mayfield, in Graves County, has 40 full-time members and 20 volunteers, and 12 other departments also serve Graves County. Ballard County has 11 departments, most of which consist of volunteers.

In the three Illinois counties within the study area, fire protection is provided by 15 departments, all but four of them made up of volunteers. The Metropolis Fire Department employs six fire fighters full time and has 10 volunteers. The Massac County Fire District consists of 17 volunteers and no full time employees. The Brookport Fire Department, also in Massac County, has a single full-time member and seven volunteers. The city of Mounds, in Pulaski County, has approximately 20 volunteer fire fighters. However, the city's fire fighters are paid a small standard fee for fires fought outside the city limits. All six of the fire departments in Johnson County are completely volunteer.

2.8.4.4 Health Care

The six-county study area is served by 5 hospitals, 208 physicians, 70 dentists, and several nursing homes and personal care facilities (CPPCD 1991). Paducah is a regional medical center that serves western Kentucky and portions of Missouri, Illinois, and Tennessee. It has 3 of the study area's 5 hospitals, 176 of the area's 208 physicians, 3 intermediate care facilities, 2 personal care centers, 2 rehabilitation facilities, and a skilled-nursing home. Other medical services available in Paducah include the Eye Surgery Center, the Paducah Magnetic Resonance facility, and Mobile Cardiac Diagnostics (KCHR 1991).

Graves County has 1 hospital, 17 practicing physicians, 4 personal care facilities, 3 intermediate care centers, and 14 dentists (see Table 13). There are no hospitals in Ballard County, but the Life Care Center in LaCenter provides 70 beds for intermediate care (KCHR 1990).

TABLE 13 Medical Resources in the Study Area, 1990

County/City, by State	Number of Hospitals	Number of Beds	Number of Physicians	Number of Dentists
KENTUCKY				
Ballard	0	0	4	1
Graves	1	89	17	14
McCracken	3	792	176	46
ILLINOIS				
Johnson	0	0	3	3
Massac	1	57	7	6
Pulaski	0	0	1	0

Source: CPPCD 1991.

In the three southern Illinois counties of the study area, only Massac has a hospital (57 beds). The county also has four nursing homes and six practicing dentists. Johnson County has two nursing homes and three dentists, while Pulaski County is served by only one physician. All three counties offer ambulance service.

2.8.4.5 Water

Water sources in the study area include the Ohio, Cumberland, and Tennessee rivers, Lake of Egypt, and various wells. The largest public system in the study area is Paducah's, with a capacity of 12 mgd and an average daily flow of 7 mgd. In Graves County, the Mayfield water system has a capacity of 3 mgd and an average daily flow of 1.3 mgd. Two public systems operate in Ballard County. The city of Wickliffe runs a system with a 1-mgd capacity and 0.22-mgd average daily flow, while the Barlow system has a capacity of 0.12 mgd and 0.08-mgd average daily flow.

The city of Metropolis, in Massac County, has the largest public water system in the study area's three Illinois counties, with a capacity of 3 mgd. The Brookport system, which relies on three wells for water, has an average daily flow of 0.17 mgd and a designed capacity of 0.20 mgd. Water from Lake of Egypt is supplied to several small communities in Johnson County through the Lake of Egypt Water District, which operates a system with a designed capacity of 0.87 mgd and an average daily flow of 0.72 mgd. Several small water districts operate systems in Pulaski County. The largest, in Mound City, has a capacity of 0.15 mgd and an average daily flow of 0.12 mgd.

2.8.4.6 Sewage

Paducah and Mayfield have the largest wastewater treatment facilities in the study area. The city of Paducah, which recently upgraded its system, has a designed treatment capacity of 12 mgd and an average daily flow of approximately 6.5 mgd (CPPCD 1991). The city's system also treats water from McCracken County District No. 2. Storm sewers within the city have varying capacities, and the city is currently drafting a stormwater management ordinance.

In Graves County, Mayfield is completing a new facility with a designed capacity of 3.1 mgd. The average daily flow in the system is 1.8 mgd, while the peak flow averages 2.3 mgd. Wickliffe, in Ballard County, has a treatment facility with a 0.6-mgd capacity and a 0.3-mgd average daily flow. The treatment facility in Kevil (Ballard County) has a capacity of 0.05 mgd and an average flow of 0.03 mgd.

2.8.4.7 Electrical Power

Electrical service in the study area is provided by several power cooperatives, the TVA, and CIPS. In Kentucky, the TVA sells power to the Paducah Power System, which serves the city of Paducah and its environs. The Jackson Purchase Electric Cooperative (JPEC) serves most of McCracken County and buys its power from the Big Rivers Electric Corp. (BREC), in Henderson, Kentucky (CPPCD 1991). Regionally, the BREC operates several plants with a combined capacity of 1,762 megawatts (MW). The largest of these plants, the Robert Green Plant in Sebree, Kentucky, has two units and a combined capacity of 490 MW.

Electricity in the three Illinois counties is provided by CIPS, Southern Illinois Electric Co-Op (SIEC), and Egyptian Electric Co-Op (EEC). CIPS sells power to Metropolis and to portions of Massac and Johnson counties. The two-unit CIPS generating station at Grand Tower, Illinois, has a capacity of 186 MW. The Southern Illinois Power Co-Op (SIPC), which consists of the SIEC, EEC, and Southeastern Electric Co-Op (SEC), operates a 270-MW, four-unit generating station east of Marion, Illinois. The SIPC Marion station provides power to large portions of Johnson, Pulaski, and Massac counties.

2.8.4.8 Solid Waste Facilities

The study area's three Kentucky counties have a total of three solid waste disposal facilities. The city of Paducah operates a 100-acre landfill that is expected to reach its capacity in approximately 3 yr (Saylor et al. 1990). McCracken County operates a landfill, but it does not accept solid waste that was generated outside of the county. The Graves County Landfill is used by the city of Mayfield and some of the surrounding counties. Ballard County, which has no solid waste disposal facility, uses the Graves County Landfill and the B&J Landfill in Hickman County.

The three Illinois counties in the study area belong to the Southern Illinois Solid Waste Reporting Region, which operates 16 landfills (SSHD 1990). Solid waste disposal for all of Massac County is processed through the Metropolis Municipal Landfill in Metropolis. The landfill also accepts solid waste from nearby Pope County. Johnson County sends some of its solid waste

to the Metropolis Municipal Landfill, but the majority of the county's solid waste is shipped to the Saline County Landfill. Pulaski County has no solid waste disposal facility and sends all of its solid waste to the Delta Regional Landfill in neighboring Alexander County.

2.9 Waste Management

The types of waste managed on the PGDP site include: (1) low-level radioactive waste, (2) hazardous waste, (3) mixed waste, (4) classified waste, (5) toxic waste, and (6) conventional solid waste. Waste management practices for each of these are presented in this section. Production volumes generated during 1990 are provided in Table 14; off-site waste disposal activities are presented in Table 15.

2.9.1 Low-Level Radioactive Waste

Current production activities result in the generation of many hundred metric tons of solid low-level radioactive waste per year (see Table 14). This waste contains no hazardous materials

TABLE 14 PGDP Waste Generation Summary, 1990

Waste Type	Volume (m^3)	Quantity (kg)	Disposition
Hazardous	52.7	55,207	Off-site at permitted facilities
Sanitary/industrial	6,890	N/A[a]	On-site landfill
PCB materials	150	77,318	Off-site at permitted facilities
Low-level radioactive	685	536,167	Temporary on-site storage
Mixed	53.4	49,309	Long-term on-site storage
PCB/radioactive materials	85	82,321	Long-term on-site storage
Asbestos	48	N/A	On-site landfill
Classified	0	0	
Clean metal	404	N/A	On-site storage
Contaminated metal	264	N/A	Long-term on-site storage
Miscellaneous non-hazardous	44	33,600	

[a]Not available.

Source: Kornegay et al. 1991.

TABLE 15 Off-Site Waste Disposal, 1990

Waste Type	Volume (m^3)	Quantity (kg)	Disposition
PCB	91.6	100,930	Incineration
PCB (solids)	41.5	48,879	Landfill
PCB	155.0	28,061	
Transformers	N/A[a]	N/A	Smelter
Hazardous	105.9	88,393	Incineration
Hazardous	1.5	35	Landfill

[a]Not available.

Source: Kornegay et al. 1991.

and is regulated under DOE Order 5820.2A, Radioactive Waste Management. Low-level radioactive wastes are presently placed in drums and stored on-site for an indefinite period, pending final disposition in the C-746-Q low-level waste storage area and in the C-746-M storage building.

Scrap metal generated in the modification or replacement of equipment is partially decontaminated and stored at the C-746-P east regulated scrap yards; this material cannot be sold as scrap.

2.9.2 Hazardous Waste

Hazardous wastes from the PGDP are generated primarily as the result of cleaning and degreasing operations, and also from operations of the analytical laboratory. These wastes contain no radioactivity and are regulated under the Resource Conservation and Recovery Act (RCRA) and DOE Order 5400.3, Hazardous and Radioactive Mixed Waste Program. Solvent wastes are stored in containers in the C-746-R waste solvent storage area. C-733 and C-746 are hazardous waste storage areas. C-400-P is a waste solution storage tank, and C-400-D is a lime precipitation tank.

Eventual disposition of the hazardous waste off-site is principally by incineration or by disposal in a landfill (Table 15).

2.9.3 Mixed Waste

Wastes that are contaminated with hazardous materials and also with uranium are typically generated as a result of degreasing and cleaning of components that are contaminated with

uranium. The majority of the mixed waste is generated in the raffinate treatment process for uranium recovery, which results in a sludge containing low levels of uranium and technetium, together with cadmium and lead in leachable forms. Mixed wastes are also regulated under DOE Order 5400.3, Hazardous and Radioactive Mixed Waste Program.

Some mixed wastes will eventually be shipped to the incinerator for materials regulated by the Toxic Substances Control Act (TSCA), located at the Oak Ridge Gaseous Diffusion Plant (ORGDP). Mixed wastes for which no appropriate disposal method is currently available are being stored temporarily in the C-746-R waste solvent storage area.

2.9.4 Classified Waste

Classified wastes are generated from equipment and materials used in the gaseous diffusion plant that are classified confidential or secret pursuant to the Atomic Energy Act and also from classified information media such as magnetic disks, tapes, and classified documents. This waste is regulated under DOE Order 5632.1A, Protection Program Operations. Classified wastes are temporarily stored on-site in secure storage areas. No classified waste was generated in 1990.

2.9.5 Toxic Waste

Nonradioactive PCBs are regulated under TSCA. PCBs are found in dielectric fluids used in electrical equipment and ventilation duct gaskets. All PCB-contaminated wastes are stored in drums in process buildings C-333 and C-337 and in C-746-A warehouse. Nonradioactive PCB wastes are shipped off-site to a commercial disposal facility for destructive incineration or disposal in a landfill. Radioactive PCB materials are being stored, awaiting shipment to the ORGDP incinerator.

Removal and disposal of nonradioactive asbestos are regulated under the Clean Air Act. Sources of waste asbestos are insulation around water and steam lines and other heat-related processes. Nonradioactive asbestos waste is disposed of in the C-746-T industrial landfill.

2.9.6 Conventional Solid Waste

Conventional solid waste consists of nonradioactive, nonhazardous, and nontoxic solid wastes. Material consisting of fly ash from burning coal for heating and processing, sanitary waste from cafeteria and site administration, sterilized medical and infectious waste from the medical facility, construction spoils from ongoing construction activities, and demolition debris are disposed of on-site in the C-746-S residential landfill or the C-746-T industrial landfill. Waste oil is stored in tanks at C-728 until recycled off-site.

Nonradioactive scrap metal is stored at the C-746-P1 west clean scrap metal yard for eventual sale to the public.

3 Additional Information Needs

The description of the PGDP site in Sec. 2 was based solely on existing information and data collected by ANL staff during the site visit. This section identifies information that is lacking and that must be collected in order to prepare a defensible EIS.

3.1 Geology

A more complete characterization of sediment types and their thicknesses in the vicinity of Big Bayou and Little Bayou creeks is needed. Recently, a seismic hazard evaluation for the PGDP was completed. The results of this study should be integrated into the EIS to be prepared.

3.2 Air Resources

The PGDP site personnel are obtaining the following for later incorporation into the EIS to be prepared:

1. Mobile source emissions for the year 1990, by pollutant, and

2. Ambient background information from the 1990 Environmental Surveillance Report. This report has been completed but awaits DOE/Headquarters approval. Current values for ambient background data will change when the new data are made available. Some background ambient data reported by the state of Kentucky for the year 1990 are now used. In the future, all background information will use the latest year, that is, 1990.

A more complete chemical emissions inventory is being prepared at the PGDP.

3.3 Noise

A noise survey similar to the one carried out by PORTS personnel is underway, and the results (in a format similar to that of the PORTS survey) will be added to the noise discussion in the EIS.

3.4 Water Resources

Since the creeks will be used to drain the discharge from PGDP, an understanding of the recharge and discharge relationship between the creeks and groundwater under high- and low-flow conditions is important in evaluating potential impacts on surface water and groundwater caused by the proposed project. Also, the extent of different types of contamination in sediment, and in the groundwater of the shallow groundwater system and the regional gravel aquifer in the vicinity of the PGDP, should be better defined.

3.5 Land Use, Recreation, and Visual Resources

Land use interpretation and classification will require the most current satellite inventory land covers and aerial photographs. Any recent land use analyses, studies, or updates conducted by counties or universities in the study area will be necessary.

A complete visual resource inventory for the immediate vicinity of the PGDP may require the assistance of outside resources such as the U.S. Forest Service or the Kentucky Division of Forestry.

3.6 Biotic Resources

In order to assess the full potential of biotic impacts resulting from the construction and operation of the proposed U-AVLIS facility at the PGDP site, additional data are needed. These data include (1) surveys to assess the population status of federal and state threatened and endangered species on the proposed U-AVLIS site and surrounding DOE property, including land leased by the West Kentucky Wildlife Management Area; (2) impingement and entrainment data from the Ohio River in the vicinity of the present PGDP intake structures; (3) quantitative data on the relative abundances of and population estimates for the Indiana bat and evening bat in the vicinity of the PGDP site; (4) similar quantitative data for the Bachman's sparrow; (5) survey for presence of appropriate habitat for threatened and endangered species, particularly the Indiana bat, evening bat, and Bachman's sparrow; and (6) verification by the U.S. Army Corps of Engineers that no jurisdictional wetlands occur on the site (Federal Interagency Committee for Wetland Delineation 1989).

3.7 Cultural Resources

Although it is unlikely that there will be any adverse impacts on cultural resources at Paducah, such a scenario is difficult to predict since cultural resources have not been surveyed on the reservation. The decision will be made by the State Historic Preservation Officer (SHPO) at the Kentucky Heritage Council as to whether an archaeological survey will be necessary. The area of the proposed U-AVLIS facility seems to have been previously disturbed, but there is the possibility that there may be areas underneath the fill that contain undisturbed loess, which, depending on its age, may contain archaeological material. The entire Ohio River Valley is rich in archaeological material, and it is likely that archaeological sites will be present within the PGDP. The Kentucky Heritage Council should be contacted concerning the proposed site. Consultation with the SHPO will determine whether a survey is necessary; this action is required under Section 106 of the National Historic Preservation Act of 1966. Of potential concern at Paducah is the possible existence of archaeological sites within or near the proposed U-AVLIS site.

3.8 Socioeconomic Factors

The 1990 population for an area circumscribed by a 50-mi radius around the PGDP must be completed in sector format. Comprehensive housing data that include the most current average

monthly rent for counties in the study area are necessary, since the ESD's latest figures are from 1989-90. The most current data concerning agriculture and commercial forestry will be needed as well. More complete information concerning pending management plans for solid waste districts and expected capacities for solid waste facilities will also be necessary.

3.9 Waste Management

The quantity of waste generated varies substantially from year to year. As the capacity of existing waste storage facilities is reached, new facilities will remain required. Thus, the waste management plan and waste inventory must be updated to remain current.

4 Potential Environmental Impacts

Detailed analysis of the environmental impacts of constructing and operating a U-AVLIS production plant at the PDGP site cannot be provided before completion of the conceptual design, including site-specific data on construction, storage, and assembly sites. In this section, a short qualitative discussion of potential environmental impacts that might be expected from a U-AVLIS production plant at the site is provided. Examples of impacts expected to be minimal are also indicated.

4.1 Geology

Windblown deposits such as loess are the most common surficial materials at the plant site. These materials are easily eroded. During the construction phase, some soil erosion is unavoidable. However, this erosion can be mitigated by use of appropriate construction practices.

4.2 Air Resources

It is not expected that air quality impacts from construction and operation of the proposed U-AVLIS production plant will exceed state of Kentucky, National Ambient Air Quality Standards, or Prevention of Significant Deterioration (PSD) regulations. There are no guidelines currently in use by Kentucky relating to new toxic air emissions. Distances to the site boundary are relatively small, but emissions are expected to be small as well. Estimated background levels of pollutants at the site are substantially below standards at this time. Only when actual emission estimates for the proposed U-AVLIS facility become available can the above statements be validated.

4.3 Noise

Noise levels at the nearest residences are low, and noise emissions from the PGDP are not now heard by the residents there. Traffic noise from passing cars is the major noise source at the residences. No state or local regulations apply. It is not expected that U-AVLIS noise sources will be heard outside the site boundary except for the proposed cooling tower and transformers. Noise problems are not expected, but final judgment is reserved until design information is made available. Ambient levels are very low, so the noise source term from U-AVLIS must be studied carefully.

4.4 Water Resources

Impacts on water due to locating the U-AVLIS facility at the PGDP include the potential disturbance of discharge and recharge balance between the creeks and the groundwater. Quantitatively, increased plant discharges would eventually increase the discharge of Big Bayou and Little Bayou creeks and would also increase the recharge of groundwater at the streambeds of

the creeks during dry weather. Qualitatively, the movement of the contaminant plumes found in PGDP groundwater could be locally disturbed.

Also, the contaminants found in the sediments at the outfalls of the site may be resuspended and transported because of the increased discharge. As the water quality of the additional discharge may differ from that of the previous discharge, the water quality of the two creeks as well as the local groundwater along the creeks would be affected.

4.5 Land Use, Recreation, and Visual Resources

The proposed facility's location on a dedicated site should have minimal impacts on land use and recreation. No surrounding land would be significantly altered, and no farmland would be taken out of production. Recreational resources in the area are developed enough to accommodate any increase in user demand brought about by construction and operation.

The regional transportation network is well developed, and a 1989 traffic count on roads and highways in and around the PGDP indicated spare capacity. While traffic in and around the PGDP would increase with construction and operation, impacts should be minimal.

Visual resources in the area should not be significantly affected by the new facility, since it will be located on a dedicated site. Visual impacts should be limited to plume effects associated with operation of the facility. The proposed facility would reside in the background (2-5 mi) or distant background (over 5 mi) for most viewsheds. The TVA and Joppa electric generating stations are located a short distance north of the PGDP, so any viewsheds with those facilities in the background would not be affected by any new facility at the PGDP.

4.6 Biotic Resources

Construction of U-AVLIS facilities on the old-field area south of the existing gaseous diffusion facility would result in several permanent adverse impacts. Approximately 80 acres of old-field (early successional) vegetation would be lost, and wildlife that use the old-field sites would be displaced for the lifetime of the project. Temporary impacts would occur as a result of construction, including disruption of wildlife activities in neighboring habitats due to construction noise and activity. An additional impact associated with construction of new facilities could be sediment runoff into Big Bayou Creek, which could affect aquatic biota.

Construction of the proposed U-AVLIS depleted uranium storage facilities at the northwest corner of the PGDP site would require the clearing of an unspecified number of acres of upland woods, streamside forest, and old-field areas. The resident wildlife of these areas would be lost for the lifetime of the project plus the length of time required for the site to return, via succession, to its predisturbance character. Here, too, wildlife not directly affected by the construction activity would be disrupted by construction noise and by human activities for the life of the project.

Because no federally listed plant or animal species occur on the construction site, no adverse effects on such species are anticipated. The population status at the PGDP site and the

surrounding DOE property of several threatened, endangered, and special-concern species needs to be fully assessed.

4.7 Cultural Resources

Although it is unlikely that there will be any adverse impacts on cultural resources at Paducah, these resources must be surveyed before potential environmental impacts can be assessed with certainty.

4.8 Socioeconomic Factors

The socioeconomic impacts associated with the proposed facility should be minimal.

4.9 Waste Management

New waste management storage facilities might be required for waste generated by the proposed U-AVLIS facility at the PGDP site. Final disposal of waste off-site might require new storage or treatment facilities to be found.

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Appendix A

Species Occurring on the PGDP Site

Appendix A

Species Occurring on the PGDP Site

TABLE A.1 Names of PGDP Species Other than Threatened and Endangered Ones

Common Name	Scientific Name
PLANTS	
American elm	*Ulmus americana*
Bitternut hickory	*Carya cordiformis*
Black willow	*Salix nigra*
Black cherry	*Prunus serotina*
Black oak	*Quercus velutina*
Blackgum	*Nyssa sylvatica*
Bulrush	*Scirpus spp.*
Butterfly weed	*Asclepias spp.*
Chestnut oak	*Quercus prinus*
Cottonwood	*Populus deltoides*
Flowering dogwood	*Cornus florida*
Hackberry	*Celtis occidentalis*
Hawthorn	*Crataegus spp.*
Hop-hornbean	*Carpinus caroliniana*
Knotweed	*Polygonum spp.*
Mockernut hickory	*Carya tomentosa*
Pawpaw	*Asimina triloba*
Plantain	*Plantago spp.*
Poison ivy	*Rhus radicans*
Pokeweed	*Phytolacca americana*
Post oak	*Quercus stellata*
Queen Anne's lace	*Daucus carota*
Raspberry	*Rubus spp.*
Red maple	*Acer rubrum*
Red elm	*Ulmus rubra*
River birch	*Betula nigra*
Rush	*Juncus spp.*
Sassafras	*Sassafras albidum*
Scarlet oak	*Quercus coccinea*
Serviceberry	*Amelanchier spp.*
Shagbark hickory	*Carya ovata*
Shingle oak	*Quercus imbricaria*
Silver maple	*Acer saccharinum*
Spike-rush	*Eleocharis spp.*
Stinging nettle	*Urtica dioica*
Sumac	*Rhus spp.*
Sweetgum	*Liquidambar styraciflua*
Touch-me-not	*Impatiens spp.*
Water hemlock	*Cicuta sp.*
White oak	*Quercus alba*
Wild plum	*Prunus sp.*
Witch-hazel	*Hamamelis virginiana*

TABLE A.1 (Cont'd)

Common Name	Scientific Name
AMPHIBIANS AND REPTILES	
American toad	*Bufo americanus*
Black racer	*Coluber constrictor constrictor*
Eastern box turtle	*Terrapene carolina carolina*
Green frog	*Rana clamitans melanota*
Northern ringneck snake	*Diadophis punctatus edwardsi*
Red-eared turtle	*Chrysemys scripta elegans*
Slimy salamander	*Plethodon glutinosus glutinosus*
Snapping turtle	*Chelydra serpentina serpentina*
Southern leopard frog	*Rana utricularia*
Woodhouse's toad	*Bufo woodhousei woodhousei*
FISH	
Bluegill	*Lepomis macrochirus*
Creek chub	*Semotilus atromaculatus*
Gizzard shad	*Dorosoma cepedianum*
Green sunfish	*Lepomis cyanellus*
Longear sunfish	*Lepomis megalotis*
BIRDS	
Bobwhite quail	*Colinus virginianus*
Cardinal	*Richmondena cardinalis*
Common grackle	*Quiscalus quiscula*
Indigo bunting	*Passerina cyanea*
Kentucky warbler	*Oporornis formosus*
Mourning dove	*Zenaida macroura*
Red-bellied woodpecker	*Centurus carolinus*
Red-eyed vireo	*Vireo olivaceus*
Rufous-sided towhee	*Pipilo erythrophthalmus*
Wood thrush	*Hylocichla mustelina*
MAMMALS	
Beaver	*Castor canadensis*
Eastern cottontail rabbit	*Sylvilagus floridanus*
Eastern gray squirrel	*Sciurus carolinensis*
Eastern fox squirrel	*Sciurus niger*
Eastern mole	*Scalopus aquaticus*
House mouse	*Mus musculus*
Meadow jumping mouse	*Zapus hudsonius*
Mink	*Mustela vison*
Muskrat	*Ondatra zibethica*
Raccoon	*Procyon lotor*
Southeastern shrew	*Sorex longirostris*
White-tailed deer	*Odocoileus virginianus*

Appendix B

National Register of Historic Places, Sites in Study Area

Appendix B

National Register of Historic Places Sites in Study Area

This appendix lists those sites that are recorded in the National Register of Historic Places, as of February 1988, for Ballard, Carlisle, Graves, Marshall, and McCracken counties in Kentucky (Saylor et al. 1990); and, as of May 1990, for Massac County in Illinois, according to the Illinois Department of Conservation, Division of Historic Sites. The date of listing is given in parentheses for each site.

BALLARD COUNTY

Lovelace vicinity. *Lovelace, Andrew Jr., House*, west of Lovelace off U.S. 62 (1-3-78)
Wickliffe. *Ballard County Courthouse*, Fourth and Court Sts. (2-27-80)
Wickliffe. *Wickliffe Site 15 BA 4* (12-8-84)

CARLISLE COUNTY

Marshall Site, 15 CE 27 (10-29-85)
Turk Site, 15 CE 6 (10-29-85)

GRAVES COUNTY

Fulton vicinity. *Mecham Manor*, 7 miles east of Fulton off KY 116 (12-31-74)
Mayfield. *Woolridge Monuments*, Maplewood Cemetery (8-11-80)
Mayfield. *U.S. Post Office*, Ninth St. and Broadway (12-2-82)
Mayfield. *Mayfield Downtown Commercial District*, roughly bounded by North, Water, Fifth, and Ninth Sts. (8-16-84)
Youngblood Site, 15 GV 26 (2-4-86)

MARSHALL COUNTY

Benton. *Lemon, James R., House*, 1309 Main St. (8-28-75)
Benton. *Stilley House*, 925 Birch St. (8-19-86)
Benton vicinity. *Archaeological Site, 15 M1 109* (1-27-83)
Calverty City. *Oak Hill*, 26 Aspen St. (12-31-74)

McCRACKEN COUNTY

Paducah. *Anderson, Artelia Hall*, 1400 H.C. Mathis Dr. (5-26-83)
Paducah. *Anderson-Smith House*, Lone Oak Rd. (3-1-84)
Paducah. *Angles, The (Quigley-Barkley House)*, Alben W. Barkley Dr. near 40th St. (7-19-76)
Paducah. *Grace Episcopal Church*, 820 Broadway (3-16-76)
Paducah. *Hotel Irvin Cobb*, Broadway and Sixth St. (8-24-78)
Paducah. *Jefferson Street-Fountain Avenue Residential District*, Jefferson and Madison Sts., Broadway, Fountain Ave., and Harahan Boulevard (7-14-82)
Paducah. *Nashville, Chatanooga and St. Louis Railway Office and Freight House*, 300 South Third St. (7-17-79)
Paducah. *Paducah Downtown Commercial District*, roughly bounded by Seventh, First, Clark, and Monroe Sts. (4-20-82)
Paducah. *Paducah Downtown Commercial District (Boundary Increase)*, roughly bounded by First, Clark, Seventh, and Monroe Sts. (5-2-85)
Paducah. *Paducah Lower Town Neighborhood District*, roughly bounded by Park Ave., Jefferson, Fifth, and Ninth Sts. (3-15-82)
Paducah. *Paducah Market House District*, Second St. between Broadway and Kentucky Ave. (4-3-78)
Paducah. *People's First National Bank and Trust Company Building*, 300 Broadway (8-11-80)
Paducah. *St. Francis De Sales Roman Catholic Church*, 116 S. Sixth St. (4-16-79)
Paducah. *Yeiser, Mayor David A., House*, Alben W. Barkley Museum, 533 Madison St. (3-7-73)
Paducah vicinity. *Archaeological Site 15McN51* (7-11-85)

MASSAC COUNTY, ILLINOIS

Brookport vicinity. *Kincaid Site*, east of Brookport on Ohio River (10-15-66)
Metropolis. *Curtis, Elijah P., House*, 405 Market St. (6-9-78)
Metropolis. *McCartney Music Hall*, 116-120 East Fourth St. (8-13-86)
Metropolis vicinity. *Fort Massac Site*, southeast of Metropolis on the Ohio River (7-14-71)

END

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