DOE/OR/06-1527&D2
Primary Document

Record of Decision for Remedial Action at Solid Waste Management Unit 91 of Waste Area Group 27 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

July 1998

Cleared for Public Release

Department of Energy
Oak Ridge Operations
Paducah Site Office
P.O. Box 1410
Paducah, KY 42001

September 22, 1998

Mr. Robert H. Daniell, Director
Division of Waste Management
Kentucky Department for Environmental Protection
14 Reilly Road, Frankfort Office Park
Frankfort, Kentucky 40601

Mr. Carl R. Froede Jr., P. G.
United States Environmental Protection Agency
Region IV
DOE Remedial Section
Federal Facilities Branch
Waste Management Division
61 Forsyth Street
Atlanta, Georgia 30303

Dear Mr. Daniell and Mr. Froede:

RECORD OF DECISION FOR REMEDIAL ACTION AT SOLID WASTE MANAGEMENT UNIT 91 OF WASTE AREA GROUPING 27 AT THE PADUCAH GASEOUS DIFFUSION PLANT, PADUCAH, KENTUCKY DOE/OR/06-1527&D2

Enclosed for your information is the final Record of Decision (ROD) for Solid Waste Management Unit 91 of Waste Area Grouping 27 at the Paducah Gaseous Diffusion Plant. The ROD was signed by the Department of Energy (DOE) July 8, 1998, and by the United States Environmental Protection Agency August 10, 1998. The Kentucky Department for Environmental Protection (KDEP) gave conditional approval of the D1 version of the ROD on June 9, 1998, pending minor modification, which DOE incorporated. Based on conversations with representatives of KDEP on September 21, 1998, the June 9, 1998, letter serves as their concurrence for the ROD.

If you have any questions or require additional information, please call Myrna E. Redfield at (502) 441-6815.

Sincerely,

Jimmie C. Hodges

Jimmie C. Hodges, Site Manager
Paducah Site Office

Enclosure

cc w/o enclosure:
R. H. Blumenfeld, CC-10
P. A. Gourieux, Bechtel Jacobs Company/Kevil
J. C. Massey, Bechtel Jacobs Company/Kevil
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CERTIFICATION

Document Identification: **Record of Decision for Remedial Action at Solid Waste Management Unit 91 of Waste Area Group 27 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky (DOE/OR/06-1527&D2 Primary Document)**

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons directly responsible for gathering the information, the information submitted is to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

U.S. Department of Energy (DOE)
Owner and Operator

Jimmie C Hodges — 6-25-98

Jimmie C. Hodges, Paducah Site Manager — Date Signed

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons directly responsible for gathering the information, the information submitted is to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Bechtel Jacobs Company LLC
Co-Operator

6/25/98

Jimmy C. Massey, Paducah Manager of Projects — Date Signed

DOE/OR/06-1527&D2
Primary Document

Record of Decision for Remedial Action at Solid Waste Management Unit 91 of Waste Area Group 27 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

July 1998

Prepared by
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Prepared for the
U.S. Department of Energy
Office of Environmental Management

Environmental Management Activities at the
Paducah Gaseous Diffusion Plant
Paducah, Kentucky 42001
managed by
Bechtel Jacobs Company LLC
for the
U.S. Department of Energy
under contract DE-AC05-98OR22700

PREFACE

This *Record of Decision for Remedial Action at Solid Waste Management Unit 91 of Waste Area Group 27 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/06-1527&D2, was prepared in accordance with requirements under the Comprehensive Environmental Response, Compensation, and Liability Act, the Resource Conservation and Recovery Act, and Kentucky Revised Statues Chapter 224, Subchapter 46. This work was performed under Work Breakdown Structure 1.4.12.7.1.11.07.05 (Activity Data Sheet 5311). This document follows the outline for records of decision contained in the *Federal Facility Agreement For The Paducah Gaseous Diffusion Plant,* DOE/OR/07-1707, and the *Guidance on Preparing Superfund Decision Documents: The Proposed Plan, The Record of Decision, Explanation of Significant Differences, The Record of Decision Amendment,* EPA/540/G-89/007. Publication of this document meets a primary document deliverable milestone for the United States Department of Energy's (DOE's) Remediation Management Group at the Paducah Gaseous Diffusion Plant. This document provides the record of information and rationale that the United States Environmental Protection Agency, the Kentucky Department for Environmental Protection, and the DOE utilized in the selection of a preferred remedial action, or corrective measure, at Solid Waste Management Unit 91 of Waste Area Group 27. Information provided in this document forms the basis for the development of the remedial design report for this project.

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ACRONYMS AND ABBREVIATIONS

The following list of acronyms and abbreviations is provided to assist in the review of this document.

^{99}Tc	technetium-99
ACO	Administrative Order by Consent
amsl	above mean sea level
AR	administrative record
ARAR	applicable or relevant and appropriate requirement
AT123D	Analytical Transient 1-, 2-, 3-Dimensional Model
BHHRA	baseline human health risk assessment
bls	below land surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
C.F.R.	Code of Federal Regulations
cis-1,2-DCE	cis-1,2-dichloroethene
cm	centimeter(s)
COC	chemical of concern
CPF	cancer potency factor
DNAPL	dense nonaqueous phase liquid
DOE	United States Department of Energy
ELCR	excess lifetime cancer risk
EPA	United States Environmental Protection Agency
Fed. Reg.	*Federal Register*
FFA	Federal Facility Agreement
ft	foot (feet)
ft^2	square foot (feet)
ft^3	cubic foot (feet)
gal	gallon(s)
HSWA	Hazardous and Solid Waste Amendments
HU	hydrogeologic unit
K.A.R.	Kentucky Administrative Regulations
KDEP	Kentucky Department for Environmental Protection
kg	kilogram(s)
km	kilometer(s)
KPDES	Kentucky Pollutant Discharge Elimination System
l	liter(s)
m	meter(s)
m^3	cubic meter(s)
MCL	maximum contaminant level
mg	milligram(s)
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priorities List
O&M	operation and maintenance
pCi	picocurie(s)
PGDP	Paducah Gaseous Diffusion Plant
ppm	parts per million
POE	point of exposure
PORTS	Portsmouth Gaseous Diffusion Plant
PRAP	proposed remedial action plan
PRP	potentially responsible parties
RAO	remedial action objective

RCRA	Resource Conservation and Recovery Act
RGA	Regional Gravel Aquifer
ROD	record of decision
SARA	Superfund Amendments and Reauthorization Act
sec	second(s)
SESOIL	Seasonal Soil Compartment Model
SWMU	solid waste management unit
TBC	to be considered
TCE	trichloroethene
TVA	Tennessee Valley Authority
U.S.C.A.	United States Code Annotated
UCRS	Upper Continental Recharge System
USEC	United States Enrichment Corporation
WAG	waste area group
yd^3	cubic yard(s)
yr	year(s)
UF_6	uranium hexafluoride
μg	microgram(s)

PART 1

DECLARATION

DECLARATION FOR THE RECORD OF DECISION FOR SOLID WASTE MANAGEMENT UNIT 91 OF WASTE AREA GROUP 27

SITE NAME AND LOCATION

Solid Waste Management Unit 91 of Waste Area Group 27
Paducah Gaseous Diffusion Plant
United States Department of Energy
Paducah, Kentucky

STATEMENT OF BASIS AND PURPOSE

This decision document presents the remedial action for the Solid Waste Management Unit (SWMU) 91 of Waste Area Group (WAG) 27 at the Paducah Gaseous Diffusion Plant (PGDP) near Paducah, Kentucky. The remedial action outlined in this document was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986, the National Oil and Hazardous Substances Pollution Contingency Plan, and Kentucky Revised Statutes Chapter 224, Subchapter 46. This decision is based on the administrative record (AR) for the response action at SWMU 91.

With participation from the Kentucky Department for Environmental Protection (KDEP), both the United States Environmental Protection Agency (EPA) and the United States Department of Energy (DOE) entered into an Administrative Order by Consent (ACO) effective November 23, 1988. The ACO was drafted pursuant to Sections 104 and 106 of CERCLA, which provide authority for conducting remedial actions in response to releases of hazardous substances, pollutants, or contaminants. The PGDP was placed on CERCLA's National Priorities List (NPL) May 31, 1994 (effective date June 30, 1994).

Pursuant to the PGDP listing on the NPL, the DOE entered into the Federal Facility Agreement (FFA) with the EPA and the KDEP (signed February 13, 1998) to integrate the overlapping requirements of the CERCLA and the Resource Conservation and Recovery Act (RCRA) that apply to the PGDP. Upon signature of the FFA, the ACO was terminated and remediation at the PGDP will be conducted under the terms and conditions of the FFA.

The DOE was issued a Kentucky Hazardous Waste Management Permit and an EPA Hazardous and Solid Waste Amendments (HSWA) permit July 16, 1991. The KDEP portion of the RCRA permit was issued pursuant to Chapter 224 of the Kentucky Revised Statutes by authority granted from the EPA to the KDEP. The EPA issued its portion of the RCRA permit pursuant to the HSWA. Throughout this document, the two permits are referred to collectively as the RCRA permits. The RCRA permits require the proper treatment, storage, and disposal of waste; corrective action (i.e., cleanup); closure of regulated units; and investigation of off-site contamination.

On August 13, 1997, the DOE determined that Lasagna™ was a proven technology at the PGDP, as well as the appropriate technology for a remedial action at SWMU 91. The Lasagna™ technology uses electroosmosis to move contaminants by flushing water through treatment zones where they can be captured or chemically altered to non-toxic products. This decision was based on several documents that comprise the AR for this remedial action (e.g., the *Preliminary Site Characterization/Baseline Risk Assessment/ Lasagna™ Technology Demonstration At Solid Waste Management Unit 91 of the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/EM-128; the *Feasibility Evaluation for Trichloroethene-Contaminated Soil at Solid Waste Management Unit 91 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/06-1557&D3; and the *Proposed Remedial Action Plan for Solid Waste Management Unit 91, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/06-1499&D3). The AR includes detailed documentation of the rationale for undertaking this remedial action at SWMU 91 of WAG 27. The remedial action will be initiated pursuant to the PGDP's RCRA permits and this Record of Decision (ROD). Values corresponding to the 1994 DOE Policy on the National Environmental Policy Act also were incorporated in the documentation. The Commonwealth of Kentucky concurs with the DOE and the EPA on the selected remedial action. The scope of this action warrants the incorporation of the selected remedy into the Hazardous Waste Permit KY8-890-008-982. This ROD will serve as the primary document for the modification to the permit. This action will address the chemical of concern (COC) in the soil [i.e., trichloroethene (TCE)] at SWMU 91 of WAG 27 and will serve as a step toward comprehensively addressing PGDP site problems.

ASSESSMENT OF THE SITE

Actual or threatened releases of hazardous substances from SWMU 91 of WAG 27 currently do not present an imminent and substantial danger to public health, welfare, or the environment according to the *Preliminary Site Characterization/Baseline Risk Assessment/Lasagna™ Technology Demonstration at Solid Waste Management Unit 91 of the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/EM-128. However, leachate and transport computer modeling [e.g., Seasonal Soil Compartment Model (SESOIL)] as presented in the *Preliminary Site Characterization/Baseline Risk Assessment/Lasagna™ Technology Demonstration at Solid Waste Management Unit 91 of the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/EM-128, indicates that the COC (TCE) present in the soil could contaminate the Regional Gravel Aquifer at the point of exposure (POE) at levels that could exceed the EPA maximum contaminant levels.

DESCRIPTION OF SELECTED REMEDY

The primary objective of this remedial action is to reduce the level of TCE-contaminated soil thereby reducing the potential future concentrations in ground water that could pose a threat to human health and the environment at the POE (i.e., the DOE property boundary). The potential for migration of the contaminant from the soil to the off-site aquifer is the concern associated with this SWMU. The soil at this SWMU contains TCE with an average concentration of 84 mg/kg (ppm) that may migrate to the nearest POE at unacceptable levels. Ground-water modeling indicates that reducing the concentration of TCE in soil at SWMU 91 to less than 5.6 mg/kg will result in ground water that is less than 5 μg/l at the PGDP's security fence. The selected remedial action reduces the potential ground-water risk to human health and the environment by remediating the TCE-contaminated soil to below 5.6 mg/kg.

Alternative 2 — *In Situ* Remediation (Lasagna™) is the selected remedy. The Lasagna™ technology was developed by an industrial consortium (Monsanto, DuPont, and General Electric), in cooperation with the DOE Office of Environmental Management, Office of Science and Technology (EM-50) and the EPA Office of Research and Development.

The Lasagna™ technology was developed to remediate soils and ground water contaminated with TCE and is especially suited to sites with low-permeability soils. The process uses electroosmosis to move soil contaminants by flushing multiple pore volumes of water through treatment zones where the TCE can be captured or chemically altered to non-toxic products.

The success of the technology's initial demonstration (Phase I) that began January 3, 1995, and ran for 120 days at SWMU 91, led to a full scale Phase IIA field demonstration that was conducted at SWMU 91 from August 1996 through July 1997. The Phase IIA demonstration was executed on an area of approximately 6 m x 9 m (20 ft x 30 ft) and approximately 14 m (45 ft) deep. The demonstration used a mixture of kaolin clay and iron particles as the treatment zone medium. The treatment zone material was installed using a hollow mandrel. Iron filings were mixed with wet kaolin clay to form a slurry that was poured down the 14 m (45 ft) mandrel. As a treatment medium, iron has been shown to reduce TCE chemically to non-toxic end products.

The components of Alternative 2 — *In Situ* Remediation (Lasagna™) include these.

- Electrodes energized by direct current that cause soluble contaminants (i.e., TCE) to be transported into or through the treatment layers and heat the soil. The contaminated water in the pore volumes will flow from the anode through treatment zones toward the cathode.

- Treatment zones containing reagents that either can decompose the TCE to non-toxic products or can adsorb the TCE contaminants for immobilization, depending on the medium design.

- A water management system that recycles and returns the water that accumulates at the cathode back to the anode for acid-base neutralization.

If SWMU 91 has not reached the regulatory approved risk assessment cleanup level (i.e., soil levels) of 5.6 mg/kg within two years, the operation may be continued until cleanup levels are reached. However, if the technology is not successful, even after an extended operating time, the DOE, in agreement with the EPA and the KDEP, may proceed to remediate the unit with Alternative 3, *In Situ* Enhanced Soil Mixing.

The components of Alternative 3 — *In Situ* Enhanced Soil Mixing include the following:

- A crane or other mechanical mixing unit;

- An agent delivery system (e.g., hot air, steam, or hydrogen peroxide); and

- An off-gas collection/treatment system (e.g., activated carbon that will be regenerated or stored onsite).

The EPA and the KDEP have participated in the development of this ROD, including review and comment on the content of the document.

STATUTORY DETERMINATIONS

Both remedial technologies [*In Situ* Remediation (Lasagna™) and *In Situ* Enhanced Soil Mixing] are protective of human health and the environment and comply with federal and state applicable or relevant and appropriate requirements. The remedial actions also are cost effective and follow the statutory mandate for permanent solutions and alternative treatment technologies to the maximum extent practicable. Additionally, they meet the statutory preference for remedies that employ treatments that reduce toxicity, mobility, or volume through treatment as a principal element. If unrestricted use and unlimited exposure remain at the unit after the operational period, a five-year review evaluating whether the remedy continues to provide adequate protection for human health and the environment will be required.

_______________________________ Date 7-8-98

Rodney R. Nelson
Assistant Manager for Environmental Management
United States Department of Energy

_______________________________ Date 8/16/98

Richard Green
~~Acting~~ Director, Waste Management Division
United States Environmental Protection Agency, Region 4

PART 2

DECISION SUMMARY

DECISION SUMMARY

2.1 Site Name, Location, and Description

The Paducah Gaseous Diffusion Plant (PGDP) is located in western Kentucky, approximately 16 km (10 miles) west of Paducah and about 6 km (4 miles) south of the Ohio River (Figure 2-1). This plant is an uranium enrichment facility owned by the United States Department of Energy (DOE). The PGDP, which has been in operation since 1952, supplies fuel for commercial reactors.

The Energy Policy Act of 1992 transferred operation of the DOE's uranium enrichment facilities to the United States Enrichment Corporation (USEC). Effective July 1, 1993, Martin Marietta Utility Services, Inc., (now Lockheed Martin Utility Services, Inc.) contracted with the USEC to provide operation and maintenance (O&M) services. The DOE continues to perform environmental restoration, decontamination and decommissioning, and waste management activities at the PGDP under its Environmental Management Program contracted to Bechtel Jacobs Company LLC.

Under the DOE's Environmental Management Program, cleanup activities currently are being conducted at the PGDP to address contamination that resulted from past waste-handling and disposal practices. These cleanup activities comply with the requirements of the Commonwealth of Kentucky, the United States Environmental Protection Agency (EPA), and the DOE.

This Record of Decision (ROD) addresses one of the solid waste management units (SWMUs), the Cylinder Drop Test Area (SWMU 91), identified at the PGDP (Figure 2-2). This SWMU is grouped in Waste Area Group (WAG) 27 as a potential source of trichloroethene (TCE), a dense nonaqueous phase liquid (DNAPL) that has contaminated the ground water of the Regional Gravel Aquifer (RGA). While the action described in this ROD will remediate this suspected source of ground-water contamination, any risks to human health or the environment present at the site due to contaminated ground water will be addressed as part of the ground-water integrator operable unit evaluation (WAG 26).

2.2 Site History and Enforcement Activities

The Cylinder Drop Test Area (SWMU 91) encompasses approximately 0.7 hectares (1.7 acres) and is located in the extreme west-central area of the plant on the southern edge of the C-745-B Cylinder Yard (Figure 2-2). Drop tests were conducted at the PGDP from late 1964 until early 1965 and in February 1979 to demonstrate the structural integrity of the steel cylinders used to store and transport uranium hexafluoride (UF_6). Prior to structural testing, the cylinders went through thermal conditioning by immersing them in a concrete pit containing dry ice and TCE. During the tests, a crane lifted the cylinders to a specified height and dropped them onto a concrete and steel pad to simulate worst-case transportation accidents.

In the first test period, a brine-ice bath was used to chill one cylinder prior to its drop test. The 1979 test used a TCE- and dry-ice bath to chill one of the steel cylinders. The concrete in-ground pit that held the TCE refrigerant for cylinder immersion leaked and resulted in contamination of the surrounding shallow soil and ground water. Although one corner of the pit was located, the exact location of the entire pit is unknown. The pit is approximately 9 m (30 ft) from the drop pad.

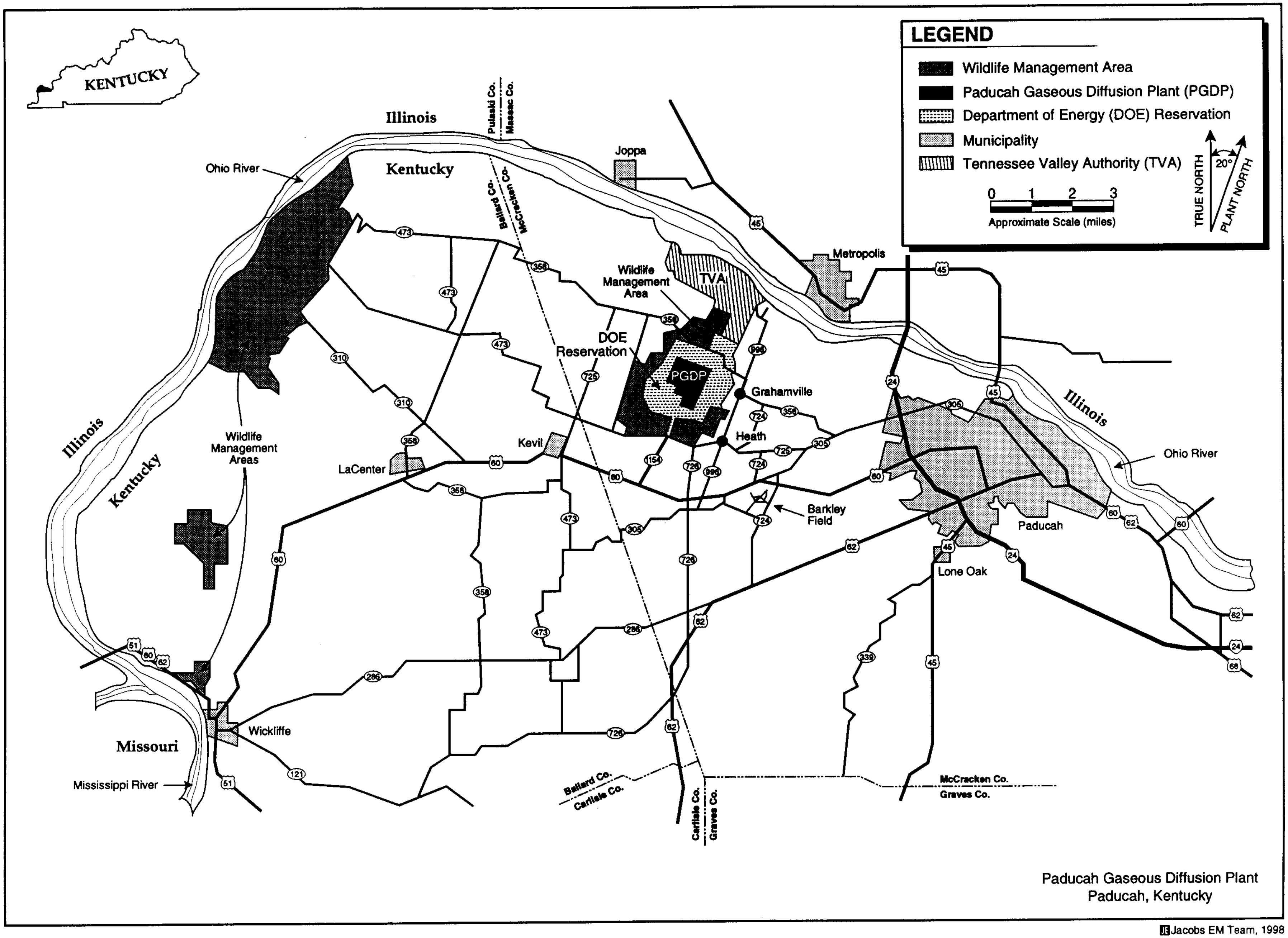

Figure 2-1. Paducah Gaseous Diffusion Plant Vicinity Map

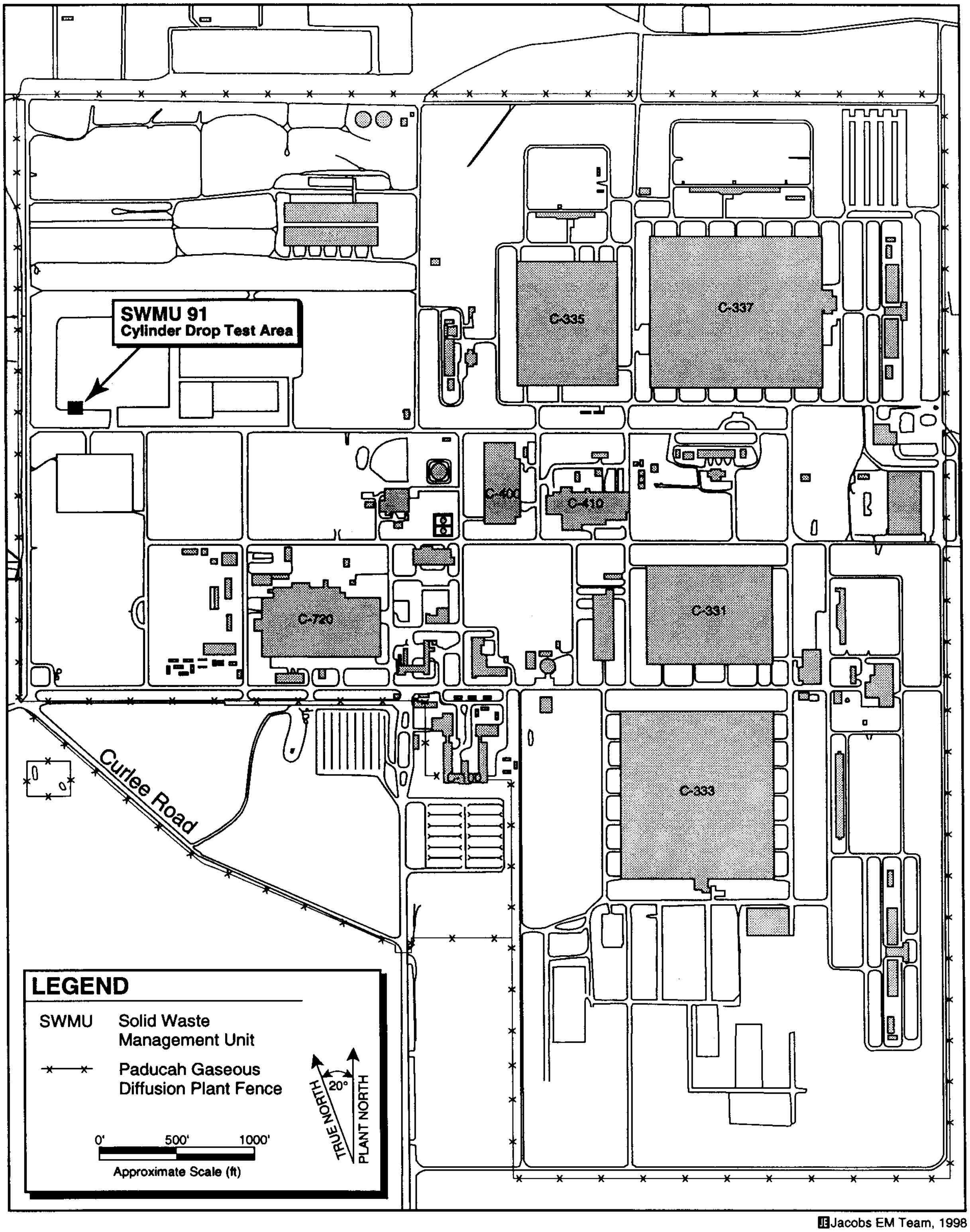

Figure 2-2. Location of Solid Waste Management Unit 91, Cylinder Drop Test Area

The amount of TCE released at the drop test site can be estimated based on the size of the cylinders. The cylinders are 3.7 m (12.2 ft) long and 1.2 m (4 ft) in diameter with a 15.2-cm (6-inch) stiffening ring/lifting lug offset on each side, yielding a minimum tank width of 1.5 m (5 ft). The likely maximum quantity lost to the surrounding soil is approximately 1,627.5 liters (430 gals) as presented in the *Preliminary Site Characterization/Baseline Risk Assessment/Lasagna™ Technology Demonstration at Solid Waste Management Unit 91 of the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/EM-128.

2.3 Highlights of Community Participation

A Notice of Availability was published in *The Paducah Sun*, a regional newspaper, February 22, 1998, announcing the beginning of the 45-day public review period for the *Proposed Remedial Action Plan for Waste Area Group 91 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/06-1499&D3. The public comment period began February 23, 1998, and ended April 8, 1998. Specific groups that received individual copies of the Proposed Remedial Action Plan (PRAP) include the Natural Resource Trustees and the Site Specific Advisory Board. There were no requests for a public meeting or hearing; therefore, the tentatively scheduled public meeting and the hearing on March 24, 1997, were canceled.

2.4 Scope and Role of Operable Unit

Contamination levels that could pose a threat to human health and the environment are present in the soil at SWMU 91. The Lasagna™ field demonstration previously treated a portion of the TCE contamination in the soil and shallow ground water at this SWMU. Trichloroethene is present in the subsurface soil at this unit at concentrations indicative of possible DNAPL pockets in the saturated soil. These DNAPL pockets could allow long-term releases into the ground water. The shallow ground water beneath this unit also contains elevated concentrations of dissolved TCE. This ground water is not used for drinking water purposes, but it is hydraulically connected to the RGA and is the pathway of concern.

The DOE proposes the *in situ* treatment of soil containing chemicals of concern (COCs) that exceed remediation levels at SWMU 91 using the Lasagna™ process. The purpose of the selected response action is to destroy or break down TCE *in situ* reducing contaminant levels below remediation levels. This response action will mitigate future migration of dissolved TCE through ground water to the RGA and keep off-site releases from this unit below regulatory limits.

2.5 Response Action and the Site Management Strategy

The PGDP presents unusually complex problems in terms of hazardous waste management and environmental releases. The DOE's proposed strategy is to divide the site into operable units grouped by source areas and ground- and surface-water integrator operable units. Discrete response actions will be selected and implemented for each source area operable unit, as well as the integrator operable units that are impacted by commingled releases from the source area operable units. Prioritization for investigation and possible remedial action have been assigned to each of the integrator operable units and source area operable units depending on their potential for contributing to off-site contamination. As a suspected source of off-site ground-water contamination, SWMU 91 is a high priority for remediation.

The DOE already has begun to address the ground-water integrator operable units through remedial actions on the Northwest and Northeast Plumes. By addressing this future source of off-site ground-water contamination, the DOE is following the cleanup strategy for the PGDP as outlined in the *Site Management Plan, Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/07-1207&D3.

2.6 Summary of Site Characteristics

This section briefly describes the hydrogeology of the PGDP and discusses the local hydrogeologic and contaminant characteristics of SWMU 91. It also presents an overview of the actions conducted to date at the site.

2.6.1 Hydrogeologic Characteristics of the Paducah Gaseous Diffusion Plant Area

Unless otherwise noted, the information presented in this section is derived from the *Report of the Paducah Gaseous Diffusion Plant Groundwater Investigation Phase III,* KY/EM-150, and the *Preliminary Site Characterization/Baseline Risk Assessment/Lasagna™ Technology Demonstration at Solid Waste Management Unit 91 of the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* KY/EM-128.

2.6.1.1 Regional surface-water hydrology

The PGDP is located in the western portion of the Ohio River Basin (Figure 2-3). A local drainage divide causes the plant's surface-water flow either to be to the east and northeast toward Little Bayou Creek or to the west and northwest toward Bayou Creek. Bayou Creek and Little Bayou Creek are perennial streams that eventually discharge into the Ohio River.

Bayou Creek flows generally northward along the western boundary of the plant from approximately 4 km (2.5 miles) south of the plant to the Ohio River. Little Bayou Creek originates within the West Kentucky Wildlife Management Area and flows northward along the eastern boundary of the plant. Little Bayou Creek joins Bayou Creek in a marsh located approximately 4.8 km (3 miles) north of the PGDP. Other surface-water bodies located in the area surrounding the PGDP include the Ohio River, Metropolis Lake, Crawford Lake, numerous small ponds, gravel pits, and settling basins.

At the PGDP, man-made drainage ditches receive storm water and effluent from the plant. These waters are routed through outfalls and eventually discharge into Bayou and Little Bayou Creeks. The majority of the flow in these creeks can be attributed to effluent water from the plant. The Kentucky Pollutant Discharge Elimination System (KPDES) permitted outfalls have a combined average daily flow of 18.5 million liters per day (4.88 million gallons per day) and are monitored by PGDP personnel.

2.6.1.2 Regional geology

The PGDP is located in the Jackson Purchase Region of western Kentucky, at the northern tip of the Mississippi Embayment. The stratigraphic sequence at the PGDP consists of a sequence of unconsolidated sediments unconformably overlying Paleozoic limestone bedrock at a depth of approximately 104 m (340 ft). The sediments overlying the bedrock consist of the following strata, in order of decreasing depth: the Mississippian rubble zone, the McNairy Formation, the Porters Creek Clay, the Eocene Sands, the continental deposits, and surficial loess and/or alluvium. Figure 2-4 presents a schematic diagram illustrating the relationships between the geologic horizons present at the PGDP.

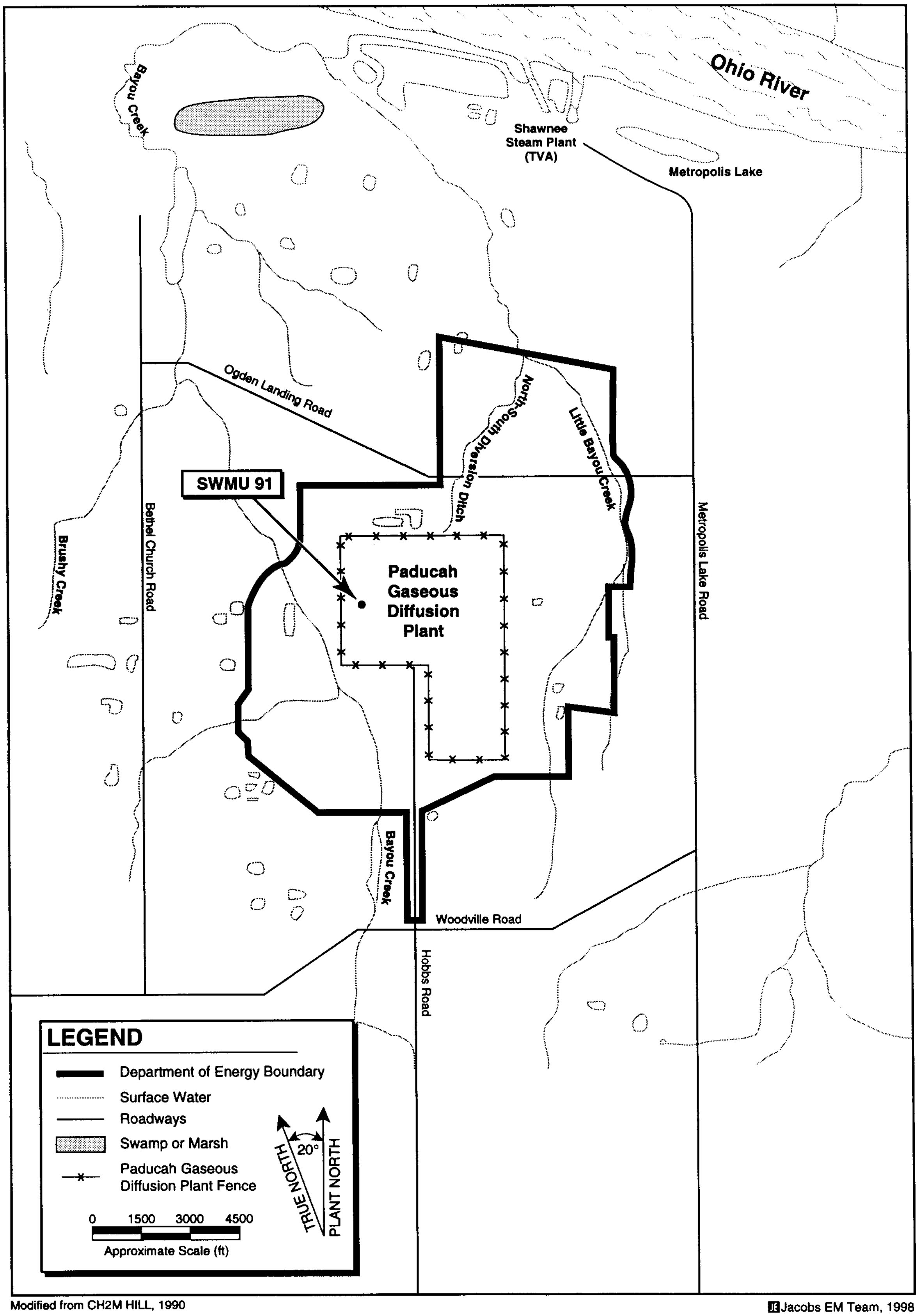

Figure 2-3. Surface-Water Features in the Vicinity of the Paducah Gaseous Diffusion Plant

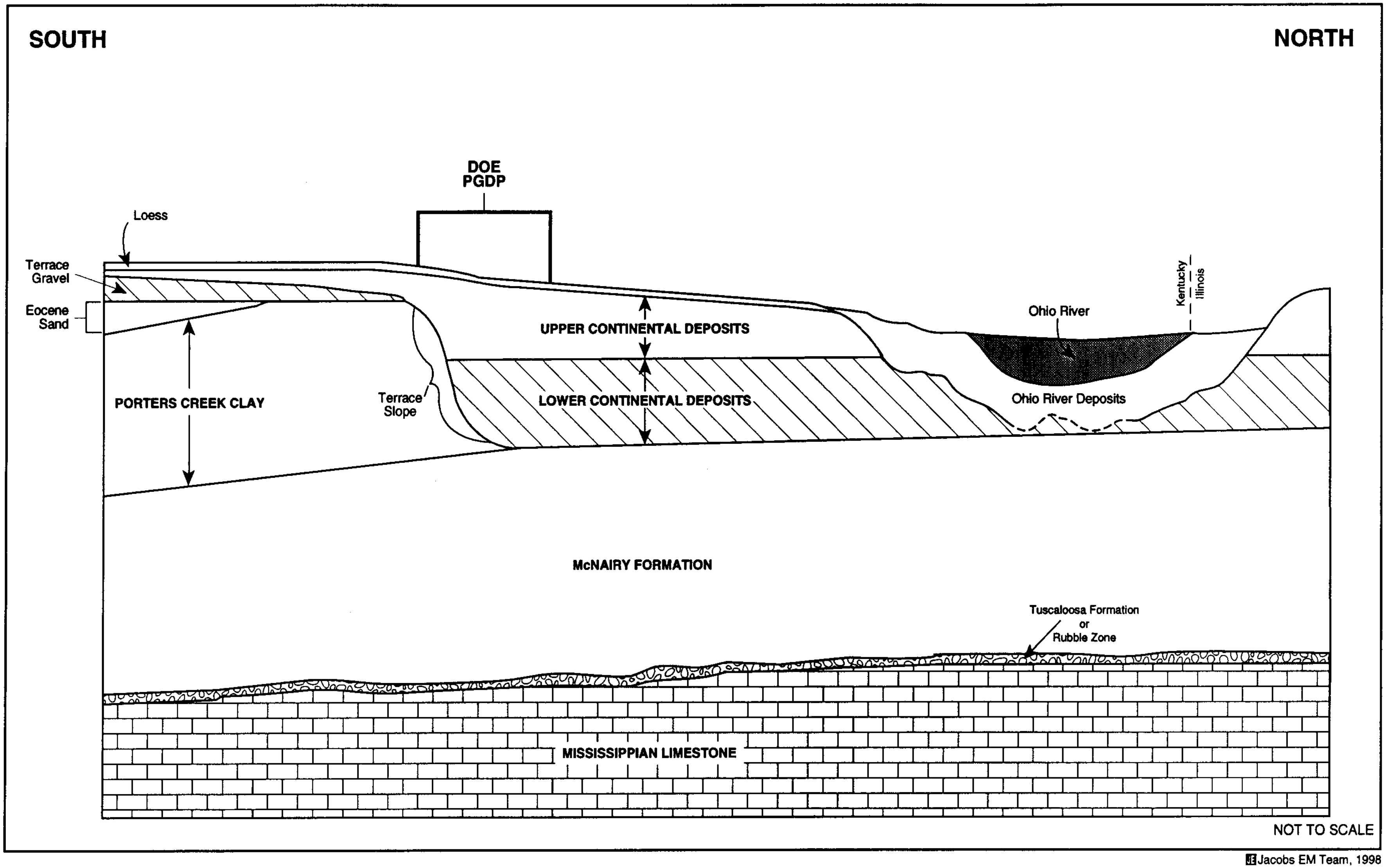

Figure 2-4. Schematic of Stratigraphic and Structural Relationships near the Paducah Gaseous Diffusion Plant

The principal geologic feature in the PGDP area is the Porters Creek Clay Terrace, a large, low-angle, subsurface terrace trending approximately east-west across the southern portion of the plant. This terrace is believed to be the result of the erosion of the Porters Creek Clay by the ancestral Tennessee River. Due to the erosion, the Porters Creek Clay essentially is absent from the PGDP area north of the terrace slope.

In the PGDP area south of the terrace slope, the Porters Creek Clay directly overlies the McNairy Formation, a sequence of marine clays, silts, unconsolidated sands, and occasional fine gravel. The Porters Creek Clay is unconformably overlaid by either the Eocene Sands or the continental deposits. The principal gravel facies within the continental deposits south of the Porters Creek Clay Terrace are Miocene-Pliocene gravels, commonly referred to as Terrace Gravel deposits.

North of the terrace slope, the McNairy Formation is directly overlaid by continental deposits. The continental deposits are subdivided informally into the Lower Continental Deposits, which consist of chert gravel in a matrix of sand and silt, and the Upper Continental Deposits, which consist of thin interbedded layers of clayey silt, sand, and occasional gravel. In the PGDP area, the continental deposits commonly are overlaid by fine-grained aeolian deposits called loess; however, along rivers or creeks, the surficial deposits are typically alluvium.

2.6.1.3 Regional ground-water hydrology

Several water-bearing zones are present in the PGDP area. South of the Porters Creek Clay Terrace Slope, the principal water-bearing units, in order of increasing depth, are the Terrace Gravel, the Eocene Sands, and the McNairy Formation. The primary water-bearing units north of the buried terrace are the RGA, the Upper Continental Recharge System (UCRS), and the McNairy Formation.

The RGA, defined as the uppermost aquifer at the PGDP, is present north of the Porters Creek Clay Terrace. The RGA consists of the gravel and sand facies of the Lower Continental Deposits and also includes the sands of the upper part of the McNairy Formation where they are present directly below the RGA. The unit ranges in thickness from 3 to 12 m (10 to 40 ft) and pinches out at the base of the Porters Creek Clay Terrace Slope. The hydraulic conductivity values determined by aquifer pump tests for the RGA range from 1.87×10^{-2} to 4.23×10^{-1} cm/sec (5.297×10^{1} to 1.093×10^{3} ft/day). Ground-water velocity within the RGA is estimated to range from 61 to 122 m/yr (200 to 400 ft/yr) to the north-northeast, toward the Ohio River. Recharge to the RGA primarily is via infiltration from the Upper Continental Deposits and underflow from the Terrace Gravel.

The UCRS is present north of the Porters Creek Clay Terrace and consists of the Upper Continental Deposits and overlying loess. It includes numerous sand and gravel lenses within a less-permeable, clayey silt matrix. These sand and gravel lenses occur at various elevations and their degree of interconnection is not known. The flow direction in the UCRS is primarily downward. Below the sands and gravel, a clay, silt, or clayey-silt layer separates the UCRS sands and gravels from the underlying RGA. This layer is relatively continuous across the PGDP, but its thickness varies.

Immediately south of the Porters Creek Clay Terrace slope, the principal water-bearing unit within the continental deposits is the Terrace Gravel. The Terrace Gravel consists of interbedded gravel, sand, silt, and clay. Near the Porters Creek Clay Terrace slope, the Terrace Gravel transmits ground water laterally along the impermeable surface of the Porters Creek Clay to the continental deposits north of the slope and to the alluvial deposits of nearby streams.

2.6.2 Hydrogeologic Characteristics of Solid Waste Management Unit 91

The information presented in this section is derived from the *Results of the Site Investigation, Phase III*, KY/E-150, and the *Preliminary Site Characterization/Baseline Risk Assessment/Lasagna™ Technology Demonstration At Solid Waste Management Unit 91 of The Paducah Gaseous Diffusion Plant*, KY/EM-128.

2.6.2.1 Surface features and surface water at Solid Waste Management Unit 91

The ground surface at SWMU 91 is relatively flat and ranges in elevation from 113 m (371 ft) amsl near the drop test pad to 112 m (367 ft) amsl in the ditch to the south (Figure 2-5). Most of the ground surface is covered with approximately 1.24 m (4 ft) of gravel road base. The concrete and steel pad used during the drop tests covers an area approximately 3 m x 3 m (10 ft x 10 ft). Runoff from SWMU 91 predominately flows into the ditch immediately south of the drop test area and discharges via KPDES Outfall 015 to Bayou Creek, which is located approximately 457 m (1,500 ft) to the west.

2.6.2.2 Geology and hydrogeology of Solid Waste Management Unit 91

The following investigations conducted in the vicinity of SWMU 91 have provided data useful for characterizing the lithology and hydrogeology of the site:

- The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site investigation conducted in 1991 and 1992, which included the installation of four deep soil borings (H003, H201, H202, and H203) and three ground-water monitoring wells (MW 158, MW 159, and MW 160) at the unit (Figure 2-5);

- Geophysical surveys conducted in the area in 1993, including magnetometer, resistivity, terrain conductivity, and ground penetrating radar surveys;

- Ground-water and soil sampling conducted April and May 1993 in support of the INTERA sand and gravel surfactant demonstration;

- Installation of temporary wells and piezometers for the purpose of conducting pump and slug tests during May and August 1993; and

- Three additional phases of soil sampling were conducted at the unit in May 1994, May through June 1995, and February through March 1996 in support of the Lasagna™ demonstration.

The lithologies encountered beneath the unit are as follows, in order of increasing depth: gravel fill material, loess deposits, the Continental Deposits, and the McNairy Formation. The loess deposits consist of approximately 4.6 m (15 ft) of silty clay directly underlying the surficial gravel cover at SWMU 91, as shown on cross section A-A′ (Figures 2-5 and 2-6). The Upper Continental Deposits underlie the loess at a depth of about 6 m (20 ft) bls and are from 9- to 12-m (30- to 40-ft) thick. These deposits consist of a matrix of silty clay containing sand and gravel lenses. The shallow ground-water system at the site, the UCRS, consists of the upper Continental Deposits

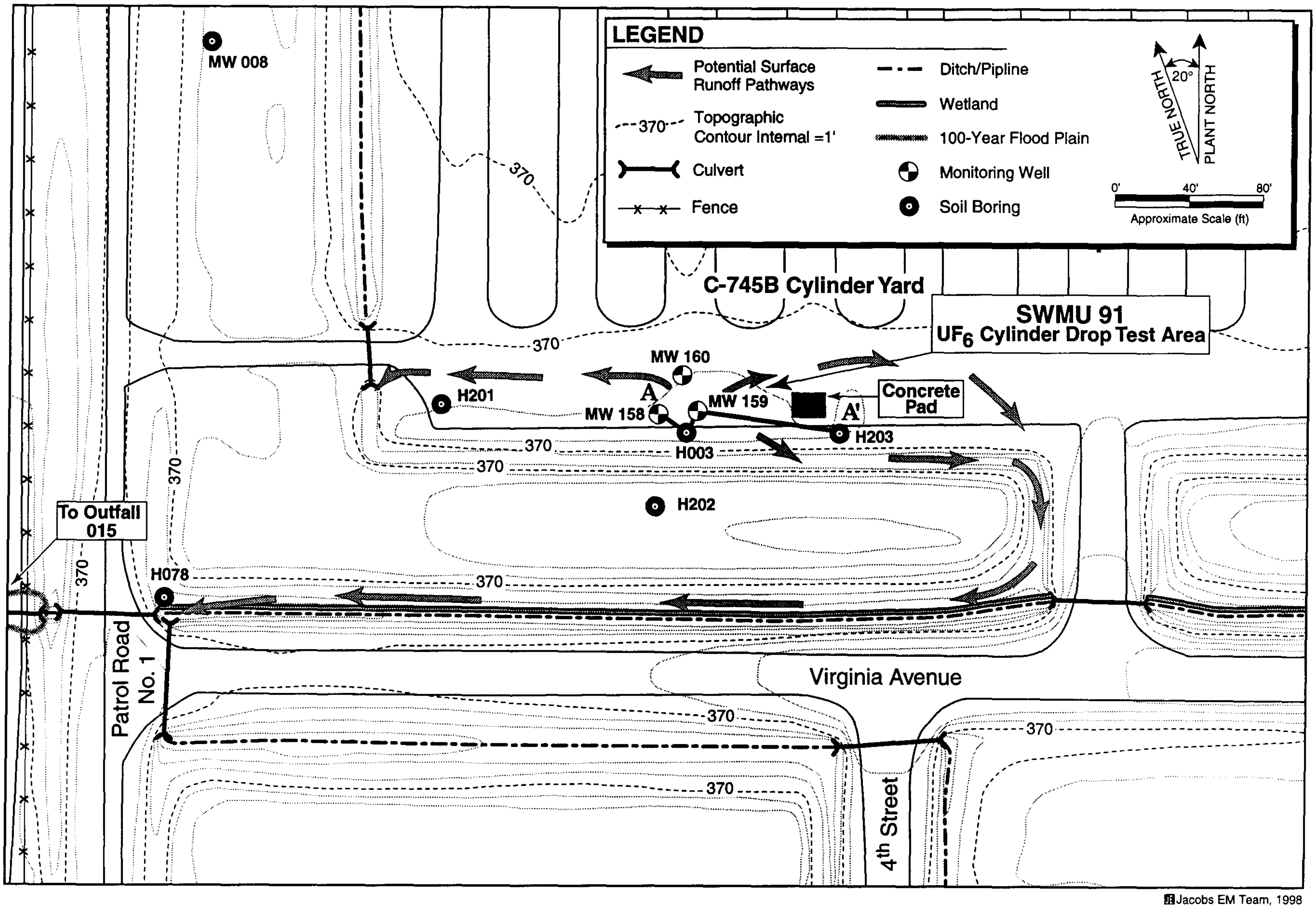

Figure 2-5. Location of Cross Section A-A'

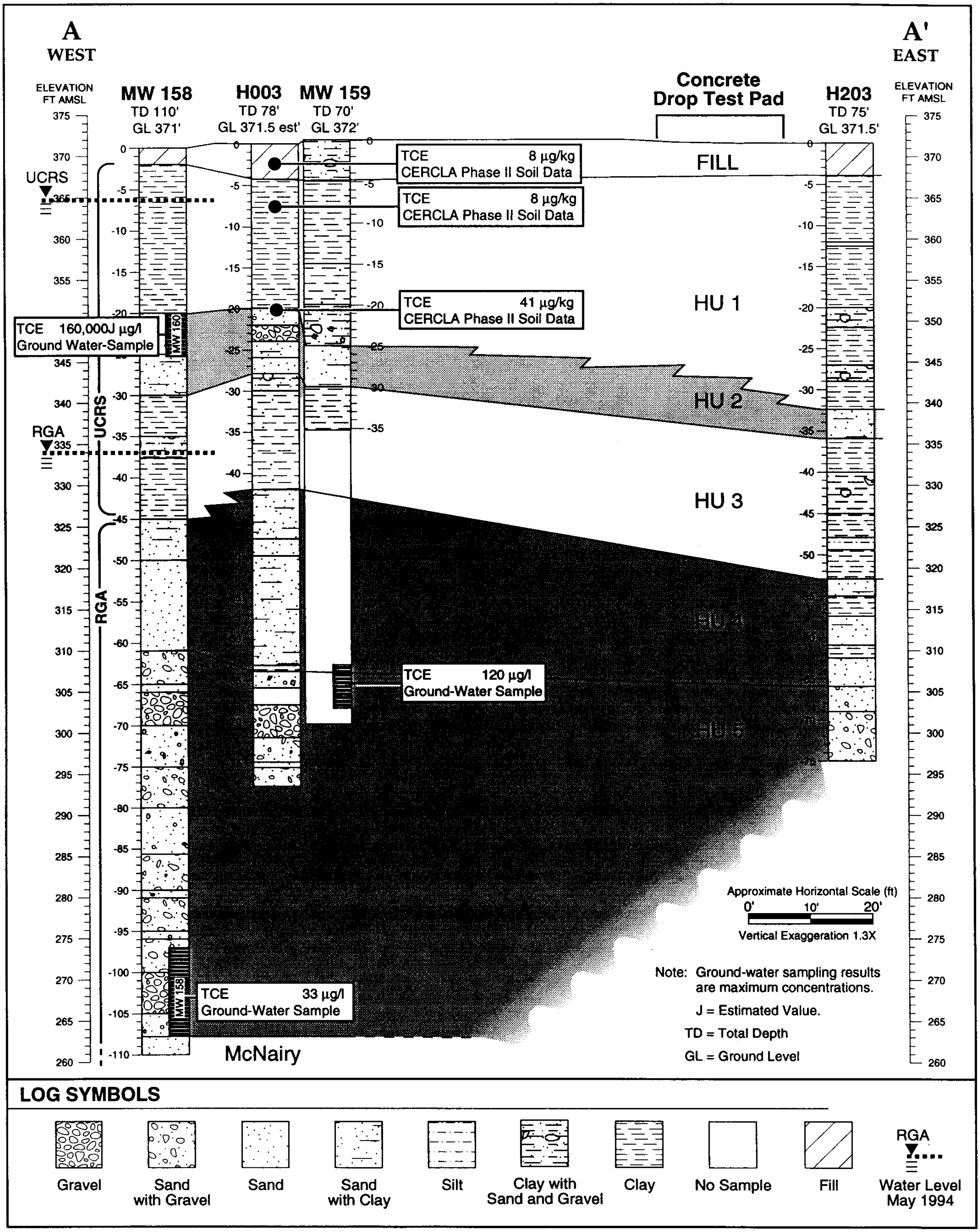

Figure 2-6. Cross Section A-A' at Solid Waste Management Unit 91, Cylinder Drop Test Area

and overlying loess and has been divided into the following hydrogeologic units (HUs): clay to clayey silt (HU 1), sand and gravel (HU 2), and clay or silty clay (HU 3). A pump test in the area measured the hydrologic properties of HU 2, a 3-m (10-ft) thick layer of sand and gravel encountered at a depth of 6 to 9 m (20 to 30 ft) bls. Resulting hydraulic conductivities values ranged from 3.70×10^{-6} to 3.97×10^{-5} cm/sec (1×10^{-2} to 1.12×10^{-1} ft/day) and storage coefficients ranged from 7.43×10^{-3} to 5.9×10^{-2}. Water level measurements taken in MW 160, which is screened in HU 2, indicate that the depth to the water table is approximately 2 m (7 ft) bls at SWMU 91. The clay aquitard at the base of the UCRS (HU 3) is approximately 4.6 m (15 ft) thick and occurs between approximately 9 to 15 m (30 to 50 ft) bls. Flow within the UCRS is predominantly downward into the uppermost aquifer, the RGA.

The RGA consists of a 4.6- to 6.1-m (15- to 20-ft) thick sand unit (HU 4) overlying 14 to 15 m (45 to 50 ft) of sandy, pebble- to cobble-sized chert gravel (HU 5) and sand (upper McNairy Formation). Two monitoring wells have been completed in the RGA at SWMU 91: MW 159, which is screened in the upper RGA at 19 to 21 m (63 to 68 ft) bls, and MW 158, which is screened in the lower RGA at 31 to 32.9 m (102 to 108 ft) bls. The depth to water in MW 158 was approximately 11 m (37 ft) bls [102 m (334 ft) amsl] in May 1994. Water levels in upper RGA MW 159 typically are slightly higher than those measured in MW 158, indicating predominantly horizontal flow with a small downward component of flow within the RGA. The top of the McNairy Formation is encountered at 33 m (108 ft) bls in MW 158.

2.6.3 Operable Unit Characteristics

Results of the investigations conducted at SWMU 91 indicate that organic contaminants are present in both soil and ground water at the unit. The COC is TCE with maximum levels of 1,523 mg/kg (ppm) and 943 mg/l detected in subsurface soil and shallow ground-water samples, respectively. The concentration of TCE detected in shallow (UCRS) ground-water samples approaches the solubility limit for TCE (1,100 mg/l), strongly suggesting the presence of DNAPL at the site. The concentrations of TCE in the RGA ground-water samples at the unit are much lower, ranging from 8 to 120 µg/l, indicating that DNAPL likely is confined to the shallow (UCRS) soils at the site. The areal extent of TCE-impacted soils at SWMU 91 has been estimated as approximately 558 m^2 (6,000 ft^2), with TCE concentrations in this area averaging 84 mg/kg. The sampling results indicate that TCE has migrated below the water table into the UCRS but has not fully penetrated through the HU 3 aquitard at the unit. Residual contamination is present in the subsurface soils to an approximate depth of 14 m (45 ft) bls.

Other organic compounds have been detected, at low concentrations, in shallow (UCRS) and deep (RGA) ground water at this unit. Those detected in UCRS ground-water samples include the following: 1,1,1-trichloroethane; cis-1,2-dichloroethene (cis-1,2-DCE); tetrachloroethylene; carbon tetrachloride; acetone; bromodichloromethane; chloroform; and bis(2-ethylhexyl)phthalate. With the exception of the TCE degradation product cis-1,2-DCE, these organic contaminants were detected only once and at concentrations less than 20 µg/l. Cis-1,2-dichloroethene and two likely lab contaminants, bis(2-ethylhexyl)phthalate and carbon disulfide, have been detected at low levels in RGA ground-water samples at the unit. Several organic compounds also were detected at low levels in soil samples at the site, including bis(2-ethylhexyl)phthalate, fluoranthene, phenanthrene, pyrene, acetone, and methylene chloride. However, the only organic compound detected at high levels in soil samples from the unit is TCE.

Six metals (aluminum, antimony, cadmium, chromium, iron, and manganese) have been detected at elevated concentrations in unfiltered ground-water samples from the unit. Of these metals, three (aluminum, iron, and manganese) were detected above regulatory limits [maximum contaminant level (MCL) or secondary maximum contaminant levels] in filtered UCRS ground-water samples. One, manganese, was detected above regulatory limits in filtered RGA ground-water samples. Two metals, cobalt (15 mg/kg) and aluminum (12,700 mg/kg), were detected at levels slightly exceeding the PGDP background values (13.3 mg/kg and 12,000 mg/kg, respectively) in subsurface soil samples collected from H003. This limited occurrence of metals in the ground water and soils at the unit indicates that SWMU 91 likely is not a significant source of metals contamination.

One radionuclide, technetium-99 (^{99}Tc), has been detected in UCRS and RGA ground-water samples from SWMU 91. With the exception of one reported value of 336 pCi/l from MW 160, the levels of ^{99}Tc detected at the unit generally are near the analytical quantification limit of 25 pCi/l. The low activities detected in ground water and the absence of ^{99}Tc from soil samples at the unit indicate its presence likely is related to more general plant activities rather than to specific past activities at this SWMU.

2.6.4 Summary of Actions Taken to Date

In 1993, SWMU 91 was selected as the site of an innovative technology demonstration. The technology, known as Lasagna™, was developed by a consortium (Monsanto, DuPont, and General Electric) with the support of the DOE and the EPA. The Lasagna™ technology is an *in situ* technology that uses electrical voltage to move shallow ground water and contaminants in fine-grained or clayey soils. Contaminants are treated by passing contaminated ground water through in-ground treatment cells.

For Phase I of the technology demonstration, corrugated metal sheet piles were driven into the subsurface at SWMU 91 to act as electrodes on the east and west sides of the designated treatment area. The Phase I treatment area encompassed an area of 3.0 x 4.6 m (10 x 15 ft) and extended to a depth of 4.6 m (15 ft). The water treatment zones consisted of activated carbon strips that adsorbed contaminants from the ground water, including the target compounds (i.e., TCE and TCE degradation products). Sampling and analytical results documenting the Phase I study are reported in the *Preliminary Site Characterization/Baseline Risk Assessment/Lasagna™ Technology Demonstration at Solid Waste Management Unit 91 of the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/EM-128. The Phase I demonstration was conducted over a four-month period ending in May 1995 and resulted in a 98.4% reduction of TCE levels in soils within the treatment area.

The success of the Phase I demonstration led to implementation, in August 1996, of a large-scale demonstration (Phase IIA). The Phase IIA demonstration was carried out on an area approximately 6.4 m x 9.1 m (21 x 30 ft) and approximately 14 m (45 ft) deep. The ground-water treatment zones consisted of a mixture of clay and iron particles that were expected to degrade TCE chemically *in situ* to nontoxic end products. Post-test soil sampling conducted for the Phase IIA demonstration indicated that cleanup effectiveness of TCE ranged from 50% to 140%. As anticipated, TCE did not appear to have been converted to higher concentrations of intermediate chlorinated compounds, such as cis-1,2-DCE or vinyl chloride, but it was degraded to the end products ethane, ethylene, and acetylene. The initial average TCE concentrations in soil were 18, 42, 52, 34, and 34 mg/kg at sampling locations 2A-01, 2A-02, 2A-03, 2A-04, and 2A-05, respectively. After a treatment period of 11 months, the average concentrations had dropped to 0.87 (2A-01), 24 (2A-02), 0.16 (2A-03), 11 (2A-04), and 9.2 (2A-05) mg/kg. The cleanup objectives were achieved at locations 2A-01 and 2A-03, and significant reductions occurred at the remaining locations (Figure 2-7).

2.6.5 Contaminant Characteristics

The conceptual site model (Figure 2-8) illustrates primary and secondary contaminated media, transport pathways, exposure pathways, and receptors that may be affected by releases. This model identifies contaminant leaching from soil to ground water as the probable migration pathway from SWMU 91. The selected remedy presented in this ROD is intended to address the source of contamination, thereby decreasing migration from the unit and risks to potential receptors. It must be noted that potential receptors listed in the conceptual site model currently are protected by the PGDP's water policy, which offers an alternative water source to plant personnel and the surrounding community. Potential impacts to human health and the environment addressed by the selected remedy are discussed in Section 2.7.

2.7 Summary of Site Risks

The *Preliminary Site Characterization/Baseline Risk Assessment/Lasagna™ Technology Demonstration at Solid Waste Management Unit 91 of the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/EM-128, contains the baseline human health risk assessment (BHHRA) and an evaluation of potential ecological risks at the Cylinder Drop Test Area. This assessment employed state and federal guidance to evaluate risks resulting from exposure to ground water and soil contaminated with TCE and its breakdown products at SWMU 91. Environmental transport of TCE to ground water below SWMU 91, to the PGDP security fence, to the DOE property boundary, and to the Ohio River was considered in the baseline risk assessment using computer modeling programs: RISKPRO™, SESOIL, and AT123D.

Specific information regarding the results of the human health and preliminary ecological risk assessments are presented in the following sections. Those elements that are the focus of the remedial action decision are discussed as appropriate.

2.7.1 Human Health Risk Assessment

Data from soil and ground-water samples collected during the SWMU 91 site characterization were evaluated and used in the BHHRA. In addition to the data evaluation, the BHHRA included an exposure assessment, a toxicity assessment, a risk characterization, and a discussion of associated uncertainties.

The potential for human contact with contaminants is evaluated in the exposure assessment. As illustrated in Figure 2-8, soil and ground water are the primary media through which exposure may occur. The only receptor evaluated for potential soil exposure in the BHHRA is a future excavation worker [assumed to be exposed to contaminants in the top 3 m (10 ft) of soil 20 days/year for one year]. Receptors evaluated for potential ground-water exposure in the BHHRA include: a future industrial worker (assumed to come into direct contact with contaminated ground water 250 days/year for 25 years); and a rural resident [including both an adult (assumed to come into direct contact with contaminated ground water 350 days/year for 34 years) and a child (assumed to come into direct contact with contaminated ground water 350 days/year for 6 years)]. Upon completion of the exposure assessment, doses for each chemical of potential concern (COPC) are calculated for integration with toxicity assessment information.

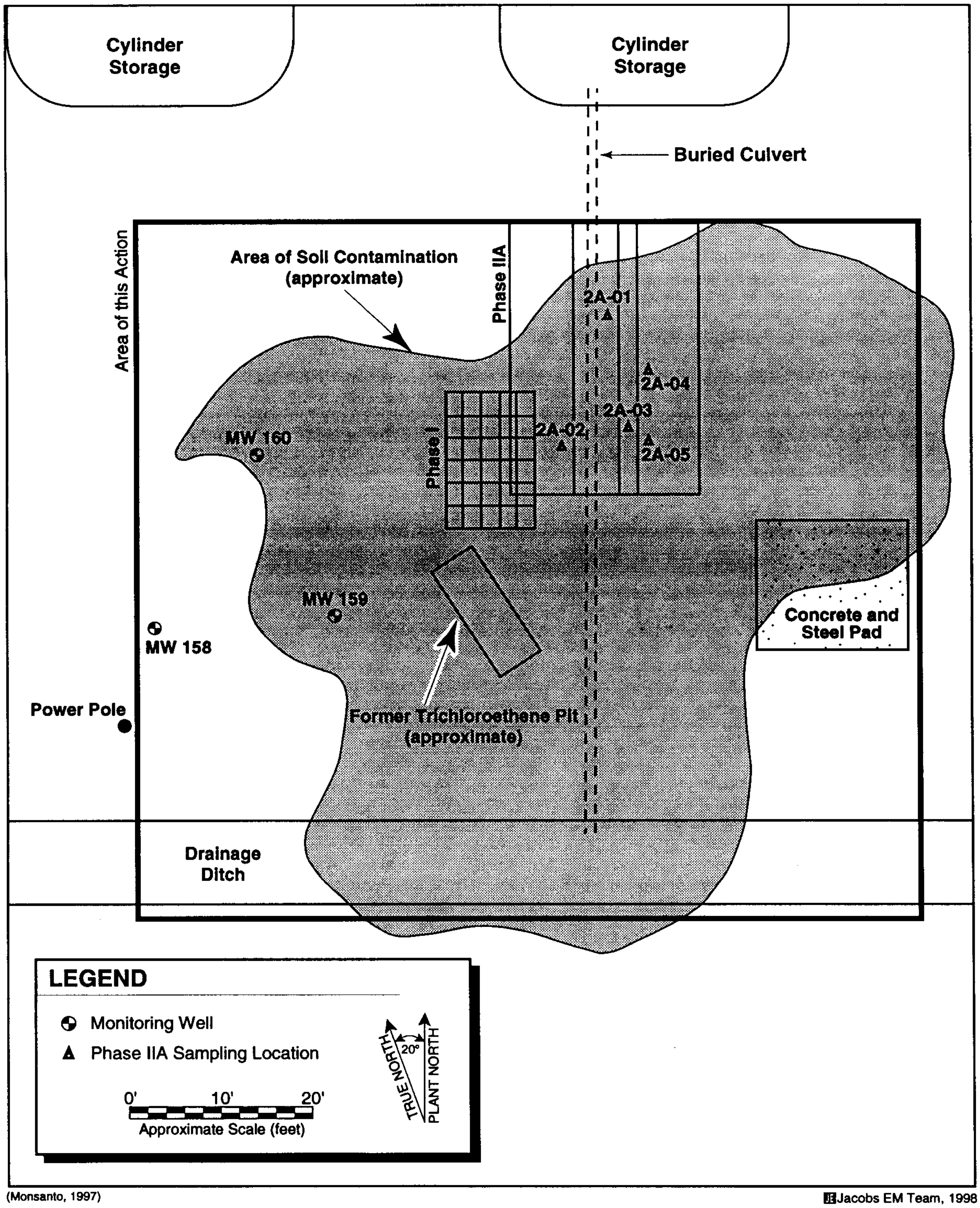

Figure 2-7. Approximate Extent of Soil Contamination and Area to be Remediated

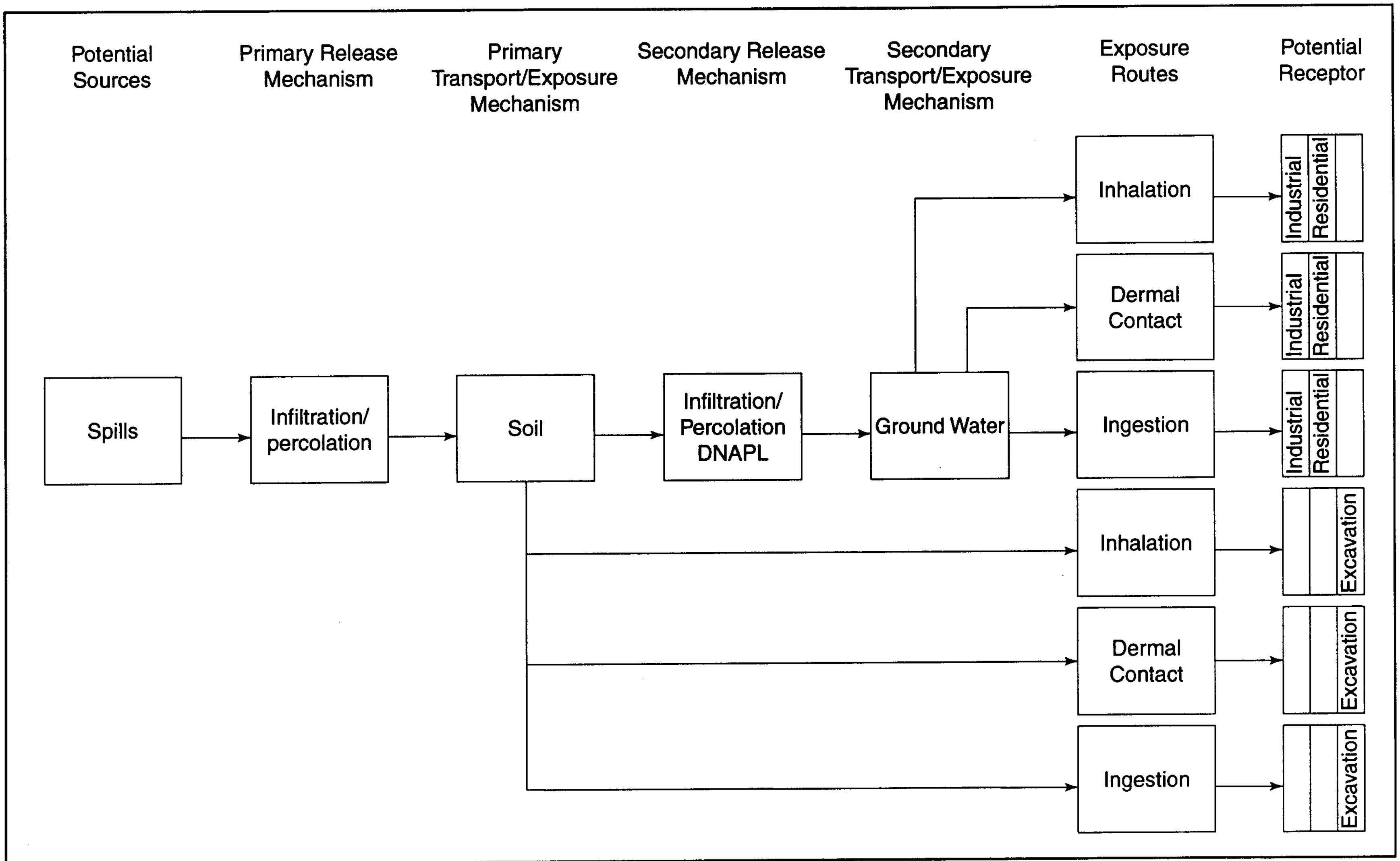

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Figure 2-8. Conceptual Site Model for Solid Waste Management Unit 91, Cylinder Drop Test Site

The toxicity assessment evaluates adverse effects to human health resulting from exposure to all COPCs; however, the only COC at SWMU 91 is TCE. Consequently, the toxicity assessment for this document focuses on TCE. During the development of the *Preliminary Site Characterization/Baseline Risk Assessment/Lasagna™ Technology Demonstration at Solid Waste Management Unit 91 of the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/EM-128, TCE was still classified as a B2 chemical, which may cause cancer in humans through prolonged exposure. Since the development of this document, the classification of TCE now is considered a Class C (possible carcinogen) to B2 (probable) chemical, meaning there still is scientific uncertainty about whether TCE will cause cancer in humans through prolonged exposure. To estimate excess lifetime cancer risks (ELCRs) associated with prolonged exposure to potentially carcinogenic materials, the EPA's Carcinogenic Assessment Group developed cancer potency factors (CPFs) (also referred to as cancer slope factors). The *Guidance on Preparing Superfund Decision Documents: The Proposed Plan, The Record of Decision, Explanation of Significant Differences, and The Record of Decision Amendment*, EPA/540/G-89/007, outlines the use of CPF as follows:

> CPFs, which are expressed in units of $(mg/kg\text{-}day)^{-1}$, are multiplied by the estimated intake of a potential carcinogen, in mg/kg-day, to provide an upper-bound estimate of the ELCR associated with exposure at that intake level. The term "upper-bound" reflects the conservative estimate of the risks calculated from the CPFs. This approach makes underestimation of the actual cancer risk highly unlikely.

The cancer potency factors for TCE used in the BHHRA assume TCE is a B2 carcinogen; they are as follows: for the oral pathway, 0.011 $(mg/kg\text{-}day)^{-1}$; for the inhalation pathway, 0.006 $(mg/kg\text{-}day)^{-1}$; and for the dermal absorption pathway, 0.073 $(mg/kg\text{-}day)^{-1}$. After assessing the toxicity of the contaminants, the results are combined with the exposure assessment and used to develop the risk characterization.

The risk characterization indicates that currently there are no unacceptable risks to human health at SWMU 91 and that risks to future workers are considered minimal. This is partially due to the fact that the unit is covered with approximately 1.2 m (4 ft) of soil and rock that eliminate the potential for direct contact with contaminated surface soil. This eliminates surface soil as a pathway of concern for current and future workers. The total cancer risk (i.e., ELCR) for exposure to subsurface soil by an excavation worker is 1×10^{-7}, which is well below Kentucky Department for Environmental Protection's (KDEP's) allowable *de minimus* risk level of 1×10^{-6}; therefore, the subsurface soil is not a pathway of concern. To protect ground-water users, the DOE provides an alternate water source to the PGDP and the surrounding community. Since the alternate water source used by the plant will continue to be used in the future, ground water is not a pathway of concern for current and future industrial workers. Currently, the alternate water supply is used by all residents in the surrounding area whose wells are contaminated; consequently, ground water can be eliminated as a pathway of concern for current residents. However, transport modeling indicates that the levels of TCE present in the soil at SWMU 91 will migrate to ground water below the unit and eventually may reach the nearest point of exposure (POE) above the regulatory level of 5 µg/l (i.e., the MCL), which may present a risk to future potential ground-water users.

The maximum concentration of TCE predicted to reach the PGDP northern security fence is 200 µg/l, which corresponds to a 1×10^{-5} ELCR. Consequently, a future potential off-site ground-water user may come into direct contact with unacceptable concentrations of TCE. To protect the future potential off-site ground-water users, the

DOE will take an action that will lower the concentration of TCE in soil at the unit, which will reduce the potential for contaminant migration to the nearest POE at unacceptable levels. Ground-water modeling indicates that reducing the concentration of TCE in soil at SWMU 91 to less than 5.6 mg/kg will result in a concentration in ground water that is less than 5 μg/l at the PGDP's security fence, which reduces the ELCR to a future potential ground-water user by an order of magnitude to approximately 3×10^{-7}, thus protecting human health at the nearest POE, the DOE property boundary. Current ground-water contamination below the unit (i.e., RGA) will be evaluated more thoroughly, relative to cumulative impacts, in the WAG 27 investigation and the ground-water integrator operable unit investigation.

Uncertainties that could affect the results of the risk assessment and the ground-water modeling are detailed in Appendix G of the *Preliminary Site Characterization/Baseline Risk Assessment/Lasagna™ Technology Demonstration at Solid Waste Management Unit 91 of the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* KY/EM-128, and are summarized as follows:

- Trichloroethene and its breakdown products were singled out for much of the sampling efforts at SWMU 91; therefore, contributions to total risk from other contaminants that may be present are not considered;

- Frequencies of contact were used in the risk assessment that exceed current rates and may exceed expected future rates, resulting in overestimated risks;

- Uncertainties in toxicity values related to their derivation generally are addressed by applying factors that lower the values resulting in overestimated risks; and

- Uncertainties associated with the ground-water modeling performed; specifically that the modeling did not consider attenuation of TCE, which may result in lower concentrations at the nearest POE.

2.7.2 Ecological Risk Assessment

Potential ecological effects and whether SWMU 91 poses an immediate threat are qualitatively evaluated in the preliminary ecological risk assessment. The ecological evaluation concluded that currently there are no factors that pose a threat to ecological receptors. In addition, no factors indicate the possibility of future exposure to ecological receptors at SWMU 91, and it is likely there will be no exposure along contaminant migratory pathways. These conclusions are based primarily upon SWMU 91's location within the facility boundaries inside the PGDP security fence. No critical habitats, populations of, or potential habitats for federally listed, proposed, or candidate species exist within the PGDP security fence. No waterfowl or fish are present in the ditches surrounding the SWMU. The plant communities exist mostly in mowed grass and channeled ditches. Therefore, assessing direct toxic effects on wildlife populations at SWMU 91 is inappropriate due to the industrial nature and small scale of the unit. Furthermore, the cumulative effects of contamination of small areas of terrestrial habitat and contaminant migration from multiple source units to receiving areas (e.g., streams) will be assessed in the PGDP baseline ecological risk assessment for the surface-water integrator operable unit.

Based on the findings of the ecological risk evaluation, only the results of the BHHRA were used to evaluate the need for action at SWMU 91 and to develop the remedial action objective (RAO); however, implementing a technology to address human health concerns will improve conditions in the ecosystem by accelerating the natural attenuation process.

2.7.3 Conclusions of the Risk Assessment

While the impacts of these uncertainties to the risk assessment results and ground-water modeling vary, data conclusively shows that TCE is distributed throughout the soil within SWMU 91. In addition, underlying ground water in the UCRS appears to have been impacted as a result of TCE migration. In consideration of all available information, TCE is identified as a human health COC, which is the primary emphasis for remedial decisions at SWMU 91.

2.7.4 Remedial Action Objective

Results of the human health risk assessment indicate that the concentration of TCE in the soil at SWMU 91 is not at levels that are associated with unacceptable risk. However, modeling indicates that TCE may migrate to the ground water and eventually to the nearest POE at concentrations exceeding the MCL of 5 µg/l. The RAO is intended to prevent rural residents from exposure to the only COC, TCE. Thus, the RAO for SWMU 91 is to mitigate migration of TCE beyond the SWMU boundary through the ground water by the soil leaching pathway. The Lasagna™ technology demonstration has been shown to meet effectively the RAO for SWMU 91 by treating TCE contaminated soils present in SWMU 91 to less than 5.6 mg/kg. Remediating TCE levels in soil below 5.6 mg/kg will reduce TCE concentrations below MCLs (less than 5 µg/l), thereby protecting human health at the nearest POE in ground water.

2.8 Description of Alternatives

Twenty-one technologies were evaluated and screened in *the Feasibility Evaluation for Trichloroethene-Contaminated Soil at Solid Waste Management Unit 91 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/06-1557&D3. Three alternatives were retained for detailed evaluation. The following paragraphs present a description of the three detailed alternatives evaluated for SWMU 91.

2.8.1 Alternative 1 — No Action

Pursuant to 40 C.F.R. § 300.430(e) of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), the DOE is required to consider a no action alternative. This alternative serves as a baseline to which the other alternatives will be compared. Under this alternative, no further action would be taken at SWMU 91.

Under this alternative, the DOE would take no action to address soil and future ground-water contamination problems or to minimize further contaminant releases from SWMU 91. The alternative would not reduce future risk. No additional costs are associated with this alternative.

2.8.2 Alternative 2 — *In Situ* Remediation (Lasagna™)

Alternative 2 consists of *in situ* soil treatment for TCE. The in-place soil treatment proposed is a new, yet demonstrated, technology at the PGDP that is provided under the trademark Lasagna™. The Lasagna™ process uses electroosmosis (electrical fields) to drive pore volumes of water containing TCE to treatment zones that also are located in the ground (Figure 2-9). The volume of soil proposed for treatment at SWMU 91 is estimated to be 32 m (105 ft) long by 18 m (60 ft) wide by 14 m (45 ft) deep, which

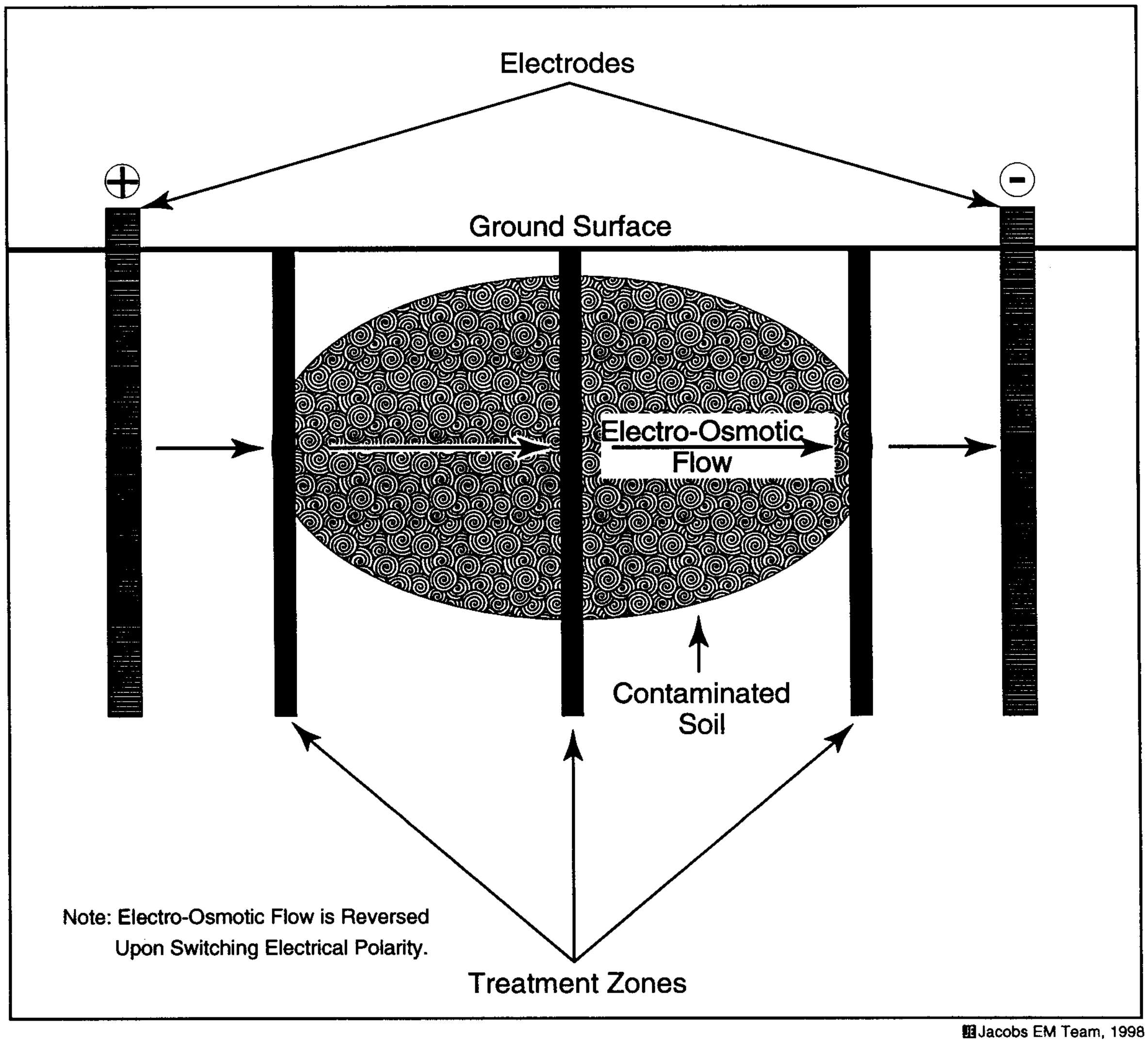


Figure 2-9. Conceptual Schematic of Lasagna™

equates to approximately 7,645 m^3 (270,000 ft^3 or 10,000 yd^3). The treatment zones (approximately 20) are estimated to be 18 m (60 ft) long by 14 m (45 ft) deep and approximately 5 cm (2 inches) thick. The media used for treatment may consist of a variety of products such as iron, kaolin clay, and water with the specific treatment medium being determined during design. Electrodes will be placed at the ends of the area and most likely at evenly spaced intervals between treatment zones to supply the electrical current for treatment.

2.8.3 Alternative 3 — *In Situ* Enhanced Soil Mixing

Alternative 3 consists of stripping volatile organics using a crane-mounted auger (Figure 2-10). The diameter of the soil auger ranges from 0.9 to 3.6 m (3 to 12 ft). Steam, hot air, or hydrogen peroxide is injected through the auger to assist in stripping volatile organics (i.e., TCE) from the soils. Soil vapors, contaminated with volatile organic compounds, are collected under a surface shroud and transported to an off-gas treatment system (e.g., activated carbon that would be regenerated or stored onsite). Treatment zones are overlapped to address the entire contaminated area.

This technology is particularly suited to shallow applications [i.e., effective at depths down to 12 m (40 ft)] above the water table, but it can be used at greater depths [some commercial vendors have successfully operated this process at depths to 30.5 m (100 ft) with the smaller diameter augers)]. This technology appears to be applicable to all types of soils (i.e., sandy, silty, or clayey). This technology may require an off-gas treatment system if the expected contaminant concentrations exceed emission standards; therefore, the cost presented in the following text includes off-gas treatment. Application of this technology at the Portsmouth Gaseous Diffusion Plant (PORTS) site indicated that removal efficiencies decreased as depths increased; however, none of the depths conducted at PORTS exceeded the 7-m (22-ft) depth interval. Removal efficiencies also increased with operation times.

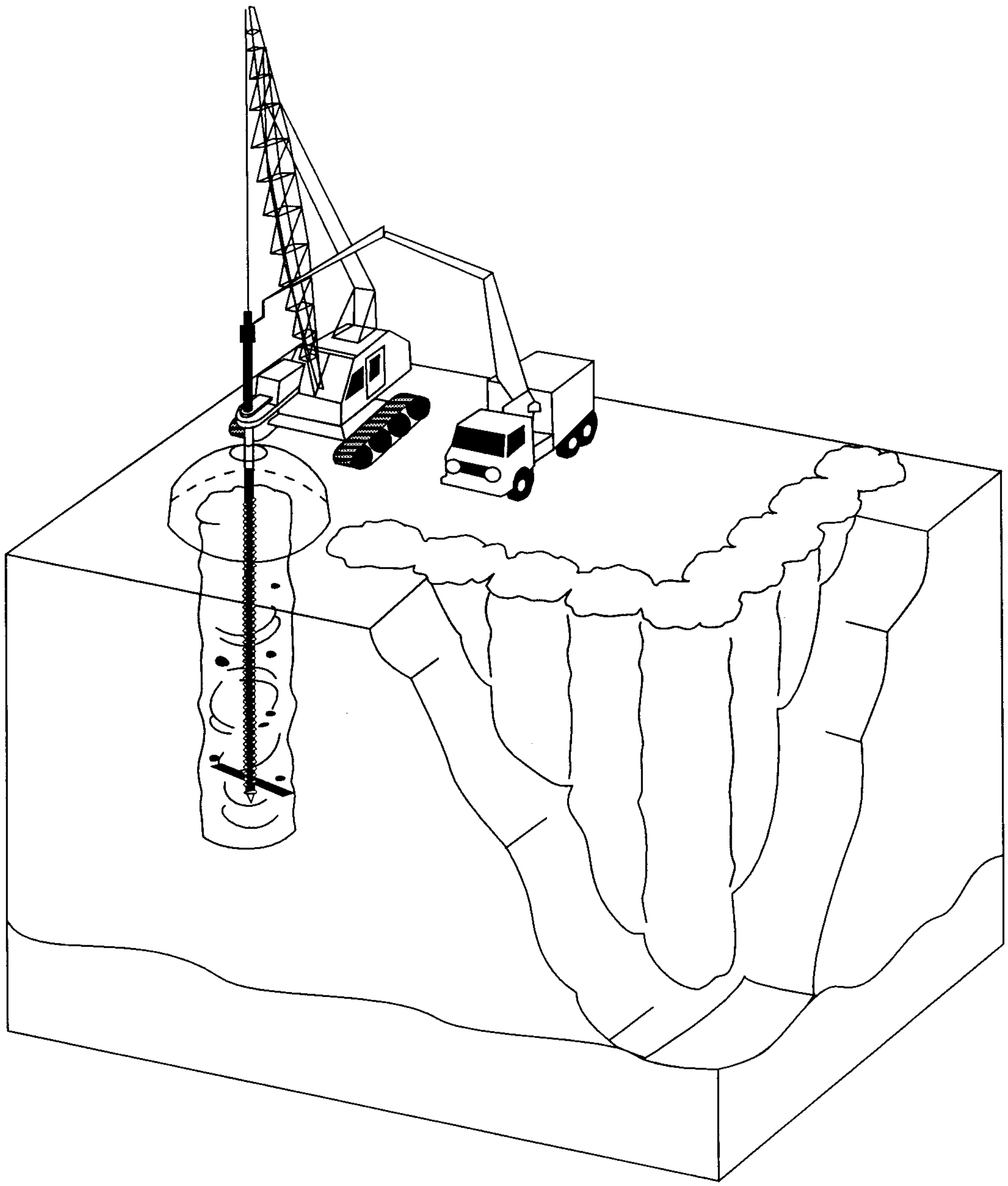
2.9 Summary of the Comparative Analysis of Alternatives

This section provides the basis for determining which alternative does the following: (1) meets the threshold criteria for overall protection of human health and the environment, and complies with applicable or relevant and appropriate requirements (ARARs); (2) provides the best balance between effectiveness and reduction of toxicity, mobility, or volume through treatment, implementability, and cost; (3) satisfies both state and community acceptance; and (4) is consistent with the Hazardous Waste Permit.

Nine criteria are required by the CERCLA for evaluating the expected performance of remedial actions. The remedial alternatives have been evaluated based on the nine criteria that are identified as follows.

(1) *Overall protection of human health and the environment.* This threshold criterion requires that the remedial alternative adequately protects human health and the environment, in both the short and long term. Protection must be demonstrated by the elimination, reduction, or control of unacceptable risks.

(2) *Compliance with ARARs.* This threshold criterion requires that the alternatives be assessed to determine if they attain compliance with ARARs of both state and federal law.



Note: Treatment agents (e.g., hot air or steam) are delivered through the mixing blade with emissions captured in the shroud covering the mixed region.

Source: Modified from Mutch and Ash, 1993

Jacobs EM Team, 1998

Figure 2-10. *In Situ* Enhanced Soil Mixing Schematic

(3) *Long-term effectiveness and permanence.* This primary balancing criterion focuses on the magnitude of residual risk and the adequacy and reliability of the controls used to manage remaining waste (untreated waste and treatment residuals) over the long term (i.e., after remedial objectives are met). Remedial actions that provide the highest degree of long-term effectiveness and permanence are those that leave little or no waste at the site, make long-term maintenance and monitoring unnecessary, and minimize the need for institutional controls.

(4) *Reduction of contaminant toxicity, mobility, or volume through treatment.* This primary balancing criterion is used to evaluate the degree to which the alternative employs recycling or treatment to reduce the toxicity, mobility, or volume of the contamination.

(5) *Short-term effectiveness.* This primary balancing criterion is used to evaluate the effect of implementing the alternative relative to the potential risks to the general public, potential threat to workers, potential environmental impacts, and the time required for protection to be achieved.

(6) *Implementability.* This primary balancing criterion is used to evaluate potential difficulties associated with implementing the alternative. This may include technical feasibility, administrative feasibility, and the availability of services and materials.

(7) *Cost.* This primary balancing criterion is used to evaluate the estimated costs of the alternatives. Expenditures include the capital cost, annual O&M, and the combined total present value of capital and O&M costs.

(8) *State acceptance.* This modifying criterion requires consideration and incorporation of any comments on the ROD from the Commonwealth of Kentucky.

(9) *Community Acceptance.* This modifying criterion provides for consideration of any formal comments from the community concerning the PRAP.

2.9.1 Overall Protection of Human Health and the Environment

An alternative must meet this threshold criterion to be eligible for selection. Alternative 2 would meet this criterion because it remediates the contaminated soil and reduces the future potential for contaminants to migrate to the aquifer and offsite. Alternative 3 also meets this criterion because it remediates the contaminated soil and reduces the future potential for contaminants to migrate to the aquifer. Alternative 1 does not meet this criterion since it does not address the remediation of contaminants in the soil and the potential of the contaminant to migrate to the ground water and potentially off site.

2.9.2 Compliance with Applicable or Relevant and Appropriate Requirements

An alternative must meet this threshold criterion to be eligible for selection. The chosen remedial action will provide compliance with ARARs. Both Alternatives 2 and 3 would meet ARARs. A detailed description of ARARs is presented in Section 2.11 of this ROD. Alternative 1 would not comply with ARARs.

2.9.3 Long-term Effectiveness and Permanence

Alternative 2 would reduce potential long-term impacts to the aquifer by treating the contaminated soil (i.e., destroy TCE). However, untreated TCE in the soil may remain and could require minor maintenance and some monitoring. The specific needs for maintenance and monitoring, if any, will be determined after the operational period. Also, Alternative 3 would reduce potential long-term impacts to the aquifer by treating the contaminated soil. Untreated TCE soil contamination may remain that could require minor maintenance and some monitoring. Reliability for Alternative 1 is not applicable, since no remedial action is taken.

2.9.4 Reduction of Contaminant Toxicity, Mobility, or Volume through Treatment

Alternative 2 will reduce toxicity, mobility, and volume through the treatment of TCE-contaminated soil. This alternative will be designed to treat the soil to an average level below 5.6 mg/kg by the Lasagna™ process, which uses electroosmosis (electrical fields) to drive pore volumes of water to treatment zones. The Lasagna™ technology is predicted to remediate the contaminated soil to cleanup levels within two years. If the unit has not reached cleanup levels after approximately two years, the process may be allowed to continue for an extended time. However, if the process is not successful at achieving cleanup levels, DOE, in agreement with the EPA and KDEP, may use another technology (e.g., Alternative 3). Alternative 3 will also reduce toxicity, mobility, and volume through the treatment of TCE-contaminated soil. Alternative 3 would be designed to treat the soil to an average level below 5.6 mg/kg by conducting *in situ* soil mixing combined with vapor extraction (e.g., hot air injection) and off-gas collection/treatment. Alternative 1 will not reduce toxicity, mobility or volume through treatment.

2.9.5 Short-term Effectiveness

Short-term effectiveness is not applicable for Alternative 1. No negative impacts on the community or environment are anticipated for Alternative 2 or Alternative 3. Risk to workers by volatile emission will be controlled by engineering methods and is within acceptable limits for Alternative 3.

2.9.6 Implementability

Alternative 1 would be technically and administratively feasible to implement since no action is involved. Availability of services and materials is not applicable since construction would not take place.

Alternative 2 would be technically and administratively feasible to implement. Construction and operation of the technology on a smaller scale have been proved at the PGDP.

Alternative 3 would be technically and administratively feasible to implement. Materials and services are available and the technology has been demonstrated at other DOE facilities.

2.9.7 Costs

Estimated present worth, escalated capital costs, and 30-year O&M costs for each alternative are presented in Table 2-1. The total present worth cost and O&M costs for each alternative also are presented in the Table 2-1.

Table 2-1. Cost Estimates

Criteria	Alternative 1 - No Action	Alternative 2 - *In Situ* Remediation (Lasagna™)	Alternative 3 - *In Situ* Enhanced Soil Mixing
Cost			
Total escalated capital cost	$0	$1,924,000	$2,879,000
Total present worth capital cost	$0	$1,849,000	$2,762,000
Annual O&M cost	$0	$7,000	$7,000
Present worth O&M costs	$0	$99,000	$102,000
Total present worth cost	$0	$1,948,000	$2,864,000

2.9.8 State Acceptance

This remedial action will be initiated pursuant to provisions of the PGDP's Kentucky Hazardous Waste Management Permit KY8-890-008-982. The *Preliminary Site Characterization/Baseline Risk Assessment/Lasagna™ Technology Demonstration at Solid Waste Management Unit 91 of the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, KY/EM-128, was issued to the KDEP and the EPA for review. The *Feasibility Evaluation for Trichloroethene-Contaminated Soil at Solid Waste Management Unit 91 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/06-1557&D3 and the *Proposed Remedial Action Plan for Solid Waste Management Unit 91, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/06-1499&D3 have been approved by the KDEP and EPA.

2.9.9 Community Acceptance

As previously discussed in Section 2.3 and later in the Responsiveness Summary, which is Section 3 of this ROD, the public has been provided the opportunity to comment on the selected remedial action. No member of the public stated opposition to the selected remedial action or any other aspect of the proposed plan.

2.10 Selected Remedy

Based upon the evaluation of the alternatives utilizing the nine CERCLA criteria, the remedy that best meets the threshold, balancing, and modifying criteria for the scope and objectives of this remedial action is Alternative 2.

The selected remedy will, at a minimum, consist of the following elements.

- *In situ* soil treatment for TCE (Lasagna™).

- The Lasagna™ process uses electroosmosis (electrical fields) to drive pore volumes of water containing TCE to treatment zones located in the ground.

- The volume of saturated soil proposed for treatment at SWMU 91 is estimated to be 32 m (105 ft) long by 18 m (60 ft) wide by 14 m (45 ft) deep, which equates approximately to 7,645 m^3 (270,000 ft^3 or 10,000 yd^3).

- The treatment zones (approximately 20) will be nearly 18 m (60 ft) long by 14 m (45 ft) deep and approximately 5 cm (2 inches) thick.

- The media used for treatment may consist of products such as iron, kaolin clay, and water with the exact composition being determined during design.

- Electrodes will be placed at the ends of the area to be remediated and, most likely, at evenly spaced intervals between the treatment zone boundaries to supply the electrical current needed for treatment.

The DOE will prepare a detailed design for this remedial action in accordance with the requirements specified in the Declaration of this ROD. During remedial design and remedial construction activities, some changes may be made.

This action is expected to provide overall protection of human health and the environment. It also can be implemented in compliance with ARARs. This action will serve as a remedial action for the soil at SWMU 91 of WAG 27. Contaminant mobility to the underlying aquifer will be reduced as a result of the treatment. This alternative will provide short-term effectiveness and may be readily implemented. As shown in Table 2-1, the total present worth estimated cost for Alternative 2 is $1,948,000.

The Lasagna™ process is an innovative technology. If the unit has not reached cleanup levels within two years, the process may be allowed to continue operation until cleanup is achieved. However, if the process is not successful at achieving cleanup levels, the DOE may use another technology, Alternative 3 — *In Situ* Enhanced Soil Mixing, to remediate the unit. This technology consists of the following elements:

- A crane or other mechanical mixing unit;

- An agent delivery system (e.g., hot air, steam, or hydrogen peroxide); and

- An off-gas collection/treatment system (e.g., activated carbon that will be regenerated or stored onsite).

2.11 Statutory Determinations

This remedial action is protective of human health and the environment and complies with both federal and state ARARs. This remedial action is cost-effective, and it follows the statutory mandate for permanent solutions and alternative treatment technologies to the maximum extent practicable. Additionally, this action meets the statutory preference for remedies that employ treatments that reduce toxicity, mobility, or volume as a principal element. Since contaminants may remain at the unit, a five-year review evaluating whether the remedy's cleanup levels provide adequate protection for human health and the environment may be required.

2.11.1 Overall Protection of Human Health and the Environment

The selected action contributes to protection of human health for PGDP employees and the public through treatment, which will limit the potential for direct exposure and mitigate migration of contaminants from the SWMU. The remedy provides effective sampling and management of all residual wastes generated during implementation of the action, if unlimited use and unrestricted exposure remain after remediation.

2.11.2 Applicable or Relevant and Appropriate Requirements

The United States Congress specified in CERCLA § 121 (42 U.S.C.A. § 9621) that remedial actions for the cleanup of hazardous substances must comply with the requirements, criteria, standards, or limitations under federal or more stringent state environmental laws that are legally applicable or relevant and appropriate to the hazardous substances or circumstances at a site. The EPA categorizes ARARs as being either "applicable" or "relevant and appropriate" to a site. The terms and conditions pertinent to these categories are discussed as follows.

- *Applicable requirements* are "those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site" (40 C.F.R. § 300.5).

- *Relevant and appropriate requirements* are "those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site" (40 C.F.R. § 300.5).

Requirements under federal or state law may be either applicable or relevant and appropriate to CERCLA cleanup actions, but not both. If a requirement is not applicable, then it must be both relevant and appropriate in order for it to be an ARAR. In cases where both a federal and a state ARAR are available, or where two potential ARARs address the same issue, the more stringent regulation must be selected. However, in cases where the implementation of a federal environmental program has been delegated by the EPA to a state, typically, the analogous state regulations would be used as ARARs.

Other information that does not meet the definition of an ARAR may be necessary to determine what is protective or may be useful in developing CERCLA remedies. In addition, ARARs do not exist for every chemical or circumstance likely to be found at a CERCLA site. Therefore, the EPA believes that it may be necessary, when determining cleanup requirements or designing a remedy, to consult reliable information that would not otherwise be considered a potential ARAR. Criteria or guidance developed by the

EPA, other federal agencies, or states may assist in determining, for example, health-based cleanup levels for a particular contaminant or the appropriate method for conducting an action for which no ARARs exist. This other information is to be considered (TBC) information and may be used when developing CERCLA remedies. The TBC information generally falls within three categories: (1) health effects information, (2) technical information on performing or evaluating investigations or response actions, and (3) policy. A possible fourth category of TBC information is proposed regulations, if the proposed regulation is non-controversial and likely to be promulgated as drafted.

The EPA further categorizes ARARs based on whether they are specific to the chemical(s) present at the site (chemical-specific), the remedial action being evaluated (action-specific), or the location of the site (location-specific). Terms and conditions relevant to this categorization include the following.

- *Chemical-specific* ARARs usually are "health- or risk-based numerical values or methodologies which, when applied to site-specific conditions, result in the establishment of numerical values" [53 Fed. Reg. 51437 (December 21, 1988)]. These values establish the acceptable amount or concentration of a chemical that may remain in, or be discharged to, the ambient environment.

- *Action-specific* ARARs usually are "technology- or activity-based requirements or limitations placed on actions taken with respect to hazardous wastes, or requirements to conduct certain actions to address particular circumstances at a site" [53 Fed. Reg. 51437 (December 21, 1988)]. Selection of a particular remedial action at a site will trigger action-specific ARARs that specify appropriate technologies and performance standards.

- *Location-specific* ARARs "generally are restrictions placed upon the concentration of hazardous substances or the conduct of activities solely because they are in special locations" [53 Fed. Reg. 51437 (December 21, 1988)]. Some examples of special locations include floodplains, wetlands, historic places, and sensitive ecosystems or habitats.

The EPA designated these categories to assist in the identification of ARARs; however, they are not necessarily precise [53 Fed. Reg. 51437 (December 21, 1988)]. Some ARARs may fit into more than one category, while others may not fit definitively into any one category.

According to the preamble to the NCP at 53 Fed. Reg. 51443 (December 21, 1988), potentially responsible parties (PRPs) conducting remedial actions, or portions of remedial actions entirely onsite as defined in 40 C.F.R. § 300.5, must comply with the substantive portions of ARARs, but not the procedural or administrative requirements. Substantive requirements pertain directly to the actions or conditions at a site, while administrative requirements (e.g., permit applications and procedural requirements) facilitate remedial action implementation. Also, CERCLA § 121(d)(4) [42 U.S.C.A. § 9621(d)(4)] provides several ARAR waiver options that may be invoked, provided that human health and the environment are protected. Moreover, under CERCLA § 121(e) [42 U.S.C.A. § 9621(e)], PRPs are not required to obtain federal, state, or local permits in order to conduct on-site response actions.

In the NCP at 40 C.F.R. § 300.150, the EPA has addressed the relationship of ARARs to worker protection standards. The EPA states that CERCLA response actions must comply with the worker protection standards and requirements of the Occupational

Safety and Health Act of 1970 (29 U.S.C.A §§ 651 through 678) and analogous state laws; however, the standards and requirements are not ARARs [55 Fed. Reg. 8680 (March 8, 1990)].

The DOE, in Order 5480.4, *Environmental Safety and Health Standards*, establishes general requirements for environmental protection, safety, and health standards for all DOE and contractor operations. The Order is an internal standard, and, consistent with 40 C.F.R. § 300.150, is not an ARAR. Nonetheless, DOE Order 5480.4 must be followed during the design, construction, operation, modification (if any), and decommissioning phases of the remedial action.

Lastly, while CERCLA requires that the RCRA and other environmental laws be evaluated as ARARs [42 U.S.C.A. § 9621(d)(2)(A) and 40 C.F.R. § 300.420(f)(1)(i)(A)], this in no way limits, takes away, or negates the KDEP's RCRA authority at the PGDP.

Chemical-, location-, and action-specific ARARs and TBC information that exist for remedial action at SWMU 91 are described in the following sections. These ARARs apply both to the preferred Lasagna™ technology and to the contingency remedy, *In Situ* Enhanced Soil Mixing, unless otherwise noted.

2.11.2.1 Chemical-specific applicable or relevant and appropriate requirements

Ground-water contamination.

The Kentucky Administrative Regulations at 401 K.A.R. 8:250-420 may be relevant and appropriate for contaminated ground water at SWMU 91. The MCLs defined in these regulations are legally applicable to water "at the tap" but are not applicable to the cleanup of ground water. However, they may be considered as relevant and appropriate in situations where ground water may be used for drinking water. The MCL for TCE is 0.005 mg/l (401 K.A.R. 8:420 § 3). This ARAR is relevant and appropriate to both the preferred and contingency remedy. Either technology is expected to reduce the soil contamination to a level that would no longer contribute to ground-water contamination.

2.11.2.2 Location-specific applicable or relevant and appropriate requirements

Wetlands and floodplains.

No adverse impacts to floodplains or wetlands in the vicinity of SWMU 91 are anticipated. Consequently, although all ARARs discussed in this section are applicable, those referring to floodplains and wetlands will be met by avoidance of the resource. However, if impacts become apparent, due to construction or other plan modifications, additional requirements (compliance with the substantive requirements of Nationwide Permit (NWP) 38, 33 C.F.R. § 330) will need to be addressed and/or initiated during the remedial design and/or remedial action phase to comply with the ARARs. The requirements discussed in this section will apply to both remedial technologies.

Wetlands, and a small portion of the 100-year floodplain of Bayou Creek, have been identified in a drainage ditch approximately 100 feet south of SWMU 91. Construction activities must avoid or minimize adverse impacts to wetlands and act to preserve and enhance their natural and beneficial values [Executive Order 11990; 40 C.F.R. § 6.302(a); 40 C.F.R. § 6, Appendix A; and 10 C.F.R. § 1022]. In addition, construction activities must minimize potential harm to the 100-year floodplain (Executive Order 11988 and 10 C.F.R. § 1022).

The DOE will avoid, to the extent practicable, the long- and short-term adverse impacts to floodplains and wetlands [10 C.F.R. § 1022.3(a)]. The DOE will undertake a careful evaluation of the potential effects of any DOE action taken in a floodplain [10 C.F.R. § 1022.3(c)].

Construction in wetlands will be avoided unless there are no practicable alternatives [40 C.F.R. § 6.302(a)]. Degradation or destruction of wetlands will be avoided to the extent possible [40 C.F.R. § 230.10 and 33 U.S.C. § 1344(b)(1)]. Considerations about protection of wetlands will be incorporated into planning, regulating, and decision making [10 C.F.R. § 1022.3(b)]. Any action involving the discharge of dredged or fill material into wetlands will be avoided to the extent possible (13 U.S.C. § 1344, 40 C.F.R. § 230, and 33 C.F.R. §§ 320 to 330).

2.11.2.3 Action-specific applicable or relevant and appropriate requirements

Solid waste management unit cleanup.

The regulations that apply to the cleanup of SWMUs are applicable to Lasagna™ and *In Situ* Enhanced Soil Mixing. These applicable regulations do not contain specific cleanup standards, but instead they require corrective action measures that will result in the protection of human health and the environment (40 C.F.R. § 264.101 and 401 K.A.R. 34:060 § 12). Either technology would comply with this ARAR.

Site preparation activities.

Although fugitive dust associated with the implementation of either remedial action would be minimal, on-site construction activities may produce airborne pollutants. The Kentucky Air Quality standards found in 401 K.A.R. 63:010 §§ 3-4 contain general standards of performance governing fugitive dust emissions. The standards require the use of water or chemicals, if possible, and/or placement of asphalt or concrete on roads and material stockpiles to control dust [401 K.A.R. 63:010 § 3(1)(b)]. The standards also require that visible dust generated from implementation of the remedial alternative not be discharged beyond the property line of the PGDP [401 K.A.R. 63:010 § 3(2)]. Additionally, all open-bodied trucks that operate outside the property boundary and that may emit materials that could become airborne must be covered [401 K.A.R. 63:010 § 4(1)]. These requirements are applicable.

Toxic air emissions.

No TCE emissions are anticipated with the Lasagna™ technology. However, if the contingency remedy, *In Situ* Enhanced Soil Mixing, is implemented, the potential exists for TCE emissions to occur. The DOE must first determine if the regulations at 401 K.A.R. 63:022 apply by calculating the significant emission level for the specific toxic air pollutant (as specified in Appendix B of 401 K.A.R. 63:022). If it is determined that the toxic air regulations apply, normally, a permit would be required. However, because this is a CERCLA action, only the substantive provisions must be followed. The regulation specifies that no source is to exceed the allowable emission limit specified in Appendix A of 401 K.A.R. 63:022. If the emission limit cannot be met, even after the application of best available control technology, then best available control technology must be used (401 K.A.R. 63:022 § 3). Appropriate measures would be taken, if the contingency remedy were implemented, to comply with this ARAR.

Surface-water control for construction activities.

Storm-water discharges from construction activities onsite at the PGDP are regulated by the KPDES Permit (KY0004049) established pursuant to 401 K.A.R. 5:055. The PGDP's KPDES Permit specifies that best management practices and sediment and erosion controls be implemented at a site to control storm-water runoff. These requirements are applicable during the construction of either remedy identified in this ROD.

Hazardous waste determination.

During construction of the remedial action, either Lasagna™ or *In Situ* Enhanced Soil Mixing, a minimal amount of soil will be generated. The soil must undergo a hazardous waste determination pursuant to 40 C.F.R. § 262.11 and 401 K.A.R. 32:010 § 2. If the waste is determined to be hazardous, RCRA Subtitle C requirements would be applicable (40 C.F.R. § 262.34, 401 K.A.R. 34:030 § 5). Any waste generated during implementation of the remedial action will be characterized appropriately.

Radioactive waste determination.

Any waste generated with the remedial action must be characterized with sufficient accuracy to permit proper segregation, treatment, storage, and disposal [DOE Order 5820.2A, III.3.d(1)]. The DOE Order 5820.2A is TBC information to the disposition of any radioactive waste associated with this action. Waste characterization data must be recorded on a waste manifest and must include the following: the physical and chemical characteristics of the waste; volume of the waste; weight of the waste; major radionuclides and their concentrations; and packaging date, package weight, and external volume. Again, during the implementation of Lasagna™ or *In Situ* Enhanced Soil Mixing, appropriate characterization will occur.

Table 2-2 lists the chemical-, location-, and action-specific ARARs for remedial action at SWMU 91.

2.11.3 Cost Effectiveness

The preferred remedy provides overall effectiveness to remove and treat contaminants and to reduce potential risk while being proportional to its cost. The preferred remedy represents the least expensive remedial alternative that employs innovative treatment.

2.11.4 Utilization of Permanent Solutions and Alternative Treatment Technologies

The selected remedy (Lasagna™) meets the statutory requirement to utilize permanent solutions and treatment technologies to the maximum extent practicable. The selected remedy also satisfies the five primary balancing criteria. It provides long-term effectiveness and permanence; it provides the greatest reduction of toxicity, mobility, and volume through treatment; it provides short-term effectiveness; it is administratively and technically feasible to implement; and it is the most cost-effective remedial alternative evaluated.

Table 2-2. Applicable or Relevant and Appropriate Requirements and To Be Considered Information for the Remedial Action (Lasagna™ with *In Situ* Enhanced Soil Mixing Contingency)

Regulatory Triggers	Requirements	Prerequisites	Federal Citation	K.A.R. Citation
CHEMICAL-SPECIFIC				
Protection of drinking water	Treatment to MCLs: TCE 0.005 mg/l.	Contaminants that have leached into potential sources of drinking water — **Relevant and appropriate to ground-water remediation, applicable at the "tap."**	40 C.F.R. § 141.60	401 K.A.R. 8:420 § 3
LOCATION-SPECIFIC				
Protection of wetlands	Avoid or minimize adverse impacts to wetlands to preserve and enhance their natural and beneficial values.	Any federal action that will have an impact on wetlands — **Applicable if avoidance is not achieved.**	10 C.F.R. § 1022 and Executive Order 11990	
	Avoid degradation or destruction of wetlands to the extent possible.	Any action involving discharge of dredged or fill material into wetlands — **Applicable if avoidance is not achieved.**	40 C.F.R. § 230.10 and 13 U.S.C. § 1022.3(b)	
	Incorporate considerations about protection of wetlands into regulating and decision making. Follow substantive requirements of general Nationwide Permit conditions.	Any federal action that will have an impact on wetlands — **Applicable if avoidance is not achieved.**	10 C.F.R. § 1022.3(b) and 33 C.F.R. § 330	
Protection of floodplains	Avoid siting or construction in any 100-year floodplains.	Any federal action within a 100-year floodplain — **Applicable if avoidance is not achieved.**	10 C.F.R. § 1022 and Executive Order 11988	

Table 2-2. Applicable or Relevant and Appropriate Requirements and To Be Considered Information for the Remedial Action (Lasagna™ with *In Situ* Enhanced Soil Mixing Contingency) (Continued)

Regulatory Triggers	Requirements	Prerequisites	Federal Citation	K.A.R. Citation
ACTION-SPECIFIC				
Site preparation and construction activities	Reasonable precaution must be taken to prevent particulate matter from becoming airborne. Such precautions may include the following: • Use water or chemicals to control dust from construction activities and/or place asphalt, oil, water, or suitable chemicals on roads and material stockpiles to control dust; • Ensure that no visible fugitive dust is emitted beyond the property line; and • Ensure that all open-bodied trucks are covered if any materials in the truck could become airborne.	Handling, processing, construction, road-grading, and land-clearing activities — **Applicable.**		401 K.A.R. 63:010 § 3 401 K.A.R. 63:010 § 3(1)(b) 401 K.A.R. 63:010 § 3(2) 401 K.A.R. 63:010 § 4(1)

2.11.5 Preference for Treatment as a Principal Element

The selected remedy meets the statutory preference for treatment as a principal element. This is accomplished by the Lasagna™ technology that remediates soils by driving the TCE-contaminated pore volume water through treatment zones. The process uses electroosmosis to move contaminants in the soil pore water into treatment zones where the contaminants can be captured or decomposed.

2.12 Documentation of Significant Changes

The *Proposed Remedial Action Plan for Solid Waste Management Unit 91 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/06-1499&D3, was made available for a 45-day public review and comment period that began February 23, 1998, and ended on April 8, 1998. No meeting was requested for the proposed plan nor were any comments received from the public; therefore, the DOE has determined that no significant changes to the remedy are necessary.

PART 3

RESPONSIVENESS SUMMARY

RESPONSIVENESS SUMMARY

3.1 Responsiveness Summary Introduction

The responsiveness summary has been prepared to meet the requirements of sections 113(k)(2)(b)(iv) and 117(b) of the CERCLA, as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, that requires DOE as "lead agency" to respond ". . . to each of the significant comments, criticisms, and new data submitted in written or oral presentations" on the SWMU 91 of WAG 27 Proposed Remedial Action Plan.

The DOE has gathered information on the types and extent of contamination found, evaluated remedial measures, and recommended a remedial action that will reduce the potential migration of contaminants from the soil to the aquifer (i.e., off-site ground water to the POE). As part of the remedial action process, a notice of availability regarding the PRAP was published in *The Paducah Sun*, a major regional newspaper of general circulation. The *Proposed Remedial Action Plan for Solid Waste Management Unit 91 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/06-1499&D3, was released to the general public February 23, 1998. This document was made available to the public at the Environmental Information Center in the West Kentucky Technology Park in Kevil, Kentucky, and at the Paducah Public Library. A 45-day public comment period began February 23, 1998, and continued through April 8, 1998. The PRAP also contained information that provided the opportunity for a public meeting to be held, if requested. No request for the meeting was made by the public, so no meeting was held. Specific groups that received individual copies of the PRAP included the Natural Resource Trustees and the Site Specific Advisory Board.

Public participation in the CERCLA process is required by the SARA. Comments received from the public are considered in the selection of the remedial action for the site. The responsiveness summary serves two purposes: (1) to provide the DOE with information about the community preferences and concerns regarding the remedial alternatives, and (2) to show members of the community how their comments were incorporated into the decision-making process. However, there were no public comments.

3.2 Community Preferences/Integration of Comments

No comments, written or oral, were received from the public; therefore, this document does not address public comments, except to the extent that it is assumed that the proposed plan is satisfactory to the public.