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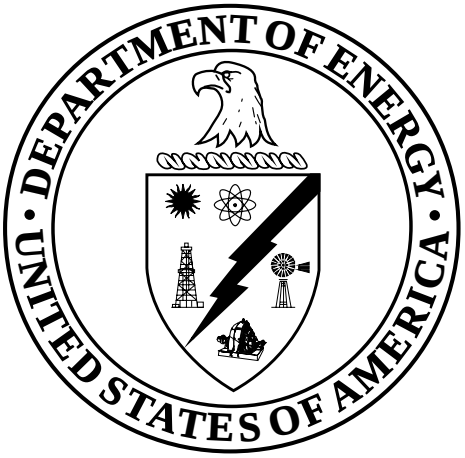
Feasibility Study for the Groundwater Operable Unit at Paducah Gaseous Diffusion Plant Paducah, Kentucky

Volume 2. Appendix A Data Summary Report



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contributed to the preparation of this document and should not be considered an eligible contractor for its review.

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Feasibility Study for the Groundwater Operable Unit at Paducah Gaseous Diffusion Plant, Paducah, Kentucky

Volume 2. Appendix A Data Summary Report

Date Issued—June 2001

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-ACO5-98OR22700

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ACRONYMS AND ABBREVIATIONS

2,3,7,8-TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
ACO	Administrative Order by Consent
Amsl	above mean sea level
AOC	Areas of Concern
AT123D	Analytical Transient 1-, 2-, 3-Dimensional Model
BERA	baseline ecological risk assessment
BGOU	Burial Grounds Operable Unit
Bgs	below ground surface
BHHRA	baseline human health risk assessment
BRA	baseline risk assessment
BTEX	benzene, toluene, ethylbenzene, and xylenes
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	contaminant of concern
COE	U.S. Army Corps of Engineers
COPC	contaminant of potential concern
COPEC	contaminant of potential ecological concern
CPT	cone penetrometer technology
D&D	decontamination and decommissioning
DCA	dichloroethane
DCE	dichloroethene
DNAPL	dense, nonaqueous-phase liquid
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DPT	direct push technology
DRO	diesel range organic
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
FFA	Federal Facility Agreement
FFCA	Federal Facility Compliance Agreement
FS	feasibility study
FTA	Fire Training Area
GWOU	Groundwater Operable Unit
HI	hazard index
HSA	hollow stem auger
HSWA	Hazardous and Solid Waste Amendments
HU	hydrologic unit
KDEP	Kentucky Department for Environmental Protection
KOW	Kentucky Ordnance Works
KPDES	Kentucky Pollutant Discharge Elimination System
LDR	land disposal restriction
MCL	maximum contaminant level
MEPAS	Multimedia Environmental Pollutant Assessment System (software)
NEPA	National Environmental Policy Act
NFA	No Further Action
NOV	Notice of Violation
NPL	National Priorities List

ACRONYMS AND ABBREVIATIONS (continued)

NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NSDD	North-South Diversion Ditch
ORAU	Oak Ridge Associated Universities
OSHA	Occupational Safety and Health Administration
OU	operable unit
PAH	polyaromatic hydrocarbon
PCE	tetrachloroethene
PGDP	Paducah Gaseous Diffusion Plant
PID	photoionization detector
PVC	polyvinyl chloride
RA	remedial action
RAD	radionuclide
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act
RD	remedial design
RESRAD	Residual Radioactivity (computer code)
RFI	RCRA Facility Investigation
RGA	Regional Gravel Aquifer
RI	remedial investigation
ROD	Record of Decision
SESOIL	Seasonal Soil Compartment Model
SHPO	State Historic Preservation Officer
SI	site investigation
SOU	Soils Operable Unit
SVOA	semivolatile organic analyte
SVOC	semivolatile organic compound
SWMM	Storm Water Management Model
SWMU	solid waste management unit
SWOU	Surface Water Operable Unit
T&E	threatened and endangered
TAL	Target Analyte List
TCA	trichloroethane
TCE	trichloroethene
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TLD	thermoluminescent dosimeter
TRU	transuranic
TSCA	Toxic Substances Control Act
TSD	treatment, storage, and disposal
TVA	Tennessee Valley Authority
UCRS	Upper Continental Recharge System
UF_6	uranium hexafluoride
COE	U.S. Army Corps of Engineers
UST	underground storage tank
VOA	volatile organic analyte
VOC	volatile organic compound

ACRONYMS AND ABBREVIATIONS (continued)

WAG	waste area grouping
WKWMA	Western Kentucky Wildlife Management Area
WTP	Water Treatment Plant

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1. INTRODUCTION

This chapter describes the purpose and organization of this Data Summary Report. Additionally, background information for the Groundwater Operable Unit (GWOU) and the site regulatory setting are presented. This Data Summary Report supports the *Feasibility Study for the Groundwater Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* and is identified as Appendix A.

1.1 PURPOSE AND ORGANIZATION OF THE DATA SUMMARY REPORT

This section presents the purpose, scope, and organization of the Data Summary Report.

1.1.1 Purpose

This Data Summary Report was developed for the GWOU project to provide a comprehensive summary of previous site investigations and to provide site background information. Additionally, this report utilizes the data from these investigations to develop nature and extent for the GWOU.

1.1.2 Report Organization

The Data Summary Report includes the chapters outlined below.

Chapter 1: Introduction. This chapter describes the scope of the project, report organization, and background information for the GWOU.

Chapter 2: Characterization of Environmental Setting. Chapter 2 contains a brief description of the environmental setting of the Paducah Gaseous Diffusion Plant (PGDP) including location, demography and land use, meteorology, topography, geology, hydrology, and ecology.

Chapter 3: Summary of Previous Investigations. Chapter 3 presents summary information for each of the remedial investigations (RIs) and groundwater investigations completed at the PGDP. Included in this chapter are descriptions of solid waste management units (SWMUs), site setting, summary of major contaminants, identification of nature and extent, fate and transport summaries, and risk assessment summaries.

Chapter 4: Nature and Extent of Contaminants. Chapter 4 presents the GWOU database and discusses the major data sets. This chapter also presents the nature and extent of the operable unit (OU) contamination and the major uncertainties.

Chapter 5: Contaminant Fate and Transport. Chapter 5 includes the modeling assumptions and results for sources not identified previously.

Chapter 6: Summary and Conclusions. Chapter 6 presents the GWOU conceptual site model and summarizes the major conclusions reached within this Data Summary Report.

References cited in this report are contained behind the text of each chapter.

1.1.3 Sources of Information

Prior to calendar year 2000, several RIs were completed following the original remedial strategy that emphasized a SWMU-by-SWMU approach. The groundwater and soil data collected from these investigations

along with data from separate groundwater investigations and the groundwater monitoring program have been compiled and used for this Data Summary Report. Since these data are sufficient for decision-making purposes, a separate GWOU RI was not necessary. All sources of information are cited and a complete reference list is available in Chap. 8 of this report.

1.2 BACKGROUND INFORMATION

The following section presents background information concerning the regulatory setting at the PGDP. Section 1.2.2 provides the scope of the GWOU and a summary of the GWOU SWMUs.

1.2.1 Regulatory Setting

The U.S. Department of Energy's (DOE's) approach to remediation at the PGDP integrates the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 U.S.C.A. §9601 to 9675), the Resource Conservation and Recovery Act (RCRA) (42 U.S.C.A. §6901 to 6992), and the National Environmental Policy Act (NEPA) (42 U.S.C.A. §4321 to 4370). This section discusses the requirements of these environmental statutes and how they have impacted the regulatory framework at the PGDP.

After the discovery of off-site groundwater contamination at the PGDP, the U.S. Environmental Protection Agency (EPA) entered into an Administrative Order by Consent (ACO) with the DOE on November 23, 1988, pursuant to the CERCLA (EPA 1988). The ACO required the DOE to monitor the residential wells, provide an alternate drinking water source to affected residents, identify the nature and extent of contamination, and take action to protect human health and the environment.

State and federal RCRA permits are in place at the PGDP to address corrective action and the treatment, storage, and disposal of hazardous waste at the facility. The Commonwealth of Kentucky issued the Hazardous Waste Management Permit (KY8-898-890-008-982) on July 16, 1991. On the same date, the EPA issued the Hazardous and Solid Waste Amendments (HSWA) Permit (KY8-890-008-982). Since the Commonwealth had not yet received authorization to implement the HSWA provisions of the RCRA. The Kentucky Department for Environmental Protection (KDEP) was delegated HSWA authority from the EPA in April 1996 [61 Fed. Reg. 18504 (April 26, 1996)]. However, EPA's HSWA permit remains in effect.

The PGDP was placed on the National Priorities List (NPL) June 30, 1994 [59 Fed. Reg. 27989, 27993 (May 31, 1994)]. Section 120 of the CERCLA requires federal facilities on the NPL to enter into a Federal Facility Agreement (FFA) with the appropriate regulatory agencies. The FFA for the PGDP was signed by DOE, EPA, and the KDEP on February 13, 1998 (EPA 1998). At that time, the FFA superseded the ACO.

The FFA coordinates the CERCLA process with the requirements of the RCRA Permits and delineates a comprehensive plan for cleanup at the PGDP. As part of this plan, the FFA has defined potentially contaminated areas at the PGDP as follows.

- Solid Waste Management Unit means any discernible unit at which solid wastes have been placed at any time, irrespective of whether the unit was intended for the management of solid or hazardous waste (EPA 1998).

- Area of Concern (AOC) means any area having a probable or known release of a hazardous waste, hazardous constituent, or hazardous substance which is not from a SWMU and which poses a current or potential threat to human health or the environment (EPA 1998).

One of the requirements of the FFA is that all SWMUs and AOCs at the PGDP undergo an integrated RI/feasibility study (FS) process. This requirement applies to the sites that originally were scheduled for investigation under the RCRA permits as well as any sites discovered during subsequent investigations.

In addition to the coordination of CERCLA and RCRA requirements, the NEPA requirements are incorporated into the planning and implementation of remedial actions at the PGDP pursuant to DOE Order 451.1A, *National Environmental Policy Act Compliance Program*, and the DOE's *Secretarial Policy on NEPA*. The Order establishes DOE's internal requirements and responsibilities for implementing the NEPA, the EPA's procedural provisions for the NEPA (40 C.F.R. Parts 1500 to 1508), and the DOE's procedures for implementing the NEPA (10 *CFR* Part 1021).

Additional regulatory drivers at the PGDP include the Federal Facility Compliance Agreements (FFCAs) that pertain to the storage of land disposal restriction (LDR)/radionuclide (RAD) mixed waste, Toxic Substances Control Act (TSCA)/RAD mixed waste, and waste not characterized by the RCRA-specified Toxicity Characteristic Leaching Procedure (TCLP). The DOE and the EPA entered into the LDR FFCA (EPA 1992a) and TCLP FFCA (EPA 1992b) pursuant to the Federal Facility Compliance Act (42 U.S.C.A. § 6991 to 6195), an amendment to the RCRA. The Act also requires DOE facilities that generate or store mixed waste to develop plans for treating their mixed waste. The PGDP's Site Treatment Plan (DOE 1996) includes such a plan for the treatment, storage, and disposal (TSD) of the DOE's mixed waste. The LDR FFCA and TSCA FFCA (EPA 1992c) allow the DOE to store LDR/RAD and TSCA/RAD mixed waste at the PGDP until treatment and disposal options become available.

1.2.2 Scope of the Groundwater Operable Unit

In April and August 1998, the DOE, the EPA, and the KDEP met to refine the remedial strategy for the PGDP. As a result of that meeting, the parties agreed to restructure the strategy to reflect accomplishment of sitewide remedial objectives as opposed to the original strategy that emphasized a SWMU-by-SWMU approach. Consequently, the basis for the new strategy is protection of human health and the environment through implementation of various actions focused on accomplishing the following remedial objectives:

(1) protection of off-site residents from consumption of contaminated groundwater;

(2) protection of recreational user associated with Bayou/Little Bayou Creeks and the Western Kentucky Wildlife Management Area (WKWMA);

(3) protection of industrial workers; and

(4) protection of ecosystems.

To accomplish these objectives, four remedial action OUs have been defined with each having a specific emphasis corresponding to one of the above remedial objectives. These OUs include the GWOU, Surface Water Operable Unit (SWOU), Soils Operable Unit (SOU), and Burial Grounds Operable Unit (BGOU). Once completed, a Comprehensive Sitewide Operable Unit will be conducted in conjunction with facility decontamination and decommissioning (D&D) to evaluate any remaining residual contamination and the cumulative effects from all media (Massey 1998a; Massey 1998b).

The GWOU project will focus on meeting the first remedial objective: protection of off-site residents from consumption of contaminated groundwater. As stated in Sect. 1.1.3, groundwater and soil data from previous RIs, groundwater investigations, and the groundwater monitoring program have been compiled and used for this Data Summary Report, the GWOU Risk Assessment, and the GWOU FS Report.

1.2.3 Waste Area Groupings/Solid Waste Management Units within the Groundwater Operable Unit Project

Table 1.1 and Fig. 1.1 identify the waste area groupings (WAGs) and SWMUs currently within the scope of the GWOU. Detailed information for each of these SWMUs is located in Chap. 3 of this report.

Table 1.1. WAG and SMWU listing for the GWOU at the PGDP

WAG	SWMU	Description	Was an FS or other similar documentation previously completed for this SWMU?	Was groundwater contamination deferred for this SWMU?
WAG 3	SWMU 4	C-747 Contaminated Burial Ground	No	Yes
WAG 6	SWMU 11	C-400 TCE Leak Site	No	NA
	SWMU 26	C-400 to C-404 Underground Transfer Line	No	NA
	SWMU 40	C-403 Neutralization Pit	No	NA
	SWMU 47	C-400 Technetium Storage Tank Area	No	NA
	SWMU 203	C-400 Waste Discard Sump	No	NA
WAG 26	AOC 201	Northwest Plume	Interim action; ROD (DOE 1993a); Technical Memorandum (DOE 1993b); Focused FS (DOE 1994a); pump-and-treat currently in place	NA
	AOC 202	Northeast Plume	Interim action; ROD (DOE 1995a); Technical Memorandum (DOE 1995b); pump-and-treat currently in place	NA
	AOC 210	Southwest Plume	No	NA
WAG 27	SWMU 1	C-747-C Oil Landfarm	FS (DOE 1996) and Action Memorandum (DOE 1997a) for surface soils only	NA
	SWMU 91	C-745-B Cylinder Drop Test Area	Feasibility Evaluation (DOE 1997b); ROD (DOE 1998a)	NA
	SWMU 196	C-746-A Septic Systems	No	NA
	SWMU 209	C-720 Compressor Shop Pit	No	NA
	AOC 211	C-720 TCE Spill Site - Northeast	No	NA
	C-720	Maintenance and Stores Building	No	NA
WAG 28	SWMU 99	C-745 Kellogg Building Site	No	NA
	SWMU 183	McGraw Underground Storage Tank	Identified as No Further Action in WAG 28 RI/FS Workplan	NA
	SWMU 193	McGraw Construction Facilities	No	NA
	SWMU 194	McGraw Construction Facilities	No	NA
	AOC 204	Dykes Road Historical Staging Area	No	NA
WAG 22	SWMU 2	C-749 Uranium Burial Ground	No	Yes
	SWMU 3	C-404 Low-Level Radioactive Waste Burial Ground	No	Yes
	SWMU 7	C-747-A Burial Ground	Yes — FS (DOE 1998b) (pending)	Yes
	SWMU 30	C-747-A Burn Area	Yes — FS (DOE 1998b) (pending)	Yes

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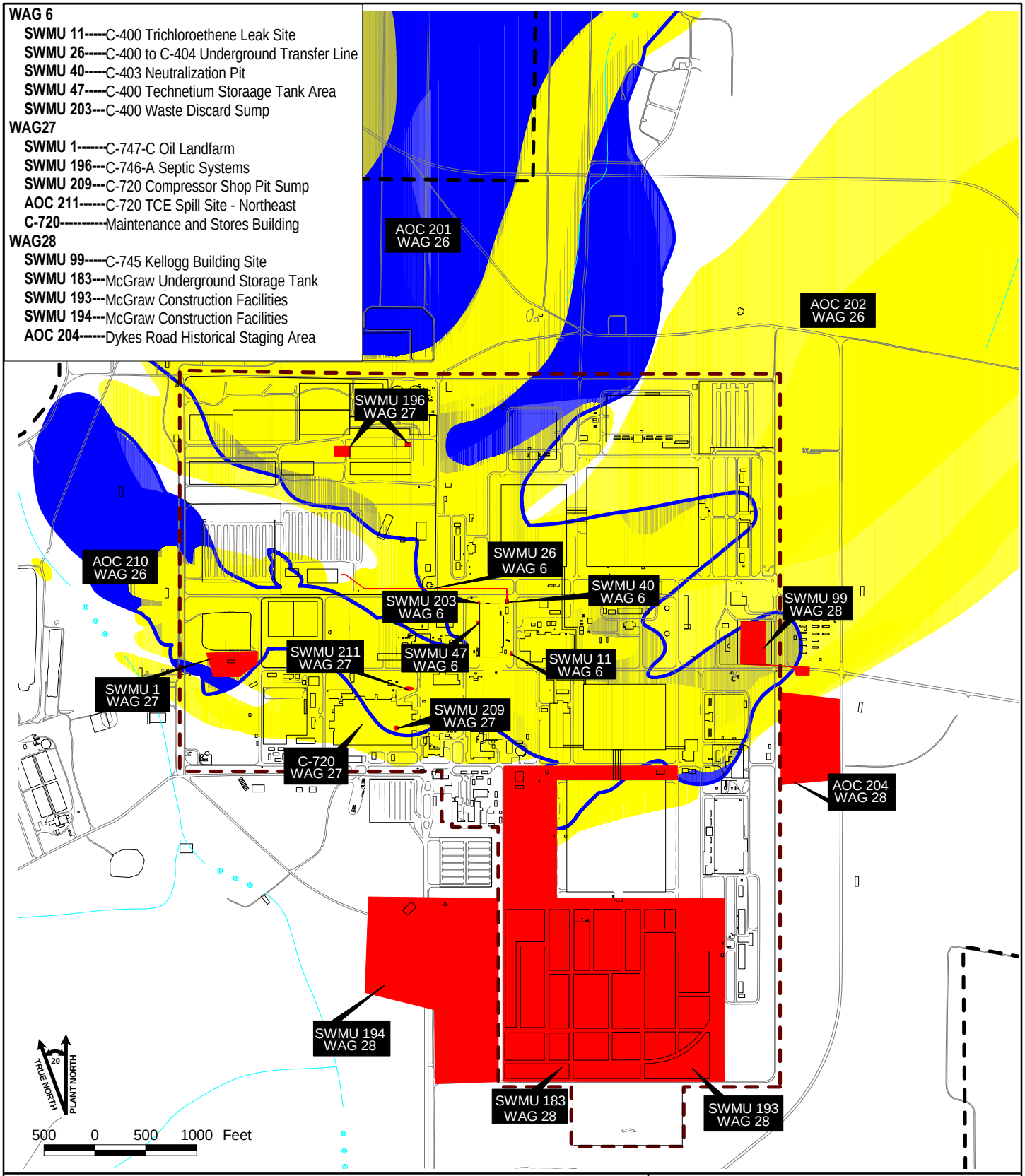
WAG 6
- **SWMU 11**-----C-400 Trichloroethene Leak Site
- **SWMU 26**-----C-400 to C-404 Underground Transfer Line
- **SWMU 40**-----C-403 Neutralization Pit
- **SWMU 47**-----C-400 Technetium Storaage Tank Area
- **SWMU 203**---C-400 Waste Discard Sump

WAG27
- **SWMU 1**------C-747-C Oil Landfarm
- **SWMU 196**---C-746-A Septic Systems
- **SWMU 209**---C-720 Compressor Shop Pit Sump
- **AOC 211**-----C-720 TCE Spill Site - Northeast
- **C-720**---------Maintenance and Stores Building

WAG28
- **SWMU 99**-----C-745 Kellogg Building Site
- **SWMU 183**---McGraw Underground Storage Tank
- **SWMU 193**---McGraw Construction Facilities
- **SWMU 194**---McGraw Construction Facilities
- **AOC 204**-----Dykes Road Historical Staging Area



LEGEND:
- STREAM
- ROAD
- DOE BOUNDARY
- PGDP BOUNDARY
- SOLID WASTE MANAGEMENT UNIT
- EXTENT OF TECHNETIUM-99 CONTAMINATION
- EXTENT OF TRICHLOROETHENE CONTAMINATION

U.S. DEPARTMENT OF ENERGY
DOE OAK RIDGE OPERATIONS
PADUCAH GASEOUS DIFFUSION PLANT

BECHTEL JACOBS COMPANY, LLC
MANAGED FOR THE US DEPARTMENT OF ENERGY UNDER US GOVERNMENT CONTRACT DE-AC-05-98OR22700
Oak Ridge, Tennessee • Paducah, Kentucky • Portsmouth, Ohio

Fig. 1.1. Solid Waste Management Unit Locations at the Paducah Gaseous Diffusion Plant.

Science Applications International Corporation
P.O. Box 2502
Oak Ridge, Tennessee 37831

Figure No. FS1-1
DATE 05-25-01

1.3 REFERENCES

EPA 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA,* Office of Solid Waste and Emergency Response (OSWER) Directive No. 9355.3-01, United States Environmental Protection Agency, Washington, DC, October.

EPA 1992a. *Federal Facility Compliance Agreement for the Storage of Radioactive Mixed Waste Subject to Land Disposal Restrictions for the Paducah Gaseous Diffusion Plant*, Docket No. 92-03-FFR, U.S. Environmental Protection Agency, Region 4, Atlanta, GA, July 10.

EPA 1992b. *Federal Facility Compliance Agreement for Toxicity Characteristic Leaching Procedure*, Paducah Gaseous Diffusion Plant, Docket No. 91-03-FFR, U.S. Environmental Protection Agency, Region 4, Atlanta, GA, July 10.

EPA 1992c. *Federal Facility Compliance Agreement Between the United States Department of Energy and the United States Environmental Protection Agency, Toxic Substances Control Act*, U.S. Environmental Protection Agency, Region 4, Atlanta, GA, July 10.

EPA 1998. *Federal Facility Agreement for the Paducah Gaseous Diffusion Plant*, DOE/OR/07-1707,United States Environmental Protection Agency, Region 4, Atlanta, GA, February.

DOE 1996. *Site Management Plan, Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/07-1207&D3, United States Department of Energy, Paducah, KY, October.

Massey 1998a. Massey, J. C., Bechtel Jacobs Company LLC, electronic mail message to Bruce E. Phillips, Jacobs EM Team, Kevil, KY, August 7.

Massey 1998b. Massey, J. C., Bechtel Jacobs Company LLC, Manager of Projects, letter to Jimmie C. Hodges, Site Manager, United States Department of Energy, Paducah, KY, August 28.

2. CHARACTERIZATION OF ENVIRONMENTAL SETTING

Chapter 2 presents a summary of the physical setting of the PGDP and the terrestrial and aquatic habitats found in the contiguous area. The following data are taken from numerous site-specific and regional studies.

2.1 INTRODUCTION

The PGDP is one of two operating gaseous diffusion plants in the United States that enriches uranium for government programs and commercial customers, primarily electric utilities that operate nuclear power plants. Construction of the PGDP began January 1951 and was completed in 1954, although production of enriched uranium began in 1952 (BJC 1998). The PGDP is owned by the DOE; however, the DOE leased the production areas of the site to the United States Enrichment Corporation in July 1993. At the PGDP, the ^{235}U isotope is enriched via a physical separation process based on the faster rate at which ^{235}U diffuses through a barrier compared with the rate of diffusion of the heavier ^{238}U isotope. Product from the PGDP must be processed further before being used as a nuclear fuel.

The PGDP consists of a diffusion cascade, which is housed in five buildings covering a total of about 30 hectares (75 acres), and extensive support facilities. Some of the major support facilities include a steam plant, four major electrical switchyards, four sets of cooling towers, a building for chemical cleaning and decontamination, a water treatment plant, maintenance facilities, laboratory facilities, and one active landfill. Several inactive facilities also are located on the PGDP site. A raw water treatment plant and solid waste landfill are the main operating areas outside of the security area.

2.2 DEMOGRAPHY AND LAND USE

The PGDP is located in western McCracken County, Kentucky, about 4.8 km (3 miles) south of the Ohio River and approximately 16 km (10 miles) west of the city of Paducah (Fig. 2.1). Approximately 90% of the area within an 8-km (5-mile) radius of the plant is agricultural or forested land. Urban and industrial lands comprise less than 4% of the surrounding area, and surface-water bodies cover approximately 5% (MMES 1993).

The total amount of land held by the DOE at the Paducah Reservation is 1,439 hectares (3,556 acres). The industrial portion of the PGDP is situated within a fenced security area consisting of approximately 303 hectares (748 acres). Within this area, designated as secured (i.e., fenced and patrolled) industrial land use, are numerous buildings and offices, support facilities, equipment storage areas, and active and inactive waste management units. Outside the fenced security area is approximately 804 hectares (1,986 acres) of land that the DOE leases to the Commonwealth of Kentucky as part of the WKWMA. The entire WKWMA covers approximately 2,761 hectares (6,823 acres). The land leased to the WKWMA is designated as recreational and is used extensively for outdoor recreation such as hunting and fishing. The remaining portions of the reservation consist of approximately 279 hectares (689 acres) of land maintained by the DOE and 54 hectares (133 acres) of easements acquired by the DOE (Massey 1996). The DOE property outside the fence is classified as on-site, unsecured (i.e., not fenced) industrial. Figure 2.2 details the current land use surrounding the PGDP. No changes to land use are expected in the future.

There are four federal highways (U.S. 45, 60, 62, and 68) and one interstate highway (I-24) in the vicinity of the PGDP. Highway 60 is used most frequently by plant personnel for access to the PGDP. The closest commercial airport is Barkley Regional Airport, which is located approximately 8 km (5 miles) southeast of the plant.

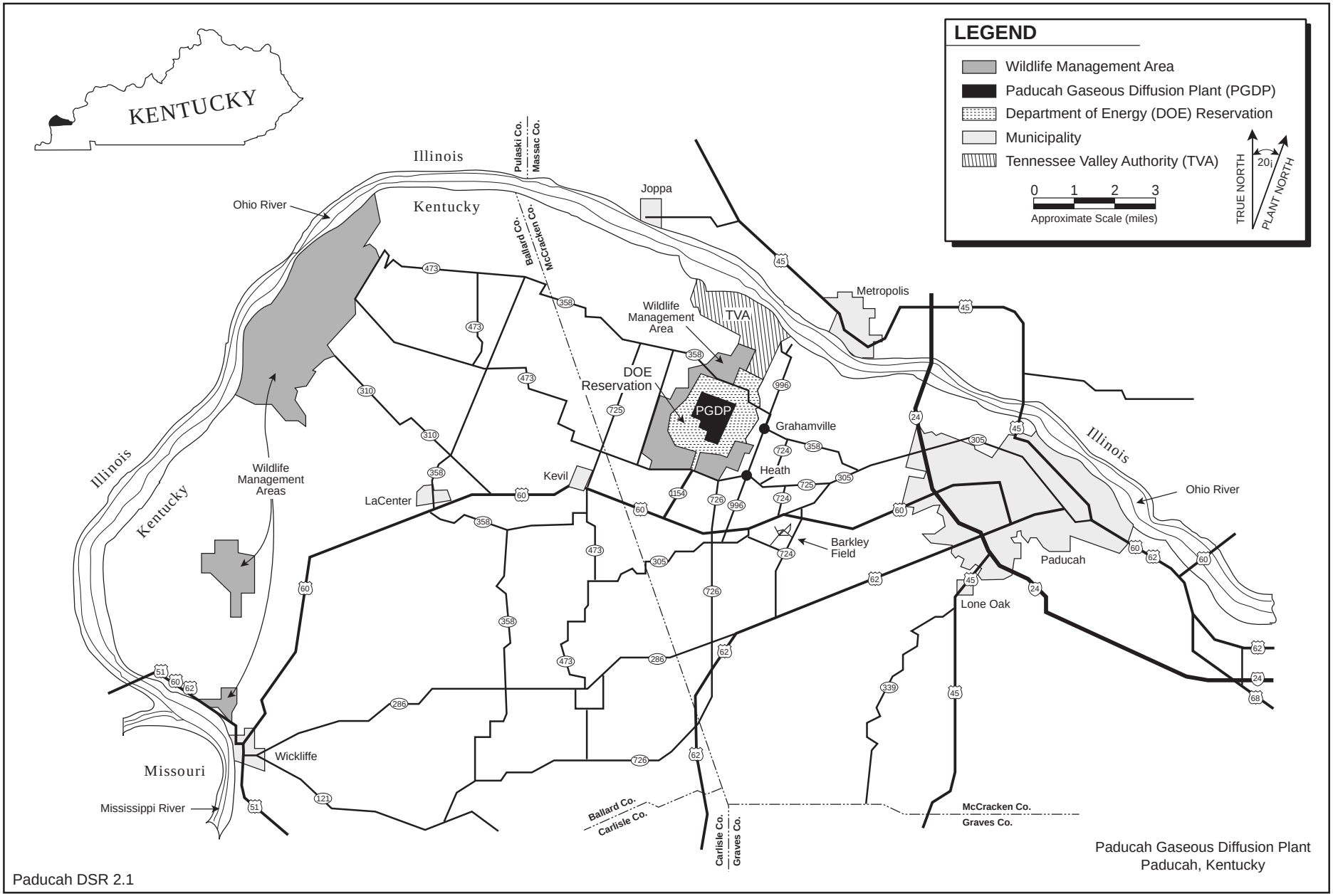


Fig. 2.1. Location Map of the PGDP.

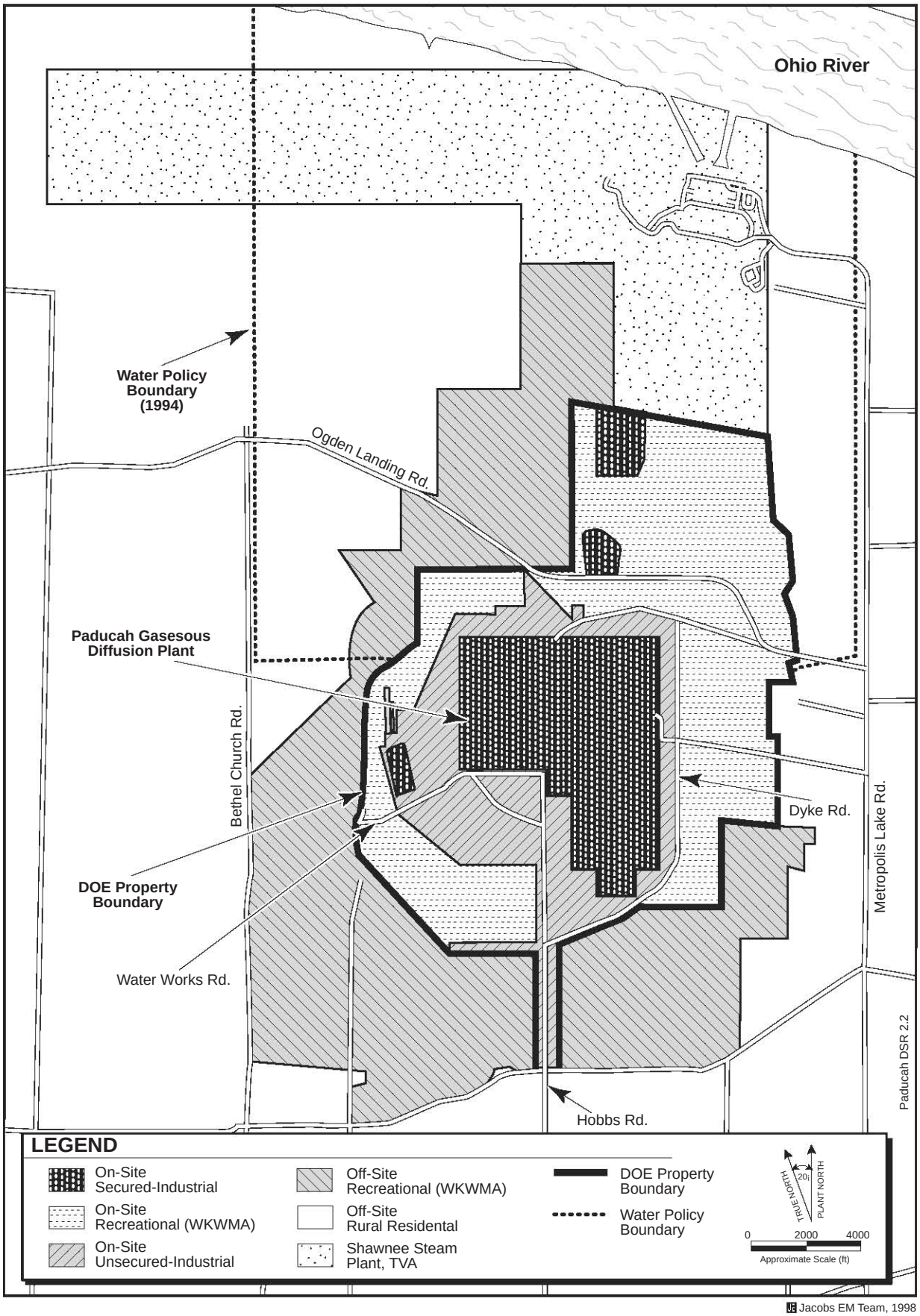


Fig. 2.2. Land Use Surrounding PGDP.

The population of McCracken County, as of July 1995, was reported as 64,577 persons. Counties adjacent to McCracken in closest proximity to the plant reported the following populations: Ballard County, Kentucky, 8,232 and Massac County, Illinois, 15,370 (DOC 1995). The total population within a 80-km (50-mile) radius of the plant was estimated at 500,000 with approximately 66,000 people residing within a 16-km (10-mile) radius of the PGDP (DOC 1994). Between 300 and 500 individuals reside within the boundaries of the former Kentucky Ordnance Works (KOW) (TCT-St. Louis 1992). The small communities of Grahamville, Heath, and Kevil are within a 5-km (3-mile) radius of the DOE property boundary. Larger municipalities such as Paducah and LaCenter, Kentucky, and Joppa and Metropolis, Illinois, are within a 16- to 32-km (10- to 20-mile) radius of the site.

McCracken County's employment was recorded at 34,523 persons in June 1999, with unemployment recorded as 1,368 persons, or 4% (KCWD 1999). In 1998 in the Purchase Area of Kentucky, which includes the counties of Ballard, Calloway, Carlisle, Fulton, Graves, Hickman, McCracken, and Marshall, construction accounted for 15% of employment, manufacturing accounted for 34%, mining accounted for 14%, services accounted for 13%, and trade accounted for 15% (KCWD 1998). The PGDP employs approximately 1,750 workers (LMES 1997). The average 1993 per capita income in McCracken County was $19,647 as compared to 1994 averages of $17,807 per capita in Kentucky and $21,809 in the United States (DOC 1995).

Principal crops grown in the three-county area surrounding PGDP include corn, sorghum, wheat, soybean, hay, and tobacco. In addition, 26% of the total land area of Ballard County and 24% of McCracken County is designated as commercial forest land. In the vicinity of PGDP, the main crops include soybeans, corn, and various grain crops. Other foods grown in the area include persimmons and apples. A variety of small gardens also are present where tomatoes, squash, beans, peppers, okra, potatoes, and other vegetables are grown (CH2M HILL 1991a).

2.3 METEOROLOGY

The climate of the PGDP area can be described as humid-continental. It is characterized by warm and humid summers and moderately cold and humid winters. Temperatures for the summer months average 29.4°C (85°F), while winter temperatures average 2.2°C (36°F). During the winter months, temperatures drop below freezing an average of 60 nights and 10 days.

Precipitation is distributed relatively evenly throughout the year and averaged 128 cm (50 in.) per year from 1969 to 1989 (CH2M HILL 1992). The five-year average annual precipitation for the region from 1990 to 1994 was 113.13 cm (44.54 in.) per year (MCC 1995). Most groundwater recharge and stream flooding occur between November and May, when evapotranspiration normally is less than the remainder of the year.

The average prevailing wind in the area is from the south to southwest at approximately 16 km per hour (9.8 mph). Generally, stronger winds are observed when the winds are from the southwest or northwest.

The PGDP is located in the Paducah-Cairo Interstate Air Quality Control Region of Kentucky, which includes McCracken County and 16 other counties in western Kentucky. Data from the state's air monitors are used to assess the region's ambient air quality for the criteria pollutants (ozone, nitrogen oxides, carbon monoxide, particulates, lead, and sulfur dioxide) and to designate nonattainment areas (i.e., those areas for which one or more of the National Ambient Air Quality Standards are not met). McCracken County is classified as an attainment area for all six criteria pollutants (KEQC 1992). In addition, the PGDP operates an ambient air monitoring system to assess the impact of various air contaminants emitted by the PGDP on the surrounding environment. Ambient air monitoring of gaseous

fluorides and radioactive particulates (gross alpha and gross beta) is accomplished by 12 continuous samplers (four fence line and eight off-site) (MMES 1993). The off-site ambient concentrations of fluorides at the PGDP in 1994 were well below the air quality standards set by the EPA (40 C.F.R. §61.90) and the KDEP, Division for Air Quality. Six additional ambient air sampling stations—one inside the plant, two on DOE property, and three off-site—went into operation during July 1995.

Noises associated with plant activities generally are restricted to areas inside buildings located on site. Noise levels beyond the security fence are limited to wildlife, hunting, traffic moving through the area, and operation and maintenance activities associated with outside waste storage areas located close to the security fence.

2.4 TOPOGRAPHY AND SURFACE FEATURES

The PGDP is situated in an area characterized by low relief. Elevations vary from about 107 to 119 m (350 to 390 ft) above mean sea level (amsl) on the plant property, with the ground surface sloping at a rate of approximately 5 m/km (27 ft/mile) toward the Ohio River. Two main topographic features dominate the landscape in the surrounding area: the loess-covered plains, at an average elevation of 119 m (390 ft) amsl; and the Ohio River floodplain zone, dominated by alluvial sediments, at an average elevation of 96 m (315 ft) amsl (Humphrey 1976). The terrain of the PGDP area is modified slightly by the dendritic drainage systems associated with the two principal streams in the area, Bayou Creek, commonly referred to as Big Bayou Creek and Little Bayou Creek. These northerly flowing streams have eroded small valleys that are approximately 6.1 m (20 ft) below the adjacent plain.

2.5 GEOLOGY

The subsurface at the PGDP site consists of Cretaceous, Tertiary, and Quaternary sediments unconformably overlying Paleozoic bedrock. Immediately overlying bedrock at the PGDP is the Upper Cretaceous McNairy Formation. The McNairy Formation, consisting of interbedded and interlensing sand, silt, and clay, is not exposed near the PGDP. In stratigraphic order, the McNairy Formation is overlaid by the Paleocene Porters Creek Clay, undifferentiated Eocene sediments, and Pliocene and Pleistocene continental deposits.

The erosion and subsequent fill of the ancestral Tennessee River Valley during the Pleistocene is a primary factor controlling the geologic units beneath the PGDP. During the Pleistocene, the ancestral Tennessee River occupied a position close to the present-day course of the Ohio River. The southern edge of the former Tennessee River Valley underlies the PGDP. Figure 2.3 presents a general north-south cross-section of the geologic units extending from the PGDP to the Ohio River.

2.5.1 Porters Creek Clay/Porters Creek Terrace

The Paleocene Porters Creek Clay occurs in southern portions of the site as a massive, glauconitic clay with lesser interbeds of sand. A terrace slope of the ancestral Tennessee River completely cuts through the thickness of the Porters Creek Clay under the south end of the PGDP. The Porters Creek Clay is approximately 30 m (100 ft) thick immediately southwest of the PGDP but is absent, or present only as thin isolated remnants, to the north of the terrace slope.

Outcrops of the Porters Creek Clay on the PGDP reservation are limited to a few isolated locations in the bed of Bayou Creek and its tributaries. However, borehole data are sufficient to show that the top

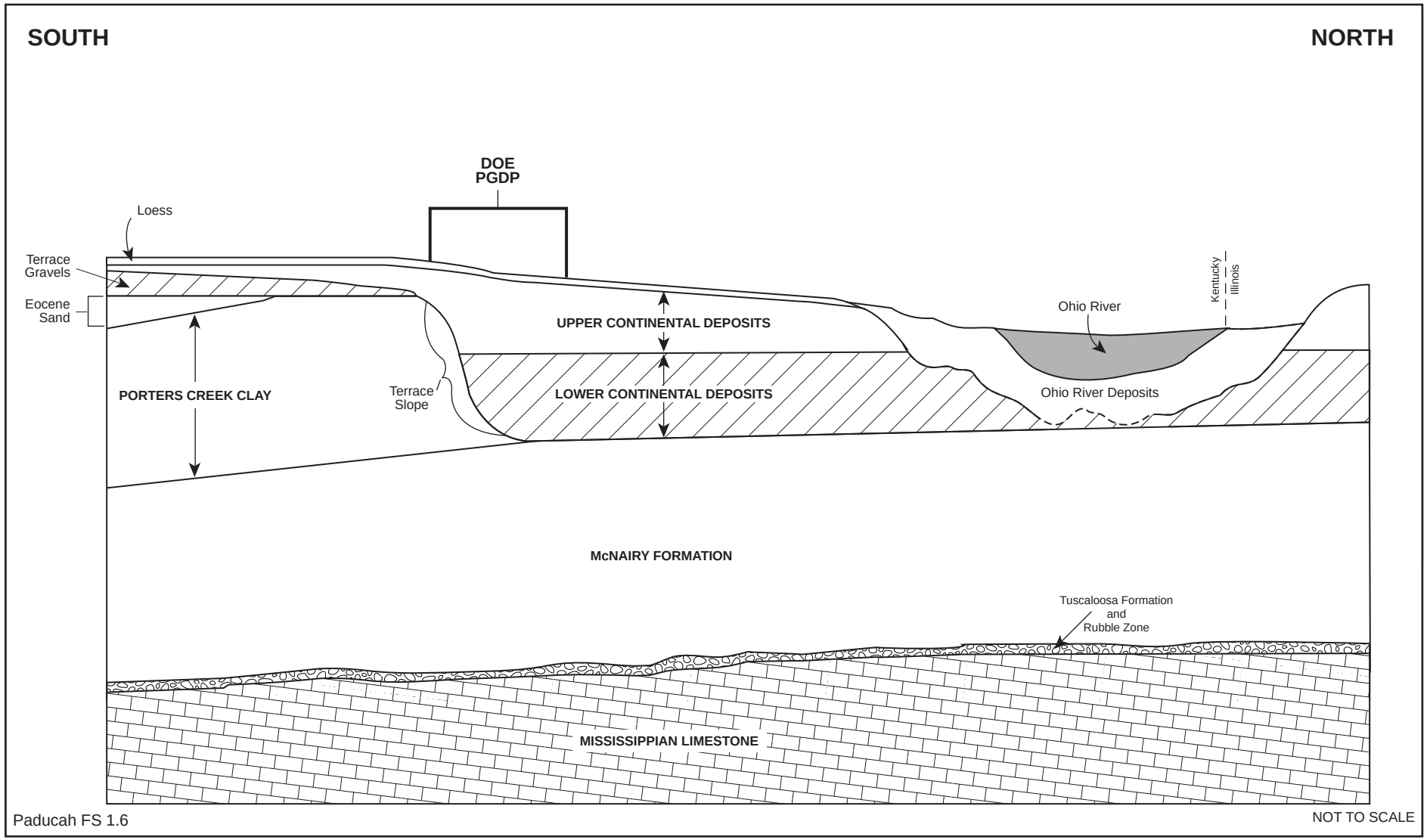


Fig. 2.3. Schematic of stratigraphic and structural relationships near the P GDP.

of the Porters Creek Clay south of the PGDP has significant topographic relief. Immediately south and west of the PGDP, the high elevation of the top of the Porters Creek Clay limits the development of a shallow groundwater system in that area. A greater depth to the top of the Porters Creek Clay to the east of the PGDP permitted deposition of a relatively permeable Pliocene gravel deposit near surface.

2.5.2 Eocene Sands

Eocene sands, silts, and clays overlie the Porters Creek Clay south of the PGDP. Researchers have not attributed these sediments to a specific formation. The thickness of the Eocene sands increases southward to greater than 30 m (100 ft). Eocene deposits do not underlie the PGDP.

2.5.3 Continental Deposits

Pliocene and Pleistocene continental deposits unconformably overlie the Cretaceous through Eocene strata in the vicinity of the PGDP. The Pliocene deposits consist of lobes of poorly sorted, silty sand and gravel that occur south of the PGDP. These sediments represent an alluvial fan deposit that covered all of western Kentucky and parts of Tennessee and Illinois during the Pliocene.

Beginning under the south end of the PGDP and extending north beyond the Ohio River, a thick sequence of Pleistocene continental deposits fills the buried valley of the ancestral Tennessee River. This sediment package consists of a basal sand and gravel member, the lower continental deposits, and an overlying finer-textured lithofacies, the upper continental deposits. Where fully developed, the upper continental deposits include a bottom sand unit overlaid by a thick silt and clay interval containing at least two horizons of sand and gravel.

Lower Continental Deposits – Pleistocene sand and gravel units, collectively averaging 9 m (30 ft) thick, underlie most of the PGDP. Depth to top of this lower member is approximately 18 m (60 ft). The matrix is characteristically medium to coarse sand and chert gravel of variable sorting. Thickness of the individual depositional units varies widely. However, the lateral continuity of the individual depositional units is typically limited.

Upper Continental Deposits – The upper member sediments (Pleistocene) include a wide variety of textures within three depositional series:

1) A basal sand unit is generally present, representing the transition from gravel and coarser sand of the lower member continental deposits to the overlying silty clay unit. The sand generally has a fining-upward texture, becoming siltier toward the top of the unit.

2) An overlying interval of fine-textured sediments defines a middle unit. This unit typically is present as a silty clay or clayey silt beneath the plant site. However, a silty, fine sand facies is common. The thickness of the unit varies widely, from <3 m (10 ft) up to 12 m (40 ft).

3) Sand and gravel deposits define an upper unit. Texture and sorting is widely variable among the sand and gravel deposits. Where the unit is fully developed, three horizons are present: (1) a basal sand and gravel horizon; (2) a middle finer-textured horizon, typically consisting of a silty fine sand or silt; and (3) an upper sand and gravel horizon.

Other than the broad lens-character of some sand and gravel units, the upper member continental deposits do not contain recognizable bedding features. Gradational textural charges are common. Silt and clay facies are typically mottled with frequent vertical fracture traces. The fractures are filled with lighter colored silt or clay.

2.5.4 Surficial Deposits/Soils

Silt of the Pleistocene Peorian Loess and an older unit tentatively identified as the Roxanna Loess covers sediments both north and south of the buried terrace slope (DOE 1997a). The loess deposit virtually is indistinguishable from silt facies of the upper member of the continental deposits. Loess typically is 3 to 5 m (10 to 15 ft) thick beneath most of the PGDP; however, construction activities have excavated the loess or replaced the loess with fill material in many areas. Soils of the area are predominantly silt loams that are poorly drained, acidic, and have little organic content. Section 2.7 discusses the soil types found at the PGDP.

2.6 HYDROLOGY

The PGDP occurs in an area of abundant surface-water and groundwater resources. Creeks that bound the east and west sides of the PGDP flow north from the PGDP to join with the Ohio River. The sand and gravel deposit that forms the shallow aquifer beneath most of the PGDP and the contiguous area to the north begins at the Porters Creek Clay Terrace under the south end of the PGDP and extends to the north beyond the Ohio River.

2.6.1 Surface-Water Hydrology

The PGDP is located in the western portion of the Ohio River basin. The plant is within the drainage areas of Bayou and Little Bayou Creeks and is situated on the divide between the two creeks.

Bayou Creek is a perennial stream with a drainage area of approximately 29.9 km^2 (18.6 $miles^2$) that flows generally northward from approximately 4 km (2.5 miles) south of the plant to the Ohio River and extends along the western boundary of the plant. Little Bayou Creek, which becomes a perennial stream due to PGDP discharges, originates within the WKWMA, flows northward to the Ohio River, and extends along the eastern boundary of the plant. The approximate drainage area of Little Bayou Creek is 13.6 km^2 (8.5 mi^2) (CH2M HILL 1992). The confluence of the two creeks is approximately 3 miles north of the plant site (as measured over land), just upstream of the location at which the creeks discharge into the Ohio River. The drainage areas for both creeks generally are rural; however, they receive surface drainage from numerous swales that drain residential and commercial properties, including the WKWMA, PGDP, and Tennessee Valley Authority (TVA) Shawnee Steam Plant. A major portion of the flow in both creeks north of the PGDP is effluent water from the plant, discharged through Kentucky Pollutant Discharge Elimination System-permitted outfalls. Deer Lick, Snake Creek, and Slough Creek drain the northwestern portion of the PGDP boundary.

The United States Geological Survey maintains gauging stations on Bayou Creek 6.6 and 11.7 river km (4.1 and 7.3 river miles) from the Ohio River and a station on Little Bayou Creek 3.5 river km (2.2 river miles) upstream from its confluence with Bayou Creek. The mean monthly discharge at Bayou Creek varies from 0.9 to 1.7 m^3/s (6.5 to 60.7 ft^3/s). The mean monthly discharge on Little Bayou Creek ranges from 0.03 to 0.9 m^3/s (0.89 to 33.5 ft^3/s).

Two studies have investigated the dynamics of interaction between surface water and groundwater in Bayou and Little Bayou Creeks. The United States Geological Survey (USGS) performed a seepage survey in Bayou and Little Bayou Creeks on August 15 and 16, 1989 (Evaldi and McClain 1989). Mr. Eric Wallin monitored indicators of seepage between the creeks and groundwater during the period July 22, 1996 through October 12, 1997, as the subject for a Master of Science thesis at the University of Kentucky (Fryar and Wallin 1998).

The 1989 survey determined a point on both Bayou and Little Bayou Creeks where the creeks changed from losing streams (Bayou Creek) or streams of no groundwater interaction (Little Bayou Creek) to gaining streams. On Bayou Creek, the gaining reach began approximately 5.5 river-km (3.5 river-miles) upstream from the Ohio River. On Little Bayou Creek, the point where the creek became a gaining stream was located approximately 4.2 river-km (2.6 river-miles) upstream from the Ohio River. The USGS researchers noted channel-bank seeps along the lower reaches of both creeks.

The July 1996 through October 1997 study assessed both spatial and temporal trends in stream-to-groundwater interaction along the creeks. This study assessed Bayou Creek from south of the PGDP to the Ohio River and Little Bayou Creek from the plant outfalls to the river. The investigation found that the magnitude of seepage varied with season but concurred with the 1989 survey location of the inflection point on Little Bayou creek where the stream begins to gain. The later study found that gaining reaches on Bayou Creek are limited to the area south of the PGDP and very near the Ohio River.

In summary, gaining reaches of Bayou Creek are found south of the PGDP and north of the plant in the Ohio River floodplain. Gaining reaches of Little Bayou Creek are limited to the Ohio River floodplain.

Man-made drainages receive stormwater and effluent from the PGDP. The plant monitors 17 outfalls, which have a combined average daily flow of approximately 4.9 million gallons per day (LMES 1992a). Water flow in these ditches is intermittent based on seasonal rainfall. The plant ditches generally are considered to be located in areas where the local groundwater table is below the bottoms of the ditch channels. Therefore, the ditches probably function as influent (losing) streams most of the time, resulting in some discharge to the subsurface.

Surface-water bodies in the vicinity of the PGDP include the Ohio River to the north, Metropolis Lake (located east of Shawnee Steam Plant), Bayou Creek, Little Bayou Creek, numerous small tributaries and creeks, as well as surface-water ditches and lagoons located within the plant boundary. There is a marshy area just south of the confluence of Bayou and Little Bayou Creeks. The smaller surface-water bodies are expected to have only localized effects on the regional groundwater flow pattern.

2.6.2 Groundwater Hydrology

The Jackson Purchase Region is characterized by a thick sequence of unconsolidated Cretaceous through Holocene sediments deposited on an erosionally truncated Paleozoic surface. The flow system in the vicinity of the PGDP exists primarily within unconsolidated sediments.

The regional groundwater flow systems occur within the Mississippian Bedrock, Cretaceous McNairy Formation, Eocene Sands, Pliocene Terrace Gravel, Pleistocene Lower Continental Deposits, and Upper Continental Deposits. Terms used to describe the hydrogeologic flow system are the McNairy Flow System, Eocene Sands, Pliocene Terrace Gravel, the Regional Gravel Aquifer (RGA), and the Upper Continental Recharge System (UCRS). Specific components for the regional groundwater flow system have been identified and are defined in the following subsections.

2.6.2.1 Paleozoic bedrock aquifer

Limestone, which is believed to be Mississippian-age Warsaw Limestone, subcrops beneath the PGDP. Groundwater production from the bedrock aquifers comes from fissures and fractures and from the weathered rubble zone near the top of the bedrock. The bottom of a rubble zone developed in the top of the Mississippian carbonate bedrock generally marks the base of the active groundwater flow system beneath the PGDP.

2.6.2.2 McNairy flow system

This component, formerly termed the "deep groundwater system," consists of the interbedded and interlensing sand, silt, and clay of the Cretaceous McNairy Formation. The sand in the McNairy Formation is an excellent aquifer in the southeastern part of the Jackson Purchase Region; however, near the PGDP, the McNairy Formation contains significant amounts of silt and clay (LMES 1992b). Regionally, the McNairy Formation recharges along areas of outcrop in the eastern part of the region, near Kentucky Lake and Lake Barkley (USGS 1973). Water movement is north and northwest toward discharge areas in Missouri and along the Ohio River.

The McNairy Formation subcrops beneath the plant at depths ranging from approximately 30 to 216 m (100 to 710 ft). Overall, sand facies account for 40 to 50% of the total formation thickness of approximately 68.6 m (225 ft). The upper and middle McNairy members in the area of the PGDP are predominately silty and clayey fine sands. However, where the RGA is in direct hydraulic connection with coarser-grained sediments of the McNairy Formation, the McNairy flow is coincident with that of the RGA.

Values of hydraulic conductivity for the McNairy Flow System were reported as ranging from 1.4×10^{-8} to 4.6×10^{-2} cm/s in a 1973 study (USGS 1973). During the WAG 6 RI, values of hydraulic conductivity were measured from 8.2×10^{-8} to 1.1×10^{-3} cm/s (DOE 1998). The range of five to six orders of magnitude difference is due to depositional heterogeneity between the sand and clay of the McNairy Formation. A 1996 assessment of hydraulic conductivity of the McNairy Formation (LMES 1996), based on annual water level cycles, determined the large-scale horizontal conductivity to be approximately 6.3×10^{-6} cm/s and the large-scale vertical conductivity to be approximately 1.6×10^{-7} cm/s.

2.6.2.3 Pliocene Terrace Gravels and Eocene Sands

Pliocene-age gravel deposits and Eocene-age reworked sand and gravel overlie the Paleocene Porters Creek Clay in the southern portion of the DOE reservation. A water table flow system developed in these units provides some throughflow to the north, across the Porters Creek Terrace. Most of this throughflow is realized east of the PGDP, where the Pliocene Terrace Gravel is thickest adjacent to the Porters Creek Terrace. The water table flow systems immediately south and west of the PGDP generally discharge to Bayou Creek because of the shallow depth of the Porters Creek Clay in those areas.

2.6.2.4 Regional Gravel Aquifer

The RGA consists primarily of the coarse sand and gravel facies of the Lower Continental Deposits. Permeable sands of the Upper Continental Deposits and the McNairy Formation, where they occur adjacent to the Lower Continental Deposits are included in the RGA. The RGA is found throughout the plant area and to the north, but pinches out to the south, southeast, and southwest along the slope of the Porters Creek Terrace. Regionally, the RGA includes the Holocene-aged alluvium found adjacent to the Ohio River.

The RGA is the shallow aquifer beneath the PGDP and is the dominant groundwater flow system in the area extending from the PGDP to the Ohio River. In general, the hydraulic gradient of the RGA dips to the north. East-west heterogeneities within the Lower Continental Deposits and leaks from PGDP utilities cause groundwater flow to be directed locally to the northeast and northwest of the plant. Differences in permeability and aquifer thickness also affect the hydraulic gradient. Low gradients in the north–central portion of the plant site are the result of a thick section of the RGA containing higher fractions of coarse sand and gravel. Northward, near the Ohio River, the hydraulic gradient increases as a result of either a thinner section of RGA or of low-permeability bottom sediments in the Ohio River.

Regional groundwater flow within the RGA trends north–northeast toward base level represented by the Ohio River. The hydraulic gradient varies spatially but is on the order of 1×10^{-4} to 1×10^{-3} m/m. Hydraulic conductivities from the RGA have been reported as ranging from 10^{-4} to 1 cm/s (DOE 1997b).

2.6.2.5 Upper Continental Recharge System

The UCRS consists of a thick surface loess unit and the Upper Continental Deposits. Hydrogeologists at the PGDP have differentiated the UCRS into three general horizons, which are as follows:

- Hydrologic Unit (HU) 1—an upper silt and clay interval (the surface loess unit),
- HU 2—an intervening interval of common sand and gravel lenses, and
- HU 3—a lower silt and clay interval.

Groundwater flow in the UCRS is predominately downward into the RGA, hence the term "recharge system." Vertical hydraulic gradients generally range from 0.5 to 1 m/m where measured by wells completed at different depths in the UCRS. The presence of steep but undetermined vertical gradients for most areas of the PGDP has limited the ability to map a water table at the PGDP. However, the available UCRS well network is sufficient to determine the main features of the water table. In general, the water table is less than 6 m (20 ft) deep in the western half and south quadrant of the PGDP. Depth to water is as much as 12 m (40 ft) in a broad trough in the water table in the northeast and central areas of the PGDP.

Regionally, the thickness of the saturated UCRS ranges from 0 to 15.2 m (0 to 50 ft). Measurements of UCRS hydraulic conductivity from the WAG 6 RI ranged from 1.7×10^{-8} to 3.2 cm/s (DOE 1998). The range of eight orders of magnitude reflects the varied textures of the UCRS matrix.

2.7 SOILS

Six soil types are associated with the PGDP as mapped by the Natural Resources Conservation Service (NRCS), formerly the Soil Conservation Service (USDA 1976). These are Calloway silt loam, Grenada silt loam, Loring silt loam, Falaya-Collins silt loam, Vicksburg silt loam, and Henry silt loam. The dominant soil types, the Calloway and Henry silt loams, consist of nearly level, somewhat poorly drained to poorly drained soils that formed in deposits of loess and alluvium. These soils tend to have low organic content, low buffering capacity, and acidic pH ranging from 4.5 to 5.5. The Henry and Calloway series have a fragipan horizon, a compact and brittle silty clay loam layer that extends from 66 cm (26 in.) below land surface to a depth of 127 cm (50 in.) or more. The fragipan reduces the vertical movement of water and causes a seasonally perched water table in some areas at the PGDP. In areas within the PGDP where past construction activities have disturbed the fragipan layer, the soils are best classified as "urban."

Prime farmland, as defined by the NRCS, is land that is best suited for food, feed, forage, fiber, and oilseed productions, excluding "urban built-up land or water" (7 *CFR* §§657 and 658). The NRCS determines prime farmland based on soil types found to exhibit properties best suited for growing crops. These characteristics include suitable moisture and temperature regimes, pH, drainage class, permeability, erodibility factor, and other properties needed to produce sustained high yields of crops in an economical manner.

2.8 ECOLOGY

2.8.1 Terrestrial Systems

The upland habitats in the PGDP area support a variety of plant and wildlife species. Because much of the PGDP's terrestrial habitat is managed for multiple uses, the diversity of habitat is excellent. Forest and shrub tracts alternate with fencerows and transitional edge habitats (ecotones) along roads and transmission-line corridors. Fencerow communities are dominated by elm, locust, oak, and maple, often with a thick understory of sumac, honeysuckle, blackberry, and grape. Herbaceous growth in these areas includes clover, plantain, and numerous grasses. The numerous ditches, upland embankments along streams, and open areas around ponds in the area also provide diversity of habitat for wildlife and for recreational hunting (CH2M HILL 1991a).

The terrestrial community is described by the dominant vegetation sites that characterize the community. The communities range from oak-hickory forest, in areas that have been relatively undisturbed, to managed fencerows and agricultural lands. Detailed investigations of vegetation have been conducted for Ballard and McCracken Counties in Kentucky by the WKWMA and the U.S. Army Corps of Engineers (COE). Significant areas of PGDP include vegetation managed for consumption by wildlife, especially deer. Principal crops grown in the three-county area surrounding PGDP include corn, sorghum, wheat, soybean, hay, and tobacco. In addition, 26% of the total land area of Ballard County and 24% of McCracken County is designated as commercial forestland.

Most of the area in the vicinity of the PGDP has been cleared of vegetation at some time, and much of the grassland habitat is mowed regularly by PGDP personnel. Approximately 810 hectares (2,000 acres) in the WKWMA consist of old field grasslands. Much of this herbaceous community is dominated by members of the *Compositae* (sunflower) family and various grasses. Other common grasses associated with grassland areas include broom sedge (*Agropyron virginicus*), plume grass (*Erianthus alopecuroides*), panic grass (*Panicum scoparium*), and three awn grass (*Aristida purpurescens*). Woody species, such as red maple, also are present occasionally.

A large percentage of the WKWMA grasslands are managed to promote native prairie vegetation using burning, mowing, and various other techniques. These areas have the greatest potential for restoration and establishment of a sizable prairie preserve in the Jackson Purchase area and promote native prairie species such as big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), Indian grass (*Sorghastrum nutans*), compass plant (*Silphium laciniatum*), and rattlesnake master (*Eryngium yuccafolium*), among others (KSNPC 1991). Some of this acreage also includes remnant prairie, which is characterized by the presence of eastern Gamma grass (*genus Tripsacum*) and Indian grasses.

Approximately 324 hectares (800 acres) within the WKWMA are in scrub or shrub habitat. This community represents a more diverse habitat than grasslands, including both herbaceous and woody species. Dominant species include black locust (*Robinia pseudoacacia*), cherry (*Prunus spp*), persimmon (*Diospyros virginiana*), sumac (*Rhus sp.*), and young red maples (*Acer rubrum*) along with various vines and herbaceous species.

Forested habitats characteristic of the WKWMA include two species of hickory (*Carya spp.*) and three species of oak (*Quercus spp.*), as well as scattered growths of sweetgum (*Liquidambar styraciflua*) and hackberry (*Celtis*). Some mature trees in the area are over 100 years old. Understory species include snowberry (*Symphoricarpos orbiculatus*), poison ivy (*Toxicodendron radicans*), trumpet creeper (*Campsis radicans*), Virginia creeper (*Parthenocissus quinquefolia*), and Soloman's seal (*Smilacina racemosa*),

among others. The WKWMA also has planted white pine in selected areas and performs controlled burning, provides food plantings for wildlife, or otherwise manages about 203 hectares (500 acres) per year.

Wildlife commonly found in the PGDP area consists of species indigenous to open grassland, thickets, and forest habitats. No quantitative surveys of terrestrial wildlife near the PGDP were conducted as part of site investigation (SI) activities. However, observations by ecologists during SIs and information from WKWMA staff have provided a qualitative description of wildlife communities likely to inhabit the vegetation communities in the vicinity of the PGDP. Open herbaceous areas are frequented by rabbits, mice, and a variety of other small mammals. Birds include red-winged blackbirds, quail, sparrows, and predators such as hawks and owls. In ecotones (including fencerows, low shrub, and young forests), a variety of wildlife is present, including opossum, vole, mole, raccoon, and deer. Birds typical in the ecotones include red-winged blackbird, shrike, mourning dove, quail, turkey, cardinal, and meadowlark. Several groups of coyotes also reside in the vicinity of PGDP. In mature forests, squirrel, various songbirds, and great horned owls may be present. The primary game species hunted for food in the area are deer, turkey, opossum, rabbit, raccoon, and squirrel. Much of the area is attractive to game and nongame species because of the intense management program for game that has been implemented in the WKWMA (CH2M HILL 1991a).

Small mammal surveys conducted on the WKWMA documented the presence of southern short-tailed shrew (*Blarina carolinensis*), prairie vole (*Microtus ochrogaster*), house mouse (*Mus musculus*), rice rat (*Oryzomys palustris*), and deer mouse (*Peromyscus sp.*) (KSNPC 1991). Larger mammals commonly present in the area include coyote (*Canis latrans*), eastern cottontail (*Sylvilagus floridanus*), opossum (*Didelphis marsupialis*), groundhog (*Marmota monax*), white-tailed deer (*Odocoileus virginianus*), raccoon (*Procyon lotor*), and gray squirrel (*Sciurus carolinensis*).

Late spring roadside surveys conducted by Battelle reported some 45 species of birds in the PGDP area with northern bobwhite (*Colinus virginianus*), northern cardinal (*Cardinalis cardinalis*), indigo bunting (*Passerina cyanea*), common grackle (*Quiscalus quiscula*), eastern towhee (*Pipilo erythrophthalmus*), and European starling (*Sturnus vulgaris*) being the most abundant. Other common species include mourning dove (*Zenaida macroura*), barn swallow (*Hirundo rustica*), blue jay (*Cyanocitta cristata*), American crow (*Corvus brachyrhynchos*), northern mockingbird (*Mimus polyglottos*), brown thrasher (*Toxostoma rufum*), common yellowthroat (*Geothlypis trichas*), eastern meadowlark (*Sturnella magna*), and red-winged blackbird (*Agelaius phoeniceus*). Red-tailed hawk (*Buteo jamaicensis*) and American kestrel (*Falco sparverius*) were the most common raptors (Battelle 1978).

Amphibians and reptiles present at PGDP include cricket frog (*Acris crepitans*), Fowler's toad (*Bufo woodhousii fowleri*), common snapping turtle (*Chelydra serpentina*), green treefrog (*Hyla cinerea*), chorus frog (*Pseudacris triseriata*), southern leopard frog (*Rana utricularia utricularia*), eastern fence lizard (*Sceloporus undulatus*), and red-eared slider (*Trechemys scripta elegans*) (KSNPC 1991).

Mist netting activities in the PGDP area have captured red bat (*Lasiurus borealis*), little brown bat (*Myotis lucifugus*), Indiana bat (*Myotis sodalis*), northern long-eared bat (*Myotis septentrionalis*), evening bat (*Nycticeus humeralis*), and eastern pipistrelle (*Pipistrellus subflavus*) (KSNPC 1991).

2.8.2 Aquatic Systems

Both Bayou and Little Bayou Creeks and tributaries support a variety of aquatic life. The dominant fish taxa in PGDP surface waters (based on density or biomass) include several species of sunfish, especially bluegill (*Lepomis macrochirus*) and green and longear sunfish *(L. cyanellus and L. megalotis*), as well as spotted and largemouth bass (*Micropterus punctulatus and M. salmoides*), bullheads (*Ameiurus spp.*),

and creek chub (*Semotilus atromaculatus*). Shallow streams, characteristic of the two main area creeks, are dominated by bluegills, green and longear sunfish, and central stonerollers (*Campostoma anomalum*).

In addition to stream habitats, about 13 fishing ponds are located primarily in the WKWMA. Most of these ponds are used for public fishing by about 2,000 registered visitors per year and by many other users who do not register (CH2M HILL 1991a). Pond areas generally are dominated by largemouth bass, bluegill, and to a lesser extent, green sunfish. Prior to the SI studies, Little Bayou Creek also was fished; however, due the detection of elevated concentrations of PCBs in fish taken from Little Bayou Creek, consumption warnings have been posted. Aquatic habitats are used by muskrat and beaver. Many species of water birds, including wood duck, geese, heron, and species of migratory birds, also use these areas. There also are many other smaller ponds and abandoned gravel pits that usually contain water and may have functioning ecosystems.

2.8.3 Wetlands

Habitats that have soil and hydrology capable of supporting vegetation adapted for hydric environments are considered wetlands. These habitats include marshes (wetlands dominated by herbaceous species) and swamps (wetlands dominated by woody species), as well as many other ecotones between terrestrial and aquatic habitats. Near the PGDP, there are numerous areas where these conditions prevail, particularly in the region adjacent to the Ohio River. Within the WKWMA, approximately 1,620 hectares (4,000 acres) have been identified as having hydric soil capable of supporting wetlands. Some of these systems include a special-status species, the water hickory. Approximately 162 hectares (400 acres) of this area are Tupelo Swamp, and another 243 hectares (600 acres) are bottomland hardwood. The Tupelo Swamp, which is located near the site, is considered very unusual by state and federal land managers and is thought to be only one of three similar systems left in the United States. Most of the remainder of the wetlands in the PGDP vicinity is in agricultural use or is in some stage of succession to wetland scrub. Other wetland habitats are found associated with the shorelines of ditches and creeks (riparian vegetation), although many of these are incised and have only marginal areas of wetlands. Most ponds also include shallow wetland systems along their shorelines and along contiguities with bottomland hardwood systems (CH2M HILL 1991a).

The 1994 COE environmental investigations identified 4,742 hectares (11,719 acres) of wetlands surrounding the PGDP. This investigation identified and grouped wetlands into vegetation cover types encompassing forested, scrub/shrub, and emergent wetlands (COE 1994). Wetland vegetation species include sedges (*Carex spp.*), rushes (*Juncus and Scirpus spp.*), spikerushes (*Eleocharis spp.*), and various other grasses and forbs in the emergent areas; red maple (*Acer rubrum*), sweet gum (*Liquidambar styraciflua*), oaks (*Quercus spp.*), and hickories (*Carya spp.*) in the forested areas; and black willow (*Salix nigra*) and saplings of a variety of other species in the scrub/shrub areas.

Wetlands inside the plant security fence are confined to portions of drainage ditches traversing the site (CDM Federal 1994). Functions and values of these areas as wetlands are low to moderate (Jacobs 1995) with regard to groundwater recharge, floodwater retention, and sediment/toxicant retention. While the opportunity for these functions and values is high, the effectiveness is low due to water exiting the area quickly via the drainage system. Other functions and values, such as wildlife habitat/benefits, are low.

A floodplain analysis performed by the COE in 1994 found much of the built-up portions of the plant lie outside the 100- and 500-year floodplains of these streams. In addition, this analysis reports that ditches within the plant area can contain the expected 100- and 500-year discharges (COE 1994).

2.8.4 Threatened and Endangered Species

Potential habitat for federally listed threatened and endangered (T&E) species was evaluated for the area surrounding the PGDP during the 1994 COE environmental investigation of the PGDP and inside the fence of the PGDP during the 1994 investigation of sensitive resources at the PGDP (COE 1994; CDM Federal 1994). No T&E species or potential habitat for any T&E species were observed during the inside-the-fence investigation. However, the Indiana bat is known to be present near the PGDP. Potential habitat for the Indiana bat (listed endangered) has been observed in the area surrounding the PGDP.

2.9 REFERENCES

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3. SUMMARY OF PREVIOUS INVESTIGATIONS

3.1 INTRODUCTION

Chapter 3 of this Data Summary Report provides summary level information for the RIs completed at each of the WAGs. Additionally, this chapter provides background information for the groundwater investigations completed at the PGDP. This document is intended to provide only an overview of these investigations; all references are identified for the reader. For investigations that were very large, this report focuses on the groundwater aspects of the investigation.

3.2 REMEDIAL SITE INVESTIGATIONS

The following subsections provide summary information for the remedial studies and site investigations completed at the PGDP. Historical information, site geology, nature and extent of contamination, and summaries of risk assessments are included.

3.2.1 Phase I Site Investigation

3.2.1.1 Scope

After the discovery of off-site groundwater contamination at the PGDP, EPA entered into an ACO (EPA 1988) with DOE on November 23, 1988, pursuant to the CERCLA. The ACO required the DOE to monitor the residential wells, provide an alternate drinking water source to affected residents, identify the nature and extent of contamination, and take action to protect human health and the environment. To meet the objectives of the Consent Order, an SI was conducted in two phases. The *Results of the Site Investigation Phase I* (CH2M HILL 1991) documents the results of the first phase of fieldwork completed between 1989 and 1990. The primary objectives of Phase I were (1) to determine the lateral and vertical extent of the contamination in surface water and groundwater, (2) to evaluate the on-site sources of ^{99}Tc and trichloroethene (TCE) most likely to be contaminating groundwater and surface water, and (3) to evaluate the on-site sources of PCB that may be the cause of sediment and surface-water contamination.

3.2.1.2 Areas of investigation and investigation methods

The Phase I Investigation evaluated the following areas for the PGDP: contaminant sources, surface water and sediment, hydrogeology, surface-water and groundwater users' survey, and the ecology. Each of these is described in more detail below.

Contaminant Sources

To meet the objectives of the Phase I Investigation, potential TCE, ^{99}Tc, and PCB contaminant sources were investigated. Twelve SWMUs, which included SWMUs 1, 30, 33, 74, 75, 79, 80, 81, 82, 83, 84, and 85, were investigated as probable sources of PCB contamination. Soil samples were taken from 0 to 1.83 m (0 to 6 ft). Twelve soil borings completed to an average depth of 21 m (70 ft) were completed to investigate potential on-site sources of TCE and ^{99}Tc. Borings were located within Ditch 001, SWMU 1, SWMU 3, SWMUs 7 and 30, SWMU 11, SWMU 17, SWMU 18, and SWMU 91. Figure 3.1 identifies these locations.

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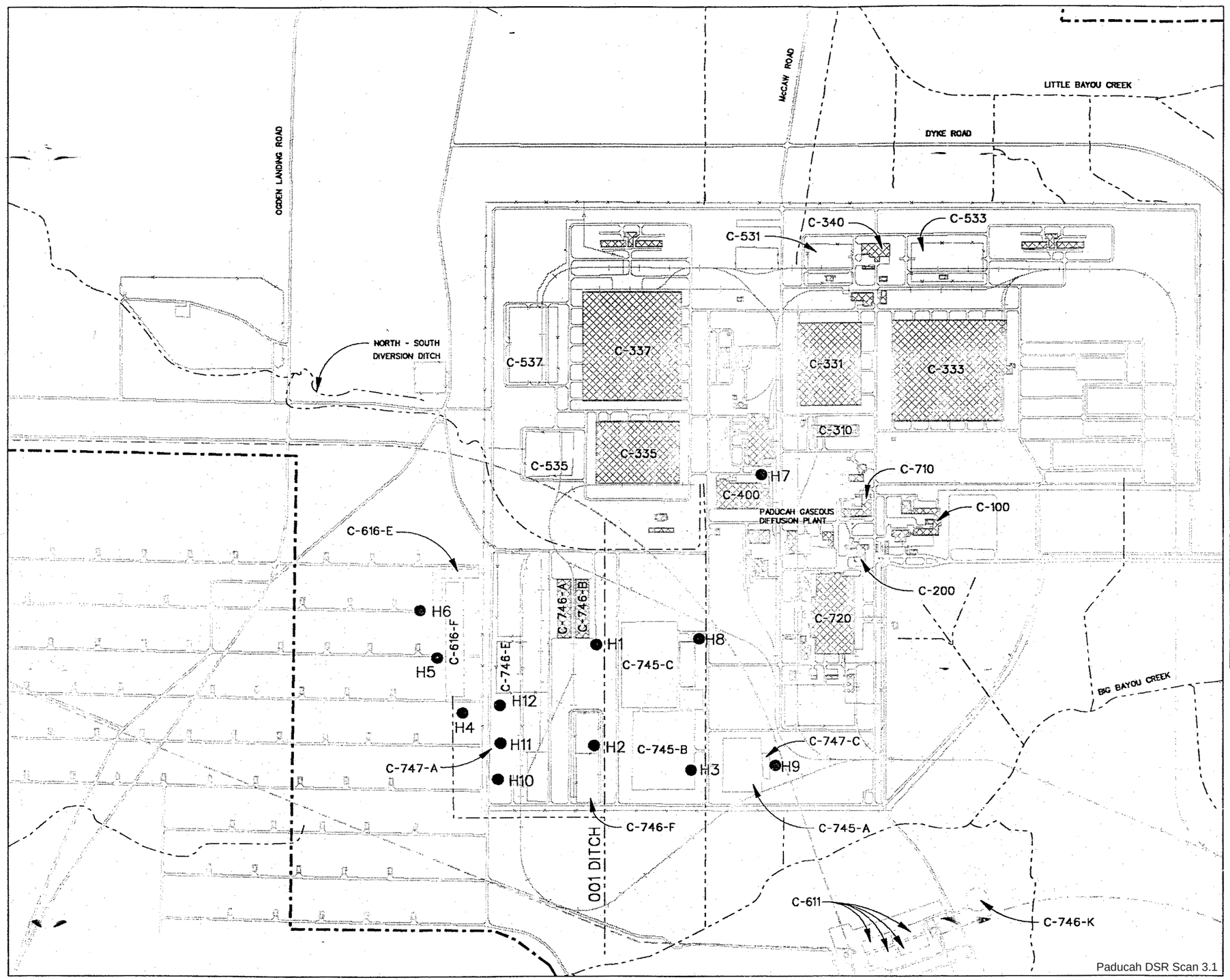
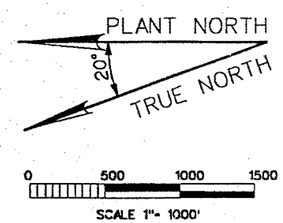


LEGEND

- DOE BOUNDARY
- WATER LINE
- SURFACE WATER
- FENCE
- RR TRACKS
- ● H1 APPROXIMATE DEEP ONSITE BORING LOCATION AND NUMBER

WMU NUMBER	TARGET WMU	BORING NUMBER
--	001 DITCH (EAST)	H1
--	001 DITCH (WEST)	H2
91	CYLINDER DROP TEST AREA	H3
18	C-616-F FULL FLOW LAGOON	H4
17, 18	C-616-F/E FULL FLOW & SLUDGE LAGOONS	H5, 6
11	C-400 TCE LEAK SITE	H7
3	C-404 RAMP	H8
1	OIL LANDFARM	H9
7, 30	C-747-A BURN AREA & BURIAL GROUND	H10,11,12



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PADUCAH GDP, KY.
SITE INVESTIGATION, PHASE I

Fig. 3.1. Phase I Investigation Deep On-Site Soil Borings.

CH2M HILL

Seventeen shallow soil samples were taken to evaluate the distribution and migration of ^{99}Tc into soil from possible past airborne releases. The Phase I Investigation also performed a radiological survey of 27 rubble piles and a radiological walkover survey of Little Bayou Creek, Bayou Creek, North-South Diversion Ditch (NSDD), and KPDES ditches 001, 002, 010, 011, 012, and 013. A soil gas survey was conducted within the plant boundary at 76 m (250 ft) intervals around C-400 and at 229 m (750 ft) intervals at other areas. The Phase I Investigation also conducted background soil sampling to evaluate radioactivity within the soils around the PGDP.

Surface water and sediment. Surface-water samples were collected from Bayou Creek, Little Bayou Creek, Metropolis Lake, a marsh on TVA property, and the NSDD at various time intervals between June of 1989 and August 1990. Sediment samples were collected from 15 stations along Bayou and Little Bayou Creeks and from Metropolis Lake and area wetlands. Likewise, creek-bank sediment samples were collected from 20 locations on the NSDD, Bayou Creek, and Little Bayou Creek. Additionally, shallow soil samples were taken from the banks of the NSDD, Ditch 15, and Ditch 003. The Phase I Investigation also conducted a storm sewer evaluation survey and completed sampling in 14 ponds around the PGDP.

Hydrogeology. The Phase I Investigation evaluated the integrity of 80 monitoring wells, and Martin Marietta Energy Systems, Inc., performed geophysical logging on 25 wells at the site. The Phase I Investigation installed a total of 35 monitoring wells as identified in Fig. 3.2. Water-level measurements were taken discretely (e.g., as wells were installed) and continuously for a 2-week period in July 1990.

Groundwater samples were collected from residential wells around the PGDP and from on-site and off-site monitoring wells. The groundwater data were evaluated (1) to identify residents in need of an alternative water supply, (2) to determine background conditions, (3) to determine nature and extent of off-site groundwater contamination, (4) to focus subsequent investigations, and (5) to determine the interaction between surface water and groundwater.

Groundwater samples were collected from 39 monitoring wells, 22 residential wells, and four TVA wells on five separate sampling events between June 1989 and September 1990. Samples were analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides, PCBs, and metals.

Variable-head (slug) tests were conducted in a number of wells at the PGDP to determine order-of-magnitude estimates of *in situ* hydraulic conductivity. Additionally, an aquifer pumping test was performed near the C-404 area.

Surface-water and groundwater users' survey. The Phase I Investigation conducted a survey identifying surface-water and groundwater users. The area surveyed was approximately 6.4 km (4 miles) in diameter from the center of the plant.

Ecology. Five ecological investigations were performed that included deer sampling, fish sampling, benthic macroinvertebrate sampling, opportunistic sampling, and a terrestrial survey. Twelve whitetail deer were taken from the WKWMA and various tissues were sampled for VOCs, SVOCs, pesticides, PCBs, metals, and radionuclides. Fish taken from local creeks, ponds, and lagoons were tested for VOCs, SVOCs, pesticides, PCBs, metals, and radionuclides. In the fall of 1989, a terrestrial survey documented the dominant vegetation, the wildlife, and the general habitat types within a 6.4-km (4-mile) boundary. Opportunistic sampling of various plants and animals also was conducted.

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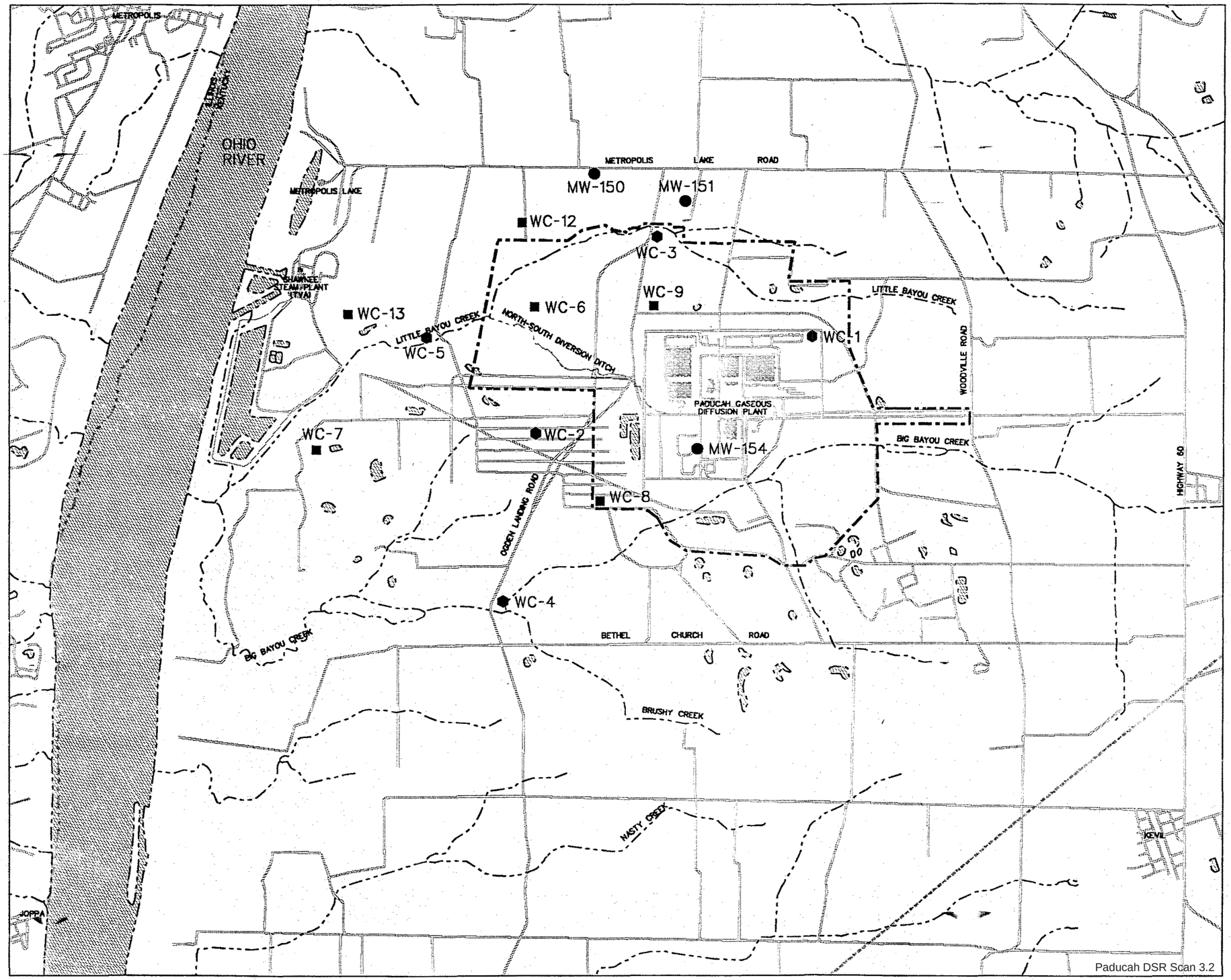


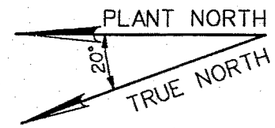
LEGEND

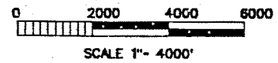
- FENCE
- RR TRACKS
- DOE BOUNDARY
- SURFACE WATER
- WC-1 ● WELL CLUSTER LOCATION AND NUMBER (>2 WELLS)
- WC-9 ■ WELL PAIR LOCATION AND NUMBER
- MW-151 ● SINGLE WELL LOCATION AND NUMBER

WELL NUMBER/ZONE

WELL CLUSTER #	DGS WELL #	DEEP RGA WELL #	SHALLOW RGA WELL #	FULL RGA WELL #	SGS WELL #
1	120	-	-	-	129,130,131
2	121	125	123	-	127
3	122	124	126	-	128
4	140	141	142	-	143
5	133	135	137	-	138
6	-	132	139	-	-
7	-	146	147	-	-
8	-	134	97*	-	-
9	-	144	145	-	-
-	-	-	-	150	-
-	-	-	-	151	-
12	-	-	-	148	149
13	-	-	-	152	153
-	-	-	-	-	154

* WELL IS STILL BEING DEVELOPED
DGS - DEEP GROUNDWATER SYSTEM
SGS - SHALLOW GROUNDWATER SYSTEM
RGA - REGIONAL GRAVEL AQUIFER





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PADUCAH GDP, KY.
SITE INVESTIGATION, PHASE I

Fig. 3.2. Phase I Investigation Monitoring Wells.

CH2MHILL

3.2.1.3 Conclusions

The Phase I Investigation provided information on soil, groundwater, and surface-water contamination at the PGDP and served as a framework to guide other SIs and studies. The following subsections briefly summarize the nature and extent of contamination for groundwater and the general conclusions of the risk assessment.

Nature and Extent of Contamination

The Phase I Investigation concluded that the RGA was the primary transport route for off-site groundwater contamination and that the RGA was contaminated by organic contaminants (primarily TCE) and by ^{99}Tc. Tables 3.1 and 3.2 summarize the results from residential wells, monitoring wells, and TVA wells. These data provided an early conception of the plumes at the PGDP. The Phase I Report concluded that one TCE plume was emanating from the center of the plant (near the C-400 Building) and migrating northeastwardly, and that a separate TCE plume emanating from the northwestern corner of the plant was migrating northwestwardly. The Phase I Report also concluded that a ^{99}Tc plume coincided with the northeasterly plume and that a separate ^{99}Tc plume was migrating northward from the SWMUs in the northwestern part of the plant.

Summary of Risk Assessment

The summary presented in this section was taken from *Results of the Site Investigation, Phase I, at the Paducah Gaseous Diffusion Plant* (CH2M HILL 1991) (i.e., Phase I SI). Specifically, Chaps. 6 and 7 of the Phase I SI contain the pertinent risk information that follows.

According to Chapter 6.1 of the Phase I SI:

> The assessment of offsite receptors is an evaluation of the potential risks posed by PGDP-related contaminants. More specifically, the assessment covers risks from PGDP contaminants to the health of the public living off the site. The goal of this assessment is to establish a "snapshot" of the health risks that may arise from the levels of contamination identified in Phase I of the site investigation. Normally, such an assessment would be made much later in an investigation. The assessment does not reconstruct the history of contaminant levels or predict contaminant levels. The assessment focuses on contaminant levels at points or locations of possible human exposure, such as health risks from contaminants detected at certain concentrations in residential wells that supply drinking water or in creeks used for swimming and fishing. No attempt is made to model or project releases of contaminants to other areas, such as to wells that may not have been sampled as part of the study.

No attempt was made to identify risks not related to the site and therefore define the total risk to an individual living near the site. Similarly, contribution to risk from "background" levels on sources of chemicals or radionuclides are not expressly characterized or defined in this assessment.

Although some human health risks may be increased by exposure to both chemicals and radionuclides, the risks have been discussed and quantified separately for each of the two categories.

Table 3.1. Groundwater Analytical Results of Phase I Investigation

Contaminant of concern	Residential wells			Monitoring wells			TVA wells		
	Detection frequency[b]	Concentration (µg/L)[a]		Detection frequency	Concentration (µg/L)[a]		Detection frequency	Concentration (µg/L)[a]	
		Range	Average[c]		Range	Average		Range	Average
Organic									
4-Nitrophenol				2/18	15.0-15.0	15.0			
Bis(2-ethylhexyl)phthalate	6/44	2.0-69.0	27.8	9/18	5.0-320.0	119.7			
Di-n-butyl phthalate	2/44	2.0-3.0	2.5	1/18	2.0	2.0			
Di-n-octyl phthalate	1/44	27.0	27.0	1/18	5.0	5.0			
Diethyl phthalate				1/18	2.0	2.0	1/4	11.0	11.0
1,2-Dichloroethane	4/61	1.0-2.0	1.3						
1,2-Dichloroethene (total)	2/61	5.0-18.0	11.5	4/42	2.0-12.0	7.3			
2-Butanone				1/26	7.0	7.0			
Benzene				1/43	3.0	3.0			
Carbon tetrachloride	3/61	1.0-8.0	5.3						
Chloroform	6/61	1.0-34.0	13.3	2/43	1.0-2.0	1.5			
Tetrachloroethene	3/61	1.0-2.0	1.3						
Toluene	2/61	1.0-2.0	1.5	5/43	1.0-23.0	7.6			
Trichloroethene	15/61	1.0-1,600.0	380.0	16/43	1.4-340.0	119.2	5/28	1.0-74.0	16.0
Xylene				2/43	3.0-4.0	3.5			
Inorganic									
Aluminum	30/44	24.1-3,400	384.1	18/18	31.4-66,300	9,998.9	5/6	1,270.0-58,600	14,528
Arsenic	6/44	1.3-2.5	1.9	3/17	0.6-1.9	1.1	3/6	1.8-38.2	14
Barium	44/44	19.4-464	121.2	18/18	42.8-1,030	304.2	6/6	71.2-536	189.3
Beryllium	12/44	0.05-2.5	0.6	7/18	0.2-9.3	3.4	3/6	2.4-4.2	3
Cadmium	2/44	1.8-1.9	1.9	5/17	0.9-4.1	3.0			
Chromium	8/44	4.4-107	19.5	15/18	7.0-178	66.7	4/6	7.4-94.6	33.8
Copper	33/44	5.4-1,120	59.3	18/18	3.6-622	62.5	4/6	16.9-76	36.5
Iron	31/44	23.1-166,000	7,422.5	18/18	51.3-288,000	36,735.3	6/6	491.0-121,000	32,383.5
Lead	37/44	1.0-287	15.6	18/18	0.6-42.6	9.7	5/6	2.0-21.3	8.7
Magnesium	44/44	1,810.0-24,300	790	18/18	5,950.0-20,500	11,333.9	6/6	3,570.0-15,900	8,075
Mercury	3/44	0.2-0.2	0.2						
Nickel	8/44	5.7-58.6	17.9	15/18	6.1-159	55.3	4/6	21.4-73.8	47.4
Selenium	16/43	1.1-13.8	4.7	12/18	0.4-7.2	3.3	3/4	1.6-10.3	5.1
Silver	3/44	2.1-10.3	6.1	3/15	12.4-27.5	19.9	1/6	4.9-4.9	4.9
Zinc	39/44	3.4/5,090	291.7	18/18	41.7-537	176.6	6/6	48.1-371	178.9

[a]Total metals (unfiltered sample).
[b]Number of detected values/total samples (including duplicates).
[c]Average of detected values only (including duplicates).

Table 3.2. Groundwater Analytical Results of Phase I Investigation

Radionuclide	Residential well: concentration range (pCi/L)	Monitoring well: concentration range (pCi/L)
^{99}Tc	1.82 to 1,200.0	4.0 to 220.0
^{238}U	1.50 to 3.40	0.21 to 97.0
^{235}U	0.13 to 0.13	0.08 to 2.00
^{239}Pu	0.02 to 0.07	0.06 to 0.6
^{237}Np	Not found	Not found
^{230}Th	0.21 to 1.10	0.24 to 3.50

According to Chapter 7.1.3 of the Phase I SI:

> "For calculating the risk to off-site receptors, the pathways of exposure were evaluated; see Table 7-16. The receptors can be ranked according to significance as follows:
>
> (1) Ingestion of Groundwater
> (2) Ingestion of Fish
> (3) Ingestion of Soil by Children
> (4) External Exposure to Little Bayou Creek
>
> The risks of the various exposure situations are summarized in Table 7-16. See Tables 7-17 through 7-24 for risks of the specific situations."

For ease of reference, Table 7-16 of the Phase I SI is recreated here and titled Table 3.3. The primary contaminants identified in groundwater in Tables 7-17 through 7-24 were TCE, arsenic, bis(2-ethylhexyl)phthalate, ^{99}Tc, ^{238}U, ^{235}U, ^{234}U, ^{230}Th, and ^{239}Pu.

Table 3.3. Summary of Phase I Site Investigation risk[a]

Pathway	Excessive lifetime cancer risk	Fatal cancer risk (Rad)*	Systemic risk
Residential Use of Groundwater: Residential Wells	6×10^{-4} (Chemical) 5×10^{-5} (Rad)	2×10^{-5}	—
Residential Use of Groundwater: Monitoring Wells	1.8×10^{-4} (Chemical) 5×10^{-5} (Rad)	2×10^{-5}	—
Ingestion of Fish:			
Ponds	3×10^{-4} (Chemical)	3×10^{-6}	20
Bayou	1×10^{-4} (Chemical)		
Combined	3×10^{-6} (Rad)	1.4×10^{-6}	
Sediment or Soil Ingestion	1.1×10^{-4} (Chemical) 2.61×10^{-5} (Rad)	— 1.8×10^{-5}	—
Direct Gamma Exposure, Little Bayou, South	1.35×10^{-4} (Rad)	8.5×10^{-5}	—
Ingestion of Food:			
Apples	6×10^{-5} (Chemical)	—	—
Deer	4×10^{-5} (Chemical) 4.5×10^{-5} (Rad)	1.4×10^{-5}	
Residential Use of Groundwater: TVA Wells	3×10^{-5} (Chemical) 3×10^{-4} (Rad)	— 1×10^{-4}	—

[a] Formerly Table 7-16, "SUMMARY OF RISK" of Phase I SI. *Source*: CH2M Hill 1991.

3.2.2 Phase II Site Investigation

3.2.2.1 Scope

The Phase II SI (CH2M HILL 1992) was conducted from 1990 through 1991 to further assess the nature, extent, and risk of off-site contamination identified during the Phase I investigation. Phase II field activities were conducted in two stages. In Stage A, potential on-site sources were characterized to estimate probable limits of the source areas or source-specific contamination, and to identify the nature of releases attributable to each source area. The Stage B activities included further evaluation of boundary conditions of the off-site plume configuration and aquifer characteristics identified during Phase I activities, as well as further evaluation of the extent and nature of off-site contamination. Information contained in this section was taken from *Results of the Site Investigation, Phase II at the Paducah Gaseous Diffusion Plant* (CH2M HILL 1992).

The Phase II SI consisted of the following field activities:

1. Water level measurements

2. Geophysical field work
   (a) Geophysical surveys
   (b) Surface radiation survey

3. Groundwater well installation and development

4. Aquifer testing
   (a) Slug tests
   (b) Pump tests

5. Groundwater sampling
   (a) Stage A
   (b) Stage B

6. Soil sampling
   (a) Stage A
   (b) Stage B

7. Surface-water/sediment sampling
   (a) Sediment and surface water
   (b) Outfalls, creeks, floodplains sediments, and surface water

8. Double-ring infiltrometer testing

9. Radiation dose assessment

10. Test pits

3.2.2.2 Areas of Investigation

The areas of investigation varied depending upon the field activities conducted. Areas of investigation are listed for each of the individual field activities identified above.

Water Level Measurements

Groundwater level measurements were collected from numerous wells across the PGDP site, screened at various depths within three distinct hydrologic units: the Shallow Groundwater System, the Regional Groundwater Aquifer, and Deep Groundwater System.

Geophysical Field Work

Geophysical survey. Surface reconnaissance surveys using electromagnetic ground conductivity and magnetic techniques were used to delineate the location and distribution of buried waste and scrap at select SWMUs. Table 3.4 lists those SWMUs where electromagnetometer and/or magnetometer field activities were conducted and the interpretation of the results.

Table 3.4. Location of Phase II SI electromagnetometer/magnetometer surveys

SWMU	Investigation type	Results
Oil Landfarm (SWMU 1)	electromagnetometer	Three areas indicative of buried wastes or landfarming; two areas appear to contain buried metals
Contaminated Burial Yard (SWMU 4)	electromagnetometer; magnetometer	Five areas appear indicative of buried wastes.
C-747-A Burial Ground (SWMU 7) and C-747-A Burn Area (SWMU 30)	electromagnetometer; magnetometer	Seven areas indicative of buried wastes; scrap metal located at the surface in some areas.
UF6 Cylinder Drop Test Area (SWMU 91)	magnetometer	One area identified which could not be attributed to known structures.

Surface radiation survey. Surface radiation surveys were conducted at select SWMUs and along the drainage ditches south of SWMUs 2 and 3 and SWMUs 7 and 30 to identify areas of surface radiological contamination, bound the radiologically contaminated areas, and differentiate beta and gamma radiation. Table 3.5 provides a list of those areas where surface radiation surveys were conducted.

Table 3.5. Location of surface radiation surveys during Phase II SI

SWMU or AOC	Investigation type
1	Gamma walkover survey and beta/gamma measurements
4	Gamma walkover survey and beta/gamma measurements
7	Gamma walkover survey and beta/gamma measurements
30	Gamma walkover survey and beta/gamma measurements
91	Gamma walkover survey and beta/gamma measurements
Ditches south of SWMUs 2 and 3	Gamma walkover survey and beta/gamma measurements
Ditches south of SWMUs 7 and 30	Gamma walkover survey and beta/gamma measurements

Groundwater Well Installation and Development

Fifty-one monitoring wells were installed and developed on-site and off-site during the Phase II investigation, with one to three wells constructed at each location. The locations were selected to provide information about the shallow groundwater system and the RGA. Phase II SI off-site well locations are shown in Fig. 3.3. The soils encountered in the deepest boring at each well cluster location were sampled. Analytical results from soil samples collected during well installation were used with other on-site soil data to evaluate the effect of potential sources on the adjacent soil and groundwater. All wells were sampled and analyzed for radionuclides, Target Analyte List (TAL), and Target Compound List (TCL) constituents. Additionally, 12 wells surrounding the C-404 Burial Area (SWMU 3) were sampled for RCRA Appendix IX parameters.

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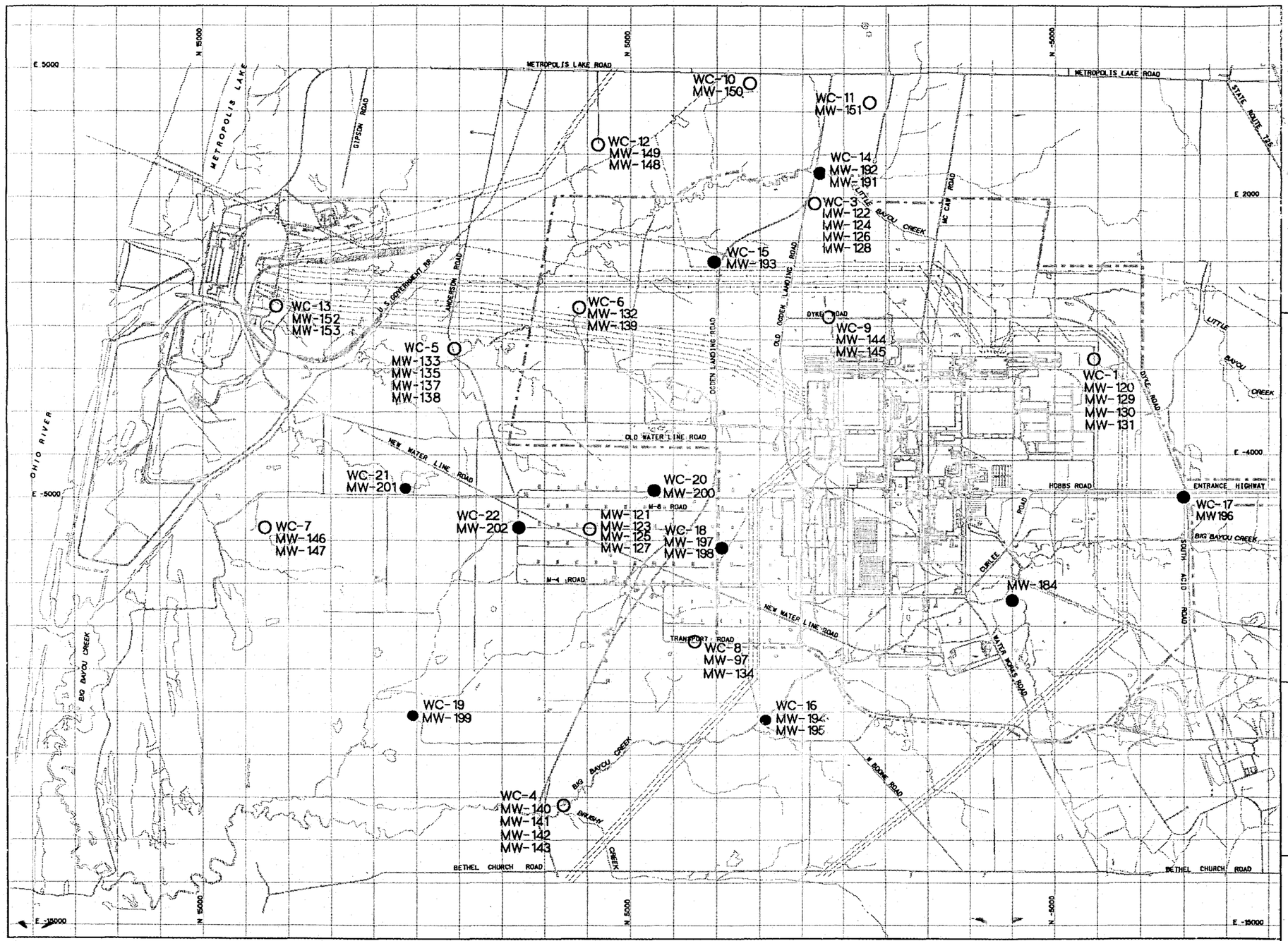

AQUIFER	MW NO.
DEEP GROUNDWATER SYSTEM	MW-120, MW-121, MW-122, MW-133, MW-140
REGIONAL GRAVEL AQUIFER (TOP)	MW-97, MW-123, MW-126, MW-137, MW-139, MW-142, MW-145, MW-147, MW-156, MW-159, MW-191, MW-193, MW-194, MW-197, MW-199 MW-200, MW-201, MW-202
REGIONAL GRAVEL AQUIFER (BOTTOM)	MW-124, MW-125, MW-132, MW-134, MW-135, MW-141, MW-144, MW-146, MW-148, MW-150, MW-152
SHALLOW GROUNDWATER SYSTEM	MW-127, MW-128, MW-129, MW-130, MW-131, MW-138, MW-143, MW-149, MW-151, MW-153, MW-184, MW-192, MW-195, MW-196, MW-198

LEGEND

- DOE BOUNDARY
- POWER LINE
- SURFACE WATER
- FENCE
- RR TRACKS
- ● MW-191 — PHASE II MONITORING WELL LOCATION
- ○ MW-121 — PHASE I MONITORING WELL LOCATION
- WC-3 — WELL CLUSTER NUMBER

NOTE: WHERE MULTIPLE WELLS ARE LOCATED CLOSE TOGETHER ONLY ONE SYMBOL IS SHOWN, BUT ALL WELLS ARE LISTED

PLANT NORTH
20°
TRUE NORTH

0 1250 2500 3750
SCALE 1"= 2500'

Fig. 3.3. Locations of groundwater monitoring wells installed during Phase II SI.

PADUCAH GASEOUS DIFFUSION PLANT
PADUCAH, KY.
PHASE II SITE INVESTIGATION

Aquifer Testing

Slug tests. Aquifer slug tests were performed to evaluate the hydraulic characteristics of the hydrogeologic units underlying the PGDP. Slug tests were conducted on 35 select wells completed during Phase II SI activities to assess the screened aquifer unit properties and evaluate the areal distribution of permeable zones throughout the site.

Pump tests. A 72-h-duration pump test of the RGA was conducted on a well installed during the Phase II SI. The objectives of the pump test were to obtain data necessary to estimate transmissivity, storativity, and hydraulic conductivity of the RGA, obtain data relative to the anisotropy in the RGA, and evaluate leakage into the RGA from overlying shallow groundwater system. The pump test well location is shown in Fig. 3.4.

Groundwater Sampling

Two rounds of groundwater sampling (Stages A and B) were conducted to provide a more complete understanding of groundwater contamination at a given time and to provide data concerning contaminant trends over time. Analytical results from the sampling were also used in estimating the nature and extent of contamination and evaluating the potential sources of contamination at the site.

Soil Sampling

Twenty-five deep soil borings were drilled near SWMUs and other areas of concern during the Phase II SI field activities. Soil samples were also taken from ground surface and from 25 shallow borings. Information from the borings was used to evaluate the depth of contamination at SWMUs and AOCs. Surface soil samples were used to estimate the probable limits of the surface source areas, and to identify the nature of the extent of releases attributable to each source area. Boring and surface soil samples were most often taken from the perimeter of the SWMU or AOC to provide direct indications of surface and subsurface migration of mobile contaminants. Surface soil sampling locations at PCB spill areas were selected to evaluate the extent of contaminant migration and transport through drainage ditches located on-site.

Surface-Water/Sediment Sampling

Surface-water samples were collected from outfalls within the PGDP to assess whether existing plant discharges (as opposed to past disposal practices) may affect water quality. Sediment samples were collected and analyzed to assess the nature and extent of sediment contamination at the PGDP. Figure 3.5 shows the locations of surface-water sampling locations and sediment sampling locations during the Phase II SI.

Double-Ring Infiltrometer Testing

Double-ring infiltrometer testing was conducted at five units: SWMUs 1, 2, 4, 7, 30, and 91. The test was performed to estimate the infiltration rate of the soil overlaying the waste cells at these units. Infiltrometer test data, used in conjunction with data collected from soil sampling and groundwater sampling, were used in estimating the potential quantity of rainfall percolation in the waste, and the volume of leachate which may be produced from the waste cells. The test results were also used to evaluate the effectiveness of any soil caps or covers placed over the respective waste cell.

Radiation Dose Assessment

Using data obtained during a radiation walkover survey conducted in 1990, a detailed radiological dose assessment was conducted in 1991 to characterize the radiation exposure distribution within the banks

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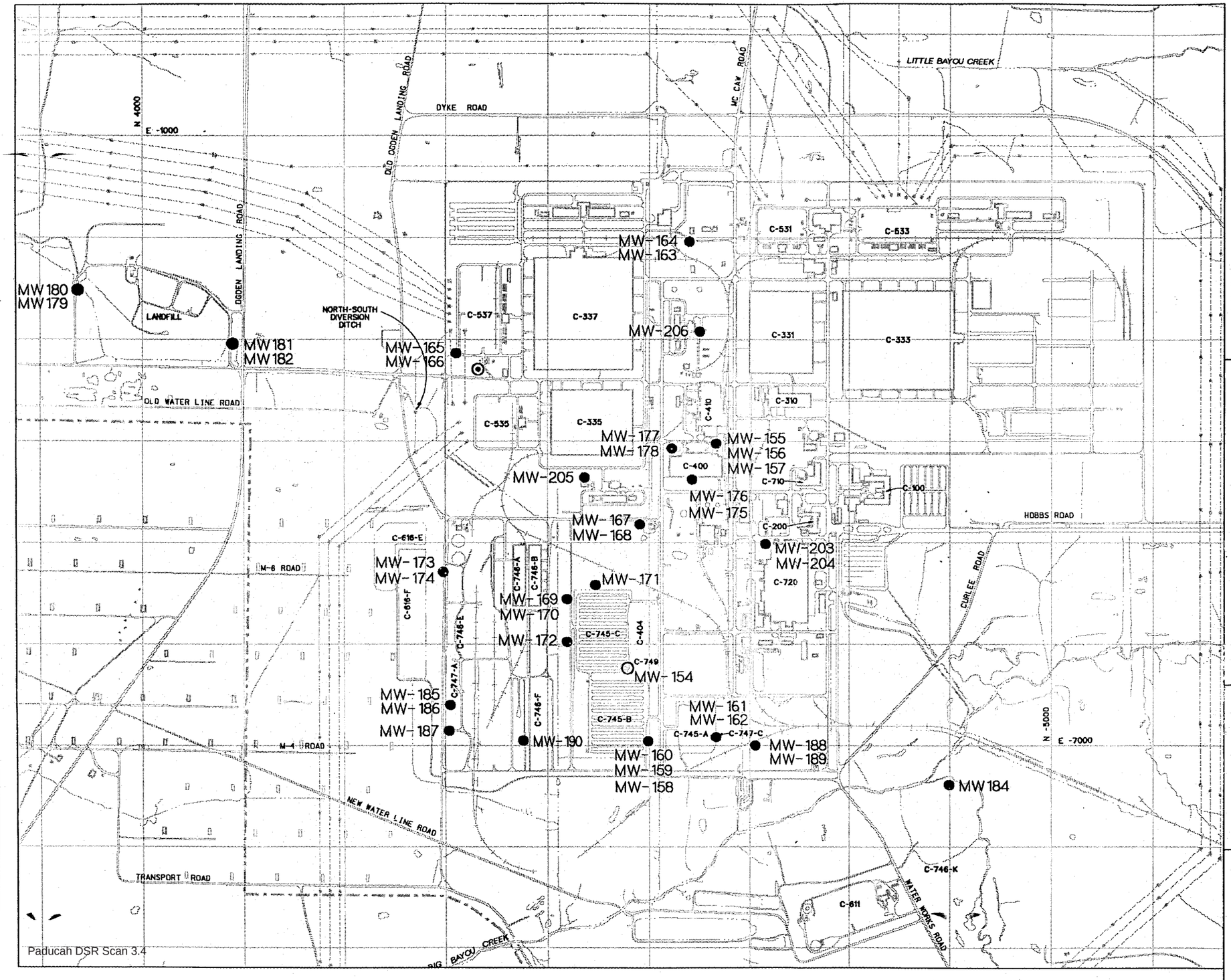

AQUIFER	MW NO.
REGIONAL GRAVEL AQUIFER (TOP)	MW-156,MW-159,MW-161,MW-163,MW-165, MW-168,MW-169, MW-173, MW-175, MW-178, MW-179, MW-181, MW-185, MW-188, MW-203, MW-205, MW-206
REGIONAL GRAVEL AQUIFER (BOTTOM)	MW- 155, MW-158
SHALLOW GROUNDWATER SYSTEM	MW-154, MW-157, MW-160, MW-162, MW-164, MW-166, MW-167, MW-170, MW-171, MW-172, MW-174, MW-176, MW-177, MW-180, MW-182, MW-186, MW-187, MW-189,MW-190, MW-204

LEGEND

- DOE BOUNDARY
- POWER LINE
- SURFACE WATER
- FENCE
- RR TRACKS
- C-333 FACILITY NUMBER
- ● MW-165 PHASE II MONITORING WELL LOCATION
- ○ MW-154 PHASE I MONITORING WELL LOCATION
- ⊙ PUMP TEST WELLS

NOTE: WHERE MULTIPLE WELLS ARE LOCATED CLOSE TOGETHER ONLY ONE SYMBOL IS SHOWN, BUT ALL WELLS ARE LISTED

PLANT NORTH
20°
TRUE NORTH

0 500 1000 1500
SCALE 1"= 1000'

Fig. 3.4. Location of the Phase II SI groundwater pump test.

PADUCAH GASEOUS DIFFUSION PLANT
PADUCAH, KY.
PHASE II SITE INVESTIGATION

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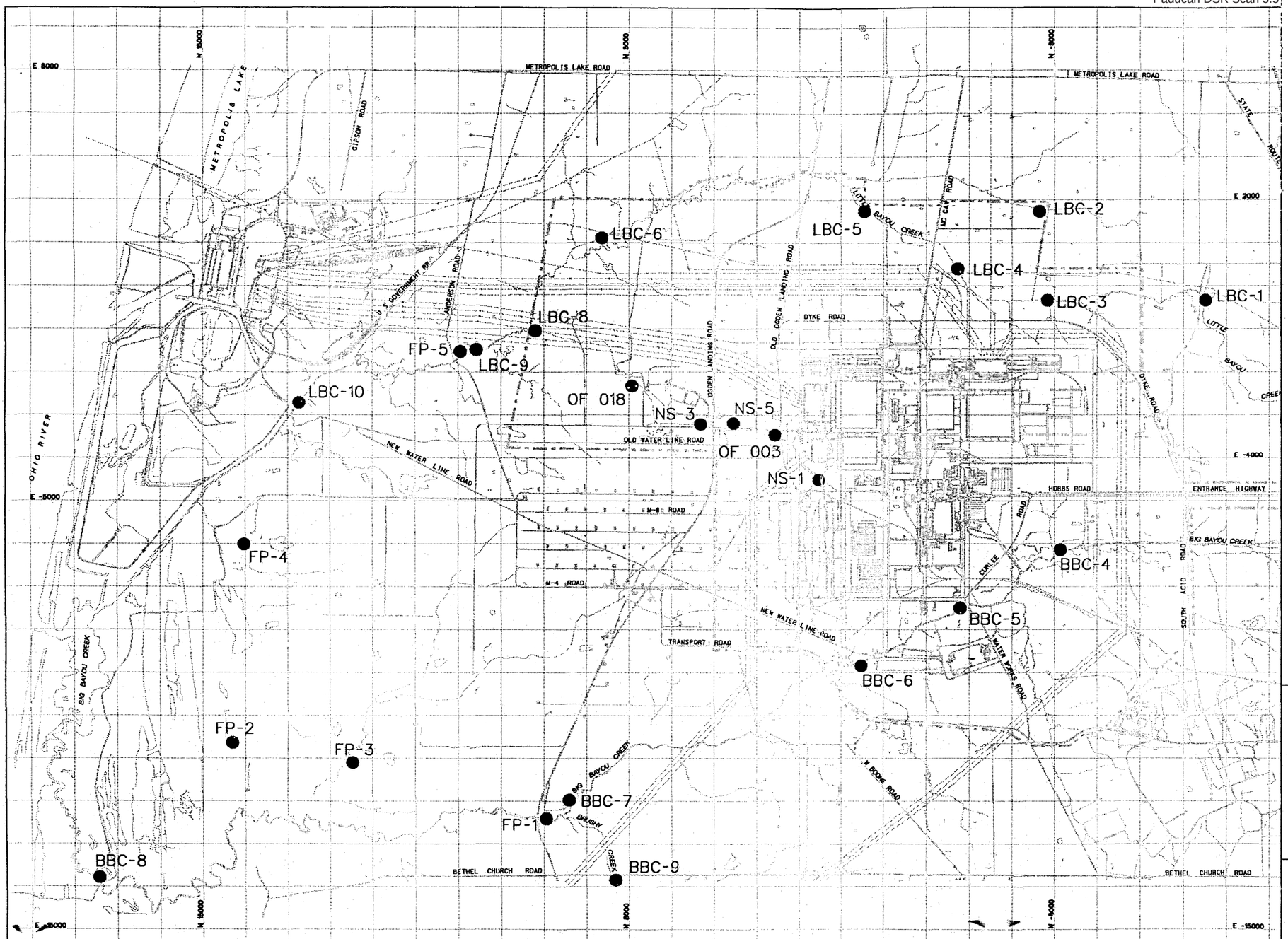
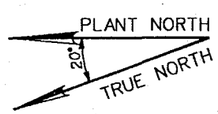
Paducah DSR Scan 3.5



LEGEND

- DOE BOUNDARY
- POWER LINE
- SURFACE WATER
- FENCE
- RR TRACKS
- ● STREAM SAMPLING SITE
- ● FP FLOODPLAIN SAMPLING SITE
- BBC BIG BAYOU CREEK SAMPLING SITE
- LBC LITTLE BAYOU CREEK SAMPLING SITE
- NS NORTH-SOUTH DIVERSION DITCH SAMPLING SITE
- OF KPDES OUTFALL SAMPLING SITE



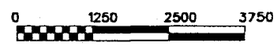


Fig. 3.5. Surface-water and sediment sampling locations during Phase II SI.

PADUCAH GASEOUS DIFFUSION PLANT
PADUCAH, KY.
PHASE II SITE INVESTIGATION

of Bayou Creek and Little Bayou Creek. The specific objectives were to provide accurate, time-integrated radiation dose rate data from along the creek beds and to provide specific dose information on the relative extent of the contamination in the creek banks.

Test Pits

A total of four test pits were excavated with a tracked backhoe at SWMUs 7 and 30 to evaluate the presence of drums or other containers of buried wastes. Data collected from the electromagnetic terrain conductivity and magnetometer surface geophysical surveys were used to locate the excavations. Test pits were excavated from 1.5 to 3.0 m (5 to 10 ft) deep, and were terminated when groundwater was encountered. Locations of the test pits are shown in Fig. 3.6.

3.2.2.3 Investigation methods

Water Level Measurements

Water level data were collected from 61 of the scheduled 76 groundwater wells; access arrangements from 12 TVA wells could not be obtained in time for measurements, MWs 69 and 153 were dry, and MW27 could not be located. Water level measurements were taken with an electronic water level meter, measuring from the top of the datum index.

Geophysical Field Work

Geophysical survey. Instruments used in the field investigations included a Geonics™ Model EM31 ground conductivity meter to collect the electromagnetometer data, and a GEM™ magnetometer/gradiometer for the magnetic investigation. Each of the areas was plotted into a 6- by 3-m (20- by 10-ft) grid, with data recorded in field logs.

Surface radiation survey. A 15- by 1.5-m (50- by 5-ft) grid coordinate system was developed over each of the survey areas. Low-level gamma radiation surveys were conducted using an SPA-3 to determine the location of elevated gamma readings. SWMUs 1, 7, and 30 were surveyed, with areas of elevated count marked with pin flags, and shielded/unshielded GM™ detector measurements were then taken. At other locations where the background gamma radiation was elevated due to gamma radiation emanating from nearby sources, such as the uranium cylinder storage yards, point measurements were generally taken at 8-m (25-ft) intervals with a cone shield.

Point shielded and unshielded GM™ detector measurements were taken at the four grid corners at each SWMU. Additionally, biased point measurements were taken at locations where elevated readings were identified during the gamma walkover survey. Measurements were taken using thin-window GM™ detectors and portable ESP-1 and PRS-1 count rate meters.

Groundwater Well Installation and Development

Two stages of groundwater installation and development occurred during the Phase II SI field activities. The objective of Stage A was to characterize on-site sources of contamination; 35 groundwater monitoring wells were installed on-site and adjacent to SWMUs. The objective of the Stage B well installation activities was to further define the vertical and lateral extent of the TCE and ^{99}Tc plumes by characterizing the water quality downgradient of the PGDP. The target of the Stage A and Stage B well installation was the shallow groundwater system of the Upper Continental Deposits and the deep groundwater of the RGA. Groundwater well boreholes were drilled using hollow stemmed augers. All boreholes were

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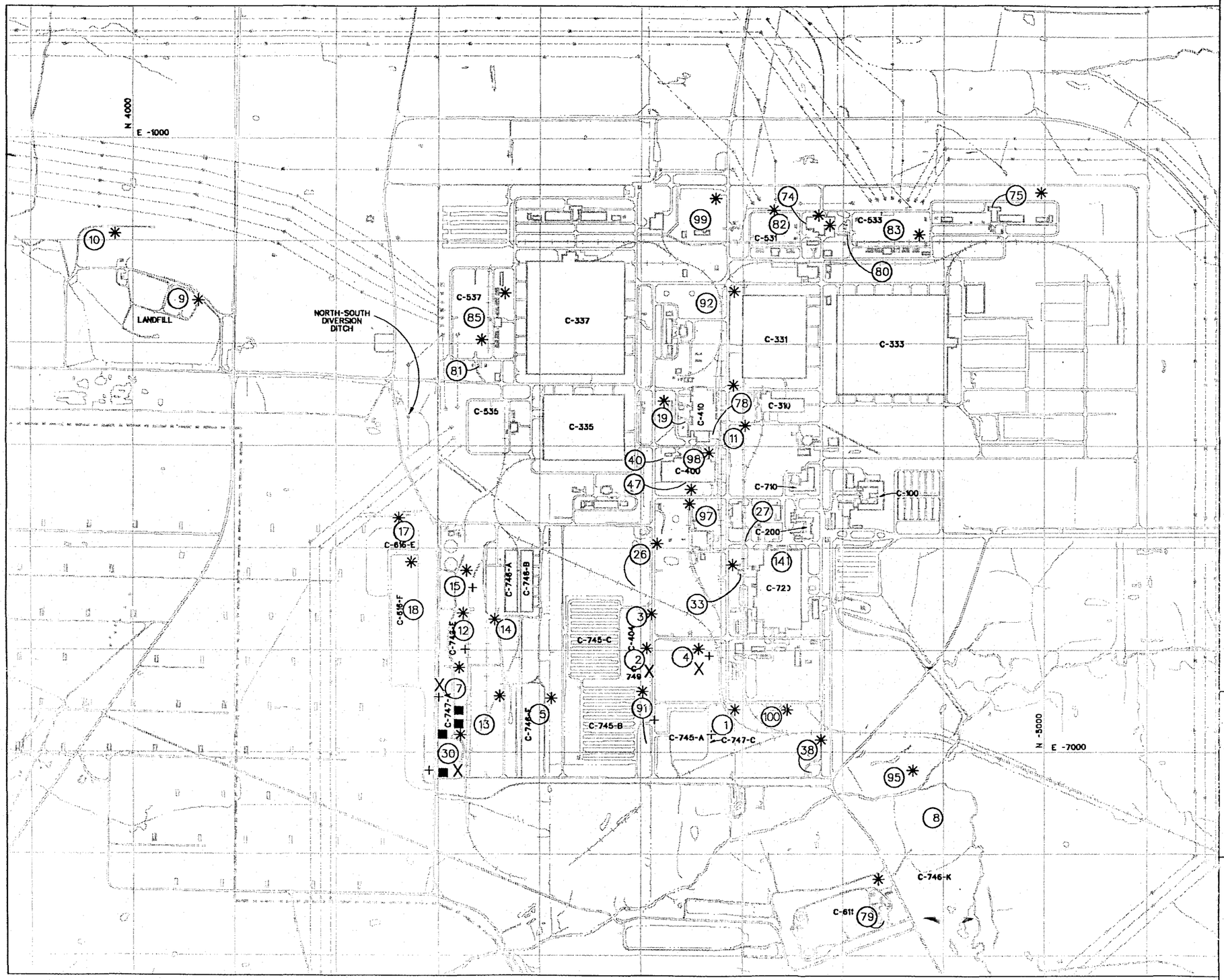


Paducah DSR Scan 3.6

LEGEND

- DOE BOUNDARY
- POWER LINE
- SURFACE WATER
- FENCE
- RR TRACKS
- C-333 FACILITY NUMBER
- (17) WASTE MANAGEMENT UNIT LOCATION AND NUMBER (SEE TABLE 2-9 FOR A LIST OF WMUs)
- ✱ SOIL OR SEDIMENT SAMPLING
- \+ GEOPHYSICAL OR RADIOLOGICAL SURVEY
- ■ TEST PIT
- X INFILTRATION TEST

NOTE:
SEE FIGURES 2-2 AND 2-3 FOR LOCATIONS OF MONITORING WELLS INSTALLED IN PHASE II.

PLANT NORTH
20°
TRUE NORTH

0 500 1000 1500
SCALE 1"= 1000'

Fig. 3.6 Test pit locations during the Phase II SI.

PADUCAH GASEOUS DIFFUSION PLANT
PADUCAH, KY.
PHASE II SITE INVESTIGATION

logged in the field, and soil samples were collected from the deepest borehole at each well group location. Each groundwater monitoring well was developed prior to sampling.

Aquifer Testing

Slug tests. Slug tests were conducted by measuring the rate of water level recovery after it had been lowered by either pressurized gas or a solid slug. With the gas method, the water level in a well was lowered by attaching a manifold to a well head and, using pressured nitrogen gas, displacing water from the well screen. Releasing the pressure with a valve allowed groundwater to flow back in to the well; the rate at which the water level rose within the well was recorded, providing data about the aquifer hydraulic properties. With the second method, a solid slug was lowered into the well, partially displacing water upward, higher in the well casing. The water level in the well was observed and measured until it returned to pre-test levels. After the water level stabilized, the slug was quickly removed from the well, and the rate of water level rise in the well was recorded.

Pump tests. The pumping well, located north of the process buildings in an area just west of the C-537 Switchyard (SWMU 85), was constructed to be a fully penetrating well, and eight observations wells (five in the RGA and three in the shallow groundwater systems) were constructed nearby to observe drawdown in both the stressed aquifer and the overlying units. Following a step rate test to determine the specific capacity of the well, the pumped well was stressed at approximately 92 gal/min for the duration of the test. Multichannel data loggers were used to record piezometric pressure in observation and monitoring wells during the test and for several days prior to and following.

Groundwater Sampling

Stage A. One round of samples was collected from on-site plant wells, all wells installed in the Phase I and Phase II SIs, and selected TVA and residential wells. Existing plant monitoring wells that had been sampled during Phase I were re-sampled to provide a more complete understanding of groundwater contamination at the given time, and to provide data concerning trends over time. The residential wells sampled include those in which contaminants had previously been detected. Samples were analyzed for Target Analytical List (TAL), Target Compound List (TCL), and radionuclides. Additionally, water samples from eight select wells were analyzed for general water quality parameters.

Stage B. A second round of sampling and analysis was conducted on the 51 groundwater monitoring wells installed for the Phase II SI as a confirmatory sampling event. These samples were analyzed for TCL organic, TAL inorganics, and radionuclides from filtered aliquots. Also, samples were collected from Phase I SI well clusters 2, 7, 12, and 13 to be analyzed for TCE and ^{99}Tc.

Soil Sampling

Twenty-five deep soil borings (12 to 38 m, 40 to 125 ft, deep) were drilled during the Phase II SI. At suspected spill sites, borings were drilled to depths of approximately 21 m (70 ft), or to about 3 m (10 ft) of the RGA. Additional borings were drilled to just above the water table [approximately 12 m, 40 ft, below ground surface (bgs)]. Three borings extended through the RGA for stratigraphic control. The borings conducted near burial areas were conducted so the boring did not extend through the waste mass; these borings were intended to evaluate whether or not contaminants were migrating from the SWMUs.

Surface-Water/Sediment Sampling

Where sediment was present for collection, samples were taken at the same locations as surface-water samples to allow comparison of contaminants. Sediment samples were also collected from locations

along Little Bayou Creek, Bayou Creek, and the NSDD. Sediment samples were collected from the outfall structure sediment traps to confirm contamination reported by earlier studies.

Additionally, samples of sediment deposited in the floodplains of Bayou and Little Bayou Creeks during high water events were also collected and analyzed. Preference was given to sampling floodplain deposits in areas used for crop production.

Double-Ring Infiltrometer Testing

Double-ring infiltrometer tests were performed in general accordance with ASTM-D-3385, "Infiltration Rate of Soil in Field Using Double-Ring Infiltrometers." The results of the infiltrometer testing are provided in Table 3.6.

Table 3.6. Results of double ring infiltrometer testing during Phase II SI

SWMU	Infiltration rate range, cm/sec
1	$2 \times 10^{-4} - 4 \times 10^{-6}$
2	$5 \times 10^{-6} - 2 \times 10^{-6}$
4	$5 \times 10^{-6} - < 3 \times 10^{-6}$
7	$2 \times 10^{-3} - < 2 \times 10^{-6}$
30	$1 \times 10^{-4} - < 2 \times 10^{-6}$
Background	$2 \times 10^{-5} - < 2 \times 10^{-6}$

Radiation Dose Assessment

This study used thermoluminescent dosimeters (TLDs) to measure background radiation levels, as well as dose levels from suspected contamination areas. Approximately 150 TLDs were placed along the creeks to collect dosage data throughout the majority of the stream reaches where contamination was known or suspected to exist. The TLDs were left in place over a 3-month period to collect site-specific dose data and reduce uncertainties caused by short-term fluctuations in ambient or background dose rates.

Test Pits

During the excavations, a clean access road was provided for a track hoe to approach the test pit area. Spoils pads were constructed near the excavations to contain excavated materials.

Test Pit 1 (TP-1) was located in the southeast corner of SWMU 30, north of the clean road. This location was selected due to a magnetic geophysical anomaly in the area. The excavation log indicated the presence of railroad rails at 1.1 m (3.5 ft) bgs, and burn ash with wood and metal at a depth of approximately 1.2 to 1.5 m (4 to 5 ft) bgs. Radiological survey indicated 400 to 500 cpm beta/gamma counts on the excavated materials.

Test Pit 2 (TP-2) was located in the northeast quadrant of SWMU 30, approximately 31 m (100 ft) west of MW66. This location was selected due to a large magnetic geophysical anomaly in the area. The pit was excavated in a north–south line. The excavation log indicated rebar and metal shavings encountered at 0.6 to 1.2 m (2 to 4 ft) bgs, burn ash and solid cinder ash at 1.2 to 1.5 m (4 to 5 ft) bgs, and railroad railing at the 1.5- to 2.1-m (5- to 7-ft) depth interval. Radiological surveys conducted on the excavated materials indicated 150 to 400 cpm beta/gamma contamination. Groundwater was encountered at approximately 2.1 m (7 ft) bgs.

Test Pit 3 (TP-3) was located in the northwestern quadrant of SWMU 7, in an area suspected to contain contaminated non-combustible scrap. This location was selected due to large geophysical anomalies in the area. The original pit location was moved 3 m (10 ft) to the east to excavate a slope assumed to be the cover for the burial area. The excavation log indicated the presence of uranium salt in the 0- to 0.6 m (0- to 2-ft) depth interval; metal strips, wire, and wood debris in the 0.6 to 1.5 m (2- to 5-ft) depth interval; waste metal, wood, drum pieces, metal pipe, and oily material with a notable petroleum odor in the 1.5- to 1.8-m (5- to 6-ft) depth interval; no notable materials in the 1.8- to 2.4-m (6- to 8-ft) depth interval, but high radiological readings; and at the 2.4- to 3.0-m (8- to 10-ft) depth interval, groundwater with a black oily sheen on the surface was encountered. A radiological survey of the excavated material indicated beta/gamma readings as high as 7,900 in the excavated materials.

A decision was made to excavate Test Pit 5 (TP-5) instead of the proposed Test Pit 4 (TP-4) due to extenuating circumstances. Test Pit 5 was located in the southwest quadrant of SWMU 7. This location was selected due to large magnetic geophysical anomalies in the area. A radiological survey of green and yellow salt material noticeable on the ground surface indicated in excess of 200,000 cpm beta/gamma readings. The excavation log indicated the presence of green salts in the 0- to 0.6-m (0- to 2-ft) depth interval, and buried drums at the 0.6- to 1.2-m (2- to 4-ft) depth interval. Groundwater was detected at the 1.2- to 1.5-m (4- to 5-ft) depth interval. At least six drums were uncovered during the excavation activities. Two drums were removed, and placed in overpacks; the remaining drums were left in the pit. A radiological survey of the excavated materials indicated beta/gamma readings as high as 40,000 cpm in the subsurface materials.

All excavated material was returned to the test pits, and clean fill material was used to cover the test pit areas.

3.2.2.4 Geology/Hydrogeology

Deep soil borings and groundwater monitoring wells installed during the Phase II SI provided information of the on-site stratigraphy at the PGDP. In general, well borehole logs generally correlated with the borehole logs collected during the Phase I investigation.

The first 15 to 23 m (50 to 75 ft) of deposits contain the shallow groundwater system within the relatively permeable sands and occasional gravels of the Upper Continental Deposits. Site stratigraphy consisted of 0 to 1.8 m (0 to 6 ft) of fill underlain by approximately 4.6 to 7.6 m (15 to 25 ft) of lean clay, underlain by alternating layers of sands (typically less than 1.5 m, 5 ft, thick) and up to 18 m (60 ft) of clayey sands or sandy clays. The boring logs revealed an uppermost stratigraphic unit consisting of a clay and clayey sand underlain by a silty clay. This two-part unit can be up to 11 m (35 ft) thick and is underlain by what is interpreted as the Upper Continental Deposits.

The Upper Continental Deposits consist of alternating layers of sand and clay or clayey sand with thin layers of angular to sub angular gravel. The total depth to the bottom of the Upper Continental Deposits was determined to be 11 to 20 m (35 to 65 ft). In general the Upper Continental Deposits were determined to contain the shallow groundwater system. Data collected during the Phase II suggested that the flow gradient within the shallow groundwater system is predominantly vertical to the RGA.

The Upper Continental Deposits were noted to be underlain by the Lower Continental Deposits, consisting of gravel with varying amounts of non-cohesive silt and sand. The Lower Continental Deposits contain the RGA. Typically, there were approximately 0.6 to 11 m (2 to 35 ft) of loose sands directly above the RGA. These sands appeared to be in hydraulic connection with the RGA. The RGA, identified by loose sands and gravels was encountered consistently at depths between 15 and 24 m (50 and 80 ft) bgs.

The base of the gravel aquifer was established, underlain by a fine grained sand and sandy lean clay, and a lean clay across the site. From data collected during the Phase II, it appeared that groundwater flowed north across most of the plant. Data also indicate that water level elevations within the Ohio River influence water levels in the RGA at or near the river, and gradients in these areas are upward into the shallow groundwater system. Groundwater flow velocities in the RGA were calculated to range from 4.2×10^{-8} to 8.54×10^{-5} cm/s.

The Lower Continental Deposits were determined to be underlain by the Porters Creek Clay, the McNairy Formation, and Eocene Sands across the site. A small downward gradient from the RGA to the deep groundwater system was noted, suggesting vertical connectivity. According to available hydraulic gradient and conductivity data, groundwater flow rates in the deep groundwater system ranged from 4.64×10^{-11} to 4.64×10^{-5} cm/s.

3.2.2.5 Nature and extent of contamination

Soil

The evaluation of chemical and radiological contaminant distribution in the off-site soils indicated that metals concentrations were within a range of common values. Further, no pattern of off-site radiological contamination was apparent.

Groundwater

Off-site groundwater contamination was determined to consist primarily of TCE and ^{99}Tc plumes within the RGA, although contamination within the shallow groundwater system has also occurred. The deep aquifer system (i.e., McNairy Formation) was generally free of contamination, although trace amounts of petroleum products and ^{99}Tc were reported. Both TCE and ^{99}Tc are mobile in groundwater and were determined to be migrating from the plant from several source areas.

The presence of TCE as a dense, nonaqueous-phase liquid (DNAPL) was inferred in two locations on-site: the C-400 TCE Spill Site and the Cylinder Drop Test Area (SWMU 91). The occurrence of DNAPL was also suspected to be present at the C-747-A Burial Ground.

Surface-Water and Sediment

Chemical and radiological contamination associated with the PGDP was detected in Little Bayou Creek and the NSDD in both the surface water and sediment. Contaminants included uranium and PCBs.

3.2.3 WAG 6

3.2.3.1 Overview of WAG 6

The WAG 6 RI focused upon five SWMUs associated with the C-400 Cleaning Building processes and included a general Site Evaluation of the C-400 Building area. Information contained in this section was compiled from the *Remedial Investigation Report for Waste Area Grouping 6 at the Paducah Gaseous Diffusion Plant* (DOE 1999a). These SWMUs were grouped together as suspected sources of off-site groundwater contamination by TCE and ^{99}Tc that were expected to be addressed collectively. Table 3.7 lists the specific SWMUs targeted by the WAG 6 project.

Table 3.7. The SMWUs of WAG 6

SWMU	PGDP facility number	Description
11	C-400	Trichloroethene Leak Site
26	not applicable	C-400 to C-404 Underground Transfer Line
40	C-403	Neutralization Pit
47	C-400	Technetium Storage Tank Area
203	C-400	C-400 Waste Discard Sump

The C-400 Building is located near the center of the PGDP fenced security area. In addition to the immediate C-400 area, the WAG 6 RI characterized the SWMU 26 corridor, extending west from C-400 along Virginia Avenue to the C-404 Radioactive Waste Burial Area, and confirmed the occurrence of a C-400 groundwater contaminant plume extending to the east, in the area south of the C-335 and C-337 Process Buildings. Figure 3.7 shows the location of the area addressed by the WAG 6 RI as it relates to the PGDP groundwater contamination plumes.

3.2.3.2 SWMU 11—C-400 Trichloroethene Leak Site

Location

The C-400 Trichloroethene Leak Site consists principally of TCE-contaminated soil along the 11th Street storm sewer near the southeast corner of the C-400 Building. Figure 3.8 is a map of the SWMU 11 area.

Setting

SWMU 11 is located in a graveled lot, measuring 12.2 m (40 ft) wide and 36.6 m (120 ft) long, located between 11th Street and the east-side C-400 Building security fence. An access road to the C-400 Building office parking lot and a paved truck unloading dock bound the SWMU to the north and south, respectively.

Surface-water hydrology, wetlands, and floodplains. Surface drainage is routed through storm sewers to the Outfall 008 effluent ditch, which empties into Bayou Creek on the west side of the plant. There are no streams, wetlands, or 100-year floodplain areas within SWMU 11.

Biological resources. The C-400 Trichloroethene Leak Site is maintained as a graveled lot that is nearly devoid of vegetation. This setting does not provide critical habitat for T&E species of plant or animal.

Soils and prime farmland. The soils of SWMU 11 are Calloway series silt loams, with a shallow fragipan. However, construction and maintenance activities and the excavation and placement of backfill in the C-400 TCE Leak Site have heavily disturbed the original soil structure.

Underground utilities. The 11th Street storm sewer, at a depth of approximately 4.0 m (13 ft) bgs, is the primary utility of interest. A utilities corridor containing a connector pipe between the storm sewer and a C-400 Building basement sump, a sanitary water line, and a sanitary sewer pipe, underlies the north boundary of SWMU 11. Electrical service lines cross the 11th Street storm sewer in the vicinity of MW157.

Manufacturing/TSD Processes

A basement sump for the nearby C-400 Building TCE degreaser inadvertently discharged leaks and spills of TCE, along with wastewater, to the storm sewer line. Before the discovery of the TCE leak, it

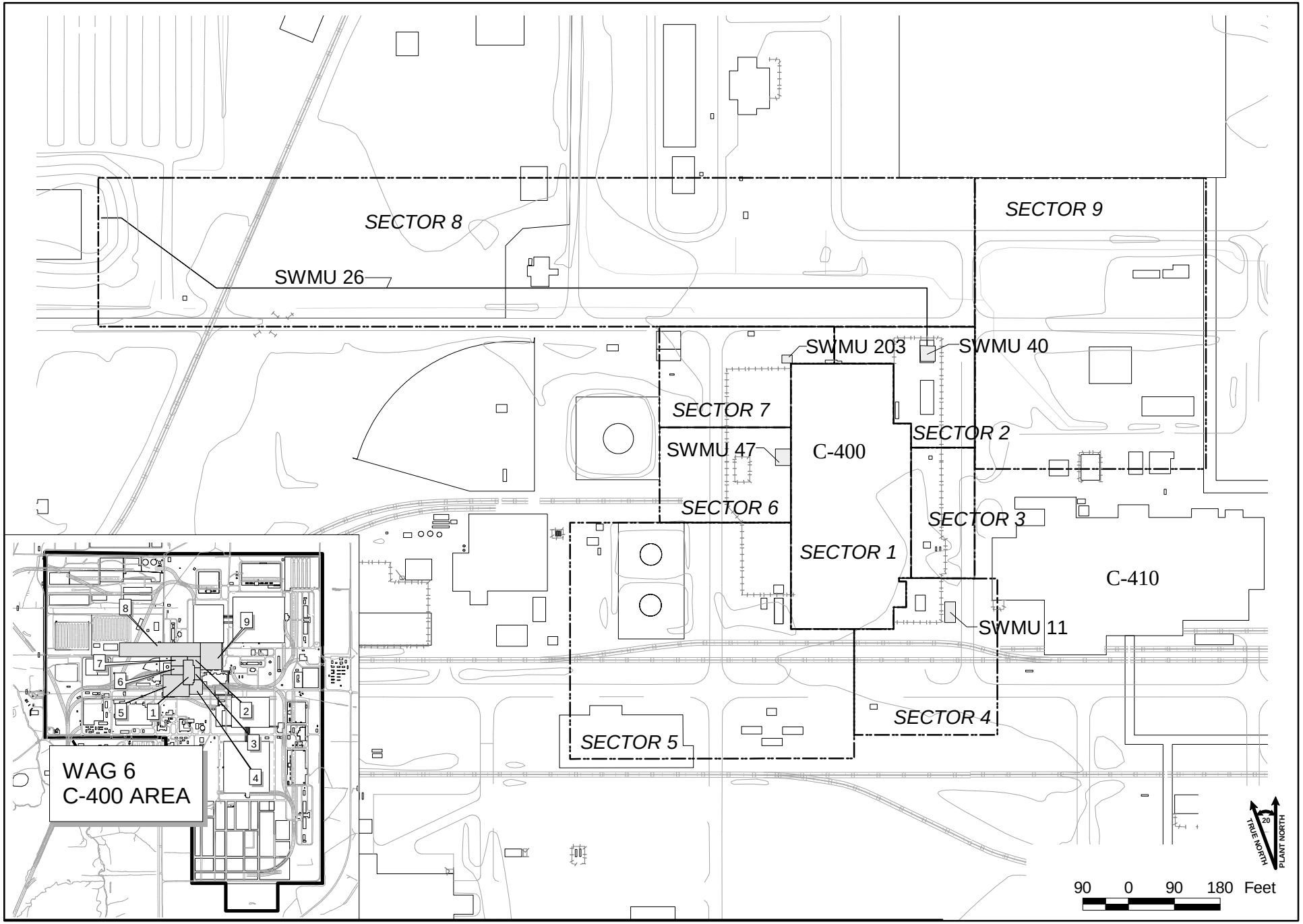

SECTOR 8
SECTOR 9
SWMU 26
SWMU 203
SWMU 40
SECTOR 7
SECTOR 2
SWMU 47
C-400
SECTOR 6
SECTOR 3
SECTOR 1
C-410
SWMU 11
SECTOR 4
SECTOR 5
WAG 6
C-400 AREA
1
2
3
4
5
6
7
8
9
TRUE NORTH
20
PLANT NORTH
90 0 90 180 Feet

Fig. 3.7. WAG 6

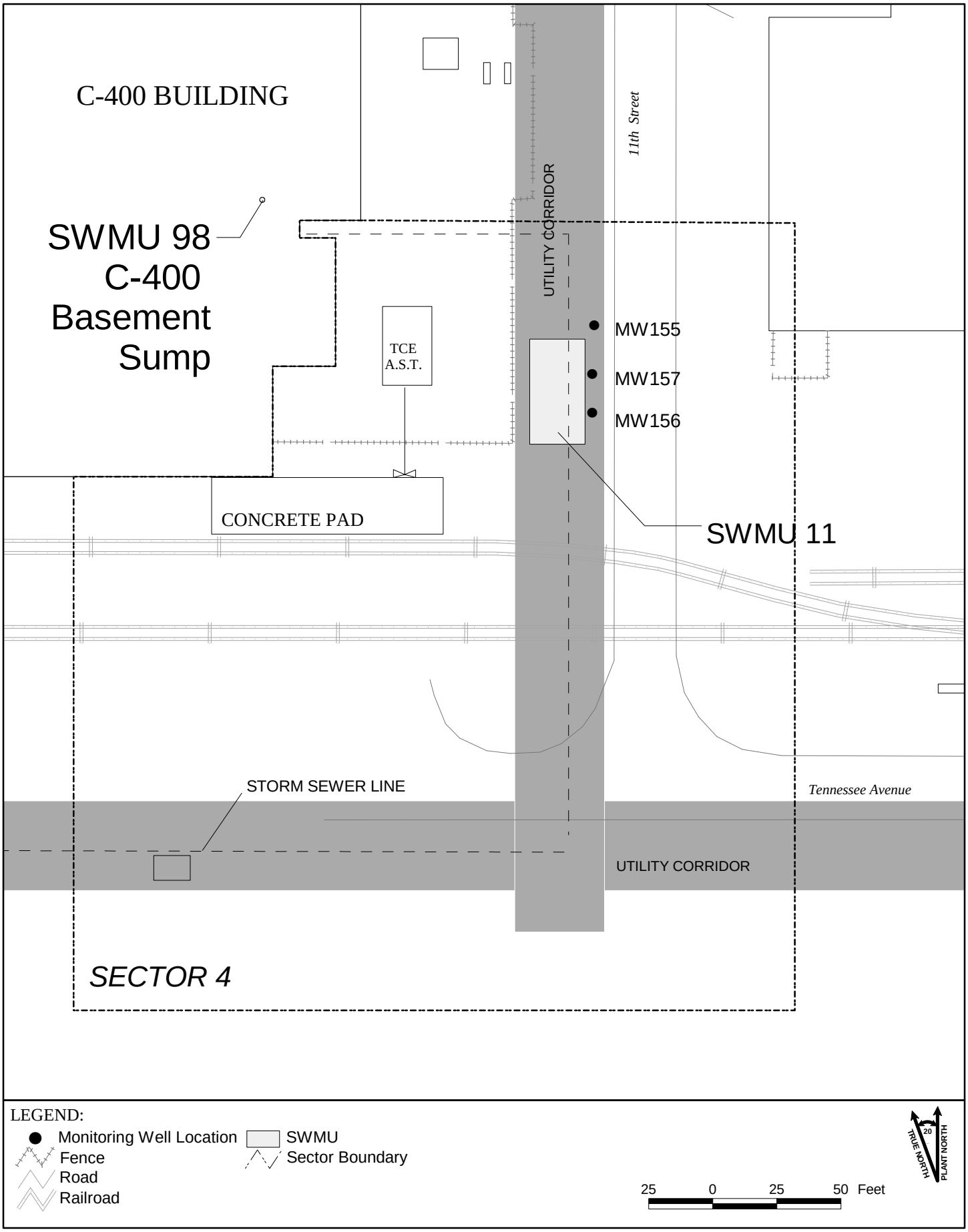


Fig. 3.8. SWMU 11 Area

was thought that the basement sump discharged to the C-403 Neutralization Pit. Although the actual duration of the leak is unknown, it is believed that TCE may have been discharged to the storm sewer from the early 1950s until the discovery of the leak in 1986.

Previous Remedial Action

An excavation along the 11th Street storm sewer in June 1986, to connect a discharge line from a truck-unloading-dock containment sump, revealed the TCE-contaminated soils. Once the leak was discovered, the DOE routed the basement sump discharge line into 208-liter (55-gal) drums and excavated an area measuring approximately 6.1 m (20 ft) wide (east to west) by 12.2 m (40 ft) long (north to south). A 3.0 m (10 ft)-wide trench, centered on the storm sewer, was dug 4.9 m (16 ft) deep to expose the storm sewer. The remainder of the excavation was 2.1 m (7 ft) deep. Analysis of soil samples collected adjacent to and below the storm sewer line revealed TCE concentrations as great as 7,000 mg/kg (ppm). Some contaminated soil is known to have been left in place because of concerns for the structural integrity of 11th Street and the TCE Tank Pad, located between the spill site and the C-400 Building. The DOE backfilled the excavation with clean soil and capped the area with a layer of clay. Approximately 8.8 m^3 (310 ft^3) of TCE-contaminated soils was drummed for off-site disposal.

Summary of previous investigations

Analyses of soil and water samples of the C-400 Trichloroethene Leak Site are derived from three separate investigations, in addition to the routine Environmental Surveillance program.

After the initial discovery of the TCE leak, the DOE had four soil borings drilled adjacent to the excavation area to better define the lateral and vertical extent of soil contamination. The samples revealed that soil contamination existed along the storm sewer, to depths of 6.7 and 8.5 m (22 and 28 ft), but not east of 11th Street.

The Phase I and Phase II SIs (1989 through 1991) included the C-400 Trichloroethene Leak Site. As part of the SIs, soil boring H007 and MW155 (basal RGA well), MW156 (upper RGA well), and MW157 (UCRS well) were installed in the SWMU 11 area. Soil samples from boring H007 contained TCE at detectable concentrations throughout the sample interval [1.2 to 28.3 m (4 to 93 ft)] bgs with the highest levels, 220 μg/kg, occurring from 16.8 to 18.3 m (55 to 60 ft) bgs. Technetium-99 was detected in the 3.0- to 4.6-m (10- to 15-ft) bgs sample at 6.6 pCi/g. No other compounds or analytes were detected in any of the samples. Dissolved TCE levels were highest in groundwater samples from the UCRS well, up to 890,000 μg/L, and declined with depth, 360,000 μg/L in the upper RGA and 2,000 μg/L in the basal RGA.

The WAG 6 RI characterized soil contamination in the immediate C-400 Trichloroethene Leak Site vicinity with nine soil borings located adjacent to the utility pipelines and sampled at the depth of the utilities, one area soil boring drilled to 7.6 m (25 ft) depth, and three other area soil borings completed to 14.6 m (48 ft) depth. The soil analyses revealed that TCE levels of 10,000 to 15,000 μg/kg were common along the utility lines and that concentrations as high as 8,208,600 μg/kg remained below the leak site at a depth of 9.8 m (32 ft) bgs.

To further characterize deeper contamination, the WAG 6 RI collected water samples of the RGA from MWs 155 and 156 and soil and water samples of the RGA and McNairy from two nearby soil borings. Dissolved TCE levels remain highest in the upper RGA beneath SWMU 11.

Sources of Data

As described in the previous section, a number of investigations have targeted the SWMU 11 area. Of these investigations, the WAG 6 RI provides the most comprehensive characterization of the area. Figure 3.9 shows the location of area boreholes, wells, and piezometers.

Geology/Hydrogeology

Where undisturbed, the shallow sediments consist of silt with clay (HU1) to a depth of 8.5 m (28 ft). In the area of the SWMU 11 excavated soils, the backfill is composed of sand overlain by 2.4 m (8 ft) of clayey silt. From 8.5 m (28 ft) to 12.5 m (41 ft) bgs, interbedded sand and gravel lenses with lesser silt and clay beds make up the HU2 member. This, in turn, is underlain by clayey silt (HU3) to a depth of 16.5 m (54 ft) bgs. Area borings have shown that the HU3 becomes very sandy locally.

Coarse sand and gravel units of the HU4 and HU5 members (RGA) occur from 16.5 m (54 ft) to 28.0 m (92 ft) bgs at the C-400 Trichloroethene Leak Site. These sediments overlie interbedded fine to medium sand and clay of the McNairy Formation.

The water table in the UCRS is approximately 11.3 m (37 ft) bgs in the SWMU 11 area. An anomaly occurs in the immediate vicinity of MW157 where the water table typically is elevated to 9.3 m (30 ft) bgs. As measured in MWs 155 and 156, the hydraulic potential of the RGA averages 15.5 m (51 ft) bgs. Thus, a vertical hydraulic gradient of approximately 1 exists across the HU3 interval over most of SWMU 11.

The strong vertical gradient across the HU3 member allows little lateral flow of shallow groundwater to occur. Once in the RGA, however, groundwater flow is predominately lateral to the northwest from SWMU 11.

Nature and Extent of Contamination

The primary contaminant associated with SWMU 11 is TCE. Trichloroethene levels of up to 8,208,600 µg/kg were detected in the soils below the backfill of the former excavation. These concentrations are indicative of the presence of DNAPL. High contaminant levels in the soils adjacent to the storm sewer to the south of the excavation area suggest DNAPL has spread in that direction through the pipeline bedding.

The WAG 6 RI discovered another area leak site associated with a former TCE unloading pump. The subsurface area impacted by these two leak sites merge to form a single large DNAPL zone off the southeast corner of the C-400 Cleaning Building with over 464.5 m^2 (5,000 ft^2) in area in the UCRS. High dissolved-phase TCE levels in the RGA to the southeast of the C-400 Building indicate DNAPL has migrated into the RGA from these UCRS source areas.

Polyaromatic hydrocarbons (PAHs) and ^{99}Tc were the only other contaminants found in SWMU 11 above the RI reference levels. There was no systematic distribution of these contaminants that suggested that SWMU 11 was the source.

Fate and Transport

The SWMU 11 area is a graveled lot with storm sewers that collect surface runoff. Therefore, the primary exposure route for contaminants to reach a receptor was modeled as the RGA. In the model, soil contaminants leach to groundwater and migrate off-site as dissolved contamination in the RGA. Both the distribution of TCE and the location of potential sources of TCE suggested at least two distinct release

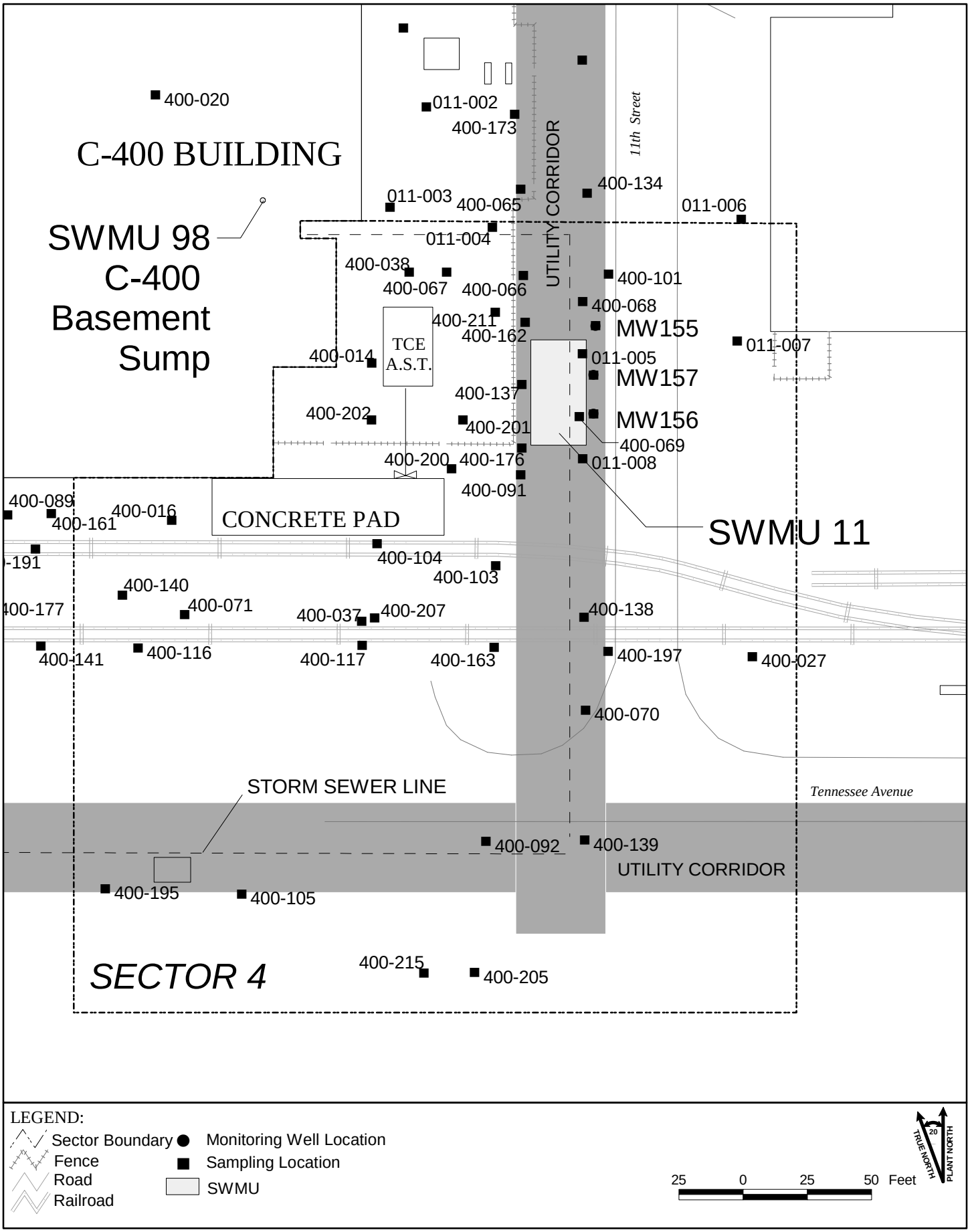


Fig. 3.9. Sampling locations in the SWMU 11 area

points in the southeast C-400 sector. In the conceptual model of the TCE sources, TCE was distributed along the entire length of the SWMU 11 storm sewer within the sector. In addition, the RI sample analyses defined a distinct TCE source associated with a TCE off-loading pump station. The modeled TCE source term for the UCRS in the southeast C-400 sector was a combined volume of both sources. A TCE degradation product, vinyl chloride, was included in the source term.

Based on the one available surface soil sample, the RI identified the PCB Aroclor-1262 and phenanthrene as contaminants in surface soils. Within the UCRS, ^{237}Np was identified as an area-wide subsurface soil contaminant, whereas ^{239}Pu was a subsurface soil contaminant only in the area of the TCE spill. Several other organic compounds and chromium were found associated with one soil boring within the UCRS DNAPL source zone. Table 3.8 summarizes the model results for the southeast C-400 sector.

Table 3.8. Fate and transport modeling results for the SWMU 11 area

	Plant fence		Property boundary	
Constituent	**Max conc. (mg/L) (pCi/L)**	**Time (year)**	**Max conc. (mg/L) (pCi/L)**	**Time (year)**
		Surface		
PCB	0.00E+00	10,000	0.00E+00	10,000
Phenanthrene	6.34E-07	7,559	4.03E-07	7,979
		Subsurface		
1,1-Dichloroethene	4.14E-03	62	2.50E-03	67
Carbon Tetrachloride	4.87E-04	386	2.94E-04	406
Phenanthrene	6.36E-06	10,280	3.89E-06	10,830
Tetrachloroethene	6.44E-04	285	3.89E-04	298
Trichloroethene	5.00E+01	105	3.17E+01	112
Vinyl Chloride	1.14E-03	54	7.27E-04	61
Chromium[a]	2.69E-53	10,000	0.00E+00	NA
^{237}Np	1.47E-06	455	9.08E-07	497
^{239}Pu	1.22E-08	10,200	7.00E-09	11,960

[a] Chromium did not reach a maximum during the model runs.

The C-400 Cleaning Building, in general, and the southeast corner of C-400, in particular, is the source of a large DNAPL zone in the RGA. This DNAPL zone is the principal source of one large dissolved-phase plume of TCE known as the Northwest Plume and a contributor to another large dissolved-phase plume of TCE known as the Northeast Plume. The Northwest Plume monitoring results, spanning 10 years, and the vast extent of the Northwest Plume suggest the Northwest Plume has been developed fully for decades. Thus, transport modeling was not required to assess levels of contaminant exposure from the RGA DNAPL zone.

3.2.3.3 SWMU 26—C-400 to C-404 Underground Transfer Line

Location

The C-400 to C-404 Underground Transfer Line is located approximately 18.3 m (60 ft) north of Virginia Avenue, between the C-400 Cleaning Building and the C-404 Radioactive Waste Burial Area. Figure 3.10 is a map showing the trace of the pipeline and other features in the vicinity of SWMU 26.

Setting

Feeder lines extend north from the C-403 Neutralization Pit (SWMU 40) and the Waste Discard Pit (SWMU 203) to join with the Transfer Line. The Transfer Line parallels Virginia Avenue for a distance

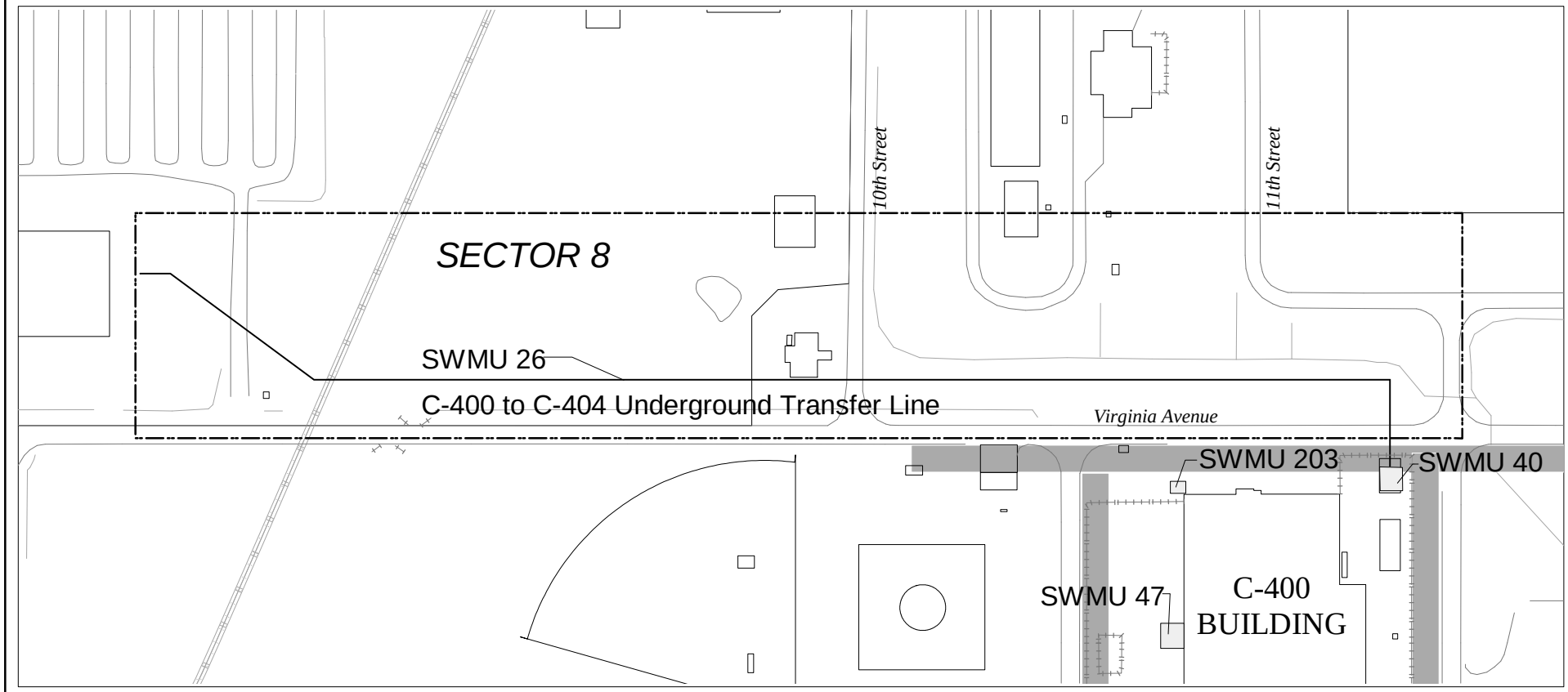


Fig. 3.10. SWMU 26 area.

of approximately 410 m (1,350 ft), at depths of 0.9 to 1.5 m (3 to 5 ft). As the Transfer Line passes under the rail spur located east of C-404, the line deviates to the northwest to meet C-404 on its east side. The DOE maintains most of the areas overlying the pipeline as nearly level, grassed plots.

Surface-water hydrology, wetlands, and floodplains. North of C-400, the Transfer Line lies adjacent to the NSDD. Flow is routed north in the NSDD, to discharge to Little Bayou Creek near the north DOE property boundary. However, west of 10th Street, the Transfer Line parallels a roadside drainage ditch of the 015 Outfall effluent ditch system. The effluent of the 015 Outfall empties into Bayou Creek on the west side of the plant. Neither of the ditches, where they are adjacent to SWMU 26, is included in wetlands or a 100-year floodplain.

Biological resources. SWMU 26 is maintained as mowed grass lots within the PGDP security-fenced area. Vegetation is limited to fescue grasses. This setting does not provide critical habitat for T&E species of plant or animal.

Soils and prime farmland. The Transfer Line is buried in Henry Silt Loam. These soils typically develop a shallow fragipan at depths of 0.5 to 1.8 m (1.5 to 6 ft). Construction and maintenance activities have disrupted the original soil profiles across most of the PGDP site, including SWMU 26. Hence, the site contains no prime farmland.

Underground utilities. The only utility of significance in the area of SWMU 26 is the Transfer Line, itself. Little is known about the construction characteristics of the Transfer Line. Available documentation of the pipe material provides conflicting information. The pipe material was reported as being 15.2-cm (6-in.) vitrified clay pipe and 10.2-cm (4-in.) iron pipe with leaded points. Excavation of a small section of the pipe in 1998 showed to pipe to be made of metal, probably iron.

Manufacturing/TSD Processes

Between 1952 and 1957, the Transfer Line conveyed liquid effluent from the C-403 Neutralization Pit (SWMU 40) and Waste Discard Sump (SWMU 203) to the C-404 Radioactive Waste Burial Area. Blueprints document the location of feeder lines that extend north from the C-400 Building to the Transfer Line. Pumps in the C-403 Neutralization Pit and the Waste Discard Sump pressurized the system during discharge periods.

With the development of treatment facilities within the C-400 Building, the Transfer Line was abandoned in 1957. At that time, effluent from the C-403 Neutralization Pit and the Waste Discard Sump was allowed to discharge to the NSDD. No spills or releases associated with the Transfer Line have been documented or are known.

Summary of Previous Investigations

The Phase II SI (1990 through 1991) sampled shallow soils at six locations in the vicinity of the Transfer Line. The soil analyses revealed the presence of pentachlorophenol and several metals above reference values. Prior to the WAG 6 RI, the only data available for assessment of the historical pipeline contents were samples from the C-403 Neutralization Pit and the Waste Discard Sump. These analyses suggested that TCE, PCBs, and radionuclides also may be chemicals of concern.

To assess the Transfer Line, the WAG 6 RI sampled surface soils and subsurface soils immediately below the pipeline in 15 locations. In addition, samples of the sludge remaining in the pipeline were collected from a break in the east end of the line where the previous C-403 feeder line crossed the NSDD. Figure 3.11 maps the sample locations related to SWMU 26.

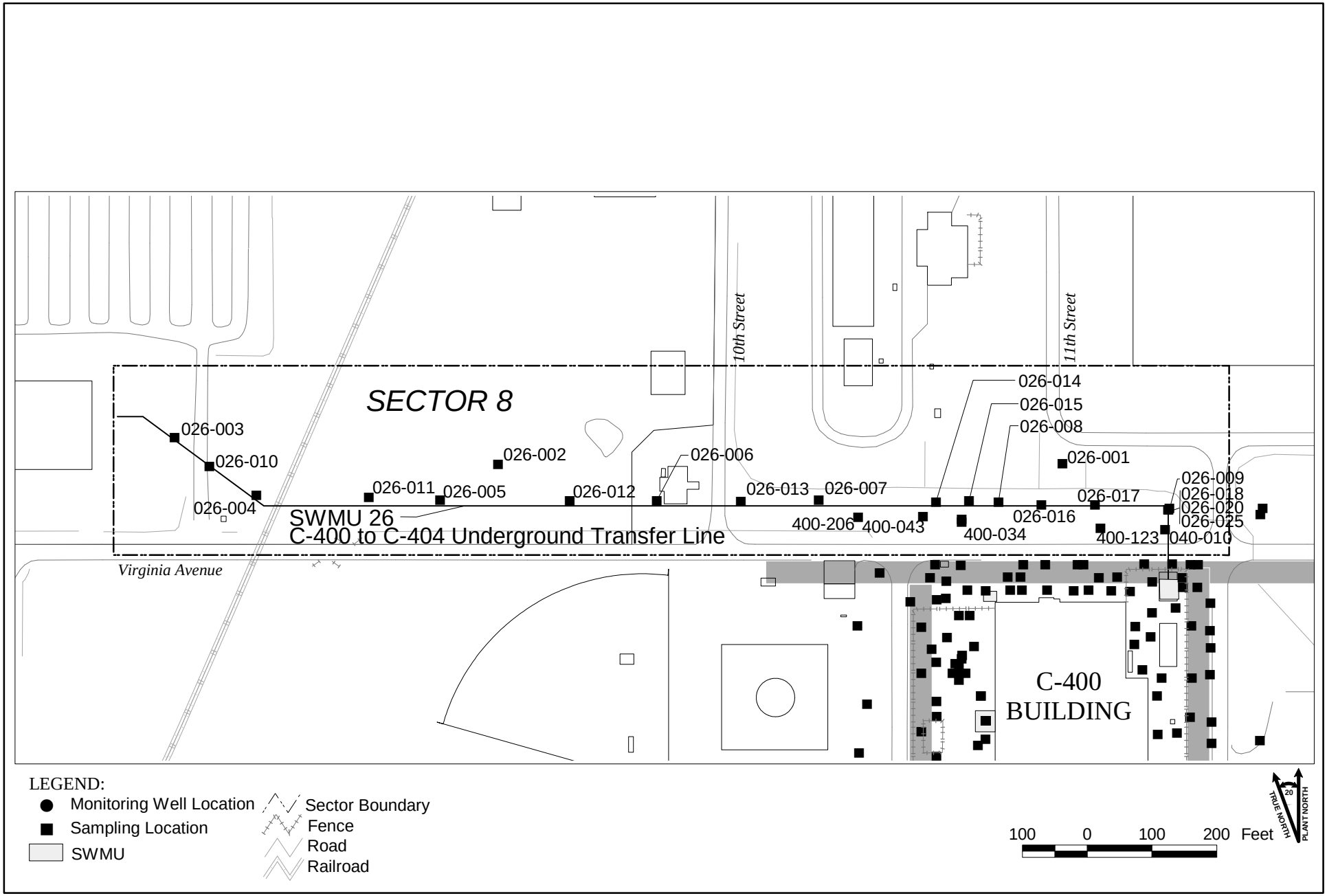


Fig. 3.11. Sample locations in the SWMU 26 area.

The sample results identify the east end break in the pipeline to be an impacted area. Metals and radionuclides with elevated levels in the soils collected directly beneath the pipeline match the contents of the pipe sludge. PCBs were also found in the subsurface soil samples from the east end break. Both elevated radionuclide levels and VOCs were found in soil samples taken from along the far west end of the Transfer Line. These contaminants may be related either to the pipeline or to the C-404 Radioactive Waste Burial Area. The only indication of potential leakage along the main length of the pipeline was low levels of VOCs and SVOCs in the subsurface soils.

Sources of Data

The Phase II SI and WAG 6 RI afford the only contaminant characterization data for area soils as well as the best description of the SWMU 26 geology/hydrogeology setting. Figure 3.11 is a map of area sample locations.

Geology/Hydrogeology

Clayey silt loess deposits (HU1) underlie SWMU 26 to a depth of 5.5 to 8.2 m (18 to 27 ft) bgs. Overall, the HU2 interval is relatively uniform in thickness (6.1 m/20 ft) and depth [over the interval of 6.1 to 12.2 m (20 to 40 ft)] bgs. The HU2 sediments are composed predominately of gravel and sand lenses with minor silt and clay interbeds. In contrast, the HU3 interval thickness varies significantly [1.5 to 6.4 m (5 to 21 ft)], depending upon the elevation of the underlying HU4 horizon. Silty clay and silty sand make up the HU3 sediments.

The HU4 and HU5 sediments beneath the Transfer Line uniformly grade downward from a silty sand in the HU4 interval to sandy gravel and gravely sand in the HU5 interval. These coarse-grained deposits overlie the McNairy Formation with its typical interbeds of sandy silt, clayey silt, and fine sand.

The depth-to-water of the UCRS water table varies significantly across the length of the Transfer Line. On the north end of the C-400 Building, depth-to-water ranges typically between 9.1 and 12.2 m (30 and 40 ft). A steep rise in the water table occurs immediately west of the C-400 Building, reflecting a more effective HU3 barrier to vertical flow. The depth of the water table west of C-400 is approximately 3.7 m (12 ft).

Vertical gradients across the UCRS in the vicinity of SWMU 26 typically range between 1 and 2. Thus, there exists a significant vertical (downward) component of flow in the UCRS. Once in the RGA, groundwater flow is predominately lateral. The orientation of groundwater contaminant plumes indicates that RGA groundwater flow bifurcates beneath the C-400 Cleaning Building. On the east end of the Transfer Line, groundwater flow is eastward, while flow from the northwest corner of the C-400 Building is to the northwest. Near the C-404 Radioactive Waste Burial Area, groundwater flow in the RGA is predominately west.

Nature and Extent of Contamination

In general, area surface soils near the C-400 Building were found to be contaminated with trace levels of semivolatile organic analytes (SVOAs) and four radionuclides. These contaminants appeared to be unrelated to a release from the Transfer Line. Subsurface soil samples taken along the pipeline commonly contained low levels of toluene (up to 320 µg/kg), TCE (maximum of 34 µg/kg), and *cis*-1,2-dichloroethene (*cis*, 1-2,-DCE) (as much as 15 µg/kg), as well as several radionuclides that only slightly exceeded the RI reference levels. The two detections of PCBs, 32 mg/kg PCB-1254 and 63 mg/kg PCB-1260, were from pipeline subsurface soils.

The uranium isotopes ^{234}U (7 pCi/g) and ^{238}U (53.2 pCi/g) were found in soils from the western end of the pipeline. A break on the eastern end of the pipeline is also a site of elevated soil contaminants. The subsurface soil contaminants copper (390 µg/kg), nickel (467 µg/kg), ^{99}Tc (265 pCi/g), ^{234}U (28.2 pCi/g), and ^{238}U (36.5 pCi/g) from the east end soils match contaminants found in the pipeline sludge.

Fate and Transport

The primary sources of contamination for the C-400 to C-404 Underground Transfer Line were modeled as subsurface releases. Contaminants have infiltrated the soil surrounding the line. The contaminants in soil have impacted the groundwater via further infiltration and percolation and are migrating off-site through the RGA. Fate and transport modeling of the Transfer Line for the WAG 6 RI simulated three source zones: an east end source associated with the break in the pipeline, the central main trunkline, and the west end of the pipeline adjacent to the C-404 Radioactive Waste Burial Area. Table 3.9 presents a summary of the model results for the SWMU 26 area.

Table 3.9. Fate and transport modeling results for the SWMU 26 area

	Plant fence		Property boundary	
Constituent	**Max conc. (mg/l) (pCi/L)**	**Time (year)**	**Max conc. (mg/L) (pCi/L)**	**Time (year)**
		Surface		
Phenanthrene	9.92E-06	7,560	7.29E-06	7,980
^{237}Np	2.16E-07	320	1.50E-07	359
^{239}Pu	3.40E-09	10,200	2.30E-09	11,800
^{99}Tc	9.24E-07	2,090	6.61E-07	2,340
^{238}U	1.03E-07	5,160	7.37E-08	5,950
		Subsurface		
2,4-Dinitrotoluene	1.07E-01	47	3.73E-02	50
Phenanthrene	5.40E-05	10,500	3.63E-05	10,800
Chromium[a]	1.59E-26	10,000	0.00E+00	NA
Copper	4.00E-01	9,505	2.56E-01	11,100
Nickel	1.25E-02	9,814	8.41E-03	10,840
^{241}Am	2.97E-21	13,500	3.21E-24	14,900
^{137}Cs	0.00E+00	10,000	0.00E+00	10,000
^{237}Np	9.41E-05	455	5.82E-05	497
^{239}Pu	5.67E-07	10,200	3.46E-07	11,960
^{99}Tc	1.14E-03	2,213	7.48E-04	2,463
^{230}Th	3.99E-50	10,000	0.00E+00	10,000
^{234}U	4.90E-05	5,162	3.48E-05	5,953
^{235}U	2.04E-06	5,163	1.32E-06	5,951
^{238}U	9.37E-05	5,163	6.67E-05	5,951

[a] Chromium did not reach a maximum during the model runs.

3.2.3.4 3.2.3.4 SWMU 40—C-403 Neutralization Pit

Location

The C-403 Neutralization Pit is located off the northeast corner of the C-400 Cleaning Building, at the intersection of 11th Street and Virginia Avenue. MWs 177 and 178 are positioned on the south side of the tank. Figure 3.12 shows the location of SWMU 40.

Setting

SWMU 40 consists of a 7.6-m (25-ft) square by 7.9-m (26-ft) deep, in-ground open-top tank constructed of concrete and lined with two layers of acid brick. A Hypalon awning stretched over a

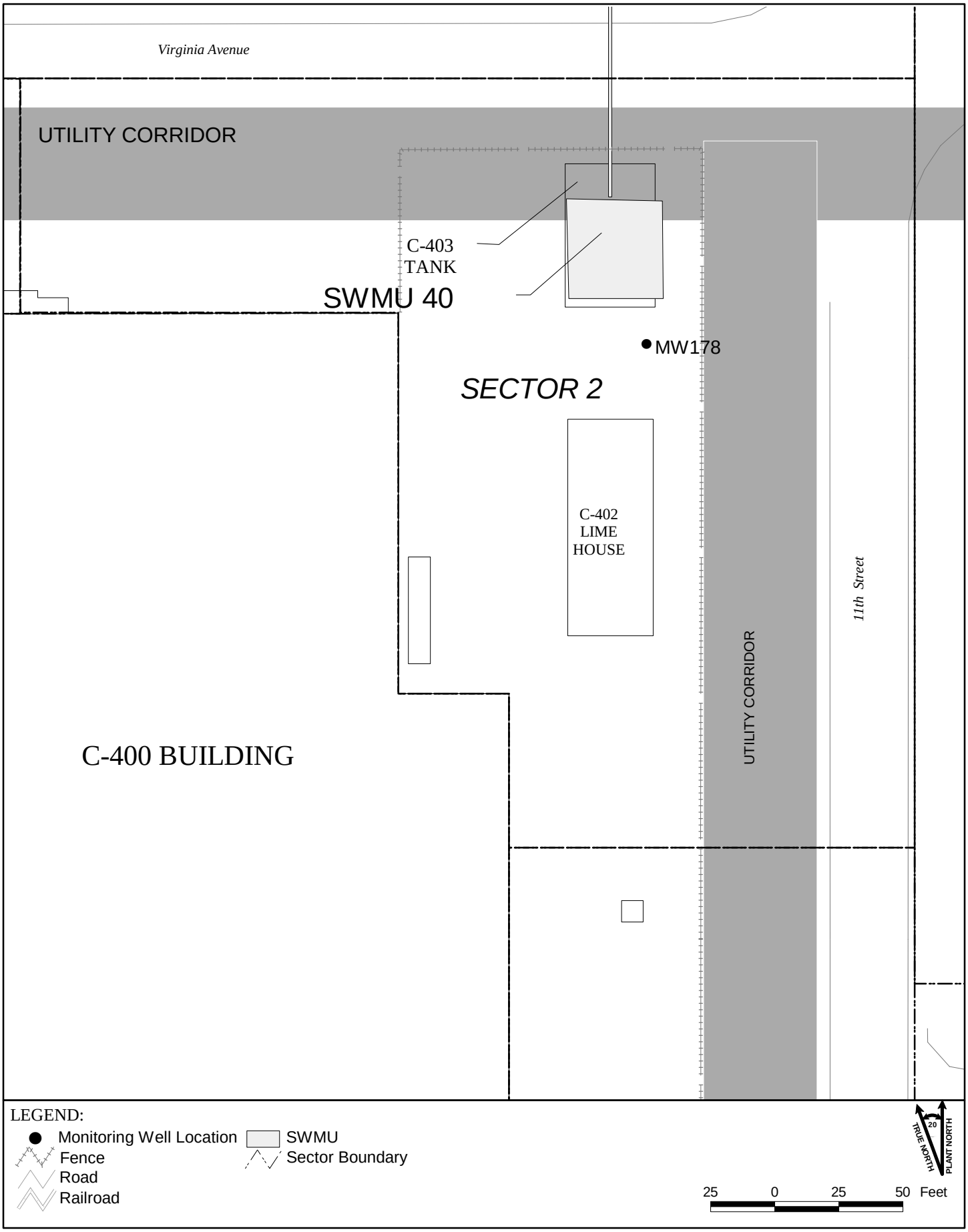


Fig. 3.12. SWMU 40 area

wooden frame prevents the accumulation of rainwater in the tank. The area surrounding SWMU 40 is a level lot, paved with concrete on three sides and covered in gravel on the south side.

Surface-water hydrology, wetlands, and floodplains. Runoff from SWMU 40 collects in the 11th Street storm sewer and is routed through the storm sewer network to the Outfall 008 effluent ditch. Outfall 008 discharges into Bayou Creek on the west side of the plant. There are no streams, wetlands, or 100-year floodplain area within SWMU 40. The eastern end of the NSDD is located across Virginia Avenue from SWMU 40 but receives no contribution from the C-403 area.

Biological resources. The C-403 Neutralization Pit is located in a heavy industrial setting, surrounded by concrete pavement or gravel cover. There is no significant vegetation in the immediate vicinity. Threatened or endangered species do not rely on this area for critical habitat.

Soils and prime farmland. The original undisturbed soils of the SWMU 40 area were Calloway series silt loams with a shallow fragipan. Construction activities have significantly disrupted the original soil structure. Gravel or concrete pavement now cover the area. There is no prime farmland present at SWMU 40.

Underground utilities. Underground influent and effluent lines connect to the C-403 Neutralization Pit from all four sides. A duriron acid waste line from the C-400 Cleaning Building joins with C-403 on the west side. The C-402 Lime House amendments to C-403 entered through a cast iron pipeline on the south side. Effluent from C-403 passed through a discharge line on the north side of the tank. A recent excavation of the north end of this pipeline revealed it to be constructed of iron. A vitreous clay pipe connection, via a storm sewer, with the C-410-B HF Neutralization Lagoon joins with C-403 on the east side.

Buried sanitary water and return cooling water pipelines pass east–west against the north end of the C-403 Neutralization Pit. A buried north–south electrical line lies near the west side of the tank.

Manufacturing/TSD Processes

The C-403 Neutralization Pit was used for the storage and treatment (i.e., neutralization) of acidic uranium-bearing waste solutions generated during cleaning operations in Building C-400. The operation of the C-403 Neutralization Tank may have been limited to the period between 1952 and 1957, although effluents from the C-400 Cleaning Building were discharged to the C-403 Neutralization Pit until 1990. These discharges included UF_6 cylinder hydrostatic-test water, overflow, and runoff from cleaning tanks, discharge from floor drains, and other unknown sources.

A lime slurry was added to the wastewater from the C-402 Lime House to raise the pH and precipitate out the uranium in the form of a low-level radioactive sludge. Once the pH was raised to the proper level (10 to 12 standard units), the effluent was discharged to the C-404 Radioactive Waste Burial Area (previously a holding pond) where the sludge was allowed to settle out of the solution. In 1957, treatment equipment installed in C-400 allowed the building effluent to be discharged to the NSDD, where it flowed to the Little Bayou Creek. In the late 1970s, the flow from the NSDD was routed into the C-616-F Full Flow Lagoon, and direct discharge to Little Bayou Creek subsequently was discontinued. Drawings for C-403 document a 38.1-cm (15-in.) vitreous-clay pipe was installed between the C-403 Neutralization Pit and the C-410-B HF Neutralization Lagoon, using part of an existing stormwater line. The intended purpose of this line is unknown. The C-410-B HF Neutralization Lagoon was used for the treatment of hydrogen fluoride cell electrolyte.

Summary of Previous Investigations

The Phase II SI (1991 and 1992) installed two monitoring wells south of C-403. MW177 was screened in the UCRS and MW178 was screened in the upper RGA. As part of the characterization of the site, five composite soil samples were collected from the 4.3- to 13.4-m (14- to 44-ft) depth range and water samples were collected from the wells. No contamination was detected in the soil samples. However, elevated TCE and ^{99}Tc levels were discovered in the water samples from both wells.

The DOE conducted a RCRA characterization of the C-403 Neutralization Pit contents in 1993. Water and sediment samples revealed the presence of elevated levels of TCE, PCBs, and uranium in the tank.

The WAG 6 RI characterized soil contamination from the adjacent utility and influent and effluent lines with five soil borings, and from the in-ground tank with three deeper soil borings. In addition, possible surface soil contamination was investigated by three samples located to the west of C-403. The soil analyses revealed the presence of elevated radionuclides and metals (i.e., silver and antimony), but limited to the backfill around the tank and along the storm sewer connection to the C-410-B HF Neutralization Lagoon.

Contingency samples of soil and water were collected from the tank backfill using six soil borings to specifically investigate the backfill as a source of elevated radiological activity and TCE to water that had collected in the tank during the RI. Elevated levels of both alpha and beta activity were detected in the samples of backfill material. However, TCE was not detected in the soil samples.

Sources of Data

The WAG 6 RI provides the primary data available to characterize SWMU 40. In addition to the previously described investigations, the DOE's environmental surveillance program contributes groundwater analyses for MWs 177 and 178. Figure 3.13 shows the location of sample points for the SWMU 40 area.

Geology/Hydrogeology

The HU1 interval in the C-403 area is primarily composed of a loess-derived silt to depths of approximately 5.5 m (18 ft). However, thick clay lenses locally underlie the silt deposit, deepening the HU1 interval to 7.4 m (24 ft). It appears that the C-403 Neutralization Pit completely penetrates the HU1 horizon. In many borehole locations adjacent to the tank, gravel backfill is encountered to 4.9 to 5.5 m (16 to 18 ft) bgs.

The local character of the HU2 member is highly variable, composed of thin interbeds of sand and gravel with silt and clay. However, the HU3 appears to be a uniform, 4.6-m (15-ft) thick clay. The RGA is dominated by gravel and sandy gravel units. Only 1.5 m (5 ft) of sand defines the HU4 horizon. Interbedded fine-to-medium grained sands and clays make up the upper McNairy Formation.

UCRS water levels are highly variable. Depth of water in the HU2 horizon ranges from near negligible to approximately 2.4 m (8 ft) over a distance of 21.6 m (71 ft). This variation reflects the heterogeneity of the HU2 sediments and the strong downward vertical gradients typical of the UCRS, but may also attest to enhanced recharge around the C-403 Neutralization Pit. As determined by a TCE plume that passes beneath SWMU 40, area groundwater flow in the RGA is typically eastward.

Nature and Extent of Contamination

The 1993 RCRA characterization of contained water and sediments determined the presence of TCE, PCBs, and uranium. Dissolved contaminant levels ranged up to 1,300 μg/L TCE, 110 μg/L PCBs, and

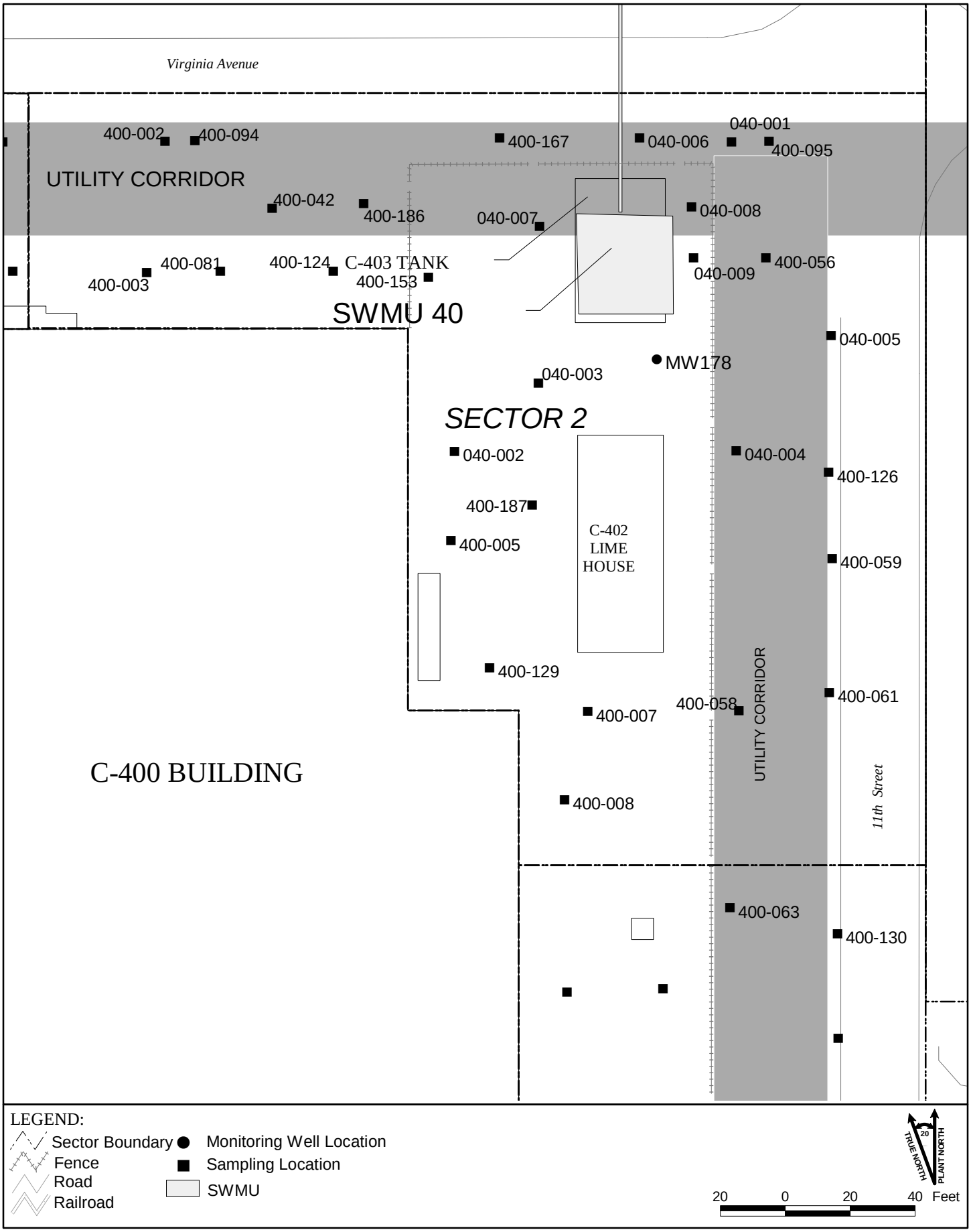


Fig. 3.13. Sample locations in the SWMU 40 area

1.075 pCi/L uranium. Contaminant levels in the sediments were as high as 6,700 µg/kg TCE, 17.6 mg/kg PCBs, and 1.073 pCi/g uranium.

The WAG 6 RI samples of the backfill around the tank revealed the presence of elevated levels of alpha (62.2 pCi/g) and beta activity (243 pCi/g) in the gravel fill material but no TCE. Several radionuclides were discovered in a soil sample of an adjacent borehole collected from below the depth of the tank. Uranium-238 activity, at 13.4 pCi/g, was highest among the isotopes detected. Apparently, the soil contamination is limited to the immediate vicinity of the tank and the former storm sewer. The Phase II SI soil samples from the nearby MW178 borehole did not contain any detectable levels of contaminants. However, soil samples near the storm sewer connector line [at approximately 4.6 m (15 ft) bgs] contained silver and antimony at 4.28 and 4.7 mg/kg, respectively, and up to 20.2 pCi/g ^{238}U.

The WAG 6 water samples collected from the tank backfill contained up to 2,340 pCi/L beta activity and 400 µg/L TCE. Water samples from UCRS MW177 and RGA MW178 were collected during the Phase II SI. The ^{99}Tc activities of the two water samples, 1,200 and 1,735 pCi/L, respectively, were the highest levels reported for groundwater during the SIs.

Fate and Transport

The probable release mechanism identified by the WAG 6 RI for the C-403 Neutralization Pit was a subsurface leak from the tank or from the storm sewer connection to the C-410-B HF Neutralization Lagoon. Contaminants have infiltrated the soil surrounding the tank and line. The fate and transport model for SWMU 40 assessed the potential for contaminants to reach a point of exposure through the RGA. Soil contaminants were modeled to leach to groundwater and migrate off-site as dissolved contamination in the RGA.

The WAG 6 investigation detected contamination from several sources in the vicinity of the C-403 Neutralization Pit that were unrelated to the tank processes. The fate and transport model collectively assessed the area contamination. Table 3.10 reports the model results for contaminants detected in the SWMU 40 area.

Table 3.10. Fate and transport modeling results for the SWMU 40 area

	Plant fence		Property boundary	
Constituent	**Max conc. (mg/L) (pCi/L)**	**Time (year)**	**Max conc. (mg/L) (pCi/L)**	**Time (year)**
		Surface		
Phenanthrene	4.68E-06	7,560	3.00E-06	7,980
^{238}U	7.22E-08	5,160	4.51E-08	5,950
		Subsurface		
N-Nitroso-di-propylamine	2.17E-02	24	1.37E-02	27
Phenanthrene	8.62E-06	7,810	5.41E-06	8,450
Chromium[a]	2.56E-53	10,000	0.00E+00	NA
Thallium	8.45E-04	31	4.94E-04	37
^{234}U	9.61E-07	6,460	6.08E-07	7,580
^{235}U	3.41E-08	6,640	2.16E-08	7,580
^{238}U	6.62E-06	7,380	4.28E-06	8,050

[a] Chromium did not reach a maximum during the model runs.

Previous Remedial Actions

At the time of the 1993 RCRA characterization of the C-403 Neutralization Pit water and sediments, 295,230 l (78,000 gal) of water were contained in the tank along with a limited amount of sediment [<0.3 m (<1 ft)]. A new Hypalon plastic cover was placed over the top of the tank to prevent additional rainwater from entering the tank. This new cover replaced a cover installed in 1990. The inlet pipe from the C-410-B Neutralization Lagoon also was plugged to prevent additional stormwater runoff from entering C-403. The DOE pumped the contents from the tank and shipped the wastewater to the TSCA incinerator in Oak Ridge, Tennessee, for treatment.

3.2.3.5 SWMU 47—C-400 Technetium Storage Tank Area

Location

The C-400 Technetium Storage Tank Area consists of a former tank site outside of the C-400 Building on the west side of the building. Figure 3.14 is a map of the SWMU 47 area.

Setting

A 3-m (10-ft) wide concrete pad and soil berm, measuring approximately 6.1 m (20 ft) on the west side and 7.6 m (25 ft) on the north and south sides, marks the site of the Technetium Storage Tank. The bermed area is located against the west wall of the C-400 Building in a graveled yard.

Surface-water hydrology, wetlands, and floodplains. No streams are found in the vicinity of SWMU 47. Rainwater runoff accumulates in ditches on the east side of 10th Street, which, in turn, drains to the Outfall 008 stormwater sewer system. There are no wetlands or 100-year floodplain areas near the Technetium Storage Tank Area.

Biological resources. Little vegetation can be found in the graveled lot containing the Technetium Storage Tank Area. It is an industrial setting which does not provide critical habitat for threatened or endangered species of plants and animals.

Soils and prime farmland. Soils of both the Calloway series silt loams and the Henry Silt Loam were found in the Technetium Storage Tank Area prior to construction of the PGDP. Construction and maintenance activities have heavily disturbed the soils. No prime farmland exists near SWMU 47.

Underground utilities. The only utility to directly underlie the C-400 Technetium Storage Tank is a drain line that originally collected the effluent of the west-side floor drains and routed the wastes to the C-400 Waste Discard Sump (SWMU 203). A buried north–south utility corridor, consisting of a sanitary sewer line and return cooling water lines, passes to the west of the bermed area.

Manufacturing/TSD Processes

SWMU 47 contained a 15,000 liter (4,000 gal) tank that was used in the early 1960s to store waste solutions containing ^{99}Tc and chromium. The tank was located in an asphalt-paved, bermed area. Drain lines from C-400 Building processes were connected directly to the tank. There are no documented spills or releases from the tank.

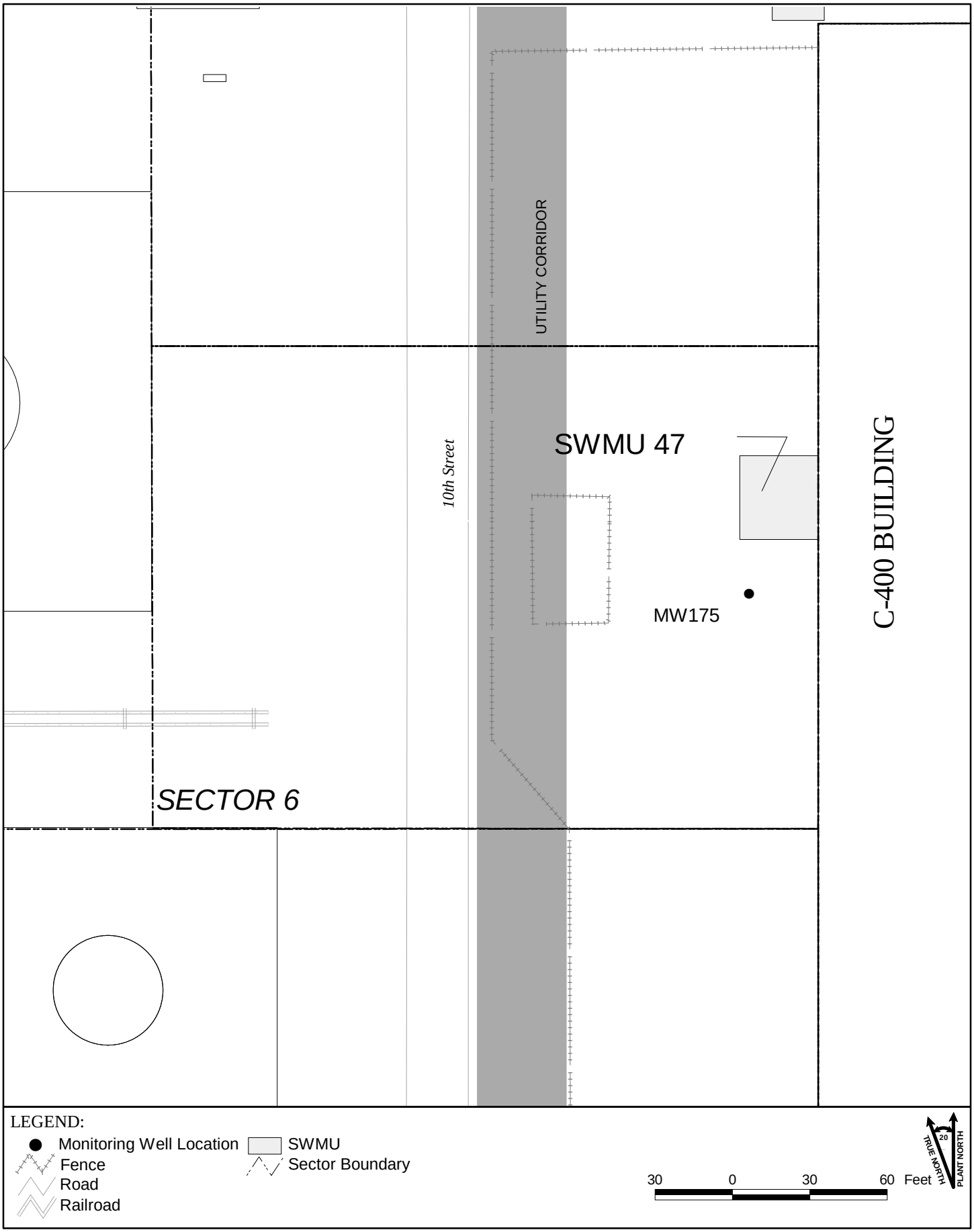


Fig. 3.14. SWMU 47 area

Previous Remedial Actions

The Technetium Storage Tank was removed in December 1986 and placed in an on-site mixed waste storage facility. At the time of removal, the tank contained approximately 750 liters (200 gal) of aqueous waste and 1,500 liters (400 gal) of sludge. The sludge had elevated levels of chromium and the radionuclides ^{237}Np, ^{239}Pu, ^{99}Tc, ^{230}Th, and the uranium isotopes.

Summary of Previous Investigations

In December 1986, 13 concrete samples were collected from the concrete pad and 16 soil samples were collected from the area surrounding the tank pad. The samples were collected over a uniform grid covering an area of 4.3 m by 4.3 m (14 ft by 14 ft). Elevated levels of chromium and uranium were detected in both media.

Subsurface characterization data for SWMU 47 are derived from the Phase II SI and the WAG 6 RI. The Phase II SI installed two monitoring wells on the south side of the bermed area, MW175 (screened in the upper RGA) and MW176 (screened in the UCRS). Soil samples collected from the well boreholes contained TCE, chromium, and ^{99}Tc above reference levels. Elevated levels of dissolved ^{99}Tc and TCE were present in RGA water samples from MW175. In addition, the Phase II SI sampled one shallow soil boring in the vicinity of the Technetium Storage Tank Area. The maximum radionuclide activities for soil samples collected during the SI were reported from this boring.

The WAG 6 RI of the Technetium Storage Tank Area included the collection of seven surface soil samples from within the berm area, sampling subsurface soils in one borehole to a depth of 14.3 m (47 ft), and installation of a UCRS piezometer. Elevated levels of TCE, PAHs, and radionuclides were associated with the site.

Sources of Data

As previously discussed, several sources of data are available for the characterization of SWMU 47. Figure 3.15 presents the location of area boreholes, wells, and piezometers.

Geology/Hydrogeology

In the Technetium Storage Tank Area, clayey silt makes up the uppermost sediments, the HU1 member, to a depth of 6.1 m (20 ft). This, in turn, is underlain by a 6.1-m (20-ft) thick interval of sand and gravel units separated by thin silty clay layers that constitute the HU2 horizon. A 3-m (10-ft) thick interval of several clay beds with variable sand content, the HU3 member, forms the base of the UCRS.

Locally, the RGA interval (both the HU4 and the HU5 horizons) is comprised of several coarse sediment packages that form an overall fining upward sequence. The contact of the basal sandy gravel member of the RGA and the underlying clays of the McNairy Formation occurs at a depth of 26.8 m (88 ft).

The HU1 and HU2 intervals of the Technetium Storage Tank Area and most of the west C-400 block are unsaturated. Groundwater flows northward in the RGA.

Nature and Extent of Contamination

The immediate vicinity of the Technetium Storage Tank berm is contaminated with radionuclides, SVOAs, and PCBs. All surface soil samples from the berm area contained elevated levels of some

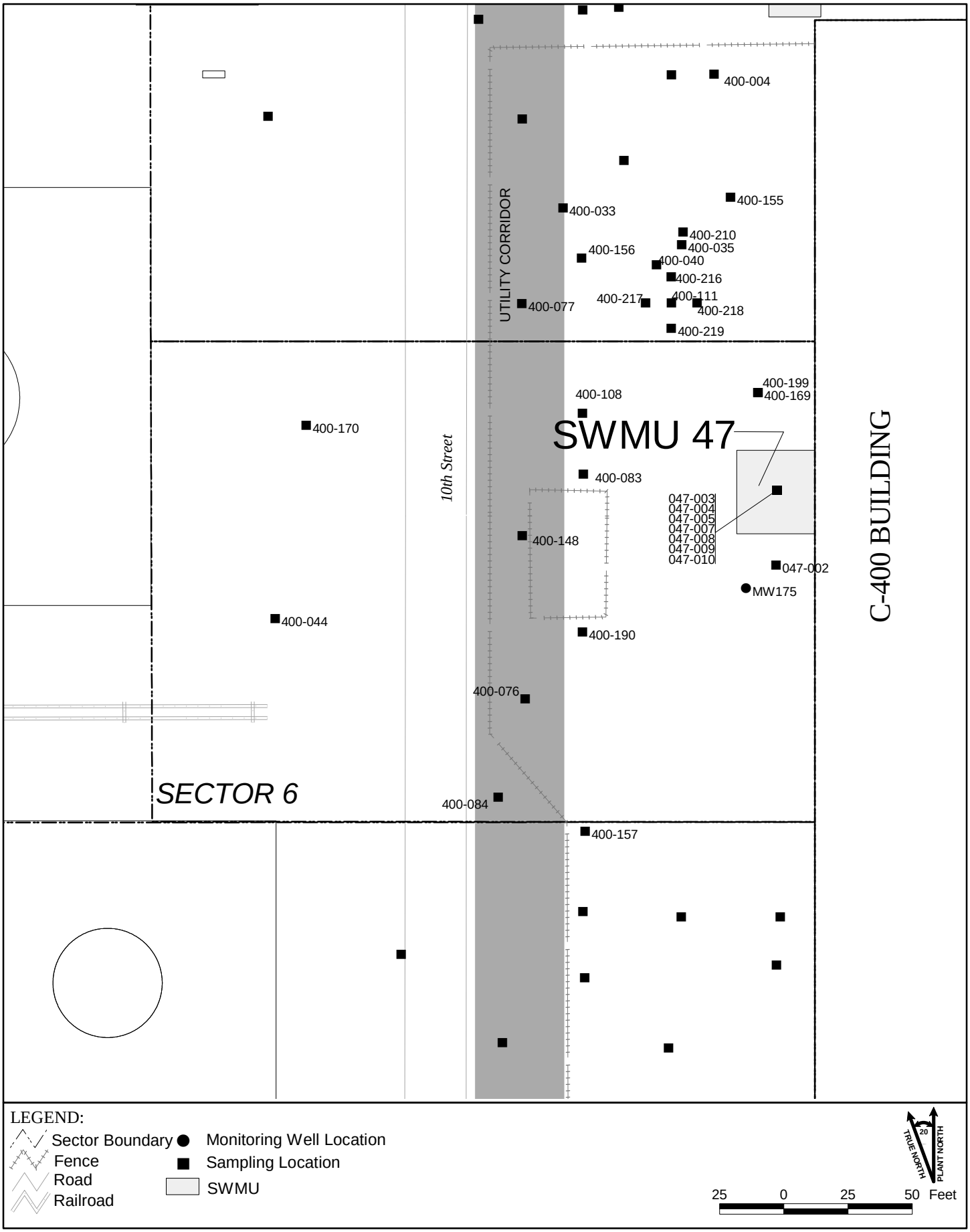


Fig. 3.15. Sample locations in the SWMU 47 area

radionuclides. A total of nine radioisotopes were identified from the area surface soil samples with activities exceeding background levels, including ^{99}Tc (maximum of 53 pCi/g), ^{234}U (maximum of 31.1 pCi/g), ^{235}U (maximum of 1.9 pCi/g), and ^{238}U (maximum of 39.5 pCi/g).

The WAG 6 RI identified 15 PAH compounds and 1 phenol compound from the berm-area surface soil samples. Chrysene, fluoranthene, phenanthrene, and pyrene were commonly detected SVOAs. Contamination by these compounds is typical of areas that were previously paved with asphalt.

The PCB Aroclor-1254 was identified in surface soil only, in two samples from the berm area. Contamination levels were 77 and 960 µg/kg.

Radionuclide and SVOA levels decreased significantly with depth. The uranium isotopes ^{234}U (at 41.7 pCi/g) and ^{238}U (at 42.8 pCi/g) were the most significant subsurface contaminants in the 0.3 to 1.4 m (1 to 4.5 ft) sample. Most of these contaminants were less than the RI reference levels in the samples collected below 1.4 m (4.5 ft). However, volatile organic contaminants appeared in samples collected at 2.6 m (8.5 ft) and persisted throughout the depth of area subsurface soil samples [9.0 m (29.5 ft)]. The primary volatile organic contaminants were TCE (maximum of 1,700 µg/kg), *cis*-1,2-DCE (maximum of 82 µg/kg), *trans*-1,2-DCE (maximum of 2,500 µg/kg), and 2-propanol (maximum of 220 µg/kg).

Fate and Transport

The shallow sources of contamination for the Technetium Storage Tank Area were modeled as surface releases and spills from the tank and transfer lines. In the model, the deeper volatile organic contaminants were associated with the drain line feeding the C-400 Waste Discard Sump (SWMU 203). Contaminants released from these sources have infiltrated the surface and subsurface soils and contaminated the groundwater. The model simulated the migration of contaminants to an off-site receptor via groundwater flow in the RGA. Table 3.11 summarizes the model results.

3.2.3.6 SWMU 203—C-400 Waste Discard Sump

Location

The C-400 Waste Discard Sump is an in-ground collection tank with sump found outside the northwest corner of the C-400 Cleaning Building. Figure 3.16 shows the location of SWMU 203.

Setting

SWMU 203 is a concrete pit measuring 1.8 m (6 ft) wide by 3.4 m (11 ft) long and 1.8 m (6 ft) deep. A 1.2-m (4-ft) diameter by 1.4-m (4.5-ft) deep sump is located in the pit floor. The pit is located in a gently sloping gravel lot. The east side of the pit lies close to the concrete apron driveway/storage yard outside the north end of the C-400 building.

Surface-water hydrology, wetlands, and floodplains. The gravel lot around the Waste Discard Sump is contoured to direct runoff to drainage ditches on the east side of 10th Street. These ditches empty into the 008 storm sewer system. Rainfall on the north C-400 concrete apron flows across Virginia Avenue either into the 015 drainage ditch system or into the NSDD. The 008 and 015 drainage systems, and the NSDD (via a transfer line to the 001 Outfall system), discharge to Bayou Creek on the west side of the plant. There are no streams, wetlands, or 100-year floodplain areas within the SWMU 203 area.

Table 3.11. Fate and transport modeling results for the SWMU 47 area

	Plant fence		Property boundary	
Constituent	**Max conc. (mg/L) (pCi/L)**	**Time (year)**	**Max Conc. (mg/L) (pCi/L)**	**Time (year)**
		Surface		
2-Methylnaphthalene	1.27E-06	2,390	7.90E-07	2,530
Dibenz(a,h)anthracene	0.00E+00	10,000	0.00E+00	10,000
^{241}Am	1.54E-24	13,500	1.80E-27	14,900
^{137}Cs	0.00E+00	10,000	0.00E+00	10,000
^{237}Np	2.26E-09	320	1.34E-09	359
^{99}Tc	1.81E-08	2,090	1.10E-08	2,340
^{230}Th	0.00E+00	10,000	0.00E+00	10,000
^{234}U	4.32E-09	5,160	2.61E-09	5,950
^{235}U	2.67E-10	5,160	1.63E-10	5,950
^{238}U	5.54E-09	5,160	3.37E-09	5,950
		Subsurface		
1,2-Dichloroethene	7.64E-02	21	4.78E-02	23
Trichloroethene	9.58E-03	105	6.03E-03	112
^{241}Am	4.51E-22	13,500	4.65E-25	14,900
^{237}Np	8.79E-09	378	5.41E-09	438
^{99}Tc	2.24E-11	2,090	1.36E-08	2,340
^{230}Th	2.62E-50	10,000	0.00E+00	10,000
^{234}U	4.55E-08	5,410	2.74E-08	6,190
^{235}U	2.43E-09	5,410	1.47E-09	6,190
^{238}U	5.54E-09	5,160	3.37E-09	5,950

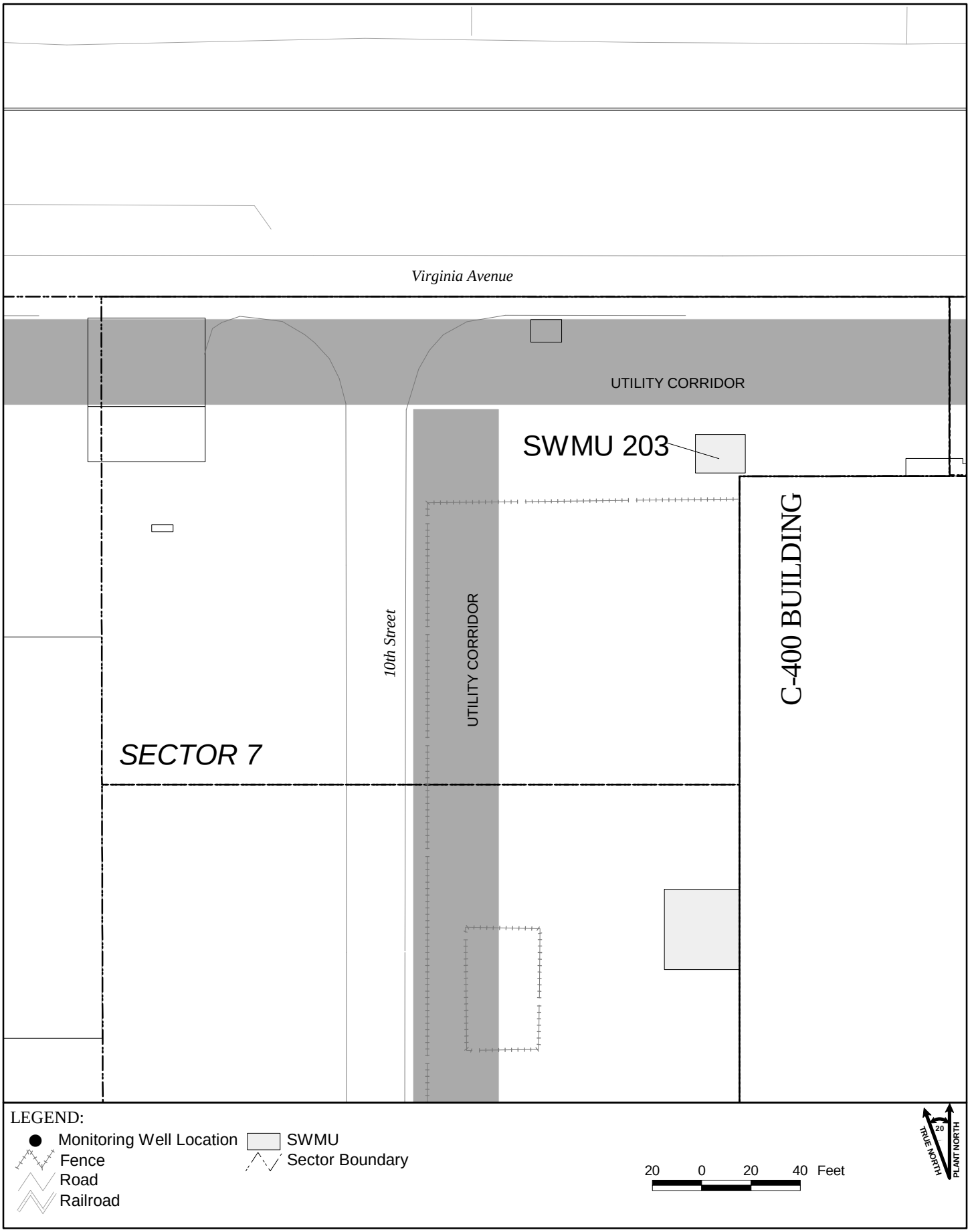


Fig. 3.16. SWMU 203 area

Biological resources. The Waste Discard Sump lies adjacent to a high-traffic area on the north side of the C-400 Building and is maintained to minimize vegetation. This setting does not provide critical habitat for T&E species of plant or animal.

Soils and prime farmland. Both Calloway series silt loams and Henry Silt Loam occur in the vicinity of the Waste Discard Sump. Pavement or gravel overlies all soils in the area. There is no prime farmland at the site.

Underground utilities. The original influent and effluent lines to the Waste Discard Sump are sections of buried vitreous clay pipe on the north and south ends of the pit. Flow from the Waste Discard Sump now is routed through a drain in the pit sump to the NSDD via a storm sewer line. Buried utility corridors pass 4.6 m (15 ft) to the north of the pit and 12.2 m (40 ft) to the west of the pit.

Manufacturing/TSD Processes

The Waste Discard Sump is a convergence point for effluent from the C-400 Cleaning Building (primarily from the west side). C-400 process wastes emptied to the Waste Discard Sump via a floor drain system to a buried vitreous clay pipeline located on the west side of the building.

Prior to 1957, a sump-mounted pump discharged effluent to the C-400 to C-404 Underground Transfer Line. Primary sources of water to the sump included treated effluent from the dissolvers and the spray booth pit sump. Beginning in 1957, additional wastewater treatment processes were added to C-400 and many of the former discharges were discontinued. The Waste Discard Sump was connected to a storm drain system and allowed to discharge by gravity feed to the NSDD.

The sump continues to collect effluent from a high pressure waterjet system in the C-400 Spray Booth and a vacuum pump on the C-400 Lime Precipitation Unit. No contaminants are expected from the current waste streams.

Previous Remedial Action

The DOE collected samples to characterize the sump sludge and adjacent surface soil in late 1994 and early 1995. The analyses revealed that the sludge was contaminated with TCE, PCBs, and several radionuclides.

Approximately 15.2 cm (6 in.) of sludge covered the base of the sump in June 1995 when the DOE performed a removal action. A total of 28 drums of sludge and water were purged from the sump.

Summary of Previous Investigations

The WAG 6 RI characterized the immediate vicinity of the Waste Discard Sump with four soil borings. Samples were collected from surface and near-surface soils through the top of the HU3 clays at a depth of 13.9 m (45.4 ft) bgs, including samples taken from near the effluent lines leading to the NSDD and the former C-400-to-C-404 Underground Transfer Line. The soil analyses revealed surface soil contamination by PAHs, the metals antimony and mercury, and the radionuclides ^{99}Tc and ^{238}U. A soil sample from near the base of the sump was contaminated with TCE and ^{99}Tc.

Sources of Data

The 1994/1995 characterization analyses and the WAG 6 RI are the only sources of data for the C-400 Waste Discard Sump. Figure 3.17 is a map of area sample locations.

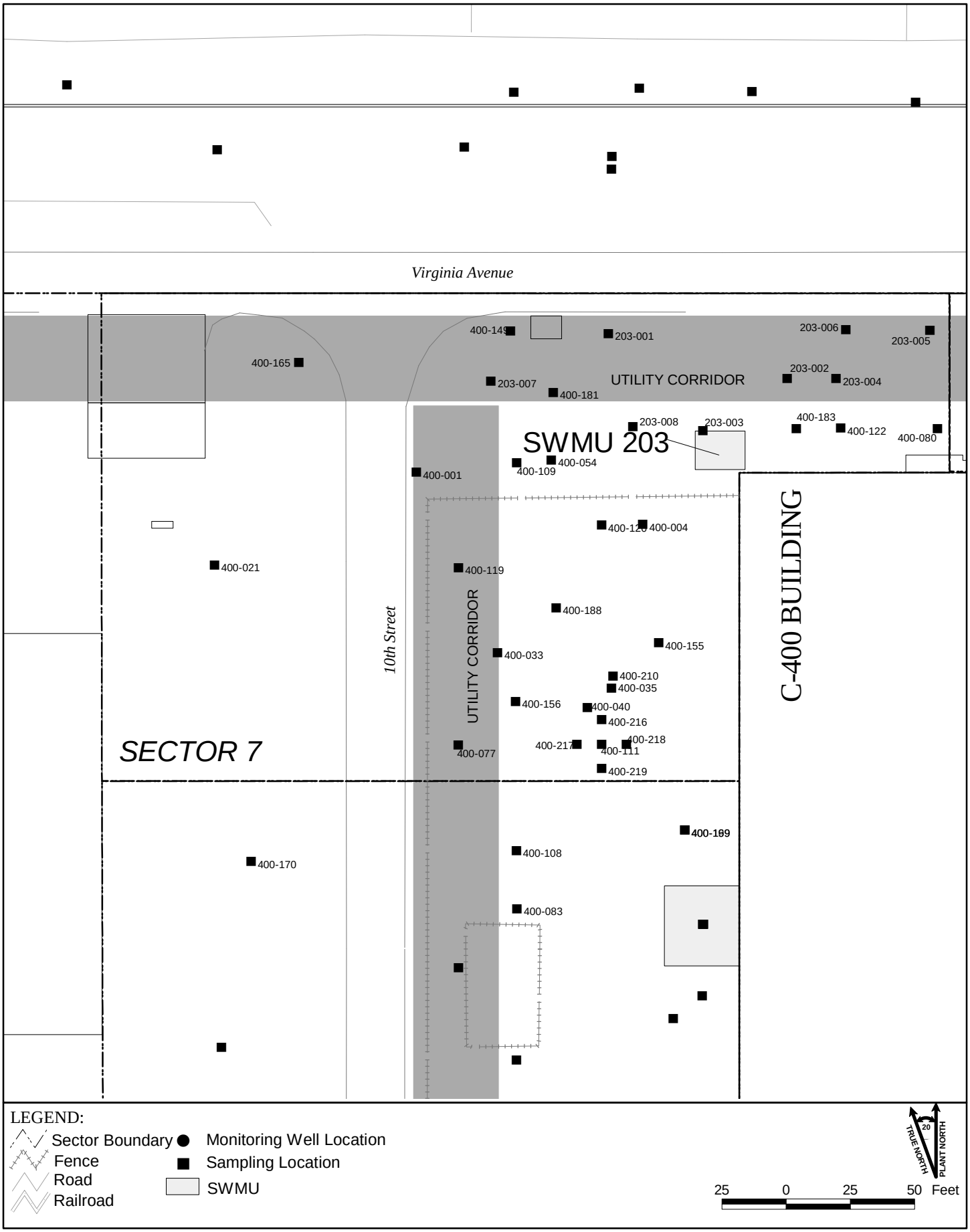


Fig. 3.17. Sample locations in the SWMU 203 area

Geology/Hydrogeology

At the Waste Discard Sump, loess-derived silt of the HU1 member extends to a depth of 6.7 m (22 ft). The texture of the underlying HU2 interval grades from interbedded silt, sand and gravel units northeast of the sump to a stack of gravely sand lenses to the southwest. These rest upon a clay HU3 member at a depth of 13.7 m (45 ft) bgs. Deeper area borings show the thickness of the HU3 to range from 1.0 to 5.0 m (3.5 to 16.5 ft).

Where the HU3 interval is thin, the RGA consists of an upper sand member (HU4) and a basal sandy gravel member (HU5). The HU4 member is absent where the HU3 interval is thickest. In both settings, the base of the RGA is at approximately 25.9 m (85 ft). The underlying McNairy Formation sediments consist primarily of thick clay and clayey sand members interbedded with some sand units.

A UCRS water table occurs approximately 11 m (36 ft) bgs in the vicinity of the Waste Discard Sump. As is typical of the WAG 6 area, a strong, downward vertical gradient prevails across the HU3 member. Thus, lateral flow distances in the UCRS are limited. Groundwater flow in the RGA is to the northwest.

Nature and Extent of Contamination

There was no widely distributed surface soil contamination that was associated with the Waste Discard Sump. Mercury and several radionuclides, notably ^{99}Tc (at 43.3 pCi/g) and ^{238}U (at 14.8 pCi/g), contaminated surface soil adjacent to the sump. Isolated occurrences of PAHs and an elevated antimony level were detected from surface soil samples in more remote locations.

The 1994/1995 characterization data identified TCE, PCBs, and several radionuclides as contaminants in the sludge of the Waste Discard Pit. (The dissolved TCE levels were near the saturation limit of TCE.) Soil samples collected from below the base of the sump contained elevated levels of TCE (maximum of 4,500 μg/kg) and ^{99}Tc (maximum of 3.1 pCi/g).

Fate and Transport

The most likely route of contamination for the Waste Discard Sump is a release or spill from the influent or effluent lines or overflow of the pit. Contaminants would have impacted surface and subsurface soil. The Fate and Transport modeling for SWMU 203 assumed the soils were leaching to groundwater and migrating downward to the RGA. Groundwater flow in the RGA then carried the dissolved contaminants off-site where exposure was possible. Table 3.12 presents the results of modeling for the Waste Discard Sump, as well as other potential contaminant sources in the northwest C-400 area.

3.2.3.7 The C-400 Building

Location

The C-400 block is located near the center of the industrial section of the PGDP, bound by 10th and 11th Streets to the west and east, respectively, and Virginia and Tennessee Avenues to the north and south, respectively. Figure 3.18 shows the location of the C-400 Building.

Setting

In general, the C-400 Cleaning Building rests on a 0.4-m- (16-in.-) thick concrete floor designed with four main pits/sumps and an east-side basement area. The east-side basement includes degreasing units, chemical cleaning tanks, and a plenum and fan room system to ventilate the building.

Table 3.12. Fate and transport modeling results for the SWMU 203 area

Constituent	Plant fence		Property boundary	
	Max conc. (mg/L) (pCi/L)	Time (year)	Max conc. (mg/L) (pCi/L)	Time (year)
		Surface		
Chromium	0.00E+00	10,000	0.00E+00	10,000
^{238}U	5.65E-08	5,160	3.57E-08	5,950
		Subsurface		
Trichloroethene	3.84E-03	84	2.10E-03	96
Antimony	5.73E-03	707	3.58E-03	824
Mercury	0.00E+00	NA	0.00E+00	NA
^{241}Am	2.85E-22	13,500	2.91E-25	14,900
^{237}Np	9.07E-07	397	5.69E-07	458
^{99}Tc	5.35E-06	2,090	3.37E-06	2,460
^{230}Th	0.00E+00	10,000	0.00E+00	10,000
^{234}U	3.91E-07	6,640	2.55E-07	7,350
^{235}U	3.33E-09	5,160	2.01E-09	5,950
^{238}U	5.80E-07	6,640	3.79E-07	7,350

Floor drains originally found throughout the building emptied into interior and exterior building sumps or directly to storm sewer lines. Sumps for wastewater treatment and/or disposal are located northeast (SWMU 40) and northwest (SWMU 203) of the C-400 Building. Many buried utilities service C-400 and/or pass under the block.

Drawings and construction photographs indicate the building floor overlies approximately 3.0 m (10 ft) of gravel backfill.

Surface-water hydrology, wetlands, and floodplains. The 008 storm sewer system collects most of the runoff from the C-400 block and passes the water to Bayou Creek on the west side of the plant. Ditches are located on the east and west sides of the block, adjacent to 10th and 11th Streets to funnel runoff to the storm sewer grates. The most significant surface-water feature in the vicinity of the C-400 block is the NSDD, which is located across from (north of) Virginia Avenue from the C-400 Building. Originally, the NSDD served as a main effluent channel for C-400 processes. Currently, the C-400 Building discharges little wastewater to the NSDD.

The C-400 area is designed to promote rapid runoff of stormwater. There are no streams, wetlands, or floodplains within the C-400 block.

Biological resources. Virtually all land surrounding the C-400 Building is paved or covered in gravel. There is little vegetation within the C-400 block. Moreover, the C-400 Building is a heavy industrial setting with continuous operation. The area is used sparingly by area wildlife and does not provide critical habitat for T&E species of plant or animal.

Soils and prime farmland. Construction and maintenance activities within the C-400 block have significantly disrupted the original soil structure. Moreover, practically all available area around the C-400 Building is covered by either pavement or gravel. There is no prime farmland within the C-400 block.

Underground utilities. Buried utilities that service the C-400 Cleaning Building include storm and sanitary sewer lines, sanitary water lines, return cooling water lines, and electrical ducts. Buried utilities are found beneath all sides of the C-400 block to a depth of approximately 4.6 m (15 ft).

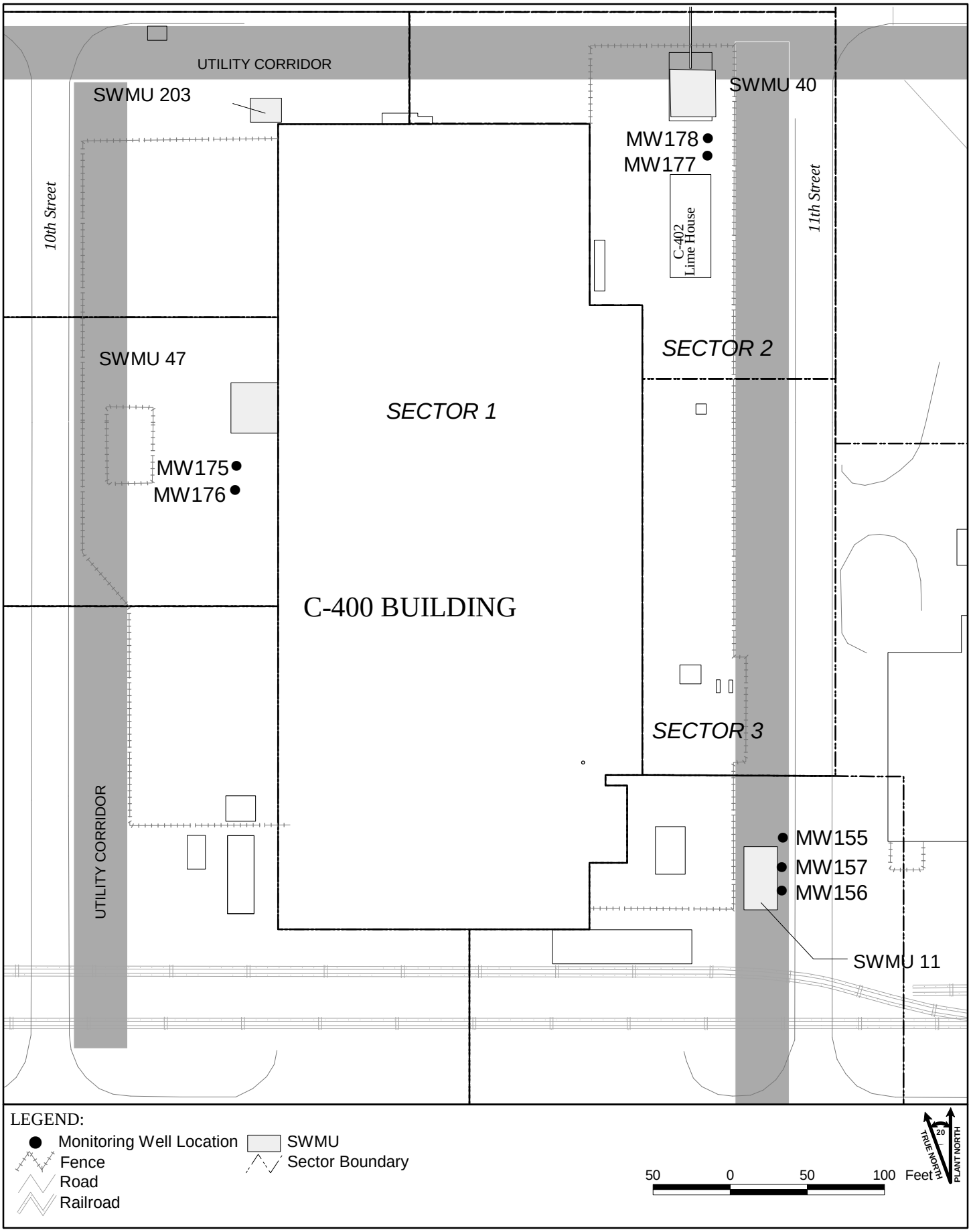


Fig. 3.18. C-400 area

Manufacturing/TSD Processes

Cleaning (clothes laundry and machinery parts), disassembly of cascade components, and testing of cascade components are the primary activities for which the C-400 Building was designed to support. The building has also housed many other activities, including recovery of precious metals and enrichment of radionuclides.

Suspected sources of leaks and spills at C-400 that have contaminated area soil and groundwater include: (1) degreaser and cleaning tank pits, (2) drains and sewers, (3) the east side plenum/fan room basement, (4) tanks and sumps outside the building, and (5) various first floor C-400 processes. These sources have resulted in contamination of soil and groundwater by volatile organic analytes (VOAs) (primarily TCE), SVOAs, and various metals and radionuclides.

Summary of Previous Investigations

Several SWMUs within the C-400 block have been previously investigated. These investigations have been summarized in the preceding text. The most significant sources of characterization data for the C-400 block, in general, come from the Phase I and Phase II SIs and the WAG 6 RI.

Over both phases of the SI, five deep soil borings were completed around the C-400 Building. These borings resulted in 65 soil samples, from the land's surface through the base of the RGA. In addition, the SI installed three wells screened in the UCRS, three wells screened in the upper RGA, and one well screened at the base of the RGA.

The subsequent WAG 6 RI included characterization of known SWMUs and a C-400 Site Evaluation. This Site Evaluation assessed the occurrence of undocumented releases and established whether the numerous buried utilities associated with the C-400 Building were conduits for the migration of contaminants.

The RI divided the WAG 6 SWMUs and C-400 block into nine sectors to organize the evaluation of the data. Of the nine sectors, five contained a SWMU that was specifically addressed as part of the WAG 6 RI. The C-400 Building occupied an entire sector and contained several SWMUs that, due to continuing operations, could not be thoroughly evaluated during the WAG 6 RI. Table 3.13 summarizes the areas included in each sector.

Table 3.13. The WAG 6 RI sectors

Sectors	SWMU	PGDP facility number	Description	Location within the C-400 block
1	None	C-400	Cleaning Building	Central
2	40	C-403	Neutralization Tank Area	Northeast
3	None	N/A	Area Between SWMU 11 and SWMU 40	East
4	11	C-400	Trichloroethene Leak Site	Southeast
5	None	N/A	Area Between SWMU 11 and SWMU 47	Southwest
6	47	C-400	Technetium Storage Tank Area	West
7	203	C-400	C-400 Waste Discard System Sump	Northwest
8	26	C-401	C-400 to C-404 Transfer Line	Outside
9	None	N/A	Open Area Northeast of C-400 Building	Outside

The WAG 6 RI collected 48 surface soil samples, 496 subsurface soil samples, and 223 borehole groundwater grab samples. These samples represented the UCRS, RGA, and upper McNairy Formation. The WAG 6 RI also installed 18 piezometers in the UCRS and 3 wells in the RGA around the C-400 Building.

Sources of Data

In addition to the PGDP SI and WAG 6 RI, previous characterization sampling of individual SWMUs, as previously summarized, and routine sampling of area monitoring wells for DOE's environmental monitoring program provide valuable data for the assessment of the C-400 area. Figure 3.19 shows the location of soil and groundwater sample points within the C-400 block.

Geology/Hydrogeology

Details of the geologic and hydrologic settings around the C-400 Building are summarized in previous sections. In general, the upper 6.1 m (20 ft) of sediments in the C-400 block area were originally a homogenous loess-derived silt. Construction and maintenance excavations have significantly compromised the ability of this silt unit to retard the downward migration of contamination. Utility lines, which in some cases are sources of the contamination or migration pathways, were routinely installed to depths of approximately 4.6 m (15 ft). The C-400 Building contains an east-side basement and several sumps that required the excavation and placement of backfill to depths of approximately 3.0 m (10 ft). Moreover, the waste collection pits on the north side of the C-400 Building extend to significant depths.

The HU2 horizon is a heterogeneous assemblage of sand, gravel, and silt lenses beneath C-400. However, the cumulative thickness remains approximately 6.1 m (20 ft) across the block. In general, the bottom 2 m (6 ft) of the HU2 sediments are saturated on the east and north sides of the C-400 block. The HU2 interval is unsaturated on the west and southwest areas of the C-400 block. Lateral hydraulic gradients within the UCRS beneath the C-400 block during the WAG 6 RI ranged between 1.8×10^{-2} and 5.6×10^{-2}.

An HU3 horizon of finer-textured sediments occurs across the site. However, the thickness of the silts and clays varies significantly. At all locations where lower UCRS and RGA hydraulic potential measurements can be compared, the vertical hydraulic gradient across the HU3 interval is downward and approximately 1.

The RGA beneath C-400 consists of a thick river deposit of sand and gravel resting upon the McNairy Formation at a depth of approximately 25.9 m (85 ft). Overall, the RGA sediments comprise a fining-upward sequence with HU4 sands overlying HU5 sandy gravel and gravel units. Thick deposits of much finer-textured sediments occur locally. The slight gradients and significant heterogeneities of the RGA make it difficult to interpret local groundwater flow directions. However, RGA contaminant plumes determine that groundwater flow is generally northward and diverges strongly to the east and northwest at the north end of the C-400 block. This divergence appears to be due, at least in part, to a significant source of leakage from one of the plant utilities located north of the C-400 Building.

Deep boreholes were completed to depths of 15 m (50 ft) within the upper McNairy Formation around the C-400 Building. Sand occurs in the upper McNairy cores but the predominant sediment textures are silt and clay.

Nature and Extent of Contamination

The WAG 6 RI confirmed that SWMU 11 was the site of a TCE DNAPL zone. In addition, the C-400 Site Evaluation discovered an adjacent TCE leak site, where a transfer pump was previously located, and a TCE DNAPL zone which had spread along utility lines at the southwest corner of the C-400 Building. Contaminant levels (up to 11,055,000 µg/kg in a shallow soil sample) indicate that the transfer pump leak site was the most significant of the TCE source zones, with DNAPL migrating from this source to the south along a buried sanitary sewer line and then downward into the RGA. Dissolved-phase TCE levels from the southeast corner of the C-400 block ranged up to 438,324 µg/L in a UCRS water sample and up

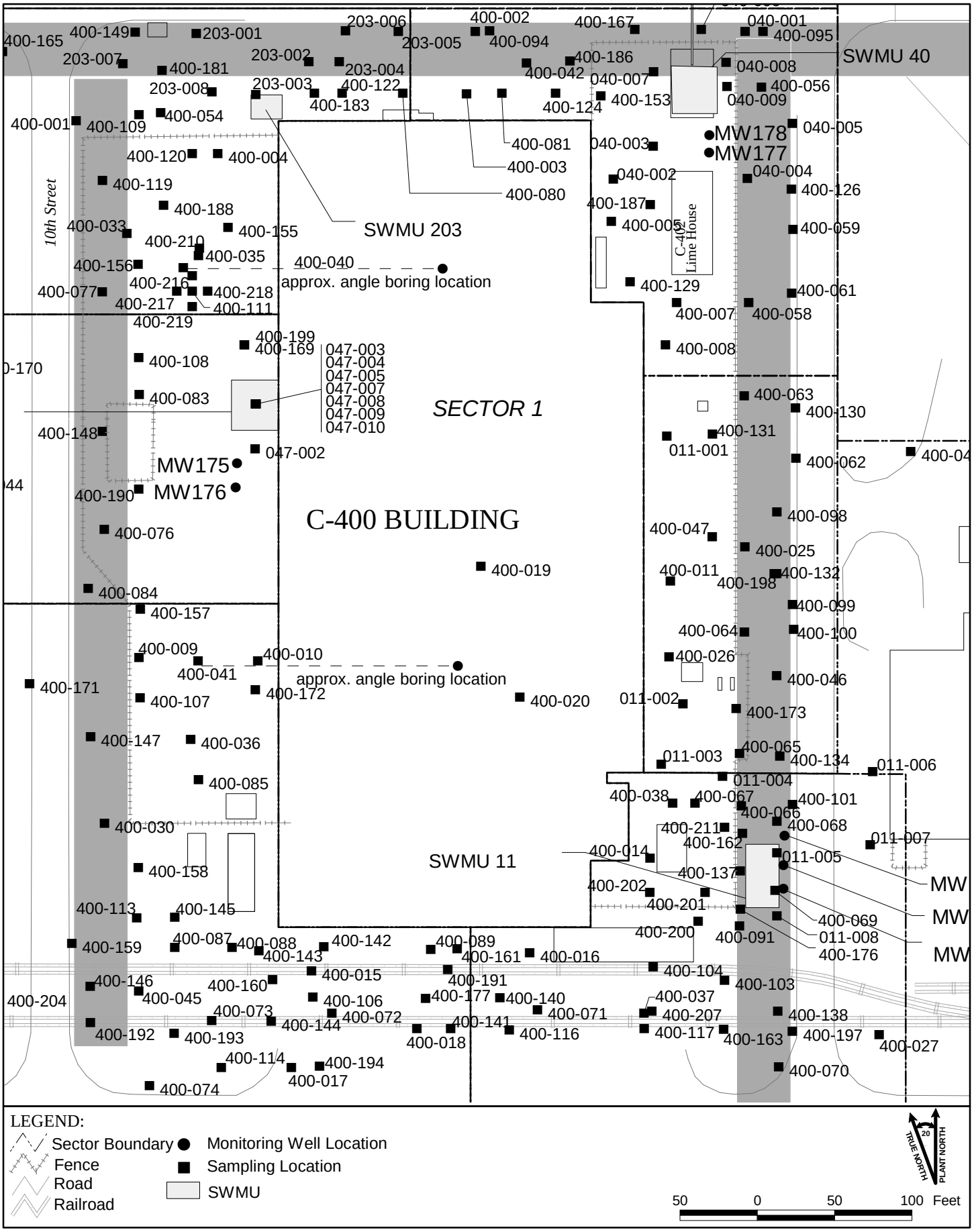


Fig. 3.19. Location of soil and groundwater samples in the vicinity of C-400

to 701,184 μg/L in a RGA water sample. A marked decrease in dissolved TCE levels in the upper McNairy Formation below the RGA DNAPL zone indicates the DNAPL has not penetrated into the McNairy. The RI samples also showed that the high ^{99}Tc activity observed in the Northwest Plume does not originate from the southeast C-400 DNAPL sources.

As previously suspected, the dissolved-phase TCE plume in the RGA was shown to migrate from the southeast corner of the C-400 building to the northwest, beneath the northwest corner of the C-400 block. WAG 6 RI samples also confirmed the existence of a TCE and ^{99}Tc plume migrating to the east from the northeast corner of the C-400 Building.

Elevated ^{99}Tc activity (up to 33 pCi/g) was observed in several surface soil and shallow subsurface soil samples from the WAG 6 SWMUs. However, samples with high ^{99}Tc activity were not identified from the deeper UCRS soil samples. The RI concluded that the likely ^{99}Tc sources were the NSDD and the C-403 Neutralization Pit.

The WAG 6 RI identified several other contaminants within the C-400 Block. Surface soil contamination by PAHs, and low levels of radionuclides (above the RI reference levels), and PCBs were common. In general, the locations of surface soil contamination by PAHs and PCBs were isolated. Subsurface soils contaminated by PAHs or PCBs were rare. Higher activities of radionulides, particularly ^{230}Th (up to 4.2 pCi/g), ^{234}U (up to 10.9 pCi/g), and ^{238}U (up to 16.7 pCi/g), were occasionally detected. The analyses of subsurface soil samples demonstrate that radionuclide activities decline with depth to background levels within the UCRS.

Antimony (up to 7.5 mg/kg) and arsenic (up to 25.8 mg/kg) were among the most common metal contaminants to occur at levels significantly above background levels in soils. A point source of these metals was not obvious. Beryllium concentrations were elevated (0.7 to 1.2 mg/kg) in many samples of soils from the west side of the C-400 Building. The WAG 6 RI also detected isolated occurrences of cobalt, lead, silver, and thallium at elevated levels.

Within the RGA, TCE is the most common contaminant. Only small quantities of a few SVOA compounds were detected. Phenol (up to 40 μg/L) was the most common of the SVOAs. Of the metals, only nickel appeared as a contaminant with a systematic distribution. The five detections of dissolved nickel concentrations above background grouped on the northwest side of the C-400 Building. Among the radionuclides, ^{99}Tc (detected at levels up to 17,000 pCi/L) appears to be the only significant contaminant in the RGA that is associated with the C-400 Building. The WAG 6 RI analyses reported 20 other isotopes that were detected at least once at levels above background.

TCE concentrations were equal to or less than 5 μg/L in all water samples taken 15 m (50 ft) deep within the McNairy Formation. The maximum ^{99}Tc level observed in McNairy water samples was 1.82 pCi/L. Similar to the RGA, analyses of McNairy water samples indicated the presence of 19 radioisotopes with levels above screening criteria.

Fate and Transport

The WAG 6 RI modeled contaminant transport for each of the C-400 block sectors and SWMU 26. Many of the results are reported in previous sections. Tables 3.14 and 3.15 present a summary of the maximum derived contaminant levels at the model points of exposure (the PGDP security fence and the DOE property boundary).

Table 3.14. Maximum exposure levels of WAG 6 contaminants—UCRS sources

Constituent	C-400 block sector	Plant fence		Property boundary	
		Max conc. (mg/L) (pCi/L)	Time (year)	Max conc. (mg/L) (pCi/L)	Time (year)
		Surface Soils			
2-Methylnaphthalene	West	1.27E-06	2,390	7.90E-07	2,530
Acenaphthylene	Southwest	2.66E-04	1,336	1.71E-04	1,419
Benz(*a*)anthracene	Southwest	0.00E+00	10,000	0.00E+00	10,000
Benz(*a*)pyrene	Southwest	0.00E+00	10,000	0.00E+00	10,000
Benz(*b*)fluoranthene	Southwest	0.00E+00	10,000	0.00E+00	10,000
Benz(*k*)fluoranthene	Southwest	0.00E+00	10,000	0.00E+00	10,000
Dibenz(*a*,*h*)anthracene	West	0.00E+00	10,000	0.00E+00	10,000
PCB	Southeast, East	0.00E+00	10,000	0.00E+00	10,000
Phenanthrene	Southwest	8.57E-05	7,559	5.66E-05	7,979
Chromium	Southwest	0.00E+00	9,799	0.00E+00	10,000
Thallium	Southwest	5.35E-03	31	3.29E-03	37
^{241}Am	West	1.54E-24	13,500	1.80E-27	14,900
^{137}Cs	West	0.00E+00	10,000	0.00E+00	10,000
^{237}Np	SWMU 26	2.16E-07	320	1.50E-07	359
^{239}Pu	SWMU 26	3.40E-09	10,200	2.30E-09	11,800
^{99}Tc	SWMU 26	9.24E-07	2,090	6.61E-07	2,340
^{230}Th[a]	East	3.29E-53	10,000	0.00E+00	10,000
^{234}U	Southwest	1.25E-07	5,162	8.04E-08	5,953
^{235}U	Southwest	7.00E-09	5,163	4.51E-09	5,951
^{238}U	Southwest	1.82E-07	5,163	1.17E-07	5,951
		Subsurface Soils			
1,1-Dichloroethene	Southeast	4.14E-03	62	2.50E-03	67
1,2-Dichloroethene	West	7.64E-02	21	4.78E-02	23
2,4-Dinitrotoluene	SWMU 26	1.07E-01	47	3.73E-02	50
Carbon Tetrachloride	Southeast	4.87E-04	386	2.94E-04	406
N-Nitroso-di-propylamine	Northeast	2.17E-02	24	1.37E-02	27
Phenanthrene	SWMU 26	5.40E-05	10,500	3.63E-05	10,800
Tetrachloroethene	Southeast	6.44E-04	285	3.89E-04	298
Trichloroethene	Southeast	5.00E+01	105	3.17E+01	112
Vinyl Chloride	Southeast	1.14E-03	54	7.27E-04	61
Antimony	Northwest	5.73E-03	707	3.58E-03	824
Chromium[a]	SWMU 26	1.59E-26	10,000	0.00E+00	NA
Copper	SWMU 26	4.00E-01	9,505	2.56E-01	11,100
Mercury	Northwest	0.00E+00	NA	0.00E+00	NA
Nickel	SWMU 26	1.25E-02	9,814	8.41E-03	10,840
Thallium	Southwest	4.74E-01	34	2.99E-01	39
^{241}Am	SWMU 26	2.97E-21	13,500	3.21E-24	14,900
^{137}Cs	SWMU 26	0.00E+00	10,000	0.00E+00	10,000
	Southwest				
^{237}Np	SWMU 26	9.41E-05	455	5.82E-05	497
^{239}Pu	SWMU 26	5.67E-07	10,200	3.46E-07	11,960
^{99}Tc	SWMU 26	1.14E-03	2,213	7.48E-04	2,463
^{230}Th	SWMU 26	3.99E-50	10,000	0.00E+00	10,000
^{234}U	SWMU 26	4.90E-05	5,162	3.48E-05	5,953
^{235}U	SWMU 26	2.04E-06	5,163	1.32E-06	5,951
^{238}U	SWMU 26	9.37E-05	5,163	6.67E-05	5,951

[a] Did not reach maximum during model runs.

Table 3.15. Maximum exposure levels of WAG 6 contaminants—RGA sources

Constituent	C-400 block sector	Plant fence		Property boundary	
		Max conc. (mg/L) (pCi/L)	Time (year)	Max conc. (mg/L) (pCi/L)	Time (year)
		RGA Soils			
Chromium[a]	Northwest	6.91E-05	10,000	1.71E-13	10,000
Cobalt	Northwest	2.74E-02	224	1.33E-02	374
Iron	Northwest	8.18E+01	377	3.96E+01	631
Manganese	Northwest	5.71E-01	633	2.77E-01	1,060
^{237}Np	Southwest	6.17E-07	435	4.06E-07	478

[a] Did not reach maximum during model runs.

Neither TCE nor ^{99}Tc sources were modeled for the RGA. The contaminant plumes from these sources are well documented. The WAG 6 RI concluded that TCE concentrations in the Northwest Plume, in the absence of the Northwest Plume Pump-and-Treat System, are at steady state based on monitoring data from the previous 10 years and the "full" extent of the dissolved-phase plume. Trends indicate that the ^{99}Tc levels of the Northwest Plume are declining; thus, the current contaminant levels are the maximum expected exposure levels.

3.2.3.8 WAG 6 Risk Assessment Summary

The summary presented in this section was taken from *Remedial Investigation for Waste Area Group 6 at the Paducah Gaseous Diffusion Plant* (DOE 1999a). Specifically, the Executive Summary of the WAG 6 BRA contains the pertinent risk information that will be repeated here. This document provides information on the baseline risks posed to human health and the environment from contamination at WAG 6 that will be used to support the need for remedial action in WAG 6 and to assist in the selection of the remedial alternatives.

The following is excerpted from the Executive Summary of the WAG 6 BRA.

> In 1997, the U.S. Department of Energy (DOE) conducted a Remedial Investigation/Resource Conservation and Recovery Act Facility Investigation for solid waste management units (SWMUs) 11, 26, 40, 47, and 203 in WAG 6 at the PGDP. In addition, this RI included areas surrounding the C-400 Building that are not part of any recognized SWMU. The overall purpose of this activity was to determine the presence, nature, and extent of contamination at each of the SWMUs and in the C-400 area. The primary focus of the remedial investigation was to collect sufficient information about surface and subsurface soil and the shallow groundwater of the UCRS contamination to support an assessment of risks to human health and the environment and the selection of actions to reduce these risks. In addition, contamination in the RGA and McNairy Formation was characterized to determine if contamination in the RGA acted as a secondary source of contamination to groundwater. Investigative activities included sampling and analysis of surface and subsurface soils, groundwater, and investigation derived waste.

To facilitate data aggregation and to focus results on specific areas, this BRA derives risk estimates for the sectors defined in Vol. 1 of this report in addition to the whole of WAG 6. The sectors and their definitions are as follows:

- Sector 1—the area under the C-400 Building.
- Sector 2—the area to the northeast of the C-400 Building. This sector contains SWMU 40.

- Sector 3—the area to the east of the C-400 Building. This sector does not contain a SWMU.
- Sector 4—the area to the southeast of the C-400 Building. This sector contains SWMU 11.
- Sector 5—the area to the southwest of the C-400 Building. This sector does not contain a SWMU.
- Sector 6—the area to the west of the C-400 Building. This sector contains SWMU 47.
- Sector 7—the area to the northwest of the C-400 Building. This sector contains SWMU 203.
- Sector 8—the area to the far north and northwest of the C-400 Building. This sector contains SWMU 26.
- Sector 9—the area to the far east and northeast of the C-400 Building. This sector does not contain a SWMU.

Consistent with regulatory guidance and previous agreements, the BHHRA evaluates scenarios that encompass current use and several hypothetical future uses of the WAG 6 area and areas to which contaminants from WAG 6 may migrate. These are as follows.

- Current on-site industrial—direct contact with surface soil (soil found 0 to 0.3 m, 0 to 1 ft, bgs).

- Future on-site industrial—direct contact with surface soil at and use of groundwater drawn from aquifers below the WAG 6 area.

- Future on-site excavation scenario—direct contact with surface and subsurface soil (soil found 0.3 to 4.6 m, 1 to 15 ft, bgs).

- Future on-site recreational user—consumption of game exposed to contaminated surface soil.

- Future off-site recreational user—direct contact with surface water impacted by contaminants migrating from sources and consumption of game exposed to this surface water.

- Future on-site rural resident—direct contact with surface soil at and use of groundwater drawn from aquifers below the WAG 6 area, including consumption of vegetables that were posited to be raised in this area.

- Future off-site rural resident's use in the home of groundwater drawn from the RGA at the DOE property boundary.

This report also contains a BERA for nonhuman receptors that may come into contact with contaminated media at or migrating from sources in the WAG 6 area. As with the BHHRA, the BERA utilizes information collected during the recently completed remedial investigation.

Major conclusions and observations of the BHHRA and BERA are presented below.

General

- For all sectors and the C-400 area, the cumulative human health excess lifetime cancer risk (ELCR) and systemic toxicity exceeds the accepted standards of the KDEP and the United States Environmental Protection Agency (EPA) for one or more scenarios. The results for each scenario and sector combination are presented in the Executive Summary. More detailed summaries of the human health risk assessment results for all land uses, including contaminants of concern (COCs) and pathways of concern (POCs) are in Tables ES.2 to ES.11 of the Executive Summary of the Baseline Risk Assessment (BRA). Note, Tables ES.2 to ES.11 present the risk results calculated using default exposure parameters, exposure pathways, and toxicity values. Because there is considerable uncertainty in some of these exposure parameters, exposure pathways and toxicity values, four additional tables

(Tables 3.17 through 3.20) present results of a quantitative uncertainty analysis. In this analysis, approved toxicity values and site-specific exposure parameters and exposure pathways are used to calculate risk estimates for the current and future industrial worker. Although Tables ES.2 to ES.11 of the Executive Summary of the BRA summarize the risk results for all land uses, only the results for the current land use and the most plausible future land use are discussed.

- Because the WAG 6 area is located in the heavily industrialized portion of the PGDP, the BERA concluded during problem formulation that it would not be appropriate to derive risk estimates for impacts to nonhuman receptors in the WAG 6 area under current conditions. However, in an analysis to determine potential impacts to nonhuman receptors exposed to contaminants in surface soil in the future if the industrial infrastructure was removed or abandoned and to estimate the potential impact of surface migration of contaminated media, several contaminants in surface soil were found to be at concentrations greater than those derived from ecological benchmarks for protection of nonhuman receptors. Summary tables of the risk assessment done for the WAG 6 BRA are presented here. Table 3.16 presents the land uses of concern found in Table ES.1 of the WAG 6 BRA. Tables 3.17 through 3.20 present the risk results and the quantitative risk summaries found in Tables ES.12 through ES.15 of the WAG 6 BRA.

3.2.4 WAG 27

The sites that comprise WAG 27 are suspected sources of off-site groundwater contamination (DOE 1996a). Four units/areas are included in WAG 27:

- C-747-C Former Oil Landfarm (SWMU 1),
- UF_6 Cylinder Drop Test Area (SWMU 91),
- C-746-A Septic Systems (SWMU 196), and
- C-720 Complex (including the C-720 Building and surrounding areas).

SWMU 1 and SWMU 91 were grouped into WAG 27 because they were suspected sources of TCE contamination in the RGA. However, because PCB contamination was found in surface soils at SWMU 1 during the Phase I and Phase II SI, the surface soils were included in WAG 23, with subsurface soils and groundwater being assigned to WAG 27. Although no specific releases have been documented at SWMU 196, it was included in WAG 27 as a potential source of off-site contamination in the Northwest Plume because it was recognized that the potential exists for past TCE releases through the septic systems. The C-720 Complex was included in WAG 27 because it was identified as a possible source of TCE contamination in the southwestern portion of the plant during the Phase IV Groundwater Investigation. Two additional sites associated with the C-720 Building, the C-720 Compressor Shop Pit Sump (SWMU 209) and the C-720 TCE Spill Site- Northeast (AOC 211), are also included in WAG 27.

The following subsections present site-specific information concerning the SWMUs/areas comprising WAG 27. A list identifying the sites included in WAG 27 and a map showing the locations of these sites are given in Table 3.21 and Fig. 3.20, respectively. Unless otherwise noted, the information presented is derived from the *Remedial Investigation Report for Waste Area Group 27 at the Paducah Gaseous Diffusion Plant* (DOE 1999b).

Table 3.16. Land uses of concern for WAG 6[a]

Scenario	WAG 6	Location (sector number) 1	2	3	4	5	6	7	8	9
Results for systemic toxicity[b]										
Current Industrial Worker	X[e]	NA	ñ	ñ	ñ	X	X	X[e]	ñ	X
Future Industrial Worker										
Exposure to Soil	X[e]	NA	ñ	ñ	ñ	X	X	X[e]	ñ	X
Exposure to Water[c]	X[e]									
Future Excavation Worker	X[e]	X	X	X[f]	X[e]	X[e]	X	X[e]	X[e]	X[e]
Future Recreational User	X[f]	NA	ñ	ñ	ñ	ñ	ñ	ñ	ñ	ñ
Future On Site Resident										
Exposure to Soil	X[e]	NA	X	X	X	X	X	X[e]	X	X
Exposure to Water[c]	X[e]									
Future Off Site Resident	X	ñ	ñ	ñ	X	X	ñ	X	X	ñ
Exposure to Water[d]										
Results for excess lifetime cancer risk										
Current Industrial Worker	X	NA	X	X	X	X	X	X	X	X
Future Industrial Worker										
Exposure to Soil	X	NA	X	X	X	X	X	X	X	X
Exposure to Water[c]	X									
Future Excavation Worker	X	X	X	X	X	X	X	X	X	X
Future Recreational User	X	NA	ñ	X	ñ	X	X	ñ	X	ñ
Future On Site Resident										
Exposure to Soil	X	NA	X	X	X	X	X	X	X	X
Exposure to Water[c]	X									
Future Off Site Resident										
Exposure to Water[d]	X	NA	X	X	X	X	X	X	X	ñ

Notes: Scenarios where risk exceeded the benchmark levels are marked with an X.
Scenarios where risk did not exceed a benchmark level are marked with a ñ.
NA indicates that the scenario/land use combination is not appropriate.

[a] Formerly Table ES.1. Land Uses of Concern for WAG 6.

[b] For the future recreational user, the future teen recreational user results are used. For the future on-site resident, the results for exposure to a child are used.

[c] In the BHHRA, the risk from exposure to water was assessed on a WAG 6 area basis; therefore, these risks are not summed with those from exposure to soil. Additionally, the BHHRA assessed risks from use of water drawn from the RGA separately from use of water drawn from the McNairy Formation. The value reported here is for use of water from the RGA.

[d] Based on results of contaminant transport modeling. X indicates that the location contains a source of unacceptable off-site contamination.

[e] Even if contribution from lead is not considered, these remain of concern.

[f] If contribution from lead is not considered, then the total HI falls below 1, and the scenario is not of concern.

Table 3.17. Risk Results and Quantitative Risk Summaries for WAG 6 SWMUs

Location	Default ELCR[a]	Site-specific ELCR[b]	Default ELCR minus common laboratory contaminants	Default ELCR calculated using EPA default dermal absorption values[c]	Default ELCR minus analytes infrequently detected	Lower-bound ELCR[d]
WAG 6	3.3×10^{-4}	2.1×10^{-5}	3.3×10^{-4}	4.1×10^{-5}	3.3×10^{-4}	2.6×10^{-6}
Sector 1	NV	NV	NV	NV	NV	NV
Sector 2	1.7×10^{-5}	1.1×10^{-6}	1.7×10^{-5}	3.8×10^{-6}	1.7×10^{-5}	2.4×10^{-7}
Sector 3	8.5×10^{-5}	5.4×10^{-6}	8.5×10^{-5}	3.0×10^{-5}	8.5×10^{-5}	1.9×10^{-6}
Sector 4	3.7×10^{-6}	2.3×10^{-7}	3.7×10^{-6}	5.9×10^{-7}	3.7×10^{-6}	3.8×10^{-8}
Sector 5	4.0×10^{-4}	2.6×10^{-5}	4.0×10^{-4}	4.5×10^{-5}	4.0×10^{-4}	2.9×10^{-6}
Sector 6	1.1×10^{-3}	7.3×10^{-5}	1.1×10^{-3}	1.5×10^{-4}	1.1×10^{-3}	9.8×10^{-6}
Sector 7	1.2×10^{-4}	7.9×10^{-6}	1.2×10^{-4}	5.7×10^{-6}	1.2×10^{-4}	3.7×10^{-7}
Sector 8	2.4×10^{-4}	1.5×10^{-5}	2.4×10^{-4}	9.8×10^{-6}	2.4×10^{-4}	6.2×10^{-7}
Sector 9	5.2×10^{-6}	3.3×10^{-7}	5.2×10^{-6}	3.7×10^{-6}	5.2×10^{-6}	2.3×10^{-7}

Notes: NV indicates that a value is not available because the sector encompasses the area below the C-400 Building.

[a]These values were derived using the default exposure rates for the reasonable maximum exposure scenario approved by regulatory agencies.

[b]These values were derived using site-specific exposure rates for general maintenance workers at PGDP. (See Subsect. 1.6.2.5.)

[c]The values were calculated using the soil dermal absorption rates suggested by EPA. (See Subsect. 1.6.2.4.)

[d]These values were derived using site-specific exposure rates for general maintenance workers at PGDP and EPA default dermal absorption values and omitting contributions from common laboratory contaminants and infrequently detected analytes. The values should be used as a lower-bound estimates of risk when considering the appropriate actions to address contamination at WAG 6.

*Formerly “Table ES.12. Quantitative Summary of Uncertainties for the Current Industrial Worker– Excess Lifetime Cancer Risk”

Table 3.18. Risk Results and Quantitative Risk Summaries for WAG 6 SWMUs

Location	Default ELCR[a]	Site-specific ELCR[b]	Default ELCR minus common laboratory contaminants	Default ELCR calculated using EPA default dermal absorption values[c]	Default ELCR minus analytes infrequently detected	Lower-bound ELCR[d]
WAG 6 McNairy[e]	4.5×10^{-3}	4.5×10^{-3}	4.5×10^{-3}	4.5×10^{-3}	1.7×10^{-3}	1.7×10^{-3}
WAG 6 RGA[e]	2.7×10^{-3}	2.7×10^{-3}	2.7×10^{-3}	2.7×10^{-3}	2.1×10^{-3}	2.0×10^{-3}
WAG 6 soil	3.3×10^{-4}	3.3×10^{-4}	3.3×10^{-4}	4.1×10^{-5}	3.3×10^{-4}	4.1×10^{-5}
Sector 1	NV	NV	NV	NV	NV	NV
Sector 2	1.7×10^{-5}	1.7×10^{-5}	1.7×10^{-5}	3.8×10^{-6}	1.7×10^{-5}	3.8×10^{-6}
Sector 3	8.5×10^{-5}	8.5×10^{-5}	8.5×10^{-5}	3.0×10^{-5}	8.5×10^{-5}	3.0×10^{-5}
Sector 4	3.7×10^{-6}	3.7×10^{-6}	3.7×10^{-6}	5.9×10^{-7}	3.7×10^{-6}	5.9×10^{-7}
Sector 5	4.0×10^{-4}	4.0×10^{-4}	4.0×10^{-4}	4.5×10^{-5}	4.0×10^{-4}	4.5×10^{-5}
Sector 6	1.1×10^{-3}	1.1×10^{-3}	1.1×10^{-3}	1.5×10^{-4}	1.1×10^{-3}	1.5×10^{-4}
Sector 7	1.2×10^{-4}	1.2×10^{-4}	1.2×10^{-4}	5.7×10^{-6}	1.2×10^{-4}	5.7×10^{-6}
Sector 8	2.4×10^{-4}	2.4×10^{-4}	2.4×10^{-4}	9.8×10^{-6}	2.4×10^{-4}	9.8×10^{-6}
Sector 9	5.2×10^{-6}	5.2×10^{-6}	5.2×10^{-6}	3.7×10^{-6}	5.2×10^{-6}	3.7×10^{-6}

Notes: NV indicates that a value is not available because the sector encompasses the area below the C-400 Building.

[a]These values were derived using the default exposure rates for the reasonable maximum exposure scenario approved by regulatory agencies.

[b]These values were also derived using the default exposure rates for the reasonable maximum exposure scenario because it is unknown what the site-specific exposure rates may be in the future.

[c]These values were calculated using the soil dermal absorption rates suggested by EPA. (See Subsect. 1.6.2.4.)

[d]These values were derived using default exposure rates for the reasonable maximum exposure scenario and EPA default dermal absorption values and omitting contributions from laboratory contaminants and infrequently detected analytes. The values should be used as lower-bound estimates of risk when considering the appropriate actions to address contamination at WAG 6.

[e]Values are for groundwater use by the future industrial worker.

*Formerly “Table ES.13. Quantitative Summary of Uncertainties for the Future Industrial Worker–Excess Lifetime Cancer Risk”

Table 3.19. Risk Results and Quantitative Risk Summaries for WAG 6 SWMUs

Location	Default HI[a]	Default HI w/o lead	Site-specific HI w/o lead[b]	Default HI minus common laboratory contaminants w/o lead	Default HI calculated EPA default dermal absorption values w/o lead[c]	Default HI minus analytes infrequently detected w/o lead	Lower-bound HI[d]
WAG 6	1,160	1.8	< 1	1.8	< 1	1.8	< 1
Sector 1	NV	NV	NV	NV	NV	NV	NV
Sector 2	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Sector 3	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Sector 4	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Sector 5	1.8	1.8	< 1	1.8	< 1	1.8	< 1
Sector 6	1.2	1.2	< 1	1.2	< 1	1.2	< 1
Sector 7	1,890	1.6	< 1	1.6	< 1	1.6	< 1
Sector 8	1.0	1.0	< 1	1.0	< 1	1.0	< 1
Sector 9	1.3	1.3	< 1	1.3	< 1	1.3	< 1

Notes: NV indicates that a value is not available because the sector encompasses the area below the C-400 Building.

< 1 indicates that the hazard index is less than the *de minimus* level.

[a]These values were derived using the default exposure rates for the reasonable maximum exposure scenario approved by regulatory agencies.

[b]These values were derived using site-specific exposure rates for general maintenance workers at PGDP. (See Subsect. 1.6.2.5.)

[c]The values were calculated using the soil dermal absorption rates suggested by EPA. (See Subsect. 1.6.2.4.)

[d]These values were derived using site-specific exposure rates for general maintenance workers at PGDP and EPA default dermal absorption values and omitting contributions from common laboratory contaminants and infrequently detected analytes. The values should be used as a lower-bound estimates of risk when considering the appropriate actions to address contamination at WAG 6.

*Formerly “Table ES.14. Quantitative Summary of Uncertainties for the Current Industrial Worker–Systemic Toxicity”

Table 3.20. Risk Results and Quantitative Risk Summaries for WAG 6 SWMUs

Location	Default HI[a]	Default HI w/o lead	Site-specific HI w/o lead[b]	Default HI minus common laboratory contaminants w/o lead	Default HI calculated using EPA default dermal absorption values w/o lead[c]	Default HI minus analytes infrequently detected w/o lead	Lower-bound HI[d]
WAG 6 McNairy[e]	11,500	20.6	20.6	20.6	20.6	20.6	20.6
WAG 6 RGA[e]	3,320	37.7	37.7	37.7	37.7	37.7	37.7
WAG 6 soil	1,160	1.8	1.8	1.8	< 1	1.8	< 1
Sector 1	NV	NV	NV	NV	NV	NV	NV
Sector 2	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Sector 3	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Sector 4	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Sector 5	1.8	1.8	1.8	1.8	< 1	1.8	< 1
Sector 6	1.2	1.2	1.2	1.2	< 1	1.2	< 1
Sector 7	1,890	1.6	1.6	1.6	< 1	1.6	< 1
Sector 8	1.0	1	1	1.0	< 1	1.0	< 1
Sector 9	1.3	1.3	1.3	1.3	< 1	1.3	< 1

Notes: NV indicates that a value is not available because the sector encompasses the area below the C-400 Building.
< 1 indicates that the hazard index is less than the *de minimus* level.

[a]These values were derived using the default exposure rates for the reasonable maximum exposure scenario approved by regulatory agencies.

[b]These values were also derived using the default exposure rates for the reasonable maximum exposure scenario because it is unknown what the site-specific exposure rates may be in the future.

[c]These values were calculated using the soil dermal absorption rates suggested by EPA. (See Subsect. 1.6.2.4.)

[d]These values were derived using default exposure rates for the reasonable maximum exposure scenario and EPA default dermal absorption values and omitting contributions from laboratory contaminants and infrequently detected analytes. The values should be used as lower-bound estimates of risk when considering the appropriate actions to address contamination at WAG 6.

[e]Values are for groundwater use by the future industrial worker.

*Formerly “Table ES.15. Quantitative Summary of Uncertainties for the Future Industrial Worker–Systemic Toxicity”

Table 3.21. WAG 27 SWMU sites

SWMU	Description
SWMU 1	C-747-C Former Oil Landfarm
SWMU 91	UF6 Cylinder Drop Test Area
SWMU 196	C-746-A Septic Systems
SWMU 209	C-720 Compressor Shop Pit Sump
C-720 Complex	C-720 Maintenance and Stores Building and Surrounding Areas
AOC 211	C-720 TCE Spill Site- Northeast

3.2.4.1 SWMU 1

Location and Description

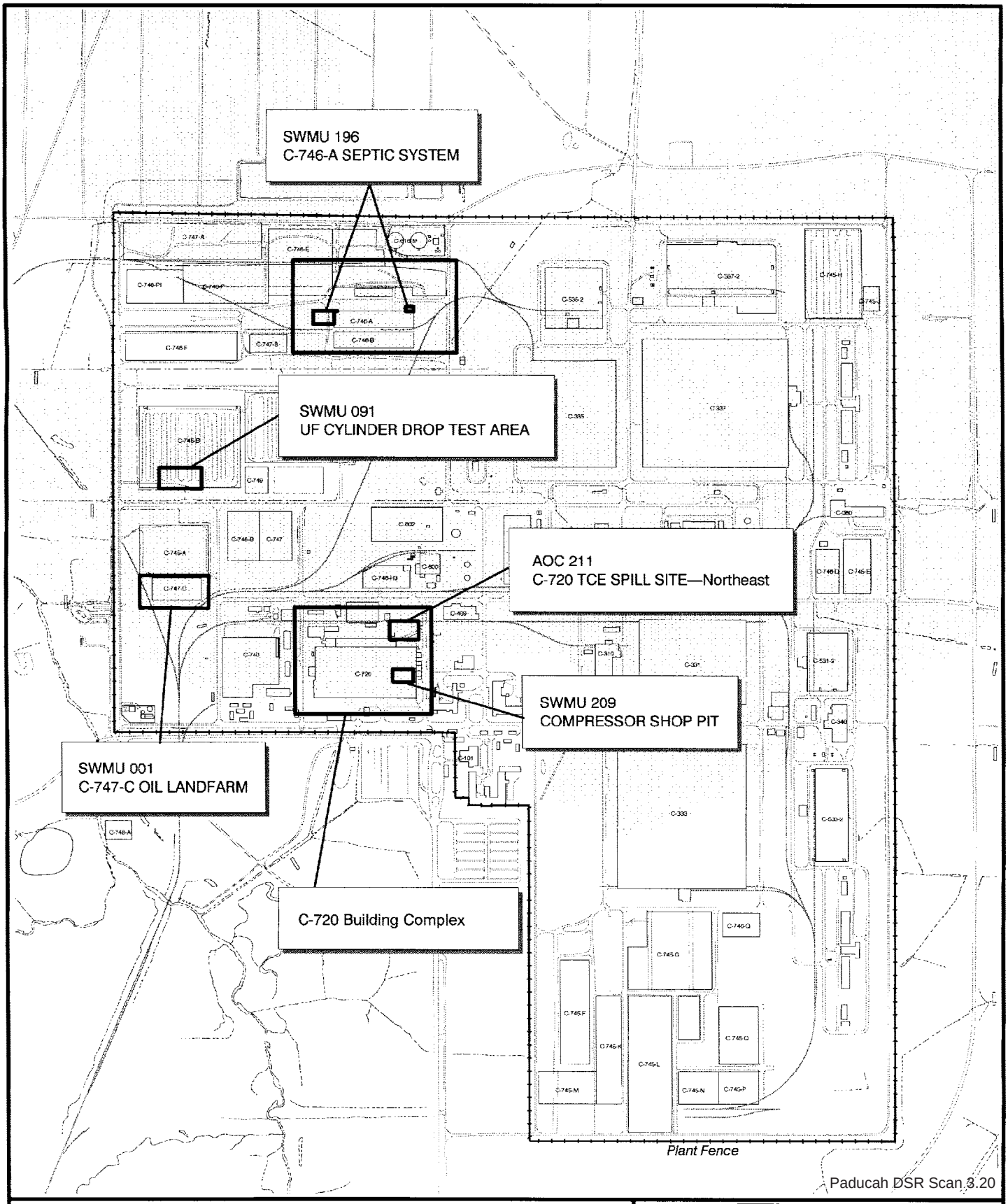
The C-747-C Oil Landfarm (SWMU 1) is located in the southwest portion of the fenced security area of the plant, south of the C-745-A Cylinder Yard. The SWMU includes the area bounded by Fourth Street to the east and by perimeter ditches on the north, west, and south (Fig. 3.21). The total area of the SWMU is approximately 8,947 m^2 (96,300 ft^2) and encompasses two disposal plots covering approximately 104.5 m^2 (1,125 ft^2) each. Based on historical aerial photographs and trench excavations conducted during the WAG 27 RI, these plots are thought to be located in the northern portion of SWMU 1 (DOE 1999b). Surface geophysical surveys at SWMU 1 have identified three anomalous areas, two of which possibly contain buried metal and the third likely containing a metal pipe. These three areas are labeled A, B, and C, respectively, in Fig. 3.21.

Setting

The following paragraphs describe the surface-water hydrology, wetlands, ecological and cultural resources, soils, and buried utilities at SWMU 1. The information presented is derived from the *Remedial Investigation Report for Waste Area Group 27 at the Paducah Gaseous Diffusion Plant* (DOE 1999b) and the *Feasibility Study for Waste Area Group 23 and Solid Waste Management Unit 1 of Waste Area Group 27 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1996a).

Surface-water hydrology, wetlands, and floodplains. The ground surface at SWMU 1 is grass-covered and relatively flat, grading gently from 114 m (375 ft) amsl on the east to about 113 m (370 ft) amsl on the west. West-trending drainage ditches are present on the north and south sides of the unit and a south-trending drainage ditch is present on the west. Stormwater runoff from SWMU 1 flows to one of these perimeter ditches and discharges via KPDES Outfall 008 to Bayou Creek. Some runoff from the C-745-A Cylinder Yard and the C-740 Material Yard also enters the ditches at the north side and south side of SWMU 1, respectively. Jurisdictional wetlands identified in the vicinity of SWMU 1 are limited to the perimeter drainage ditches and are shown in Fig. 3.21. A 100-year floodplain is located to the southwest of SWMU 1.

Ecological and cultural resources. The site is covered with grassy vegetation that is maintained by mowing. However, the ditches are grass-covered and so potentially provide limited wildlife habitat. The ditches generally are dry and do not support an aquatic community. No potential habitats for federally listed T&E species are present within the fence (CDM Federal 1994). All of the area inside the PGDP security fence has been previously disturbed and, consequently, is not likely to contain any undisturbed sites of archaeological significance. In addition, no properties in the vicinity of SWMU 1 currently are included on, or nominated for inclusion on, the National Register of Historic Places (NRHP).



Paducah DSR Scan 3.20

Legend

Surface Water Drainage

Plant Boundary Fence

Approximate TCE Plume

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Fig. 3.20. WAG 27 SWMU Sites.

Paducah Gaseous Diffusion Plant
Paducah, Kentucky

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SITE GRID COORDINATES

1050 1100 1150 1200 1250 1300 1350 1400 1450 1500 1550

SITE GRID COORDINATES

1050 1000 950 900 850 800 750

CYLINDER STORAGE AREA

(Culvert) (Culvert) (Culvert) (Culvert) (Culvert) (Culvert) (Culvert)

A

B

C

GRAVEL ROAD

UTILITY (WATER)

4th Street

MANHOLE COVER

RR TRACKS

RR TRACKS

DITCH

LEGEND

EM SURVEY LINE

MAGNETOMETER SURVEY LINE

NOTES:
1. All locations are approximate
2. Grid coordinates do not correspond to PGDP coordinate system

CONTOUR INTERVAL = 10 millimhos / meter

Grid North

0 50'

SCALE IN FEET

Fig. 3.21. Wag 27 SWMU 1 location.

PADUCAH GASEOUS DIFFUSION PLANT
PADUCAH, KY
PHASE II SITE INVESTIGATION

Soils and prime farmland. Soils at SWMU 1 have been classified as Calloway silt loam (0% to 2% slope). The Calloway soil series contains poorly-drained acidic soils formed in loess or alluvium (USDA 1976). The soils in the oil landfarm have been disturbed by past operations and, consequently, are not classified as prime farmland.

Underground utilities. Electromagnetic ground conductivity and magnetometer surveys were performed at SWMU 1 during the Phase II SI. The purpose of the geophysical surveys was to find approximate locations of the former landfarm plots and the raw water pipeline at the unit. The results of the surveys showed no evidence of the landfarm plots or the reported gravel underdrain beneath the plots. However, a linear anomaly crossing the site from northeast to southwest was identified as the buried raw water pipeline.

Manufacturing/TSD Processes

The landfarm was used for the biodegradation of contaminated waste oils from 1975 to 1979. When in use, the area was plowed to a depth of 0.3 to 0.6 m (1 to 2 ft), and then waste oils, contaminated with TCE, 1,1,1-trichloroethane (TCA), uranium, and PCBs, were spread across the surface. It is estimated that approximately 5000 gal of waste oil were applied to the landfarm, with the oil being added to the plots at 3- to 4-month intervals (CH2M HILL 1992). Although sources of the waste oils are not reported, it is assumed that they were derived from virtually all areas of the plant. Periodically, lime and fertilizers were plowed into the soil to promote the biodegradation of contaminants. At one time, a layer of gravel was placed below the soil in the landfarm to improve drainage. After use of the landfarm was discontinued in 1979, a minimal cover [< 30 cm (<12 in.)] was placed over the two disposal plots (DOE 1999b).

Summary of Previous Investigations at SWMU 1

The following subsections describe the previous sampling activities conducted at SWMU 1 and provide summaries of the nature and extent of contamination, fate and transport of contaminants, and previous risk assessments at the unit. The information presented is primarily derived from the *Integrated Remedial Investigation/Feasibility Study Work Plan for Waste Area Grouping 27 at Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1997a) and the *Remedial Investigation Report for Waste Area Group 27 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1999b).

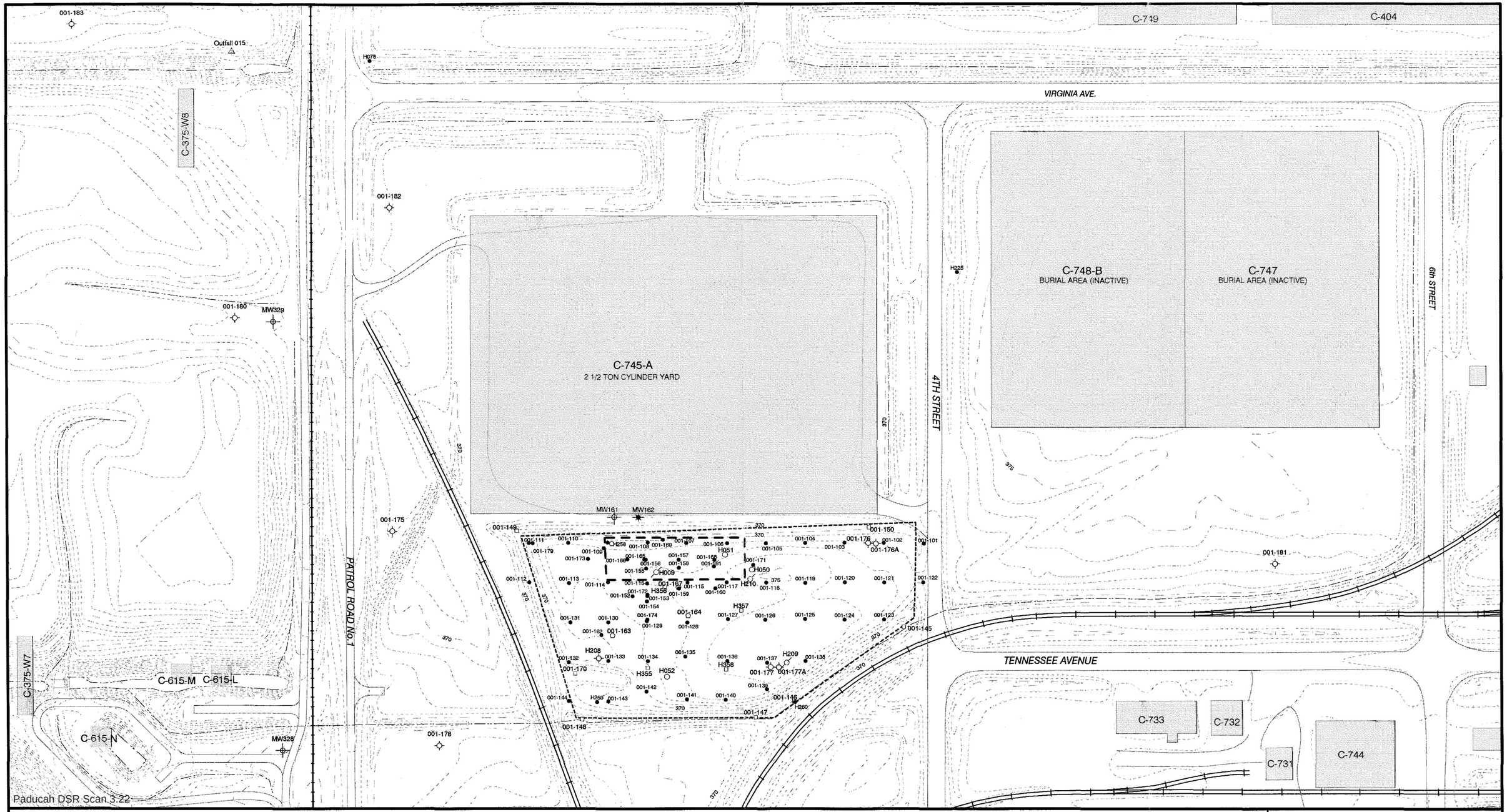
Sources of Data

The following investigations and sampling activities have been conducted at SWMU 1.

- The two-phased CERCLA SI conducted in 1991 and 1992, which included the installation of four RGA soil borings, 10 shallow soil borings, and four groundwater monitoring wells at the unit. In addition, two surface geophysical surveys, electromagnetic and magnetometer, were conducted during the Phase II SI (CH2M HILL 1992). Aquifer slug tests were conducted at two RGA wells (MWs 161 and 188) and two UCRS wells (MWs 162 and 189) in the vicinity of SWMU 1. The location of the SI sampling points are shown in Fig. 3.22.

- Soil sampling activities at SWMU 1 focusing on the delineation of the extent of PCB and dioxin contamination in surficial soils at the unit. These sampling activities were performed in support of WAG 23 RI/FS and so are discussed in Sect. 3.2.8.

- The Environmental Surveillance (Annual Monitoring) Program at the PGDP, which includes the collection of groundwater samples from upgradient and downgradient RGA monitoring wells (MWs 188 and 161, respectively). In addition, historical groundwater sampling data are available from two shallow (UCRS) monitoring wells in the vicinity of the unit (MWs 162 and 189).



Legend

- 1 foot Elevation Contours
- 5 foot Elevation Contours
- SWMU 001 Boundary
- Surface Water Drainage
- Plant Boundary Fence
- Approximate Landfarm Plot Boundary
- UCRS (WAG27 RI) Soil Boring
- Sediment Sample
- Phase I (shallow-Loess) Boring
- Cone Penetrometer Test (CPT) Boring
- RGA (deep) Soil Boring
- McNairy (deep) Soil Boring
- RGA Monitoring Well
- Outfall Sample
- UCRS Monitoring Well

N

50 0 50 100 Feet

Scale 1:1440

JE JACOBS ENGINEERING

Fig. 3.22. Locations of WAG 27 sampling points.

Paducah Gaseous Diffusion Plant
Paducah, Kentucky

NZehms 9/30/99 swmu1_samp.apr

- The WAG 27 RI activities at SWMU 1. These activities included a surface geophysical survey (EM-61 magnetometer), soil sampling from eight test pits dug to investigate geophysical anomalies, sediment sampling from seven locations in the ditches, and soil and groundwater sampling from 73 borings. The locations of the WAG 27 sampling points are shown in Fig. 3.22.

Geology/Hydrogeology

The hydrogeologic conceptual model for SWMU 1 is shown in Fig. 3.23. The following lithologies are encountered at the landfarm, in order of increasing depth: surface soil/loess [between 0 to 4.6 m (0 to 15 ft) bgs], continental deposits [between 4.6 to 32 m (15 to 105 ft) bgs], and the McNairy Formation [at approximately 32 m (105 ft) bgs]. The loess consists primarily of silty clay to clayey silt, with occasional traces of fine sand and gravel. The Upper Continental Deposits are approximately 12.2 m (40 ft) thick and consist of silty or sandy clay with occasional, discontinuous layers of sand or gravel. The Lower Continental Deposits consist of 12.2 to 18.3 m (40 to 60 ft) of gravelly sand or chert gravel.

The depths to the top of the McNairy Formation vary from a low of approximately 79 m (259 ft) to a high of 83 m (273 ft) amsl in the vicinity of the landfarm. Lithologic data from boreholes in the surrounding area indicate an east–west trending subsurface trough (as evidenced by a structural low in the top of the McNairy) may exist north of SWMU 1. A micaceous silty clay layer, believed to be the Levings Member of the McNairy Formation, is generally encountered approximately 13.7 m (45 ft) below the top of the McNairy at a depth of approximately 45.7 m (150 ft) bgs.

Based on soil boring logs and monitoring well data for the area, three flow systems have been delineated at the SWMU 1 site. These layers correspond to the permeable sand and gravel layers within the UCRS [generally found between 4.6 and 12.2 m (15 and 40 ft) bgs], the RGA [lying between approximately 16.8 to 32 m (55 to 105 ft) bgs], and the McNairy Flow System. Figure 3.23 presents a cross-section delineating these layers. The sand and gravel lenses of the UCRS are separated from the RGA by a 3- to 4.6-m (10- to 15-ft) thick silty or sandy clay interval, designated the HU3 aquitard.

Large differences in hydraulic head (as much as 9 m, 30 ft) between the UCRS and the RGA have been measured in MW162 (UCRS) and MW161 (RGA) on the northern edge of the SWMU 1 (DOE 1999b). Water within the UCRS tends to flow downward as a result of this large hydraulic gradient between the UCRS and the RGA. However, colloidal borescope measurements at MW162 suggest there is also a southeasterly component of flow within the UCRS that may have an impact on shallow groundwater movement at the northern edge of the landfarm (DOE 1996a). Slug tests conducted at MWs 162 and 189 yielded an average hydraulic conductivity of 3×10^{-5} cm/sec (0.08 ft/d) in the UCRS (CH2M HILL 1992).

Groundwater flow in the RGA at SWMU 1 is primarily toward the northwest and the hydraulic gradient typically is less than 2.0×10^{-4}. According to water-level measurements conducted at the landfarm in January 1998, the potentiometric surface ranges from 98.83 to 98.78 m (324.24 to 324.09 ft) amsl. Aquifer slug tests completed in MWs 161 and 188 in 1992 yielded an average hydraulic conductivity value of 3.1×10^{-2} cm/sec (87.8 ft/d) in the RGA.

Nature and Extent of Contamination

Previous sampling activities at SWMU 1 can be divided into two categories: sampling conducted to address the PCB and dioxin contamination in surface soils and ditch sediments at the unit, and sampling conducted to investigate contamination present in subsurface soils and groundwater. The surface soil and sediment sampling at SWMU 1 is discussed as part of WAG 23 (Sect. 3.2.8) and so is not presented here. The following discussion focuses on the results of groundwater and subsurface soil sampling conducted

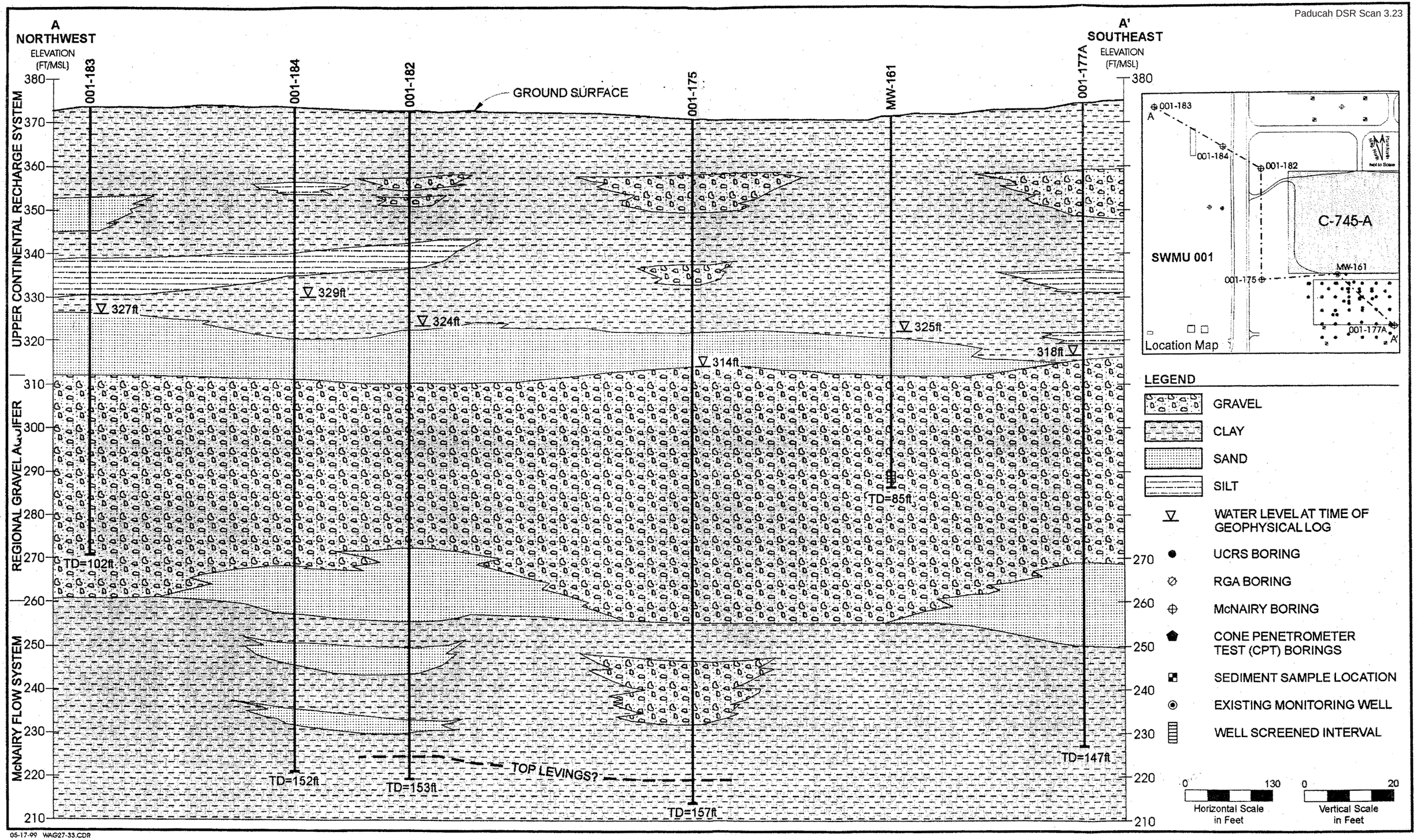


Fig. 3.23. Geologic cross section of SWMU 1.

during previous investigations. The results of subsurface soil and groundwater sampling conducted at SWMU 1 for the WAG 27 RI are summarized in Table 3.22.

To investigate subsurface soils at SWMU 1, 198 soil samples were collected from 73 borings varying in depth from 1.5 to 15 m (5 to 50 ft) bgs during the WAG 27 RI. Two VOAs, TCE and vinyl chloride, were detected in subsurface soil samples at levels exceeding screening values. The maximum TCE concentration was 439,000 µg/kg, detected at a depth of 4.6 m (15 ft) bgs from boring 001-165 in the north–central portion of SWMU 1. This concentration is above levels considered indicative of the presence of DNAPL. Four other soil borings at SWMU 1 contained soil samples with TCE concentrations greater than 10,000 µg/kg. In addition, the TCE breakdown product *cis*-1,2-DCE was detected at a concentration of 2,400,000 µg/kg at a location east of boring 001-165 during WAG 23 soil sampling conducted in February 1996. The elevated concentrations of TCE and its breakdown products detected in subsurface soils at SWMU 1 indicate a small DNAPL source area may exist within shallow (<10 m, 32 ft, bgs) UCRS soils. The potential DNAPL source is likely confined to the HU1 clays and HU2 sands and gravels in the immediate area surrounding soil boring 001-165. A water sample from boring 001-173 at elevation 98 m (322 ft) amsl provides characterization of dissolved-phase TCE levels in the upper RGA immediately downgradient of the Former Oil Landfarm. The TCE-in-water level is 312 µg/L, which compares favorably to inferred dissolved-phase levels in the "hot spot" zone and suggests a deep UCRS or RGA DNAPL source does not occur (higher dissolved levels would be expected).

Metals contamination was identified in subsurface soil from 1.5 to 4.6 m (5 to 15 ft) bgs. Radionuclides were not detected above screening level in subsurface soil samples.

Fate and Transport

Contaminant fate and transport modeling has been conducted for SWMU 1, Modeling was conducted for the WAG 23 FS using the Summers Model and the Residual Radioactivity (RESRAD) computer code and for the WAG 27 FS using Multimedia Environmental Pollutant Assessment System (MEPAS) software. The results of the Summers and RESRAD modeling indicated that ^{99}Tc was present in surface soils at the unit at levels that could potentially leach into the RGA. However, the area where ^{99}Tc contamination was identified was removed during the excavation of dioxins conducted as part of a non-time critical removal action at WAG 23. Additional WAG 23 modeling results focus on the fate and transport of surface contaminants and so are further discussed in Sect. 3.2.8.

The MEPAS model calculates the fate and transport of contaminants from specified source terms and determines the associated risk to identified receptors. For this modeling, the groundwater contaminant transport portion of MEPAS was used to model contaminant concentrations to two receptor points: the PGDP security fence and the DOE property boundary.

Subsurface soil data were provided by the WAG 27 RI, the CERCLA SI, and the May 1998 investigation (which included test pit excavations) of geophysical anomalies at the unit (DOE 1998f). RGA soil-sampling data were available from three soil borings installed at the unit for the CERCLA SI (CH2M HILL 1992) and from additional borings installed for the groundwater data gaps investigation in 1999.

Previous Remedial Actions

The DOE conducted a non-time critical removal action at SWMU 1 in January and February 1998. This action was taken to address PCB contamination in surface soils at SWMU 1, and so is included in the discussion of WAG 23 in Sect. 3.2.8. No actions have been taken to address existing groundwater contamination at the unit.

Table 3.22. Results of Soil and Sampling Conducted for SWMU 1 at the PGDP

Sample Type	Analytical Group	Analytical Compound	Number of Analyses[a]	Number of Detections above BG[a]	Number of Detections above BG & PRG Screening Values[a]	Maximum Result above BG[a]	Minimum Result above BG[a]	Average Result above BG[a]	Units
Trench	VOA	Trichloroethene	5	4	2	1,200.000	11.000	434.000	µg/kg
		Vinyl chloride	5	2	2	270.000	67.000	168.500	µg/kg
	SVOA	Phenol	2	2	0	23,000.000	2,900.000	12,950.000	µg/kg
		2,4-Dimethylphenol	1	1	0	15,000.000	15,000.000	15,000.000	µg/kg
		Di-n-butyl phthalate	1	1	0	9,000.000	9,000.000	9,000.000	µg/kg
		m,p-Cresol	5	1	0	8,600.000	8,600.000	8,600.000	µg/kg
		Total Cresols	5	1	0	8,600.000	8,600.000	8,600.000	µg/kg
	PCB	PCB-1242	2	2	2	500.000	500.000	500.000	µg/kg
		PCB-1268	2	2	2	5,600.000	4,200.000	4,900.000	µg/kg
		Polychlorinated biphenyl	5	2	2	17,100.000	4,700.000	10,900.000	µg/kg
		PCB-1260	1	1	1	11,000.000	11,000.000	11,000.000	µg/kg
	Metals	Mercury	5	2	0	0.310	0.260	0.285	mg/kg
		Chromium	5	1	0	17.100	17.100	17.100	mg/kg
		Nickel	5	1	0	116.000	116.000	116.000	mg/kg
	Radioactive isotopes	Uranium	5	5	0	80.000	6.800	42.840	pCi/g
		Technetium-99	5	3	0	10.000	6.000	8.667	pCi/g
		Neptunium-237	5	2	0	0.570	0.410	0.490	pCi/g
		Americium-241	5	1	0	0.430	0.430	0.430	pCi/g
		Plutonium-239/240	5	1	0	0.130	0.130	0.130	pCi/g
Sediment	Metals	Barium	7	1	1	247.000	247.000	247.000	mg/kg
		Beryllium	7	1	1	0.800	0.800	0.800	mg/kg
		Chromium	7	1	0	16.800	16.800	16.800	mg/kg
		Cobalt	7	1	0	15.400	15.400	15.400	mg/kg
		Manganese	7	1	1	1,990.000	1,990.000	1,990.000	mg/kg
		Nickel	7	1	0	23.400	23.400	23.400	mg/kg
		Thallium	7	1	1	1.560	1.560	1.560	mg/kg
		Zinc	7	1	0	67.000	67.000	67.000	mg/kg
	Radioactive isotopes	Uranium	6	6	0	12.300	3.200	5.983	pCi/g
		Uranium-238	6	6	0	5.200	2.100	3.117	pCi/g
		Plutonium-239/240	6	5	1	26.820	0.070	5.482	pCi/g
		Neptunium-237	6	3	1	12.150	0.110	4.143	pCi/g
		Technetium-99	6	3	0	24.300	3.200	10.400	pCi/g
		Americium-241	6	2	0	7.830	7.830	7.830	pCi/g
		Cesium-137	6	2	0	0.550	0.510	0.530	pCi/g
		Thorium-230	6	2	1	187.900	2.610	95.255	pCi/g
		Uranium-234	6	2	0	6.840	3.500	5.170	pCi/g
		Uranium-235	6	2	0	0.310	0.180	0.245	pCi/g

Table 3.22. Results of soil and sampling conducted for SWMU 1 at the PGDP (continued)

Sample Type	Analytical Group	Analytical Compound	Number of Analyses[a]	Number of Detections above BG[a]	Number of Detections above BG & PRG Screening Values[a]	Maximum Result above BG[a]	Minimum Result above BG[a]	Average Result above BG[a]	Units
Subsurface soil	VOA	Trichloroethene	222	72	49	439,000.000	6.000	18,520.194	µg/kg
		trans-1,2-Dichloroethene	222	36	0	16,000.000	20.000	1,786.111	µg/kg
		1,1-Dichloroethane	27	10	0	4,300.000	90.000	1,095.000	µg/kg
		cis-1,2-Dichloroethene	222	6	0	6,000.000	2.000	1,975.333	µg/kg
		Vinyl chloride	222	6	6	4,800.000	200.000	1,250.000	µg/kg
		Acetone	4	4	0	8.000	3.000	5.750	µg/kg
		1,2-Dichloroethene	199	1	0	2.000	2.000	2.000	µg/kg
	SVOA	Bis(2-ethylhexyl)phthalate	138	17	0	100.000	35.000	56.353	µg/kg
		Di-n-butyl phthalate	138	2	0	50.000	50.000	50.000	µg/kg
		2,4-Dimethylphenol	138	1	0	40.000	40.000	40.000	µg/kg
		4-Methylphenol	115	1	0	480.000	480.000	480.000	µg/kg
		Butyl benzyl phthalate	138	1	0	200.000	200.000	200.000	µg/kg
		Diethyl phthalate	138	1	0	60.000	60.000	60.000	µg/kg
		Phenol	138	1	0	1,900.000	1,900.000	1,900.000	µg/kg
		Total Cresols	23	1	0	4,400.000	4,400.000	4,400.000	µg/kg
	Metals	Sodium	138	50	50	570.000	343.000	421.520	mg/kg
		Cadmium	138	46	19	3.840	0.220	1.828	mg/kg
		Beryllium	138	26	26	1.660	0.700	0.892	mg/kg
		Zinc	138	24	0	306.000	60.200	100.646	mg/kg
		Antimony	138	15	15	1.720	0.530	0.928	mg/kg
		Vanadium	138	13	13	68.100	39.200	49.577	mg/kg
		Aluminum	138	8	8	18,700.000	12,700.000	14,712.500	mg/kg
		Magnesium	138	8	8	2,630.000	2,110.000	2,313.750	mg/kg
		Arsenic	138	6	6	16.700	9.410	11.568	mg/kg
		Barium	138	6	0	215.000	174.000	187.000	mg/kg
		Chromium	138	5	0	123.000	43.500	67.280	mg/kg
		Cobalt	138	5	0	29.900	13.300	20.300	mg/kg
		Iron	138	5	5	35,500.000	28,200.000	30,620.000	mg/kg
		Manganese	138	5	5	2,160.000	871.000	1,178.800	mg/kg
		Nickel	138	5	0	29.700	24.000	26.740	mg/kg
		Lead	138	1	1	29.700	29.700	29.700	mg/kg
		Mercury	138	1	0	0.150	0.150	0.150	mg/kg
		Silver	138	1	1	73.900	73.900	73.900	mg/kg
	Radioactive isotopes	Uranium	66	40	0	22.000	1.500	3.528	pCi/g
		Uranium-238	66	21	0	9.000	1.300	2.610	pCi/g
		Uranium-234	66	5	0	12.600	3.200	7.500	pCi/g
		Uranium-235	66	4	0	0.570	0.160	0.393	pCi/g
		Plutonium-239/240	66	3	0	2.720	0.060	0.950	pCi/g
		Americium-241	66	2	0	0.100	0.080	0.090	pCi/g
		Technetium-99	68	2	0	8.600	4.500	6.550	pCi/g

Table 3.22. Results of soil and sampling conducted for SWMU 1 at the PGDP (continued)

Sample Type	Analytical Group	Analytical Compound	Number of Analyses[a]	Number of Detections above BG[a]	Number of Detections above BG & PRG Screening Values[a]	Maximum Result above BG[a]	Minimum Result above BG[a]	Average Result above BG[a]	Units
Subsurface soil (cont.)	Radioactive isotopes (cont.)	Neptunium-237	66	1	0	0.200	0.200	0.200	pCi/g
		Thorium-230	66	1	0	18.430	18.430	18.430	pCi/g
Groundwater	VOA	1,1-Dichloroethene	1	1	1	7.000	7.000	7.000	µg/L
		trans-1,2-Dichloroethene	1	1	1	46.000	46.000	46.000	µg/L
		Trichloroethene	1	1	1	312.000	312.000	312.000	µg/L
	Radioactive isotopes	Technetium-99	1	1	1	41.100	41.100	41.100	pCi/L
		Uranium	1	1	1	0.040	0.040	0.040	mg/L

[a]Number of analyses/detections include both environmental samples and duplicate results.

3.2.4.2 SWMU 91

Location and Description

The Cylinder Drop Test Area (SWMU 91) is located in the extreme west-central area of the plant between the southern edge of the C-745-B Cylinder Yard and Virginia Avenue. It encompasses approximately 0.7 hectares (1.7 acres). Figure 3.24 shows the location and physical features of SWMU 91.

Setting

The following subsections describe the surface-water hydrology, ecological resources, soils, geology, and hydrogeology at the cylinder drop test area. The information presented is primarily derived from the *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 1998a) and the *Remedial Investigation Report for Waste Area Group 27 at the Paducah Gaseous Diffusion Plant* (DOE 1999b).

Surface-water hydrology, wetlands, and floodplains. 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. Most of the ground surface is covered with approximately 1.2 m (4 ft) of gravel road base. The concrete and steel pad used during the drop tests covers an area approximately 3×3 m (10×10 ft) and is approximately 2.1 m (6.75 ft) thick. The exact location of the entire test pit is unknown, but one corner of the pit was located during Phase IIA of the Lasagna demonstration at SWMU 91 (Hines 1997). The pit was constructed of concrete with a metal lip and was located approximately 0.5 m (1.5 ft) bgs. 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 460 m (1,500 ft) to the west. Wetlands have been identified in the ditches adjacent to SWMU 91, and a 100-year floodplain has been identified in the vicinity of SWMU 91 (Fig. 3.24).

Ecological and cultural resources. The Cylinder Drop Test Site is covered by a gravel layer approximately 1.2 m (4 ft) thick, and does not provide a suitable habitat for ecological receptors. The drainage ditch south of the unit is a grassy area that may provide wildlife habitat, but the small size limits its significance as wildlife habitat. The ditch is generally dry and does not support an aquatic community. No potential habitats for federally listed T&E species are present at the cylinder drop test area.

Soils and prime farmland. The predominant soil type at the unit is a poorly drained acidic soil classified as Henry Silt Loam (USDA 1976). The soils in this area have been disturbed by past activities and, consequently, are not classified as prime farmland.

Manufacturing/TSD Processes

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 groundwater. Although the location of one corner of the pit was determined, the exact location of the entire pit is unknown. The pit is approximately 9 m (30 ft) from the drop pad.

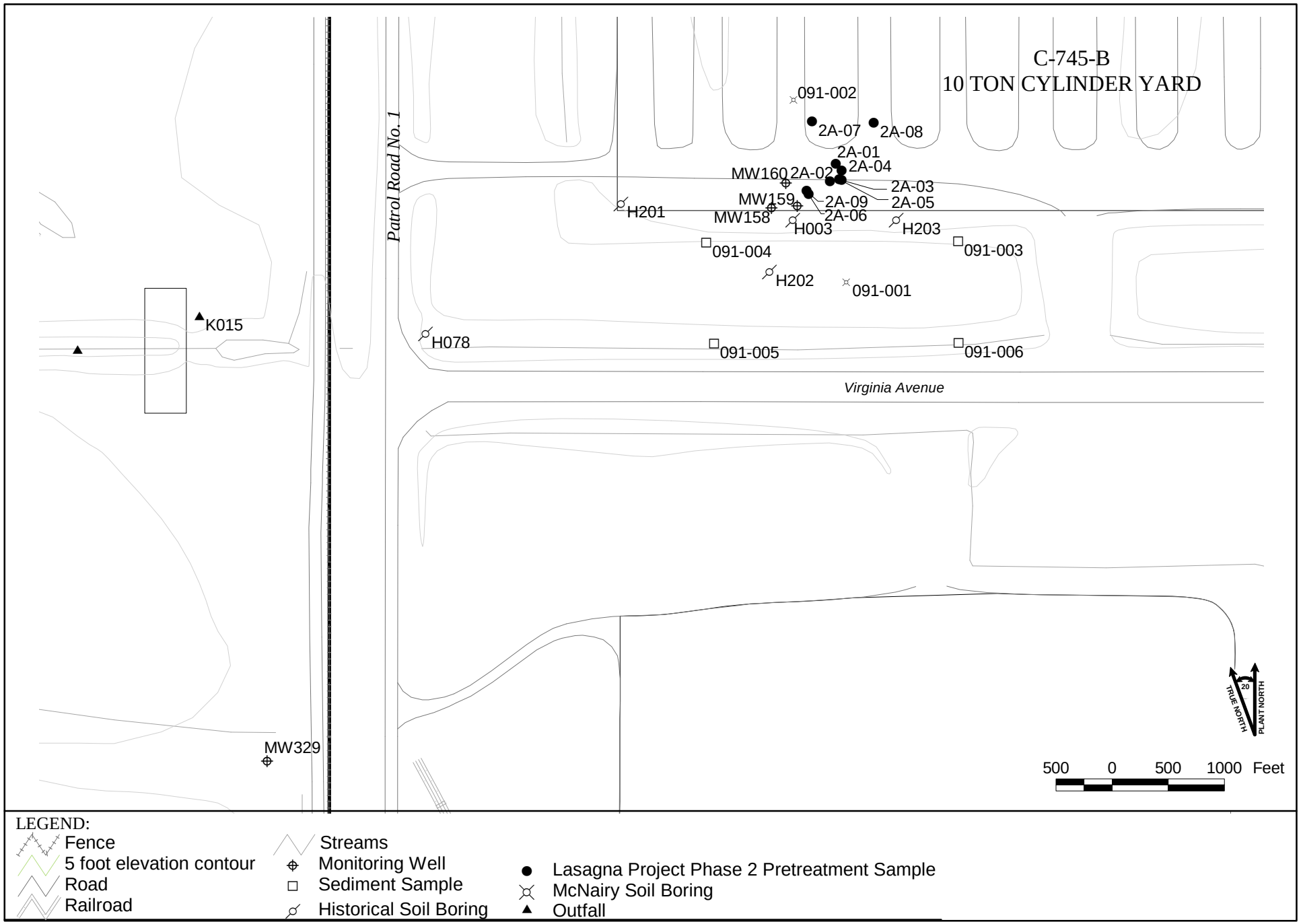


Fig. 3.24. Location and physical features of SWMU 91.

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-in.) 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 gal) (DOE 1996b).

Summary of Previous Investigations

The following subsections describe the previous sampling activities conducted at SWMU 91 and provide summaries of the nature and extent of contamination, contaminant fate and transport, and previous risk assessments at the unit. The information presented is primarily derived from the *Remedial Investigation Report for Waste Area Group 27 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1999b) and the *Preliminary Site Characterization/Baseline Risk Assessment Technology Demonstration at Solid Waste Management Unit 91 of the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1996b).

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

- The CERCLA SI conducted in 1991 and 1992, which included the installation of four deep soil borings (H003, H201, H202, and H203) and three groundwater monitoring wells (MWs 158, 159, and 160) at the unit.

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

- Groundwater 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.

- 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.

- Groundwater, soil, and sediment sampling conducted in 1998 in support of the WAG 27 RI. The sampling included sediment sampling at four locations in the perimeter ditches (091-003 through 091-006) and soil and groundwater sampling from two deep (McNairy) borings (091-001 and 091-002).

Geology/Hydrogeology

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. The Upper Continental Deposits underlie the loess at a depth of about 6 m (20 ft) bgs 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 groundwater system at the site, the UCRS, consists of the upper Continental Deposits and overlying loess and has been divided into the following 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) bgs. 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/d) and storage coefficients ranged from 7.43×10^{-3} to 5.9×10^{-2}. Water level measurements taken in MW160,

which is screened in HU 2, indicate that the depth to the water table is approximately 2 m (7 ft) bgs 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) bgs. 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: MW159, which is screened in the upper RGA at 19 to 21 m (63 to 68 ft) bgs, and MW158, which is screened in the lower RGA at 31 to 32.9 m (102 to 108 ft) bgs. The depth to water in MW158 was approximately 11 m (37 ft) bgs [102 m (334 ft) amsl] in May 1994. Water levels in upper RGA MW159 typically are slightly higher than those measured in MW158, 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) bgs in MW158.

Nature and Extent of Contamination

Results of the investigations conducted at SWMU 91 indicate that elevated concentrations of organic contaminants are present in both shallow soil and UCRS groundwater at the unit. The predominant contaminant is TCE with maximum levels of 1,523 mg/kg and 943 mg/L detected in subsurface soil and shallow groundwater samples, respectively. The concentrations of TCE detected in shallow (UCRS) groundwater samples approach the solubility limit for TCE (1100 mg/L), which strongly suggests the presence of DNAPL at the site. In general, the analytical data show concentrations of TCE decrease with depth, with the highest concentrations occurring in the sand and gravel unit (HU2) found at depths between 6 to 8 m (20 to 25 ft) bgs. The concentrations of TCE in RGA groundwater 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.

Soil sampling conducted at the site indicates that TCE contamination is confined to an area of approximately 558 m^2 (6,000 ft^2), with the concentrations of TCE within the impacted area averaging 84 ppm. The sampling results indicate that TCE has migrated below the water table into the UCRS to a depth of approximately 14 m (45 ft), but it has not fully penetrated through the clay aquitard at the unit; therefore, TCE contamination does not appear to have reached the RGA at SWMU 91.

The only organic compound detected at high levels in soil samples from SWMU 91 is TCE. However, other organic compounds have been detected, at low concentrations, in shallow (UCRS) and deep (RGA) groundwater at this unit. Those detected in UCRS groundwater samples include 1,1,1-TCA; *cis*-1,2-DCE; tetrachloroethene (PCE); 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-DCE and two likely lab contaminants, bis(2-ethylhexyl)phthalate and carbon disulfide, have been detected at low levels in RGA groundwater 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.

Six metals (aluminum, antimony, cadmium, chromium, iron, and manganese) have been detected at elevated concentrations in unfiltered groundwater samples from the unit. Of these metals, three (aluminum, iron, and manganese) were detected above regulatory limits in filtered UCRS groundwater samples and one (manganese) was detected above regulatory limits in filtered RGA groundwater samples. Two metals, cobalt and vanadium, were detected once at levels exceeding the PGDP background values in subsurface soil samples collected from H003. This limited occurrence of metals in the groundwater and soils indicates that SWMU 91 likely is not a significant source of metals contamination.

One radionuclide, ^{99}Tc, has been detected in UCRS and RGA groundwater samples from SWMU 91. With the exception of one reported, and likely erroneous, value of 336 pCi/L from MW160, the levels of ^{99}Tc detected at the unit are generally near the analytical quantification limit of 25 pCi/L. The low activities detected in groundwater and the absence of ^{99}Tc from soil samples at the unit indicate its presence is likely related to more general plant activities rather than to past activities at this SWMU.

Contaminant Fate and Transport

The principal organic compound detected at the site is TCE. In groundwater, TCE is transported in dissolved phase primarily by advection and mechanical dispersion. Processes such as hydrolysis, biodegradation, and bioaccumulation are not as significant to the fate of TCE in groundwater. The presence of low permeability soils and the discontinuous nature of the coarser-grained materials of the shallow deposits at SWMU 91 restrict lateral groundwater flow within the UCRS.

TCE usually is fairly stable in groundwater, although degradation to other chlorinated organics may occur at a slow rate. The breakdown products of TCE detected at the unit include *cis*-1,2-DCE and TCA. Under anaerobic conditions, TCE will biodegrade first to DCE and eventually to vinyl chloride. The physical and chemical properties of the TCE degradation products are similar to those discussed for TCE.

Screening modeling conducted in support of risk assessments at SWMU 1 provide information concerning contaminant fate and transport at the unit. Contaminant transport modeling was conducted to simulate vertical transport of TCE from SWMU 91 to the RGA beneath the unit and horizontal transport within the RGA to the plant perimeter fence. The input parameters and assumptions used in the models are 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* (DOE 1996b). Results of the modeling indicate that TCE from the shallow soils at SWMU 91 eventually will reach the RGA and migrate to the PGDP security fence at levels exceeding the MCL (5 µg/L).

DNAPL at SWMU 91

TCE has the potential to be transported in the form of DNAPL. DNAPL transport behavior is highly dependent upon lithology and stratigraphic dip, as well as groundwater gradient. After a spill, DNAPLs continually can volatilize or percolate downward into underlying sediments under the influence of gravity. Lateral spreading occurs due to capillary forces and subsurface heterogeneities, with some residual liquid remaining trapped in the soil by surface tension. When TCE reaches sufficient volume to overcome the capillary forces, it will penetrate a layer and continue to sink until a relatively impermeable layer is encountered. Upon reaching the low permeability layer, these DNAPL pools may migrate slowly in the direction of the dip or groundwater flow. The pools will dissolve slowly into the groundwater and, through dispersion and advection processes, can cause contamination of the aquifer downgradient from the pools.

The presence of TCE in shallow subsurface soils at concentrations up to 1,523 mg/kg supports the contention that DNAPL is present within the UCRS at SWMU 91. Conservative site-specific estimates provided by DuPont indicate that concentrations of TCE in soil greater than 220 mg/kg are indicative of DNAPL at SWMU 91 (DuPont 1997). Because of the heterogeneity of the sediments beneath SWMU 91, the distribution of DNAPL is highly variable. Sampling results indicate that TCE DNAPL has not migrated from the UCRS to the RGA at the unit; the layer of clay at the base of the UCRS provides a confining layer between the shallow gravel unit and the underlying RGA.

Previous Remedial Actions

In 1993, SWMU 91 was selected as the site of an innovative technology demonstration. The technology, known as Lasagna™, is an *in situ* technology that uses electro-osmosis to move shallow groundwater and contaminants in fine-grained or clayey soils. Contaminants are treated by passing contaminated groundwater through in-ground treatment cells designed to degrade TCE chemically to nontoxic end products. An initial 120-d demonstration (Phase I), conducted between January and May 1995, resulted in a 98.4% reduction of TCE levels in soils within a treatment area approximately 3.0 m × 4.6 m (10 ft × 15 ft) and 4.6 m (15 ft) deep. Sampling and analytical results documenting the Phase I study are reported in the Preliminary Site Characterization Report (DOE 1996b). The success of the Phase I demonstration led to a full-scale demonstration (Phase IIA) that was conducted from August 1996 through July 1997. The Phase IIA demonstration was carried out on an area approximately 6.4 m × 9.1 m (21 × 30 ft) and approximately 14 m (45 ft) deep. During the second phase of the technology demonstration, the average TCE concentration in the demonstration area soil was reduced by 95%. Post-test soil sampling conducted for the Phase IIA demonstration indicated that cleanup effectiveness of TCE ranged from 50% to 140%. The results of the Phase IIA are discussed further in the Lasagna™ Summary Report (DOE 1996b).

The DOE selected Lasagna™ for full-scale remediation in the SWMU 91 Record of Decision (ROD) issued by the DOE, with EPA approval and KDEP concurrence, September 1998. The ROD identified the selected remedy, outlined the performance objectives, and provided rationale for the remedy selection. The remedy consisted of treatment of contaminated soil pore water by the Lasagna™ electroosmosis technology. It focuses on the TCE contamination present in the shallow (<14 m, 45 ft, bgs) soils at SWMU 91. The specific components of the selected remedy included the following.

- 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 (DOE 1998a).

Full-scale operations began in October 1999. The Lasagna™ system will operate for 2 years in an attempt to meet cleanup objectives specified in the ROD. If, after 2 years, the technology does not meet its objectives, the system may operate an additional 24 months. The ROD included a contingency action to implement *in situ* enhanced soil mixing to remediate the unit in the event that the Lasagna™ technology is incapable of achieving established cleanup objectives. Additional information regarding the selected remedy is presented in the ROD for SWMU 91 (DOE 1998a).

3.2.4.3 SWMU 196

Location and Description

The C-746-A Septic System (SWMU 196) is located inside the PGDP security fence in the northwest portion of the plant. This SWMU consists of two underground, out-of-service septic systems, one at the northeast corner and the other at the northwest corner of the C-746-A North Warehouse Building (Fig. 3.25).

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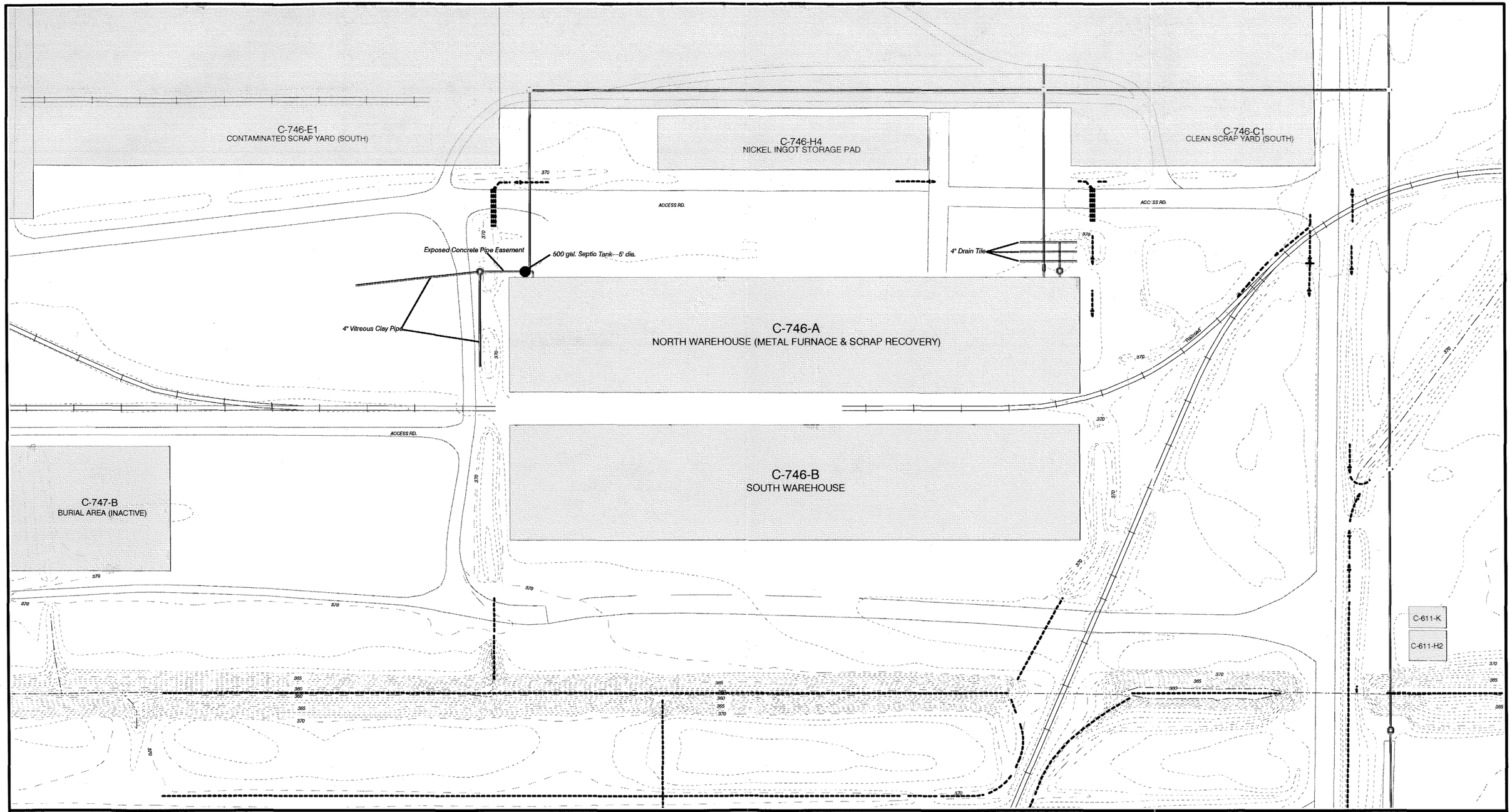

Paducah DSR Scan 3.25

Legend

- 5 foot Elevation Contours
- 1 foot Elevation Contours
- Sanitary Sewer
- Storm Sewer
- Surface Water Drainage

N

50 0 50 100 Feet

Scale 1:1200

JACOBS ENGINEERING

Fig. 3.25. Location of the C-746-A Septic System.

Paducah Gaseous Diffusion Plant
Paducah, Kentucky

NZehms 9/23/99 swmu196_samp.apr

On the northeast corner of the building, the septic system consists of a 3,634-liter (960-gal) concrete septic tank that flows to a 18.3 by 6.1 m (60 by 20 ft) leach field. The septic tank is rectangular and is approximately 1-m (40-in.) wide, 2.1-m (84-in.) long, and 1.7-m (66-in.) deep. The leach field consists of 10-cm (4-in.) vitreous clay drain tiles lying in shallow soils.

On the northwest corner of the C-746-A Building, the septic system consists of a 1,893-liter (500-gal) cylindrical, concrete septic tank [approximately 1.5-m (5-ft) in diameter by 1.0-m (3.4-ft) deep] connected to a sanitary sewer system. A subsurface vitreous clay pipeline extends from the septic tank to a junction box located 14.3 m (47 ft) west of the tank. (As further discussed below, a portion of this line and the junction box was destroyed in 1982 as a result of regrading the western drainage ditch.) From the junction box, sanitary wastes flowed into two 10-cm (4-in) vitreous clay pipelines buried 0.3 to 0.6 m (1 to 2 ft) bgs. One pipe extends 30.5 m (100 ft) to the south and the other extends 39.6 m (130 ft) to the west.

Setting

The following subsections describe the topography, surface-water features, ecological resources, soils, geology, and hydrogeology at SWMU 196. The information presented is primarily derived from the *Remedial Investigation Report for Waste Area Group 27 at the Paducah Gaseous Diffusion Plant* (DOE 1999b).

Topography. The ground surface at SWMU 196 is relatively flat and ranges from 112 to 113 m (368 to 371 ft) amsl. Most of the area overlying the sewage systems is covered with grass that is maintained by regular mowing. However, a portion of the northwest sewage system is covered by a gravel access road located approximately 12.2 m (40 ft) west of the C-746-A Building. A north–south drainage ditch collects surface runoff from the western portion of the SWMU, eventually discharging through KPDES Outfall 001 to Bayou Creek.

Wetlands and floodplains. Jurisdictional wetlands identified in the vicinity of SWMU 196 are limited to the perimeter drainage ditches. No 100-year floodplains are adjacent to SWMU 196.

Ecological and cultural resources. Henry silt loam is the predominant soil type at SWMU 196. Vegetation at SWMU 196 is mowed grass but due to its location in the industrialized area inside the plant security fence, this small area provides very little to no wildlife habitat. No potential habitats for federally listed T&E species are present within the fence (CDM Federal 1994). No properties inside the fence at the PGDP currently are included on, or nominated for inclusion on, the NRHP. Additionally, the State Historic Preservation Officer (SHPO) has concurred with the determination that the subsurface area inside the fence previously has been disturbed and, consequently, is not likely to contain any undisturbed sites of archaeological significance.

Manufacturing or TSD Processes

The C-746-A Building was originally used as a warehouse during plant construction in the early 1950s. From 1956 to 1985, an aluminum smelter was operated in the west end of the building and from 1975 to 1985, a nickel smelter operated in the east end of the building. Current operations include the storage of hazardous and PCB wastes. There is a potential for metal (particularly aluminum and nickel) and radiological contamination in the septic systems as a result of these activities. In addition, the potential exists for TCE releases through the septic systems or through an unrecorded spill of TCE in the C-746-A Warehouse area.

The northeast septic system was in operation from April 1958 until February 1980. It originally processed sanitary waste from a toilet, a urinal, a bathroom floor drain, and a bathroom sink in the C-746-A Building.

Modifications made in August 1975, when a change house and break area were added to the area as part of a nickel smelter operation in the east end of the C-746-A Building, resulted in the processing of additional sanitary waste from a kitchen sink, a water cooler, two showers, a second urinal, and the change house floor drains. The northwest septic system was in operation from November 1956 until February 1980. This system processed sanitary waste from a toilet, two showers, a sink, and a water cooler installed shortly after construction of the aluminum smelter operation. In 1980, both septic systems were plugged and abandoned in place when the C-746-A Building was tied into the C-615 Sewage Treatment Plant system.

In 1982, regrading of a drainage ditch on the west side of the C-746-A Building resulted in the destruction of the junction box and approximately 8 m (25 ft) of the vitreous clay pipe in the northwest septic system. At the time of abandonment in 1980 some sanitary waste was left in the 10-cm (4-in.) line at a location approximately 8.5 m (28 ft) downgradient (west) of the septic tank. These wastes may have been released to the sediments of the drainage ditch as a result of the regrading activities. However, since the septic system was plugged in 1980 as part of the abandonment activities, this is not a continuing release into the ditch.

Summary of Previous Investigations at SWMU 196

The following subsections describe the previous sampling activities conducted at SWMU 196 and provide summaries of the nature and extent of contamination, contaminant fate and transport, and previous risk assessments at the unit. The information presented is primarily derived from the *Remedial Investigation Report for Waste Area Group 27 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1999b) and the *Final Report for WAG 15, C-200-A UST and C-710-B UST, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1996c).

Overview of Previous Investigations and Sampling Activities

The following investigations and sampling activities have been conducted at SWMU 196:

- Soil sampling to investigate SWMU 139, an abandoned underground storage tank (UST) formerly used for fuel oil storage located northwest of the C-746-A North Warehouse Building;

- Geophysical surveys conducted in 1996 and 1998 in support of the WAG 15 investigation and WAG 27 RI, respectively; and

- WAG 27 RI sampling activities, which included the collection of sludge samples from the two septic tanks (three samples from each tank) and the collection of surface soil and subsurface soil samples from 15 locations adjacent to the northeast and northwest septic systems.

The sampling conducted in 1996 for the WAG 15 investigation at SWMU 139 consisted of subsurface soil sampling at six stations (139-002 through 139-007) that are located within the boundaries of the northwest septic system leachfield. In addition, a composite of three shallow soil samples (139-001-1 through 139-001-3) was taken along the UST pipeline, located immediately adjacent to the northwestern corner of the C-746-A Building. No borings extended beneath a depth of 3 m (10 ft). A surface geophysical survey (EM-61) was conducted near the northwest corner of the C-746-A Building to determine if an additional UST (SWMU 140) was located west of the SWMU 139 UST (DOE 1996c). All previous sampling locations in the SWMU 196 area, including the WAG 15 site evaluation sampling points, are shown on Fig. 3.26.

The WAG 27 sampling activities included surface and subsurface soil sampling at seven stations adjacent to the drain tiles and the tank in the northeast septic system and at six stations adjacent to the vitreous

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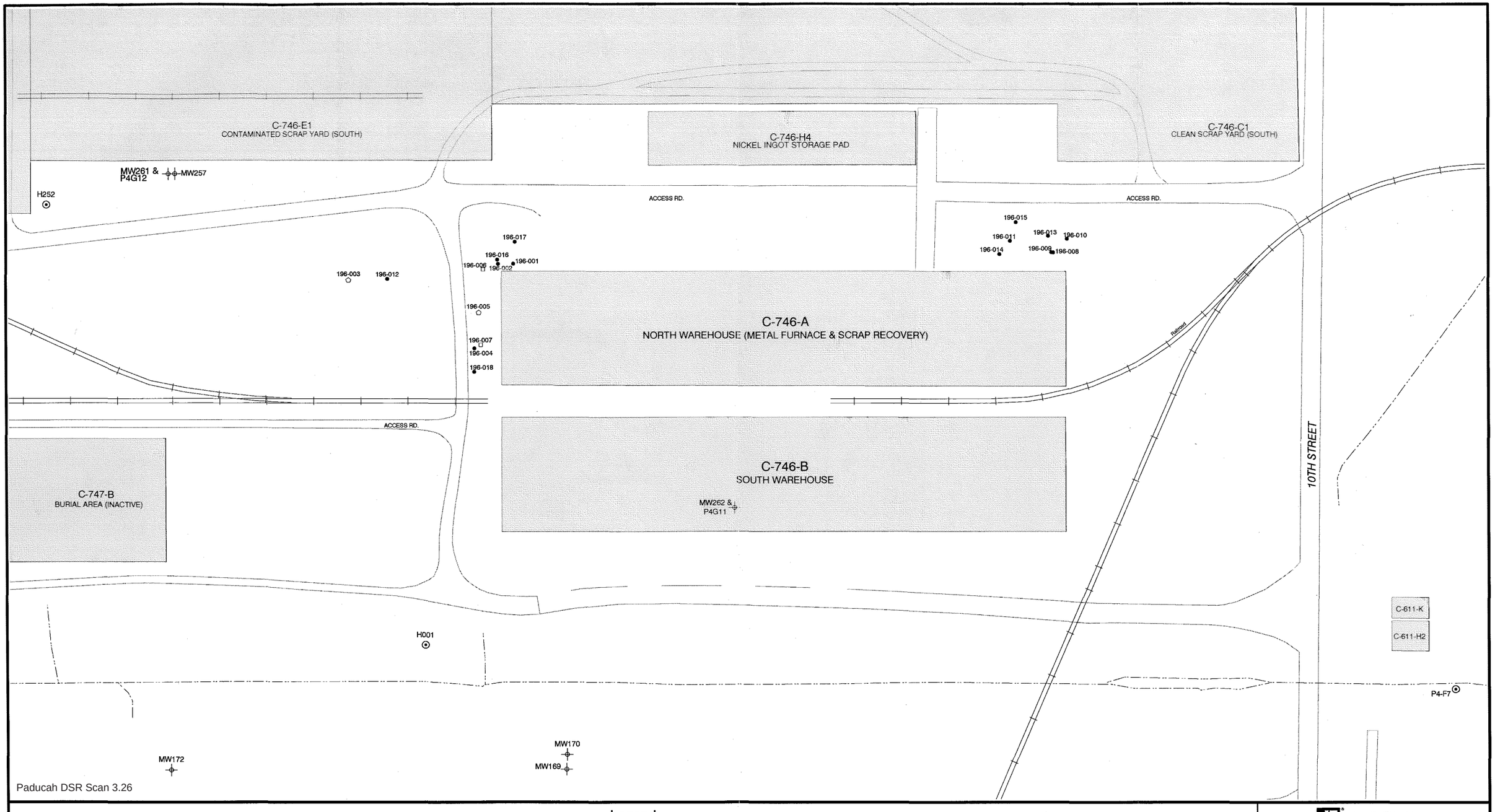

Legend

- Surface Water Drainage
- Sediment Sample
- Cone Penetrometer Test (CPT) Boring
- UCRS Boring
- Soil Boring
- Monitoring Well

N

50 0 50 100 Feet

Scale 1:1200

JACOBS ENGINEERING

Fig. 3.26. Sampling locations at the WAG 15 site.

Paducah Gaseous Diffusion Plant
Paducah, Kentucky

NZehms 9/23/99 swmu196_samp.apr

clay pipes in the northwest septic system. The subsurface soil samples were taken continuously at 0.6-m (2-ft) intervals to varying depths down to 6 m (20 ft) bgs. In addition, two sediment samples (at 196-006 and 196-007) were collected along the north–south trending pipeline in the northwest septic system. One of these sediment sampling stations (196-006) was located between the septic tank and the destroyed clay line to assess the potential impact of any remaining sanitary wastes in the abandoned septic system upgradient of the demolished portion of the line. A cone penetrometer test, located at 196-012 adjacent to the east–west trending line in the northwest field, was extended to a depth of 11 m (35 ft) bgs to assess the presence of UCRS groundwater. However, because no water was encountered at the cone penetrometer technology (CPT) point and photoionization detector (PID) screening did not indicate the presence of VOAs, no samples were submitted for VOA analysis.

Geology/Hydrogeology

The hydrogeologic conceptual model for SWMU 196 is shown in Fig. 3.27. Based on lithologic logs for surrounding borings, the following lithologies underlie SWMU 196, in order of increasing depth: gravel and gravelly sand fill [0 to 0.6 m (0 to 2 ft) bgs], loess deposits [0.6 to 4.5 m (2 to 15 ft) bgs], and the Upper Continental Deposits [4 to 32 m (13 to 105 ft) bgs]. No borings have penetrated below 10. 5 m (35 ft) at SWMU 196, but based on boring P4G12, located approximately 91 m (300 ft) northwest of SWMU 196, the Lower Continental Deposits are encountered at a depth of approximately 17.7 m (58 ft) bgs and extend to the top of the McNairy Formation at a depth of 29.6 m (97 ft) bgs. The loess consists primarily of silty clay to clayey silt, with occasional traces of fine sand and gravel. The Upper Continental Deposits are approximately 12.2 m (40 ft) thick and consist of silty or sandy clay with occasional, discontinuous layers of sand or gravel. The Lower Continental Deposits consist of 12.2 to 18.3 m (40 to 60 ft) of gravelly sand or chert gravel.

Nature and Extent of Contamination

The sampling conducted for SWMU 139 during the WAG 15 Site Evaluation provided data concerning concentrations of benzene, toluene, ethylbenzene, and xylenes (BTEX), TCE, PAHs, diesel range organics (DROs) and PCBs in shallow soils at in the northwest septic system. No contaminants of concern (COCs) were found to pose a risk to human health and the environments. However, SWMU 139 will be re-investigated to determine the significance of sporadic detections of low levels of several DRO constituents in several WAG 15 borings and at one WAG 27 boring location (196-002).

Results of the WAG 27 investigation conducted at SWMU 196 indicate the presence of metals contamination in shallow soils (<3 m, 10 ft, bgs) adjacent to both the northeast and northwest septic systems. The area impacted by metals at the northeast system includes a 21 × 18 m (70 × 60 ft) area surrounding the septic tank and leachfield. The areas impacted within the northwest septic system include a 30 × 3 m (100 × 10 ft) area along the north–south trending line and a 55 × 3 m (180 × 10 ft) area along the east–west trending line, west of the septic tank. The metals detected above screening levels (and their maximum detected concentrations) include antimony (121 mg/kg), beryllium (113 mg/kg), cadmium (116 mg/kg), and thallium (114 mg/kg). The results of the soil, sediment, and tank sludge sampling conducted at SWMU 196 are summarized in Table 3.23. Due to the lack of shallow (<15 m, 50 ft, bgs) groundwater at SWMU 196, no water samples were collected at the unit.

Previous Remedial Actions

No previous response actions have been taken at SWMU 196.

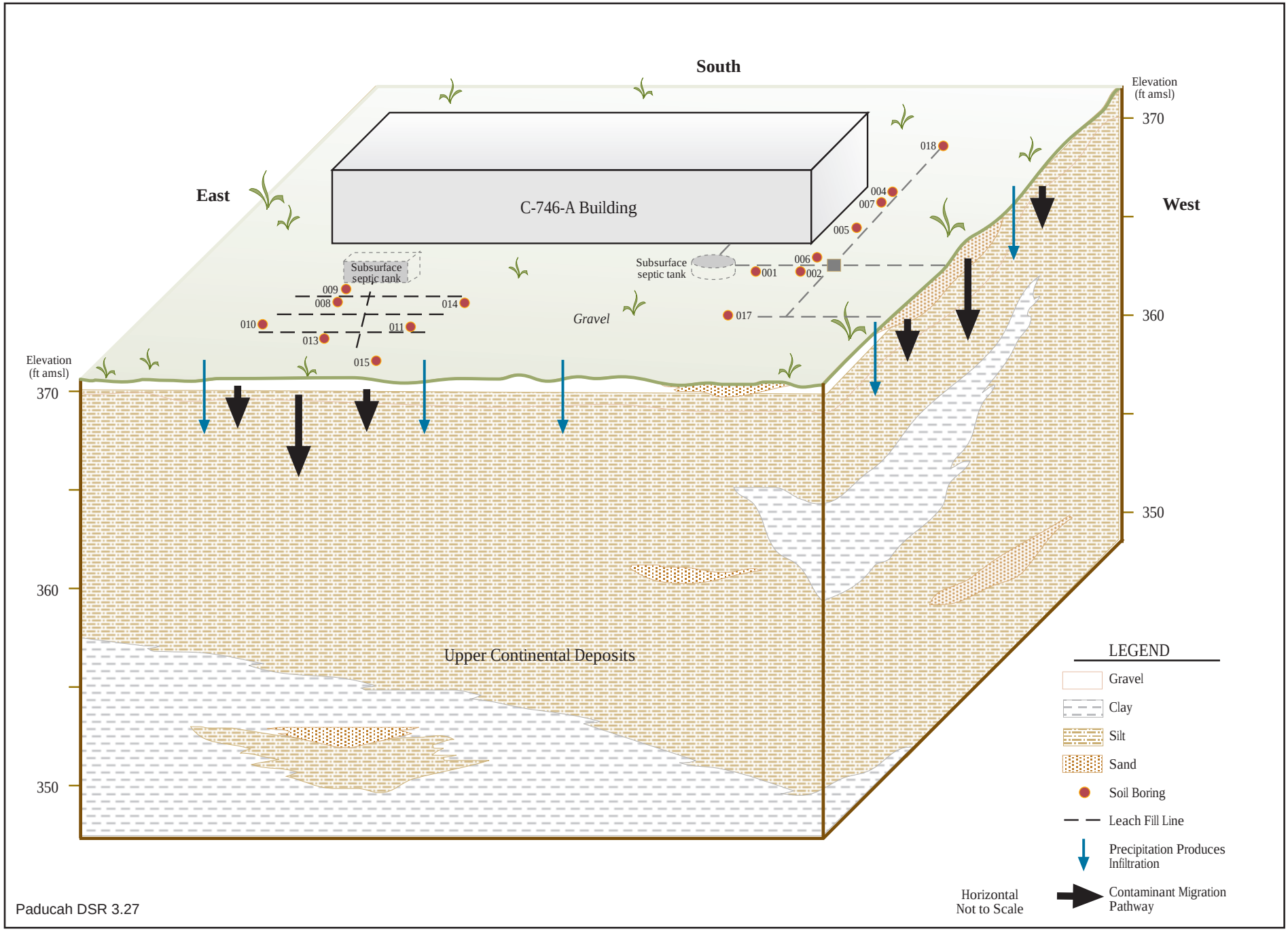

Fig. 3.27. Hydrogeologic conceptual model for SWMU 196.

Table 3.23. Results of Soil, Sediment and Tank Sludge Sampling for SWMU 196

Sample Type	Analytical Group	Analytical Compound	Number of Analyses[a]	Number of Detections above BG[a]	Number of Detections above BG & PRG Screening Values[a]	Maximum Result above BG[a]	Minimum Result above BG[a]	Average Result above BG[a]	Units
Sludge	PCB	Polychlorinated biphenyl	7	3	3	300.000	100.000	200.000	µg/kg
		PCB-1260	1	1	1	200.000	200.000	200.000	µg/kg
	Metals	Mercury	7	7	2	2.140	0.240	0.791	mg/kg
		Nickel	7	6	1	326.000	36.700	122.900	mg/kg
		Cadmium	7	3	3	12.500	6.770	9.483	mg/kg
		Lead	7	3	3	55.100	29.300	38.633	mg/kg
		Selenium	7	3	0	4.820	2.130	3.100	mg/kg
		Silver	7	1	0	21.000	21.000	21.000	mg/kg
	Radioactive isotopes	Technetium-99	7	7	0	40.000	9.600	24.229	pCi/g
		Uranium	7	7	0	10.000	3.500	8.700	pCi/g
		Neptunium-237	7	6	0	0.290	0.070	0.170	pCi/g
		Plutonium-239/240	7	2	0	3.160	0.160	1.660	pCi/g
		Uranium-235	1	1	0	0.640	0.640	0.640	pCi/g
Surface soil	Metals	Cadmium	13	8	0	1.480	0.220	0.754	mg/kg
		Antimony	13	7	7	62.200	0.760	27.937	mg/kg
		Zinc	13	5	0	119.000	67.100	88.960	mg/kg
		Sodium	13	3	3	418.000	331.000	379.000	mg/kg
		Chromium	13	2	0	32.800	17.000	24.900	mg/kg
		Magnesium	13	2	2	10,000.000	9,010.000	9,505.000	mg/kg
		Nickel	13	2	0	172.000	80.100	126.050	mg/kg
		Aluminum	13	1	1	13,800.000	13,800.000	13,800.000	mg/kg
		Calcium	13	1	1	216,000.000	216,000.000	216,000.000	mg/kg
		Copper	13	1	0	25.200	25.200	25.200	mg/kg
		Potassium	13	1	1	1,650.000	1,650.000	1,650.000	mg/kg
	Radioactive isotopes	Uranium	5	1	0	2.500	2.500	2.500	pCi/g
		Uranium-238	5	1	0	1.300	1.300	1.300	pCi/g
Sediment	Metals	Antimony	2	2	0	0.370	0.290	0.330	mg/kg
		Cadmium	2	2	1	2.530	1.830	2.180	mg/kg
		Nickel	2	2	0	73.600	31.700	52.650	mg/kg
		Sodium	2	2	2	423.000	322.000	372.500	mg/kg
		Zinc	2	2	0	222.000	148.000	185.000	mg/kg
		Copper	2	1	0	20.900	20.900	20.900	mg/kg
	Radioactive isotopes	Technetium-99	2	2	0	33.400	12.300	22.850	pCi/g
		Uranium	2	2	0	5.000	3.900	4.450	pCi/g
		Uranium-238	2	2	0	3.100	2.300	2.700	pCi/g
		Neptunium-237	2	1	0	0.680	0.680	0.680	pCi/g
		Plutonium-239/240	2	1	0	0.370	0.370	0.370	pCi/g

Table 3.23. Results of soil, sediment, and tank sludge sampling for SWMU 196 (continued)

Sample Type	Analytical Group	Analytical Compound	Number of Analyses[a]	Number of Detections above BG[a]	Number of Detections above BG & PRG Screening Values[a]	Maximum Result above BG[a]	Minimum Result above BG[a]	Average Result above BG[a]	Units
Subsurface Soil	Metals	Magnesium	78	22	22	5,660.000	2,110.000	2,820.455	mg/kg
		Antimony	78	19	19	121.000	0.830	18.774	mg/kg
		Aluminum	78	17	17	17,900.000	12,100.000	14,535.294	mg/kg
		Calcium	78	16	16	223,000.000	6,290.000	50,061.250	mg/kg
		Zinc	78	15	0	1,650.000	61.700	218.307	mg/kg
		Cadmium	78	11	2	116.000	0.300	11.363	mg/kg
		Barium	78	8	2	389.000	172.000	223.875	mg/kg
		Nickel	78	8	2	587.000	24.700	156.000	mg/kg
		Beryllium	78	7	7	113.000	0.710	16.851	mg/kg
		Potassium	78	5	5	6,430.000	1,080.000	2,438.000	mg/kg
		Sodium	78	5	5	5,920.000	344.000	1,512.800	mg/kg
		Cobalt	78	4	0	112.000	13.800	39.975	mg/kg
		Manganese	78	3	3	1,980.000	855.000	1,401.667	mg/kg
		Thallium	78	3	3	114.000	0.560	38.377	mg/kg
		Vanadium	78	3	3	62.500	37.300	47.867	mg/kg
		Arsenic	78	2	2	8.740	7.990	8.365	mg/kg
		Chromium	78	2	0	112.000	66.000	89.000	mg/kg
		Iron	78	2	2	30,200.000	29,600.000	29,900.000	mg/kg
		Selenium	78	2	0	3.930	2.130	3.030	mg/kg
		Copper	78	1	0	112.000	112.000	112.000	mg/kg
		Lead	78	1	1	116.000	116.000	116.000	mg/kg
		Mercury	78	1	0	0.140	0.140	0.140	mg/kg
		Silver	78	1	1	65.400	65.400	65.400	mg/kg
	Radioactive isotopes	Uranium	25	18	0	5.000	1.600	2.461	pCi/g
		Uranium-238	25	11	0	3.000	1.400	1.850	pCi/g
		Plutonium-239/240	25	3	0	0.190	0.070	0.123	pCi/g
		Americium-241	25	1	0	0.180	0.180	0.180	pCi/g
		Neptunium-237	25	1	0	0.060	0.060	0.060	pCi/g
		Technetium-99	25	1	0	5.000	5.000	5.000	pCi/g

[a]Number of analyses/detections include both environmental samples and duplicate results.

3.2.4.4 C-720 Complex

WAG 27 includes three SWMUs/AOCs associated with the C-720 Complex: SWMU 167 (the C-720 White Room Sump), SWMU 209 (the C-720 Compressor Shop Pit Sump), and AOC 211 (the C-720 TCE Spill Site-Northeast). In addition, WAG 27 includes the backfill areas around major floor drain exit points from the C-720 Building. Figure 3.28 presents the SWMUs and the physical location of the C-720 Complex.

Four additional SWMUs are associated with the C-720 Building but are not addressed in WAG 27. Two of them, SWMU 090 (an underground petroleum naphtha pipe) and SWMU 141 (an inactive TCE degreaser), have been designated as No Further Action (NFA) in the PGDP SMP (DOE 1999c). The remaining two, SWMU 027 (acid neutralization tank) and SWMU 031 (compressor pit storage tank) are being addressed under WAG 9 and WAG 5, respectively.

Location and Physical Description

C-720 Building. The C-720 Maintenance and Stores Building is located in the southwest portion of the fenced security area of the PGDP, southwest of the C-400 Building. It occupies 26,124 m^2 (281,200 ft^2) and consists of several repair and machine shops as well as other support operations. The building was constructed in the early 1950s and is composed of structural steel and corrugated transite siding.

Compressor Shop Pit and Compressor Shop Pit Sump (SWMU 209). The C-720 Compressor Shop Pit is located in the southwest portion of the plant in the east–central part of the C-720 Building. The pit is constructed of concrete and is 9.1-m (30-ft) long by 18.3-m (60-ft) wide by 4.6-m (15-ft) deep. The floor of the pit is sloped toward a central drain at a grade of 0.125 m/m. The Compressor Shop Pit Sump (SWMU 209) is located in the northwest corner of the pit and is constructed of unjointed reinforced concrete with "ironite waterproofing." The sump is 1.2-m (4-ft) wide by 1.2-m (4-ft) long by 2.4-m, 10-cm (8-ft, 4-in.) deep.

A subsurface vitreous clay floor drain surrounds the compressor shop pit and extends outside the eastern exterior wall of the C-720 Building. The drain is 10 cm (4 in.) in diameter and has open joints spaced approximately 1.3 cm (½-in.) apart. The lower portion of the joints is open, allowing drainage into surrounding soils. The floor drain is gravity-sloped downward from east to west, with the lowest elevation being the connection point between the drain and the compressor shop pit sump.

White Room Sump (SWMU 167). The White Room Sump is located in the south–central portion of the C-720 Building. The sump has dimensions of 2.4-m (8-ft) long by 1.8-m (6-ft) wide by 2.4-m (8-ft) deep and is constructed of concrete. Influent to the sump was directed through limestone to neutralize any acids prior to discharging to the building drainage system. This sump was active from the mid-1960s through the mid-1970s as part of the "clean room" operations, which manufactured electric circuit boards for Sandia National Laboratories. The sump is no longer in use and is covered with a metal plate.

C-720 TCE Spill Site-Northeast (AOC 211). During the WAG 27 RI, a large rectangular area impacted by TCE contamination was defined north of the C-720 Building. The area measured 320 × 68 m (1050 × 225 ft) and includes an estimated 133,812 m^3 (4,725,000 ft^3) of VOA-contaminated soil located between 5 and 13 m (17 and 42 ft) bgs. This area has been designated as AOC 211. The maximum TCE concentration measured was approximately 14,000 µg/kg.

Building Drainage System Exit Points. Eight major building drainage system exit points from the C-720 Building have been identified, and all eight discharge to the plant stormwater system. Approximately 150 floor drains are located within the C-720 Building; however, many are currently plugged and a few

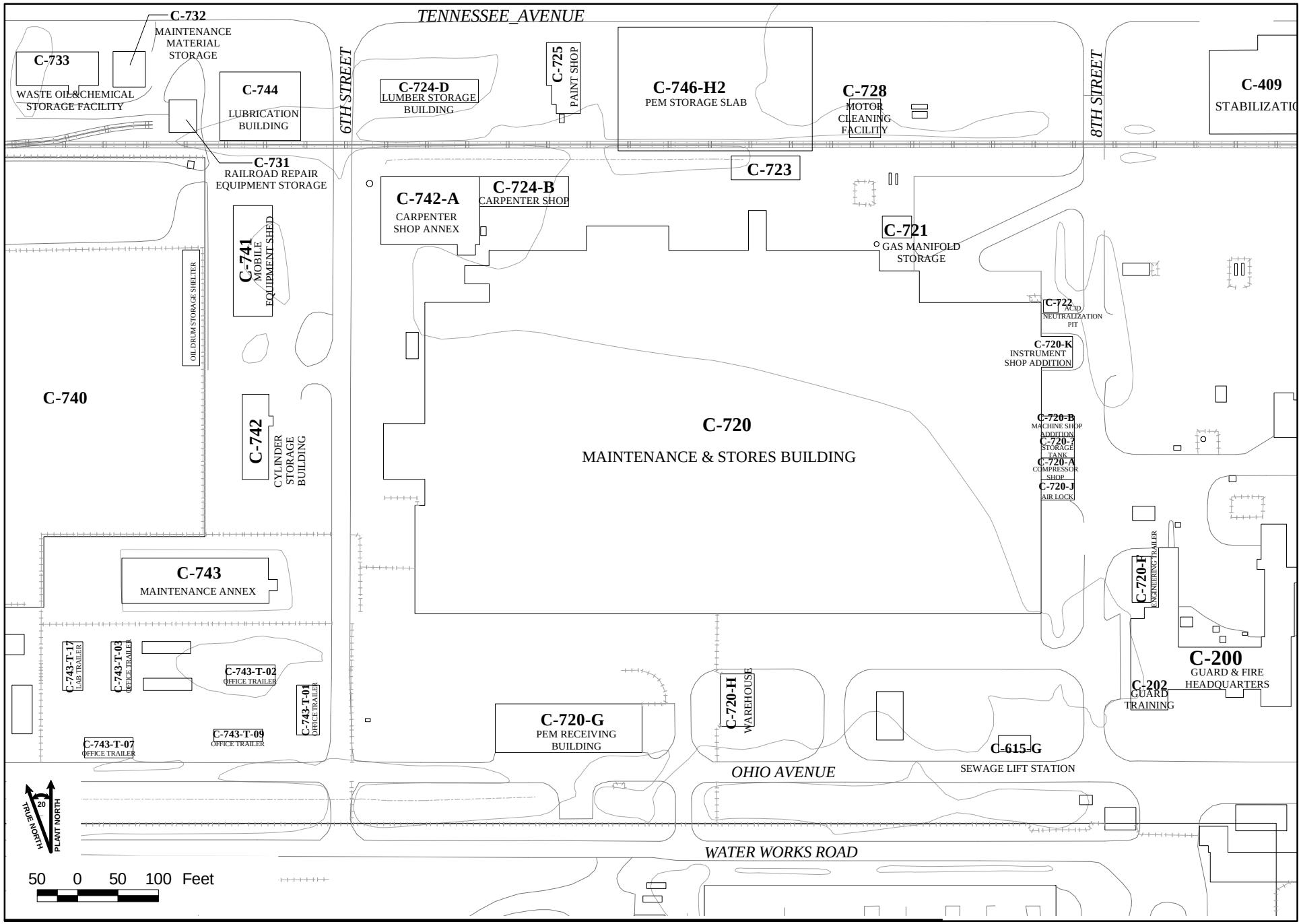

Fig. 3.28. C-720 complex.

are backed up. Although most of the floor drains discharge into the stormwater drainage system, floor drains located in the bathrooms discharge to the sanitary water system, and a few floor drains located in the instrument shop in the northeast portion of the C-720 Building discharge to the acid neutralization pit. Storm sewers are constructed of either reinforced concrete piping or vitreous clay piping.

Setting

The following subsections describe the topography, surface-water features, ecological resources, soils, geology, and hydrogeology at the C-720 Complex. The information presented is primarily derived from the *Remedial Investigation Report for Waste Area Group 27 at the Paducah Gaseous Diffusion Plant* (DOE 1999b).

Surface-water hydrology, wetlands, and floodplains. Most of the area surrounding the C-720 Building is covered by concrete or asphalt. The topography is relatively flat, with elevations ranging from approximately 113 to 115 m (371 to 376 ft) amsl. Drainage from the C-720 Complex is via the PGDP storm drain system that eventually discharges through KPDES Outfalls 008 and 009 to Bayou Creek. No wetlands or 100-year floodplains are located adjacent to the C-720 Building.

Ecological and cultural resources. The C-720 Area is covered by concrete and provides no suitable habitat for ecological receptors. All of the area inside the PGDP security fence has been previously disturbed and, consequently, is not likely to contain any undisturbed sites of archaeological significance. In addition, no properties in the vicinity of the C-720 Building are currently included on, or nominated for inclusion on, the NRHP.

Manufacturing/TSD Processes

C-720 Building. The C-720 Maintenance and Stores Building has been used since the early 1950s for the fabrication, assembling, cleaning, and repairing of process equipment. Various shops housed within the C-720 Building include the compressor shop, machine shop, paint shop, instrument shop, vacuum pump shop, welding shop, and valve shop. Based on practices performed in these shops, the potential contaminants associated with the C-720 Building include VOAs, SVOAs, metals, PCBs, and radionuclides.

Compressor Shop Pit and Compressor Shop Pit Sump. Housed within the C-720 building is the Compressor Shop pit and SWMU 209, the Compressor Shop pit sump. The major releases associated with this area are subsurface leaks from the subterranean drain located near the Compressor Shop pit. Historically, fluids drained from compressors in the shop were directed into the compressor trench, which is located to the west of the Compressor Shop pit. A floor drain located in the compressor trench drains by gravity from west to east into the Compressor Shop pit. The release potential from the Compressor Shop was determined to be high due to the design of the subterranean drain surrounding the pit. The drain was used as a discharge mechanism in the event that the sump pump located in the northwestern portion of the pit failed to operate. Based on the design of the drain lines, liquids that accumulated in the Compressor Shop pit sump during pump failure would discharge to the surrounding soils via this drain line. Potential contaminants associated with the Compressor Shop included VOAs, primarily TCE and its degradation products, SVOAs, PCBs, metals, and radionuclides. This area is still in use on a minimal basis for compressor reworking.

White Room Sump (SWMU 167). The White Room was used to build and clean circuit boards. Waste solutions associated with printed circuit board operations were discharged to the sump, flushed through limestone to neutralize acids, and ultimately discharged to the building drainage system. Wastes associated with processes performed in this area include TCE, cyanide, gold, silver, tin, lead, and chromium.

The sump is no longer in use, and the sludge in the sump was sampled to determine whether any potential health hazard existed if the sump were to remain unfilled. PCBs were detected in the sludge at concentrations ranging from 1.8 to 2.5 mg/kg. Based on available data, the integrity of the sump itself has not been established. The release potential from the White Room sump was considered low. Any analytes of concern that would have been processed through the White Room sump would have been discharged to the building drainage system. The potential contaminants for the White Room sump are primarily metals, VOAs, and radionuclides.

C-720 TCE Spill Site-Northeast (AOC 211). An area located north of the east end of the C-720 Building was identified during the field investigation as having a moderately high release potential. Based on interviews with former employees, routine equipment cleaning and rinsing was performed in that area. Solvents were used to clean parts, and the excess solvent was discharged on the ground. TCE, its degradation products, and metals are the primary analytes of concern in this area.

Building Drainage System Exit Points. A thorough blueprint review and a process history review of general activities performed in the C-720 Building were conducted for the WAG 27 RI. The findings suggest that the backfill areas in the vicinity of the building drainage system exit points, as they connect to the storm sewer system, are potential release pathways of contaminants to the subsurface. Several maintenance and repair operations were performed in the C-720 Building, and the major discharge location for wastewater from these processes was through the floor drains located throughout the building. Based on the construction of the drains, the connecting joints from the drainage system to the storm sewer system are considered to be the most likely source of a release. TCE, radionuclides, mineral spirits, and various other electrical cleaning fluids have reportedly been discharged through the stormwater or sanitary water drains within the C-720 Building. Mercury that was used as part of the C-720 Building process was routed through an acid drain line to a building sump prior to discharge.

Previous Remedial Actions

No previous remedial actions have been taken at the C-720 Complex.

Summary of Previous Risk Assessments

The summary presented in this section was taken from *Remedial Investigation for Waste Area Grouping 27 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (Volume IV. Baseline Risk Assessment) (DOE 1999b). Specifically, the Executive Summary and Chapter 1.7 of the WAG 27 BRA contains the pertinent risk information that will be repeated here. This document provides information on the baseline risks posed to human health and the environment from contamination at WAG 27 that will be used to support the need for remedial action in WAG 27 and to assist in the selection of the remedial alternatives.

According to the Executive Summary of the WAG 27 BRA:

> In 1998, the U.S. Department of Energy (DOE) conducted a Remedial Investigation/Resource Conservation and Recovery Act Facility Investigation for Waste Area Grouping (WAG) 27. WAG 27 includes Solid Waste Management Units (SWMUs) 1, 91, 196, and the C-720 Area at the Paducah Gaseous Diffusion Plant (PGDP) in Paducah, Kentucky. The overall purpose of this activity was to determine the presence, nature, and extent of contamination at SWMUs 1, 91, 196, and areas associated with the C-720 Area. The primary focus of the remedial investigation was to collect sufficient information about surface soil, subsurface soil, surface water, sediment and the shallow groundwater of the Upper Continental Recharge System (UCRS) contamination to support an assessment of risks to human health and the environment and the selection of actions

to reduce these risks. In addition, contamination in the Regional Gravel Aquifer (RGA) and McNairy Formation was characterized to determine if contamination in the RGA acted as a secondary source of contamination to groundwater. The SWMUs that were assessed for risk to human health and the environment were: SWMUs 1, 91, 196, and the areas associated with the C-720 Area.

To facilitate data aggregation and to focus results on specific areas, this baseline risk assessment derives risk estimates for the following SWMUs or areas. The SWMUs and areas and their definitions are as follows:

- SWMU 1–the C-747-C Oil Land Farm.
- SWMU 91–the UF_6 Cylinder Drop Test Area.
- SWMU 196–the C-746-A Septic System.
- C-720 Area (includes SWMU 209 - the compressor pit sump).

Consistent with regulatory guidance and agreements contained in the approved human health risk assessment methods document, the BHHRA was used to evaluate scenarios that encompass current use and several hypothetical future uses of the WAG 27 SWMUs and the areas to which contaminants from the WAG 27 SWMUs may migrate. The scenarios assessed are as follows.

- Current on-site industrial—direct contact with sediment and surface soil (soil found 0 to 0.3 m, 0 to 1 ft, bgs).

- Future on-site industrial—direct contact with sediment, surface soil, and use of groundwater drawn from aquifers below the WAG 27 SWMUs.

- Future on-site excavation scenario—direct contact with surface soil combined with subsurface soil (soil found 0 to 5 m, 0 to 15 ft, bgs).

- Future on-site recreational user—direct contact with sediment and consumption of game exposed to contaminated surface soil.

- Future off-site recreational user—direct contact with surface water impacted by contaminants migrating from sources and consumption of game exposed to this surface water.

- Future on-site rural resident—direct contact with surface soil at and use of groundwater drawn from aquifers below the WAG 27 SWMUs, including consumption of vegetables that were posited to be raised in this area.

- Future off-site rural resident—use in the home of groundwater drawn from the RGA at the DOE property boundary.

This report also contains a BERA for nonhuman receptors that may come into contact with contaminated media at or migrating from sources in the WAG 27 area. As with the BHHRA, the BERA utilizes information collected during the recently completed remedial investigation.

Major conclusions and observations of the BHHRA and BERA are presented below.

General

- For all SWMUs, the cumulative human health excess lifetime cancer risk (ELCR) and systemic toxicity exceed the accepted standards of EPA and KDEP for one or more scenarios when assessed

using default exposure parameters. The scenarios for which risk exceeds *de minimus* levels (i.e., a cumulative excess lifetime cancer risk of 1×10^{-6} or a cumulative hazard index (HI) of 1) are summarized in Table 3.24. This information is taken from the risk summary tables located at the end of the Executive Summary of the BRA which present the cumulative risk values for each scenario, the contaminants of concern (COCs), and the pathways of concern (POCs).

- Because the WAG 27 SWMUs are located in the industrialized portion of the PGDP, the BERA project team concluded during problem formulation that it would not be appropriate to derive risk estimates for impacts to nonhuman receptors under current conditions. However, an analysis to determine potential impacts to nonhuman receptors exposed to contaminants in surface soil or ditch sediment in the future, if the industrial infrastructure was removed, and to estimate the potential impact of surface migration of contaminated media was performed. Because contaminants at the C-720 Area and SWMU 91 are restricted to subsurface soils below gravel- or cement-covered areas, effectively eliminating potential exposure, the BERA project team concluded that it would not be appropriate to derive risk estimates for nonhuman receptors to contaminants in surface soil at these two sites. Surface soils at SWMU 1 have already been evaluated and addressed as part of the WAG 23 ROD, so they are not reevaluated for SWMU 1 here. Several contaminants in surface soil from SWMU 196 and sediments in drainage ditches associated with SWMUs 1, 91, and 196 were found to be at concentrations greater than levels protective of nonhuman receptors. Summary tables of the risk assessment done for the WAG 27 BRA are presented here. Table 3.24 presents the land uses of concern found in Table ES.2 of the WAG 27 BRA. Tables 3.25 through 3.28 present the risk results and the quantitative risk summaries found in Exhibits 1.64a through 1.65b of the WAG 27 BRA.

  Chapter 1.7 of the WAG 27 BRA provides the following explanation of the risk summary tables.

  > To summarize the effect that multiple uncertainties have upon the risk estimates for the most likely current and future use at the WAG 27 SWMUs, Exhibits 1.64 and 1.65 were prepared. Exhibit 1.64 presents a quantitative comparison between ELCR estimates as various uncertainties are addressed. Exhibit 1.65 presents the same information for systemic toxicity. Specific uncertainties addressed in these exhibits are use of the provisional lead RfD (Exhibit 1.65 only), use of site-specific exposure values, use of EPA dermal absorption defaults, and inclusion of analytes that are infrequently detected. These exhibits do not include common laboratory contaminants because the effect of this uncertainty was imperceptible for each SWMU. In addition, the last column in each exhibit presents the total risk that results when several uncertainties are addressed simultaneously. The risks in this column were calculated using site-specific exposure assumptions, and the EPA default dermal absorption values, but omitting infrequently detected contaminants of potential concern (COPCs). Note, the intent of the information in this column is to provide a rational, quantitative lower-bound risk estimate for the industrial worker at each location that can be used by risk managers when making remedial decisions. The results in this column, and the exhibit in general, are not meant to indicate which risks are real for the WAG 27 SWMUs.
  >
  > As shown in Exhibit 1.64a, the ELCR estimates calculated for the current industrial worker, using the default exposure rates (column 1), vary from the lower-bound estimates (last column). Generally, the decrease in ELCR is about one order of magnitude. Indeed, in all cases, the lower-bound estimate is close to the *de minimus* level established in the Methods Document (i.e., ELCR = 1×10^{-6}). Interestingly, the intermediate columns in the table indicate that using the EPA default dermal absorption values is the one uncertainty that accounts for most of the decrease in ELCR.

Table 3.24. Land uses of concern for WAG 27 BRA

(formerly "Table ES.2. Scenarios for which human health risk exceeds de minimus levels")

Scenario	Location			
	SWMU 1	**SWMU 91**	**SWMU 196**	**C-720 Area**
Results for excess lifetime cancer risk[a]:				
Current On-Site Industrial Worker				
Exposure to Soil	NA	NA	X	NA
Exposure to Sediment	X	X	X	NA
Future On-Site Industrial Worker				
Exposure to Soil	NA	NA	X	NA
Exposure to Sediment	X	X	X	NA
Exposure to Groundwater[b]	X	X	—	X
Future On-Site Excavation Worker				
Exposure to Soil	X	X	X	X
Future On-Site Recreational User				
Exposure to Game	NA	NA	—	NA
Exposure to Sediment	X	X	X	NA
Future Off-Site Recreational User				
Exposure to Surface Water	—	—	—	—
Future On-Site Rural Resident				
Exposure to Soil	NA	NA	X	NA
Exposure to Groundwater[b]	X	X	—	X
Future Off-Site Rural Resident				
Exposure to Groundwater[c]	X	X	X	X
Results for systemic toxicity[a]:				
Current On-Site Industrial Worker				
Exposure to Soil	NA	NA	—	NA
Exposure to Sediment	X	X	X	NA
Future On-Site Industrial Worker				
Exposure to Soil	NA	NA	—	NA
Exposure to Sediment	X	X	X	NA
Exposure to Groundwater[b]	X	X	—	X
Future On-Site Excavation Worker				
Exposure to Soil	X	X	X	—
Future On-Site Recreational User				
Exposure to Game	NA	NA	—	NA
Exposure to Sediment	X	X	X	NA
Future Off-Site Recreational User				
Exposure to Surface Water[c]	—	—	—	—
Future On-Site Rural Resident				
Exposure to Soil	NA	NA	X	NA
Exposure to Groundwater[b]	X	X	—	X
Future Off-Site Rural Resident				
Exposure to Groundwater[c]	X	X	X	X

Notes: Scenarios where risk exceeded the benchmark levels are marked with an X. Scenarios where risk did not exceed a benchmark level are marked with a —. NA indicates that the scenario/land use combination is not appropriate.

[a] For the future recreational user and the future on-site resident, the child results are used.

[b] The BHHRA assessed risks from use of water drawn from the RGA separately from use of water drawn from the McNairy Formation. The value reported here is for use of water from the RGA.

[c] Based on results of contaminant transport modeling. X indicates that the location contains one or more sources of off-site contamination that exceeded benchmark levels and — indicates that the location is not a source of off-site contamination.

Table 3.25. Summary of risk results and uncertainties for the current industrial worker ELCR for WAG 27

(formerly "Exhibit 1.64a. Quantitative summary of uncertainties for the current industrial worker–excess lifetime cancer risk")

Location	Default ELCR[a]	Site-specific ELCR[b]	Default ELCR minus common laboratory contaminants[c]	Default ELCR calculated using EPA default dermal absorption values[d]	Default ELCR minus analytes infrequently detected[e]	Lower-bound ELCR[f]
SWMU 1 (sediment)	1.3×10^{-4}	8.3×10^{-6}	1.3×10^{-4}	2.7×10^{-5}	1.3×10^{-4}	1.6×10^{-6}
SWMU 91 (sediment)	5.8×10^{-4}	3.7×10^{-5}	5.8×10^{-4}	4.7×10^{-4}	5.8×10^{-4}	3.0×10^{-5}
SWMU 196 (sediment)	8.7×10^{-5}	8.7×10^{-5}	8.7×10^{-5}	1.1×10^{-5}	8.7×10^{-5}	9.3×10^{-6}
SWMU 196 (soil)	4.8×10^{-6}	4.8×10^{-6}	4.8×10^{-6}	4.8×10^{-6}	4.8×10^{-6}	4.8×10^{-6}

Notes:
[a] These values are identical to the values presented in Exhibit 1.27.
[b] These values are identical to the values presented in Exhibit 1.62.
[c] These values are identical to the values presented in Table 1.110.
[d] These values are identical to the values presented in Exhibit 1.61.
[e] These values are identical to the values presented in Table 1.108.
[f] These values were derived using site-specific exposure rates for general maintenance workers at PGDP (see Subsect. 1.6.2.5) and EPA default dermal absorption values and omitting contributions from common laboratory contaminants and infrequently detected analytes.

Table 3.26. Summary of risk results and uncertainties for the future industrial worker ELCR for WAG 27

(formerly "Exhibit 1.64b. Quantitative summary of uncertainties for the future industrial worker–excess lifetime cancer risk")

Location	Default ELCR[a]	Site-specific ELCR[b]	Default ELCR minus common laboratory contaminants[c]	Default ELCR calculated using EPA default dermal absorption values[d]	Default ELCR minus analytes infrequently detected[e]	Lower-bound ELCR[f]
SWMU 1 (RGA)	1.9×10^{-3}	1.9×10^{-3}	1.9×10^{-3}	1.9×10^{-3}	1.9×10^{-3}	1.7×10^{-3}
SWMU 91 (RGA)	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	9.6×10^{-4}
C-720 (RGA)	6.0×10^{-4}	6.0×10^{-4}	6.0×10^{-4}	6.0×10^{-4}	5.9×10^{-4}	5.3×10^{-4}

Notes:
[a] These values are identical to the values presented in Exhibit 1.37.
[b] These values are identical to the values presented in Exhibit 1.62.
[c] These values are identical to the values presented in Table 1.110.
[d] These values are identical to the values presented in Exhibit 1.61.
[e] These values are identical to the values presented in Table 1.108.
[f] These values were derived using site-specific exposure rates and default EPA dermal absorption rates and omitting contributions from common laboratory contaminants and infrequently detected analytes.

Table 3.27. Summary of risk results and uncertainties for the current industrial worker systemic toxicity for WAG 27

(formerly "Exhibit 1.65a. Quantitative summary of uncertainties for the current industrial worker–systemic toxicity")

Location	Default HI[a]	Default HI w/o lead[b]	Site-specific HI w/o lead[c]	Default HI calculated EPA default dermal absorption values w/o lead[d]	Default HI minus analytes infrequently detected w/o lead[e]	Lower-bound HI[f]
SWMU 1 (sediment)	1,160	1.71	<1	<1	1.71	<1
SWMU 91 (sediment)	1,190	1.96	<1	<1	1.96	<1
SWMU 196 (sediment)	2,000	2.1	2.1	<1	2.1	<1
SWMU 196 (soil)	3,160	<1	<1	<1	<1	<1

Notes:
[a] These values are identical to the values presented in Exhibit 1.25.
[b] These values are identical to the values presented in Table 1.94.
[c] These values are identical to the values presented in Exhibit 1.63.
[d] These values are identical to the values presented in Exhibit 1.61.
[e] These values are identical to the values in Table 1.108.
[f] These values were derived using site-specific exposure rates for general maintenance workers at PGDP (see Subsect. 1.6.2.5) and EPA default dermal absorption rates and omitting infrequently detected analytes.

Table 3.28. Summary of risk results and uncertainties for the future industrial worker systemic toxicity for WAG 27

(formerly "Exhibit 1.65b. Quantitative summary of uncertainties for the future industrial worker–systemic toxicity")

Location	Default HI[a]	Default HI w/o lead[b]	Site-specific HI w/o lead[c]	Default HI calculated EPA default dermal absorption values w/o lead[d]	Default HI minus analytes infrequently detected w/o lead[e]	Lower-bound HI[f]
SWMU 1 (RGA)	5,390	14.2	14.2	14.2	14.2	11
SWMU 91 (RGA)	962	4.24	4.24	4.24	4.24	1.8
C-720 (RGA)	546	3.03	3.03	3.03	2.8	1.2

Notes:
[a] These values are identical to the values presented in Exhibit 1.29.
[b] These values are identical to the values presented in Table 1.96.
[c] These values are identical to the default HI values (w/o lead) because site-specific exposure rates for the future industrial worker are unknown.
[d] These values are identical to the values presented in Exhibit 1.61.
[e] These values are identical to the values in Table 1.108.
[f] These values were derived using default exposure rates and default EPA dermal absorption rates and omitting infrequently detected analytes.

Exhibit 1.64b shows that the ELCR estimates for future industrial worker exposure to groundwater under default and lower-bound conditions do not vary dramatically. Although substantial percentage decreases are seen, the actual changes are less than one order of magnitude, and the resulting lower-bound ELCR estimate still greatly exceeds the *de minimus* level.

The HI estimates for both current and future industrial worker exposure to soil calculated using the default exposure rates (column 1) vary dramatically from the lower-bound estimates (last column) for those locations where lead was included as a contaminant of potential concern (COPC), and the provisional lead RfD was used (see Exhibits 1.65a and 1.65b). For those locations, omitting lead from the list of COPCs decreases the HIs by about 4 orders of magnitude. Other uncertainties investigated in both Exhibit 1.65a and 1.65b have little effect on the HI estimates. For the current industrial worker, for all locations, the lower-bound estimates of HI are less than the *de minimus* level established in the Methods Document (i.e., HI = 1). For the future industrial worker, for all locations in the RGA, the lower-bound estimate still exceeds an HI of 1.0."

3.2.5 WAG 28

3.2.5.1 Overview of WAG 28

Waste Area Group 28 includes potential sources of groundwater contaminants located on the east side of the PGDP. The WAG 28 Remedial Investigation (RI) addressed the following areas: SWMU 99, the C-745 Kellogg Building site; SWMUs 193 and 194, McGraw construction facilities; and AOC 204, an area of approximately 3 acres between Patrol Road 3 and Dyke Road on the eastern side of the PGDP. Table 3.29 and Fig. 3.29 present the areas assessed under the WAG 28 RI. Another SWMU of WAG 28, the McGraw UST (SWMU 183), is being managed under the PGDP UST Program.

Table 3.29. WAG 28 areas

SWMU Name	SWMU Number
C-745 Kellogg Building Site	99
McGraw Construction Facilities	193
McGraw Construction Facilities Leach Fields	194
Area of Concern (AOC)	204

The following subsections present site-specific information concerning the SWMUs/AOC comprising WAG 28. Unless otherwise noted, the summarized information is derived from the *Remedial Investigation Report for Waste Area Grouping 28 at the Paducah Gaseous Diffusion Plant* (DOE 2000).

Solid Waste Management Unit 99 — Kellogg Building Site

Location. The C-745 Kellogg Building Site is located on the eastern side of the PGDP, south of Building C-360, immediately north of Tennessee Avenue and west of Patrol Road 3.

Setting. The topography in the vicinity of SWMU 99 is relatively flat, with drainage from the vicinity of the SWMU toward Outfall 010.

Surface-water hydrology, wetlands, and floodplains. Surface drainage is routed through surface swales and ditches to storm sewers, which discharge to the Outfall 010 effluent ditch and into Little Bayou Creek on the east side of the plant. There are no streams, wetlands, or 100-year floodplain areas within SWMU 99.

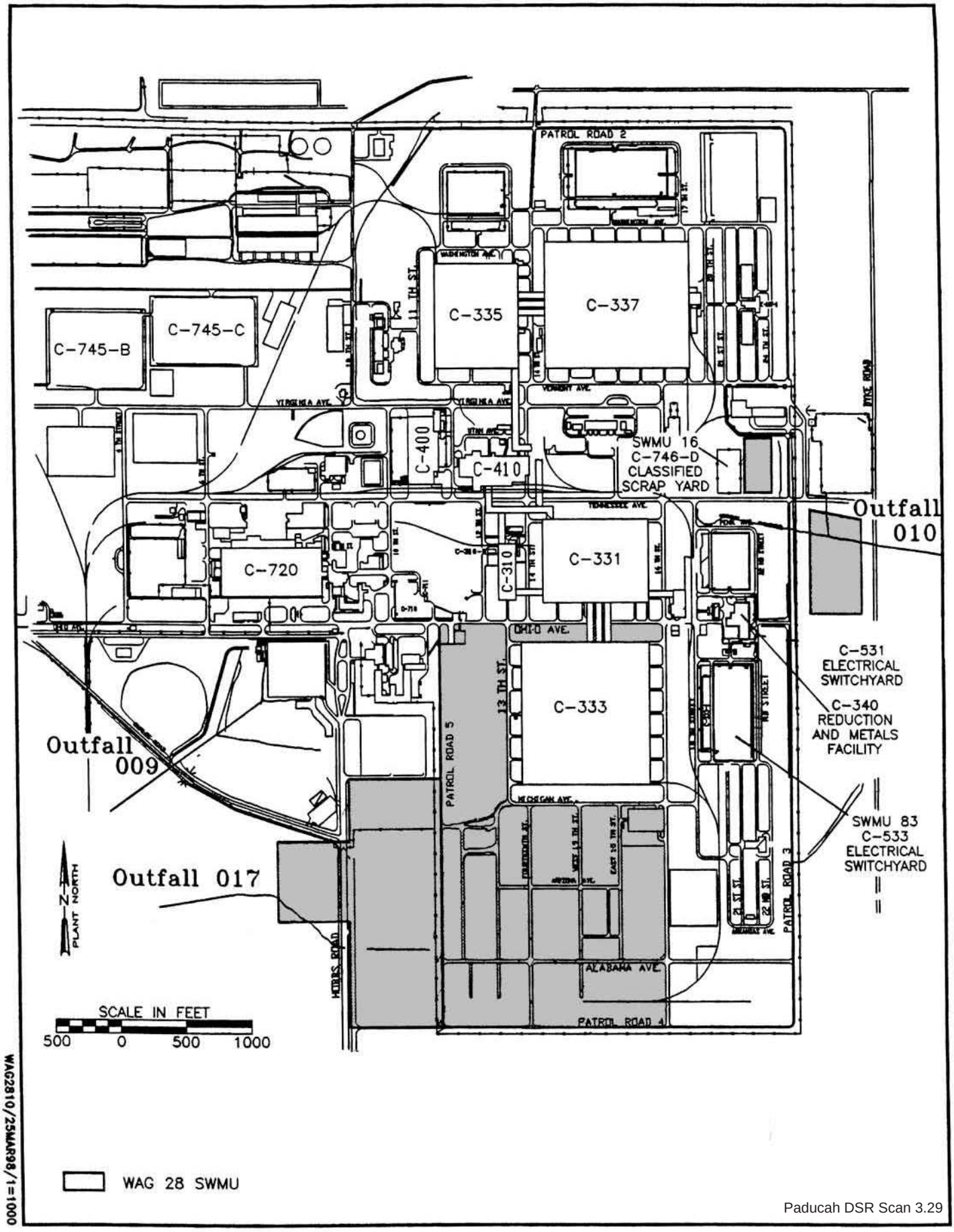

Fig. 3.29. Location of WAG 28 SWMUs.

Biological resources. The Kellogg Buildings site consists of concrete pads and gravel lots that are nearly devoid of vegetation. The area of the leach field was a grass-covered area, maintained by mowing. During the summer of 1999, this area was converted to a gravel-covered parking lot. These settings do not provide critical habitat for T&E species of plants or animals.

Soils and prime farmland. The soils of SWMU 99 are Calloway series silt loams, with a shallow fragipan. However, construction and maintenance activities have heavily disturbed the original soil structure.

Underground utilities. A septic tank and a leach field, which were connected to the Kellogg Buildings by a vitreous clay drain line, are located approximately 107 to 122 m (350 to 400 ft) southeast of the building sites in the grass-covered field east of Patrol Road 3. The tank and leach field are believed to have been designed to receive sanitary waste from the buildings' operations; however, the actual configuration of the drainage system is unknown. No records exist as to what was done with the residual contents of the tank after the buildings were demolished or whether any closure or removal actions were taken. Portions of the lateral lines for the leach field were encountered during construction activities in late 1994. A surface geophysical survey (EM-31 terrain conductivity) was performed during the WAG 28 RI field activities to locate the position of the leach field and drainpipe. The survey was unsuccessful in delineating either feature. Measurements in the field, based on construction drawings, placed the leach field near the base of a high-voltage power line tower. It is possible that the below-grade construction of the tower base destroyed the leach field. No evidence of the pipe was found.

Manufacturing/treatment, storage, disposal process. The SWMU 99 site originally consisted of two steel and sheet metal buildings built in 1951 as temporary support facilities during the construction of the cascade facilities. The buildings were erected on concrete slabs with a gravel access road between the buildings. A septic tank and a leach field that formerly serviced the Kellogg Buildings also have been identified at SWMU 99. No other information is available regarding the construction and design of the facility. It is suspected that TCE was used at these buildings to degrease equipment and machinery. The Kellogg Buildings were taken out of service and demolished in 1955, leaving only the concrete pads.

The building pads are now used to store UF_6 cylinders and classified waste. The C-745-E Cylinder Storage Yard is located in the area that formerly housed the eastern building, and the C-746-D Classified Scrap Yard is located in the area that formerly housed the western building. The C-746-D (identified as SWMU 16 based on its current usage) is used to store converter cells that have been modified for the storage of classified waste.

Previous remedial action. The Kellogg Buildings have been removed and the site currently is used as a storage area. No previous remedial actions have been taken at SWMU 99.

Summary of investigations. Solid Waste Management Unit 99 was investigated during the CERCLA Phase II SI performed by CH2M HILL (CH2M HILL 1992). Analysis of soil samples from shallow borings revealed the presence of trace levels of xylene and several metals at concentrations that exceeded the investigation screening levels. Uranium-238 was the only radionuclide detected above screening levels. Deeper soil samples collected from the drilling of area MW163 contained a similar suite of metals present above screening levels (barium, copper, lead, mercury, and vanadium).

The Phase II SI installed two groundwater monitoring wells (MW163, screened in the RGA, and MW164, screened in the UCRS) northwest of C-746-D. Water samples collected from both wells contained volatile organic compounds (VOCs) (primarily TCE), metals, and ^{99}Tc. The investigation report concluded that the metals and radionuclide contaminants observed in soil and groundwater were unrelated.

The Groundwater Phase IV Investigation drilled borings to the east, northeast, and west of the septic tank and leach field. Groundwater samples collected from these borings revealed TCE concentrations greater than 1000 µg/L throughout the RGA east and northeast (downgradient) of the leach field. The results from this investigation are presented in the *Northeast Plume Preliminary Characterization Summary Report* (DOE 1995a), which recommends further investigation of the septic tank and leach field as potential sources of the TCE encountered during the Groundwater Phase IV Investigation.

The WAG 28 RI, conducted in 1999, evaluated releases from SWMU 99 to determine if the SWMU is a source of TCE contamination in the RGA in the Northeast Plume. The investigation included multiple cone penetrometer technology (CPT) logs to identify water-bearing units within the UCRS followed by direct push technology (DPT) sampling of surface and subsurface soil in the UCRS. Groundwater was sampled in the UCRS, where present, and in two RGA borings installed with a Dual Wall Reverse Circulation (DWRC) air rotary drill rig. In addition, two surface soil/sediment samples were collected from the drainage ditch parallel to the East Patrol Road 3 and two soil samples were collected from a collapsed drainpipe excavation in the southwest corner of SWMU 99.

Several metals were detected in soil samples that may represent small isolated spills or leaks. PCBs were found in one sample and low concentrations of several semi-volatile organic compounds SVOCs were detected in multiple samples. Trichloroethene was present in two subsurface samples. Concentrations of radioisotopes above screening levels were detected in two surface samples. The WAG 28 investigation did not identify a source for metals, VOCs, or radionuclides in the soils at SWMU 99. Elevated levels of radioisotopes were detected in a soil sample collected from an excavation related to a collapsed drainpipe in the southwest corner of SWMU 99. The source of the radionuclides is believed to be runoff from the Classified Scrap Yard at SWMU 99.

Elevated levels of TCE and ^{99}Tc are found in the shallow groundwater of the UCRS and near the base of the RGA. Two borings in SWMU 99 sampled the groundwater in the RGA. The first boring (099-034) was located upgradient of SWMU 99 to test for an upgradient contaminant source and the second boring (099-035) was located in the center of SWMU 99. Trichloroethene was detected in the borings at similar levels to those observed during the Phase IV Groundwater Investigation (boring P4E6). Technetium-99 and related gross alpha/beta activity was detected in the RGA in SWMU-99. No VOCs were noted in the area of the leach fields in the shallow groundwater of the UCRS. The WAG 28 investigation concluded that the main source of the groundwater contaminants at SWMU 99 is located upgradient.

Geology/Hydrogeology. Twenty-six soil borings were drilled in SWMU 99 during the 1999 WAG 28 RI. The WAG 28 RI reports the lithologies encountered beneath the unit, in order of increasing depth, are as follows: gravel fill material, loess deposits (HU1), upper fluvial/alluvial deposits (HU2), the confining to semiconfining layer of the upper Continental Deposits (HU3), the lower Continental Deposits of the RGA (HU4 and HU5), and the Porters Creek Clay. Approximately 3 to 5 m (11 to 16 ft) of rust brown to gray brown silty clays underlying 0.6 m (two ft) of surficial fill material of gravel and sand, comprise the loess deposit. The upper fluvial/alluvial deposits consist of approximately 9 to 12 m (30 to 39 ft) of rust brown to yellow brown clayey silty sand encountered at depths ranging from 4 to 6 m (13 to 20 ft) bgs. Approximately 2 to 4 m (5 to 12 ft) of clay to silty clay encountered at depths of 13 to 15 m (44 to 50 ft) bgs make up the HU3 deposits.

The shallow groundwater system at the site, the UCRS, consists of the upper Continental Deposits and overlying loess. Flow within the UCRS is predominantly downward into the uppermost aquifer, the RGA.

The RGA/lower Continental Deposits, composed of an upper sand with gravel and silt (HU4) was encountered at depths of 16 to 18 m (51 to 58 ft) bgs. The lower portion of the RGA (HU5) consists of

gravel with sand and silt, found at depths of 21 to 30 m (70 to 100 ft) bgs. The entire RGA thickness in the area of SMWU 99 is approximately 15 m (50 ft). The Porters Creek Clay, a dark gray to dark green, slightly to very micaceous clay with some interbedded fine grained clayey sand, underlies the RGA. Porters Creek Clay was encountered at depths of 30 to 32 m (100 to 105 ft) bgs.

Fate and Transport. Contaminant fate and transport modeling was used to assess the WAG 28 SWMUs. Modeling was conducted for the WAG 28 RI using the Multimedia Environmental Pollutant Assessment System (MEPAS) software developed by the Pacific Northwest National Laboratory. The MEPAS model calculates the fate and transport of contaminants from specified source terms and determines the associated risk to identified receptors. For this modeling, only the groundwater contaminant portion of the MEPAS was used to model contaminant concentrations in groundwater at receptor points within the RGA. Concentrations were modeled to two receptor points: the PGDP security fence and the DOE property boundary.

For SWMU 99, area soil boring logs provided the basis to delineate three model layers (two partially saturated and one saturated). These layers correspond to the upper portion of the UCRS (HU1 and HU2) [0.3-13 m (1-43 ft) bgs], the HU3 aquitard [13-18 m (43-60 ft) bgs], and the RGA (HU4 and HU5) [18-32 m (60-105 ft) bgs]. The travel distances that were modeled varied depending upon the location of the source volume. For SWMU 99 sources located east of the former Kellogg Building site, outside the fence, a small value was used [3 m (10 ft)] as the distance to the PGDP security fence. (The MEPAS model does not accept zero distance values.) These sources required a modeled travel distance of 1372 m (4500 ft) to transport dissolved contaminants to the DOE property boundary on the eastern side of the plant. For sources located west of the former Kellogg Building site, the distances used were 213 m (700 ft) to the PGDP security fence and 1463 m (4800 ft) to the DOE property boundary.

Table 3.30 summarizes model results for selected contaminants detected in the SWMU 99 area. This table presents the maximum levels of each contaminant that were modeled to reach the two receptor locations. The SWMU 99 model also assessed 4 other metals, 17 radionuclides (includes daughter products), and 1 SVOC.

Table 3.30. Fate and transport modeling results for SWMU 99

	Plant fence		Property boundary		
Constituent	**Max conc. (mg/L)**	**Time (year)**	**Max conc. (mg/L)**	**Time (year)**	**Location of source relative to plant fence**
lithium	46.86	67	7.22×10^{-1}	95.5	Outside
strontium	3.78	8952	6.12×10^{-4}	9899–15,655	Outside

Modeling indicates that SWMU 99, the Kellogg Building and the leach fields, are not contributors of TCE contamination. The results of sampling conducted west of the Kellogg building reveal that a source of radionuclide contamination may be contributing to groundwater contamination in the area near 082-014. However, the MEPAS modeling shows that the elevated ^{99}Tc concentrations in the UCRS soils in the vicinity of this boring will not result in RGA groundwater concentrations exceeding 900 pCi/L, the calculated MCL for ^{99}Tc, at the fence or the DOE property boundary.

Solid Waste Management Unit 193 — McGraw Construction Facilities

The McGraw Construction Facilities include a series of construction support facilities located to the south and west of the C-333 Building. During the construction of the PGDP, the area contained several temporary buildings including a steel fabrication shop, electrical warehouse, sheet metal shop, light and

heavy equipment shops, steel reinforcing shop, truck wash, millwright shop, pipe fabrication shop, and concrete production plant. The SWMU covers approximately 100 acres. The portion of the SWMU south of the C-333 Building is currently used for UF_6 cylinder storage. Cylinder storage yards include the C-745-G, F, K, L, D, Q, M, N, and P yards.

Setting. The surface topography of the approximately 40-hectare (100-acre) site is relatively flat. Approximately one half of the area is now used to store UF_6 cylinders. Little information exists documenting the handling and potential disposal of wastes in this area during the time the construction facilities were active. There is the potential for releases of cleaning solutions and other chemicals, given the nature of the facilities in this area.

Surface-water hydrology, wetlands, and floodplains. The area is drained on the southwest by KPDES Outfall 017 and by Outfall 013 on the southeast. The area south of the C-333 Building drains through the plant storm drain system and discharges through KPDES Outfall 012 while the area north of the building drains through the storm drain system to discharge through KPDES Outfall 011, both of which empty into Little Bayou Creek on the east side of the plant. The area west of C-333 drains through Outfall 009. There are no streams, wetlands, or 100-year floodplain areas within SWMU 193.

Biological resources. The area south of the C-333 Building consists of concrete and gravel cylinder storage areas. The areas north and immediately west of the C-333 Building are covered with gravel. None of these areas support significant vegetation. Across the street, west of C-333, the ground surface is a grass-covered area, maintained by mowing. These settings do not provide critical habitat for T&E species of plants or animals.

Soils and prime farmland. The soils of SWMU 193 are Calloway series silt loams, with a shallow fragipan. However, construction and maintenance activities have heavily disturbed the original soil structure.

Underground utilities. Several sanitary leach fields are noted in early drawings of the area (DOE 1998b). There are numerous underground lines immediately adjacent to the C-333 Building that provide utility services to the building.

Manufacturing/treatment, storage, disposal process. About one half of the SWMU 193 area currently is used for storage of UF_6 cylinders. There are no descriptions of historic waste handling practices or of any inadvertent releases into the environment. Due to the likely waste handling practices and the types of wastes expected to have been generated in the early 1950s, there is the possibility that metals and VOCs may have been released. Types of possible releases include disposal of solvents and metal-containing fluids into the sanitary system as well as disposal adjacent to buildings (DOE 1998b).

Previous remedial action. No previous remedial actions have been conducted at SWMU 193.

Summary of investigations. The SWMU 193 site was investigated during the 1995 Site Evaluation of SWMUs 193 and 194 with the purpose of identifying possible sources of contamination associated with some of the staging areas used during construction of the PGDP. These areas are considered potential source areas for the Northeast Plume (DOE 1995a). The site evaluation included a geophysical survey, CPT soil borings, and DPT water samples. Twenty-one soil borings and 15 groundwater samples were collected. Completed concurrently with the site evaluation was the Groundwater Phase IV Investigation. The results from these investigations indicate that VOCs (primarily TCE and its degradation products) are Contaminants of Potential Concern (COPCs) in the RGA. No VOCs or radionuclides were detected in the subsurface soils; however, cadmium, lead, and chromium were detected.

The WAG 28 Remedial Investigation conducted in 1999 intended to further investigate two areas of SWMU 193; the Millwright Shop, formerly located immediately west of Building C-333, and the Schulman Pipe Fabrication Shop, formerly located in the northeastern corner of the SWMU, as potential source areas contributing to the Northeast Plume. In addition, the area including the sanitary leach fields, the light and heavy equipment shop, the sheet metal shops, and the steel fabrication shop, located in the southern portion of the SWMU were considered potential sources of metals in the soil. The investigation completed two cone penetrometer technology (CPT) logs to identify water-bearing units within the UCRS followed by eleven direct push technology (DPT) sample borings for surface and subsurface soil in the UCRS. Seven borings were drilled to the top of the Levings Member of the McNairy Formation in the northern half of the site, to further delineate the boundaries of the Northeast Plume using a Dual Wall Reverse Circulation (DWRC) air rotary drill rig. The groundwater in the RGA was sampled at 1.5 m (5 ft) intervals (where available) and the McNairy groundwater was sampled at 3.0 m (10 ft) intervals (where available).

Multiple SVOCs were detected in the surface and subsurface soils located in the vicinity of the former Millwright Shop. Metals were detected in each of the three subunits. Isolated occurrences of aluminum, chromium, cobalt, manganese, and lead detected in the surface and subsurface soils at SWMU 193 may represent small releases or outliers of natural conditions. No radionuclides were detected at activities above the screening levels in any of the SWMU 193 surface or subsurface soils.

Several organic compounds exceeding screening levels, including relatively small quantities of TCE and *cis*-1,2-dichlorethene, were detected in the UCRS groundwater. Three radionuclides, ^{99}Tc, ^{234}Th, and ^{235}U were detected above screening levels in samples collected from the UCRS groundwater. Trichloroethene (detected in 30 samples) and its related degradation products were the most common organic constituents identified in the RGA groundwater. Technetium-99 was the most commonly detected radionuclide. Uranium-235 was also reported.

Trichloroethene was not detected in the SWMU 193 soil samples. Therefore, SWMU 193 does not appear to be a TCE source area. A significant decrease in the TCE concentrations in the RGA beneath the Millwright Shop was observed between the 1994 sampling event and the WAG 28 sampling event. This occurrence may be attributed to dilution and diffusion of TCE as the zone of dissolved contamination migrated to the north-northeast during the five-year period. The WAG 28 investigation also indicated that the distribution and location of the highest concentrations of techntium-99 in the RGA are similar to the distribution of TCE, implying the two contaminants have a common release point.

Geology/Hydrogeology. Twenty-two soil borings were drilled in SWMU 193 during the 1999 WAG 28 RI. As reported by the WAG 28 RI, the lithologies encountered beneath the unit are as follows, in order of increasing depth: gravel fill material, loess deposits (HU1), upper fluvial/alluvial deposits (HU2), the confining to semiconfining layer of the upper Continental Deposits (HU3), the lower Continental Deposits of the RGA (HU4 and HU5 in the northwestern portion of the site), the Porters Creek Clay (in the southeastern portion of the site), and the McNairy Formation. The loess deposits consist of approximately 6 m (20 ft) of rust brown to gray brown silty clays directly underlying the surficial gravel cover at SWMU193. Approximately 9 to 18 m (30 to 60 ft) of rust brown to yellow brown clayey silty sand to depths ranging from 17 m (55 ft) bgs to 24 m (80 ft) bgs make up the upper fluvial/alluvial deposits. The HU3 deposits consist of approximately 2 m (5 to 7 ft) of clay to silty clay in the northwestern portion of the site.

The shallow groundwater system at the site, the UCRS, consists of the upper Continental Deposits and overlying loess. Flow within the UCRS is predominantly downward into the uppermost aquifer, the RGA. The first encounter of significant groundwater in the UCRS was noted at 11 m (37 ft) bgs in one boring.

The RGA lower Continental Deposits consists of 8 to 12 m (25 to 40 ft) of sands, gravels, and silts in the northwestern portion of the site, encountered at depths of 20 to 24 m (65 to 80 ft) bgs. In this area, the RGA pinches out to the southeast into the Porters Creek Terrace. The Porters Creek Clay consists of a dark gray, slightly to very micaceous clay with some interbedded fine-grained clayey sand. Both the Porters Creek Clay and the RGA are underlain by the McNairy Formation at depths ranging from 27 to 38 m (90 to 125 ft) bgs. The McNairy Formation consists of grayish white to dark gray micaceous clay, often silty, interbedded with fine sand.

Fate and Transport. Geologic data from the SWMU 193 investigation defined two model layers. An upper, partially saturated layer [0.3-21 m (1-68 ft) bgs] consisted of the combined loess deposits of HU1, the permeable but discontinuous sand and gravel lenses of HU2, and the silty clay aquitard of HU3. The lower, saturated layer [21-28 m (68-93 ft) bgs] was composed of the RGA (HU4 and HU5). MEPAS modeling provided a way to assess derived dissolved contaminant concentrations at two receptor points: the PGDP security fence [at a distance of 914 m (3000 ft)] and the DOE property boundary [at a distance of 2256 m (7400 ft)].

Table 3.31 is a condensation of the model results for selected contaminants detected in the SWMU 193 area. This table presents the maximum levels of each contaminant that were modeled to reach the two receptor locations. The SWMU 193 model also assessed 3 other metals.

Table 3.31. Fate and transport modeling results for SWMU 193

	Plant fence		Property boundary	
Constituent	Max conc. (mg/L)	Time (year)	Max conc. (mg/L)	Time (year)
chromium	3.80	5929	2.13	7744
lithium	38.05	48.8	38.09	69.8
manganese	5.11	2655	3.65	3624
strontium	7.45	9854–10,834	4.56×10^{-3}	9846–13,283

The results of the MEPAS modeling for SWMU 193 indicate that no significant sources of groundwater contamination are present at the unit.

Solid Waste Management Unit 194 — McGraw Construction Facilities Leach Fields

Location. This SWMU covers approximately 9 hectares (22 acres) and is located near the southwest corner of the intersection of Hobbs Road and Patrol Road 5 in the southwestern corner of the PGDP. The SWMU is located immediately west of SWMU 193. These McGraw Construction Facilities also were built in the early 1950s during construction of the PGDP. The sites consisted of an Administrative Building [9,801.28 m^2 (105500 ft^2)], cafeteria [947.61 m^2 (10,200 ft^2)], security guard headquarters [497 m^2 (5,360 ft^2)], hospital [416.20 m^2 (4,480 ft^2)], purchasing building [1,114.84 m^2 (12,000 ft^2)], paper and stationary warehouse [362.32 m^2 (3,900 ft^2)], boilerhouse, and two leach fields located west of Hobbs Road.

Setting. The surface topography near the leach fields is relatively flat and drains to the south toward KPDES Outfall 017 or west toward KPDES Outfall 009.

Surface-water hydrology, wetlands, and floodplains. Surface drainage is routed through surface swales and ditches to either KPDES Outfall 017 or Outfall 009, both of which empty into Bayou Creek on the west side of the plant. There are 100-year floodplain areas within and along the southwest side of SWMU 194.

Biological resources. The SWMU 194 area is primarily grass-covered. Deer and small herbivores such as rabbits feed in this area. Beavers occasionally build dams in the ditches draining the area. These areas, however, receive periodic mowing and ditch maintenance so they do not provide critical habitat for T&E species of plants or animals.

Soils and prime farmland. The soils of SWMU 194 are Calloway series silt loams, with a shallow fragipan. However, construction and maintenance activities have heavily disturbed the original soil structure.

Underground utilities. No information concerning the presence of underground utilities is available.

Manufacturing/treatment, storage, disposal process. There are no descriptions of historic waste handling practices or of any inadvertent releases into the environment associated with this SWMU. Due to the likely waste handling practices and the types of wastes expected to have been generated in the early 1950s, there is the possibility that some contaminants may have been released. Possible release mechanisms include disposal of various fluids into the sanitary system as well as disposal adjacent to buildings (DOE 1998b).

Previous remedial action. No previous remedial actions have been conducted at SWMU 194.

Summary of investigations. This area was investigated during the 1995 Site Evaluation of SWMUs 193 and 194 as part of the Northeast Plume Investigation (DOE 1995a). The analytical results from these samples indicate that there is limited soil contamination at SWMU 194. Chromium and lead were detected in soil samples near the leach fields.

The Remedial Investigation for WAG 28 conducted in 1999 included a total of four direct push technology (DPT) borings, two borings within the boundaries of the northern leach field, and two within the boundaries of the southern leach field. The subsurface soils were analyzed for metals. Aluminum was detected slightly above background screening levels in three samples and chromium was detected at levels exceeding screening criteria in two samples.

Geology/Hydrogeology. Four shallow soil borings were installed in SWMU 194 during the 1999 WAG 28 RI. Based on the boring logs provided in the WAG 28 RI report, the lithologies encountered beneath the unit, in order of increasing depth, are as follows: gravel fill material, loess deposits (HU1), and upper fluvial/alluvial deposits (HU2). Fill material, composed of gravel and sand, was present at a thickness of up to 0.6 m (2 ft). Loess, yellowish brown silty clays, (HU1) extended to the approximate depth of 4 m (12 ft) bgs. Upper fluvial/alluvial yellowish brown clayey silty sand to sandy silt (HU2) was present to the approximate termination depth of 9 m (30 ft) bgs. Groundwater was only encountered in one of the UCRS borings at the depth of approximately 9 m (30 ft) bgs.

Fate and Transport. The former leach fields associated with SWMU 194 are located south of the slope of the Porters Creek Clay terrace. None of the SWMU 194 RI soil borings extended below 9 m (30 ft) bgs. Area soil borings from previous investigations provided information to supplement the SWMU 194 RI in the development of the fate and transport model.

To address contaminant migration off the terrace and into the RGA, the model included two layers. An upper, partially saturated layer [to a depth of 17 m (55 ft) bgs] consisted of the loess deposits making up HU1, permeable and discontinuous sand and gravel lenses of the Terrace Gravel and of HU2, and the thin, silty clay aquitard of HU3. The RGA made up the lower, saturated layer from 17-26 m (55-85 ft) bgs. Model distances were 3 m (10 ft) to the PGDP security fence (SWMU 194 is located outside the PGDP security fence so a small non-zero value was used) and 2652 m (8700 ft) to the DOE property boundary.

SWMU 194 model results are presented in Table 3.32. Aluminum was the only other contaminant that was modeled, with derived levels of 0 mg/L at both receptor locations.

Table 3.32. Fate and transport modeling results for SWMU 194

	Plant fence		Property boundary	
Constituent	Max conc. (mg/L)	Time (year)	Max conc. (mg/L)	Time (year)
chromium	72.4	3783	0.17	7728
lithium	67	19.7	7.57	52
strontium	10.5	55.8	5.17×10^{-4}	9824–11,832

The results of the MEPAS modeling for SWMU 194 indicate no significant sources of groundwater contamination are present at the SWMU 194 leach fields.

Area of Concern 204

Location. Area of Concern 204 includes approximately 3 acres located on the eastern side of the plant, between Patrol Road 3 and Dyke Road. The AOC is located immediately south and east of SWMU 99. It is believed that this area was used for disposal of construction debris.

Setting. The surface of AOC 204 is undulating, with surface elevations ranging from 111 to 118 m (364 to 388 ft) above mean sea level. The area is covered with heavy vegetation and young trees.

Surface-water hydrology, wetlands, and floodplains. Surface drainage is routed through surface swales and ditches to either KPDES Outfall 010 or Outfall 011, both of which empty into Little Bayou Creek on the east side of the plant. There are no streams, wetlands, or 100-year floodplain areas within AOC 204.

Biological resources. AOC 204 is primarily covered with grass and small trees. Deer and small herbivores such as rabbits feed in this area. The area, however, receives periodic mowing and ditch maintenance so it does not provide critical habitat for T&E species of plants or animals.

Soils and prime farmland. The soils of SWMU 194 are Calloway series silt loams, with a shallow fragipan. Construction and maintenance activities have heavily disturbed the original soil structure.

Underground utilities. No information concerning the presence of underground utilities is available.

Manufacturing/treatment, storage, disposal process. There are no descriptions of historic waste handling practices or of any inadvertent releases into the environment associated with this SWMU.

Previous remedial action. No previous remedial actions have been conducted at SWMU 194.

Summary of investigations. An August 1995 investigation of AOC 204 provided no evidence that the AOC posed a threat to human health or the environment (DOE 1995a). Additionally, AOC 204 also was included in the 1995 SI for Outfalls 010, 011, and 012. Results from the soil borings and six ditch samples obtained during that study indicate that there is a source of TCE, trichloroethane and dichloroethene in KPDES Outfall 011 (DOE 1995b). The likely source for the detected analytes in KPDES Outfall 011 is believed to be a small historical spill in Outfall 011.

The Remedial Investigation of WAG 28 conducted in 1999 included two sets of paired borings. Each consists of a boring to collect subsurface soil samples, installed with a Hollow Stem Auger (HSA) drill rig, and a boring to collect groundwater samples, installed with a Dual Wall Reverse Circulation (DWRC) air rotary drill rig.

Volatile organic compounds were not detected in any of the subsurface soil samples. In the UCRS groundwater, trichloroethene and its by-products were detected at concentrations below screening levels but slightly above the detection limit. Trichloroethene was noted primarily in the RGA but not in concentrations that would indicate a nearby source. Radionuclides were not observed in either the groundwater or soils at levels of concern.

Geology/Hydrogeology. Four soil borings were installed in AOC 204 during the 1999 WAG 28 Investigation. Fill material composed of gravel, sand and clay, was present at a thickness of up to 2 m (5 ft). Loess, yellowish brown silty clays and reddish brown clays (HU1) were found to the approximate depth of 7 m (24 ft) bgs. Upper fluvial/alluvial yellowish brown clayey silty sand to sandy silt, and gravel (HU2) extended to the approximate depth of 20 m (64 ft) bgs. HU3 deposits locally consist of approximately 3 m (10 ft) of yellowish brown and gray clay to silty clay.

The shallow groundwater system at the site, the UCRS, consists of the upper Continental Deposits and overlying loess. Flow within the UCRS is predominantly downward into the uppermost aquifer, the RGA. The first encounter of significant groundwater in the UCRS was noted at approximately 17 m (55 ft) bgs in AOC 204.

The lower continental deposits of the RGA (HU4 and HU5) in this area exhibits a grading thickness of 9 to 3 m (30 to 10 ft) and pinches out to the south into the Porters Creek Terrace. The Porters Creek Clay consists of dark gray to greenish black stiff clay in this area. Both the Porters Creek Clay and the RGA are underlain by the McNairy Formation. The McNairy Formation consists of grayish white to dark gray micaceous clay, often silty, interbedded with fine sand.

Fate and Transport. The AOC 204 fate and transport model consists of 3 layers (two partially saturated and one saturated), based upon soil borings of the WAG 28 RI and deep soil borings of the Groundwater Phase IV investigation (DOE 1995a). Loess deposits of the HU1 and permeable, but discontinuous, sand and gravel lenses of the HU2 constitute the top layer to a depth of 16 m (52 ft). The silty clay HU3 aquitard defines the second layer of the model at depths of 16-20 m (52-67 ft). Sandy gravel deposits of the RGA [20-29 m (67-95 ft) bgs] make up the third layer. The travel distances from the AOC 204 source were 3 m (10 ft) to the PGDP security fence (AOC 204 was located outside the security fence, so a small, non-zero value was used) and 1372 m (4500 ft) to the DOE property boundary.

Table 3.33 presents the results of the MEPAS modeling. MEPAS cannot accurately assess the trichloroethene level in the RGA groundwater at the PGDP security fence. Thus, the maximum concentration presented in Table 3.33 represents a conservative estimate.

Table 3.33. Fate and transport modeling results for AOC 204

	Plant fence		Property boundary	
Constituent	**Max conc. (mg/L)**	**Time (year)**	**Max conc. (mg/L)**	**Time (year)**
trichloroethene	14,280	110.5	3.66	163

The MEPAS modeling indicates that TCE concentrations in the UCRS soils at AOC 204 will not result in RGA groundwater concentrations exceeding MCLs at the DOE property boundary.

WAG 28 Risk Assessment Summary

The summary presented in this section was taken from *Remedial Investigation Report for Waste Area Grouping 28 at the Paducah Gaseous Diffusion Plant* (DOE 2000a). The RI document provides information on the baseline risks posed to human health and the environment from contamination at WAG 28 that will be used to support the need for remedial action in WAG 28 and to assist in the selection of the remedial alternatives.

The following is excerpted from the Executive Summary of the WAG 28 BRA.

> In 1999, the U.S. Department of Energy (DOE) conducted a Remedial Investigation (RI)/Resource Conservation and Recovery Act Facility Investigation for Waste Area Grouping (WAG) 28. WAG 28 includes Solid Waste Management Units (SWMUs) 99, 193, 194, and Area of Concern (AOC) 204 at the Paducah Gaseous Diffusion Plant (PGDP) in Paducah, Kentucky. SWMUs 99 and 193 were further subdivided into units based upon area and historical use (99a, 99b, 193a, 193b, and 193c.) The overall purpose of this investigation was to determine the presence, nature, and extent of contamination at SWMUs 99a, 99b, 193a, 193b, 193c, 194 and AOC 204. The primary focus of the RI was to collect sufficient information about surface soil, subsurface soil, and the shallow groundwater of the Upper Continental Recharge System (UCRS) contamination to support an assessment of risks to human health and the environment and the selection of remedial actions to reduce these risks. In addition, contamination in the Regional Gravel Aquifer (RGA) and McNairy Formation groundwater was characterized to determine if contamination in the sites acted as a secondary source of contamination to groundwater.

Consistent with regulatory guidance and agreements contained in the approved human health risk assessment Methods Document (DOE 1996), the baseline human health risk assessment (BHHRA) evaluates land-use scenarios that encompass current use and several hypothetical future uses of the WAG 28 sites and the areas to which contaminants may migrate. The following land-use scenarios and exposure routes are assessed.

Current industrial worker

- direct contact with surface soil

Future industrial worker

- direct contact with surface soil
- use of groundwater drawn from aquifers below WAG 28

Future excavation worker

- direct contact with surface and subsurface soil

Future recreational user

- ingestion of game exposed to contaminated surface soil

Future on-site rural resident

- direct contact with surface soil
- use of groundwater drawn from aquifers below WAG 28
- ingestion of vegetables grown in the WAG 28 area

Off-site rural resident (at PGDP security fence)

- use of groundwater drawn from aquifers at the PGDP fence boundary

This report also contains a baseline ecological risk assessment (BERA) that evaluates risks under both current and potential future conditions to several ecological receptors that may come into contact with contaminated media at or migrating from sources in WAG 28.

Summary tables of the risk assessment done for the WAG 28 BRA follow. Tables 3.34 through 3.37 present the risk results and the quantitative risk summaries found in Exhibits 1.58 through 1.61 of the WAG 28 BRA.

Table 3.34. Summary of risk results and uncertainties for the current industrial worker – ELCR – for WAG 28

(formerly "Exhibit 1.60. Quantitative summary of uncertainties for the current industrial worker—excess lifetime cancer risk")

Location	Default ELCR[a]	Default ELCR minus infequently detected analytes[b]	Default ELCR minus common laboratory contaminants[c]	Default ELCR minus analytes with provisional or withdrawn toxicity values[d]	ELCR computed using EPA Region 4 absorption factors[e]	Lower bound ELCR[f]
SWMU 99a (soil)	3.1×10^{-4}	3.0×10^{-4}	3.1×10^{-4}	7.5×10^{-5}	6.7×10^{-5}	5.8×10^{-5}
SWMU 193a (soil)	1.5×10^{-5}	1.5×10^{-5}	1.5×10^{-5}	9.2×10^{-6}	2.0×10^{-6}	1.2×10^{-6}
SWMU 193b (soil)	5.1×10^{-4}	5.1×10^{-4}	5.1×10^{-4}	2.7×10^{-9}	1.1×10^{-5}	2.7×10^{-9}
SWMU 193c (soil)	1.7×10^{-10}	1.7×10^{-10}	1.7×10^{-10}	1.7×10^{-10}	1.7×10^{-10}	1.7×10^{-10}

[a] These values are identical to the values presented in Exhibit 1.19.
[b] These values are identical to the values presented in Table 1.82.
[c] These values are identical to the values presented in Table 1.84.
[d] These values are identical to the values presented in Table 1.86.
[e] These values are identical to the values presented in Exhibit 1.55.
[f] These values were derived omitting infrequently detected analytes, laboratory contaminants, and those contaminants for which only provisional or withdrawn toxicity values are available and using EPA Region 4 dermal absorption values.

Table 3.35. Summary of risk results and uncertainties for the future industrial worker – ELCR – for WAG 28

(formerly "Exhibit 1.61. Quantitative summary of uncertainties for the future industrial worker—excess lifetime cancer risk")

Location	Default ELCR[a]	Default ELCRs minus infrequently detected analytes[b]	Default ELCR minus laboratory contaminants[c]	Default ELCR minus analytes with provisional or withdrawn toxicity values[d]	ELCR computed using EPA Region 4 dermal toxicity values	Lower bound ELCR[e]
SWMU 99a (RGA)	5.6×10^{-4}	5.6×10^{-4}	5.6×10^{-4}	3.1×10^{-4}	NA	3.1×10^{-4}
SWMU 99a (McNairy)	7.6×10^{-5}	7.6×10^{-5}	7.6×10^{-5}	5.3×10^{-5}	NA	5.3×10^{-5}
SWMU 99b (RGA)	2.6×10^{-4}	2.6×10^{-4}	2.6×10^{-4}	1.5×10^{-4}	NA	1.5×10^{-4}
SWMU 193a (RGA)	2.6×10^{-5}	1.4×10^{-5}	2.6×10^{-5}	1.7×10^{-5}	NA	3.6×10^{-6}
SWMU 193a (McNairy)	1.1×10^{-6}	1.1×10^{-6}	1.1×10^{-6}	8.8×10^{-7}	NA	8.8×10^{-7}
SWMU 193b (RGA)	4.4×10^{-5}	4.4×10^{-5}	4.3×10^{-5}	1.7×10^{-5}	NA	1.7×10^{-5}
SWMU 193b (McNairy)	8.4×10^{-7}	8.4×10^{-7}	8.4×10^{-7}	1.5×10^{-7}	NA	1.5×10^{-7}
SWMU 193c (RGA)	1.0×10^{-5}	1.0×10^{-5}	1.0×10^{-5}	1.9×10^{-6}	NA	1.9×10^{-6}
SWMU 193c (McNairy)	4.2×10^{-4}	4.2×10^{-4}	4.2×10^{-4}	2.0×10^{-4}	NA	2.0×10^{-4}
AOC 204 (RGA)	1.3×10^{-3}	1.3×10^{-3}	1.3×10^{-3}	1.0×10^{-3}	NA	1.0×10^{-3}

Notes: NA = Not Applicable.

[a] These values are identical to the values presented in Exhibit 1.29.

[b] These values are identical to the values presented in Table 1.82.

[c] These values are identical to the values presented in Table 1.84.

[d] These values are identical to the values presented in Table 1.86.

[e] These values were derived omitting infrequently detected analytes, laboratory contaminants, and those contaminants for which only provisional or withdrawn toxicity values are available and using EPA Region 4 dermal absorption values.

Table 3.36. Summary of risk results and uncertainties for the current industrial worker – systemic toxicity – for WAG 28

(formerly "Exhibit 1.58. Quantitative summary of uncertainties for the current industrial worker—systemic toxicity")

Location	Default HI[a]	Default HI w/o lead[a]	Default HI minus infequently detected analytes w/o lead[b]	Default HI minus common laboratory contaminants w/o lead[c]	Default HI minus analytes with provisional or withdrawn toxicity values w/o lead[d]	Region 4 absorption factors w/o lead[e]	Lower bound HI[f]
SWMU 99a (soil)	<1	<1	<1	<1	<1	<1	<1
SWMU 193a (soil)	<1	<1	<1	<1	<1	<1	<1
SWMU 193b (soil)	5.25	<1	5.25	5.25	<1	<1	<1
SWMU 193c (soil)	3620	<1	<1	<1	<1	<1	<1

[a] These values are identical to the values presented in Exhibit 1.17.

[b] These values are identical to the values presented in Table 1.82.

[c] These values are identical to the values presented in Table 1.84.

[d] These values are identical to the values presented in Table 1.86.

[e] These values are identical to the values presented in Exhibit 1.55.

[f] These values were derived omitting contributions from lead, infrequently detected analytes, and compounds for which only provisional or withdrawn toxicity values are available and using EPA Region 4 dermal absorption factors.

Table 3.37. Summary of risk results and uncertainties for the future industrial worker – systemic toxicity – for WAG 28

(formerly "Exhibit 1.59. Quantitative summary of uncertainties for the future industrial worker—systemic toxicity")

Location	Default HI[a]	Default HI w/o lead[a]	Default HIs minus infrequently detected analytes w/o lead[b]	Default HI minus laboratory contaminants w/o lead[c]	Default HI minus analytes with provisional or withdrawn toxicity values w/o lead[d]	Lower bound HI[e]
SWMU 99a (RGA)	8,150	5.11	5.11	5.11	2.61	2.6
SWMU 99a (McNairy)	1.64	1.64	1.64	1.64	<1	<1
SWMU 99b (RGA)	7.00	7.00	7.00	7.00	2.22	2.2
SWMU 193a (RGA)	1.64	1.64	1.63	1.63	<1	<1
SWMU 193a (McNairy)	4.69	4.69	4.43	4.69	<1	<1
SWMU 193b (RGA)	1.74	1.74	1.74	1.73	<1	<1
SWMU 193b (McNairy)	<1	<1	<1	<1	<1	<1
SWMU 193c (RGA)	1.46	1.46	1.46	1.46	1.09	1.09
SWMU 193c (McNairy)	25,100	9.92	9.92	9.92	7.55	7.5
AOC 204 (RGA)	33.3	33.3	33.3	33.3	32.1	32.1

[a] These values are identical to the values presented in Exhibit 1.21.
[b] These values are identical to the values presented in Table 1.82.
[c] These values are identical to the values presented in Table 1.84.
[d] These values are identical to the values presented in Table 1.86.
[e] These values were derived omitting contributions from lead, infrequently detected analytes, and compounds for which only provisional or withdrawn toxicity values are available and using EPA Region 4 dermal absorption factors.

As shown in Table 3.34, most of the ELCR estimates calculated for the current industrial worker using the default exposure rates (column 1) differ from the lower bound estimates (last column) to varying extents. Thus, the numerical comparisons vary from "no change" (a ratio of 1) to differences of over five orders of magnitude. Where changes occur, the uncertainties that appear to make the most significant contribution are the omission of compounds with provisional and withdrawn carcinogenicity benchmarks and the use of EPA Region 4 dermal absorption factors instead of KDEP defaults. Notwithstanding these changes, the lower bound ELCRs remain within the EPA's range of concern for two of the four sites under consideration.

By contrast to soil exposure, Table 3.35 shows that the ELCR estimates for the future industrial worker exposure to groundwater under default and lower bound conditions do not vary greatly. In general, the changes are less than one order of magnitude, with the resulting lower bound ELCR estimates still exceeding the *de minimus* level at some sites.

In Tables 3.36 and 3.37, the HI estimates for both current and future industrial worker exposure to soil calculated using the default exposure rates (column 1) vary markedly from the lower bound estimates (last column) for those locations where lead was included as a COPC, and the provisional lead RfD was used. For those locations, omitting lead from the list of COPCs decreases the HIs by about four orders of magnitude. By contrast, other uncertainties investigated in both Tables 3.36 and 3.37 have little effect on the HI estimates. For the current industrial worker exposed to surface soil at SWMUs 99a, 193a, 193b and 193c, the lower-bound estimates of HI are all less than the *de minimus* level established in the Methods Document (i.e., HI = 1). For the future industrial worker, the lower bound HI estimates still exceed an HI of 1 at several locations in RGA and McNairy groundwater.

BHHRA—Principal Findings

For all sites, the cumulative human health ELCR and systemic toxicity exceed the accepted standards of EPA and KDEP for one or more scenarios when assessed using default exposure parameters. The scenarios for which risk exceeds *de minimus* levels (i.e., a cumulative ELCR of 1E-6 or a cumulative HI of 1) are summarized in Table 3.38.

BERA—Principal Findings

Lack of quality habitat in the industrial setting of WAG 28 sites within the fence boundaries limits exposure of ecological receptors at most sites under current conditions (with the exception of the Millwright Shop at SWMU 193). However, an assessment of potential risks in the future, assuming conditions change so that suitable habitat becomes available for ecological receptors, was conducted. Several contaminants in surface soils were found to be at concentrations greater than levels that are protective of future nonhuman receptors. Table 3.39 summarizes these chemicals and radionuclides of potential ecological concern. Risk for ecological receptors was not evaluated at SWMUs 99b and 194 or AOC 204 because it was previously determined that surface soil was not a medium of concern at these sites.

3.2.6 WAG 22

WAG 22 consists of the C-749 Uranium Burial Ground (SWMU 2), the C-404 Low-Level Radioactive/ Hazardous Waste Burial Ground (SWMU 3), the C-747-A Burial Ground (SWMU 7), and the C-747-A Burn Area (SWMU 30). SWMUs 7 and 30 are located in the northwest corner of the security area, and SWMUs 2 and 3 are located in the western end of the security area as depicted in Fig. 3.30. According to the PGDP SMP, the SWMUs in WAG 22 were grouped due to their suspected contribution to off-site contamination, potential for application of a remedial technology common to the group, and similarity in contaminant types (DOE 1999c).

As indicated above, WAG 22 consists of a total of four SWMUs. Information regarding location, setting, historic manufacturing/TSD processes, is provided for each SWMU in the following sections.

3.2.6.1 C-749 Uranium Burial Ground — SWMU 2

Location

The C-749 Uranium Burial Ground (SWMU 2) is located in the west–central portion of the security-fenced area of the PGDP north of Virginia Avenue and on the western edge of the C-404 Low-Level Radioactive/Hazardous Waste Burial Ground. It encompasses an area of approximately 2,970 m^2 (32,000 ft^2) with approximate dimensions of 49 × 61 m (160 × 200 ft). Surface runoff from SWMU 2 primarily flows into the drainage ditch located south of the burial ground. This ditch is approximately 0.6 m to 1.8 m (2 ft to 6 ft) deep and is connected hydraulically to the UCRS. The western portion of the ditch receives shallow groundwater from beneath SWMU 2 during dry seasons of the year and likely acts as a local source of groundwater recharge during wet seasons (DOE 1998c).

Setting

The following subheadings provide information on the setting of SWMU 2, including geology/ hydrogeology, surface features and surface-water hydrology, transportation, floodplains, wetlands, soils and prime farmland, biological resources, and cultural resources. Additionally, a discussion of underground utilities located in the vicinity of the landfill has been included.

Table 3.38. Land uses of concern for WAG 28

(formerly "Table ES.2. Scenarios for which human health risk exceeds de minimus levels")

	Site						
Scenario	**SWMU 99a***	**SWMU 99b***	**SWMU 193a***	**SWMU 193b***	**SWMU 193c***	**SWMU 194**	**AOC 204**
Systemic Toxicity[a]							
Current industrial worker							
Exposure to soil	–	NA	–	X[b]	X[c]	NA	NA
Future industrial worker							
Exposure to soil	–	NA	–	X[b]	X[c]	NA	NA
Exposure to RGA groundwater	X[d]	X[b]	X[b]	X[b]	X[b]	NA	X[b]
Exposure to McNairy groundwater	X[b]	NA	X[b]	–	X[d]	NA	NA
Future on-site resident[a]							
Exposure to soil	X[b]	NA	X[b]	X[b]	X[d]	NA	NA
Exposure to RGA groundwater	X[d]	X[b]	X[b]	X[b]	X[b]	NA	X[b]
Exposure to McNairy groundwater	X[b]	NA	X[b]	X[b]	X[d]	NA	NA
Off-site resident							
Exposure to groundwater[e]	X[e]	–	X[e]	–	X[e]	X[e]	X[e]
Future recreational user[a]							
Exposure to soil	–	NA	–	–	X[c]	NA	NA
Future excavation worker							
Exposure to soil	X[d]	–	–	X[b]	X[d]	X[c]	–
Excess lifetime cancer risk							
Current industrial worker							
Exposure to soil	X	NA	X	X	–	NA	NA
Future industrial worker							
Exposure to soil	X	NA	X	X	–	NA	NA
Exposure to RGA groundwater	X	X	X	X	X	NA	X
Exposure to McNairy groundwater	X	NA	X	–	X	NA	NA
Future on-site resident[f]							
Exposure to soil	X	NA	X	X	–	NA	NA
Exposure to RGA groundwater	X	X	X	X	X	NA	X
Exposure to McNairy groundwater	X	NA	X	X	X	NA	NA
Off-site resident							
Exposure to groundwater[e]	–	–	–	–	–	–	X[e]
Future recreational user[f]							
Exposure to soil	X	NA	X	–	–	NA	NA
Future excavation worker							
Exposure to soil	X	X	X	X	X	X	X

Notes:

Scenarios where risk exceeded the benchmark levels (HI of 1/ELCR of 1E-6) are marked with an "X."

Scenarios where risk did not exceed a benchmark level are marked with a "–."

"NA" indicates that the scenario/land use combination is not appropriate.

*Letters following SWMU numbers designate subdivisions of SWMUs 99 and 193 based on area and historical use.

[a] For the future recreational user and the future on-site rural resident, the results for a child are presented.

[b] These scenarios are of concern even though lead was undetected.

[c] If contribution from lead is not considered, the total HI falls below 1, and the scenario is not of concern.

[d] Lead is present, and the scenario is of concern whether or not the element is included in the assessment.

[e] Based on the results of contaminant transport modeling, "X" indicates that the location contains a source of unacceptable off-site contamination.

[f] For ELCR regarding the future recreational user and the future on-site rural resident, the values are for lifetime exposure.

Table 3.39. Chemicals of potential ecological concern for WAG 28

(formerly "Table ES.2. Summary of chemicals with maximum detected or reasonable maximum exposure concentrations resulting in ecological hazard quotients greater than 1 for one or more nonhuman receptor groups")

	SWMU[a]			
Receptor group	**99a**	**193a**	**193b**	**193c**
Plants [b]	Barium, Chromium, Zinc, Technetium-99[c]	Chromium	Chromium, Vanadium	Barium, Chromium, Lead, Zinc
Soil invertebrates [b]	Chromium, Zinc, Technetium-99[c]	Chromium	Chromium	Chromium
Terrestrial wildlife [d]	None	none	Vanadium	None

[a] Surface soil was not a medium of concern at SWMUs 99b and 194 or AOC 204; therefore, ecological risks were not evaluated at those sites.
[b] Plant and soil invertebrate results are based on maximum detected concentrations or activities.
[c] See text for discussion of situation resulting in unusually high activity for ^{99}Tc.
[d] Terrestrial wildlife results are based on reasonable maximum exposure concentrations or activities.

Geology/Hydrogeology

A cross section illustrating the stratigraphy of the shallow unconsolidated deposits underlying the burial ground area is presented in Fig. 3.31.

Based on the observed top of the waste in three borings installed at the unit, the wastes at SWMU 2 are overlaid by approximately 3 m (10 ft) of surficial deposits. Historical records indicated a minimum depth of 1.8 m (6 ft) to the top of the waste (4 ft of soil cover plus an additional 2 ft-thick cap/vegetative cover), so the surficial deposits may be as thin as 1.8 m (6 ft) in some areas of the burial ground. These surficial deposits consist of silt loam and silty clay loam soils underlying a 15-cm (6-in.) clay cap and a 46-cm (18-in.) vegetative cover. The Upper Continental Deposits (HU 1 through HU 4) surround and immediately underlie the wastes. They are approximately 12.2-m (40-ft) thick in the vicinity of SWMU 2 and consist of interbedded sand and gravel deposits separated by silty and clay-rich lenses. Results of a surface seismic survey at the unit indicate that a relatively continuous refractor is present beneath the wastes at SWMU 2. This finding has been interpreted as an indication that HU 2A, the uppermost permeable unit in the Upper Continental Deposits, is a continuous lense that extends beneath the entire SWMU 2 area. Correlation of the sample logs for monitoring wells located in the surrounding vicinity indicates that HU 2A may be continuous over the northwest portion of the plant, but this layer is typically less than 1.52-m (5-ft) thick and exhibits a wide range of particle sizes and permeabilities. The variable clay content and permeabilities of these sand and gravel lenses limit the lateral movement of contamination within the UCRS.

The top of the Lower Continental Deposits typically is found at depths of approximately 18.3 to 21.3 m (60 to 70 ft) bgs. The Lower Continental Deposits consist predominantly of well-rounded chert gravel with sand and are approximately 7.6 to 9.1 m (25 to 30 ft) thick. They are underlain by the silty and clayey sands of the McNairy Formation at depths of approximately 27.4 m (90 ft) bgs.

The following summary of the hydrogeologic conditions at the burial ground is based on aquifer slug test results, aquifer pumping test results, and water level data from groundwater wells and piezometers in the vicinity of the burial grounds. Much of the information in this subsection was derived from the detailed summary of the remedial action/remedial design (RA/RD) data presented in the *Data Summary and Interpretation Report for Interim Remedial Design at Solid Waste Management Unit 2 of Waste Area Grouping 22 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1997b).

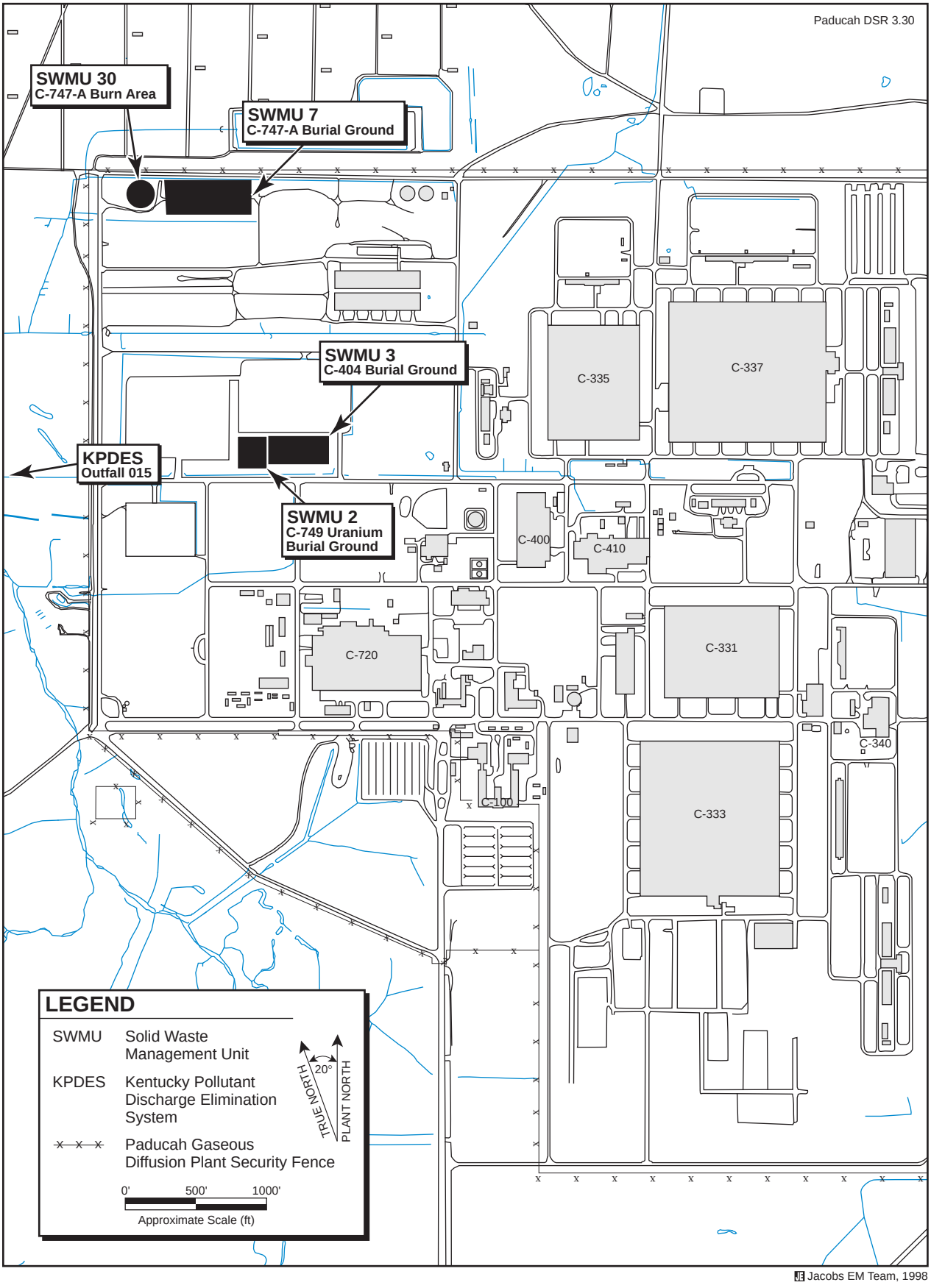

Fig. 3.30. Locations of SWMUs within WAG 22.

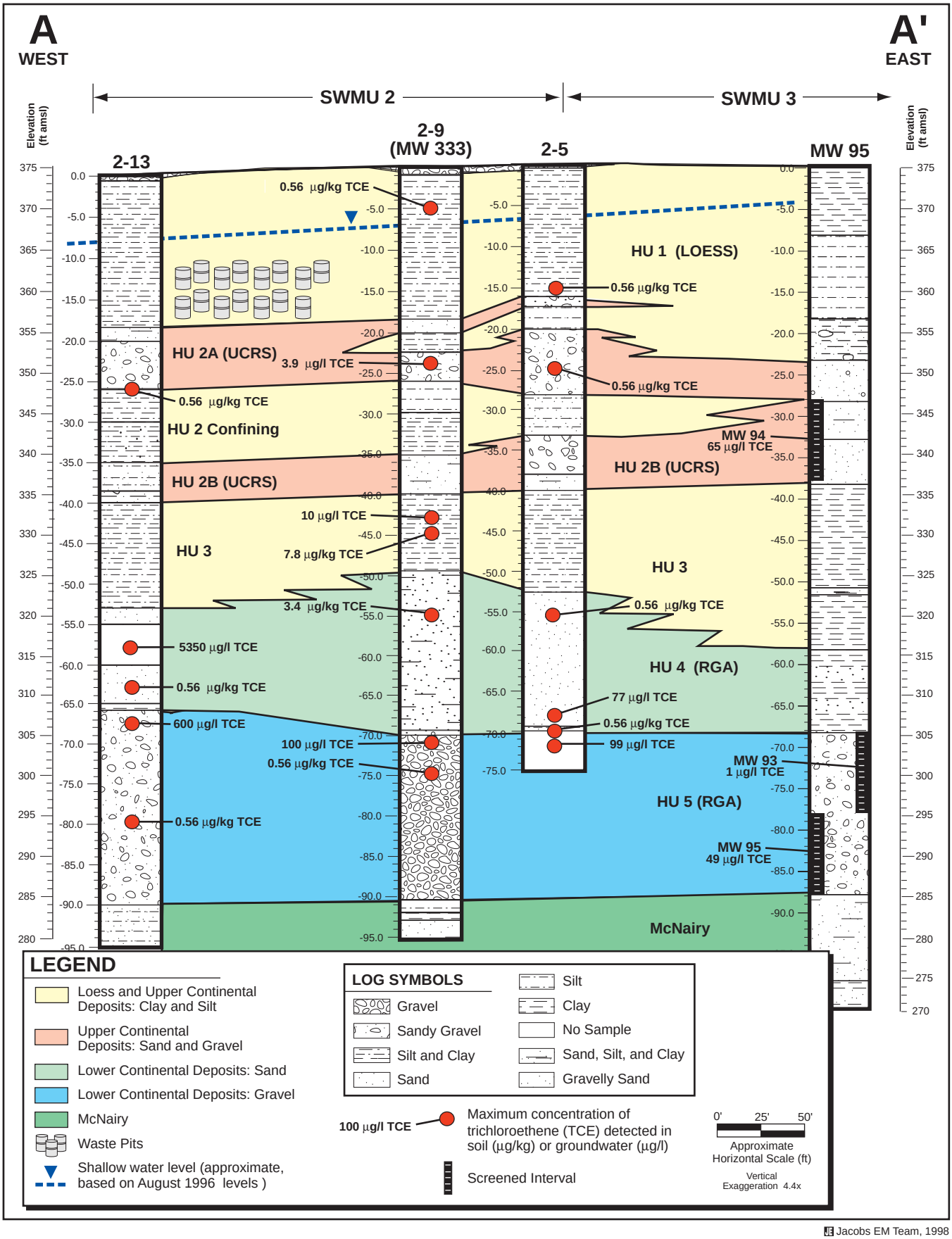

Fig. 3.31. Cross section at SWMU 2.

Water-level measurements taken in the monitoring wells and temporary piezometers at SWMU 2 indicate that a high groundwater table exists beneath SWMU 2. The top of the water table, at an approximate average depth of 2.4 m (8 ft) bgs, roughly corresponds to the top of the buried waste at the unit, indicating most of the waste is saturated. Figure 3.32 presents a map of the water levels in HU 2A, the thin, shallow gravel layer found at an average depth of 5.8 m (19 ft) bgs. These results confirm that, although the hydraulic gradient in the UCRS sands and gravels is predominantly vertical, there is a small southwestward component (0.05 m/m) of lateral flow in HU 2A. The groundwater levels in HU 2A exhibit seasonal fluctuations ranging from about 110.6 to 112.5 m (363 to 369 ft) amsl, with the highest water levels typically occurring in the winter and spring. Based on these expected water-level fluctuations, the majority of the buried waste at SWMU 2 is saturated throughout the year and all of the buried waste is saturated during the wet seasons.

Groundwater levels in the lower sand units (HU 2B) of the UCRS range from approximately 106 to 109 m (351 to 358 ft) amsl at the burial ground. The predominant direction of flow is downward, through the underlying HU 3 aquitard into the RGA. Potentiometric maps of the area indicate that the contaminants present in the RGA at SWMU 2 will migrate northward toward the Northwest Plume groundwater treatment facility (DOE 1996b). Table 3.40 lists the values of significant hydrogeologic parameters for the hydrogeologic units beneath SWMU 2. Based on these values, the amount of underflow passing through HU 2A and the quantity of leakage through HU 3 at SWMU 2 were estimated at 890 liters/d (235 gal/d) and 814 liters/d (215 gal/d), respectively (DOE 1997b).

Table 3.40. Hydrogeologic parameters at SWMU 2

Hydrogeologic unit	Horizontal gradient	Vertical gradient	Horizontal conductivity (cm/sec)	Vertical conductivity (cm/sec)
HU 1	0.05	NA	NA	1.0×10^{-7}
HU 2A	0.05	NA	1.0×10^{-5}	5.0×10^{-6}
HU 2 Confining	NA	0.6	NA	8.0×10^{-7}
HU 2B	NA	NA	5.0×10^{-6}	1.0×10^{-6}
HU 3	NA	1.0	NA	5.0×10^{-7}
HU 4 + HU 5 (RGA)	0.0005	NA	2.0×10^{-1}	NA

Source: DOE 1997a

Surface runoff from SWMU 2 primarily flows into the drainage ditch located south of the burial ground. This ditch is approximately 0.6 to 1.8 m (2 to 6 ft) deep and is connected hydraulically to the UCRS. The western portion of the ditch receives shallow groundwater from beneath SWMU 2 during dry seasons of the year and likely acts as a local source of groundwater recharge during wet seasons.

Surface features and surface-water hydrology. The surface of SWMU 2 is slightly mounded, with surface elevations ranging from 112.8 to 114.9 m (370 to 377 ft) amsl. Surface runoff from this unit flows into the drainage ditches located south and north of the SWMU and the swale located west of the unit. The ditches are approximately 0.6 to 1.8 m (2 to 6 ft) deep and discharge through KPDES Outfall 015 to Bayou Creek, which is located approximately 480 m (1,600 ft) west of SWMU 2. Some surface-water runoff across the area originates from the mounded area associated with the C-404 Low-Level Radioactive/ Hazardous Waste Burial Ground (SWMU 3), which is located immediately east of SWMU 2. The surface of SWMU 2 and the surrounding ditches are grass-covered.

Transportation. Transportation in the vicinity of SWMU 2 consists of PGDP personnel performing day-to-day activities and is confined to paved or gravel roads.

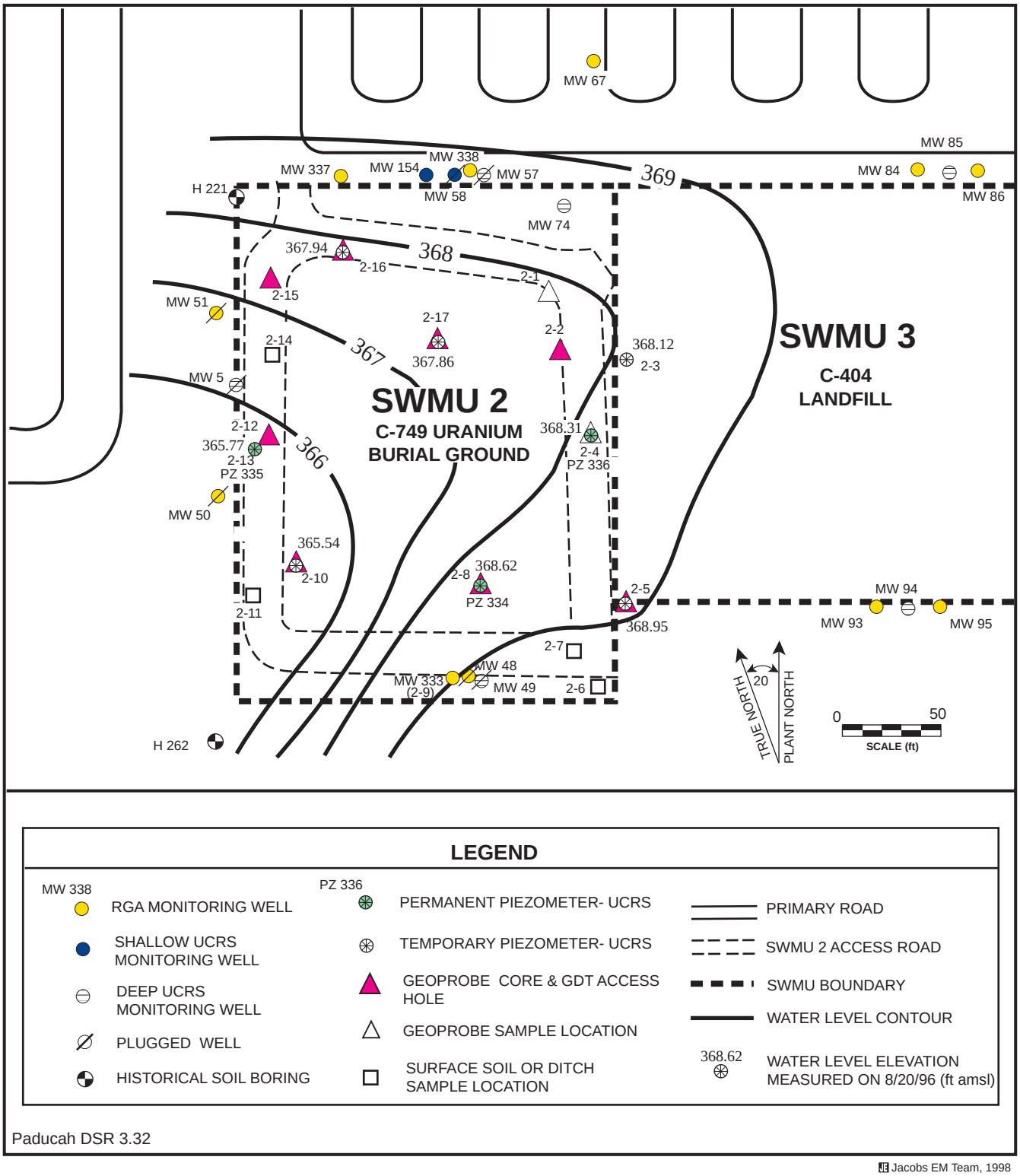

Fig. 3.32. Sampling locations and water levels at SWMU 2.

Wetlands. No wetlands have been identified at SWMU 2, but potential wetlands have been identified in the adjacent drainage ditches, which are outside the boundaries of the unit (CDM Federal 1994). Final wetland determination for these areas was not possible during the 1994 COE wetlands study, due to health and safety restrictions denying access to any ditches located on the PGDP. However, the COE made the determination that the areas identified as potential wetlands are jurisdictional wetlands. The drainage area consists of a depression adjacent to Virginia Avenue and a side road, south and east of SWMUs 2 and 3 approximately 3 m (10 ft) wide and 274 m (900 ft) long. Elevation ranges from approximately 114.3 m (375 ft) amsl at Virginia Avenue to 112.8 m (370 ft) amsl in the bottom of the drainage area. Water levels in the drainage area can range from nearly 1.5 m (5 ft) bgs. Hydrologic connection to other drainage areas is maintained with a culvert system. Water enters this area from the east through culverts and exits the area to the west as overland flow. Overall, hydrologic functions and values (e.g., groundwater recharge through production export) are rated low to moderate. The presence of an outlet, the relatively small size of the wetland, and the lack of open water limits the hydrologic functions and values. Biological functions and values (e.g., wildlife diversity/abundance through aquatic diversity/abundance) also are rated low to moderate.

Floodplains. No 100-year floodplains are adjacent to SWMU 2.

Biological resources. The majority of the area associated with SWMU 2 has been cleared previously of vegetation and consists of various grasses including rye, fescue, foxtail, and various others not identified due to mowing practices. Vegetation present within the depression adjacent to Virginia Anvenue consists of rush (*Juncus* sp.), flat sedge (*Cyperus* sp.), spikerush (*Eleocharis* sp.), sedges (*Carex* sp.), and various grasses (CDM Federal 1994).

Since SWMU 2 is within the security area and is frequently mowed, it provides limited habitat for wildlife. No endangered or threatened species are known to be present at SWMU 2 (CDM Federal 1994).

Cultural resources. All of the areas associated with SWMU 2 have been previously disturbed and, consequently, are not likely to contain any sites of archaeological significance.

Underground utilities. An old electrical conduit appears on site diagrams; it runs from the northeast to the southwest across the northern part of SWMU 2.

Manufacturing/TSD Processes

The C-749 Uranium Burial Ground (SWMU 2) was used from approximately 1951 until 1977 for the disposal of containerized and uncontainerized uranium and uranium-contaminated wastes. According to disposal records, the burial ground consists of numerous individual burial pits (or trenches); these burial pits generally correspond to 6.1 × 6.1 m (20 × 20 ft). It was reported that wastes were placed in trenches excavated to a maximum depth of approximately 2.1 to 5.2 m (7 to 17 ft) and then covered with 0.6 to 1.2 m (2 to 4 ft) of soil. The exact depth of waste burial has not been determined, but sufficient data exist to resolve the maximum depth of burial. The results of the recent investigation at SWMU 2 indicate a depth of approximately 5.6 m (18.5 ft) to the top of undisturbed soils; this value can be used as the probable maximum depth to the base of the waste pits (DOE 1997a). Sampling activities conducted during the recent investigation have revealed that the backfill surrounding the buried waste is a non-native clay likely having a lower permeability than the surrounding (native) soils. After the drums were placed into the burial cell, fires reportedly occurred from oxidation of pyrophoric uranium shavings, which are spontaneously ignitable in the presence of oxygen. No records are available documenting when and where the fires occurred at SWMU 2. No subsidence was observed as a result of these fires.

Summary of Investigations

The SWMU 2 and adjacent SWMU 3 areas are among the most fully characterized sites, hydrogeologically, at the PGDP. The principal investigations addressing potential contamination in the area are the Phase I and Phase II SIs conducted in response to the ACO (CH2M HILL 1991 and 1992) and the recent investigation (referred to here as the RA/RD field investigation) conducted to support the interim remedial action design (DOE 1997a). In addition, during the 12-year period beginning in 1979, several companies, including GeoTek (1980), D'Appalonia (1983), EDGe (1989), and Terran (1990), conducted site characterization activities in the vicinity of the burial grounds.

Sampling locations at SWMU 2 are shown on Fig. 3.32. One deep soil boring (H 221), one shallow soil boring (H 262), and numerous groundwater monitoring wells (MWs 48 through 51, MWs 57, 58, 67, and 74) were installed in the SWMU 2 area prior to the RA/RD field investigation. MW154 was installed as a replacement well for MW58, which was abandoned in 1990 because surface contamination was determined to be migrating down the casing annulus. In addition, three double-ring infiltrometer tests (DRIs 4 through 6) were conducted to estimate the amount of precipitation that percolates through the existing low-permeability cap at SWMU 2.

For the RA/RD field investigation, soil samples were collected from five shallow near-waste-cell soil borings (2-1, 2-2, 2-4, 2-8, and 2-12), and two waste samples were collected at locations 2-12c and 2-15c from within the burial pits. Soil samples also were collected from deep perimeter borings [having total depths between 21.3 to 29.0 m (70 to 95 ft) bgs] that were drilled at locations 2-3, 2-5, 2-9, 2-13, and 2-17. Three sediment (2-6, 2-11, and 2-15) and four surface soil samples (from 2-7, 2-10, 2-14, and 2-17) were collected. Groundwater samples were collected at locations 2-3, 2-5, 2-9, 2-10, 2-13, 2-16, and 2-17. Eight temporary piezometers were installed at locations 2-3, 2-4, 2-5, 2-8, 2-10, 2-13, 2-16, and 2-17 to monitor the water levels in the shallow UCRS (HU 2A). Three additional piezometers were installed at approximately 3 m (10 ft) bgs at locations 2-8, 2-10, and 2-17 to confirm the elevation of the shallow water table at SWMU 2.

Three wells, MWs 333, 337, and 338, were installed at SWMU 2 in the upper RGA for the RA/RD field investigation. These upper RGA wells, along with the three previously installed wells, MW67 (upper RGA), MW74 (lower UCRS), and MW154 (upper UCRS), make up the current groundwater monitoring program at SWMU 2.

SWMU 2 also was sampled during the Phase I and Phase II SIs. Soil samples were collected from sampling stations H221 and H262. Water samples were collected from MWs 67, 74, and 154.

Conceptual Site Model

The source area is identified as the area of direct waste deposition. The sources of contamination that make up the source area at SWMU 2 include the buried waste materials and impacted near-surface soil (i.e., near-surface soil contamination is probably from the buried waste as no contaminated soils have been deposited at SWMU 2). The sources consist of low-level radioactive waste, primarily uranium and uranium-contaminated materials, organic constituents (primarily TCE and PCBs), and metals. The waste containers are saturated by groundwater with probable migration pathways existing from waste to groundwater and potential pathways from waste to the surrounding soils and air. Potential pathways exist from surface soil to surface water and sediments. From the waste source, release mechanisms include leaching and dissolution (as a result of direct contact of water with the waste cell) into the groundwater. For surface soil, the potential release mechanisms include erosion and surface runoff. Also, direct exposure to surface soil contaminants may occur through direct contact, and direct contact with uranium

may occur as a result of physical intrusion or excavation into SWMU 2. Potential migration pathways for contaminants through the air may occur in the form of airborne particulates, radionuclides, and vapor phase organics compounds. Additional release mechanisms may be caused by physical disruption as a result of excavation into the waste. Once in the environment, contaminants can be transferred between media and transported away from the SWMU through integrator units (i.e., surface water and groundwater).

Groundwater may be contaminated by leachate generated by infiltration through the waste or by direct contact of the groundwater with the waste. SWMU 2 is situated within the loess and the Upper Continental Deposits, which are approximately 18.3 m (60 ft) in thickness. Within these deposits is the UCRS, which provides the majority of recharge to the RGA below. Two main saturated layers within the UCRS have been identified: the HU 2A sand and gravel lenses, occurring at elevations ranging from 105 to 108 m (346 to 353 ft) amsl, and the HU 2B sand and gravel lenses, occurring at elevations ranging from 102 to 105 m (335 to 346 ft) amsl. Although there is a minor lateral (westward) gradient of flow within HU 2, the predominant flow direction is downward, toward the RGA. The RGA provides the primary source of potable groundwater for the area between the Ohio River and the PGDP, and is thus the Groundwater Integrator Unit for groundwater contamination off-site.

Figure 3.33 depicts the conceptual model for groundwater conditions within SWMU 2. The relative conductivities of the lithologic units are denoted by "K" and represent the following: K_1 represents low-conductivity clays and silts; K_2 represents the higher conductivity of the disturbed soil within the waste; and K_3 represents the conductivity of the sands and gravels, which is higher than the other two conductivity groupings. The SWMU 2 data summary report indicates that the depth of the water table and the top of the buried waste coincide, and that the high water level is from the water table and not the result of perched water in the pits. Consequently, a groundwater contaminant pathway off-site exists through direct contact of groundwater with the waste, independent of leaching.

The data summary report for SWMU 2 concluded shallow groundwater is hydraulically connected with the ditch south of SWMU 2. This conclusion indicates that contaminants within SWMU 2 may migrate to the ditch via shallow groundwater. However, an evaluation of the contaminants found in the ditches discounts groundwater discharge as a significant contributor. The majority of the contaminants identified in the south ditch are metals and radionuclides whose soil-water partition coefficients (K_d) indicate an affinity for soils. Additionally, the shallow soils at SWMU 2 contain significant amounts of clay-size particles, which have a greater binding affect on contaminants. Contaminant transport in the UCRS is primarily vertical (e.g., leaching or direct contact with the waste) to the RGA. The data summary report for SWMU 2 used modeling (MEPAS and RESRAD) to quantify vertical migration. This information then was used to determine the potential effects of the contaminants on human health and the environment. The data summary report contains a more detailed discussion of the modeling performed and a presentation of the risks associated with the modeled contaminants (DOE 1997a).

Nature and Extent of Contamination of Buried Waste

The waste materials within the burial pits at SWMU 2 are considered likely sources of contamination in the surface and subsurface soils and in the UCRS and RGA at this unit. The buried waste materials within the C-749 Uranium Burial Ground contain radionuclides, metals, VOCs, and SVOCs. Estimates of the quantities and types of wastes buried at the unit are provided by disposal records, which indicate that approximately 245,000 kg (270 tons) of uranium, 223,000 liters (59,000 gal) of oil, and 1,700 liters (450 gal) of TCE were buried within the waste pits. The disposal records, although of questionable accuracy, also provide a general guide to the lateral configuration of the buried waste within the unit. Additional data was collected during the RA/RD field investigation to refine further the horizontal and vertical limits of the buried waste materials at this SWMU. The exact vertical extent of the waste has not been determined,

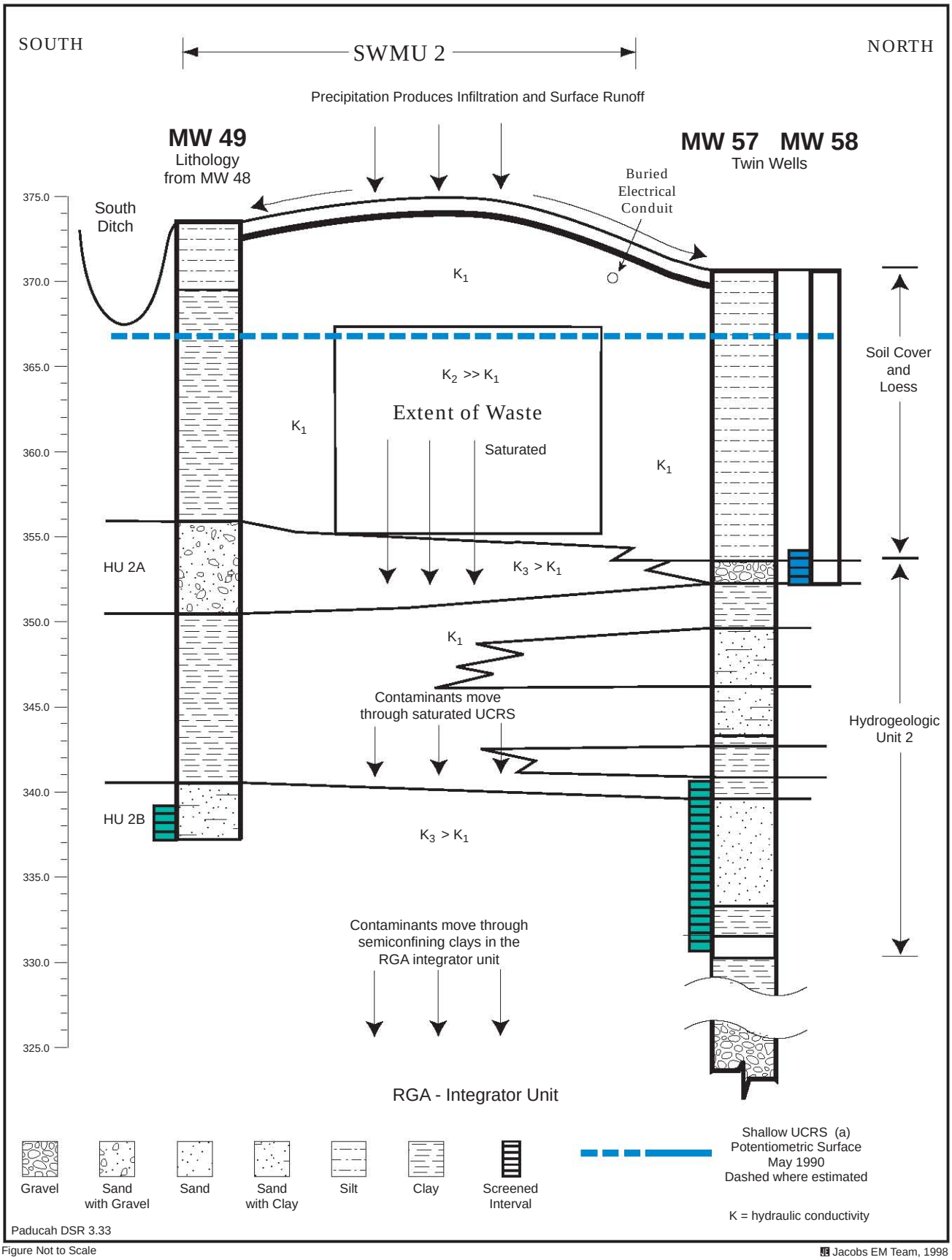

Fig. 3.33. Conceptual model of site conditions at SWMU 2.

but refraction seismic data collected in support of the geophysical diffraction tomography survey at SWMU 2 indicate that the probable maximum depth to the base of the waste is approximately 5.6 m (18.5 ft) bgs (DOE 1997a).

One of the principal source term uncertainties remaining is the predominant form of uranium present in the waste. Disposal records indicate that much of the uranium is present in the form of relatively insoluble uranium metal (including shop turnings, shavings, and sawdust), uranium alloys, and uranium oxides (approximately 13,000 kg of U_3O_8). However, more mobile forms of uranium are reportedly present as well. Disposal records indicate that drums containing uranyl fluoride solution, uranium-contaminated sludges, uranium-contaminated TCE, and UF_4 also were buried within SWMU 2. Based on the nature of the wastes reportedly buried at the unit, it is likely that the records listed as uranyl fluoride solution are primarily uranyl nitrate. With the exception of the partial excavation conducted in Area 9 in 1984, only two samples of the waste material have been collected at the unit. Waste samples from these two sampling locations (2-12 and 2-15), taken after unintentionally drilling into the burial pits, indicate that the proportion of the ^{238}U isotope present relative to the amounts of ^{234}U and ^{235}U in the waste is greater than the relative proportions typical of uranium ore. This proportion is consistent with the waste type (depleted uranium) reportedly placed in the unit. The maximum levels detected in the waste samples were 10,158,800 pCi/kg ^{238}U, 7614 pCi/kg ^{234}U, and 810 pCi/kg $^{235/236}U$. (The analysis performed could not differentiate between ^{235}U and ^{236}U.) Other radionuclides detected in the waste samples included ^{234}Th (37,710 pCi/kg) and ^{99}Tc (11.9 pCi/kg).

Although PCBs were not detected in the two waste samples, PCBs are considered likely waste contaminants, based on process knowledge and the analytical data for the recently located drum excavated from the unit in 1984. PCBs were detected in sludge samples from this drum at a maximum concentration of 7,900 mg/kg. It is likely that PCBs were present in some of the petroleum-based or synthetic oils used to stabilize the pyrophoric uranium buried within SWMU 2.

Nature and Extent of Contamination of Secondary DNAPL

One of the goals of the investigation at SWMU 2 was to determine if a DNAPL source exists beneath SWMU 2. Waste disposal records state that 1,700 liters (450 gal) of TCE were buried at the unit and sampling results indicate that high levels of TCE are present in subsurface soil and groundwater at the unit. However, the concentrations of TCE detected in UCRS and RGA groundwater at the unit do not exceed the criteria for definition of a DNAPL source (i.e., concentrations did not exceed 10,000 µg/L, or 1% of the solubility limit for TCE). During the RA/RD field investigation, the concentrations of TCE detected in groundwater were found to exceed the criteria for definition of a hot spot (0.1% solubility, or 1,000 µg/L) in both the UCRS and RGA. The highest concentration of TCE detected in the RGA groundwater during this investigation was 5,350 µg/L, detected in a sample collected from the upper RGA at a depth of 17 m (56 ft) bgs in boring 2-13. The concentration of TCE dropped to 370 µg/L in a sample from the same boring collected from the base of the RGA. The maximum TCE level detected in the three downgradient upper RGA monitoring wells (MWs 337, 338, and 67) at SWMU 2 was 8.3 µg/L, which is close to the maximum level (10 µg/L) detected in the background RGA well (MW333) located on the southern edge of SWMU 2. These sampling results indicate that DNAPLs may be present in the vicinity of SWMU 2 but likely have not reached the base of the RGA. The higher concentrations in the upper RGA may be due to vertical migration of TCE from a DNAPL source in the UCRS to the RGA beneath the unit, lateral migration from an upgradient DNAPL source in the RGA, or both. To detect any potential future releases into the RGA from SWMU 2, the RGA wells installed at the edges of the unit will continue to be monitored on a quarterly basis. Groundwater data indicate that the dissolved-phase contaminants currently present in the RGA at SWMU 2 will migrate northward toward the Northwest Plume Containment System.

Nature and Extent of Contamination of UCRS Soils

Ten metals (arsenic, barium, beryllium, chromium, manganese, nickel, silver, thallium, uranium, and vanadium) have been detected at levels above background in subsurface soil samples from the UCRS [at depths between approximately 0.3 to 15.2 m (1 to 50 ft) bgs] at SWMU 2. Radionuclides detected at activities above background in the UCRS subsurface soils at the unit and their maximum detected activities include ^{230}Th (1.55 pCi/g), ^{234}U (155 pCi/g), $^{235/236}$U (25.8 pCi/g), and ^{238}U (947 pCi/g). In addition, low levels of the radionuclides ^{241}Am (0.48 pCi/g), ^{237}Np (0.12 pCi/g), and ^{239}Pu (0.09 pCi/g) have been detected in UCRS soil samples at the unit. The organic compounds TCE and *cis*-1,2-DCE were detected in UCRS soils at maximum concentrations of 140 mg/kg and 130 mg/kg, respectively. Vinyl chloride (VC) was detected in just one subsurface soil sample at a concentration of 1.4 mg/kg. Aroclor-1248 was detected in several UCRS soil samples; its maximum concentration (4.2 mg/kg) was detected at soil boring location 2-2 at a sample depth 2.5 to 3.7 m (8 to 12 ft) bgs.

Nature and Extent of Contamination of RGA and McNairy Soils

With the exception of uranium, no analysis was performed for metals in the RGA and McNairy soil samples collected at SWMU 2 for the RA/RD investigation. During the Phase II SI, no metals were detected above background levels in subsurface soil samples collected beneath 15.2 m (50 ft) bgs. Low levels of the radionuclides ^{230}Th, ^{234}U, $^{235/236}$U, ^{238}U, and ^{99}Tc were detected in RGA and McNairy soils at SWMU 2. None of these radionuclides have been detected above background levels in the RGA soil samples. In the McNairy soils, the radionuclides ^{230}Th (1.51 pCi/g) and ^{238}U (1.2 pCi/g) were detected at levels slightly above background levels (1.45 and 1.17 pCi/g, respectively). The radionuclides ^{241}Am, ^{237}Np, and ^{239}Pu also were detected in RGA and McNairy soil samples. (No subsurface soil background levels are available at the PGDP for these radionuclides.) TCE was not detected in the McNairy soil samples, but was detected at a maximum concentration of 0.0034J mg/kg in one upper RGA soil sample [15.2 to 16.8 m (50 to 55 ft) bgs] from soil boring 2-9.

Nature and Extent of Contamination of UCRS – Groundwater

Numerous metals have been detected in UCRS groundwater samples from the SWMU 2 area at concentrations above groundwater (RGA) background levels. These metals, and the maximum detected concentrations at the unit, include barium (1,200 µg/L), beryllium (78 µg/L), chromium (279 µg/L), lead (113J µg/L), manganese (37,000 µg/L), nickel (239 µg/L), silver (46.9 µg/L), and vanadium (4,100 µg/L). During the Phase II SI, lead (up to 17.8J µg/L) and cadmium (6.8 µg/L) were detected at levels above the maximum contaminant level (MCL) in the UCRS. Groundwater sampling indicates that the principal radiological contaminants present in the UCRS at SWMU 2 are ^{99}Tc and uranium. Technetium-99 was detected at levels ranging from < 25 to 1,000J pCi/L, with the highest values reported for the Phase II replacement MW154, which was screened in HU 2A. Uranium has been detected at varying levels in UCRS wells; the maximum values (in the dissolved fraction) detected in MW58 were 360 pCi/L ^{234}U, 63 pCi/L ^{235}U, and 2,700 pCi/L ^{238}U. During the RA/RD field investigation, the maximum levels detected were 11 pCi/L ^{234}U, 0.54 pCi/L ^{235}U, 1.1 pCi/L $^{235/236}$U, and 55.8 pCi/L ^{238}U. Low levels of other radionuclides, including ^{230}Th, ^{241}Am, ^{237}Np, and ^{239}Pu, also were detected at SWMU 2 in these UCRS groundwater samples. Sampling of filtered groundwater was conducted in May 1998 to determine whether there is an appreciable amount of dissolved uranium present in the shallow groundwater beneath SWMU 2. The results of this sampling effort (ranging from nondetect to a maximum of 0.06 mg/L uranium) indicate that dissolved uranium is present in the UCRS groundwater at SWMU 2 but not at significant concentrations. The principal organic contaminant detected in the UCRS groundwater at SWMU 2 is TCE. TCE was detected in the upper UCRS gravel unit (HU 2A) in MW154 at concentrations up to 3,300 µg/L prior to the RA/RD field investigation. The highest concentration of TCE detected during the RA/RD field investigation was

39 µg/L, detected at location 2-3 in HU 2A. The TCE degradation products *cis*-1,2-DCE and vinyl chloride have also been detected in the UCRS, at maximum concentrations of 280 µg/L and 5 µg/L, respectively.

Nature and Extent of Contamination of the RGA

Abundant groundwater data have been collected since 1979 in the vicinity of the burial grounds. For the recent investigation, groundwater samples were collected from four RGA monitoring wells (MWs 333, 337, 338, and 67) and from seven borings (2-3, 2-5, 2-9, 2-10, 2-13, 2-16, and 2-17) at SWMU 2. Numerous metals (including arsenic, barium, beryllium, chromium, manganese, nickel, silver, thallium, and vanadium) and radionuclides (including ^{234}U, ^{235}U, and ^{238}U) have been detected above background levels in these RGA groundwater samples. The highest uranium activities were detected in samples from perimeter borehole groundwater samples. Lower uranium activities were detected in the groundwater monitoring wells located at the unit. For example, the highest ^{238}U activity (91.7 pCi/L) detected in RGA groundwater was for a sample collected from perimeter boring location 2-16. The maximum ^{238}U activity detected in the RGA monitoring well completed at this same location (MW337) was 0.27 pCi/L. The RGA groundwater data indicates that the higher concentrations present in the perimeter boreholes are related to the higher suspended solids content in these samples (DOE 1997a). Other radionuclides detected in the RGA groundwater at the unit include ^{241}Am (1.39 pCi/L), ^{237}Np (0.60 pCi/L), ^{239}Pu (4.29 pCi/L), ^{234}Pa (22.0 pCi/L), ^{99}Tc (77 pCi/L), and ^{230}Th (1.05 pCi/L). In general, there are lower levels of ^{238}U and ^{99}Tc contamination in the RGA than in the UCRS in the vicinity of SWMU 2.

The organic compounds TCE (5,350 µg/L), *cis*-1,2-DCE (750 µg/L), and vinyl chloride (1.40 µg/L) have been detected in the RGA. The highest TCE concentrations were detected in the upper RGA at sampling locations along the western side of SWMU 2. The results of the field gas chromatograph at SWMU 2 also indicated high levels of 1,1-DCE were present in the RGA groundwater. However 1,1-DCE was not detected in any of the samples sent to the fixed-base laboratory. Additional water samples were collected and analyzed at the fixed-base laboratory and these results (non-detect) confirmed that the field detects of 1,1-DCE were false positives. A more detailed explanation of these results can be found in the *Data Summary and Interpretation Report for Interim Remedial Design at Solid Waste Management Unit 2 of Waste Area Grouping 22 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1997b).

Nature and Extent of Contamination of McNairy Formation

Radionuclides (^{234}U, ^{235}U, and ^{238}U) and metals (beryllium, manganese, and vanadium) have been detected at levels above background in the McNairy groundwater samples collected during the RA/RD field investigation. The maximum detected activity of ^{238}U in the McNairy was 19.6 pCi/L, which was detected in groundwater samples from a depth of 26.5 m (87 ft) bgs in soil boring 2-17, located in the northern portion of the burial ground. Additional radionuclides detected in the McNairy include ^{241}Am, ^{237}Np, ^{239}Pu, ^{99}Tc, and ^{230}Th. The organic compounds TCE, *cis*-1,2-DCE, and *trans*-1,2-DCE were detected at maximum concentrations of 55 µg/L, 100 µg/L, and 100 µg/L, respectively, in the McNairy groundwater at the unit. The field gas chromatograph results for 1,1-DCE indicate high levels of this organic are present in the McNairy, but, as with the RGA samples, these results are considered false detections (DOE 1997a).

Contaminant Fate and Transport – Metals

Based on the criteria used to identify COCs, metals detected in any media include arsenic, barium, beryllium, chromium, manganese, nickel, thallium, uranium, and vanadium. Due to the highly variable nature of the lithology within SWMU 2, Table 3.41 lists K_d values for clay and sand. The corresponding retardation factor (R_d) values (dimensionless numbers that quantify the rate of movement of a particular

solute relative to the average pore water velocity) indicate a high tendency for these metals to stay bound in the soil and a low tendency to migrate. All of the R_d values for these metals are on the order of 350 or higher.

Table 3.41. Partition coefficients and retardation factors for metals at SWMU 2[a]

Chemicals	K_d (clay) (L/kg)	K_d (sand) (L/kg)	R_d (clay) (unitless)	R_d (sand) (unitless)
Arsenic	2.0E+02	2.0E+02	1.2E+03	2.1E+03
Barium	6.0E+01	6.0E+01	3.72E+02	6.4E+02
Beryllium	1.3E+03	2.5E+02	2.7E+03	8.1E+03
Chromium	1.5E+03	7.0E+01	9.3E+03	7.4E+02
Manganese	1.8E+02	5.0E+01	1.1E+03	5.3E+02
Nickel	6.5E+02	4.0E+02	4.0E+03	4.2E+03
Thallium	1.5E+03	1.5E+03	9.3E+03	1.6E+04
Uranium, total	1.6E+03	3.5E+01	9.9E+03	3.7E+02
Vanadium	1.0E+03	1.0E+03	6.2E+03	1.1E+04

[a] All values are from the 1995 D2 FS report (DOE 1995c)

Contaminant Fate and Transport – Organic Compounds

Organic compounds included in the list of COCs are Aroclor-1248, Aroclor-1260, benzo(*a*)pyrene, vinyl chloride, and TCE. These contaminants have K_d values and R_d values that are less than those for the metals.

TCE, vinyl chloride, and PCBs also have the potential to be transported in the form of a DNAPL. Groundwater detections do not indicate that presently there is TCE, vinyl chloride, or PCBs in the form of a DNAPL near SWMU 2; however, a DNAPL is a potential future scenario as existing drums within the waste continue to degrade and their contents migrate into the soil. DNAPL transport behavior is highly dependent upon lithology and stratigraphic dip. Given the heterogeneous nature of the UCRS, this makes it extremely difficult to determine the rate of potential DNAPL migration. In general, DNAPLs will be less able to migrate through clay members such as the ones separating the water-bearing units within the UCRS and the one separating the UCRS from the RGA.

There is sufficient process knowledge from past plant productions about waste disposal to indicate that uranium shavings may have been immersed in PCB oils to prevent rapid oxidation of the uranium and were disposed of in SWMU 2. PCBs have very low water solubilities (from 0.0027 mg/L for Aroclor-1260 to 15.0 mg/L for Aroclor-1221) and vapor pressures [from 0.000096 mm mercury for Aroclor-1254 to 0.0067 mm mercury for Aroclor-1221], which indicates that they do not dissolve readily in water or vaporize easily. In addition, high-partition coefficients (5.3×10^2 for sand, 5.3×10^3 for clay) for PCBs indicate an affinity both to sand and clay materials (ORNL 1994).

Naturally occurring soil acidity, ranging from a pH of 4.5 to 5.5 in the vicinity of the PGDP, potentially could affect the mobility of PCBs in soils, which results in an increased solubility for the organic fraction of soils. This increased solubility results in an increased mobility of the organics and also the PCBs, which are adsorbed to organics. Since PCBs are limited to the surface soil of SWMU 2 (excluding the waste pit where naturally occurring soil acidity should have no effect), it is likely that the pH of the soils has not increased mobility. Therefore, PCBs are anticipated to be stationary in all but surface soils, where they may be transported via surface-water runoff. Due to the relatively flat topography at SWMU 2 and the vegetation at the unit, the MUSLE modeling performed within the *Feasibility Study for Final Action at Solid Waste Management Unit 2 of Waste Area Group 22 (*DOE 1998d) to predict sediment loading to the surrounding ditches indicates PCB migration to the surrounding ditches is minimal.

The PAHs have low volatility, low mobility from sediments to groundwater, and sorb to sediments [partition coefficients for benzo(*a*)pyrene range from 5,500 in sand to 55,000 in clay]. Consequently, the potential for migration is not considered a concern.

Contaminant Fate and Transport – Radionuclides

Radionuclides included in the list of COCs that are attributed to SWMU 2 are ^{239}Pu, ^{234}U, ^{235}U, and ^{238}U. The K_d values for these radionuclides indicate in most forms there is an affinity for soils. Therefore, migration is not considered a concern.

Appendix A of the *Feasibility Study for Solid Waste Management Units 2 and 3 of Waste Area Group 22 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1995c) includes the results from DOE's RESRAD computer modeling that were used to estimate the rate of uranium migration from the SWMU to the integrator unit RGA. The model estimates that migration to the RGA is in the order of several thousands of years. Additionally, the RESRAD modeling performed in the data summary report indicated that the maximum contributed dose from all radionuclides to a potential groundwater user consuming water directly below SWMU 2 would never exceed their MCL (an effective dose equivalent of 4 mrem/year). This modeling assumed the most mobile forms of these radionuclides under the conditions present at SWMU 2.

Summary of Previous Remedial Actions

Corrective actions taken at SWMU 2 include the installation of a clay cap in 1982. Other actions taken within the unit include the August 1984 attempt to remove quantities of TCE from Pit 9 of the burial ground. Thirty-six 208-liter (55-gal) drums and four 114-liter (30-gal) drums were found. The liquid portion of the solutions found in the 114-liter (30-gal) drums was transferred to new drums and the 114-liter (30-gal) and 208-liter (55-gal) drums containing TCE were placed in overpacks. The excavated solids, drums, and surrounding soils were reburied, and the area was recapped with 15.2 cm (6 in.) of clay and 45.6 cm (18 in.) of soil.

In 1995, a ROD for interim remedial action at SWMUs 2 and 3 was completed that called for institutional controls, groundwater monitoring, and potential placement of a cap over SWMU 2. Following an additional investigation of SWMU 2 in 1996, the DOE determined that placement of a cap on SWMU 2 would not prove effective (DOE 1997a).

3.2.6.2 C-404 Low-Level Radioactive/Hazardous Waste Burial Ground—SWMU 3

Location

The C-404 Low-Level Radioactive/Hazardous Waste Burial Ground (SWMU 3) is located immediately east of the C-749 Uranium Burial Ground in the west–central area of the plant (see Fig. 3.30). The burial ground is approximately 42.7 by 115.8 m (140 by 380 ft) and a surface area of approximately 4,942.3 m^2 (53,200 ft^2).

Setting

The following subheadings provide information on the setting of SWMU 3, including geology/ hydrogeology, surface features and surface-water hydrology, transportation, floodplains, wetlands, soils and prime farmland, biological resources, and cultural resources. Additionally, a discussion of underground utilities located in the vicinity of the landfill has been included.

Geology/Hydrogeology

Approximately 30 groundwater monitoring wells have been installed in the area immediately surrounding SWMUs 2 and 3. The groundwater monitoring well locations are shown in Fig. 3.34. Water level data is presented in Technical Memorandum No. 1, Appendix 3A, of the Phase II Site Investigation Report (CH2M HILL 1992) and in the RCRA Part B Permit Modification for the C-404 Landfill (MMES 1992a).

SWMU 3 is located immediately east of SWMU 2 (i.e., the western edge of the C-404 Low-Level Radioactive/Hazardous Waste Burial Ground adjoins the eastern edge of the C-749 Uranium Burial Ground). A cross section illustrating the stratigraphy of the shallow unconsolidated deposits underlying these units is presented in Fig. 3.31. Please refer to the previous discussion of geology/hydrology at SWMU 2 for additional information.

Surface features and surface-water hydrology. The surface of SWMU 3 is mounded, with surface elevations ranging from 112.8 to 119.8 m (370 to 393 ft) amsl. Surface runoff from this unit flows into drainage ditches located immediately north, east, and south of the SWMU. The ditches are approximately 0.6 to 1.8 m (2 to 6 ft) deep and discharge through KPDES Outfall 015 to Bayou Creek, which is located approximately 537 m (1,760 ft) west of SWMU 3. These ditches are hydraulically connected to the UCRS. The surface of SWMU 2 and the surrounding ditches are grass-covered.

Transportation. Transportation in the vicinity of SWMU 3 consists of PGDP personnel performing day-to-day activities and is confined to paved or gravel roads.

Wetlands. No wetlands have been identified at SWMU 2, but potential wetlands have been identified in the adjacent drainage ditches, which are outside the boundaries of the unit (CDM Federal 1994). Final wetland determination for these areas was not possible during the 1994 COE wetlands study due, to health and safety restrictions denying access to any ditches located on the PGDP. However, the COE made the determination that the areas identified as potential wetlands are jurisdictional wetlands. The drainage area consists of a depression adjacent to Virginia Avenue and a side road, south and east of SWMUs 2 and 3 approximately 3 m (10 ft) wide and 274 m (900 ft) long. Elevation ranges from approximately 114.3 m (375 ft) amsl at Virginia Avenue to 112.8 m (370 ft) amsl in the bottom of the drainage area. Water levels in the drainage area can range from nearly 1.5 m (5 ft) to bgs. Hydrologic connection to other drainage areas is maintained with a culvert system. Water enters this area from the east through culverts and exits the area to the west as overland flow. Overall, hydrologic functions and values (e.g., groundwater recharge through production export) are rated low to moderate. The presence of an outlet, the relatively small size of the wetland, and the lack of open water limits the hydrologic functions and values. Biological functions and values (e.g., wildlife diversity/abundance through aquatic diversity/abundance) also are rated low to moderate.

Floodplains. No 100-year floodplains are adjacent to SWMU 3.

Biological resources. The vegetation at SWMU 3 consists of various grasses intended to prevent erosion of the RCRA cap. Vegetation present within the depression adjacent to Virginia Anvenue consists of rush (*Juncus* sp.), flat sedge (*Cyperus* sp.), spikerush (*Eleocharis* sp.), sedges (*Carex* sp.), and various grasses (CDM Federal 1994).

Since SWMU 3 is within the security area and is regularly mowed, it provides limited habitat for wildlife. No endangered or threatened species are known to be present at SWMU 3 (CDM Federal 1994).

Cultural resources. All of the areas included within SWMU 3 has been disturbed previously and, consequently, are not likely to contain any sites of archaeological significance.

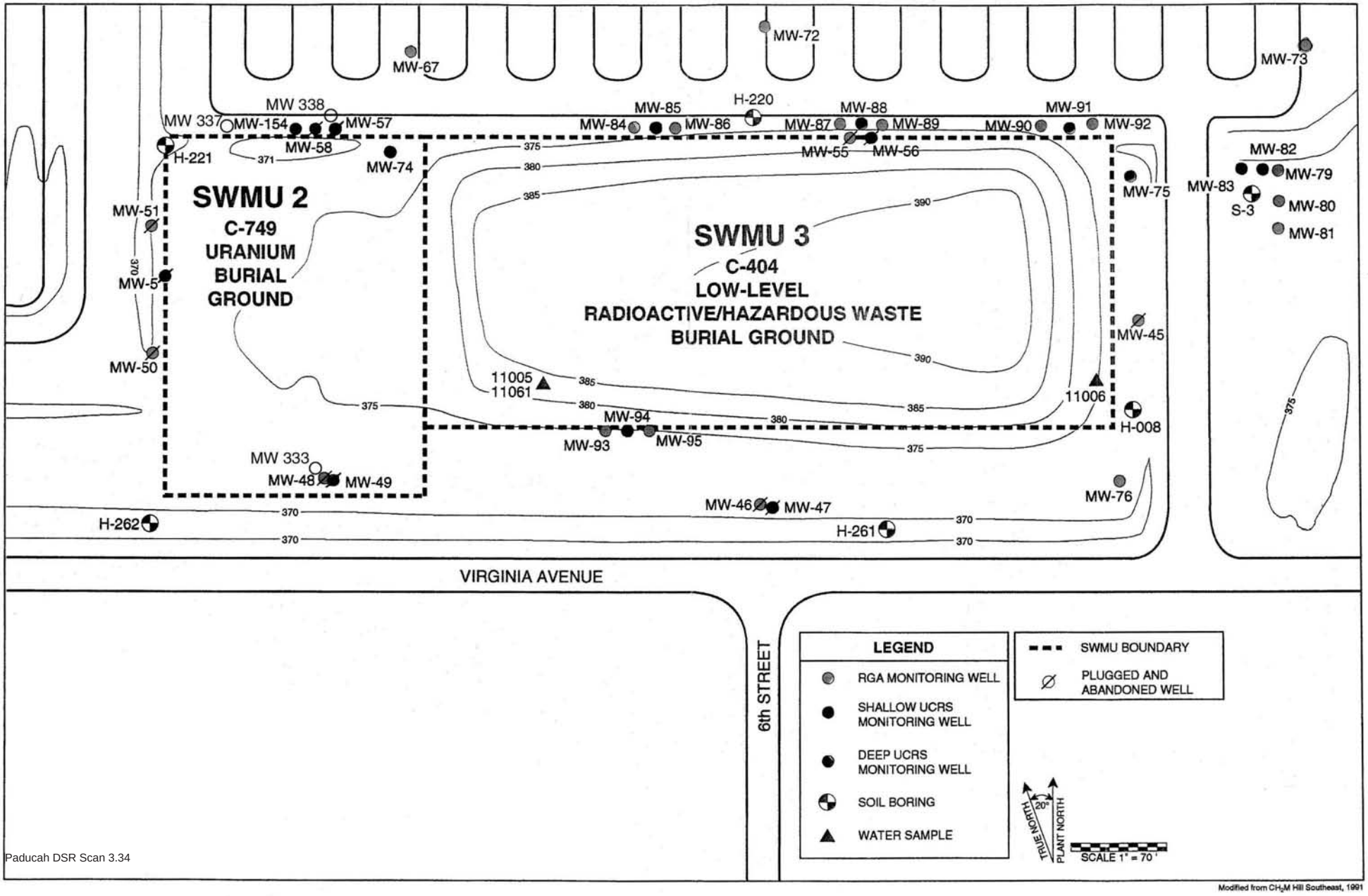

Fig. 3.34. Groundwater monitoring well locations at SWMU 3.

Underground utilities. No underground utilities currently are located at SWMU 3. Prior to 1957, the C-401 Transfer Line conveyed liquid wastes from the C-400 and C-403 facilities to the C-404 disposal facility. A leachate collection sump, which is incorporated into the RCRA cap, is located at the southern edge of the cap, north of the ditch that is adjacent to Virginia Avenue.

Manufacturing/TSD Processes

The C-404 Low-Level Radioactive/Hazardous Waste Burial Ground was originally constructed in the early 1950s as an above-ground holding pond [with an on-grade tamped earth floor and 1.8-m (6-ft) high clay dike walls] for use as a neutralization/sedimentation treatment facility for uranium-contaminated wastewater. From 1951 to 1957, C-404 was a primary disposal area for ^{99}Tc and uranium-contaminated effluent generated at the C-400 Decontamination Building. The C-400 effluents were pumped through an underground vitrified clay pipe (SWMU 26) to the eastern end of the holding pond. Water was decanted through a weir at the southwest corner of the pond and discharged to Big Bayou Creek. An estimated 3,200 pCi of ^{99}Tc from the Reactor Tails Program were discharged at a controlled rate to surface water, primarily through effluents flowing from the C-400 Building through the C-404 Holding Facility (MMES 1986). Because ^{99}Tc is mobile in an aqueous environment, some fraction of the ^{99}Tc probably passed through the C-404 Holding Pond and discharged to Big Bayou Creek. In 1957, use of the C-404 as a treatment facility for these liquids was terminated and all free liquids were removed.

From 1957 through 1976, the C-404 Burial Ground was used for bulk disposal of uranium-contaminated solid waste. Uranium-contaminated magnesium-fluoride slag from the metal reduction plant and rejected UF_4 constituted much of the disposal volume. Magnesium fluoride traps contaminated with ^{99}Tc also were disposed of in C-404. The net weight of uranium committed to the area from 1957 through 1977 is reported to be approximately 2.9×10^6 kg (3,200 tons). Until it was filled and covered in 1987, the C-404 Facility was subject to filling with rainwater, which was pumped and released to the NSDD. After the facility was filled with bulk solid waste to within 0.3 to 0.6 m (1 or 2 ft) of the top of the original dikes, it was covered with compacted earth and sloped to facilitate runoff. The weir at the southwest corner of the unit was converted to an enclosed concrete basin for use as a leachate collection sump. Leachate accumulations in this sump are routinely sampled and analyzed and then treated at the C-400 Building before discharge.

From 1977 to 1986, the upper portion of the C-404 Facility was used for the disposal of bulk and containerized uranium-contaminated solid waste. RCRA hazardous waste has reportedly been disposed of in the upper 3 m (10 ft) of the C-404 Burial Ground. The waste consists of approximately 450 drums of precipitation filter cake (gold dissolver precipitate) that was reported to be Extraction Procedure toxic due to the presence of leachable quantities of lead, cadmium, and selenium. In 1983, a partial clay cap was installed on the eastern end of the unit. After a portion of the waste buried in C-404 was discovered to be RCRA hazardous in 1986, C-404 was closed as a hazardous waste landfill. It was covered with a RCRA multilayered clay cap in 1987. Table 3.42 presents a list of the waste constituents in the C-404 Facility.

Summary of Investigations

The SWMU 2 and adjacent SWMU 3 areas are among the most fully characterized sites, hydrogeologically, at the PGDP. The principal investigations addressing potential contamination in the area are the Phase I and Phase II SIs conducted in response to the ACO (CH2M HILL 1991 and 1992) and the recent investigation (referred to here as the RA/RD field investigation) conducted to support the interim remedial action design (DOE 1997b). In addition, during the 12-year period beginning in 1979, several companies, including GeoTek (1980), D'Appalonia (1983), EDGe (1989), and Terran (1990), conducted site characterization activities in the vicinity of SWMUs 2 and 3. Please refer to the previous *Summary of Investigations* discussion for SWMU 2 for additional information.

Table 3.42. C-404 Waste Constituents

Waste	Constituents	
Gold Dissolver Precipitate[a,b]	Cadmium	Potassium
	Calcium	Selenium
	Copper	Sodium
	Lead	Uranium
	Magnesium	Zinc
	Nickel	
Calcium Carbonate Trap Material[a]	Calcium	Uranium
	Magnesium	
Furnace Liners[a]	Aluminum	Magnesium
	Calcium	Uranium
	Iron	
Decontamination Precipitate[a]	Calcium	Sodium
	Copper	Uranium
	Magnesium	Zinc
	Nickel	
Alumina Trap Mix[a]	Aluminum	Uranium
Smelter Dust[a]	Aluminum	Sodium
	Nickel	Uranium
Sodium Fluoride Trap Material[a]	Sodium	Uranium
	Fluoride	
Magnesium Fluoride Slag[c]	Magnesium	Uranium
	Fluoride	
Calcium Fluoride Slag[c]	Calcium	Uranium
	Fluoride	
Uranium Metal[c]	Uranium	
Uranium Oxides[c]	Uranium	Fluoride
Concrete[c,d]	Uranium	
Uranium tetrafluoride[c]	Uranium	Fluoride
Roofing Materials[c,d]	Uranium	
Cleanup Debris[c,d]	Uranium	
Radioactive Sources[c]	Cobalt	Cesium

Source: MMES 1992a
[a] Data based on spectrochemical and Extraction Procedure toxicity test data.
[b] Hazardous waste.
[c] No analytical data available. Major constituents listed based on knowledge of type of waste.
[d] Possible source of organic constituents, most likely petroleum-based products.

Conceptual Site Model

The source area is identified as the area of direct waste deposition. The sources of contamination that make up the source area at SWMU 2 include the buried waste materials and impacted near-surface soil (i.e., near-surface soil contamination is probably from the buried waste as no contaminated soils have been deposited at SWMU 2). The sources consist of low-level radioactive waste, primarily uranium and uranium-contaminated materials, organic constituents (primarily TCE and PCBs), and metals. Although releases of contaminants are mitigated/reduced by the RCRA cap, potential migration pathways include waste to groundwater, waste to the surrounding soils and air, and surface soil to surface water and sediments. From the waste source, potential release mechanisms include leaching into the groundwater. For surface soil, the potential release mechanisms include erosion and surface runoff. Direct contact with contaminants may occur as a result of physical intrusion or excavation. Potential migration pathways for

contaminants through the air may occur in the form of airborne particulates, radionuclides, and vapor phase organics compounds. Additional release mechanisms may be caused by physical disruption as a result of excavation into the waste. Once in the environment, contaminants may be transferred between media and transported away from the SWMU through integrator units (i.e., surface water and groundwater).

As previously noted, SWMU 3 is located immediately east of SWMU 2. Please refer to the previous discussion of geology/hydrology and the conceptual site model at SWMU 2 for additional information regarding the geology and potential transport mechanisms at SWMUs 2 and 3.

Nature and Extent of Contamination

Please refer to the previous discussion titled "Manufacturing/TSD Processes" for a complete description of the wastes buried at SWMU 3. The waste materials within SWMU 3 are considered potential sources of contamination in the subsurface soils and the UCRS. The buried waste materials contain radionuclides, VOCs, SVOCs, metals, and possibly oils containing PCBs.

Contaminant Fate and Transport

Please refer to the previous discussion of contaminant fate and transport for SWMU 2 for a description of fate and transport processes in the area near SWMUs 2 and 3.

Summary of Previous Remedial Actions

The C-404 Burial Ground (SWMU 3) was certified closed with a RCRA multilayered cap in 1987. It is regulated under RCRA as a land disposal unit and is required to comply with a RCRA post-closure permit. A revised Part B post-closure permit application and a groundwater monitoring plan for SWMU 3 were approved by the Commonwealth of Kentucky September 30, 1992 and became effective October 30, 1992. The approved application amended the RCRA permit and contains groundwater monitoring provisions requiring the PGDP to initiate detection monitoring for SWMU 3 (MMES 1992a). The detection monitoring requirements of the post-closure permit include semi-annual groundwater sampling of the uppermost aquifer, the RGA, downgradient of the unit for the following parameters: arsenic, cadmium, chromium, lead, selenium, and TCE. Two additional parameters, uranium and ^{99}Tc, also are monitored by the PGDP under the DOE Order. The list of required monitoring parameters are currently the subject of litigation between the KDEP and the DOE and may be amended in the future. Detection monitoring at the landfill will continue unless it is determined in the future that a statistically significant contaminant release to the uppermost aquifer has occurred. The most recent semiannual report, dated November 1999, did not indicate significant increases in the downgradient wells for the July 1999 sampling event. Post-Closure care will terminate 30 years after certified closure of the landfill, on July 28, 2017. Because SWMU 3 is closed with a RCRA cap and is being addressed by the post-closure permit requirements, additional remedial actions for this unit will not be evaluated in this document. Further actions at SWMU 3 may be considered after it has undergone RCRA post-closure assessment.

In 1995, a ROD for interim remedial action at SWMUs 2 and 3 was completed that called for no further action at SWMU 3 (DOE 1995d).

3.2.6.3 C-744-A Burial Ground—SWMU 7

Location

The C-747-A area is located in the extreme northwest corner of the plant. SWMU 7 comprises the eastern two-thirds of C-747-A. The SWMU is bounded on the north and south sides by perimeter ditches,

on the west side by the C-747-A Burn Area (SWMU 30), and on the east side by the C-746-E Contaminated Scrap Yard. A stockpile of radiologically contaminated scrap metal, locally known as Drum Mountain, is located over the southeast corner (overlying one of the burial pits). SWMU 7 covers approximately 22,380 m^2 (240,900 ft^2) and includes five discrete burial pit areas.

Setting

The following subheadings provide information on the setting of SWMU 7, including geology/ hydrogeology, surface features and surface-water hydrology, transportation, floodplains, wetlands, soils and prime farmland, biological resources, and cultural resources. Additionally, a discussion of underground utilities located in the vicinity of the landfill has been included.

Geology/Hydrogeology

Combined thickness of loess and upper continental deposits at SWMU 7 is approximately 18.3 m (60 ft). The vertical sequence of these materials, beginning at ground surface, consists of an upper 6.1 m (20 ft) of silt or clay overlying a horizon of sand, clay and gravel, 1.5 to 3.0 m (5 to 10 ft) thick. The underlying 6.1- to 9.1-m (20- to 30-ft) soil unit characteristically is silt or clay at the PGDP. However, silty sand facies comprise the majority of the unit at some locations in SWMU 7. A distinct sand with clay facies, up to 3.0 m (10 ft) thick, may be present at the base of the upper continental deposits. In the SWMU 7 area, the lower continental deposits is a unit of gravel with sand, 7.6 to 12.2 m (25 to 40 ft) thick. The top of the underlying McNairy Formation is a sand with gravel horizon, 3.0 to 6.1 m (10 to 20 ft) thick. Figure 3.35 is a cross section of the SWMUs 7 and 30 area, showing the lateral and vertical changes in geology.

Large vertical hydraulic gradients cause groundwater flow to be downward within the UCRS. Hydraulic conductivity of the UCRS varies between horizons and between facies within horizons. Permeameter tests of soils from each horizon of the upper continental deposits at SWMUs 7 and 30 measured hydraulic conductivities ranging from 3.4×10^{-8} to 7.1×10^{-7} cm/sec (9.6×10^{-5} to 2.0×10^{-3} ft/d). These values are among the lowest measurements of hydraulic conductivity attributed to the UCRS. Hydraulic conductivity measurements by slug tests and permeameter tests from across the PGDP site indicate the average horizontal hydraulic conductivity of the UCRS sands and gravels is approximately 1×10^{-4} cm/sec (3×10^{-1} ft/d). The bulk vertical hydraulic conductivity of the UCRS is approximately 1×10^{-6} cm/sec (2.8×10^{-3} ft/d). These values are expected to be representative of the C-747-A area.

Groundwater in the RGA tends to flow northwest beneath SWMU 7, as evidenced by the trend of the Northwest Plume. The operation of the south well field of the Northwest Plume Interim Remedial Action facility has afforded a test of the hydraulic conductivity of the RGA in the vicinity of SWMUs 7 and 30. Analysis of drawdown related to the start of pumping indicates the bulk hydraulic conductivity of the RGA is approximately 4.1×10^{-1} cm/sec (1,175 ft/d) (DOE 1996b).

MWs 186 and 187 provide historical and continuing UCRS water level measurements for SWMU 7 (Table 3.43). In addition, the SWMU 7 RI installed four temporary piezometers in the UCRS, identified as GWS-1, GWS-2, WLM-2, and WLM-5. Water level measurements of the RI indicate that a shallow water table exists across the site, generally at depths of 1.5 to 1.8 m (5 to 6 ft) bgs. Thus, the water table likely forms a broad mound under the middle of SWMU 7, at an elevation of 112.2 m (368 ft) amsl, which slopes to the ditches on the north and south sides. The ditches on the north and south sides of the SWMU are 1.2 to 1.8 m (4 to 6 ft) lower than the crest of the water table. Water level measurements during the RI indicate that a water table rise of at least 0.3 m (1 ft) occurs between dry and wet seasons.

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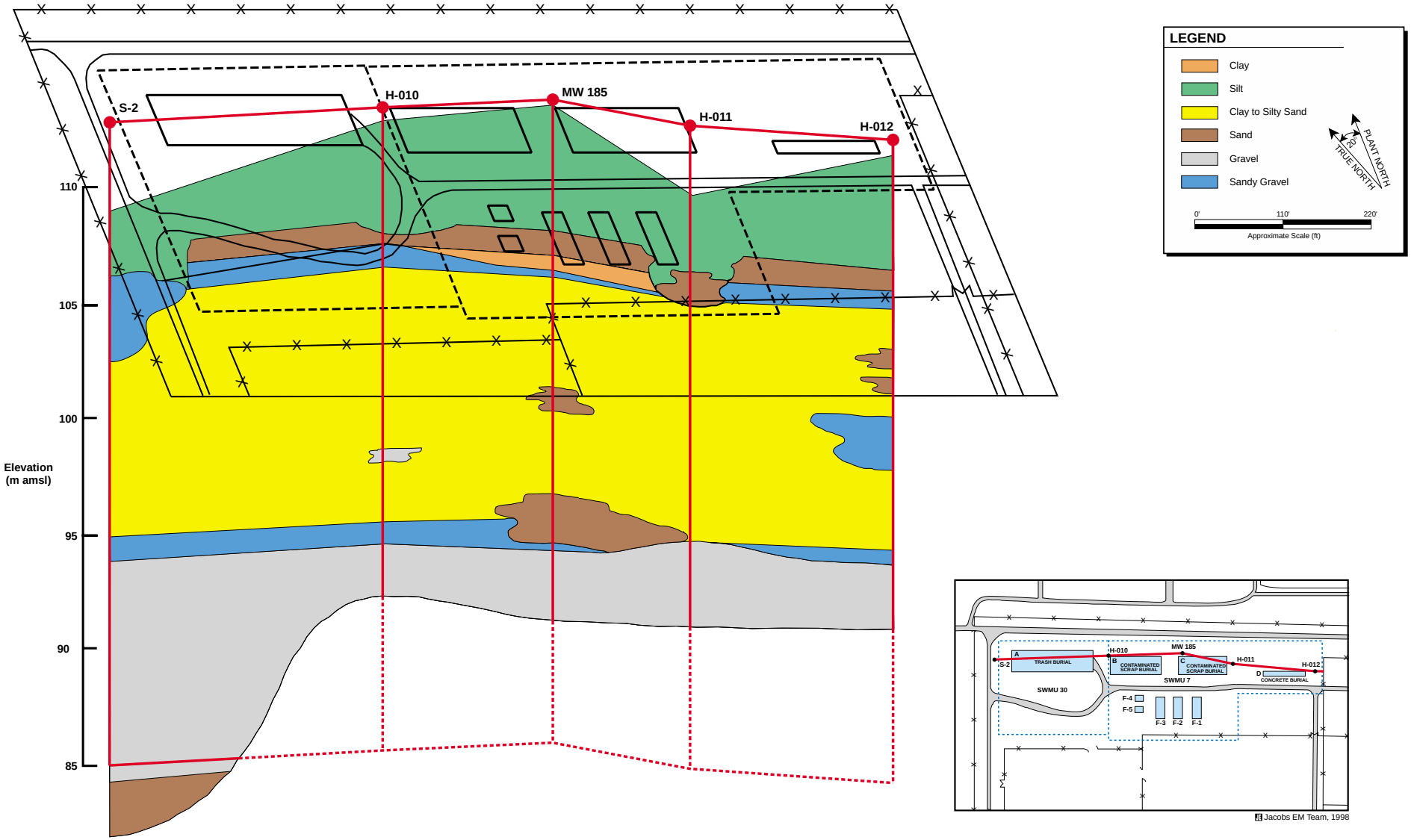

Fig. 3.35. SWMUs 7 and 30 cross section.

Table 3.43. Groundwater levels near SWMU 7

Monitoring well	AKGWA number[a]	Zone	Depth to water (bgs)	Screened interval (bgs)
MW185	8000-5174	RGA	11.2 to 14.7 m (36.8 to 48.3 ft)	20.7 to 22.3 m (68 to 73 ft)
MW186	8000-5175	UCRS	2.0 to 3.5 m (6.6 to 11.5 ft)	5.5 to 7.0 m (18 to 23 ft)

[a] AKGWA = Assembled Kentucky Ground Water Database

RGA monitoring points at SWMU 7 include MWs 185, 339, and 340, which were constructed as part of the RI. The water level record for MW185 exhibits an annual cycle of rise and fall, typically spanning 1.5 to 1.8 m (5 to 6 ft). From 1991 through 1995, the RGA water levels ranged between 99.1 and 102.4 m (325 and 336 ft) amsl. Lateral hydraulic gradients predominate in the RGA. The slope of the lateral hydraulic gradient in the RGA beneath SWMU 7 is to the northwest.

Surface features and surface-water hydrology. Henry silt loam is the predominant soil type at SWMU 7. The Henry soil series contains poorly drained, acidic soils that have a fragipan (USDA 1976). This type of soil usually is formed in loess or alluvium. This fragipan layer is likely to remain intact, exclusive of the immediate burial pit area. Henry soils typically have moderate permeability above the fragipan and low-permeability within the fragipan. Permeability in the fragipan is less than 1.41×10^{-4} cm/sec (0.4 ft/d) (USDA 1976).

During the Phase II Investigation, double-ring infiltrometer tests were conducted on surface soils at SWMU 7. Average long-term infiltration rates ranged from $<2 \times 10^{-6}$ to 2×10^{-3} cm/sec ($<5.7 \times 10^{-3}$ to 5.7 ft/d) (CH2M HILL 1992). Table 3.44 summarizes the double-ring infiltrometer tests results.

Table 3.44. SWMU 7 double-ring infiltrometer tests

Double-ring infiltrometer test	Burial pit	Long-term inner ring infiltration rate
DRI-10	Near Pit B	2×10^{-3} cm/sec
DRI-11	Near Pit F-1	$< 2 \times 10^{-6}$ cm/sec
DRI-12	Near Pit D	3×10^{-6} cm/sec

The upper 6.1 m (20 ft) of soils at SWMU 7 consists of surface soil, fill, and loess, alternatively described as silt or clay in the area boreholes. Surface soils, to a depth of 15 cm (6 in.), were sampled and described during the Phase II SI. Soil textures range from sand with gravel to lean clay with gravel. Logs of deeper soil borings demonstrate that coarse textures generally are limited to the upper 0.6 m (2 ft), with the exception of the burial pits that are now known to be as much as 3.0 m (10 ft) deep.

The surface water that drains from SWMU 7 into the surrounding ditches is carried west through Outfall 001 and on into Bayou Creek. Upgradient sources of recharge to the ditches on the north and south sides of SWMU 7 include the C-746-C Clean Scrap Yard and the C-746-E Contaminated Scrap Yard. The C-746-P Scrap Metal Yards, located south of the C-747-A area, contribute runoff to the ditch bordering C-747-A on the south side.

Transportation. Transportation in the vicinity of SWMU 7 consists of PGDP personnel performing day-to-day activities and is confined to paved or gravel roads.

Wetlands. Jurisdictional wetlands identified in the vicinity of SWMU 7 are limited to the north perimeter drainage ditch (Sadri 1995).

Floodplains. No 100-year floodplains are adjacent to SWMU 7.

Soils and prime farmland. Historically, soils within the impacted area of SWMU 7 are Henry silt loam. However, the soils associated with these areas have been disturbed by past activities and, consequently, are not classified as prime farmland.

Biological resources. Vegetation inside the fence is mowed grass providing very little to no wildlife habitat. No potential habitats for federally listed T&E species are present within the fence (CDM Federal 1994).

Cultural resources. No properties inside the fence at the PGDP currently are included on, or nominated for inclusion on, the NRHP. Additionally, the SHPO has concurred with the determination that the subsurface area inside the fence previously has been disturbed and, consequently, is not likely to contain any undisturbed sites of archaeological significance.

Underground utilities. There are no known underground utilities at SWMU 7.

Manufacturing/TSD Processes

The PGDP used the burial pits at SWMU 7 for disposal of wastes from 1957 to 1979. Table 3.45 summarizes the areal extent and waste types in the burial pits at SWMU 7. Burial Pits B, C, and G were used for disposal of noncombustible, contaminated and uncontaminated trash, material, and equipment. Contaminated concrete removed from the C-410 Feed Plant during May and June 1960 was placed in Burial Pit D. The F Burial Pits were used for disposal of uranium-contaminated scrap metal and equipment.

Table 3.45. SWMU 7 burial pits

Burial pit	Areal extent	Waste types
Burial Pit B	948 m^2 (10,200 ft^2)	Noncombustible, contaminated and uncontaminated trash and equipment
Burial Pit C	892 m^2 (9,600 ft^2)	Noncombustible, contaminated and uncontaminated trash and equipment
Burial Pit D	195 m^2 (2,100 ft^2)	Contaminated concrete
Burial Pit F	five areas each 167 m^2 (1,800 ft^2)	Uranium-contaminated scrap metal and equipment
Burial Pit G	306 m^2 (3,300 ft^2)	Noncombustible, contaminated and uncontaminated trash and equipment

A sixth burial pit area associated with the burial ground, Pit E, is located east of SWMU 7 in the C-746-E Contaminated Scrap Yard. Burial Pit E contains uranium-contaminated concrete, similar to Burial Pit D. Empty uranium and magnesium powder drums also were reported to have been buried in the F Burial Pits (Union Carbide 1978).

Records indicate the burial pits were excavated to a depth of 1.8 to 2.1 m (6 to 7 ft) bgs, filled with wastes, and covered with approximately 1 m (3 ft) of earth. However, TP-3 of the Phase II SI uncovered waste to a depth of 3.0 m (10 ft) on the west side of Burial Pit B, and boring WBP-08A sampled waste to a minimum depth of 2.4 m (8 ft) in Burial Pit C.

Summary of Investigations

The main source of the information used in this summary report for SWMUs 7 and 30 is the *Remedial Investigation Report for Solid Waste Management Units 7 and 30 of Waste Area Grouping 22 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1998c). Contributing sources include: reports of Phases I and II of *Results of the Site Investigation* (CH2M HILL 1991 and 1992), *Final Report on Drive-Point Profiling of the Northwest Plume and Analysis of Related Data* (DOE 1995e), and *Northeast Plume Preliminary Characterization Summary Report* (DOE 1995a).

The DOE performed sampling activities in SWMUs 7 and 30 in June 1998 to characterize further the presence of soluble uranium and the geochemical parameters that govern the solubility of uranium. The sample analyses reveal that low levels of soluble uranium are present in the waste pits. The dissolved uranium, at these low levels, will not exceed an unacceptable level at the point of exposure. Moreover, the geochemical setting will limit the additional formation of dissolved uranium.

Conceptual Site Model

The source area is identified as the area of direct waste deposition at SWMUs 7 and 30. The sources of contamination that make up the source area include the contaminated waste material buried in the pits and the contaminated surface soil at the units. Organic chemical and radionuclide contamination of subsurface soils is considered to represent the probable conditions at SWMUs 7 and 30, since these chemicals have been detected in sampling analyses. Surface soil previously was not delineated as a source of contamination at SWMUs 7 and 30 in the BHHRA's conceptual site model.

Once released into the environment, contaminants can be transferred between media and transported away from the SWMUs through integrator units (i.e., surface water and groundwater). The RI indicates that the buried waste in the pits may be saturated with groundwater (DOE 1998c). Potential migration pathways may exist from the waste to groundwater and to the surrounding subsurface soil as a result of the saturated conditions and from infiltration and percolation of precipitation. From the waste source, potential release mechanisms allowing contaminant migration include leaching and dissolution into the groundwater as a result of direct contact of water with the buried waste. Dissolved contaminants in the groundwater may be further transported with the groundwater flow. Vertical seepage of contaminants occurs within the UCRS and from the UCRS to the RGA as dissolved phases in percolating water or as density driven DNAPL (DOE 1998c). Vertical migration into the surrounding subsurface soil also may occur as the contaminants leach from the waste material. Less soluble contaminants may adsorb to subsurface soil and remain bound to the soil. A horizontal flow component in the UCRS may exist from Pits A, B, and C toward the north and from F Pits toward the south. However, the horizontal flow component is minimal due to the type of soil that surrounds the waste pits. The soil around the waste pits is clay, which fosters vertical flow.

Potential migration pathways may exist from the surface soil to surface water and sediment in the nearby drainage ditches. The potential release mechanisms from surface soil include dissolution by rainwater with surface-water runoff and concurrent erosion of particle-bound species. The SWMUs 7 and 30 contribute minimal sediment to the adjacent drainage systems, and it was concluded that contaminant loading from the SWMUs from overland transport should be minimal as long as a vegetative cover is maintained (DOE 1998c). Atmospheric releases by gaseous (VOC) emissions and airborne particulates are possible, although not expected to be significant, because VOCs were not found in surface soils and thick vegetative cover likely would prevent particulate entrainment (DOE 1998c). Additional release mechanisms may be caused by physical disruption as a result of excavation into the waste. Any possible future excavation activities would, however, be conducted in accordance with the PGDP standard operating procedures and in

compliance with Occupational Safety and Health Administration (OSHA) worker protection requirements, which would limit contaminant release and the potential for exposure.

Nature and Extent of Contamination

The C-747-A Burial Ground covers approximately 22,380 m^2 (240,900 ft^2) in the northwest corner of the fenced security area. SWMU 7 includes Burial Pits B, C, and D and five smaller burial pits collectively referred to as Burial Pit F. A large stockpile of radiologically contaminated scrap metal, known as Drum Mountain, covers the southeast corner of the former burial ground. The stockpile overlies Burial Pit G, which is reported to contain waste similar to that in Burial Pits B and C (noncombustible trash and equipment). Burial Pit G also is included in SWMU 7.

The primary contaminant of surface soils within SWMU 7 is uranium. Total elemental uranium in surface soils ranges as high as 1,400 mg/kg near the northeast corner of the SWMU. In general, uranium activity in surface soils is highest on the eastern edge of SWMU 7 and in a north–south oriented band in the western half of the SWMU. The level of contamination of surface soils beneath Drum Mountain has not been measured. A radiation walkover survey of SWMU 7, from the Phase II SI, revealed that radiological surface contamination exceeded three times the background gamma radiation level of a nearby reference site over approximately two-thirds of the SWMU.

The metals beryllium, chromium, copper, nickel, and zinc frequently are detected at concentrations slightly above background in surface soils across SWMU 7. PCBs and PAHs likewise are detected at low concentrations in surface soils. PCB concentrations typically are below 0.1 ppm but increase to as much as 1.8 ppm on the west side of SWMU 7. PAHs range between 0 and 24 ppm in the SWMU. The highest concentration sampled also is located in sample SS-01.

Soil erosion from SWMU 7 appears to be contributing elevated concentrations of copper, nickel, and zinc to the south drainage ditch and uranium and low levels of metals contamination to sediments and surface water in the north drainage ditch. Scrap yards to the east of SWMU 7 are upgradient sources of the same contaminants to the north ditch. Upgradient sources account for a high uranium activity present in the south ditch.

Subsurface soils, outside of Burial Pits B and C, do not appear to be contaminated. In Burial Pits B and C, soils contain high activities of uranium and ^{99}Tc and concentrations of cadmium, chromium, copper, nickel, and zinc above background levels. Soil samples from Burial Pits D and F have little to no contamination.

Metals and uranium contaminate water from Burial Pits B, C, and F. The water from Burial Pits B and C also is contaminated with BTEX compounds and fuel-related SVOCs, as well as with vinyl chloride. Water from Burial Pit F contains low levels of VOCs. In contrast, the primary UCRS contaminants are TCE and its degradation products, essentially with no uranium. Groundwater from the RGA is contaminated with TCE, at high concentrations indicative of DNAPL occurrence. High dissolved TCE levels near the base of the RGA are attributable to PGDP's Northwest Plume, which is sourced from DNAPL at the C-400 Building, located upgradient of SWMU 7. The variability of TCE levels in samples from MW66 suggests the possibility of a SWMU 7 DNAPL source for contamination in the upper RGA. This variability also may be due to the Northwest Plume.

Contaminant Fate and Transport – Metals

Metals identified as COCs in soil or sediment at SWMUs 7 and 30, include aluminum, antimony, arsenic, beryllium, cadmium, chromium, copper, iron, manganese, nickel, uranium, and vanadium. The K_d values for use in modeling constituent transport at SWMUs 7 and 30 were selected for loam soils. Values reported in the RI ranged from 30 l/kg for chromium to 1,500 l/kg for aluminum (DOE 1998c). The corresponding R_d values indicate a high tendency for these metals to stay bound in the soil and a low tendency to migrate. All of the R_d values for these metals are on the order of 100 or higher.

Contaminant Fate and Transport – Organic Compounds

One VOC, vinyl chloride, was included in the list of COCs. Because vinyl chloride is a degradation product of TCE, TCE is included in the fate and transport analysis below. Semivolatile organic compounds are benzo(*a*)anthracene, benzo(*a*)pyrene, benzo(*b*)-fluoranthene, dibenzo(*a,h*)anthracene, and indeno(1,2,3-*cd*)pyrene. The VOCs have K_d values and R_d values that are as much as two orders of magnitude less than for the metals. On the other hand, the SVOCs have K_d values and R_d values that are one to three orders of magnitude greater than for the metals. Thus the VOCs would tend to be much more mobile in the subsurface than would the metals. The SVOCs would be substantially less mobile than the metals. Because of their high volatility, the VOCs are not expected to be present in surface soils or sediments and would tend to volatilize readily if released to surface water.

TCE also has the potential to be transported in the form of a DNAPL. Groundwater detections generally indicate that TCE in the lower RGA originates upgradient of SWMUs 7 and 30, although these SWMUs do seem to contribute to the TCE plume in the upper RGA. Monitoring Well 66, located between Burial Pits B and C, is screened at the top of the RGA. At this well, detected concentrations of TCE have varied from a few hundred µg/L to a maximum level of 10,000 µg/L. A TCE concentration of 10,000 µg/L is approximately one percent of the solubility limit of TCE and often is taken as an indicator of the presence of DNAPL. As noted in the RI (DOE 1998c), the fluctuations observed in TCE concentrations in MW66 may represent a nearby DNAPL source producing dissolved TCE that is being flushed intermittently into the zone of influence of the well.

DNAPL transport behavior is highly dependent upon lithology and stratigraphic dip, as well as groundwater gradient. Given the heterogeneous nature of the subsurface materials beneath the site, this makes it extremely difficult to determine the rate of potential DNAPL migration. In general, DNAPLs will be less able to migrate through clay members such as the ones interfingered with the water bearing units within the UCRS and at the top of the RGA. Thus, the apparent DNAPL source affecting observed TCE concentrations at MW66 may be trapped in the less conductive lower UCRS rather than in the RGA.

PAHs are neutral, nonpolar, hydrophobic organic molecules. These compounds have low volatility, low mobility from soils to groundwater, and sorb to soils and sediments [partition coefficients for benzo(*a*)pyrene range from 5,500 in sand to 55,000 in clay]. The PAHs are common components of various fuels, vehicle exhausts, asphalt, asphalt road products, coal tar, roofing compounds, and hydrocarbons.

Biodegradation of PAHs by microorganisms has been identified [fluoranthene and benzo(*a*)pyrene] in soils. In addition, some PAHs that are resistant to microbial degradation as the primary energy source are susceptible to cometabolism, particularly higher molecular weight PAHs. Cometabolism occurs when a PAH is degraded in the presence of another substrate that serves as the primary energy source.

Contaminant Fate and Transport – PCBs

PCBs (Aroclor-1260) are included in the list of COCs and are considered likely to be present in the waste. PCBs have very low water solubilities and vapor pressures, which indicates that they do not dissolve readily in water or vaporize easily. Based on a K_{oc} of 8.12×10^5 l/kg, K_d values for site soils would be of the order of 2,000 l/kg, indicating high sorption to subsurface materials. Associated R_d values indicate that the movement of PCBs is anywhere from three to four orders of magnitude slower than that of the average pore-water velocity. Thus, there is a very low potential for any PCBs that may exist within the waste to migrate from the SWMUs; however, they pose a future risk for direct exposure to soil.

Naturally occurring soil acidity, ranging from a pH of 4.5 to 5.5 in the vicinity of the PGDP, potentially could affect the mobility of PCBs in soils. The acidity results in an increased solubility for the organic fraction of soils. This increased solubility results in an increased mobility of the organics and also the PCBs that are adsorbed to organics. Since PCBs are limited to the surface soils and sediments of SWMUs 7 and 30, it is likely that the pH of the soils has not increased mobility; however, PCBs may be transported via surface-water runoff. Contamination identified in sediments in the drainage ditch south of SWMU 30 indicates that this already may be occurring.

Both aerobic and anaerobic microbial dechlorination of PCBs are known to occur. Conditions that dictate degradation are adsorption-desorption, oxygen availability, and the type of microbe present. Less chlorinated PCB congeners are degraded preferentially by aerobic microbes, while anaerobic microbes preferentially reduce highly chlorinated PCBs. Therefore, both aerobic and anaerobic degradation is necessary for complete PCB destruction. In addition, both aerobic and anaerobic degradation is preferential to chlorine substitution patterns, with ortho-substitutions less readily reduced (ORNL 1994). Analytical data collected at the PGDP indicate microbial degradation of PCBs is insignificant at the plant.

Biota uptake PCBs by three primary mechanisms: (1) inhalation, (2) direct contact, and (3) ingestion of food. Studies indicate that bioaccumulation, especially in tissue and organs, appears to be higher for more highly chlorinated PCBs (ORNL 1994). Biomagnification of PCBs occurs as a series of bioaccumulation steps, as PCBs are transferred to the top of the food chain to predators (ORNL 1994).

Contaminant Fate and Transport – Radionuclides

Radionuclides included in the list of COCs are ^{99}Tc, ^{237}Np, ^{239}Pu, ^{234}U, ^{235}U, and ^{238}U. Of these, ^{99}Tc has the highest potential to migrate with groundwater flow due to its relatively low K_d and R_d values, followed by ^{237}Np. Soil-water partition coefficient values in loam soils (as assumed for the RI modeling) are of the order of 0.1 l/kg for ^{99}Tc, 25 l/kg for ^{237}Np, 250 l/kg for the uranium isotopes, and 1,200 l/kg for ^{239}Pu. Thus, ^{99}Tc is the most likely of the COC radionuclides to migrate from the SWMUs off-site.

All of these radionuclides, except ^{99}Tc and perhaps ^{237}Np, are likely to migrate from the SWMUs extremely slowly. Contaminant transport modeling reported in the RI (DOE 1998c) indicated that only ^{99}Tc potentially would migrate to the RGA exposure point at levels in excess of MCLs or risk-based concentrations (RBCs). The half-lives for the other radionuclides indicate that they are likely to remain in the soil for long periods of time, making any contaminated on-site soil a potential risk for direct exposure in the future. Table 3.46 lists the half-lives for these radionuclides.

The most commonly reported K_d values for ^{99}Tc are between 0.001 and 2 mg/L, indicating that it is mobile in soils (CH2M HILL 1992). Technetium-99 has a half-life of 214,000 years (Greenwood and Earnshaw 1984). Technetium-99 occurs in well-aerated soils in its most oxidized state, the pertechnate anion (CH2M HILL 1991). The pertechnate anion is highly soluble and generally will not be sorbed in

Table 3.46. Half-life and radioactive decay constants for the radionuclides that are COCs for SWMUs 7 and 30

COC	Half-life (years)	Radioactive decay[a] (day-1)
^{99}Tc	2.00E+05	9.50E-09
^{237}Np	2.10E+06	9.00E-10
^{234}U	2.50E+05	7.60E-09
^{235}U	7.10E+08	2.70E-12
^{238}U	4.50E+09	4.20E-13

[a] Radioactive decay was calculated from the formula: $l = (Ln\ 2)/(t_{1/2} * 365\ days)$ where $t_{1/2}$ is the half-life in years.

significant quantities on soil and sediment of predominantly negative charge. As the oxide content of the soil increases, anion adsorption would increase, thereby resulting in decreased mobility. Under reducing conditions, ^{99}Tc can be converted to the $^{99}Tc^{+4}$ cation. Cations exhibit low mobility in clay and silty clay soil. As the surface area and the clay content of the soil increase, the ability of the soil to retain cations will increase. In sandy, loamy, and sandy-loam soil, cations usually will be moderately to highly mobile. In soil with intermediate textures, cations can exhibit low, moderate, or high mobility.

Uranium associated with the subsurface soils and groundwater of SWMUs 7 and 30 derives from the burial of contaminated trash, debris, and equipment. Therefore, the emplaced uranium most likely was in the form of a diffuse powder. The high surface area of a powder would have fostered reaction with the burial ground environment. Dissolved oxygen in groundwater most likely has reacted with the uranium powder to form uranium (IV) oxide (i.e., UO_2). Any buried uranium metal also would have developed a UO_2 powder or crust. The UO_2 powder or crust is stable within the pH range of PGDP soils and groundwater, even under moderate oxidizing conditions (Langmuir 1997).

Uranium becomes appreciably soluble only when the metal is oxidized to uranium (VI). Kinetics favor the formation of uranium (VI) in waters with greater redox potential or higher pH than typically occurs in shallow soils at the PGDP. However, once in the (VI) valence state, uranium will readily form a dissolved uranyl carbonate complex.

$$UO_2^{2+} + 2HCO_3^- + CO_3^{2-} = UO_2(CO_3)_3^{4-} + 2H^+.$$

This negatively charged complex does not strongly sorb to soil and is readily mobile.

Common sulfate-reducing and iron-reducing bacteria are known to reduce enzymatically uranium (VI) to uranium (IV) in anoxic environments, resulting in precipitation of UO_2. It is likely that the frequent disposal of metal, wood, and oil in the burial pit wastes has helped stimulate the development of anoxic, reducing water. The decomposition of these materials would compete for available oxygen. Evidence of reducing bacteria in the SWMUs 7 and 30 burial pits includes the co-occurrence of high barium levels with low sulfate levels and the presence of high iron and manganese concentrations in groundwater. The field measurements of high dissolved oxygen content in groundwater likely reflect a bias introduced by the drilling and sampling technique or poor calibration or malfunction of the field instrument.

Based on the conditions at SWMUs 7 and 30, little of the buried uranium is expected to have oxidized to the mobile uranium (VI) state. Finally, the modeling performed in the RI study supports these assumptions, as the modeling indicates uranium never will reach the DOE property boundary at unacceptable levels.

Summary of Previous Remedial Actions

No previous remedial actions have been taken at SWMU 7.

3.2.6.4 C-747-A Burn Area—SWMU 30

Location

The C-747-A Burn Area (SWMU 30) includes the western one-third of C-747-A. It consists of a historical burn-and-burial pit (Burial Pit A) and the location of a former incinerator (refer to Fig. 3.30). The SWMU is bounded on the north and south sides by ditches, on the west side by Patrol Road, and on the east side by C-747-A Burial Ground (SWMU 7). The unit encompasses approximately 11,892 m^2 (128,000 ft^2).

Setting

The following subheadings provide information on the setting of SWMU 30, including geology/ hydrogeology, surface features and surface-water hydrology, transportation, floodplains, wetlands, soils and prime farmland, biological resources, and cultural resources. Additionally, a discussion of underground utilities has been included.

Geology/Hydrogeology

The geologic and groundwater setting of SWMU 30 is similar to that of SWMU 7. Approximately 6.1 m (20 ft) of loess overlies a horizon of sand, clay, and gravel 1.5 to 3.0 m (5 to 10 ft) thick. The underlying clay unit is 4.6 to 6.1 m (15 to 20 ft) thick in area boreholes. A silty sand horizon, 0.9 to 2.4 m (3 to 8 ft) thick, is present at the base of the upper continental deposits. The lower continental deposits are a sandy gravel with a thickness of 10.4 m (34 ft) in nearby boring S-2.

The UCRS, the uppermost HU, is found within the loess layer and the upper continental deposits. A continuous horizon of sand and gravel lenses occurs under both SWMUs 7 and 30 at an approximate depth of 6.1 m (20 ft). Most flow within the UCRS has been found to be vertical with a downward gradient from the UCRS to the RGA.

Water levels in a temporary piezometer placed in Pit A, as part of the 1996 RI, determined the depth to the water table to be between 1.5 and 2.1 m (5 and 7 ft). The water table elevation is approximately 112.2 m (368 ft) amsl. A shallow water table is consistent with the depth of water in TP 2, excavated in Pit A as part of the Phase II SI in 1991. In general, the water table is expected to be a subdued image of the land surface topography. The water table will coincide with the base of the ditches on the north and south sides of the SWMU where some groundwater/surface-water interaction occurs. Rainfall infiltration will cause the water table to mound beneath SWMU 30. Except for the area adjacent to the perimeter ditches, vertical hydraulic gradients are much greater than lateral gradients so that groundwater flow ultimately is downward.

In the RGA, the predominant flow direction is to the northwest. The elevation of the RGA water level in MW66 typically ranges from 98.5 to 101.8 m (323 to 334 ft) amsl.

Surface features and surface-water hydrology. The soil survey of McCracken County (USDA 1976) maps Henry silt loam across SWMU 30. However, all deeper soil borings, including Phase II SI borings H-211 and H-212, MW66, and boring S-2, encountered surficial fill material to depths of 0.6 to 3.7 m (2 to 12 ft). Phase II surface soil sample sites H-361 through H-366, H-370 and H-373 provide

characterization of surface soil texture from eight locations across SWMU 30. The upper 15 cm (6 in.) of soil ranges from lean clay to sand. Surface soil samples from the Burial Pit A area tend to be lean clay with gravel, whereas surface soil textures from the south side of SWMU 7 range from lean clay to silty sand with gravel.

The Phase II SI provided double-ring infiltrometer tests on surface soils at three locations. Average long-term infiltration rates were less than 2×10^{-6} cm/sec (6×10^{-3} ft/d) for two of the tests (Table 3.47).

Table 3.47. SWMU 30 double-ring infiltrometer tests

Double-ring infiltrometer test	Burial pit	Long-term inner ring infiltration rate
DRI-13	Pit A	$< 2 \times 10^{-6}$ cm/sec
DRI-14	Pit A	1×10^{-4} cm/sec
DRI-15	Near Pit A	$< 2 \times 10^{-6}$ cm/sec

The SWMU 30 area boreholes, H-211, H-212, MW66, and S-2 encountered loess, described as silty to sandy clay, to depths of 5.5 to 6.4 m (18 to 21 ft) bgs. The base of the loess is at approximate elevation 106.7 m (350 ft) amsl. Land surface elevation over most of Pit A is 111.3 m (365 ft) amsl or greater. At a depth of 3.7 m (12 ft), the base of the pit is at approximate elevation 107.6 m (353 ft) amsl or greater; thus, at least 0.9 m (3 ft) of loess underlies Burial Pit A.

Surface water sheds radially from the central hill at SWMU 30. All overland flow eventually drains to the perimeter ditches located to the north and south of SWMU 30. Upgradient sources of contamination to the ditches include SWMU 7 and the C-747-C, C-747-E, and C-747-P Scrap Yards.

Transportation. Transportation in the vicinity of SWMU 30 consists of PGDP personnel performing day-to-day activities and is confined to paved or gravel roads.

Wetlands. Jurisdictional wetlands exist along the drainage ditch on the north perimeter of SWMUs 7 and 30 (Sadri 1995).

Floodplains. No 100-year floodplains are adjacent to SWMU 30.

Soils and prime farmland. Historically, soils within the impacted area of SWMU 30 are Henry silt loams. However, the soils associated with these areas have been disturbed by past activities, decreasing the likelihood that any of these areas are prime farmland.

Biological resources. Vegetation inside the fence is mowed grass providing very little to no wildlife habitat. No potential habitats for federally listed T&E species are present within the fence (CDM Federal 1994).

Cultural resources. No properties inside the fence at the PGDP currently are included on, or are nominated for inclusion on, the NRHP. Additionally, the SHPO has concurred with the determination that the subsurface area inside the fence previously has been disturbed and, consequently, is not likely to contain any undisturbed sites of archaeological significance.

Underground utilities. There are no known underground utilities at SWMU 30; however, some debris may exist in the area of the former incinerator.

Manufacturing/TSD Processes

SWMU 30 was used from 1951 to 1970 to burn combustible trash, some of which may have contained uranium contamination. Ash and debris were buried below ground in Burial Pit A beginning in 1962, when use of an on-site incinerator was discontinued. Site maps and a surface electromagnetic geophysical survey of the Phase II SI identify the location of Burial Pit A. The pit is reported to have been excavated to a depth of 3.7 m (12 ft) and covered with 1.2 m (4 ft) of earth. Prior to identification by Phase II SI surface geophysics testing, it was believed that remnants of the former incinerator were not present. Ensuing searches identified photos of the incinerator at the location of the geophysical anomaly.

Summary of Investigations

The main source of the information used in this summary report for SWMUs 7 and 30 is the *Remedial Investigation Report for Solid Waste Management Units 7 and 30 of Waste Area Grouping 22 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1998c). Contributing sources include: reports of Phases I and II of *Results of the Site Investigation* (CH2M HILL 1991 and 1992), *Final Report on Drive-Point Profiling of the Northwest Plume and Analysis of Related Data* (DOE 1995e), and *Northeast Plume Preliminary Characterization Summary Report* (DOE 1995a).

The DOE performed sampling activities in SWMUs 7 and 30 in June 1998 to characterize further the presence of soluble uranium and the geochemical parameters that govern the solubility of uranium. The sample analyses reveal that low levels of soluble uranium are present in the waste pits. The dissolved uranium, at these low levels, will not exceed an unacceptable level at the point of exposure. Moreover, the geochemical setting will limit the additional formation of dissolved uranium.

Conceptual Site Model

Nature and extent. The C-747-A Burn Area includes approximately 11,892 m^2 (128,000 ft^2) on the west side of SWMU 7. Burial Pit A underlies the north half of SWMU 30. An incinerator formerly was located south of Burial Pit A within the SWMU.

Surface soil contamination by PCBs and PAHs extend from the site of the former incinerator to the south drainage ditch. All PCB detections but one are < 4 ppm. Surface soil at location SS-04 contained 15 ppm Aroclor-1260 (the carcinogenic PCB). Polycyclic aromatic hydrocarbons concentration likewise is highest (48 ppm) at location SS-04. Uranium activity of the surface soil is generally less in SWMU 30 than was observed at SWMU 7. The radiation walkover survey of SWMU 30, conducted during the Phase II Site Investigation, identified only isolated areas where surface radiological contamination exceeded three times background activity as measured at nearby reference sites.

SWMU 30 is contributing PCBs to sediments and surface water in the south ditch. However, elevated levels of metals and uranium occurring in both the north and south drainage ditches appear to be derived from upgradient sources.

Subsurface soils are contaminated with metals and radionuclides at the former incinerator site. Soil samples from Burial Pit A contain elevated levels of metals, radionuclides, and PAHs.

Metals, radionuclides, BTEX compounds, and TCE degradation products contaminate water in Burial Pit A. Despite high activities of uranium in some Pit A water samples, elevated uranium activity is not detectable in the adjacent UCRS. Trichloroethene contamination of the UCRS and RGA at SWMU 30 may be derived from local sources. However, any DNAPL that may be present has migrated into the underlying soils and is now distinct from the burial pits.

Contaminant Fate and Transport

Refer to Sect. 3.2.6.3, Contaminant Fate and Transport, for SWMU 7.

Summary of Previous Remedial Actions

No previous remedial actions have been taken at SWMU 30.

Summary of WAG 22 Risk Assessment Summary

The summary presented in this section was taken from *Remedial Investigation for Solid Waste Management Units 7 and 30 of Waste Area Grouping 22 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1998c) (SWMUs 7 and 30 BRA). Specifically, the Executive Summary of the SWMUs 7 and 30 BRA contains the pertinent risk information that will be repeated here. This document provides information about the baseline risks posed to human health and the environment from contamination at the former C-747-A Burial Ground (SWMU 7) and the former C-747-A Burn Area (SWMU 30). It includes information on risk assessments that have evaluated long-term impacts to human health and the environment. Information provided in this document form the basis for the development of the FS.

According to the Executive Summary of the SWMUs 7 and 30 BRA:

> In 1996, the U.S. Department of Energy (DOE) conducted a Remedial Investigation/Resource Conservation and Recovery Act Facility Investigation at solid waste management units (SWMUs) 7 and 30 in Waste Area Grouping (WAG) 22 at the Paducah Gaseous Diffusion Plant (PGDP) in Paducah, Kentucky. The purpose of this activity was to determine the presence, nature, and extent of contaminants (if any) at each of the units. The investigation focused on source characterization of the surrounding soils and the potential impacts of contaminants on adjoining surface waters and groundwater. Investigative activities included sampling and analysis of surface and subsurface soils, surface waters, groundwater, and waste.

This baseline risk assessment utilizes information collected during the recently completed remedial investigation and earlier investigations to characterize the baseline risks posed to human health from contact with contaminants in soil, sediment, groundwater, surface water, and buried waste at SWMUs 7 and 30 and from contact with media impacted by contaminants migrating from these units. (Baseline risks are those which may be present in absence of corrective or remedial actions.) In the assessment of the risk posed by contaminants migrating from burial pits at SWMUs 7 and 30 to the regional gravel aquifer (RGA), the transport modeling results presented in Chapters 4 and 5 of Volume 1 of this report were used. The modeling information was also used in the assessment of the risks posed by contaminants migrating from SWMUs 7 and 30 to surrounding ditches. Please note, although the SWMUs are bordered by ditches that collect and direct surface-water runoff off site, the flow in these ditches is intermittent; therefore, all sediment samples collected from these ditches were assessed as soil and not sediment in this baseline human health risk assessment (BHHRA).

Consistent with regulatory guidance and previous agreements, several land use scenarios were evaluated as part of the BHHRA. These are as follows.

- Current on-site industrial—direct contact with surface soil (0 to 1 ft).
- Future on-site industrial—direct contact with surface soil (0 to 1 ft) and use of RGA groundwater below the SWMU.

- Future on-site excavation scenario—direct contact with waste and subsurface soil (0 to 10 ft). [Note, exposure was combined for all pits within a SWMU for this BHHRA. However, a pit-specific baseline risk assessment is presented in an appendix to the feasibility study for SWMUs 7 and 30 (DOE 1997c).]

- Future on-site recreational user—consumption of game exposed to surface soil (0 to 1 ft).

- Future off-site recreational user—direct contact with surface water and consumption of game exposed to surface water.

- Future on-site rural resident—direct contact with surface soil (0 to 1 ft), use of RGA groundwater below the SWMU, and consumption of vegetables.

- Future off-site rural resident—use of RGA groundwater at the DOE property boundary.

This report also contains a screening ecological risk assessment for various nonhuman receptors that may come into contact with contaminated media at or migrating from SWMUs 7 and 30. As with the BHHRA, this screening assessment utilizes information collected during the recently completed remedial investigation and earlier investigations. However, this screening assessment concludes with an identification of a COPECs for the receptors and not with baseline risks to these receptors. The reader should note that a BERA will be completed for these units at a later date during the plant-wide ecological risk assessment for PGDP.

Major conclusions and observations of the risk assessments are as follows.

General

- For SWMUs 7 and 30 and the associated ditches, human health excess lifetime cancer risk (ELCR) and systemic toxicity of contaminants often exceed accepted standards of EPA and KDEP. Summaries of the human health risk assessment results for all land uses evaluated are in Tables ES.1 to ES.5 of the Executive Summary of the BRA. These tables present the risk results calculated using required default exposure parameters, exposure pathways, and toxicity values. Tables 3.48 and 3.49 presents the risk results of the uncertainty analysis using site-specific exposure parameters, appropriate exposure pathways, and approved toxicity values. Only discussion of the current land use and the most plausible future land use will be presented in the Executive Summary.

- Pit G (i.e., found in SWMU 7 below the drums composing SWMU 12) was not evaluated in this assessment because sampling data from this pit and the area surrounding it were not available, as discussed in Volume 1 of this report. However, it should be noted that risks to the current industrial worker and future industrial worker, resident, and recreational user from contact with contaminated surface soil at Pit G are probably similar to or greater than those determined for elsewhere at SWMUs 7 and 30. Potentially greater risks are surmised because contamination of these soils with uranium may be greater than that found elsewhere at SWMUs 7 and 30 through migration of uranium from the drums to the underlying soil. Risks to the excavation worker are probably similar to those found generally at SWMUs 7 and 30 because wastes in Pit G are similar to those found elsewhere at SWMUs 7 and 30.

- Detectable concentrations of contaminants encountered at SWMU 7, SWMU 30, north ditch, and south ditch that exceeded background were evaluated for the potential of inducing adverse ecological effects to a representative set of receptor species that potentially inhabit the study area. Table ES.8 of the Executive Summary of the BRA summarizes chemicals of potential ecological concern (COPECs)

that were retained for further study based on the results of screening contaminant concentrations against a conservative set of ecological benchmarks. A variety of analytes (primarily organic compounds) for which ecological risk could not be estimated because receptor-specific toxicity data were lacking are also retained.

Screening Ecological Risk Assessment

- The purpose of the Screening Ecological Risk Assessment was to eliminate analytes for which adverse ecological effects are not expected. Analytes that were retained as COPECs may require further study to determine if adverse ecological effects are likely if decisions for remedial actions will be based on ecological concerns. Uncertainty concerning the bioavailability of various metals (e.g., aluminum at all sites was only slightly elevated above background) and comparison of exposures to No Observed Adverse Effects Levels (NOAEL) may have lead to an overestimate of potential ecological risks. Further sampling and analysis is needed to determine if concentrations for which the potential for adverse ecological effects is indicated accurately represent conditions at specific SWMUs.

Tables 3.48 and 3.49 present the risk results and the quantitative risk summaries found in Tables ES.6 and ES.7 of the SWMUs 7 and 30 BRA, respectively. Table 3.48 and 3.49 present the risk results of the uncertainty analysis using site-specific exposure parameters, appropriate exposure pathways, and approved toxicity values. Only discussion of the current land use and the most plausible future land use will be presented.

3.2.7 WAGs 1 and 7

WAG 1 consists of the C-615 Sewage Treatment Plant (SWMU 38), the Fire Training Area (FTA) (SWMU 100), and the C-740 TCE Spill Site (SWMU 136). All three of these sites are located in the southwestern portion of the PGDP security area (Fig. 3.36). According to the PGDP SMP, the SWMUs in WAG 1 were grouped as a result of common geographic location (DOE 1999c).

WAG 7 consists of five USTs (SWMUs 130–134) located in the vicinity of the C-611 Water Treatment Plant (WTP), and the inactive C-746-K Sanitary Landfill (SWMU 8). All of these sites are located outside of the main security fence, southwest of the PGDP facility (Fig. 3.36). According to the PGDP SMP, these SWMUs were grouped due to their suspected contribution to off-site contamination, potential for application of a remedial technology common to the group, and similarity in contaminant types.

By written mutual consent, the EPA, the KDEP, and the DOE agreed that an evaluation of remedial alternatives for SWMU 38, the C-615 Sewage Treatment Plant, would be deferred until the unit ceases operation (Haight 1995). Rationale supporting this decision was that additional impacts to environmental media may occur during the operational life of this unit, thereby detracting from the effectiveness of implementing remedial actions prior to closure.

In former versions of the PGDP SMP (DOE 1999c), WAGs 1 and 7 included three SWMUs associated with operations conducted at the former KOW, a portion of which is located within the western quadrant of the DOE property boundary. By mutual consent among the EPA, the KDEP, the United States Department of Defense (DoD), the COE, and the DOE, it was agreed that evaluation and implementation of any remedial actions required for the KOW SWMUs [SWMU 94 (KOW Sewage Treatment Plant), SWMU 95 (KOW Burn Area), and SWMU 157 (KOW Toluene Spill Site)] would be the responsibility of the DoD, and conducted on behalf of the DoD by the COE. Correspondence outlining the agreed upon responsibilities of the DOE, the COE, and the DoD was submitted to the EPA and the KDEP April 5, 1996. Due to the agreements reached between these entities, further actions involving the KOW SWMUs no longer will be addressed by the DOE PGDP environmental restoration program.

Table 3.48. Summary of risk results and uncertainties for ELCR for SWMUs 7 and 30

(formerly "Table ES.6. Summary of quantitative uncertainty analysis of the human health risk assessment for excess lifetime cancer risk")

	Total Excess Lifetime Cancer Risk							
SWMU	**Total ELCR derived using all default exposure values**	**Total ELCR derived using site-specific or average exposure values**	**Total ELCR without groundwater contribution**	**Total ELCR using EPA default dermal absorption exposure values**	**Total ELCR without contribution of lead**	**Total ELCR without consumption of game contribution**	**Total ELCR without consumption of vegetables contribution (soil + gw)**	**Total site-specific or average ELCR without groundwater, with EPA default dermal values, without lead, without game, and without vegetable contribution**
Current Industrial Worker at Current Concentrations								
7	4×10^{-3}	2×10^{-4}	NA	2×10^{-4}	NA	NA	NA	1×10^{-5}
30	4×10^{-3}	2×10^{-4}	NA	2×10^{-4}	NA	NA	NA	1×10^{-5}
North ditch	4×10^{-4}	2×10^{-5}	NA	3×10^{-5}	NA	NA	NA	2×10^{-6}
South ditch	4×10^{-4}	2×10^{-5}	NA	5×10^{-5}	NA	NA	NA	3×10^{-6}
Future Industrial Worker at Current Concentrations								
7	6×10^{-3}	NA	4×10^{-3}	2×10^{-3}	NA	NA	NA	2×10^{-4}
30	4×10^{-3}	NA	4×10^{-3}	5×10^{-4}	NA	NA	NA	2×10^{-4}
North ditch	4×10^{-4}	NA	NA	3×10^{-5}	NA	NA	NA	3×10^{-5}
South ditch	4×10^{-4}	NA	NA	5×10^{-5}	NA	NA	NA	5×10^{-5}
Future Recreational User at Current Concentrations								
7	1×10^{-5}	NA	NA	NA	NA	0.0e+00	NA	0.0e+00
30	1×10^{-5}	NA	NA	NA	NA	0.0e+00	NA	0.0e+00
North ditch	1×10^{-6}	NA	NA	NA	NA	0.0e+00	NA	0.0e+00
South ditch	2×10^{-6}	NA	NA	NA	NA	0.0e+00	NA	0.0e+00
Future Rural Resident at Current Concentrations								
7	5×10^{-2}	1×10^{-2}	3×10^{-2}	4×10^{-2}	NA	NA	2×10^{-2}	1×10^{-3}
30	4×10^{-2}	9×10^{-3}	3×10^{-2}	3×10^{-2}	NA	NA	1×10^{-2}	8×10^{-4}
North ditch	9×10^{-3}	2×10^{-3}	NA	8×10^{-3}	NA	NA	1×10^{-3}	3×10^{-4}
South ditch	1×10^{-2}	3×10^{-3}	NA	1×10^{-2}	NA	NA	1×10^{-3}	5×10^{-4}
Future Excavation Worker at Current Concentrations								
7	2×10^{-3}	1×10^{-5}	NA	9×10^{-4}	NA	NA	NA	7×10^{-6}
30	1×10^{-3}	6×10^{-5}	NA	1×10^{-4}	NA	NA	NA	7×10^{-6}
North ditch	NA	NA	NA	NA	NA	NA	NA	NA
South ditch	NA	NA	NA	NA	NA	NA	NA	NA

NA = Uncertainty not evaluated or not appropriate for this land use.

Table 3.49. Summary of risk results and uncertainties for systemic toxicity for SWMUs 7 and 30

(formerly "Table ES.7. Summary of quantitative uncertainty analysis of the human health risk assessment for systemic toxicity

	Systemic Toxicity							
SWMU	**Total HI derived using all default exposure values with lead**	**Total HI derived without lead toxicity**	**Total HI derived using site-specific or average exposure values without lead**	**Total HI without groundwater contribution without lead**	**Total HI using EPA default dermal absorption exposure values without lead**	**Total HI without contribution from consumption of game**	**Total HI without contribution from consumption of vegetables (soil + gw)**	**Total site-specific or average HI without groundwater, with EPA default dermal values, without lead, without game, and without vegetable contribution**
Current Industrial worker at Current Concentrations								
7	5×10^{3}	5×10^{0}	3×10^{-1}	NA	3×10^{-1}	NA	NA	2×10^{-2}
30	4×10^{3}	4×10^{0}	3×10^{-1}	NA	2×10^{-1}	NA	NA	1×10^{-2}
North ditch	3×10^{3}	5×10^{0}	3×10^{-1}	NA	2×10^{-1}	NA	NA	1×10^{-2}
South ditch	1×10^{4}	5×10^{0}	3×10^{-1}	NA	2×10^{-1}	NA	NA	1×10^{-2}
Future Industrial Worker at Current Concentrations								
7	5×10^{4}	6×10^{1}	NA	5×10^{0}	6×10^{1}	NA	NA	3×10^{-1}
30	2×10^{4}	1×10^{1}	NA	4×10^{0}	8×10^{0}	NA	NA	2×10^{-1}
North ditch	3×10^{3}	5×10^{0}	NA	NA	2×10^{-1}	NA	NA	2×10^{-1}
South ditch	1×10^{4}	5×10^{0}	NA	NA	2×10^{-1}	NA	NA	2×10^{-1}
Future Child Recreational User at Current Concentrations								
7	3×10^{0}	7×10^{-2}	NA	NA	NA	0.0e+00	NA	0.0e+00
30	2×10^{0}	4×10^{-2}	NA	NA	NA	0.0e+00	NA	0.0e+00
North ditch	2×10^{-1}	4×10^{-3}	NA	NA	NA	0.0e+00	NA	0.0e+00
South ditch	5×10^{-1}	5×10^{-3}	NA	NA	NA	0.0e+00	NA	0.0e+00
Future Child Rural Resident at Current Concentrations								
7	9×10^{5}	1×10^{3}	1×10^{3}	4×10^{2}	1×10^{3}	NA	4×10^{2}	2×10^{0}
30	5×10^{5}	3×10^{2}	2×10^{2}	3×10^{2}	3×10^{2}	NA	7×10^{1}	2×10^{0}
North ditch	2×10^{5}	2×10^{2}	2×10^{2}	NA	2×10^{2}	NA	3×10^{1}	1×10^{0}
South ditch	7×10^{5}	3×10^{2}	2×10^{2}	NA	3×10^{2}	NA	3×10^{1}	2×10^{0}
Future Excavation Worker at Current Concentrations								
7	7×10^{3}	5×10^{0}	4×10^{-2}	NA	1×10^{0}	NA	NA	8×10^{-3}
30	5×10^{3}	4×10^{0}	2×10^{-1}	NA	9×10^{-1}	NA	NA	4×10^{-2}
North ditch	NA	NA	NA	NA	NA	NA	NA	NA
South ditch	NA	NA	NA	NA	NA	NA	NA	NA

NA = Uncertainty not evaluated or not appropriate for this land use.

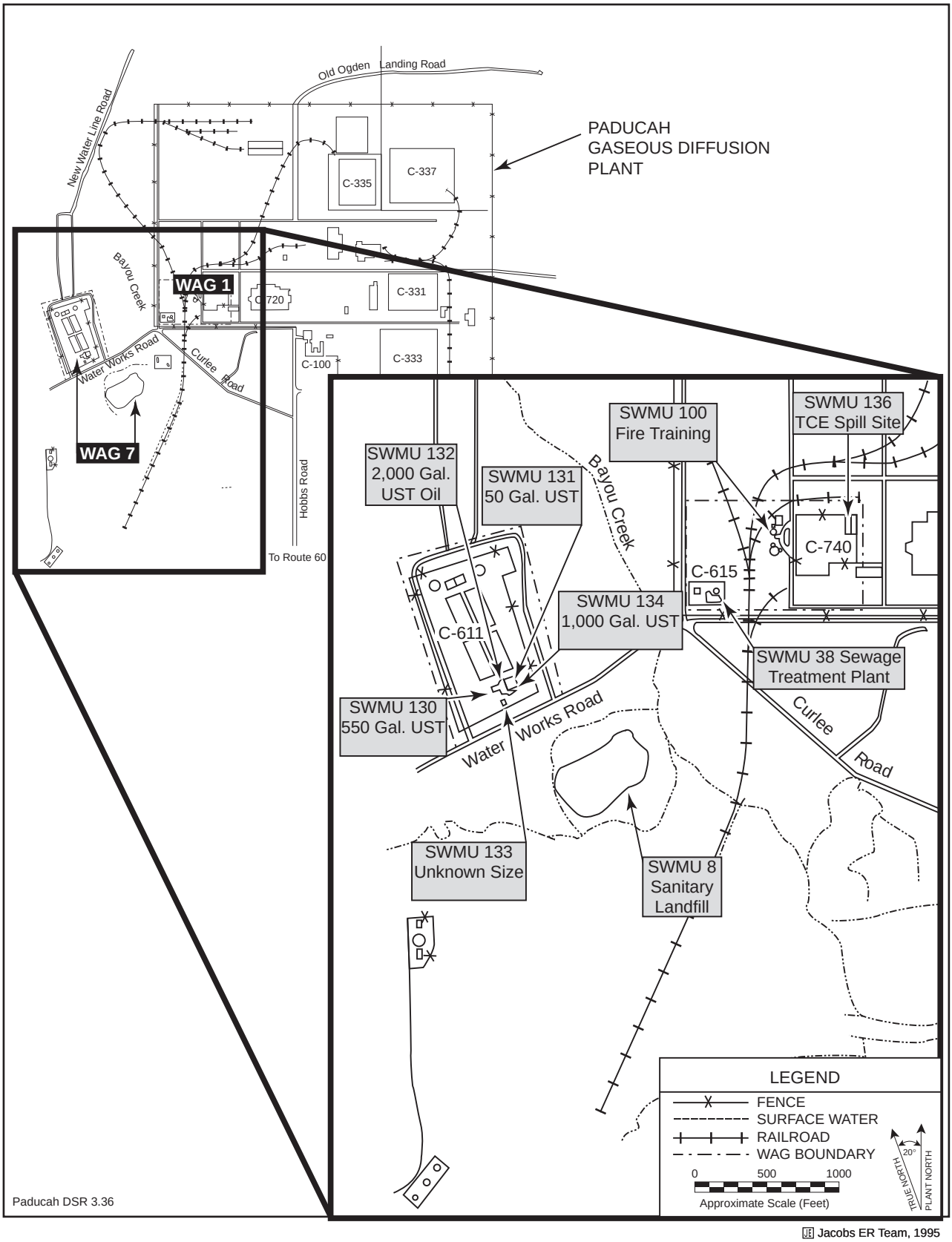

Fig. 3.36. Locations of SWMUs within WAGs 1 and 7.

As indicated above, WAGs 1 and 7 consists of a total of nine individual and diverse SWMUs. Information regarding location, setting, and historic manufacturing/TSD processes is provided for each SWMU; due to the similar nature of use and location of the C-611 USTs (SWMUs 130–134), these units have been grouped for discussion.

3.2.7.1 SWMU 8 — C-746-K Sanitary Landfill

Location

The C-746-K Sanitary Landfill (SWMU 8) is located south of the C-611 WTP, southwest of the PGDP security area (Fig. 3.37). It is situated immediately west of Bayou Creek and north of the unnamed tributary of Bayou Creek. The C-746-K Sanitary Landfill is roughly rectangular in shape and measures approximately 152 × 213 m (500 × 700 ft).

Setting

The following subheadings provide information on the setting of SWMU 8, including geology/ hydrogeology, surface features and surface-water hydrology, transportation, floodplains, wetlands, soils and prime farmland, biological resources, and cultural resources. Additionally, a discussion of underground utilities located in the vicinity of the landfill has been included.

Geology/Hydrogeology

In 1980, Wehran Engineering conducted a hydrogeologic investigation at the landfill (Wehran 1981). During the investigation, Wehran drilled ten soil borings and completed five of these as piezometers (MWs 23 through 27) screened in the Porters Creek Clay. In addition, ten test pits were excavated in and around the landfill and polyvinyl chloride (PVC) well points were installed in the backfill (MWs 28 through 37). In 1991, CH2M HILL drilled a soil boring (MW183) and installed MW184 in the Terrace Gravel at the landfill as part of the Phase II Site Investigation (CH2M HILL 1992). For the RFI/RI, nine soil borings were drilled and four shallow monitoring wells were installed around the perimeter of the landfill. Figure 3.37 shows the locations of these sampling points.

Cross sections illustrating the geology at the landfill site are presented in Figs. 3.38 and 3.39. The following lithologies were encountered beneath the unit, in order of increasing depth.

- Landfill cap material occurs in the upper 0.6 to 0.9 m (2.0 to 3.0 ft) of the landfill. A 15-cm (6-in.) clay cap and a 46-cm (18-in.) layer of subsoil and topsoil were placed on the landfill in 1982, and additional soil was added when the cap was repaired in 1992. A thin layer of stiff, highly plastic white clay that fits the description of the original clay cap was encountered in 8-SB-002 and 8-SB-002A. Soil permeability testing was completed in 1993 on nine Shelby tube samples collected from the soils (vegetative cover) overlying the landfill cap. The results range from an average hydraulic conductivity of 1.18×10^{-7} to 3.54×10^{-5} cm/sec (3.34×10^{-4} to 1.00×10^{1} ft/d).

- Fill material, composed of fly ash mixed with soil and assorted rubbish, is found beneath the clay and vegetative cap to a maximum observed thickness of 8.5 m (28 ft) in Wehran Soil Boring B-9. In general, fly ash consists primarily of silt-sized particles of amorphous glass, with quartz, mullite [Aluminum Silicate ($Al_6Si_2O_{13}$)], various iron oxides such as hematite and magnetite, and lime (MMES 1993). A magnetometer survey conducted at SWMU 8 for the RFI/RI indicated that there are at least two magnetic anomalies in the western half of the landfill. These anomalies may indicate the presence of buried drums, discrete piles of fly ash, or some other metallic objects.

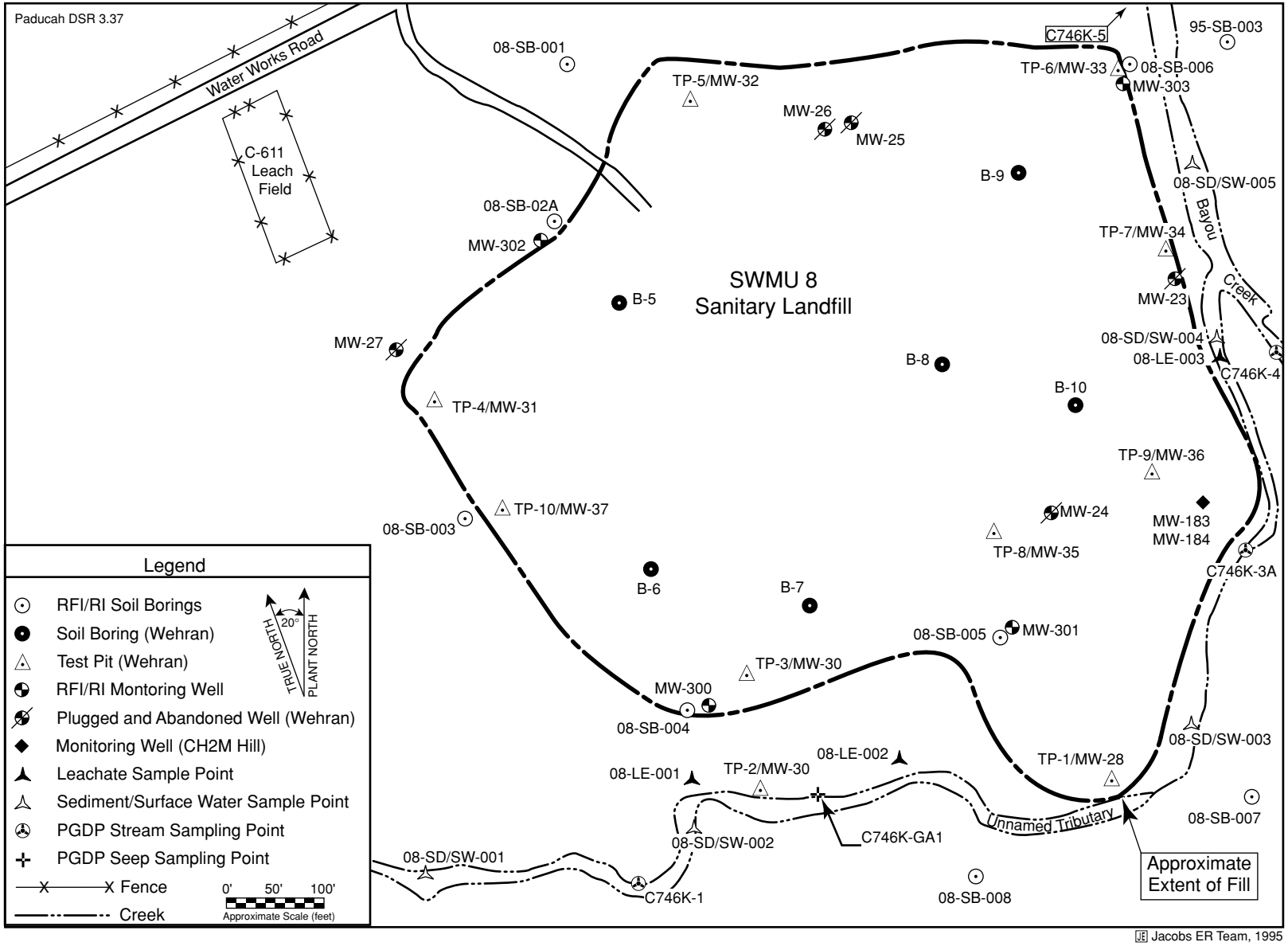

Fig. 3.37. Soil and leachate sampling locations and monitoring wells at SWMU 8.

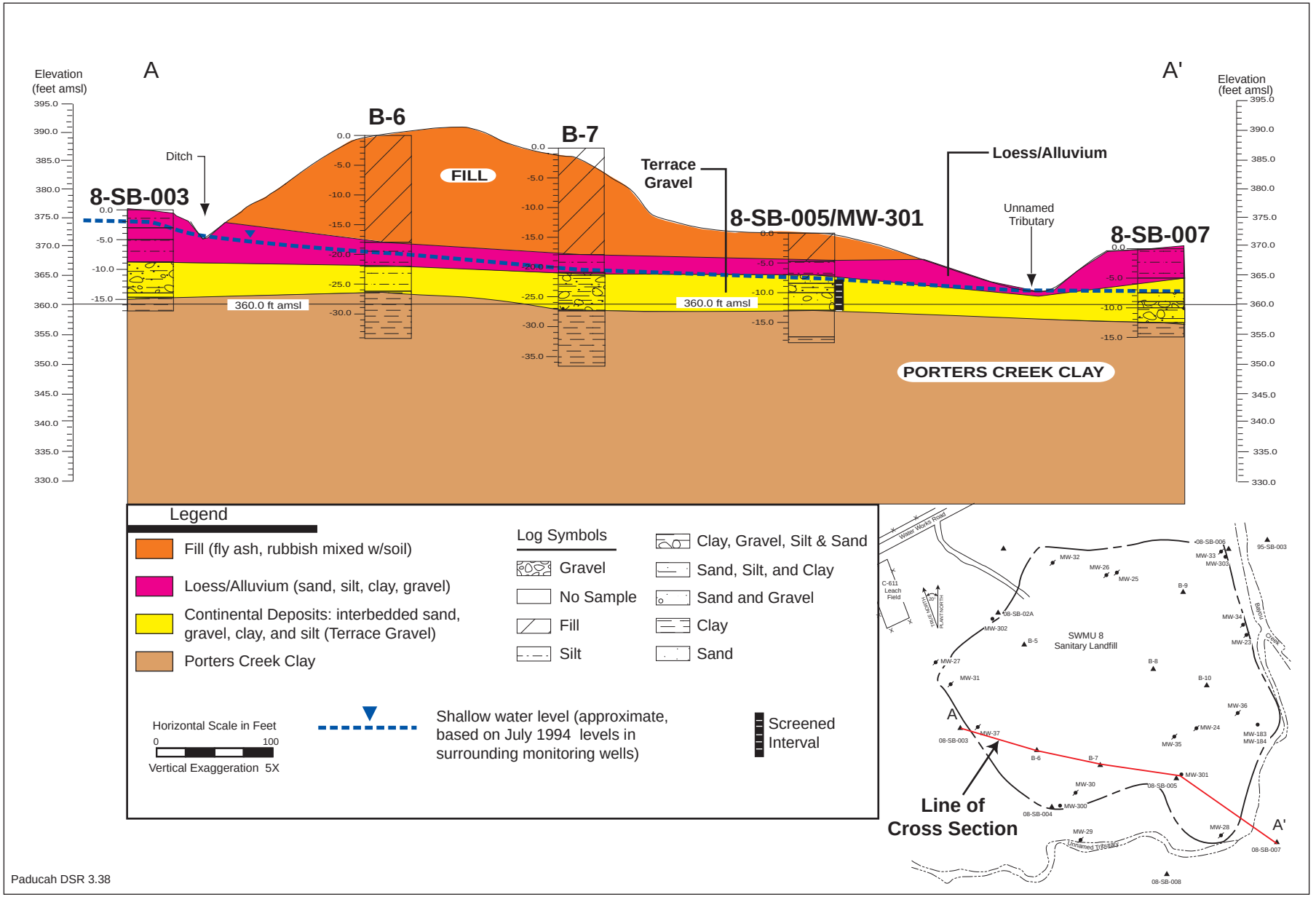

Fig. 3.38. Geologic cross-section for the C-746-K Landfill (SWMU 8).

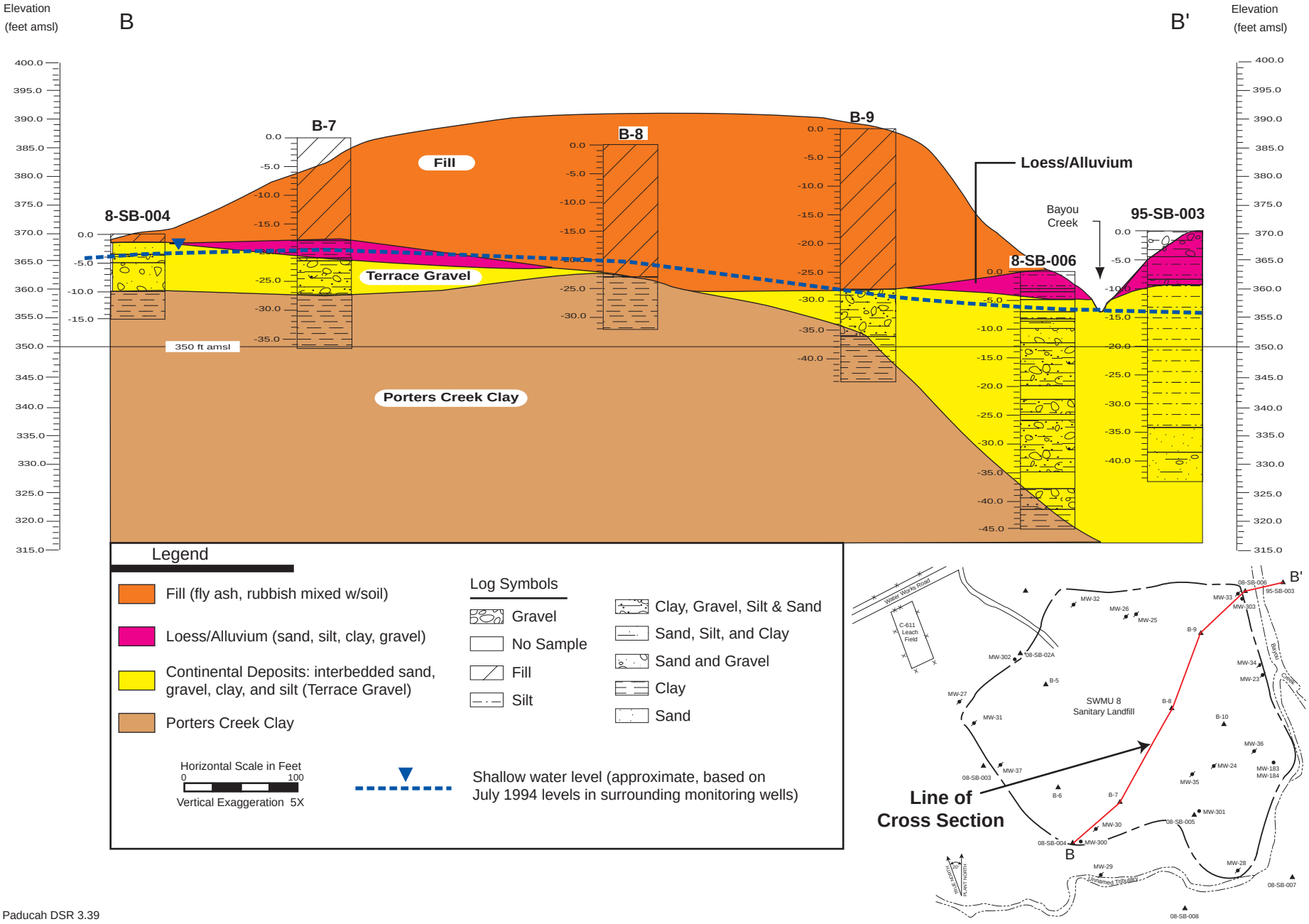

Fig. 3.39. Geologic cross-section for the C-746-K Landfill (SWMU 8).

- Loess and alluvial deposits are present in some areas underlying the landfill and range in thickness from 0 to 2 m (0 to 8 ft).

- Continental deposits consisting of up to 10 m (33 ft) of Terrace Gravel overlie the Porters Creek Clay Terrace at the landfill. The continental deposits consist of clayey silt containing coarse gravel and sand lenses and are difficult to distinguish from younger alluvial deposits near the creeks.

- Porters Creek Clay underlies the landfill at varying depths. The Porters Creek Clay Terrace slope dips relatively steeply to the north-northeast beneath the northeastern corner of the landfill. The depth to the top of the clay varies from 3.0 m (10 ft) bgs in 8-SB-004 to 12.6 m (41.5 ft) bgs in 8-SB-006. None of the soil borings or monitoring wells at this unit fully penetrated the Porters Creek Clay. The Porters Creek Clay has been described as a dark, greenish gray to black clay containing varying amounts of silt and fine sand and containing fine hairline fractures. Results of tests conducted by Wehran Engineering in 1981 indicate that the hydraulic conductivity of the Porters Creek Clay ranges from 5.5×10^{-9} to 1.3×10^{-7} cm/sec (1.56×10^{-5} to 3.68×10^{-4} ft/d) at the landfill.

The UCRS and the RGA are not present at SWMU 8. Groundwater occurs under shallow, unconfined conditions in the Terrace Gravel, loess, and alluvium overlying the Porters Creek Clay Terrace. Underflow enters the landfill from the west within the Terrace Gravel, flows laterally to the east, and discharges into the creeks, with some unquantified amount potentially flowing into the RGA north of the terrace as recharge. North of terrace slope, the predominant groundwater flow direction within the RGA is north–northeast. The degree of hydraulic connection between the Terrace Gravel and the RGA at the PGDP is not known. Groundwater flow modeling conducted for the FS at SWMU 8 was used to help define the probable shallow groundwater flow conditions at the landfill and to address the uncertainties regarding potential contaminant migration from SWMU 8 over the terrace slope into the RGA. The results of this modeling are presented in the WAGs 1 and 7 FS (DOE 1996d). The modeling of the no action alternative represents the expected conditions at the landfill. The modeling and the presence of the seeps in the surrounding surface water indicate that most of the shallow groundwater at the landfill likely discharges to the surrounding creeks.

Monthly groundwater levels measured at the landfill since 1980 indicate that groundwater levels vary seasonally, with the maximum levels typically occurring in winter and spring (MMES 1993). Groundwater mounding occurs beneath the northwestern portion of the unit. June 1992 data indicate that the shallow water levels rise to about 115 m (377 ft) amsl beneath the western part of the landfill, indicating that the lower 2 to 3 m (5 to 10 ft) of waste at the landfill is below the water table during certain times of the year. The four monitoring wells installed at SWMU 8 for the RCRA Facility Investigation (RFI)/RI were screened in the Terrace Gravel. According to water level measurements taken July 12, 1995, the depths to shallow groundwater ranges from approximately 1.6 m (5.4 ft) bgs at MW300 to 3.5 m (11.5 ft) bgs at MW303.

All available data have been used to describe the expected conditions at the C-746-K Landfill. However, a degree of uncertainty remains concerning some of the site conditions at SWMU 8; these uncertainties include the exact location and condition of the KOW yellow water line, the degree of hydraulic connection over the terrace slope, and a precise definition of the source term (waste types and volumes).

Surface features and surface-water hydrology. The ground surface in the vicinity of the C-746-K Sanitary Landfill is grass-covered and slopes in a radial fashion from a maximum elevation of 121.9 m (400 ft) near the center of the western half of the landfill to a low of approximately 109.7 m (360 ft) near Bayou Creek at the eastern edge of the landfill. Bayou Creek and the unnamed tributary are located immediately east and south of the landfill mound, respectively. A drainage ditch is located along the western edge of the landfill and flows to the south into the unnamed tributary. Surface runoff from the C-746-K Sanitary Landfill is discharged to these surface bodies.

Transportation. The road north of SWMU 8 is owned by the DOE. Traffic occurring on this road consists predominantly of recreationalists, PGDP personnel, and WKWMA personnel.

Wetlands. Wetlands identified in the vicinity of SWMU 8 during the 1994 COE environmental investigation of the PGDP and during a wetland investigation for WAGs 1 and 7 are shown in Fig. 3.40 (SAIC 1993).

Floodplains. A portion of the 100-year floodplain of Bayou Creek is located within the boundary of SWMU 8 (Fig. 3.40) and the unnamed tributary.

Biological resources. The majority of the area associated with SWMU 8 has been cleared previously of vegetation and consists of various grasses including rye, fescue, foxtail, and various others not identified due to mowing practices.

Those areas that have not been cleared of vegetation in recent times are associated with Bayou Creek and consist of species such as oak (*Quercus* spp.), hickory (*Carya* spp.), maple (*Acer* spp.), American elm (*Ulmus americana)*, sweetgum (*Liquidambar styraciflua*), and various others in the overstory. The scrub-shrub layer consists predominantly of maple, black locust (*Robinia pseudoacacia*), sumac (*Rhus* sp.), persimmon (*Diospyros verginiana*), and other mixed forest species in the sapling stage.

All of the wildlife listed in Sect. 2.8.4 could be found in these areas. Potential habitat for the copperbelly water snake exists to the east of SWMU 8 along Bayou Creek.

Soils and prime farmland. Historically, soils within the impacted area of the SWMU 8 are Calloway silt loam, 0% to 2% slope; Grenada silt loam, 6% to 12% slopes; and Fallaya-Collins silt loam. However, the soils associated with these areas have been disturbed by past activities, preventing that any of these areas from being prime farmland. The NRCS has been contacted and concurs with this determination (DOE 1996d).

Cultural resources. All of the areas associated with SWMU 8 have been previously disturbed and, consequently, are not likely to contain any sites of archaeological significance. The SHPO has been contacted and concurs with this determination (DOE 1996d).

Underground utilities. From review of available underground-utility maps for the former KOW and PGDP facilities, it appears that there are underground utilities in the area of the C-746-K Landfill. Figure 3.41 shows the location of all known underground utilities in the vicinity of the landfill.

A KOW yellow water line underlies the northern portion of the landfill site. The line was used from 1942 to 1945 to transport yellow water, an acidic and TNT-contaminated wastewater, from the KOW TNT-manufacturing area to a discharge point on Bayou Creek. The best available data concerning the location and depth of the yellow water line are the plans/drawings of the KOW area which were produced by Rust Engineering in 1942 and 1943. These drawings were used to determine the likely location of the KOW yellow water line shown in Fig. 3.41. The drawings indicate that the line was constructed of 30.5-cm (12-in.) diameter, segmented, vitrified-clay pipe. It is believed that during decommissioning of the KOW plant, the line was flushed to remove residuals and the external structures of the line (i.e., manhole covers and the pipe headwall at the point of discharge to Bayou Creek) were removed. The portions of the line crossing the area now occupied by the landfill may have been removed prior to landfill construction, but there is no documentation available to support this hypothesis. Manholes for the line have been observed west of the landfill, but no visible evidence of the line has been found in the immediate vicinity of the landfill. If the KOW yellow water line is still present beneath the landfill, it

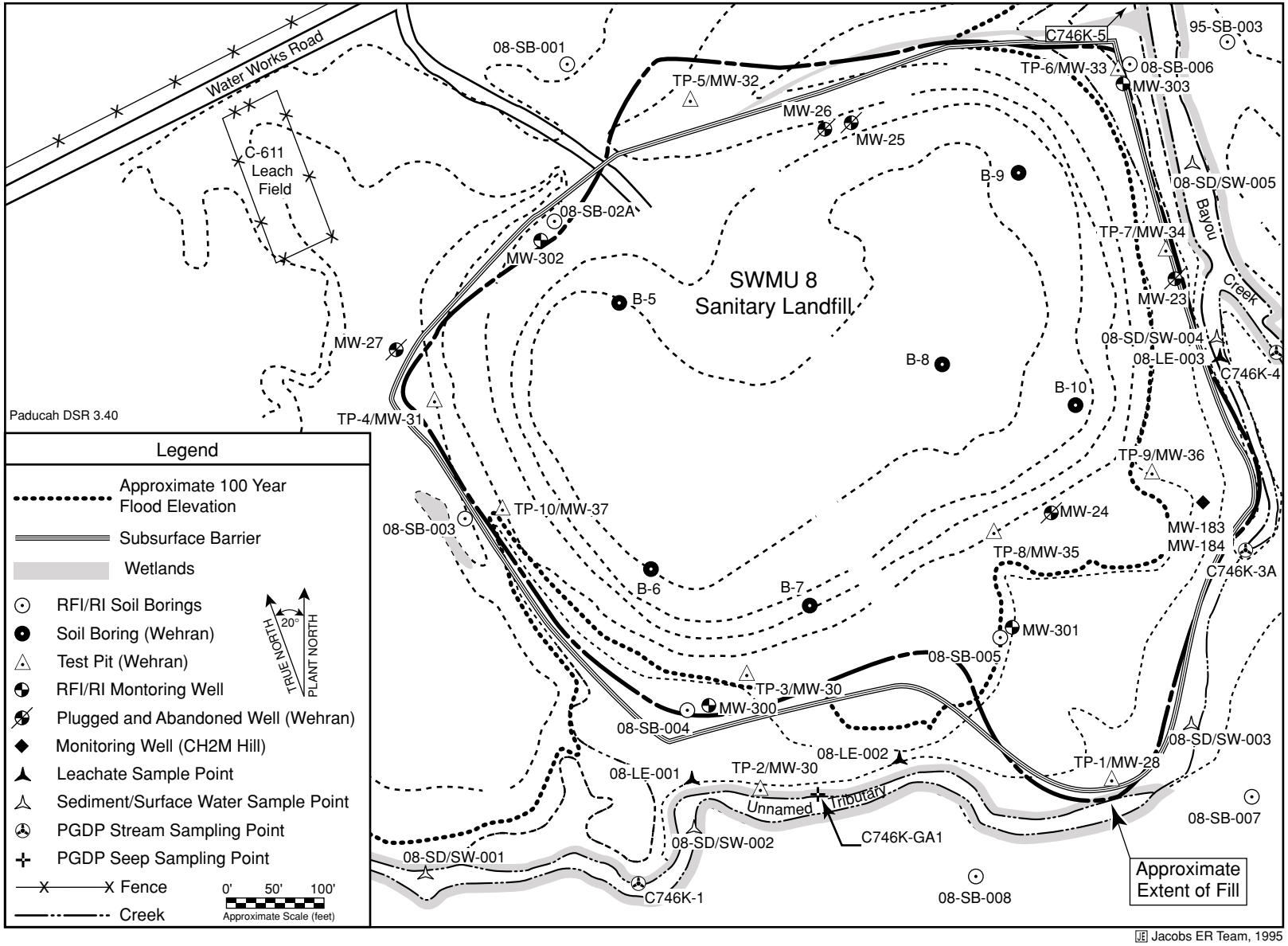

Fig. 3.40. Location of wetlands and 100-year floodplain in the vicinity of SWMU 8

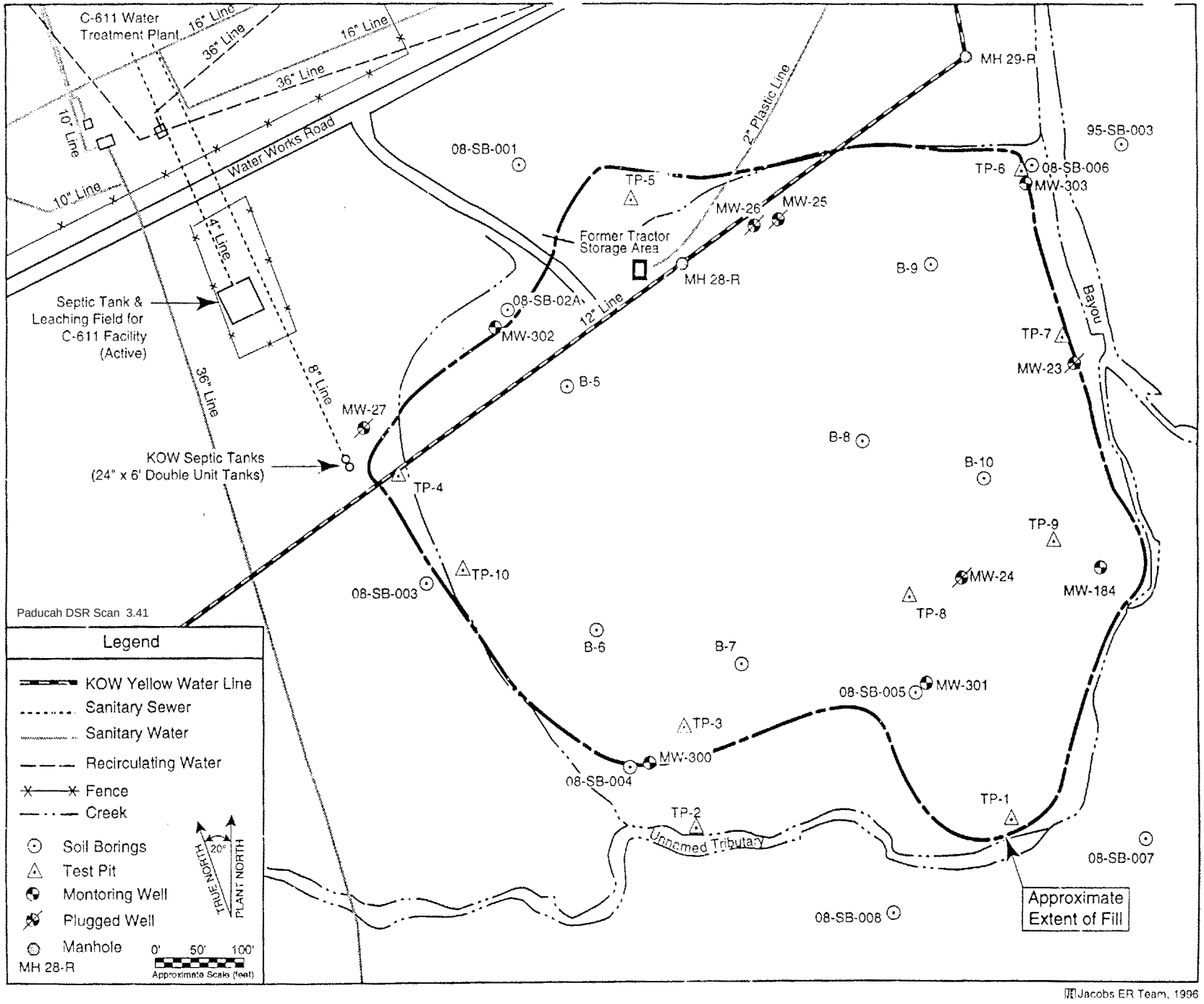

Fig. 3.41. Location of underground utilities in the vicinity of the C-746-K Landfill.

could serve as a contaminant migration pathway from the unit. Remedial activities at the landfill are expected to help resolve some of the uncertainties concerning the exact location and condition of the line.

In early April 1996, a crew from LMES-Oak Ridge conducted a survey to determine the location of the yellow water line with respect to the landfill. The survey indicates that the line runs in an east–west direction across the northern portion of the landfill site. A small portion of the landfill wastes overlie the reported location of the line. Depth of the line with respect to current ground surface varies from approximately 7.6 m (25 ft) bgs at a point located between manhole 28-R and the western edge of the landfill, to as little as 1 m (3 ft) bgs within the drainage swale located northeast of the landfill.

Utility maps indicate that a 91-cm (36-in.) diameter underground sanitary water line is located to the west of the landfill site. This line runs in a north–south direction to the C-611 complex. Utility maps dated 1982 also indicate that a 5-cm (2-in.) diameter sanitary water line is located in the northeastern portion of the landfill site. This line leads from a 41 cm (16-in.) main running adjacent to Water Works Road. The depth of the line is not indicated on available maps. It is unknown if this line is still in service, as this line would likely have been encountered during construction of drainage swales at landfill closure. Prior to any intrusive activities in this area, a survey should be conducted to determine location, depth and active status of this line.

Available utility maps also indicate a sanitary sewer line running from the C-611 complex to a septic tank and leach field located northwest of the landfill. The sanitary sewer system treats sanitary wastes from the C-611 complex. Wastes are transported to the septic tank by a 10-cm (4-in.) diameter line running from the C-611 buildings. Additionally, old (1942) drawings of the KOW area indicate the existence of a 20-cm (8-in.) diameter vitrified clay sewer line located west of the landfill at an average depth of approximately 1.5 m (5 ft) bgs. The line is shown running to septic tanks located approximately 45.7 m (150 ft) south of the C-611 leach field. The tanks are 61 cm × 1.8 m (24 in. × 6 ft) double unit tanks. No other records were available to indicate whether the septic tanks and sewer line are still present in the area. From review of available underground utility maps, it does not appear that any other mains, sewers, lines, or utility ducts are present in the area of the landfill.

Manufacturing/TSD Processes

Records indicate that the PGDP used the landfill between 1951 and 1981 for the aboveground disposal of steam plant fly ash and the burial of uncontaminated combustible waste and potentially contaminated rubbish. Trenches were cut in the ash and used for the burning of trash until 1967, after which waste was placed in the landfill without burning. In addition to these materials, sludge from the C-615 Sewage Treatment Plant may be buried at the unit, as it reportedly was used as fill material. Available soil boring data indicate that up to 9 m (28 ft) of fly ash and trash were placed in the landfill. In 1982, the landfill was closed and covered with a 15-cm (6-in.) clay cap and a 46-cm (18-in.) vegetative cover.

Summary of Investigations

Site investigations/remedial investigations. As part of an investigation into the impacts of the C-746-K landfill on groundwater quality, Wehran Engineering installed five groundwater monitoring wells at the site in 1980 (MWs 23 through 27). Each of these wells was screened in the Porters Creek Clay. One additional groundwater monitoring well was installed in 1991 by CH2M HILL, which is screened in the shallow groundwater system. Three of these wells were sampled as part of the PGDP sitewide Phase II SI (CH2M HILL 1992), and analyzed for TAL/TCL compounds, radionuclides, and major ions. This sampling confirmed PAHs and VOCs present in the groundwater at low concentrations (> 60 μg/L). Additionally,

species of radionuclides were detected in the groundwater, including ^{230}Th, ^{99}Tc, and ^{238}U. Since the Phase II sampling event, all these wells have been abandoned.

In July 1992, Oak Ridge Associated Universities (ORAU) conducted a radiological survey of the area. The results of the survey indicated no detection above background concentrations.

In 1994, the DOE conducted an RFI for the SWMUs in WAGs 1 and 7 and nearby KOW facility (SWMUs 94, 95, and 157) (DOE 1996e and 1996f). As part of this investigation, a total of 43 subsurface soil samples were collected from 8 soil borings located around the perimeter of the landfill; samples were collected at 1.5-m (5-ft) depth intervals from each boring. Boring depths ranged from 5 to 14 m (15 to 45 ft) bgs. The purpose of the soil borings was to determine the extent of soil contamination in the vicinity of the landfill. Additionally, one surface soil sample was collected from each boring location. In addition to the soil sampling, five surface-water and five sediment samples were collected to evaluate the impact that the landfill had on the surrounding surface water and sediment. Four shallow monitoring wells (MWs 300 through 303) were installed, developed, and sampled during RFI activities.

Additional data sources. Additional data gathering activities conducted at SWMU 8 include continuing groundwater monitoring program and surface-water monitoring program.

Groundwater monitoring program. Monthly groundwater monitoring was initiated at the landfill during Phase II of the CERCLA SI in 1992 (CH2M HILL 1992). Groundwater monitoring currently is conducted quarterly from four wells at the site (MWs 300 through 302 and MW344), and results are reported semiannually (BJC 1998a). These results indicate the presence of elevated concentrations of *cis*-1,2-DCE; 1,1-DCE; 1,1-dichloroethane (DCA); TCE; and vinyl chloride. Several metals (including aluminum, iron, magnesium, manganese, and nickel) have also been detected above background levels in groundwater samples from these monitoring wells.

Surface-water monitoring program. In October 1992, the PGDP started a surface-water monitoring program near the C-746-K Sanitary Landfill at Bayou Creek and the unnamed tributary. Samples were taken at monitoring points upstream and downstream of the landfill as well as at the previously sampled suspected seep source sites on the banks of Bayou Creek and the unnamed tributary. The results of the PGDP leachate and surface-water sampling conducted from November 1992 to October 1998 are presented in the WAGs 1 and 7 RI Report (DOE 1996e) and in the annual PGDP annual site environmental monitoring report (BJC 1998b). The results of this sampling indicate that several metals, including chromium, iron, magnesium, and manganese, occur at much higher concentrations in samples collected downgradient of the landfill than in samples collected upgradient of the unit. The concentrations are highest during late summer and fall, during low flow periods in the creeks. Four stations make up the surface-water monitoring network. Upstream monitoring was provided by two stations (C746K-1 and C746K-4) located on the adjacent unnamed tributary and Bayou Creek, respectively. Two other stations close to the C-746-K Sanitary Landfill (C-746K-3A and C-746K-5) provided downstream monitoring on the adjacent unnamed tributary and Bayou Creek, respectively. Samples were collected monthly through September 1995 and quarterly thereafter until October 1998. The analysis suite for samples collected from the surface-water monitoring locations included 14 common metals, mercury, uranium, VOCs, PCBs, and pH.

The data indicate that water quality at monitoring station C-746K-3A is impacted by the leachate from the C-746-K Sanitary Landfill, while monitoring station C-746K-5 appears to be unaffected. Surface-water samples from station C-746K-3A, located southeast of the landfill on the unnamed tributary, typically contained elevated levels of iron and manganese as compared to the upstream station C-746K-1 as well as low concentrations of *cis*-1,2-DCE. Iron levels at station C-746K-3A fluctuated seasonally, with greater concentrations in later summer and early fall during low stream flow periods.

The leachate from the landfill (as determined by seep sample sites GA-1 and GA-3) characteristically contained high levels of dissolved metals, low levels of dissolved VOCs, and a low pH (2.3 to 3.3). Where the acidic leachate from the landfill enters the creeks, the pH rises to approximately 6, indicating that the leachate only slightly lowers the stream pH when they mix. The low pH causes dissolved metals, particularly iron and aluminum, to form a precipitate. The precipitation of iron and aluminum oxy-hydroxides is the suspected cause of the orange to yellow staining observed seasonally at various seep sites at the landfill. The staining is most intense during dry periods (late summer to early fall) when stream flow is low.

Conceptual Site Model

The source area is identified as the area of direct waste deposition. The source at SWMU 8 consists of fly ash, uncontaminated combustible waste, potentially contaminated rubbish, and trash. Subsurface soil and groundwater are the primary contaminated media at SWMU 8; metals, organics, and radionuclides represent probable conditions at this unit.

Probable pathways from sources to receptors are demonstrated in Fig. 3.42. From the source at SWMU 8, contamination could migrate to soil and groundwater, the primary contaminated media, via infiltration, leaching, erosion, and runoff. From soil and groundwater at SWMU 8, contaminants could migrate into groundwater, air, soil, sediment, and surface water, all secondary contaminated media and probable release mechanisms, via infiltration, percolation, wind-generated dust, volatilization, erosion, and runoff. Contamination could also reach secondary contaminated media via leaching; an additional release mechanism at this unit is leachate. Due to the high topographic relief at SWMU 8, the potential for surface-water erosion and runoff is high. Surface water is included in the model, since it was addressed by a remedial action conducted at SWMU 8. As indicated in the model, all receptors and exposure routes for surface water in the model are for SWMU 8. Air is included in the model to identify it as a secondary contaminated medium; however, there are no receptors of exposure pathways identified since both units are outside and the likelihood of exposure to contamination via the air pathway outside is minimal.

Potential current exposure to contaminated sources or primary media at these units is limited since SWMU 8 is capped. However, direct exposure to soil or sediment may occur for current and future workers at SWMUs 8 via soil or sediment ingestion, dermal absorption, inhalation of particulate dust, and external exposure to ionizing radiation. Direct exposure to soil may occur for ecological receptors at SWMU 8 via ingestion, dermal absorption, inhalation, and external exposure to ionizing radiation. Additionally, direct exposure to sediment may occur for an intruder/infrequent recreational user at SWMU 8 via sediment ingestion, inhalation of particulates, dermal absorption, and external exposure. Direct exposure to sediments may occur for ecological receptors at SWMU 8 via ingestion and inhalation of particulates. Also, at SWMU 8, current and future workers, ecological receptors, and an intruder may be exposed to contaminants in surface water via dermal absorption. Finally, direct exposure to leachate may occur for an intruder/infrequent recreational user at SWMU 8 via dermal contact.

Nature and Extent of Contamination

Soil, groundwater, surface-water, sediment, and leachate sampling was conducted at the landfill for the RFI/RI. Eight soil borings and four shallow groundwater monitoring wells, MWs 300 through 303, were installed around the perimeter of the landfill. Five surface-water samples, seven sediment samples, and three leachate samples were collected during the RFI/RI from the locations shown in Fig. 3.37.

Results of the RI conducted at the landfill indicate that low levels of various organic compounds, metals, and radionuclides are likely leaching from the wastes buried in the landfill into the nearby streams and to groundwater. Leachate samples collected from two shallow holes on the bank of the unnamed

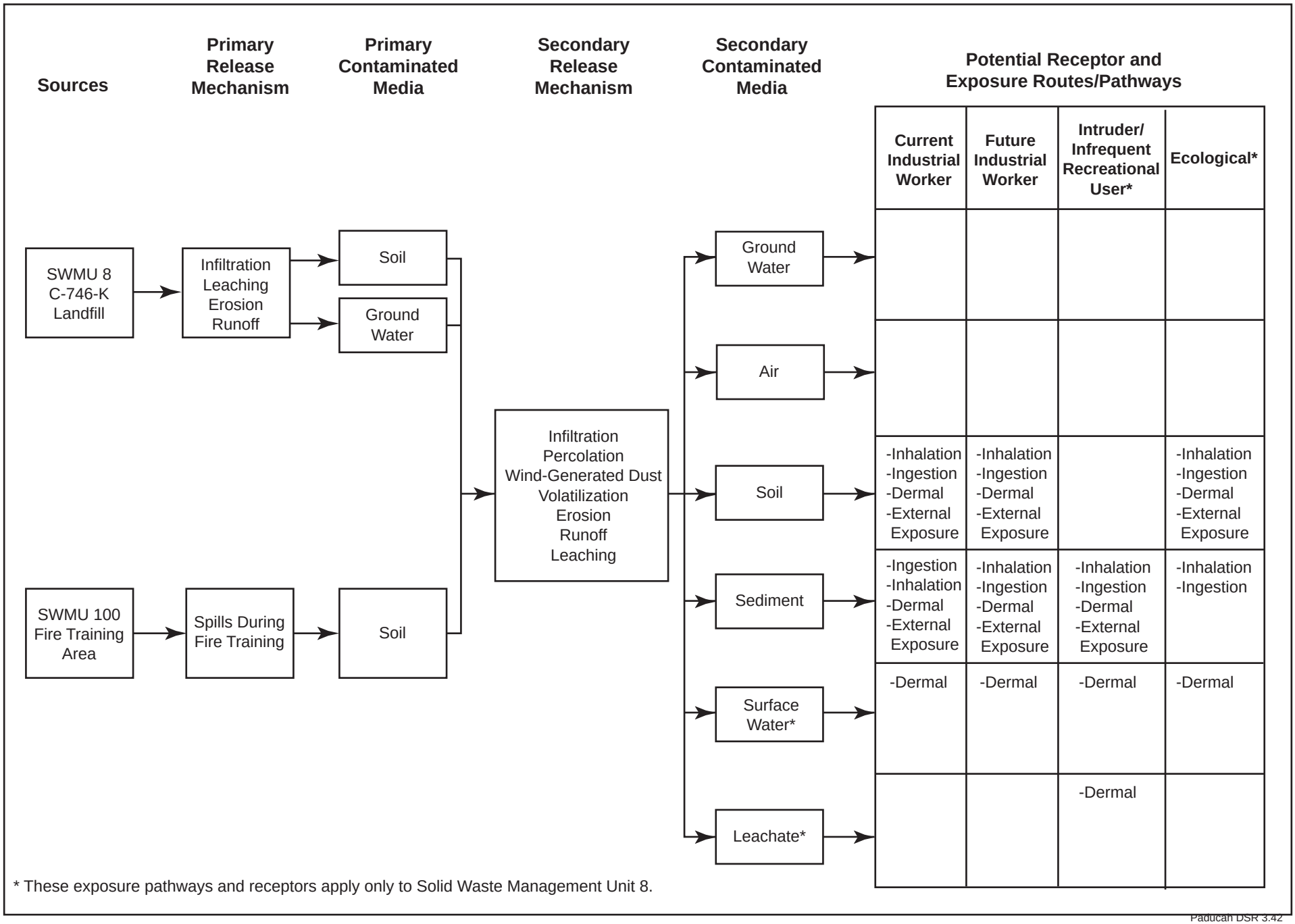

Fig. 3.42. Conceptual Site Model for SWMUs 8 and 100.

tributary south of the landfill indicate that the pH of the leachate ranges from 2.3 to 3.4 prior to mixing with stream water. Where the acidic leachate from the landfill enters the creeks, the pH rises to approximately 6, indicating that the leachate only slightly lowers the stream pH when they mix. The low pH causes dissolved metals, particularly iron and aluminum, to form a precipitate. The precipitation of iron and aluminum oxy-hydroxides is the suspected cause of the orange to yellow staining observed seasonally at various seep sites at the landfill. The staining is most intense during dry periods (late summer to early fall) when stream flow is low. Specific conductance values for the stream samples are also typically higher during the dry season and range up to approximately 2,000 µmhos/cm. The measured hardness for surface-water samples at the landfill varies from 36 to 1,085 mg/L calcium carbonate ($CaCO_3$). The detailed results of the sampling can be found in the RFI/RI for WAGs 1 and 7.

Inorganics

Numerous metals (including aluminum, antimony, beryllium, chromium, cobalt, iron, magnesium, manganese, selenium, thallium, and vanadium) were detected above background levels in soils at the unit. The metals aluminum, beryllium, cobalt, iron, magnesium, manganese, nickel, and zinc also were detected above background levels in all four monitoring wells. (The concentrations of these metals were lower in the upgradient MW302 than in the downgradient wells.) Many metals (aluminum, beryllium, calcium, cobalt, iron, magnesium, manganese, mercury, nickel, sodium, and zinc) also were detected above background levels in the leachate samples, indicating that the landfill likely is one source of the metals. Surface-water samples collected for the RFI/RI contained numerous metals at concentrations above background levels; however, according to the United States Geological Survey report, *Study and Interpretation of the Chemical Characteristics of Natural Water* (USGS 1992), only two, antimony and cadmium, were present at concentrations above those typical of natural waters. The elevated antimony concentration was detected in an upstream surface-water sample and, therefore, likely is not due to the landfill. Cadmium was detected in surface-water sample 08-SW-003, as well as in some leachate samples, at concentrations higher than the expected range for natural waters. This suggests that the landfill is a probable source of the elevated cadmium levels. Although several metals were detected in sediment samples from SWMU 8, the only metal detected above background levels was iron (47.3 mg/kg). The extent of the metals contamination in surface water appears limited to the areas upgradient of sampling location 08-SW-003.

The cause of the acidic pH of the landfill leachate has not been firmly established. A study by the Illinois State Geological Survey indicates that low pH, under some conditions, is due to the presence of high concentrations of sulfate in the fly ash. The pH of the leachate is low enough to cause the dissolution of metals. The source of some of the metals detected at elevated levels in groundwater and leachate samples at the landfill is likely due to the fly ash. However, the elevated levels of iron and manganese also may be a result of the interaction of the acidic pH with the Terrace Gravel deposits, which often have a dark brown coating, or patina, of iron and/or manganese oxides in the PGDP area.

Radionuclides

Low levels of the radionuclides, ^{99}Tc, ^{235}U, ^{234}U, ^{238}U, ^{228}Th, ^{230}Th, ^{232}Th, and ^{237}Np were detected in soils. The radionuclides ^{237}Np, ^{238}Pu, ^{99}Tc, ^{228}Th, ^{232}Th, ^{234}U, ^{235}U, and ^{238}U were detected above background levels in the leachate samples from SWMU 8. The highest activities were detected at a seep on the northern bank of the unnamed tributary, south of the landfill. Surface-water samples from two locations at SWMU 8 contained radionuclides: $^{233/234}U$ (0.45 pCi/L), ^{235}U (0.31 pCi/L), and ^{238}U (0.2 pCi/L) at 08-SW-003 and $^{233/234}U$ (0.32 pCi/L) at 08-SW-005. Very low levels of radionuclides were detected in the downgradient shallow groundwater samples from MWs 300, 301, and 303. (No radionuclides were detected above background levels in the upgradient MW302.) The contaminated rubbish reportedly disposed of in the landfill is a potential source of these contaminants.

Organics

Very low levels of VOCs were detected in the surface and subsurface soil samples at the landfill. Benzene (21 µg/kg) was detected in surface and subsurface soils at soil boring 08-SB-001 at the northeastern edge of the landfill. A possible source of the benzene, as indicated by old photographs, was the bulldozers parked in the area during landfill operations. Additional VOCs, including 1,2-DCE, carbon tetrachloride, and toluene, were detected but at concentrations below the quantitation limit. Numerous PAHs were detected in shallow soils but, with the exception of the PAHs detected in 08-SB-001, the concentrations of the PAHs were less than the quantitation limit. The surface-soil sample at soil boring 08-SB-001 had a total PAH concentration of 9,160 µg/kg. Two PCBs were detected at the landfill: (1) Aroclor-1254, detected from the 1.52 to 3.05 m (5.0 to 10.0 ft) bgs intervals in SB-006 at a concentration of 2,082 µg/kg; and (2) Aroclor-1260, detected in the surface soils at 08-SB-004 at a concentration of 183 µg/kg. Although these appear to be isolated occurrences of PCBs at the landfill, PCBs are still considered potential landfill contaminants.

The VOCs TCE (27 µg/L); 1,1-DCA (23 µg/L); 1,1-DCE (18 µg/L); and 1,2-DCE (330 µg/L) were detected in MW300 during RFI/RI sampling activities. Two of these VOCs (1,1-DCA and 1,2-DCE) also were detected in MW301. Additional sampling of MWs 300 through 303 was conducted in March 1995 and results indicated the presence of *cis*-1,2-DCE (790 µg/L); 1,1-DCE (72 µg/L); 1,1-DCA (61 µg/L); and TCE (52 µg/L). Two of the leachate samples contained the organic compounds TCE; 1,2-DCA; xylene; 1,1-DCE; and 1,2-DCE. No organic compounds were detected in the sediment samples or surface-water samples collected during the RFI/RI at the unit. However, one organic [*cis*-1,2-DCE (9 µg/L)] has been detected in a surface-water sample collected from PGDP stream sampling point C-746-K-3A, located southeast of the landfill within the unnamed tributary. The presence of VOCs in the groundwater and leachate samples indicate they likely are leaching from the landfill.

Contaminant Fate and Transport

Probable release mechanisms and exposure pathways at the C-746-K landfill include groundwater contamination by leaching of contaminants in subsurface soil and surface-water runoff transporting contaminants and contaminated sediments off-site. The Summers Model was applied to several COPCs as identified by the WAGs 1 and 7 RI to simulate subsurface migration of contaminants from the soil matrix (i.e., landfill leachate). A summary of Summers Modeling results for the C-746-K Landfill is provided in Table 3.50.

Summary of Previous Remedial Actions

PGDP personnel discovered leachate in a ditch on the southwest side of the landfill January 30, 1992. The leachate was acidic (pH from 2.3 to 5.5), orange to yellow in color, and was found to contain various volatiles and metals. Immediately upon discovering the seeps, PGDP personnel installed a sandbag dam with a hypalon liner to prevent any further release of solids to the unnamed tributary. Additional seeps have since been observed. Corrective measures taken to address seeps include the installation of a sheet metal dam upstream of the seeps, the installation of a solid precipitate filter in the drainage ditch, and the addition of cap material (and recontouring of the soil cover material) to repair subsidence of the existing landfill cap.

A CERCLA ROD, approved by EPA and KDEP (KDEP 1998), outlined remedial actions to be taken at SWMU 8. Remedial actions consisted of placement of riprap along the landfill bank of the unnamed tributary to limit exposure to the low pH leachate; riprap was also installed along a portion of the Bayou Creek bank to mitigate erosion. Signs warning of potential health hazards posed by the site were posted in locations visible from all access points to the landfill. Deed restrictions were invoked to

Table 3.50. Summary of Summers Modeling Results for the C-746-K Landfill (SWMU 8)

Constituent	Cs (95UCL) (mg/kg)	K_d (sandy soil) (L/kg)	K_d (clayey soil) (L/kg)	Cp (sandy soil) (µg/L)	Cp (clayey soil) (µg/L)
Antimony	2.22	45	250	4.93E+01	8.88E+00
Barium	76.1	60	60	1.27E+03	1.27E+03
Beryllium	0.747	250	1,300	2.99E+00	5.75E-01
Cadmium	0.381	40	560	9.53E+00	6.80E-01
Manganese	501	50	180	1.00E+04	2.78E+03
Nickel	9.62	300	650	3.21E+01	1.48E+01
1,2-Dichloroethene	6.68E-03	0.01	0.059	6.68E+02	1.13E+02
Aroclor-1254	0.13	80	400	1.63E+00	3.25E-01
Aroclor-1260	2.8E-02	400	2,000	7.08E-02	1.42E-02
Benzo(a)pyrene	0.259	1,100	5,500	2.35E-01	4.71E-02
Neptunium-237	1.82E-03	5	55	3.64E-01	3.31E-02
Plutonium-239	8.69E-05	550	5,100	1.58E-04	1.70E-05
Technetium-99	5.57E-04	0.1	1	5.57E+00	5.75E-01
Thorium-230	2.16E-02	3,200	5,800	6.75E-03	3.72E-03
Thorium-232	15	3,200	5,800	4.69E+00	2.59E+00
Uranium (total)	44.5	15	1,600	2.97E+03	2.78E+01

For organic compounds, K_d values were calculated using f_{oc} values of 0.0002 and 0.001 for sand and clay, respectively.

prohibit intrusive activities at the landfill site. Figure 3.43 depicts the locations of remedial activities at the SWMU 8 site.

Also, as part of the remedial action, a new monitoring well (MW344) was installed in the northeastern portion of the landfill site and screened in the Terrace Gravel. This well replaced the Terrace Gravel/ Porters Creek Clay monitoring well (MW303).

3.2.7.2 3.2.7.2 SWMU 100 — Fire Training Area

Location

The FTA is located within the plant security fence in the southwest corner of the PGDP, immediately west of Fourth Street in the vicinity of the C-206 Pumper Drafting Pit (Fig. 3.44). The FTA covers about 37 m^2 (400 ft^2) and consists of the following features, listed in order from north to south:

- One large rectangular surface burn area, approximately 14 × 23 m (45 × 75 ft);
- One circular burn pan area, approximately 6 m (20 ft) in diameter;
- One circular electric pump area, approximately 8 m (25 ft) in diameter;
- One circular burn area, approximately 10.7 m (35 ft) in diameter;
- An elevated and bermed fuel tank area, approximately 6.1 m (20 ft) in diameter; and
- Two square burn area depressions, each approximately 6.1 × 6.1 m (20 × 20 ft).

Setting

The following subheadings provide information on the setting of SWMU 100, including geology/ hydrogeology, surface features and surface-water hydrology, transportation, floodplains, wetlands, soils and prime farmland, biological resources, and cultural resources.

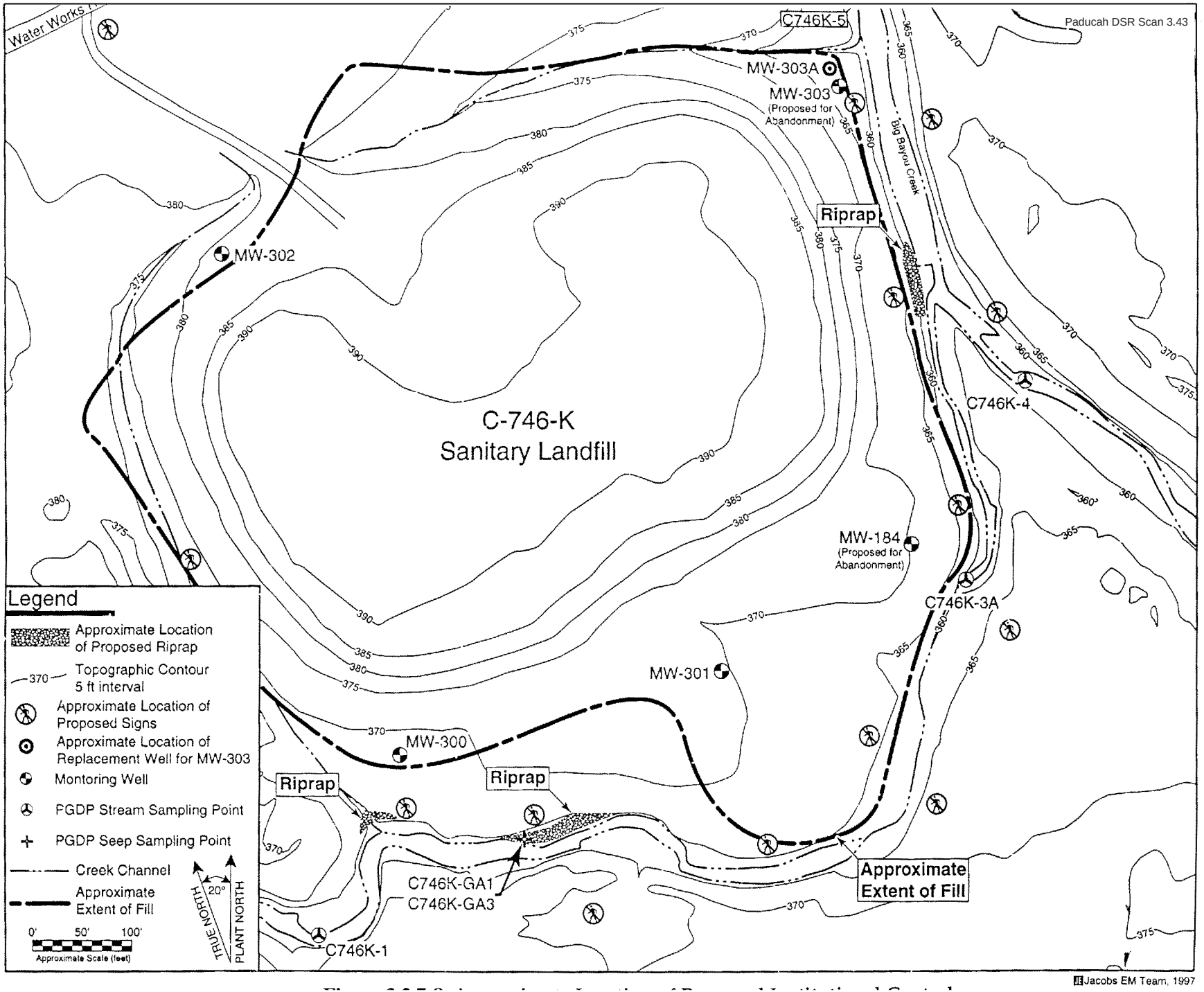

Fig. 3.43. Location of ROD remedial actions at the C-746-K Landfill (SWMU 8)

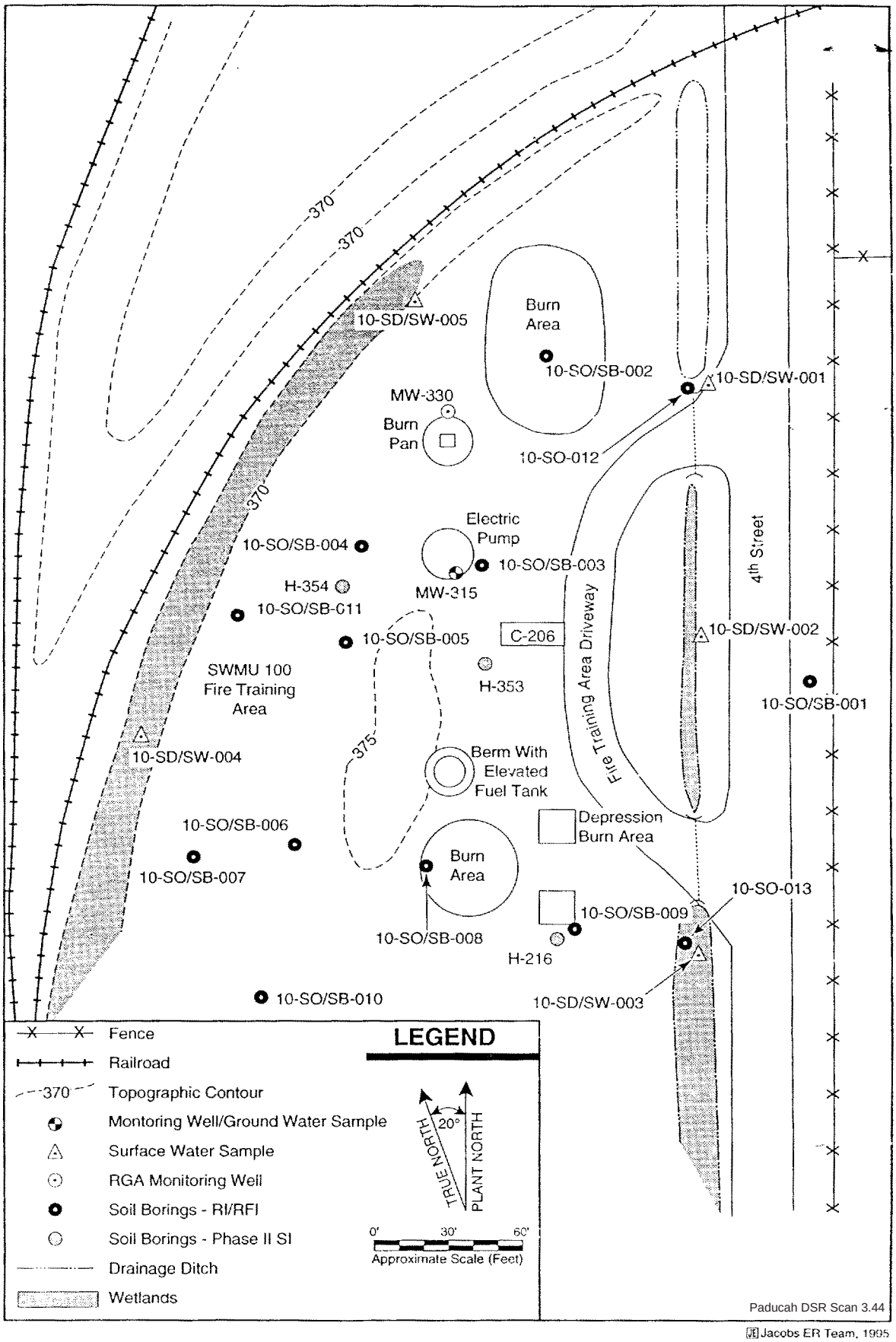

Fig. 3.44. Location of the Fire Training Area (SWMU 100).

Geology/Hydrogeology

Two shallow soil borings (H353 and H354) and one 12.2-m (40-ft) deep soil boring (H216) were drilled at the FTA for the Phase II SI. (CH2M HILL 1992). For the RFI/RI, 11 soil borings and two groundwater monitoring wells were installed. The locations of all borings and monitoring wells at SWMU 100 are shown in Fig. 3.44. The following lithologies were encountered beneath the unit, in order of increasing depth.

- Fill material, composed of silty clay and sand with minor amounts of black ash and gravel, was found at the surface in several borings.

- Loess deposits were encountered in all borings and monitoring wells at SWMU 100. They ranged in thickness from about 3 to 5 m (10 to 18 ft).

- Upper Continental Deposits were encountered in all borings and monitoring wells at the unit, but were fully penetrated in MW330 only. The uppermost water-bearing unit at this SWMU consists of about 8 m (25 ft) of well-sorted sand and gravelly sand. There is a clay aquitard at the base of the Upper Continental Deposits that is 2.9 m (9.5 ft) thick and occurs between approximately 17 to 19 m (54 to 63.5 ft) bgs [98 to 95 m (320.5 to 311 ft) amsl].

- Lower Continental Deposits are present beneath the unit and were encountered at depths between 19 and 31 m (63.5 and 103 ft) bgs in MW330. They consist of 1-m (4-ft) thick sand facies overlying 11 m (35.5 ft) of sandy, pebble- to cobble-sized chert gravel (RGA).

- Porters Creek Clay may occur beneath this unit. Although SWMU 100 is located north of the Porters Creek Clay Terrace, it may overlie the extreme northern edge of the terrace slope where a thin layer of the clay is present (Fig. 3.45). According to the sample log for MW330, a stiffer formation (possibly the Porters Creek Clay) was encountered at a depth of 31 m (103 ft) bgs, but no lithologic sample could be obtained.

- The McNairy Formation was not penetrated by any of the soil borings and monitoring wells at this unit, but it was encountered at a depth of 34 m (110 ft) [80 m (261 ft) amsl], in a soil boring (H208) located approximately 152 m (500 ft) northwest of the unit.

According to water level measurements taken July 15, 1994, in UCRS MW315, the depth of shallow groundwater at SWMU 100 is 2.45 m (8.04 ft) bgs [111.9 m (367.22 ft) amsl]. The depth to water in MW330, which is screened in the RGA, was approximately 12.8 m (42.1 ft) bgs [101.3 m (332.3 ft) amsl]. A geological cross section of SWMU 100 is provided as Fig. 3.45.

Surface features and surface-water hydrology. The ground surface at SWMU 100 is relatively flat, ranging in elevation from approximately 113 to 114 m (370 to 375 ft) amsl. Most of the ground surface is grass-covered, with the exception of the eastern part of the unit occupied by Fourth Street and the driveway. There are two drainage ditches at the site, a north-northeastern flowing drainage ditch located next to the railroad tracks at the western edge of the unit, and a north flowing drainage ditch on the eastern edge of the unit adjacent to Fourth Street. Runoff from the site flows to the ditches and discharges via KPDES Outfall 016 to the nearest surface water, Bayou Creek (DOE 1993a). Bayou Creek is located approximately 305 m (1,000 ft) to the west.

Transportation. Transportation in the vicinity of SWMU 100 consists of PGDP personnel performing day-to-day activities and is confined to paved or gravel roads.

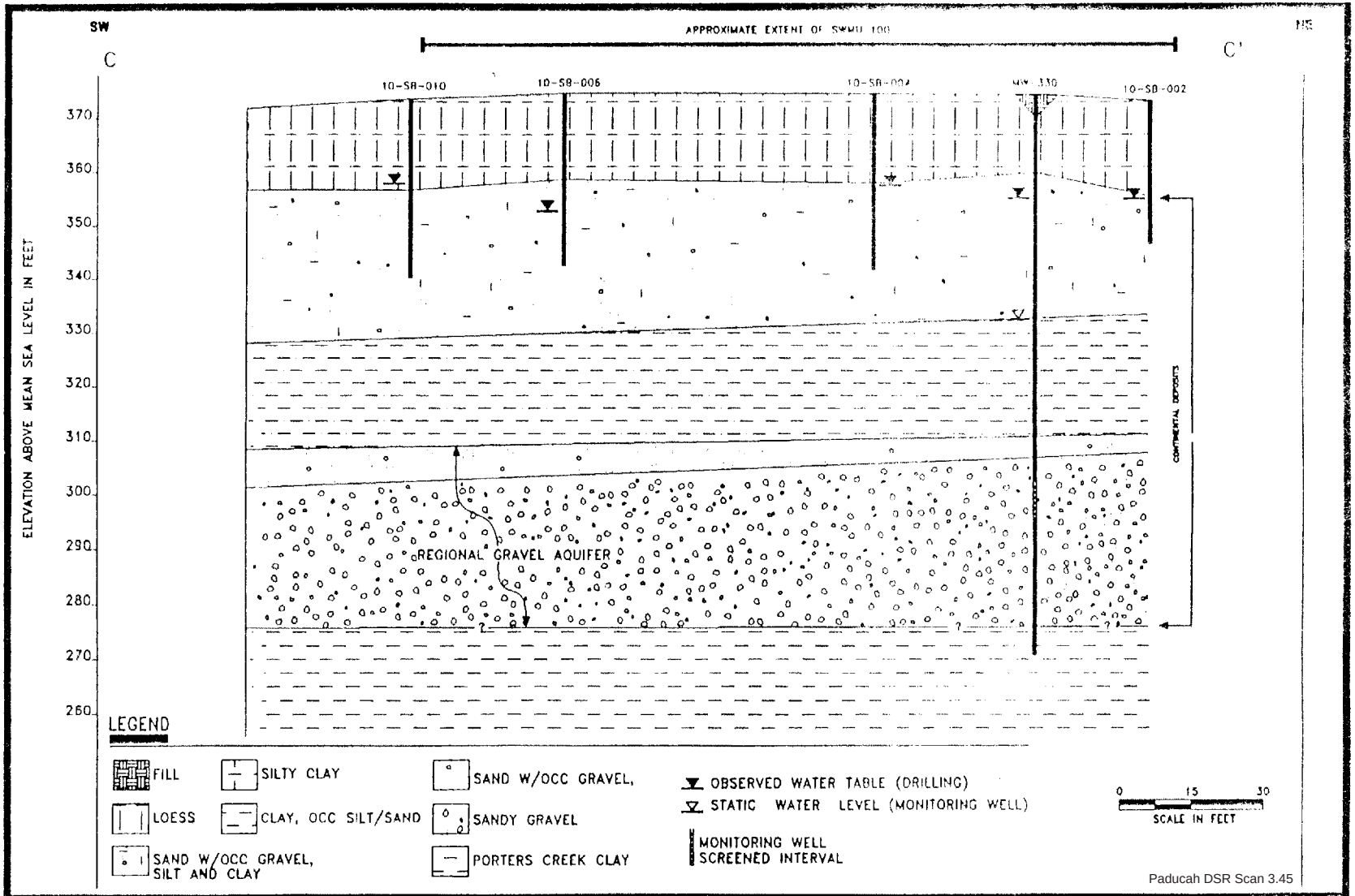

Fig. 3.45. Geologic cross section of the Fire Training Area (SWMU 100).

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PADUCAH, KENTUCKY

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Wetlands. Wetlands have been identified in drainage areas adjacent to SWMU 100 (CDM Federal 1994). These drainage areas run north and south, parallel to Fourth Street, east of SWMU 100 and the railroad tracks which are to the west of SWMU 100 (Fig. 3.44).

Floodplains. No 100-year floodplains are adjacent to SWMU 100.

Soils and prime farmland. Historically, soils within the impacted area of SWMU 100 are Calloway silt loam, 0% to 2% slope; Grenada silt loam, 6% to 12% slopes; and Fallaya-Collins silt loam. However, the soils associated with these areas have been disturbed by past activities, decreasing the likelihood that any of these areas are prime farmland.

Biological resources. Vegetation inside the fence is mown grass providing very little to no wildlife habitat. No potential habitats for federally listed or proposed for listing T&E species are present within the fence (CDM Federal 1994).

Cultural resources. Due to previous disturbance and a lack of notable structural features, it is unlikely any important cultural resources are present in the vicinity of this SWMU.

Manufacturing/TSD Processes

The PGDP has used the FTA since 1982 for fire training exercises with flammable liquids. Materials burned at the FTA include waste oils, fuels, and other combustible liquids; no records of solvents being burned are available. The burn areas are unlined and were not bermed. Combustible liquids no longer were burned in these unlined areas after 1987. The FTA still is used for fire training exercises but the use of a fire training tower prevents any impacts to soil or surface water at the site.

Summary of Previous Investigations

Site investigations/remedial investigations. As part of the sitewide PGDP Phase I investigation, soil gas samples were from the Fire Training Area in June–July 1990 (DOE 1996e). The purpose of the soil gas sampling was to assess the presence of VOCs in potential release sites. Soil gas samples were analyzed for select VOCs. Results indicated non-detectable concentrations for the select VOC compound list from the sample location.

Both surface and subsurface soils were sampled during the sitewide PGDP Phase II RI. Eight samples were collected from one boring location within the SWMU boundary; total boring depth was 12 m (40 ft) bgs. The purpose of the sampling event was to determine if the unit was a source of off-site contamination. Detectable levels of SVOCs, PAHs, and lead were present in samples collected from the boring (DOE 1996e).

In 1994, the DOE conducted an RFI for the SWMUs in WAGs 1 and 7 and nearby KOW facility (SWMUs 94, 95, and 157) to determine the nature and extent of contamination (DOE 1996e and 1996f). As part of this investigation, 11 soil borings were conducted within the SWMU boundary; total depths of borings ranged from 6 m (20 ft) bgs to 33 m (108 ft) bgs. Two monitoring wells (MWs 315 and 330) were installed, developed, and sampled at the SWMU during RI activities. MW315 was completed in the UCRS, with MW330 completed in the RGA. In addition to soil borings and monitoring well installation, four surface-water and four sediment samples were collected from the drainage pathways from SWMU 100 to evaluate the impact that the unit had on the surrounding surface water and sediment.

Additional data sources. Groundwater elevation data currently are conducted on an annual basis from the two wells at the site (MWs 315 and 330). Groundwater sampling and analysis for chemical compounds currently is not being conducted at this site (BJC 1998a).

Conceptual Site Model

The source at SWMU 100 consists of waste oils, fuels, and other combustible liquids, which were burned at the FTA. The source is in the soil since the burn areas are unlined and not bermed. Soil is the primary contaminated medium at SWMU 100. The soil at SWMU 100 is primarily contaminated with metals, and aluminum, arsenic, barium, beryllium, cadmium, iron, manganese, and vanadium are considered to represent the probable contaminants at this unit.

Probable pathways from sources to receptors are demonstrated in Fig. 3.46. At SWMU 100, contamination from the source has migrated to soil, the primary contaminated medium, from spills during fire training. From soil, contaminants could migrate into groundwater, air, soil, sediment, and surface water, all secondary contaminated media and probable release mechanisms, via infiltration, percolation, wind-generated dust, volatilization, erosion, and runoff. As illustrated in the RI report (DOE 1996e), since SWMU 100 has a flat topography, the potential for surface-water erosion and runoff is low. Air is included in the model to identify it as a secondary contaminated medium; however, there are no receptors of exposure pathways identified since this unit is outside and the likelihood of exposure to contamination via the air pathway outside is minimal.

Potential current exposure to contaminated sources or primary media at these units is limited since SWMU 100 is vegetated. However, direct exposure to soil or sediment may occur for current and future workers at SWMU 100 via soil or sediment ingestion, dermal absorption, inhalation of particulate dust, and external exposure to ionizing radiation.

Nature and Extent of Contamination

Low levels of contamination were found in soil, sediment, surface-water, and groundwater samples collected at SWMU 100. Organic compounds detected at this unit include VOCs (toluene, xylene, and benzene) and PAHs commonly associated with waste oils and diesel fuels. They were detected at low concentrations in soil samples down to a depth of 4.6 m (15 ft) bgs. However, no organic compounds were detected in groundwater, surface-water, or sediment samples indicating that these media are not impacted by organic contaminants migrating from SWMU 100. Twelve metals (aluminum, barium, cadmium, chromium, copper, iron, lead, magnesium, manganese, nickel, vanadium, and zinc) were detected at elevated concentrations in groundwater, surface-water, and sediment samples from the unit. Of these 12 metals, only three (barium, manganese, and vanadium) also were detected above background levels in surface and subsurface soils at the unit. This limited occurrence of metals in the soils at the unit indicates that SWMU 100 likely is not a significant source of metals contamination.

Radionuclides (^{99}Tc, uranium, and thorium) were detected in soil, sediment, surface-water, and groundwater samples from SWMU 100. Their widespread occurrence and low activities indicate their presence likely is related to plant activities rather than past activities at this SWMU.

The areal extent of impacted soils at SWMU 100 has been estimated as approximately 720 m^2 (7,750 ft^2) according to the WAGs 1 and 7 FS (DOE 1996d). The horizontal extent of organic and inorganic contamination in soils is restricted to depths above 4.6 m (15 ft) and 7.6 m (25 ft) bgs, respectively. The limited extent and low concentrations of organics and metals contamination at this unit may represent residual contamination from the waste oils or fuels burned at the unit.

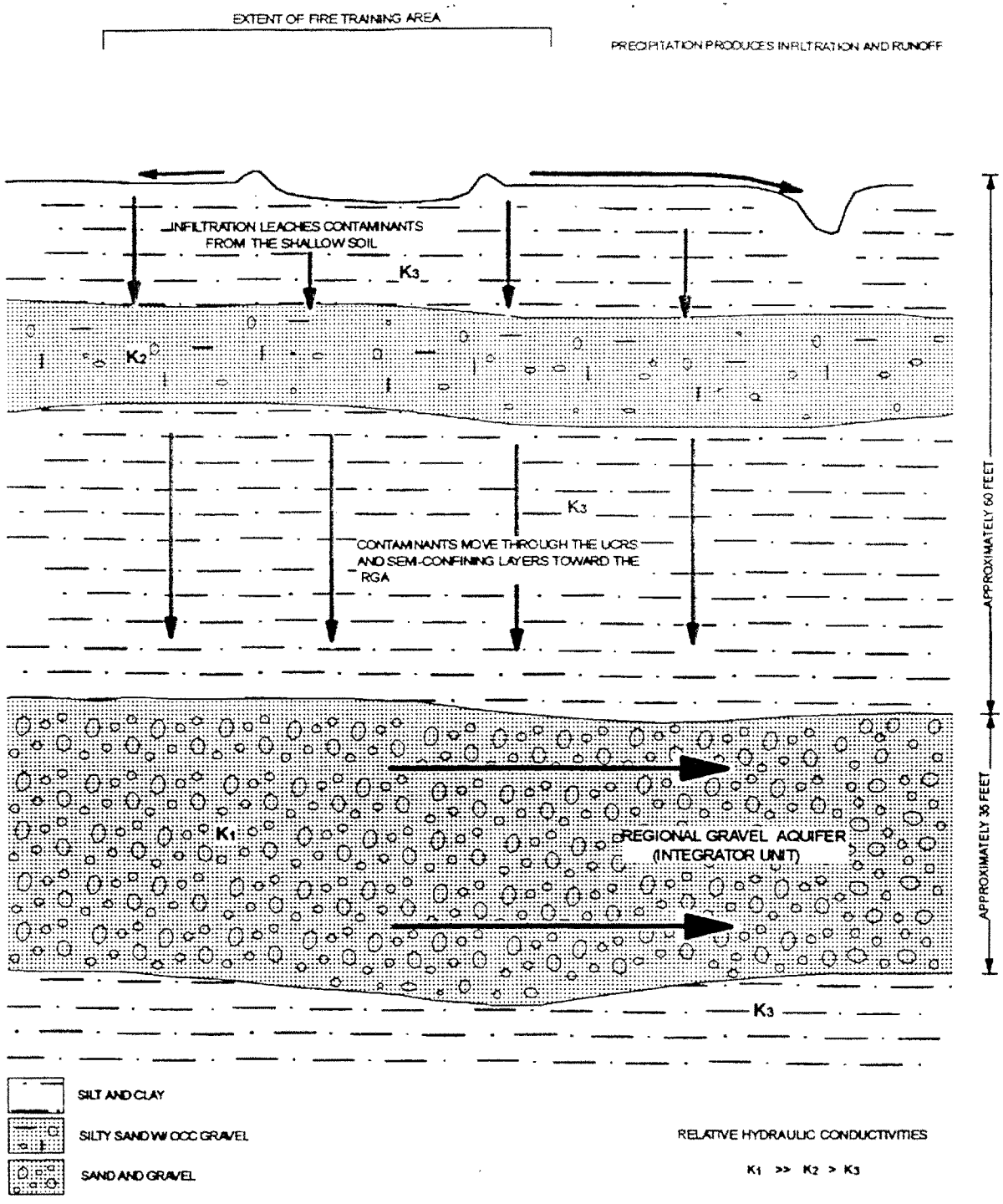

Fig. 3.46. Conceptual site model for the Fire Training Area (SWMU 100).

Contaminant Fate and Transport

Probable release mechanisms and exposure pathways at the FTA include groundwater contamination by leaching of contaminants in subsurface soil, and surface-water runoff transporting contaminants and contaminated sediments off-site (DOE 1996d). The Summers Model was applied to several COPCs as identified by the WAGs 1 and 7 RI to simulate subsurface migration of contaminants from the soil matrix (i.e., landfill leachate). A summary of Summers Modeling results for the FTA is provided in Table 3.51.

Table 3.51. Summary of Summers Modeling Results for the Fire Training Area (SWMU 100)

Constituent	Cs (95UCL) (mg/kg)	K_d (sandy soil) (L/kg)	K_d (clayey soil) (L/kg)	Cp (sandy soil) (µg/L)	Cp (clayey soil) (µg/L)
Barium	105	60	60	1,750	1,750
Manganese	5.36E+02	50	180	1.07E+04	2.98E+03
Neptunium-237	2.36E-04	5	55	4.72E-02	4.29E-03
Plutonium-238	1.76E-09	550	5,100	3.20E-09	3.45E-10
Plutonium-240	1.23E-07	550	5,100	2.24E-07	2.41E-08
Technetium-99	3.78E-05	0.1	1	3.78E-01	3.78E-02
Thorium-228	1.61E-09	3,200	5,800	5.03E-10	2.78E-10
Thorium-230	6.75E-05	3,200	5,800	2.11E-05	1.16E-05
Thorium-232	1.24E+01	3,200	5,800	3.88E+00	2.14E+00
Uranium (total)	3.16E+00	15	1,600	2.11E+02	1.98E+00

For organic compounds, K_d values were calculated using f_{oc} values of 0.0002 and 0.001 for sand and clay, respectively.

Summary of Previous Remedial Actions

No previous remedial actions have occurred at this site.

3.2.7.3 SWMU 136 — TCE Spill Site

Location

The TCE Spill Site is a small rectangular area, approximately 5 × 2 m (15 × 6 ft), located in the southwest corner of the PGDP within the plant security fence. It is situated at the northwest corner of a concrete pad at the northeastern edge of the C-740 Material Yard (Fig. 3.47).

Setting

The following subheadings provide information on the setting of SWMU 136, including geology/ hydrogeology, surface features and surface-water hydrology, transportation, floodplains, wetlands, soils and prime farmland, biological resources, and cultural resources.

Geology/Hydrogeology

Five soil borings and three monitoring wells were drilled at SWMU 136 (Fig. 3.47). The following lithologies were encountered beneath the unit, in order of increasing depth:

- Fill material, composed of chert gravel and sand, was found over the entire site at depths up to 0.8 m (2.5 ft) bgs.

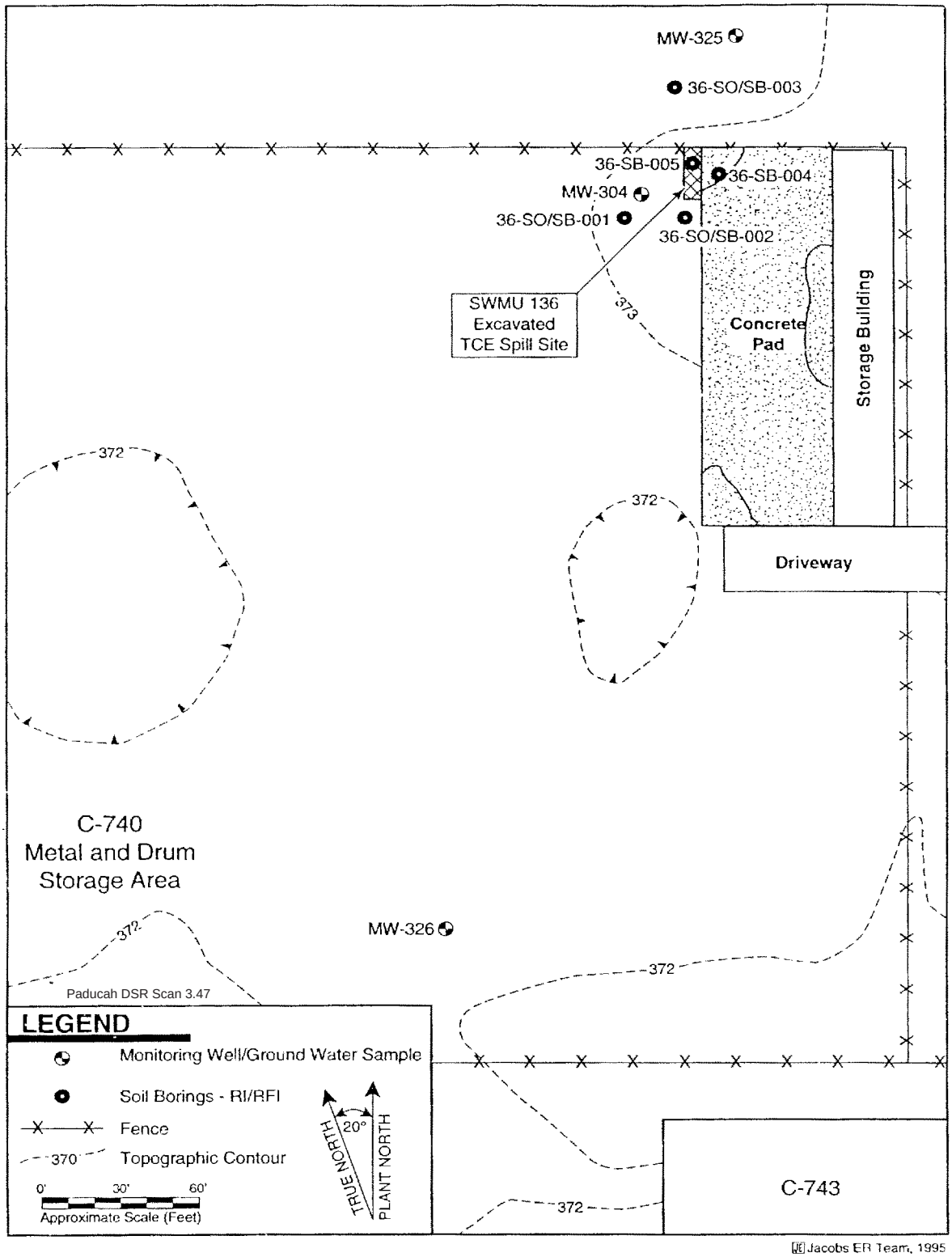

Fig. 3.47. Location of TCE Spill Site (SWMU 136).

- Loess deposits are present in all soil borings and monitoring wells at the site and range in thickness from 3.5 to 4.8 m (11.5 to 15.7 ft).

- Upper Continental Deposits, consisting of up to 15 m (50 ft) of interbedded gravel, sand, clay, and silt, are present between 4 to 20 m (13.5 to 65 ft) bgs. An 8-m (25-ft) thick aquitard, consisting of clay interbedded with thin silt and sand lenses, was encountered at the base of the Upper Continental Deposits in MWs 325 and 326.

- Lower Continental Deposits are present beneath the unit at depths between 20 to 27 m (65 and 90 ft) bgs. None of the borings or monitoring wells at SWMU 136 penetrated the full thickness of the RGA.

SWMU 136 is located north of the Porters Creek Clay Terrace where the Porters Creek Clay is absent. None of the soil borings or monitoring wells at this unit were drilled to the McNairy Formation. Figure 3.48 provides a geologic cross section of this SWMU.

According to water level measurements taken July 15, 1994, the depth to the UCRS piezometric surface at SWMU 136 is approximately 1 m (3.29 ft) bgs at MW304. This well was screened from approximately 5 to 8 m (16 to 26 ft) bgs. The depth to water in the two upper RGA wells (MWs 325 and 326) was approximately 12.5 m (41 ft) bgs, or 101 m (332 ft) amsl.

Surface features and surface-water hydrology. The ground surface at SWMU 136 is fairly level and ranges in elevation from approximately 113 to 114 m (371 to 374 ft) amsl. The TCE Spill Site is situated on the western edge of the northwest corner of the concrete pad. A 53-cm (21-in.) thick layer of compacted gravel covers the ground surface west and south of the pad, and the shallow depression created by excavation of the gravel area adjacent to the pad is covered by plastic sheeting. There are a few cracks present in the concrete pad in the area where the spill occurred. Two shallow depressions are located to the south and southwest in the C-740 Material Yard. No surface water is present at the site. The nearest surface-water body is Bayou Creek, located approximately 457 m (1,500 ft) southwest of the unit. Runoff from SWMU 136 discharges to Bayou Creek via KPDES Outfall 008.

Transportation. Transportation in the vicinity of SWMU 136 consists of PGDP personnel performing day-to-day activities and is confined to paved or gravel roads.

Wetlands. No wetlands have been identified in the vicinity of SWMU 136 (CDM Federal 1994).

Floodplains. No 100-year floodplains are adjacent to SWMU 136.

Soils and prime farmland. Historically, soils within the impacted area of SWMU 136 are Calloway silt loam, 0% to 2% slope; Grenada silt loam, 6% to 12% slopes; and Fallaya-Collins silt loam. However, the soils associated with these areas have been disturbed by past activities decreasing the likelihood that any of these areas are prime farmland.

Biological resources. Vegetation inside the fence is mown grass providing very little to no wildlife habitat. No potential habitats for federally listed or proposed for listing T&E species are present within the fence (CDM Federal 1994).

Cultural resources. Due to previous disturbance and a lack of notable structural features, it is unlikely any important cultural resources are present in the vicinity of this SWMU.

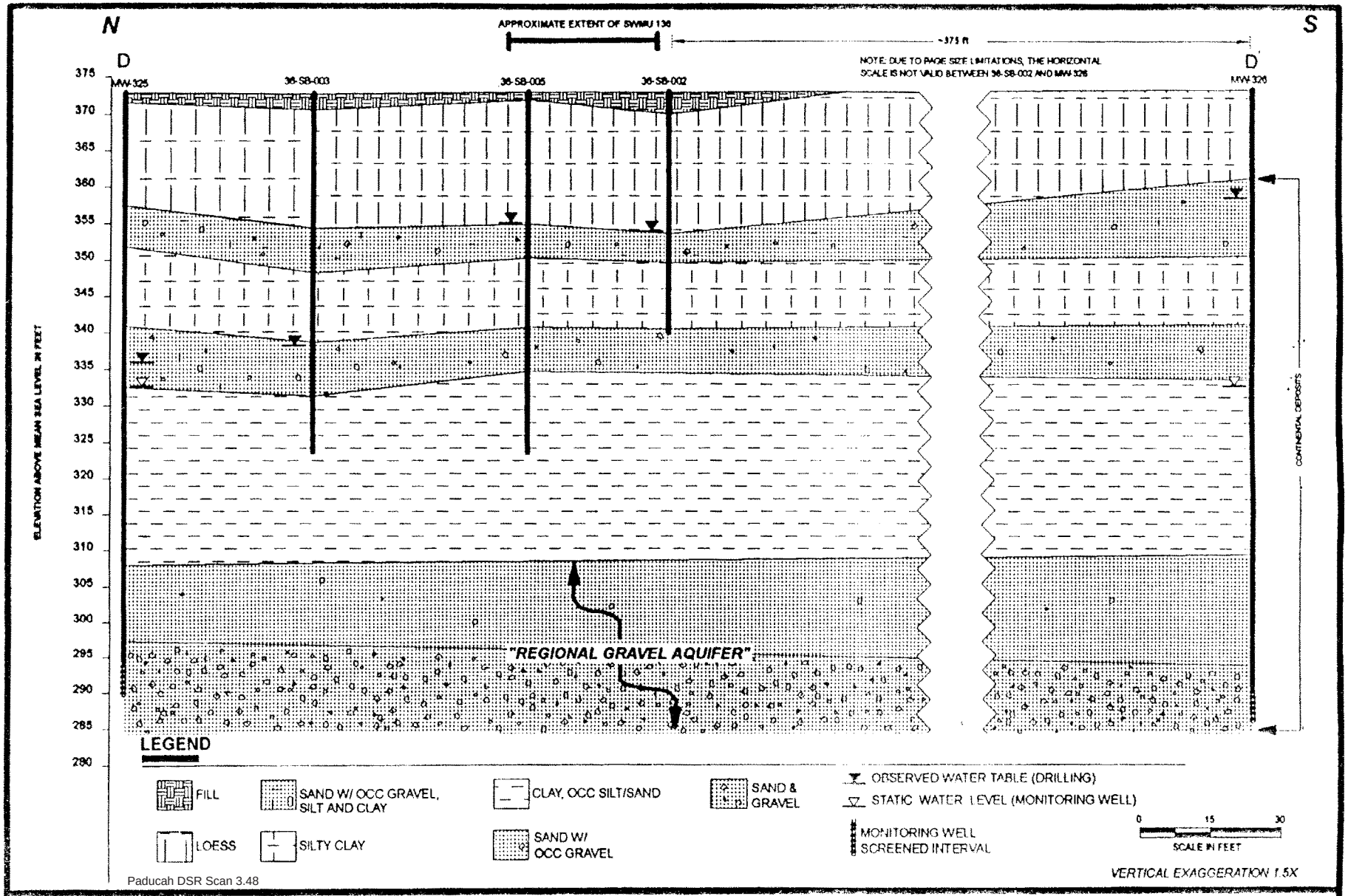

Fig. 3.48. Geological cross section of the TCE Spill Site (SWMU 136).

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Manufacturing/TSD Processes

The C-740 Material Yard is an active storage yard that has been used since the early 1970s for storing various scrap metal and drums. In May 1990, a 55-gal drum stored on the concrete pad was found to have leaked TCE onto the pad and into the adjacent gravel and soil.

Summary of Previous Investigations

Site investigations/remedial investigations. In 1994, the DOE conducted an RFI for the SWMUs in WAGs 1 and 7 and nearby KOW facility (SWMUs 94, 95, and 157) to determine the nature and extent of contamination (DOE 1996e and 1996f). As part of this investigation, five soil borings and three monitoring wells were drilled at SWMU 136; total depths of the borings ranged from 8 to 27 m (26.5 ft to 90 ft) bgs. Two groundwater monitoring wells were installed, developed, and sampled at the SWMU during the RI activities. MWs 325 and 326 are screened within the RGA.

Additional data sources. Groundwater elevation data are currently conducted on a monthly basis for MW325, and on an annual basis from MW326. Groundwater sampling and analysis for chemical compounds currently is not being conducted at this site (BJC 1998a).

Conceptual Site Model

The TCE Spill Site may have residual TCE remaining in the soil. The potentially contaminated soil may have leached contaminants to groundwater. There is no surface water or sediment at the site. Probable pathways from sources to receptors are depicted in Fig. 3.49.

The only current exposure is to the industrial worker. A current worker at the TCE Spill Site could be exposed to soil by inhalation of volatiles and particulates, ingestion, dermal contact, or external exposure. These are the exposure routes that are quantitatively evaluated for current industrial workers. Potential future receptors at the TCE Spill Site are an industrial worker, excavation worker, rural resident, and recreational user. A future worker at the TCE Spill Site could be exposed to soil and groundwater. Ingestion of soil and groundwater, dermal contact with soil and groundwater, inhalation of volatiles and particulates emitted from the soil, inhalation of volatiles in groundwater, and external exposure to soil are exposure routes that are viable exposure pathways for a future worker.

A future excavation worker at the TCE Spill Site could be exposed to soil by ingestion, dermal contact, inhalation, or external exposure. These are the viable exposure pathways for a future excavation worker.

A future resident living at the TCE Spill Site could be exposed to soil, vegetables, and groundwater. Ingestion of soil, vegetables, and groundwater; dermal contact with soil and groundwater; inhalation of soil and groundwater; and external exposure to soil are viable exposure routes for a future resident. Inhalation of contaminants in soil is considered a likely exposure route because a garden with exposed soil is assumed to be present.

The TCE Spill Site is very small and does not contain sediment or surface water. Therefore the only recreational pathway considered viable is the consumption of venison (DOE 1996e).

Nature and Extent of Contamination

Results of the RI conducted at SWMU 136, the TCE Spill Site, indicate that several organic contaminants are present above background levels in soil and groundwater at the unit. Soil samples from SWMU 136

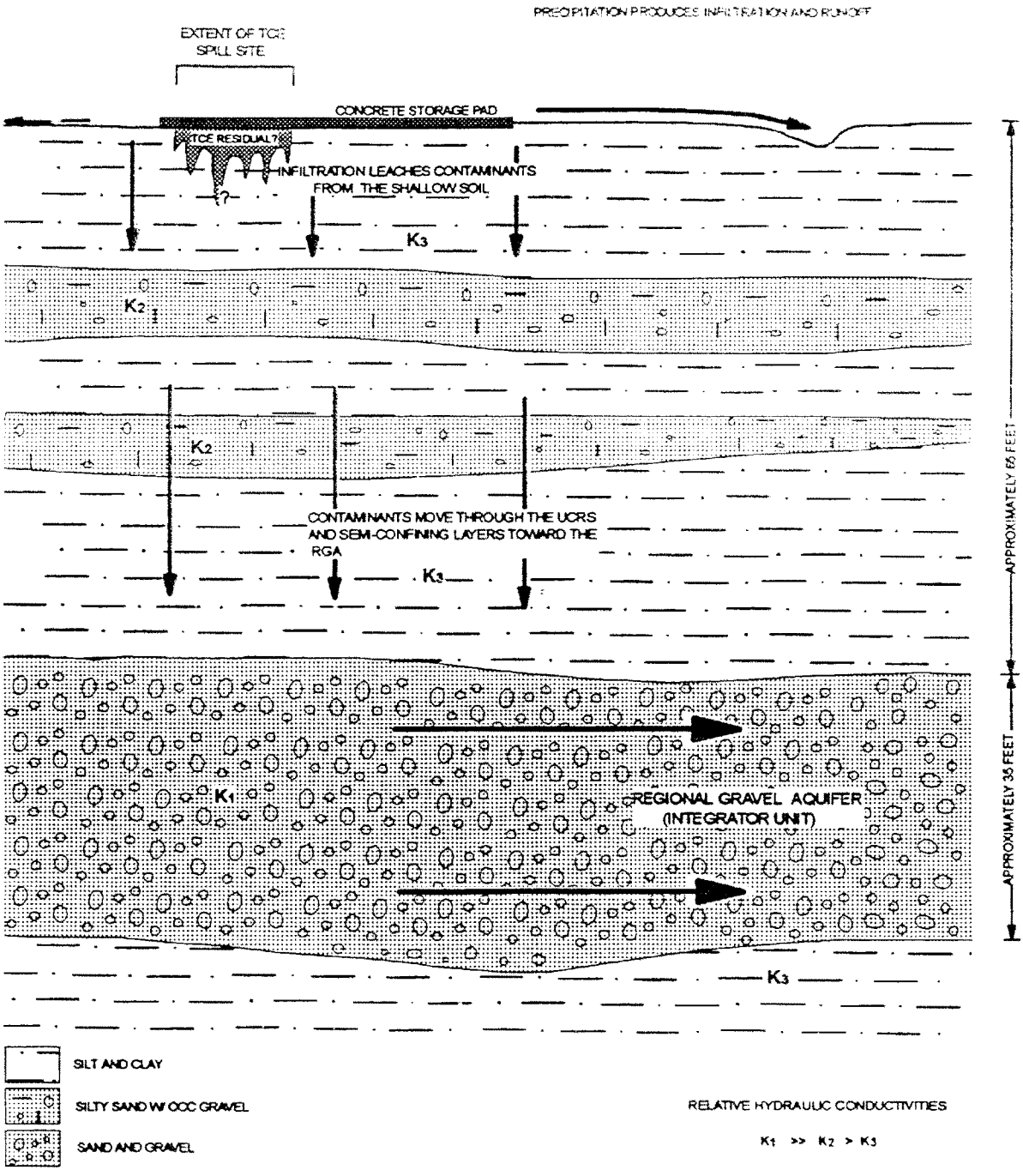

Fig. 3.49. Conceptual site model for the TCE Spill Site (SWMU 136).

PADUCAH GASEOUS DIFFUSION PLANT
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were found to contain low levels of VOCs (TCE, 1,1-DCE, 1,1,1-TCA, and 1,2-DCA) and several PAHs. Groundwater samples at the unit also contained organic contaminants. The maximum concentration of TCE in groundwater was detected in a UCRS hydraulic probe sample collected from soil boring 36-SB-004 at 442 µg/L. The highest TCE concentration observed in the RGA wells at the unit (110 µg/L) was detected in a sample from a downgradient well (MW325). Another organic compound detected in the groundwater samples was 1,1,1-TCA (4,472 µg/L), which was detected in a UCRS temporary well sample, but was not detected at concentrations above 5 µg/L in samples from the adjacent UCRS monitoring well (MW304).

Soil and groundwater samples were also found to contain metals and radionuclides at levels above background. Four metals [antimony (1.7 mg/kg), chromium (29 mg/kg), barium (439 mg/kg), and mercury (3.2 mg/kg)] were detected above background concentrations in soils at the unit. Several metals were detected above background levels in groundwater. Samples from UCRS MW304 contained iron, manganese, silver, zinc, sodium, and aluminum above background concentrations. Groundwater samples collected from the RGA wells contained barium, manganese, and zinc above background levels. The radionuclide ^{99}Tc was found above background values in the samples collected from all three monitoring wells at the unit. The levels of ^{99}Tc ranged from 1.27 to 12.21 pCi/L.

The observed contamination in soil and groundwater at the unit indicates that the spill site is a likely source of organic contamination. TCE and other chlorinated hydrocarbons have migrated below the water table at the unit into the UCRS and the RGA, leaving residual contamination in the surface and subsurface soils at the unit. However, the low concentrations of TCE detected in groundwater samples at the unit do not indicate the presence of DNAPL. The areal extent of the organic and metals contamination at the unit has been estimated as approximately 17.7 m^2 (190 ft^2) according to the WAGs 1 and 7 FS (DOE 1996d).

Contaminant Fate and Transport

Probable release mechanisms and exposure pathways at the TCE Spill Site include groundwater contamination by leaching of contaminants in subsurface soil, and surface-water runoff transporting contaminants and contaminated sediments off-site (DOE 1996e). The Summers Model was applied to several COPCs as identified by the WAGs 1 and 7 RI to simulate subsurface migration of contaminants from the soil matrix (i.e., landfill leachate). A summary of Summers Modeling results for the TCE Spill Site are provided in Table 3.52.

Table 3.52. Summary of Summers Modeling results for the TCE Spill Site (SWMU 136)

Constituent	Cs (95UCL) (mg/kg)	K_d (sandy soil) (L/kg)	K_d (clayey soil) (L/kg)	Cp (sandy soil) (µg/L)	Cp (clayey soil) (µg/L)
Technetium-99	3.53E-05	0.1	1	3.53E-01	3.53E-02
Uranium (total)	2.24E+00	15	1,600	1.49E+02	1.40E+00
1,1-Dichloroethene	4.90E-03	1.6E-02	8.0E-02	3.06E+02	6.13E+01
Benzo(a)pyrene	2.08E-01	1,100	5,500	1.89E-01	3.78E-02
Trichloroethene	4.59E-03	4.28E-02	2.14E-01	1.07E+02	2.14E+01
1,1,1-Trichloroethane	3.91E-02	0.03	0.152	1.30E+03	2.57E+02

Summary of Previous Remedial Actions

Subsequent to the discovery of the leaking TCE container in May 1990, TCE-contaminated soils were excavated from a 5 × 2 m (15 × 6 ft) area, down to a depth of 1 m (3 ft). Soil samples taken from the excavation in October 1990 had TCE concentrations as high as 21,000 µg/kg at the base of the excavation pit, indicating that TCE-contaminated soils had not been completely removed.

3.2.7.4 SWMUs 130 through 134 — C-611 Underground Storage Tanks

Location

The C-611 USTs are located southwest of the PGDP in the vicinity of the C-611 WTP, west of Bayou Creek (Fig. 3.50). The SWMUs 130 through 134 include the following USTs, all currently inactive:

- SWMU 130 is a 2,082.0-liter (550-gal) gasoline UST located at the western side of the C-611 WTP. The UST is presently inactive. It was reportedly used from approximately 1942 to 1945 in support of KOW operations. Its contents were sampled during the RFI/RI.

- SWMU 131 is a 189-liter (50-gal) gasoline UST reportedly located at the eastern side of the storage shed, on the eastern side of the C-611 WTP area. This small UST was believed to have been used from 1942 to 1945 at the former KOW site. A magnetometer survey was conducted for the RFI/RI to assist in locating this UST, but efforts to locate SWMU 131 during the RFI/RI were unsuccessful. It is possible that this UST never existed.

- SWMU 132 is a 7,571-liter (2,000-gal) fuel oil tank located on the northern side of the C-611-H WTP Building. It was used from approximately 1942 to 1955, initially as part of the KOW and later in support of PGDP activities. It was filled with sand and abandoned in-place.

- SWMU 133 is a diesel fuel tank of unknown capacity located south of the C-611 WTP. The years of operation are unknown, but it was reportedly used in support of KOW operations and is known to have been taken out of service sometime prior to 1975. It has been filled with grout and abandoned in-place.

- SWMU 134 is a 3,785 l (1,000 gal) diesel fuel UST located southeast of the C-611 WTP. This UST is currently inactive. The dates of operation are unknown, but it was taken out of service by 1975.

Setting

The following subheadings provide information on the setting of SWMUs 130–134, including geology/hydrogeology, surface features and surface-water hydrology, transportation, floodplains, wetlands, soils and prime farmland, biological resources, and cultural resources.

Geology/Hydrogeology

Five soil borings and two monitoring wells were drilled at SWMUs 130 through 134 (Fig. 3.50) during the 1994 RI. A cross section illustrating the geology at the C-611 UST site is presented in Fig. 3.51. The following lithologies were encountered beneath the unit, in order of increasing depth:

- Fill material, composed of gravel and sand, was present in several borings at thicknesses up to 2 m (5 ft).

- Loess deposits are present in all soil borings and monitoring wells at the site and range in thickness from 5 to 6 m (15 to 19 ft).

- Continental deposits consisting of interlensing gravely clay; sandy gravel; and silty, clayey gravel are present at these units from between 5 m (16.5 ft) bgs to below 14.9 m (49 ft) bgs. The USTs overlie the Porters Creek Clay Terrace at the approximate location of the terrace slope, where the slope dips to the north–northeast relatively steeply at an approximate gradient of 0.11 m/m. In this area the

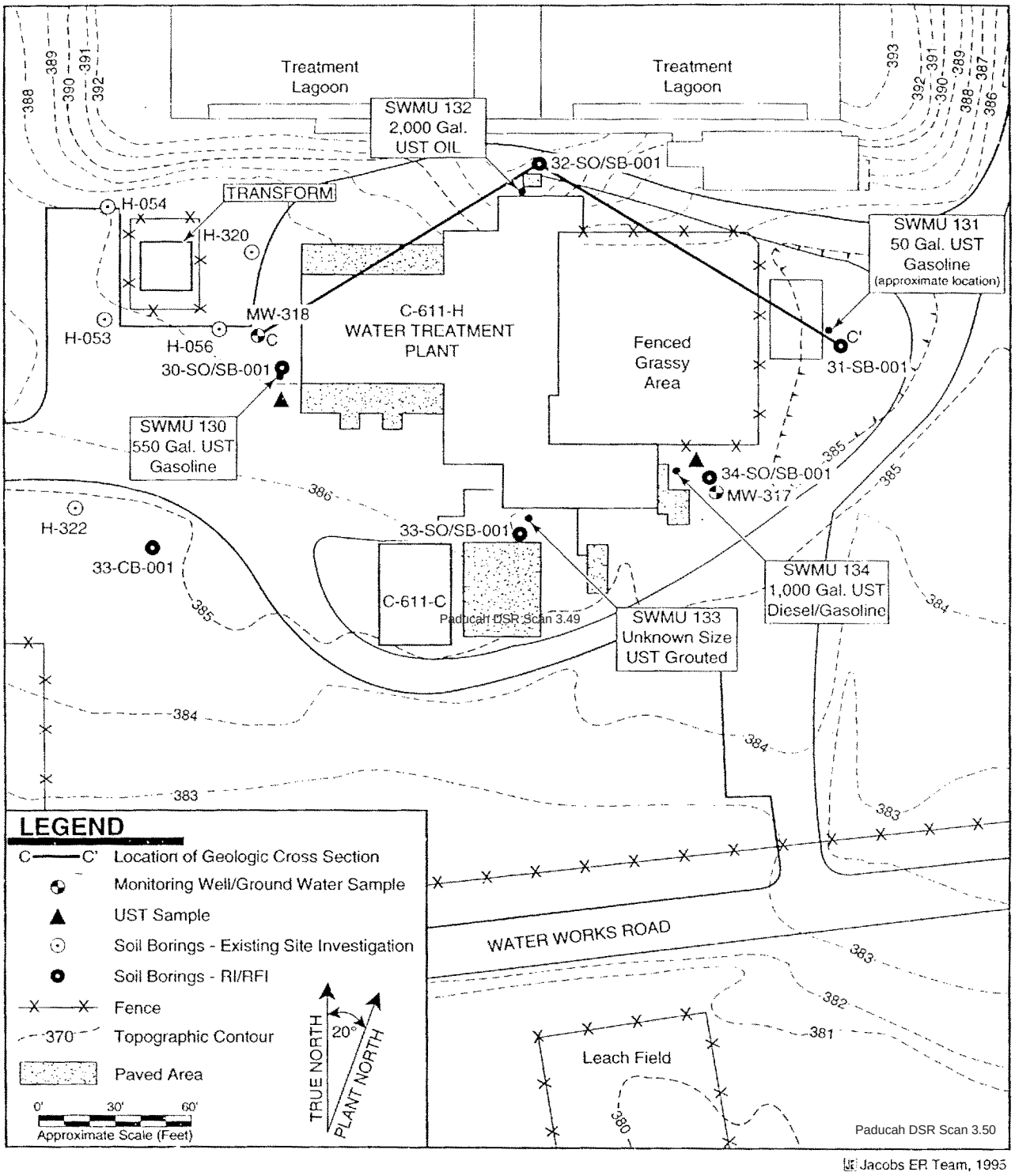


Fig. 3.50. Location of the C-611 USTs (SWMUs 130-134).

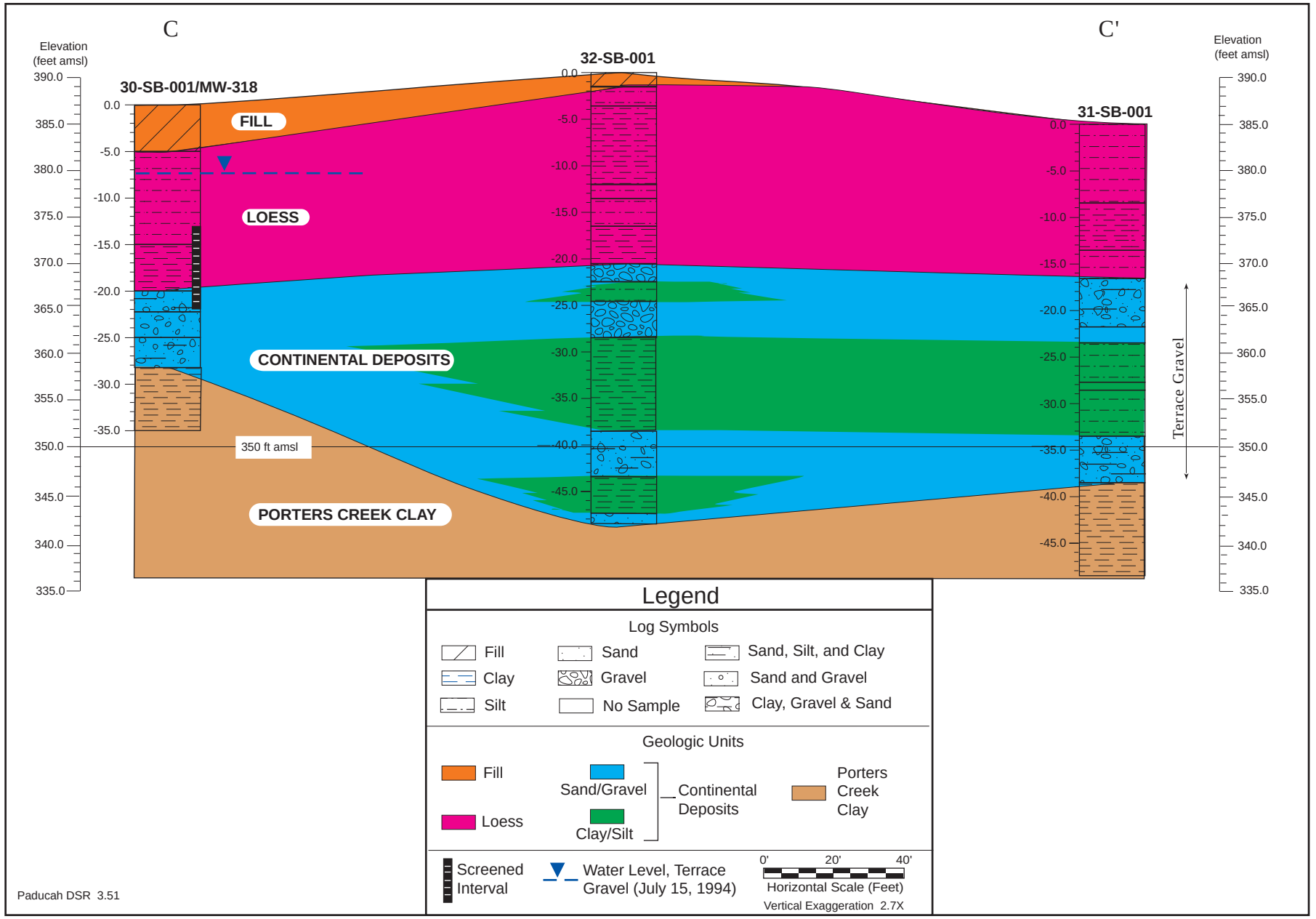


Fig. 3.51. Geologic cross section of the C-611 USTs (SWMUs 130-134).

continental deposits have not been differentiated into upper and lower members and are informally referred to as the Terrace Gravel or the Terrace Slope Gravels. The degree of connection between the Terrace Gravel and the RGA at the UST site is unknown, but some amount of underflow from the Terrace Gravel to the RGA is likely. The UCRS and RGA are not present beneath these SWMUs.

- Porters Creek Clay was encountered in three soil borings (30-CB-001, 30-SB-001, and 34-SB-001), though none of these borings fully penetrated the Porters Creek Clay. The depth to the top of the clay varies from 4 m (13 ft) bgs in the westernmost boring 30-CB-001 to 10 m (34 ft) bgs in the south–eastern boring 34-SB-001. The two borings (31-SB-001 and 32-SB-001) located in the north–northeast portion of the UST area were drilled to a depth of 14.8 m (48.5 ft) bgs, but due to the steep terrace slope in this area, did not encounter the top of the Porters Creek Clay.

The two monitoring wells installed at SWMUs 130 through 134 were screened in the Terrace Gravel. According to water level measurements taken July 15, 1994, the depths to shallow water were approximately 2.3 m (7.5 ft) bgs at MW318 and 2.8 m (9.32 ft) bgs at MW317. A map of the piezometric surface indicates the groundwater flow direction is to the east, toward Bayou Creek. Figure 3.51 provides a geological cross section for the C-611 USTs.

Surface features and surface-water hydrology. The ground surface in the vicinity of the C-611 WTP gently slopes to the south and east, and ranges in elevation from 112.8 to 121.9 m (370 to 400 ft) amsl. Surface features at the site include the C-611-H WTP Building, the C-611-C Building to the south, a storage shed to the east, and a transformer to the west. In addition, four treatment lagoons are located immediately north of the C-611 WTP buildings. The area immediately surrounding the C-611-H and C-611-C buildings is mainly gravel-covered except the asphalt- or concrete-paved areas at SWMUs 130 and 131, and the fenced, grass-covered area situated between the C-611-H WTP Building and the storage shed to the east. There is surface evidence of three of the USTs (SWMUs 132, 133, and 134) in the form of vent stacks and/or fill pipes.

No surface water is located within the boundaries of the C-611 UST area. Bayou Creek is located approximately 370 m (1,200 ft) east of the area and the unnamed tributary of Bayou Creek is located approximately 300 m (1,000 ft) south of the area. Surface runoff from the C-611 UST area is discharged via KPDES Outfall 006 to Bayou Creek (DOE 1993a).

Transportation. The road south of the USTs is owned by the DOE. Traffic on this road consists predominantly of recreationalists, PGDP personnel, and WKWMA personnel.

Soils and prime farmland. Historically, soils within the impacted area of the USTs are Calloway silt loam, 0% to 2% slope; Grenada silt loam, 6% to 12% slopes; and Fallaya-Collins silt loam. However, the soils associated with these areas have been disturbed by past activities, decreasing the likelihood that any of these areas are prime farmland.

Wetlands. No wetlands were identified in the vicinity of the USTs during the 1994 COE environmental investigation of the PGDP (CDM Federal 1994).

Floodplains. No floodplains were identified in the vicinity of the USTs during the 1994 COE environmental investigation of the PGDP (CDM Federal 1994).

Biological resources. The majority of the area associated with the USTs has been previously cleared of vegetation and consists of various grasses including rye grass (*Lolium* spp.), fescue (*Festuca* spp.), foxtails (*Setaria* spp.), and various others not identified due to mowing practices. No potential habitat for federally listed or proposed for listing T&E species exists near the USTs (COE 1994).

Cultural resources. Due to previous disturbance and a lack of notable structural features, it is unlikely any important cultural resources are present in the vicinity of these SWMUs.

Manufacturing/TSD Processes

The five USTs were installed adjacent to the C-611 Water Treatment Plant in support of former KOW operations. No records of releases from these USTs or their piping are documented.

Summary of Previous Investigations

Site investigations/remedial investigations. In 1994, the DOE conducted an RFI for the SWMUs in WAGs 1 and 7 and nearby KOW facility (SWMUs 94, 95, and 157) to determine the nature and extent of contamination (DOE 1996e and 1996f). As part of this investigation, one soil boring was conducted adjacent to each UST, and sampled at every 2-m (5-ft) interval. Additionally, surface soil samples were collected at each boring location. Shallow groundwater samples were collected from each boring location for VOC analysis, and two monitoring wells were installed, developed, and sampled as part of the investigation activities (MWs 317 and 318). Sludge samples were collected from USTs 130 and 134 (the only units containing measurable quantities of liquid.)

Additional data sources. Groundwater elevation data currently are conducted on an annual basis from the two wells at the site (MWs 317 and 318). Groundwater sampling and analysis for chemical compounds currently is not being conducted at this site (BJC 1998a).

Conceptual Site Model

All of these SWMUs are USTs. The soil above these tanks could have been contaminated when the tanks were filled. In addition, material leaking from the tanks could have contaminated the groundwater below the unit.

The only current exposure scenario at each of these units is for an industrial worker. A current worker at the USTs could be exposed to soil by ingestion, dermal contact, inhalation, and external exposure.

Potential future receptors at the USTs are an industrial worker, excavation worker, rural resident, and recreational user. A future worker at the USTs could be exposed to soil and groundwater. Ingestion of soil and groundwater, dermal contact with soil and groundwater, inhalation of volatiles in groundwater; inhalation of volatiles and particulates emitted from soil; and external exposure to soil are viable exposure routes for a future worker. Inhalation of volatiles and particulates is not considered because the SWMU is likely to remain grass-covered under future industrial use.

A future excavation worker at the USTs could be exposed to soil by ingestion, dermal contact, inhalation, or external exposure. These are the viable exposure routes for a future excavation worker.

A future resident living at the USTs could be exposed to soil, groundwater, and vegetables. Ingestion of soil, vegetables, and groundwater; dermal contact with soil and groundwater; inhalation of soil and groundwater; and external exposure to soil are viable exposure routes for a future resident. Inhalation of contaminants in soil is considered a likely exposure route because a garden with exposed soil is assumed to be present.

A future recreational user visiting the USTs could be exposed to venison. The sites are small and there is no surface water that would make the area attractive for recreation. In addition, deer could forage in the area. Consumption of venison is a viable exposure route for a future recreational user (DOE 1996e).

Nature and Extent of Contamination

A sample was collected from the tank residuals of both SWMUs 130 and 134. The location of SWMU 131 could not be determined, and SWMUs 132 and 133 had been filled with sand and grout, respectively. Both samples contained lead and BTEX as well as other VOCs and PAHs associated with petroleum products. Low levels of lead, VOCs, and PAHs also were detected in soil samples from the C-611 UST area. The only VOC detected was 1,4-dichlorobenzene (3 µg/L), which was detected in groundwater samples collected from MW317, the downgradient (eastern) shallow monitor well. The only PAH detected was naphthalene (70 µg/L), and it was found in the well upgradient of the site (MW318). Lead, the only metal for which analysis was completed in the two monitoring wells, was not detected in groundwater.

Low levels of radionuclides, including ^{235}U, ^{238}U, ^{237}Np, ^{228}Th, ^{232}Th, ^{99}Tc, and ^{238}Pu, were detected in soil and groundwater samples collected in the area. No radionuclides were detected above background levels in the UST liquids. The presence of these radionuclides in soils and groundwater likely is unrelated to any of the USTs, but the presence more likely is the result of plant-wide activities. The organic and lead contamination observed at SWMUs 130, 132, 133, and 134 appears to be limited in areal extent [35.3 m^2 (380 ft^2)] and may be indicative of past gasoline, diesel, or fuel-oil spills in the area.

Contaminant Fate and Transport

Probable release mechanisms and exposure pathways at the C-611 USTs include groundwater contamination by leaching of contaminants in subsurface soil, and surface-water runoff transporting contaminants and contaminated sediments off-site (DOE 1996d). The Summers Model was applied to several COPCs as identified by the WAGs 1 and 7 RI to simulate subsurface migration of contaminants from the soil matrix (i.e., landfill leachate). A summary of Summers Modeling results for the C-611 USTs are provided in Table 3.53.

Table 3.53. Summary of Summers Modeling results for the C-611 USTs (SWMU 130-134)

Constituent	Cs (95UCL) (mg/kg)	K_d (sandy soil) (L/kg)	K_d (clayey soil) (L/kg)	Cp (sandy soil) (µg/L)	Cp (clayey soil) (µg/L)
		SWMU 130			
Uranium (total)	2.84	15	1,600	1.89E+02	1.78E+00
		SWMU 131			
Uranium (total)	2.79	15	1,600	1.86E+02	1.74E+00
		SWMU 132			
Technetium-99	4.05E-05	0.1	1	4.05E-01	4.05E-02
Uranium (total)	3.31	15	1,600	2.21E+02	2.07E+00
		SWMU 133			
Benzo(a)pyrene	2.06	1,100	5,500	1.87	3.75E-01
Technetium-99	5.50E-05	0.1	1	5.50E-01	5.50E-02
Uranium (total)	4.03	15	1,600	2.69E+02	2.52E+00
		SWMU 134			
Benzo(a)pyrene	0.208	1,100	5,500	1.89E-01	3.78E-02
Neptunium-237	8.13E-05	5	55	1.63E-02	1.48E-03
Plutonium-238	1.17E-08	550	5,100	2.13E-08	2.29E-09
Technetium-99	3.94E-05	0.1	1	3.94E-01	3.94E-02
Thorium-228	2.31E-09	3,200	5,800	7.22E-10	3.98E-10
Thorium-230	4.59E-05	3,200	5,800	1.43E-05	7.91E-06
Thorium-232	22.6	3,200	5,800	7.06	3.9
Uranium (total)	2.84	15	1,600	1.89E+02	1.78E+00

For organic compounds, K_d values were calculated using f_{oc} values of 0.0002 and 0.001 for sand and clay, respectively.

Summary of Previous Remedial Actions

No previous remedial actions have occurred at this site.

3.2.7.5 SWMU 38 — C-615 Sewage Treatment Plant

Location

The C-615 Sewage Treatment Plant is located in the southwestern quadrant of the PGDP, inside the security fence. The unit has been operated for the treatment of PGDP sanitary sewage since 1951. The treatment plant includes settling basins, a sludge digester, a trickling filter, and concrete-lined sludge drying beds (Fig. 3.52).

Setting

The following subheadings provide information on the setting of SWMU 38, including geology/ hydrogeology, surface features and surface-water hydrology, transportation, floodplains, wetlands, soils and prime farmland, biological resources, and cultural resources.

Geology/Hydrogeology

Nine soil borings and four monitoring well borings were drilled at the unit during the 1994 RI. A cross section illustrating the geology at the C-615 Sewage Treatment Plant site is presented in Fig. 3.53. The following lithologies were encountered beneath the unit, in order of increasing depth:

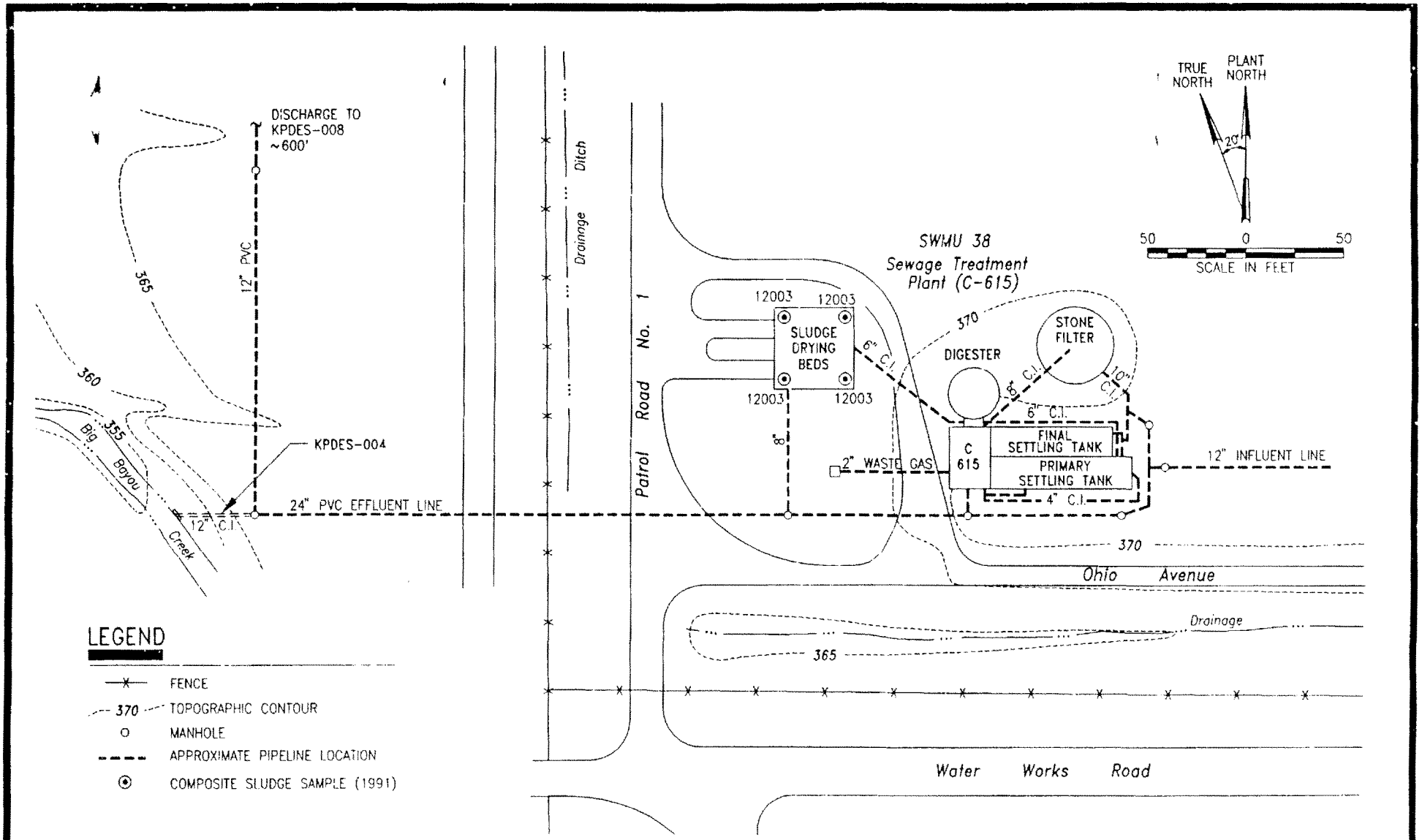
- Fill material, composed of clayey silt and gravel with a minor sand component, was reported in most borings at thicknesses up to 2.3 m (7.6 ft).

- Loess deposits are present in all soil borings and monitoring wells at the site and range in thickness from 2.1 to 4.3 m (7 to 14 ft).

- Continental deposits consisting of interbedded gravely sand; clayey sand; and silty, to sandy clay are present at these units from between 2.3 m (6.5 ft) bgs to below 18 m (52 ft) bgs. The first encountered water bearing stratum is the gravelly sand of the upper continental deposits (i.e., UCRS) at an approximate depth of 3 to 6 m (10 to 20 ft) bgs, deposited above the clay aquitard. The gray clay aquitard was encountered near the base of the upper continental deposits. Lower continental deposits (i.e., RGA) were encountered at depths of 16 to 22 m (45 to 62 ft) bgs in some borings, with a thickness of approximately 3.5 to 10.5 m (10 to 30 ft). The unit lithology consisted of moderate- to well-sorted course sandy gravel.

- Porters Creek Clay was encountered in the southern-most of the nine soil borings at a depth of 29 m (94 ft). The clay was noted as micaceous, dry, and dark-greenish/gray in color.

One monitoring well was installed in the upper continental deposits (MW316). A July 1994 sampling event indicated a shallow groundwater depth of 2.3 m (7.58 ft) below the top of the casing. Horizontal hydraulic gradients in the UCRS have not been determined. The three wells constructed in the RGA were screened in sandy gravel deposits. Depth to groundwater ranged 10.3 to 12.5 m (33.63 to 41.1 ft) from the top of the well casing. Groundwater flow direction in the vicinity of SWMU 38 appears to be toward the north to northwest. The measured hydraulic gradient is small (<0.001 m/m), and flow direction may vary seasonally (DOE 1996f). Figure 3.53 depicts the geologic cross section at SWMU 38.

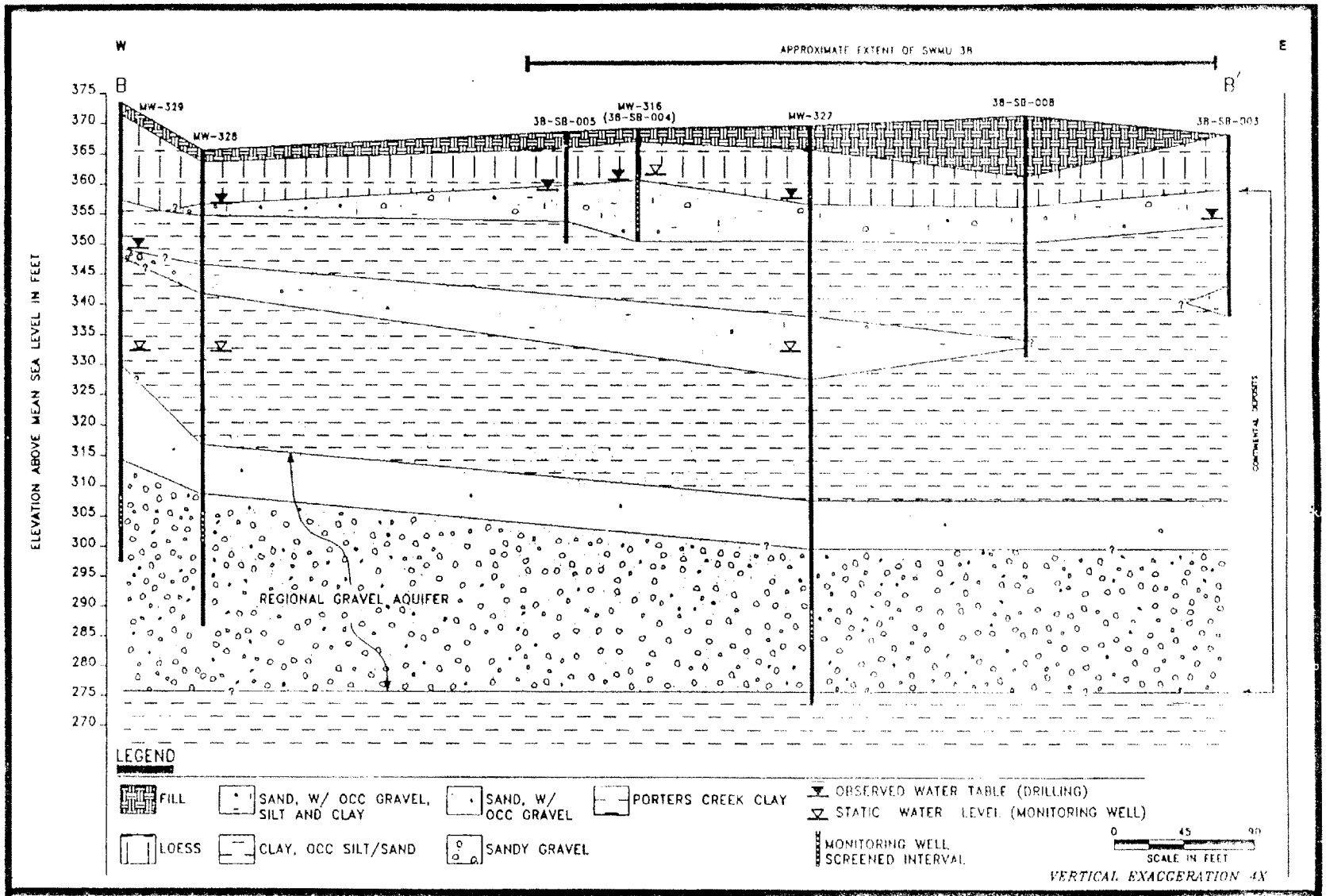


Paducah DSR Scan 3.52

Fig. 3.52. Location of the C-615 Sewage Treatment Plant (SWMU 38).

CDM FEDERAL PROGRAMS CORPORATION
a subsidiary of Camp Dresser & McKee Inc.

PADUCAH GASEOUS DIFFUSION PLANT
PADUCAH, KENTUCKY



Paducah DSR Scan 3.53

Fig. 3.53. Geologic cross section of the C-615 Sewage Treatment Plant (SWMU 38).

PADUCAH GASEOUS DIFFUSION PLANT
PADUCAH , KENTUCKY

SSKY/1444595/2

Surface features and surface-water hydrology. The Sewage Treatment Plant is located in the southwestern portion of the facility, within the PGDP security fence. The surface topography at the unit ranges from 110 to 114 m (360 to 375 ft) amsl. An eastward flowing drainage ditch exists in the southern portion of SWMU 38, and a northward flowing drainage ditch exists along the western portion. An east–west trending topographic low is present in the northern third of the unit. Most surface water at SWMU 38 probably drains to this topographic low or to either of the two drainage ditches. Bayou Creek is approximately 305 m (1000 ft) west of the unit.

Transportation. Transportation in the vicinity of SWMU 38 consists of PGDP personnel performing day-to-day activities and is confined to paved or gravel roads.

Wetlands. No wetlands have been identified in drainage areas adjacent to SWMU 38 (CDM Federal 1994).

Floodplains. No 100-year floodplains are adjacent to SWMU 38.

Soils and prime farmland. Historically, soils within the impacted area of SWMU 100 are Calloway silt loam, 0% to 2% slope; Grenada silt loam, 6% to 12% slopes; and Fallaya-Collins silt loam. However, the soils associated with these areas have been disturbed by past activities, decreasing the likelihood that any of these areas are prime farmland.

Biological resources. Vegetation inside the fence is mown grass providing very little to no wildlife habitat. No potential habitats for federally listed or proposed for listing T&E species are present within the fence (CDM Federal 1994).

Cultural resources. Due to previous disturbance and a lack of notable structural features, it is unlikely any important cultural resources are present in the vicinity of this SWMU.

Manufacturing/TSD Processes

Sewage is transported to and from the plant by vitrified clay piping. Much of the equipment was moved to this site from the former KOW Sewage Treatment Plant after closure of the KOW in 1945. The Sewage Treatment Plant accepts most plant sanitary waste with the exception of laboratory waste generated from various types of analytical testing associated with normal plant operations. Raw sewage enters the primary settling basin where solids are precipitated and collected. Overflow from the settling basins then passes through the stone trickling filter into the secondary settling tank. In the past, influent was occasionally bypassed from the outfall ditches to Bayou Creek, but this practice has been eliminated from current operating procedures. Effluent from the secondary settling tank is discharged to Bayou Creek through KPDES Outfall 008 (DOE 1993a; DOE 1996e).

Currently the sludge from both settling tanks and trickling filter is sent to the digester, but in the past it was sent to the sludge drying beds. The sludge currently contained in the sludge drying beds was deposited before 1990; this sludge has not been removed due to relatively high levels of PCBs and radionuclides detected in sludge samples (CH2M HILL 1992). Currently the sludge generated by the sludge digester is drummed and stored in the waste management area. In the past, it was used as fertilizer and construction fill material.

Summary of Previous Investigations

Site investigations/remedial investigations. Limited sampling of the plant effluent, sludge surface-water, and sediment samples at the point of discharge has been conducted during previous investigative activities.

Effluent samples collected and analyzed by the PGDP have not detected the presence of any contaminants. In addition, no PCBs and no radioactive contamination above background were detected in the surface-water and sediment samples collected during the Phase II SI (CH2M HILL 1992).

The sludge from the drying beds was sampled during previous investigations and found to contain detectable levels of VOCs, PAHs, PCBs, metals, and radionuclides (including uranium and ^{99}Tc. Radiation readings in excess of 300 counts per minute, which is approximately 220 to 250 counts per minute above background have been recorded from the sludge (DOE 1996e).

In 1994, the DOE conducted an RFI for the SWMUs in WAGs 1 and 7 and nearby KOW facility (SWMUs 94, 95, and 157) to determine the nature and extent of contamination (DOE 1996e and 1996f). As part of this investigation, nine soil borings and four monitoring wells were installed, developed and sampled during the investigation (MW316, MWs 327 through 329). Total depths of the soil borings and monitoring wells ranged from 4.4 to 29.3 m (14.5 to 96 ft) bgs. One of the four monitoring wells (MW316) was completed in the UCRS; the remaining wells were installed into the RGA (MWs 327 through 329).

In addition to soil and groundwater sampling, three treatment plant influent water samples and three effluent samples were collected during RI activities for the purpose of source characterization. The influent samples were collected from the 30-cm (12-in.) diameter influent line located east of the primary settling tank. The effluent samples were collected from the manhole upstream from KPDES Outfall 008.

Additional data sources. Groundwater elevation data currently are conducted on an annual basis from the UCRS monitoring well at the site (MW316); monthly groundwater elevation data are collected from one of the RGA wells (MW327). Quarterly groundwater sampling/analysis is conducted for MWs 328 and 329. Groundwater samples are analyzed for water quality parameters, VOCs, and radionuclides as part of the DOE's Environmental Surveillance Quarterly Monitoring Program (BJC 1998a).

Effluent from SWMU 38 is discharged through PGDP Outfall 004, which is operated by United States Enrichment Corporation. Grab samples of effluent at Outfall 004 are collected on a monthly basis and analyzed for select VOCs, metals, and radionuclides.

Conceptual Site Model

The Sewage Treatment Plant receives influent from the PGDP. The sewage is dried in basins and disposed of in drums, and the wastewater is discharged to Bayou Creek. Historic overflow and current leaching of sludge could have contaminated the soil surrounding the Sewage Treatment Plant, surface water and sediment in the ditches near the plant, and groundwater underneath the plant.

The exposure assessment evaluated in the RI (DOE 1996e) concluded that there are three specific areas that should be evaluated at SWMU 38; the two ditches (designated as 38a and 38b), and soil and groundwater (designated 38c). Soil and groundwater exposure are combined as they comprised the rest of the unit.

The only current exposure is to the industrial worker. A current worker at the Sewage Treatment Plant could be exposed to soil, sediment, and surface water. Ingestion of soil and sediment; dermal contact with soil, sediment and surface water; inhalation of volatiles and particulates emitted from soil and sediment; and external exposure to soil and sediment are viable exposure routes for a current worker.

Potential future exposure at the Sewage Treatment Plant could be to an industrial worker, excavation worker, rural resident, and recreational user. A future worker at the Sewage Treatment Plan could be exposed to soil, sediment, surface water and groundwater. Ingestion of soil, sediment, and groundwater;

dermal contact with soil, sediment, surface water, and groundwater; inhalation of groundwater; inhalation of volatiles and particulates emitted from soil and sediment; and external exposure to soil and sediment are viable exposure routes for the future worker.

A future excavation worker at the Sewage Treatment Plant could be exposed to soil or sediment by ingestion, dermal contact, inhalation, or external exposure. These are the viable exposure routes for a future excavation worker.

A future rural resident living at the site, after decommissioning and dismantling of the Sewage Treatment Plant, could be exposed to soil, groundwater, and vegetables. Ingestion of soil, vegetables, and groundwater; dermal contact with soil and groundwater; inhalation of soil and groundwater; and external exposure to soil are viable exposure routes for a future resident. Inhalation of contaminants emitted by soil is considered a likely route of exposure because a garden with exposed soil is assumed to be present.

A future recreational user visiting the site, after decommissioning and dismantling of the Sewage Treatment Plant, could be exposed to sediment, venison, and surface water. Ingestion of sediment and venison; dermal contact with sediment and surface water; inhalation of particulates and vapors emitted from sediment; and external exposure to sediment are viable exposure routes for a future recreational user (DOE 1996e).

Nature and Extent of Contamination

Organics. Low levels (> 15 μg/kg) of the compounds 2-butanone, 2-hexanone, and 4-methyl-2-pentanone were detected in the duplicate sample collected at 38-SB-004 [3 to 5 m (9 to 14 ft) depth interval], but were not detected in the primary sample; these hits are suspected of being laboratory contamination. Toluene was the only other VOC detected in SWMU 38 soils. Toluene was observed at concentrations up to 93 μg/g in the subsurface soil sample 38-SB-001, which is adjacent to the sludge digester.

Low levels of PAHs were detected in six surface and one subsurface sample (at the 0.3 to 1.5 m, 1 to 5 ft, depth interval). The relatively widespread occurrence of PAHs in the surface soils at SWMU 38 indicates that the PAH contamination may be ubiquitous in the area as a result of PGDP and TVA coal-fired combustion operations. PAHs are common components of coal tar and smoke from the burning of coal.

Measurable levels of PCBs were detected in the shallow soils from the two borings closest to the sludge drying beds (38-SB-004 and 38-SB-007). Aroclor-1254 was detected at a concentration of 1648 μg/kg in the sample collected from a depth of 0.3 m (1 ft) bgs at 38-SB-007, and Aroclor-1260 was detected at a concentration of 152 μg/kg in the surface soil sample collected from 38-SO-004. Aroclor-1254 was detected in the sludge sample collected for the Phase II SI at a concentration of 260 μg/kg, as well as in the sludge sample collected for the RI (2892 μg/kg).

The groundwater sample collected from MW316, installed in the UCRS, showed no organic contamination. Trace amounts of TCE (< 1 μg/L) were detected in the groundwater screening samples collected from temporary wells 38-HP-003 and 38-HP-005 installed for the RI. *Trans*-1,2-DCE, a biodegradation product of TCE, was detected in trace amounts in temporary wells 38-HP-004 and 38-HP-006. TCE was not detected in any other media sampled at SWMU 38 during the RI. Trace concentrations of TCE (< 1 μg/L) were detected in MW328. No other organic chemicals were detected in the three RGA monitoring wells (MWs 327 through 329) installed in the vicinity of SWMU 38 during the RI.

Inorganics. Metals in soil were detected above background levels at all soil boring locations during the RI. The 5 to 7 m (14 to 19 ft) depth interval of soil boring 38-SB-006 contained the most metals at

levels above background. Contaminants detected included cadmium (2.9 mg/kg), chromium (165 mg/kg), copper (501 mg/kg), lead (191 mg/kg), selenium (2.8 mg/kg), silver (22.2 mg/kg), and zinc (389 mg/kg). The metals detected in sample 38-SB-006 may be associated with operation of the sludge drying beds since some of these metals also were detected in sludge samples; however, soils above 5 m (14 ft) bgs in the boring had none of the previous identified metals at levels above background.

Mercury was detected considerably above background levels (> 75 times background) in the sample collected from the 3- to 5-m (10- to 15-ft) depth interval of soil boring 38-SB-003. Also at this location, mercury was detected in the surface soil at a concentration 18 times background. Soil boring 38-SB-003 is located east of the settling tanks and adjacent to the influent line. Mercury was detected in influent and sludge samples and, therefore, is believed to be related to the operations conducted in the vicinity of the settling tanks. Because mercury was detected above background from different locations and depths, it appears to be limited and sporadic in distribution.

Aluminum, iron, manganese, and zinc were all detected above background levels in the groundwater sample collected from the monitoring well installed in the UCRS at SWMU 38 (MW316). The high concentration of aluminum may represent natural variation in aluminum concentration in groundwater, or it may be related to colloidal particles being mobilized during sampling that are not mobile under ambient low conditions. These metals were also detected in influent and sludge samples collected from this SWMU.

The groundwater sample collected from the RGA monitoring well located closest to the unit (MW327) showed only manganese above background concentrations, and not other inorganic or radionuclide contaminants. The concentration of manganese was 2,030 μg/L. It is not believed that manganese is considered to be related to the activities at SWMU 38. Manganese was detected substantially above background in MWs 328 and 329 (> 1,900 mg/L).

Radionuclides. All radionuclides analyzed for at SWMU 38 were detected at low levels (< 20 pCi/g) throughout the SWMU. The widespread distribution of low concentrations of radionuclides indicates that these are not a result of a one-time release, but have accumulated because of daily plant-wide activities over an extended period of time. The higher levels of activity were detected in samples collected from the borings located closest to the sludge drying beds, indicating that the sludge drying beds are a potential source for the detected radionuclides.

Some radionuclides (gross alpha, gross beta, ^{238}Pu, ^{228}Th, ^{232}Th, ^{234}U, ^{238}U) were detected at low activities in shallow groundwater at SWMU 38. Techetium-99 activity was slightly elevated (46.7 pCi/L). Technetium-99 activity was measured at 98.9 pCi/g in the sludge sample collected from the drying beds, so it may be possible that the sludge is a source of the ^{99}Tc contamination. Low levels of ^{99}Tc (< 6 pCi/L) were detected in each of the three Sewage Treatment Plant influent and in one confirmation sample.

Techetium-99 was detected at very low activities slightly above background in the two RGA monitoring wells furthest from SWMU 38 (MWs 328 and 329). Technetium-99 is not considered a COPC at such low levels.

Contaminant Fate and Transport

Probable release mechanisms and exposure pathways at the C-615 Sewage Treatment Plant include groundwater contamination by leaching of contaminants in subsurface soil, and surface-water runoff transporting contaminants and contaminated sediments off-site (DOE 1996e). The Summers Model was applied to several COPCs as identified by the WAGs 1 and 7 RI to simulate subsurface migration of contaminants from the soil matrix (i.e., landfill leachate). A summary of Summers Modeling results for the C-615 Sewage Treatment Plant are provided in Table 3.54.

Table 3.54. Summary of Summers Modeling results for the C-615 Sewage Treatment Plant (SWMU 38)

Constituent	Cs (95UCL) (mg/kg)	K_d (sandy soil) (L/kg)	K_d (clayey soil) (L/kg)	Cp (sandy soil) (µg/L)	Cp (clayey soil) (µg/L)
Barium	63.4	60	60	1057	1057
Manganese	4.73E+02	50	180	9.46E+03	2.63E+03
Neptunium-237	1.63E-03	5	55	3.26E-01	2.96E-02
Plutonium-239	1.28E-06	550	5,100	2.33E-06	2.51E-07
Plutonium-240	5.27E-07	550	5,100	9.58E-07	1.03E-07
Technetium-99	7.64E-05	0.1	1	7.64E-01	7.64E-02
Thorium-228	1.45E-09	3,200	5,800	4.53E-10	2.50E-10
Thorium-230	7.92E-05	3,200	5,800	2.48E-05	1.37E-05
Thorium-232	1.16E+01	3,200	5,800	3.63E+00	2.00E+00
Uranium (total)	6.65E+00	15	1,600	4.43E+02	4.16E+00
Benzo(a)pyrene	4.82E-01	1,100	5,500	4.38E-01	8.76E-02
Aroclor-1254	9.65E-02	80	400	1.21E+00	2.41E-01
Aroclor-1260	4.56E-02	400	2,000	1.14E-01	2.28E-02

K_d values for Aroclor 1254 and Aroclor 1260 derived from K_{oc} values of 4×10^5 and 2×10^6, respectively (Montgomery, J.H. and L.M. Welkom, *Groundwater Chemicals Desk Reference*, Lewis Publishers, 1990) For organic compounds, K_d values were calculated using f_{oc} values of 0.0002 and 0.001 for sand and clay, respectively.

Summary of Previous Remedial Actions

No previous remedial actions have been conducted at this site.

Summary of WAGs 1 and 7 Risk Assessment

The summary presented in this section was taken from *Resource Conservation and Recovery Act Facility Investigation/Remedial Investigation Report for Waste Area Groupings 1 and 7* (DOE 1996e). Specifically, the Executive Summary of the WAGs 1 and 7 BRA contains the pertinent risk information that will be repeated here. The purpose of this activity was to determine the presence, nature and extent (if any) of contaminants at each of the units. The investigation focused on source characterization of the surrounding soils and the potential impacts of contaminants on adjoining surface waters and groundwater. Investigative activities included sampling and analysis of surface and subsurface soils, surface waters, and groundwater. The report includes the information necessary to provide definitive conclusions regarding contamination and its effect to human health and the environment in the vicinity of the subject SWMUs.

According to the Executive Summary of the WAGs 1 and 7 BRA:

> In 1994, the U.S. Department of Energy conducted a Resource Conservation and Recovery Act Facility Investigation at nine SWMUs (SWMUs) in Waste Area Groupings 1 and 7 at the Paducah Gaseous Diffusion Plant (PGDP) in Paducah, Kentucky. The purpose of this activity was to determine the presence, nature, and extent (if any) of contaminants at each of the units. The investigation focused on source characterization of the surrounding soils and the potential impacts of contaminants on adjoining surface waters and groundwater. Investigative activities included sampling and analysis of surface and subsurface soils, surface waters, and groundwater.

Major conclusions and observations of the investigation are as follows.

Baseline Human Health Risk Assessment

- The current use scenario, industrial use, has unacceptable systemic toxicity (Hazard Index > 1) at SWMUs and SWMU areas 8a (i.e., sediment and surface water at SWMU 8), 38a (i.e., sediment and surface water at ditch a at SWMU 38), 38b (i.e., sediment and surface water at ditch at SWMU 38), 38c (i.e., soil and groundwater at SWMU 38), 100a (i.e., sediment and surface water at ditch a at SWMU 100), and 100b (i.e., sediment and surface water at ditch b at SWMU 100).

- The current use scenario, industrial use, has unacceptable excess cancer risk (excess lifetime cancer risk > 1×10^{-6}) at SWMU areas 8a, 8b, 38a, 38b, 38c, 100a, 100b, and 100c.

- The most plausible future use scenario, industrial use, has total systemic toxicity that is unacceptable at SWMU areas 8a, 8b, 38a, 38b, 38c, 100a, 100b, and 100c.

- The most plausible future use scenario, industrial use, has unacceptable excess cancer risk at SWMUs or SWMU areas 8a, 8b, 38a, 38b, 38c, 100a, 100b, 100c, and 136.

Screening Ecological Risk Assessment

- Threatened and endangered species that may be present on PGDP in habitat similar to that found at the WAGs 1 and 7 sites are vascular plants (4 species), crustaceans (1 specie), fishes (3 species), amphibians (2 species), birds (3 species), and mammals (3 species).

Table 3.55 presents the SWMU descriptions. Ditches at the SWMUs were separated from the main SWMU areas so they could be assessed separately. Table 3.56 presents the land use scenarios of concern for each SWMU area. Tables 3.57 through 3.66 present the risk results found in Table ES-1 through ES-11 of the WAGs 1 and 7 BRA. No previous summarization of these tables has been completed that incorporated a quantitative uncertainty assessment. The data necessary to complete such a table are not readily available.

3.2.8 WAG 23 and SWMU 1 of WAG 27

WAG 23 includes SWMUs 32, 33, 56, 57, 74, 79, 80, and 81, and soils at SWMU 1 of WAG 27. Table 3.67 provides a description of each SWMU. The location of these units is depicted in Fig. 3.54.

The eight SWMUs in WAG 23 are located within the security-fenced area of the PGDP, except for SWMU 79, which is located within the C-611 Water Treatment Facility fence. These SWMUs have been included in the same WAG because they have similar physical characteristics, past uses, and types of contamination. Surface soil contamination at these units is the result of accidental spills and leaks of oil that contained PCBs. At the plant, oil that contains PCBs has been used in process equipment, transformers, capacitors, and other electrical equipment; however, its use is being phased out (i.e., use of PCBs at the plant is consistent with the TSCA regulation of PCBs).

SWMU 1, which is located within the security-fenced area of the PGDP, previously was used as an oil landfarm. Contaminated waste oil was placed on the soil for biodegradation at this unit from 1975 to 1979. Some of the waste oil contained trace quantities of PCBs. Consequently, the surface soil [0 to 0.3 m (0 to 1 ft)] of SWMU 1 was included in this project. SWMU 1 also is a suspected source of TCE contamination in the RGA. A detailed discussion of groundwater impacts from SWMU 1 of WAG 27 is included in Sect. 3.2.4.

Table 3.55. Solid waste management unit descriptions

WAG	SWMU	Description
1	38	C-615 Sewage Treatment Plant
1	38a	Ditch west of site at SWMU 38
1	38b	Ditch south of site at SWMU 38
1	38c	Soil and groundwater at SWMU 38
1	100	C-206 Fire Training Area
1	100a	Ditch east of the burn areas along 4th Street
1	100b	Ditch west of the burn area along the fence
1	100c	Soil and groundwater at SWMU 100
1	136	C-740 TCE Spill Site
7	130–134	USTs at the C-611 Water Treatment Plant
7	8	C-746-K Sanitary Landfill
7	8a	Creek along the landfill
7	8b	Soil and groundwater at SWMU 8

Table 3.56. Land use scenarios of concern for WAGs 1 and 7 SWMUs

	Use scenario									
	Current worker		Future worker		Excavation worker		Recreational user		Rural resident	
Area	ELCR	HI	ELCR	HI	ELCR	HI	ELCR	HI	ELCR	HI
8a	X	X	X	X			X	X	NA	NA
8b	X		X	X			NA	NA	X	X
38a	X	X	X	X	X		X	X	NA	NA
38b	X	X	X	X			X	X	NA	NA
38c	X	X	X	X			NA	NA	X	X
100a	X	X	X	X			X	X	NA	NA
100b	X	X	X	X			X	X	NA	NA
100c	X		X	X			NA	NA	X	X
130										
131										
132										
133									X	
134									X	
136			X						X	X

Table 3.57. Risk results for WAGs 1 and 7 SWMUs

	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Current industrial worker	5.2×10^{-4}	As Be	0.8 99.0	Dermal Contact with Sediment	99.8	5.97	Fe Mn V	38.4 8.8 48.9	Dermal Contact with Sediment	99.5
Future industrial worker	5.2×10^{-4}	As Be	0.8 99.0	Dermal Contact with Sediment	99.8	5.97	Fe Mn V	38.4 8.8 48.9	Dermal Contact with Sediment	99.5
Future excavation worker	1.7×10^{-6}	Be	98.3	Dermal Contact with Sediment	97.1	0.55	Fe V	44.1 43.7	Dermal Contact with Sediment	86.5
Future adult recreational user	8.4×10^{-4}	As Be	0.9 99.1	Ingestion of Sediment Dermal Contact with Sediment	0.2 99.6	2.03	Fe Mn V	38.5 8.8 48.8	Dermal Contact with Sediment	99.0
Future child recreational user	NA	NA	NA	NA		14.2	Al Be Fe Mn V	1.6 1.1 38.7 8.7 48.4	Ingestion of Sediment Dermal Contact with Sediment	1.5 97.9
Future teen recreational user	NA	NA	NA	NA		9.43	Al Be Fe Mn V	1.6 1.1 38.7 8.7 48.7	Ingestion of Sediment Dermal Contact with Sediment	1.1 98.7

Notes:

NA = ELCR not applicable to child and teen cohorts. Values for adult include exposure as child and teen.

Definitions for COCs:

Al	aluminum	Fe	iron
As	arsenic	Mn	manganese
Be	beryllium	V	vanadium

Table 3.58. Risk results for WAGs 1 and 7 SWMUs

	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Current industrial worker	1.6×10^{-4}	As Be	6.3 93.8	Dermal Contact with Sediment	100	2.1	Al Fe Mn V	9.0 28.6 26.5 28.4	Dermal Contact with Sediment	95.7
Future industrial worker	1.6×10^{-4}	As Be	6.3 93.8	Dermal Contact with Sediment	100	2.1	Al Fe Mn V	9.0 28.6 26.5 28.4	Dermal Contact with Sediment	95.7
Future adult recreational user	2.6×10^{-4}	As Be	6.5 93.2	Ingestion of Sediment Dermal Contact with Sediment	0.6 99.2	0.7	Fe Mn V	29.2 27.5 28.7	Dermal Contact with Sediment	96.6
Future child recreational user	NA	NA	NA	NA		4.9	Al As Fe Mn V	9.2 3.2 29.5 26.8 28.7	Dermal Contact with Sediment	96.3
Future teen recreational user	NA	NA	NA	NA		3.3	Al As Fe Mn V	9.2 3.2 29.4 27.0 28.8	Dermal Contact with Sediment	96.9

Notes

NA = ELCR not applicable to child and teen cohorts. Values for adult include exposure as child and teen.

Definitions for COCs:

Al	aluminum	Fe	iron
As	arsenic	Mn	manganese
Be	beryllium	V	vanadium

Table 3.59. Risk results for WAGs 1 and 7 SWMUs

	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Current industrial worker	3.8×10^{-5}	BAP	11.6	Ingestion of Soil	6.7	1.67	Al	13.9	Dermal Contact with Soil	98.8
		As	50.8	Dermal Contact with Soil	61.4		Sb	21.9		
		Np-237	7.4	External Exposure from Soil	31.9		As	7.1		
		Th-228	13.7				Hg	6.0		
		U-235	3.4				V	51.1		
		U-238	8.7							
Future industrial worker	4.2×10^{-5}	MeCl2	9.3	Ingestion of Soil	6.1	1.94	Al	11.9	Ingestion of Groundwater	13.3
		BAP	10.6	Ingestion of Groundwater	8.2		Sb	18.8	Dermal Contact with Soil	85.1
		As	46.0	Dermal Contact with Soil	55.7		As	6.1		
		Np-237	6.7	External Exposure from Soil	28.9		Mn	10.8		
		Th-228	12.4				Hg	5.2		
		U-235	3.0				V	44.0		
		U-238	7.9							
Future adult rural resident	4.1×10^{-3}	MeCl2	2.1	Ingestion of Soil	0.6	18.1	MeCl2	1.2	Ingestion of Groundwater	4.0
		A-1260	2.3	Ingestion of Groundwater	0.5		Al	20.2	Dermal Contact with Soil	11.3
		BAA	0.7	Dermal Contact with Soil	1.8		Sb	8.6	Consumption of Vegetables Irrigated	3.0
		BAP	6.4	Inhalation of Volatiles in	0.04		As	38.5	with Groundwater	
		BBF	0.9	Groundwater while Showering			Ba	1.0	Consumption of Vegetables in Soil	81.2
		As	69.6	Inhalation of Volatiles in	0.2		Mn	5.1		
		Np-237	3.5	Groundwater During Household Use			Hg	12.9		
		Th-228	3.1	External Exposure from Soil	2.2		V	12.8		
		U-234	3.8	Consumption of Vegetables	1.5					
		U-235	0.6	Irrigated with Groundwater						
		U-238	6.7	Consumption of Vegetables in Soil	93.3					
Future child rural resident	NA	NA	NA	NA		86.7	MeCl2	1.0	Ingestion of Groundwater	2.0
							Al	20.5	Ingestion of Soil	0.7
							Sb	8.9	Dermal Contact with Soil	12.1
							As	39.0	Consumption of Vegetables Irrigated	3.0
							Ba	0.7	with Groundwater	
							Mn	3.5	Consumption of Vegetables in Soil	82.7
							Hg	13.1		
							V	13.4		

Notes: NA = ELCR not applicable to child cohort. Values for adult include exposure as child.

Definitions for COCs:

A-1260	Aroclor 1260	BAP	benzo(a)pyrene	Np-237	neptunium-237	U-238	uranium-238
Al	aluminum	BBF	benzo(b)fluoranthene	Sb	antimony	V	vanadium
As	arsenic	Hg	mercury	Th-228	thorium-228		
Ba	barium	MeCl2	methylene chloride	U-234	uranium-234		
BAA	benz(a)anthracene	Mn	manganese	U-235	uranium-235		

Table 3.60. Risk results for WAGs 1 and 7 SWMUs

	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Current industrial worker	2.9×10^{-4}	As Be	5.5 94.5	Dermal Contact with Sediment	99.6	5.2	Al As Ba Cd Fe Mn V	5.2 1.9 2.3 5.6 22.9 38.2 23.3	Dermal Contact with Surface Water Dermal Contact with Sediment	7.4 92.2
Future industrial worker	2.9×10^{-4}	As Be	5.5 94.1	Dermal Contact with Sediment	99.6	5.2	Al As Ba Cd Fe Mn V	5.2 1.9 2.3 5.6 22.9 38.2 23.3	Dermal Contact with Surface Water Dermal Contact with Sediment	7.4 92.2
Future adult recreational user	4.6×10^{-4}	As Be	5.9 94.1	Ingestion of Sediment Dermal Contact with Sediment	0.6 99.3	1.8	Cd Fe Mn V	7.2 22.7 37.4 22.8	Dermal Contact with Surface Water Dermal Contact with Sediment	9.6 89.6
Future child recreational user	NA	NA	NA	NA		12.4	Al As Ba Cd Fe Mn V	5.2 2.0 2.3 5.5 23.2 38.0 23.1	Dermal Contact with Surface Water Ingestion of Sediment Dermal Contact with Sediment	7.3 1.4 91.1
Future teen recreational user	NA	NA	NA	NA		8.3	Al As Ba Cd Fe Mn V	5.3 2.0 2.3 5.5 23.1 38.0 23.1	Dermal Contact with Surface Water Dermal Contact with Sediment	7.3 91.5

Notes: NA = ELCR not applicable to child and teen cohorts. Values for adult ELCR include exposure as child and teen.

Definitions of COCs:

Al	aluminum	Be	beryllium	Mn	manganese
As	arsenic	Cd	cadmium	V	vanadium
Ba	barium	Fe	iron		

Table 3.61. Risk results for WAGs 1 and 7 SWMUs

	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Current industrial worker	2.2×10^{-4}	As Be	6.7 92.8	Dermal Contact with Sediment	99.1	2.75	Al Fe Mn V	7.5 29.4 29.9 26.9	Dermal Contact with Sediment	97.8
Future industrial worker	2.2×10^{-4}	As Be	6.7 92.8	Dermal Contact with Sediment	99.1	2.75	Al Fe Mn V	7.5 29.4 29.9 26.9	Dermal Contact with Sediment	97.8
Future adult recreational user	3.6×10^{-4}	As Be	7.0 92.5	Ingestion of Sediment Dermal Contact with Sediment External exposure from Sediment	0.6 98.9 0.3	0.94	Fe Mn V	29.6 30.0 26.8	Dermal Contact with Sediment	97.3
Future child recreational user	NA	NA	NA	NA		6.52	Al As Ba Fe Mn V	10.9 3.5 1.7 29.8 29.8 26.7	Ingestion of Sediment Dermal Contact with Sediment	1.7 96.9
Future teen recreational user	NA	NA	NA	NA		4.34	Al As Fe Mn V	7.6 3.5 29.7 29.9 26.7	Dermal Contact with Sediment	97.5

Notes: NA = ELCR not applicable to child and teen cohorts. Values for adult ELCR include exposure as child and teen.
Definitions of COCs:

Al	aluminum	Be	beryllium	V	vanadium
As	arsenic	Fe	iron		
Ba	barium	Mn	manganese		

Table 3.62. Risk results for WAGs 1 and 7 SWMUs

	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Current industrial worker	1.4×10^{-6}	Th-228	84.5	External Exposure from Soil	97.9					
Future industrial worker	1.7×10^{-6}	Th-228	71.0	External Exposure from Soil	82.2	1.44	Al	9.2	Ingestion of Groundwater	91.7
							Fe	45.6		
Future adult rural resident	7.8×10^{-5}	MeCl2	4.3	Ingestion of Groundwater	1.6	6.58	Al	8.5	Ingestion of Groundwater	55.9
		bis	1.3	External Exposure from Soil	23.9		Sb	9.7	Dermal Contact with Soil	2.9
		Th-228	69.1	Consumption of Vegetables			Ba	6.3	Consumption of Vegetables Irrigated	30.9
		U-235	5.3	Irrigated with Groundwater	3.4		Fe	42.1	with Groundwater	
		U-238	20.1	Consumption of Vegetables in	70.1		Mn	31.2	Consumption of Vegetables in Soil	8.7
				Soil			Hg	1.9		
Future child rural resident	NA	NA	NA	NA		22.7	Al	7.9	Ingestion of Groundwater	39.2
							Sb	13.9	Dermal Contact with Groundwater	0.8
							Ba	5.9	Dermal Contact with Soil	4.3
							Fe	39.3	Consumption of Vegetables Irrigated	43.2
							Mn	29.8	with Groundwater	
							Hg	2.7	Consumption of Vegetables in Soil	12.2

Notes: NA = ELCR not applicable to child cohort. Values for adult ELCR include exposure as child.

Definitions of COCs:

Al	aluminum	Fe	iron	MeCl2	methylene chloride	U-235	uranium-235
Ba	barium	Hg	mercury	Sb	antimony	U-238	uranium-238
bis	bis(2-ethylhexyl)ether	Mn	manganese	Th-228	thorium-228		

Table 3.63. Risk results for WAGs 1 and 7 SWMUs

	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Future industrial worker	6.9×10^{-6}	TCE	95.6	Ingestion of Groundwater	62.4	0.7	TCE	32.6	Ingestion of Groundwater	89.3
				Dermal Contact with groundwater	15.7		Mn	59.9		
				Inhalation of volatiles in Groundwater while Showering	18.4					
Future adult rural resident	1.1×10^{-4}	TCE	75.9	Ingestion of Groundwater	21.1	3.1	TCE	34.5	Ingestion of Groundwater	55.3
		BAA	1.2	Dermal Contact with groundwater	3.8		Ba	6.4	Dermal Contact with Groundwater	4.8339.3
		BAP	16.6	Inhalation of volatiles in Groundwater	4.0		Mn	60.1	Consumption of Vegetables	
		BBF	2.1	while Showering					Irrigated with Groundwater	
		DAHA	2.6	Inhalation of Volatiles in Groundwater	21.1					
		IcdP	1.0	During Household Use						
				Dermal Contact with Soil	1.2					
				Consumption of Vegetables Irrigated with Groundwater	26.3					
				Consumption of Vegetables in Soil	22.5					
Future child rural resident	NA	NA	NA	NA		10.5	TCE	35.6	Ingestion of Groundwater	39.7
							Sb	1.5	Dermal Contact with Groundwater	2.7
							Ba	6.1	Consumption of Vegetables	56.4
							Mn	57.0	Irrigated with Groundwater	
									Consumption of Vegetables in Soil	1.0

Notes: NA = ELCR not applicable to child cohort. Values for adult ELCR include exposure as child.

Definitions of COCs:

Ba	Barium	BBF	benzo(b)fluoranthene	Mn	manganese
BAA	benz(a)anthracene	DAHA	dibenzo(a,h)anthracene	Sb	antimony
BAP	benzo(a)pyrene	IcdP	indeno(1,2,3-cd)pyrene	TCE	trichloroethene

Table 3.64. Risk results for WAGs 1 and 7 SWMUs

	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Future adult rural resident	9×10^{-5}	BAA	9.8	Dermal Contact with Soil	5.2					
		BAP	73.1	Consumption of	94.1					
		BBF	7.9	Vegetables in Soil						
		DAHA	4.7							
		IcdP	3.5							
Future child rural resident	NA	NA	NA	NA						

Notes: NA = ELCR not applicable to child cohort. Values for adult ELCR include exposure as child.
Definitions of COCs:

BAA	benz(a)anthracene	BBF	benzo(b)fluoranthene	IcdP	indeno(1,2,3-cd)pyrene
BAP	benzo(a)pyrene	DAHA	dibenzo(a,h)anthracene		

Table 3.65. Risk results for WAGs 1 and 7 SWMUs

	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Future adult rural resident	3×10^{-6}	BAP	72.2	Consumption of Vegetables in Soil	93.9					
Future child rural resident	NA	NA	NA	NA						

Notes: NA = ELCR not applicable to child cohort. Values for adult include exposure as child.
Definition of COCs:

BAP	benzo(a)pyrene

Table 3.66. Risk results for WAGs 1 and 7 SWMUs

	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Current industrial worker	3.2×10^{-4}	As	7.7	Dermal Contact with Sediment	99.4	6.6	Sb	11.1	Dermal Contact with Surface Water	20.3
		Be	92.1				As	2.3	Dermal Contact with Sediment	79.2
							Fe	26.1		
							Mn	20.9		
							V	36.2		
Future industrial worker	3.2×10^{-4}	As	7.7	Dermal Contact with Sediment	99.4	6.6	Sb	11.1	Dermal Contact with Surface Water	20.3
		Be	92.1				As	2.3	Dermal Contact with Sediment	79.2
							Fe	26.1		
							Mn	20.9		
							V	36.2		
Future adult recreational user	9.0×10^{-4}	As	4.5	Ingestion of fish	33.1	39.8	Sb	8.2	Dermal Contact with Surface Water	1.4
		Be	62.2	Dermal contact with leachate	10.0		Cd	0.9	Dermal contact with Leachate	0.4
		^{99}Tc	33.1	Ingestion of Sediment	0.4		Fe	11.6	Consumption of fish	93.5
				Dermal Contact with Sediment	56.3		Mn	72.6	Dermal Contact with Sediment	4.4
							V	3.6	ingestion of venison from leachate	0.3
							Zn	2.6		
Future child recreational user	NA	NA	NA	NA		53.7	Al	0.4	Dermal Contact with Surface Water	5.6
							Sb	8.9	Dermal contact with Leachate	1.5
							As	0.7	Consumption of fish	69.5
							Ba	0.2	Ingestion of Sediment	0.4
							Be	0.2	Dermal Contact with Sediment	22.9
							Cd	0.7	ingestion of venison from leachate	0.2
							Fe	15.6		
							Mn	59.2		
							V	11.7		
							Zn	2.0		
Future teen recreational user	NA	NA	NA	NA		71.5	Al	0.2	Dermal Contact with Surface Water	2.8
							Sb	8.5	Dermal contact with Leachate	0.8
							As	0.3	Consumption of fish	84.6
							Cd	0.8	Ingestion of Sediment	0.1
							Fe	13.1	Dermal Contact with Sediment	11.5
							Mn	67.7	ingestion of venison from leachate	0.2
							Sr	0.2		
							V	6.5		
							Zn	2.4		

Table 3.66. Risk results for WAGs 1 and 7 SWMUs (continued)

	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Current industrial worker	4.1×10^{-5}	BAA	2.8	Ingestion of Soil	20.6	0.96	Sb	52.8	Dermal Contact with Soil	98.8
		BAP	26.3	Dermal Contact with Soil	34.9		Mn	45.6		
		BBF	3.4	External Exposure from Soil	43.7					
		Np-237	10.8							
		Th-230	15.8							
		U-235	2.5							
		U-238	33.2							
Future industrial worker	1.1×10^{-3}	1,1-DCE	3.9	Ingestion of Soil	0.8	44.9	1,2DCE	0.4	Ingestion of Groundwater	96.2
		BAA	0.1	Ingestion of Groundwater	76.6		Al	1.1	Dermal Contact with Groundwater	1.7
		BAP	1.0	Dermal Contact with Soil	1.3		Sb	1.1	Dermal Contact with Soil	2.1
		BBF	0.1	Dermal Contact with Groundwater	17.3		Be	0.3		
		Be	90.2	Inhalation of Volatiles in Groundwater while Showering	0.8		Co	0.3		
		Np-237	0.1	External Exposure from Soil	2.0		Fe	90.9		
		Th-228	0.6		1.6		Mn	5.1		
		Th-230	0.4				Ni	0.7		
		U-234	0.1							
		U-235	2.2							
		U-238								
Future adult rural resident	1.7×10^{-2}	1,1DCE	4.8	Ingestion of Soil	0.3	194	1,2DCE	1.8	Ingestion of Groundwater	62.4
		TCE	0.02	Ingestion of Groundwater	26.4		Al	1.0	Dermal Contact with Groundwater	0.9
		A-1260	0.9	Dermal Contact with Soil	0.3		Sb	1.0	Dermal Contact with Soil	0.6
		BAA	0.4	Dermal Contact with Groundwater	4.3		Be	0.3	Consumption of Vegetables Irrigated with Groundwater	34.0
		BAP	3.5				Co	0.3		
		BBF	0.4	Inhalation of Volatiles in Groundwater while Showering	0.5		Fe	88.7	Consumption of Vegetables in Soil	2.4
		BKF	0.02				Mn	6.0		
		IcdP	0.3	Inhalation of Volatiles in Groundwater During Household Use	2.4		Hg	0.2		
		Be	46.6				Ni	0.7		
		Np-237	1.3				Zn	0.1		
		Th-228	0.2	External Exposure from Soil	0.7					
		Th-230	33.4	Consumption of Vegetables Irrigated with Groundwater	18.4					
		U-234	2.9							
		U-235	0.1	Consumption of Vegetables in Soil	47.9					
		U-238	6.4							
Future excavation worker	1.09×10^{-6}	NONE		NONE		0.29	NONE		NONE	

Table 3.66. Risk results for WAGs 1 and 7 SWMUs (continued)

	Total ELCR	COCs	% Total ELCR	POCs	% Total ELCR	Total HI	COCs	% Total HI	POCs	% Total HI
Future child rural resident	NA	NA	NA	NA		642	1,1DCE	0.04	Ingestion of Groundwater	45.5
							1,2DCE	2.4	Dermal Contact with Groundwater	0.5
							TCE	0.03	Ingestion of Soil	0.03
							Al	1.0	Dermal Contact with Soil	0.09
							Sb	1.5	Consumption of Vegetables Irrigated	49.5
							Be	0.2	with Groundwater	
							Co	0.3	Consumption of Vegetables in Soil	3.5
							Fe	86.4		
							Mn	6.8		
							Hg	0.2		
							Ni	0.7		
							Sr	0.05		
							Zn	0.2		

Notes: NA = ELCR not applicable to child and teen cohorts. Values for adult include exposure as child and teen

Definition of COCs.

Al	aluminum	Be	beryllium	Mn	manganese	^{99}Tc	technetium-99
As	arsenic	Cd	cadmium	Sb	antimony	V	vanadium
Ba	barium	Fe	iron	Sr	strontium	Zn	zinc

Table 3.67. SWMUs in WAG 23 and SWMU 1 of WAG 27

SWMU	Description
1	C-747-C Oil Landfarm
32 and 33	C-728 Clean Waste Oil Tanks and Motor Cleaning Facility
56 and 80	C-540-A PCB Waste Staging Area and Spill Site
57 and 81	C-541-A PCB Waste Staging Area and Spill Site
74	C-340 PCB Spill Site
79	C-611 PCB Spill Site

3.2.8.1 SWMU 1 — C-747-C Oil Landfarm

Location and Setting

The location and setting of SWMU 1 are provided in Sect. 3.2.4 of this report. This section focuses on surface soils that were included in WAG 23 (DOE 1994a).

Surface-water hydrology, wetlands, and floodplains. The surface water that drains from SWMU 1 into the surrounding ditches is carried west through Outfall 008 into Bayou Creek (Fig. 3.55). Wetlands identified in the vicinity of SWMU 1 are shown in Fig. 3.21. A 100-year floodplain is located to the southwest of SWMU 1 (Fig. 3.56).

Biological resources. Vegetation inside the fence is mowed grass providing very little to no wildlife habitat. No potential habitats for federally listed T&E species are present within the fence (CDM Federal 1994).

Soils and prime farmland. Historically, soils within the impacted area of SWMU 1 are Calloway silt loam, 0% to 2% slope. However, the soils associated with these areas have been disturbed by past activities and, consequently, are not classified as prime farmland.

Manufacturing/TSD Processes

The landfarm was used for the biodegradation of contaminated waste oils from 1975 to 1979. When in use, the area was plowed to a depth of 0.3 to 0.6 m (1 to 2 ft), and then waste oils, contaminated with TCE, 1,1,1-TCA, uranium, and PCBs, were spread across the surface. Periodically, lime and fertilizers also were plowed into the soil. At one time, a layer of gravel was added to the landfarm to improve drainage.

Summary of Previous Investigations for SWMU 1 Surface Soils

The following section provides information about the sampling performed at SWMU 1. The focus of this description is surface soils as subsurface soils and groundwater contamination are discussed in Sect. 3.2.4. The results of the sampling performed at SWMU 1 are included in the nature and extent of contamination subsection. Sampling information used to describe soil contamination at SWMU 1 include data from Phase I and Phase II of the PGDP SI and additional sampling performed March 1996 and reported in an appendix of the FS report. Phase I and Phase II SI data were used in the FS to estimate the nature and extent of contamination, to calculate risks and hazards, and to make appropriate response action decisions. The additional samples were collected from a more defined, gridded area, in March 1996 to supplement Phase I and Phase II SI data. This information was used to refine the area and volume of PCB contamination.

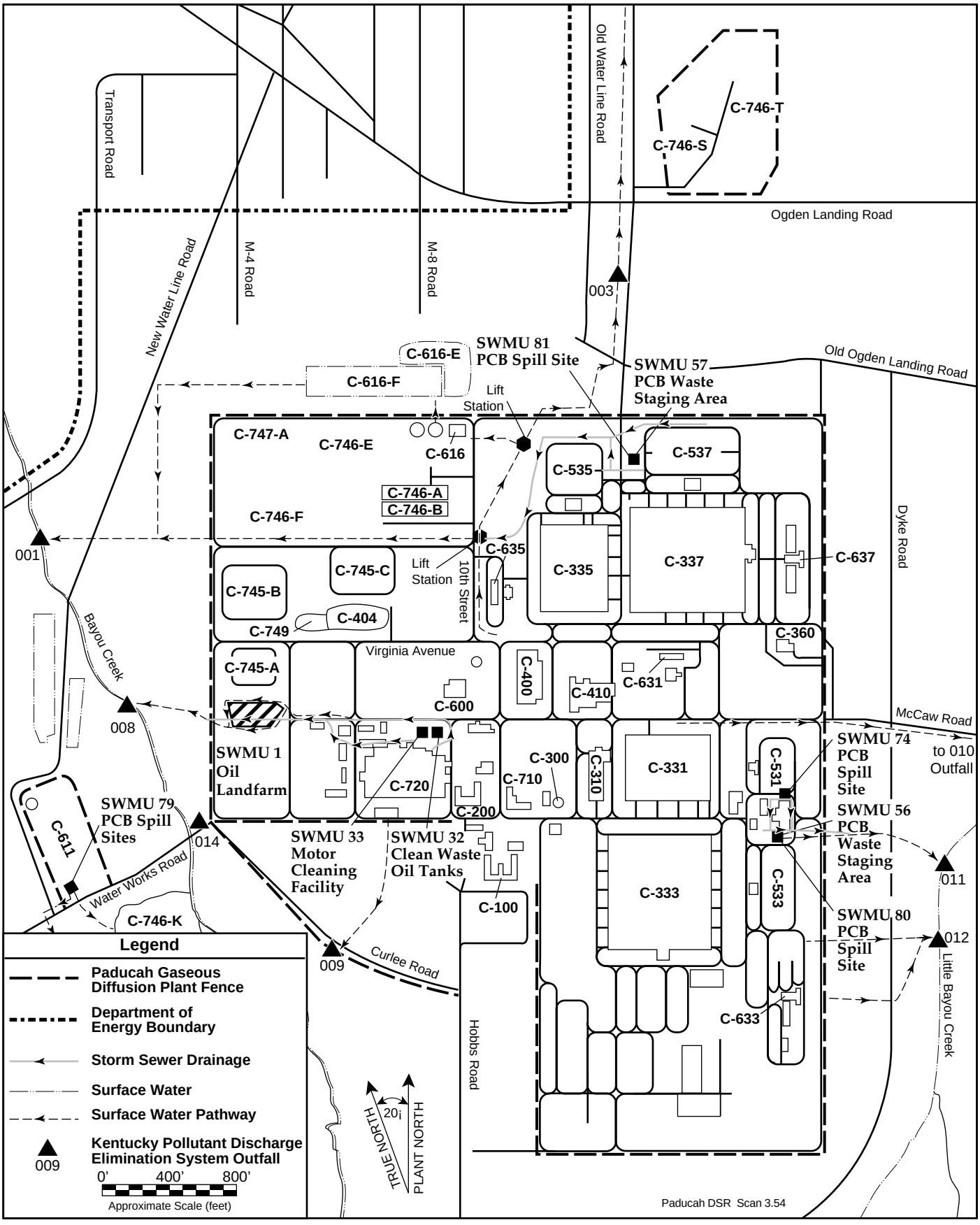


Fig. 3.54. Location of SWMU 1 and SWMUs in WAG 23 at the PGDP

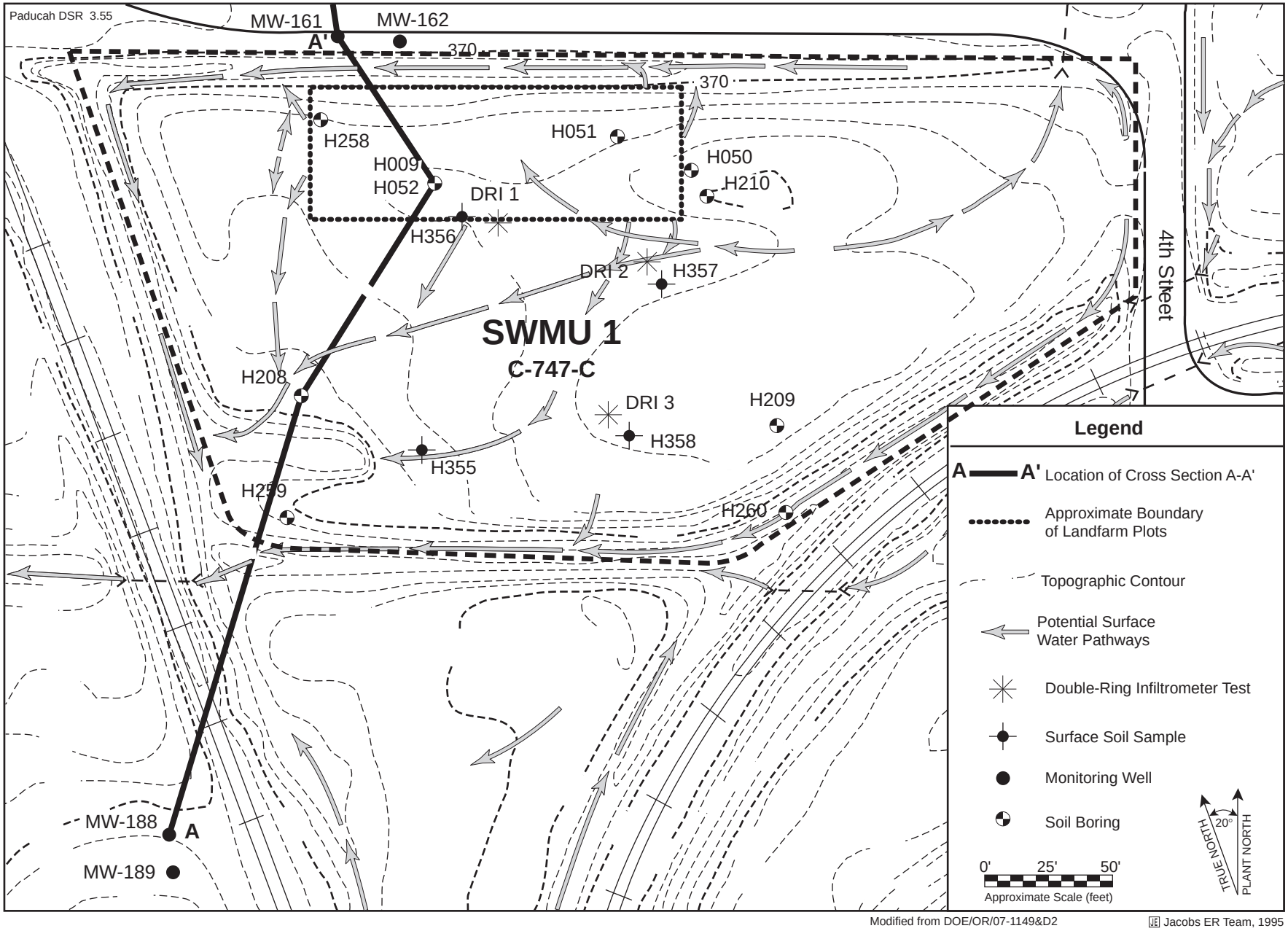


Fig. 3.55. Physical features of SWMU 1 at the PGDP.

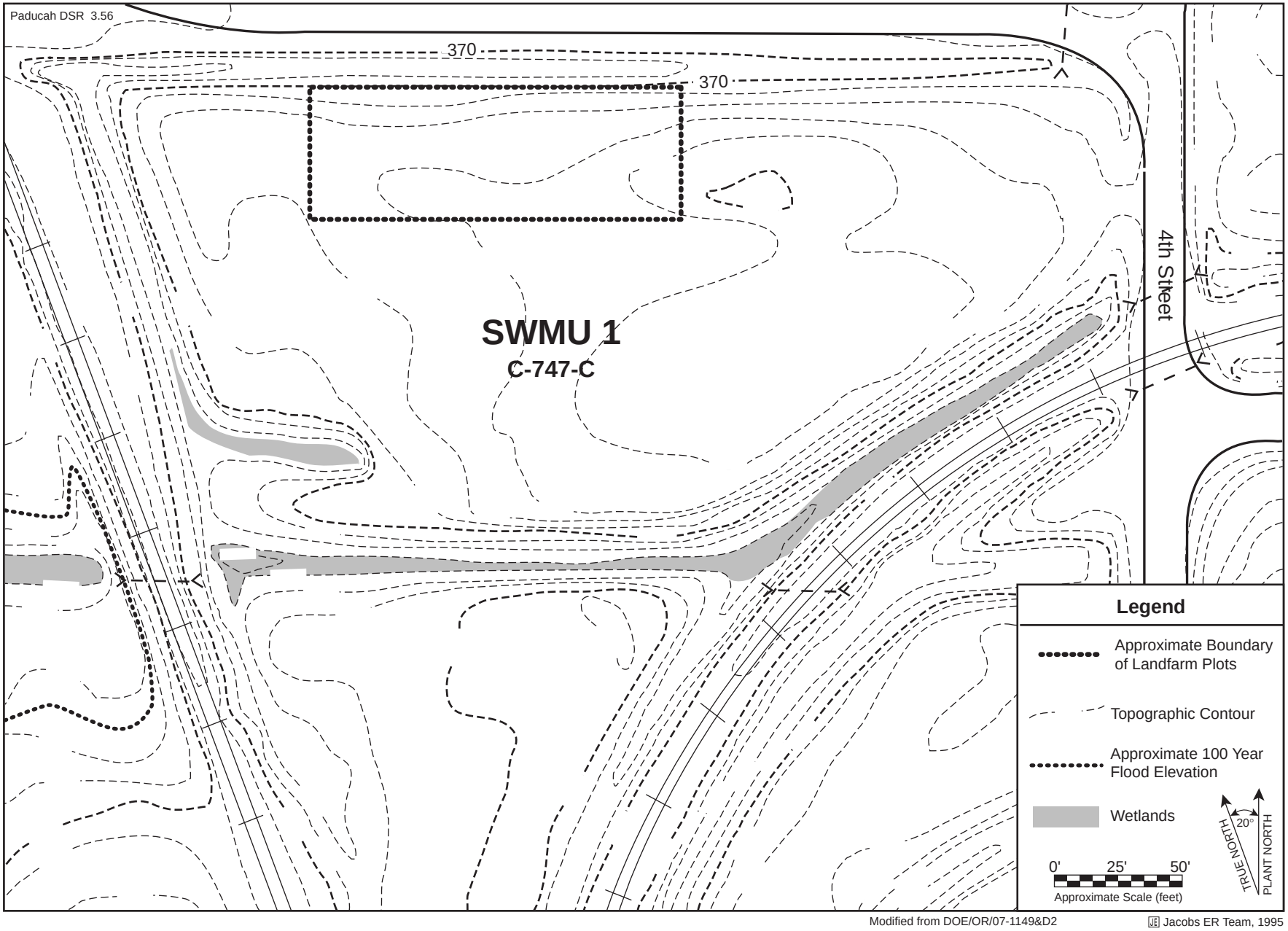


Fig. 3.56. Approximate location of wetlands and the 100-year flood elevation near SWMU 1 at the PGDP.

Phase I and Phase II SI at SWMU 1. An SI was performed to assess potential releases from the landfarm area via surface-water runoff and groundwater migration. The surface migration pathway was investigated by conducting a surface radiation walkover and by taking samples at the surface over the SWMU and in surrounding ditches (DOE 1994a). Three shallow soil borings (H050, H051, and H052) were drilled during the Phase I investigation. Shallow borings were drilled up to 1.8 m (6 ft) deep to extend below the bottom of the former 0.6-m (2-ft) deep plots. During Phase II of the SI, three more shallow soil borings (H258, H259, and H260) were drilled. Additionally, four surface soil samples were taken (H355, H356, H357, and H358) for geotechnical and treatability testing parameters were used in evaluating stabilization or thermal treatment technologies (Fig. 3.57).

Additional sampling to support the Phase I and Phase II SI. As previously mentioned, additional sampling was performed in March 1996 to support Phase I and Phase II SI data. The DOE gridded the Oil Landfarm into 44 – 7.6 × 7.6 m (25 × 25 ft) and 11 – 7.6 × 7.6 m (50 × 50 ft) sections (a total of 55 sections) and 5-point composite sampled (at the four corners and in the middle of each gridded area) at 0 to 0.3 and 1.5 m (0 to 1 and 5 ft) depth intervals (Fig. 3.57). Deeper samples [to 9.2 m (30 ft)] also were collected. The deeper borings are discussed in Sect. 3.2.4.

Geology/Hydrology

Calloway silt loam is the predominant soil type at SWMU 1. The Calloway soil series contains poorly drained acidic soils formed in loess or alluvium (USDA 1976). This type of soil usually contains a fragipan layer. Since the soil in the oil landfarm was disturbed during past operations, the fragipan layer is likely to be absent. However, the fragipan layer is probably still present at SWMU 1 outside the landfarm. Permeability in the silt loam would probably be in the range of 4.23×10^{-4} cm/sec (1.20 ft/d) and 1.41×10^{-3} cm/sec (3.99 ft/d) (USDA 1976).

During the Phase II SI, double-ring infiltrometer tests were conducted on surface soils at SWMU 1. Average long-term infiltration rates were 7×10^{-5} cm/sec (0.20 ft/d) (DRI-1), 3×10^{-4} cm/sec (0.85 ft/d) (DRI-2), and 4×10^{-6} cm/sec (0.17 ft/d) (DRI-3) (CH2M HILL 1992).

Phase I borings H050 and H051 were 1.8 m (6 ft) deep and contained damp to dry silty clay with some gravel in the upper 0.3 m (1 ft). Boring H052 contained moist to damp silty clay with some gravel occurring throughout its 1.8 m (6 ft) depth. The deepest Phase I boring is the 20-m (66-ft) deep H009.

Phase II borings H258 and H259 were 1.8 m (6 ft) deep and contained moist silty clay. Boring H260 had organic soil with gravel in the upper 0.6 m (2 ft) and moist silty clay from 0.61 to 1.8 m (4 to 6 ft). Borings H355, H356, and H358 were drilled to 1.5 m (0.5 ft) and contained moist lean clay. Boring H357 contained 0.15 m (0.5 ft) of poorly graded gravel with clay and sand. Borings H208, H209, and H210 were all deep enough to reach the upper part of the RGA.

A summary of geotechnical testing data for borings H210, H258, H259, H355, H356, H357, and H358 is provided in Table 3.68. These data were used in establishing the soil type present at the unit.

Nature and Extent of Contamination

Based on the results of the SI, the surface soils within SWMU 1 contained PCBs at concentrations up to 35,000 µg/kg; however, additional investigation of SWMU 1 in March 1996 determined that no gridded area had PCBs at a concentration greater than 25 ppm. The maximum detected PCB concentration identified in the additional sampling was Aroclor-1248 at 3,344 µg/kg in grid area 39. The PCBs detected in surrounding ditches during the SI were at significantly lower concentrations (approximately 270 µg/kg).

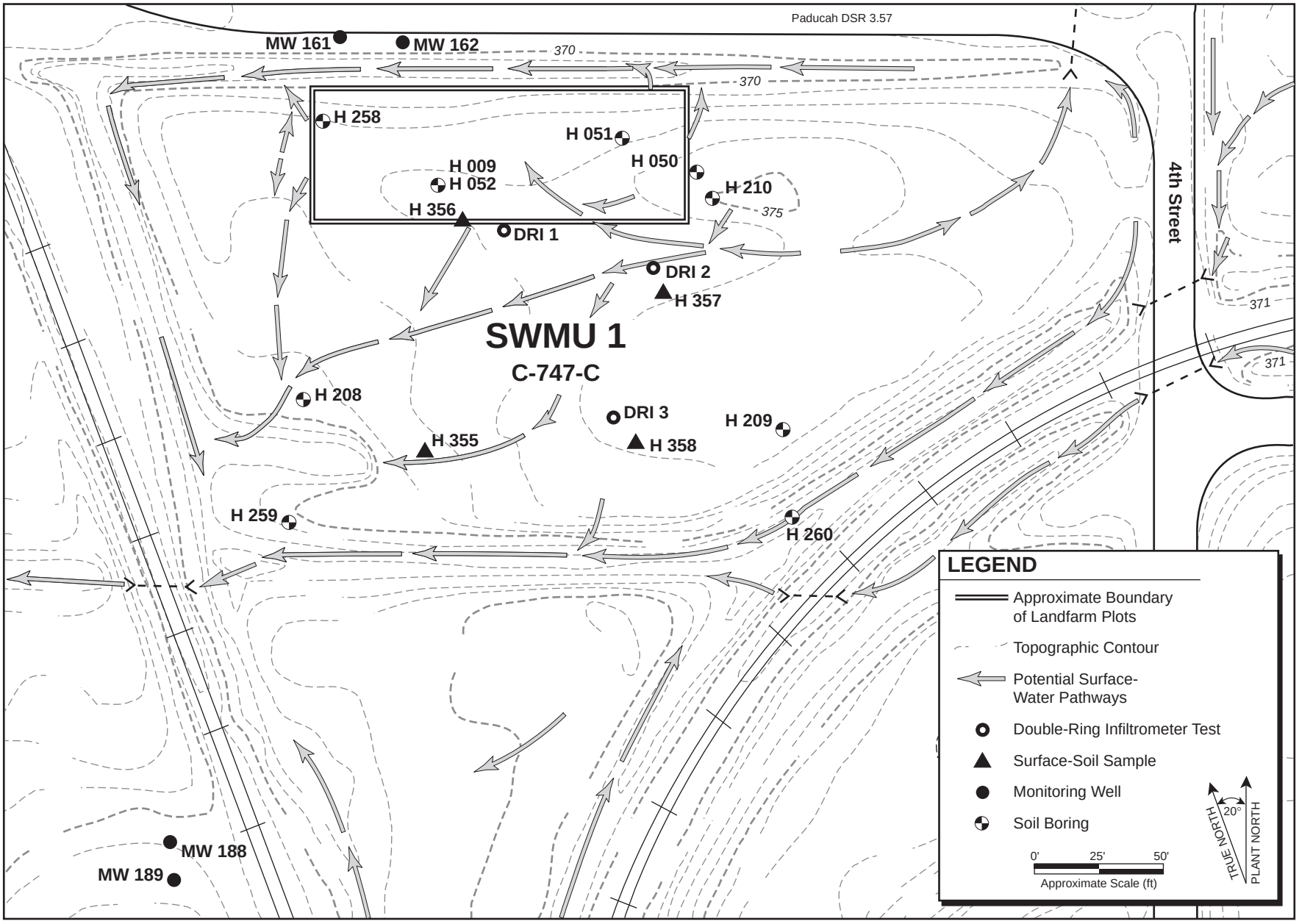


Fig. 3.57. Location of historical samples collected at SWMU 1 at the PGDP.

Table 3.68. Summary of geotechnical testing data for SWMU 1

Boring no.	Sample depth (ft)	Natural moisture content (%)	Atterberg limits (%)			pH in water	Grain size analysis			Unit weight (pcf)		Specific gravity
			L.L.	P.L.	P.I.		Finer than no. 200 (%)	Finer than no. 40 (%)	Finer than no. 4 (%)	Wet	Dry	
H210	10 to 12	22.3	27	20	7	ñ	93.6	ñ	ñ	129.5	105.9	ñ
H210	55 to 57	18.7	NP	NP	NP	ñ	16.3	ñ	ñ	127.7	107.5	ñ
H210	25 to 26.5	ñ	ñ	ñ	ñ	ñ	64.1	95	99	ñ	ñ	ñ
H258	1 to 2	21.2	35	22	13	6	77.1	82	89	ñ	ñ	2.66
H259	1 to 2	17.6	31	17	14	7	61.6	86	95	ñ	ñ	2.65
H355	0 to 0.5	20.6	37	23	14	5.9	93.2	99	100	ñ	ñ	ñ
H356	0 to 0.5	25.5	41	25	16	6.2	53.7	60	78	ñ	ñ	ñ
H357	0 to 0.5	25.4	39	23	16	6.0	84.9	93	98	ñ	ñ	ñ
H358[a]	0 to 0.5	5.0	36	26	10	7.6	14.7	29	56	ñ	ñ	ñ

[a] Sample taken of gravel road base placed during the site investigation

Source: DOE/OR/07-1149&D2

NP = Non-Plastic P.L. = Plastic Limit

L.L. = Liquid Limit P.I. = Plasticity Index

Dioxins, uranium, and ^{99}Tc also were detected in the surface soils at SWMU 1. The only dioxin value of significance was the detection of 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) at 1.43J µg/kg (J indicates the value was estimated) in boring H050. The maximum uranium detect was ^{238}U at 15 pCi/g at the surface in boring H052. The most significant detect of ^{99}Tc was identified at the surface in boring H210 at 640 pCi/g. None of these constituents appear at elevated concentrations in Outfall 008, which collects surface-water runoff from the area.

Fate and Transport of Contamination

Sediments at SWMU 1 have the potential to be transported via erosion and surface-water runoff. Runoff from this unit flows through KPDES Outfall 008 before reaching Bayou Creek. Currently, due to the relatively flat surface of the area and grass cover on SWMU 1 and the ditches leading to Outfall 008, erosion would be mitigated. Consequently, the transport of PCBs, dioxins, and furans via erosion and surface-water runoff is impeded. To date, no PCBs have been detected at Outfall 008. However, historical erosion and surface runoff originating from SWMU 1 may be responsible for the presence of PCBs, dioxin/furans, and radionuclides found in the soil within the surrounding ditches.

Summary of Previous Remedial Actions at SWMU 1

In December 1997, the DOE conducted a nontime-critical removal action at SWMU 1 to remove dioxins in excess of the cleanup goal of 1.3 ppb. The only sample location with contamination above the established cleanup level was soil boring H050. Boring H050, completed during the Phase I SI, contained a detection of 2,3,7,8-TCDD at 1.43J ppb (the J indicates that the value was estimated), which exceeded the 1.3 ppb total dioxin risk-based cleanup level without adding other dioxin congeners present. Consequently, an area of $7.6 \times 7.6 \times 0.3$ m ($25 \times 25 \times 1$ ft), or a total of approximately 18 m^3 (23 yd^3) of dioxin-contaminated soil was excavated at SWMU 1. Figure 3.57 includes a diagram of the dioxin excavation area and shows the location of boring H050.

3.2.8.2 SWMUs 32 and 33 — C-728 Clean Waste Oil Tank and Motor Cleaning Facility

Location

The C-728 Clean Waste Oil Tanks (SWMU 32) consist of two aboveground tanks east of the C-728 Motor Cleaning Facility (SWMU 33). These units are located in the central part of the plant area, south of Tennessee Avenue and west of 8th street (Fig. 3.58).

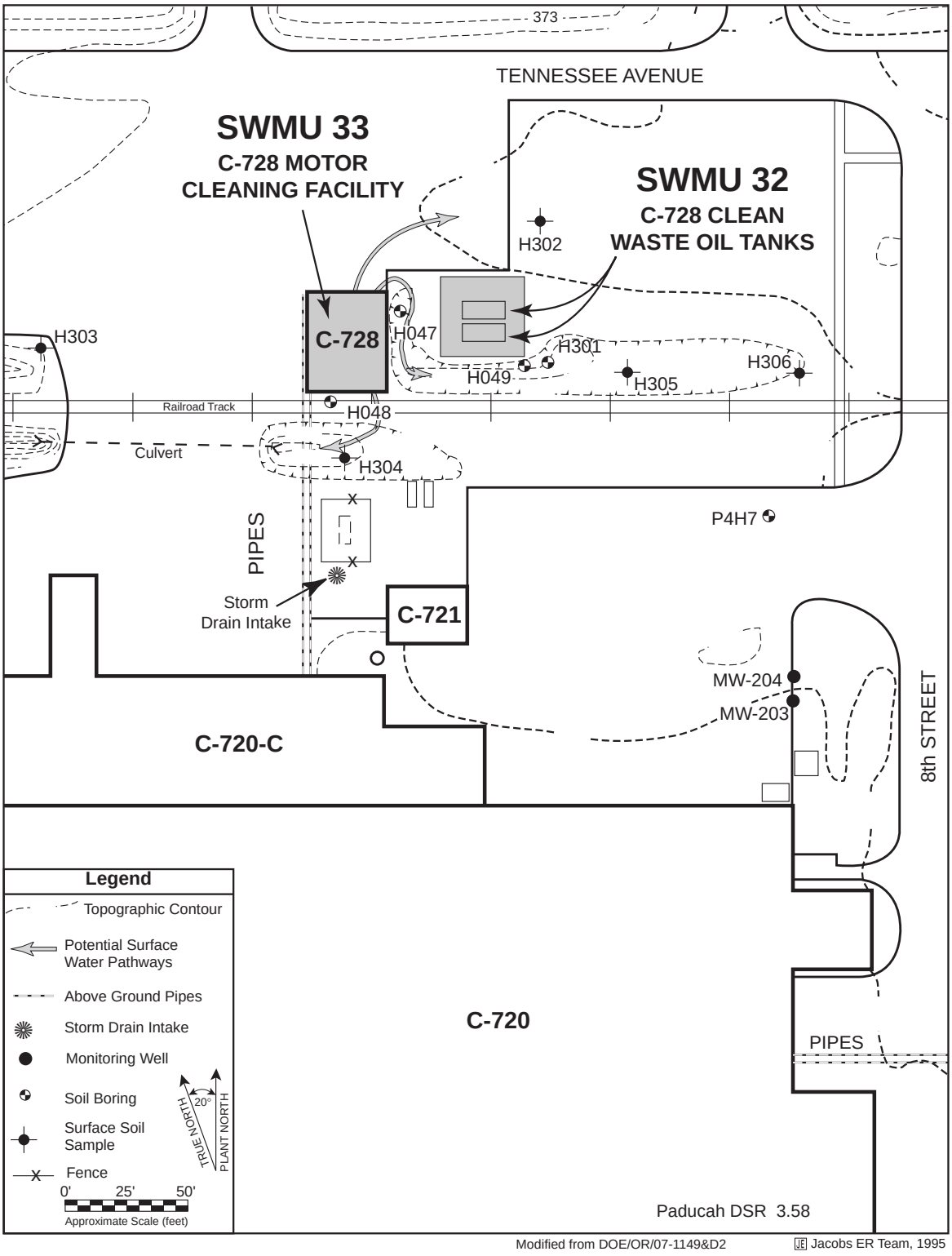


Fig. 3.58. Physical features of SWMUs 32 and 33.

Setting

At SWMU 32, the 8,000-gal tank and the 4,000-gal tank originally stored motor cleaning solvents, such as mineral spirits, but later were used for storing waste oils. A 12 × 12 m (40 × 40 ft) curbed cement pad lies beneath these tanks.

The C-728 Motor Cleaning Facility (SWMU 33), which was used for cleaning electrical motors from the cascade buildings, is made of structural steel and corrugated siding and has dimensions of 13.7 × 10.7 × 4.7 m (45 × 35 × 32 ft).

Together, SWMUs 32 and 33 cover approximately 0.2 hectares (0.5 acres). A concrete-paved parking area abuts the units to the north and west, and a rail spur borders the units to the south.

Surface-water hydrology, wetlands, and floodplains. The surface area near SWMUs 32 and 33 is relatively flat except for ditches that parallel the railroad tracks (Fig. 3.58). Surface water in these ditches generally flows to the plant storm sewers and then west to KPDES Outfall 008. A storm sewer drain intake is located in the ditch on the south side of the railroad tracks southwest of the C-728 Motor Cleaning Facility. Surface water that flows through KPDES Outfall 008 empties into Bayou Creek. No wetlands have been identified in the vicinity of SWMUs 32 and 33 (CDM Federal 1994). No 100-year floodplains are adjacent to SWMUs 32 and 33.

Biological resources. Vegetation inside the fence is mowed grass providing very little to no wildlife habitat. No potential habitats for federally listed T&E species are present within the fence (CDM Federal 1994).

Soils and prime farmland. Historically, soils within the impacted area of SWMUs 32 and 33 are Henry silt loams. However, the soils associated with these areas have been disturbed by past activities, decreasing the likelihood that any of these areas are prime farmland.

Manufacturing/TSD Processes

Currently, the C-728 tanks (SWMU 32) are not in use. SWMU 33 has been in use since 1957; however, its method of operation changed in 1975. Since then, motors have been cleaned using a steam cleaning unit and a water treatment unit instead of dipping the motors into a tank of mineral spirits, as had been done in the past. Before 1975, wastes from this facility included mineral spirits containing grease, oil, and uranium. After 1975, the waste stream included aqueous solutions of uranium and sodium hydroxide. At present, this facility is rarely used.

Summary of previous actions (excluding previous remedial actions). During early January 1994, it was learned that soils in the vicinity of C-728, C-541, and C-540 (SWMUs 32 and 33, SWMUs 57 and 81, and SWMUs 56 and 80, respectively) had been disturbed by construction activities during dike upgrades. This construction project was commissioned and managed by Lockheed Martin Utility Services.

The dike upgrade construction took place between November 1993 and April 1994. Conflicting reports have been received regarding whether any soil was removed from these sites during construction. Soil piles discovered north of C-746-F, east of the patrol road, may have been generated by the dike upgrade construction activities. These soil piles were sampled in August 1994 for total PCB contamination, which was found to be less than 0.1 mg/kg.

Summary of Previous Investigations

The following describes the sampling scheme at SWMUs 32 and 33. As with SWMU 1, data used to describe soil contamination at these units are from two sources: Phase I and Phase II of the PGDP SI, and additional sampling performed March 1996, reported in an appendix of the FS report. Phase I and Phase II SI data were used in the FS to estimate the nature and extent of contamination, to calculate risks and hazards, and to make appropriate response action decisions. The additional samples were collected from a more defined, gridded area, in March 1996 to supplement Phase I and Phase II SI data. This information was used to refine the area and volume of PCB contamination. The results of the sampling for SWMUs 32 and 33 are discussed in the nature and extent of contamination subsection.

Phase I and Phase II Site Investigations. Site investigation activities were conducted to assess potential releases via surface migration. One 4.6 m (15 ft) soil boring (H301) and eight shallow soil borings (H047, H048, H049, H302, H303, H304, H305, and H306) were drilled and sampled at SWMUs 32 and 33 (Fig. 3.59).

Additional sampling to support the Phase I and Phase II Site Investigation. As previously mentioned, additional sampling was performed in March 1996 to support Phase I and Phase II SI data. The DOE gridded SWMUs 32 and 33 into 10 – 7.6 × 7.6 m (25 × 25 ft) and 13 – 15.25 × 15.25 m (50 × 50 ft) sections (a total of 23 sections) and 5-point composite sampled (at the four corners and in the middle of each gridded area) at 0 to 0.3 m and 1.5 m (0 to 1 and 5 ft) depth intervals.

Geology/Hydrology

Silt loam and silty clay loam, which are included in the Henry silt loam soil series, make up the surficial deposits at SWMUs 32 and 33 (USDA 1976). A fragipan or low-permeability layer is characteristic of this soil type, but is not likely to be present at these units because the soil was disturbed during dike upgrade construction. Permeability of the silt loam would probably be between 4.23×10^{-4} cm/sec (1.98 ft/d) and 1.41×10^{-3} cm/sec (3.99 ft/d) (USDA 1976).

The Phase I borings H047, H048, and H049 describe the interval from 0 to 1.8 m (0 to 6 ft) as moist to wet silty clay. The Phase II borings H302, H303, H305 and H306 were 0.15 m (0.5 ft) deep and contained moist lean clay. Boring H304 also was 0.15 m (0.5 ft) deep, but this boring contained wet lean clay with gravel. Boring H301 was found to have 0.78 m (7 in.) of organic soil at the surface and moist lean (silty) clay between 0.18 m (7 in.) and 4.6 m (15 ft).

Geotechnical testing was performed on boring H301 and the results have been recorded in Table 3.69. These data were used in establishing the soil type present at the unit.

Table 3.69. Summary of geotechnical testing data at SWMUs 32 and 33

Boring No.	Sample depth (ft)	Natural moisture content (%)	Atterberg Limits (%)			Grain size analysis		
			L.L.	P.L.	P.I.	Finer than No. 200 (%)	Finer than No. 40 (%)	Finer than No. 4 (%)
H301	0 to 5	24.7	48	19	29	96	98	100
H301	8 to 10	23.0	34	19	15	96	98	100
H301	13 to 15	24.1	36	18	18	92	98	100

L.L. = Liquid Limit
P.L. = Plastic Limit
P.I. = Plastic Index

Source: CH2M HILL 1992,

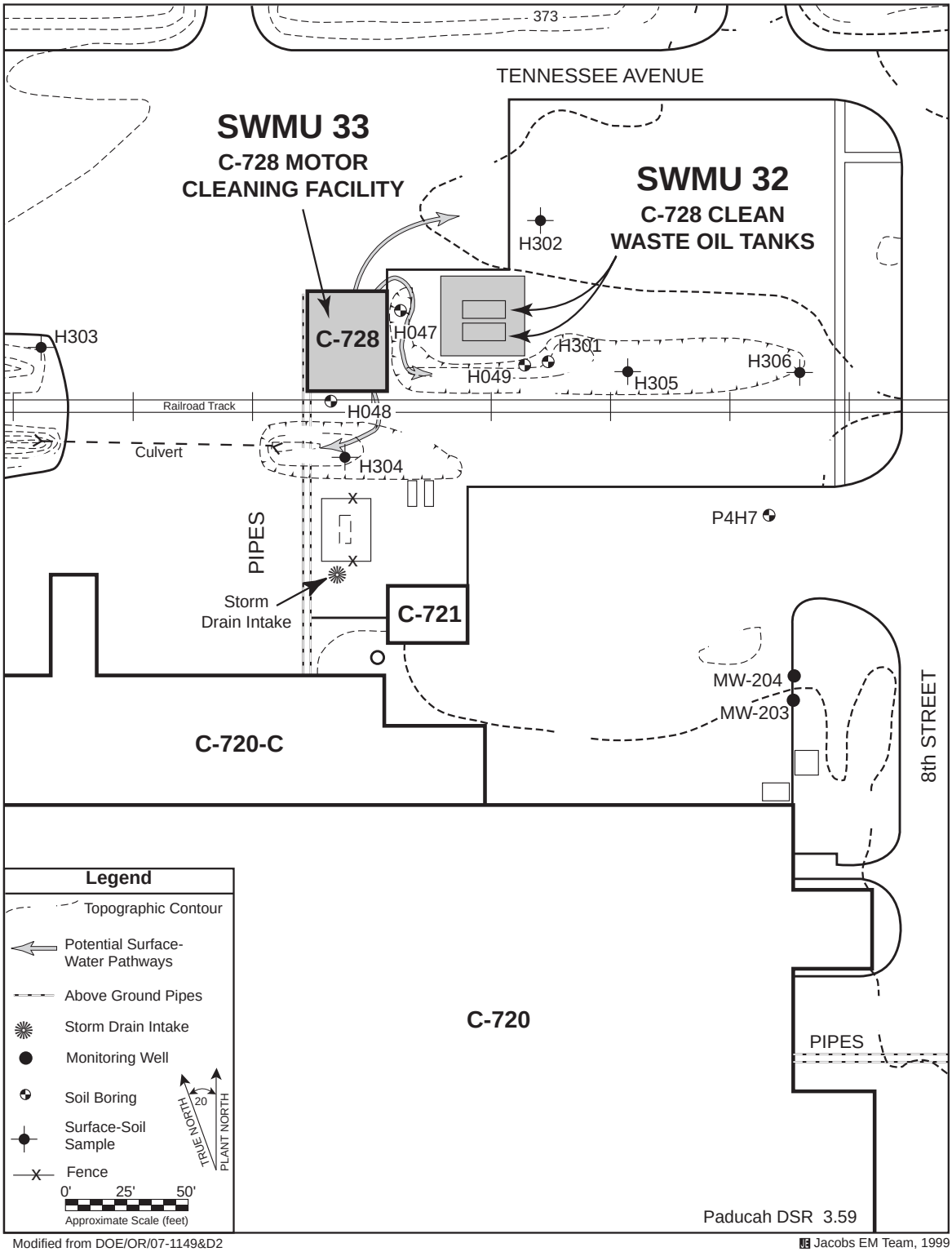


Fig 3.59. Location of historical samples collected at SWMUs 32 & 33 at the PGDP.

In the vicinity of SWMUs 32 and 33, the Upper Continental Deposits are encountered at a depth of about 6.1 m (20 ft) bgs. These Upper Continental Deposits are approximately 12.2 to 13.7 m (40 to 45 ft) thick and consist of sandy or silty clay interfingered with layers of sand and gravel. Beneath this formation lie the Lower Continental Deposits. These deposits are made up of sandy gravel and gravely sand with a thickness of about 10.7 to 12.2 m (35 to 40 ft). Underlying the Lower Continental Deposits is the McNairy Formation.

The UCRS, the uppermost hydrologic unit, is found within the loess layer and the Upper Continental Deposits. Sand lenses present in the UCRS are usually not laterally extensive over large areas. Most flow within the UCRS has been found to be vertical with a downward gradient from the UCRS to the RGA.

Water levels in the uppermost sand lenses of the UCRS will be of interest when considering types of subsurface soil remediation that may be necessary at SWMUs 32 and 33**.** In MW203 (AKGWA # 8000-5184) to the southeast, two shallow UCRS sand lenses were found to be present from 4 to 4.6 m (13 to 15 ft) bgs and from 5.8 to 6.1 m (19 to 20 ft) bgs. However, since the screens in MWs 203 and 204 (twin to MW203) were set below 14.9 m (49.0 ft) bgs, it is not known if either of these shallow lenses contains water. In the Phase IV boring H-7, the uppermost UCRS sand lens was found between 6.7 and 7.6 m (22 and 25 ft) bgs but no water level was measured for that interval. Shallow UCRS water levels from sand lenses above 7.6 m (25 ft) were not available from other monitoring wells in the vicinity because they were all screened in deeper zones. In MW204 (AKGWA # 8000-5185), deep UCRS (1994) water levels ranged from 11.6 to 13.6 m (38.0 to 44.5 ft) bgs. The well screen in MW204 was installed at 15.1 to 16.6 m (49.5 to 54.5 ft) bgs.

In the RGA, the predominant flow direction would be northward for this area. RGA water levels in MW203 for 1994 ranged from 13.0 to 14.8 m (42.6 to 48.4 ft) bgs. This well screen was set from 21.6 to 23 m (71 to 76 ft) bgs.

Nature and Extent of Contamination at SWMUs 32 and 33

The PCBs, dioxins, and furans at SWMUs 32 and 33 were not found at levels of concern in surface soils or in ditches leading from the units to the west. In addition, they were not found in surface water or sediment leaving the plant boundary through Outfall 008, which drains runoff from this area. Also, since no PCB, dioxin, or furan contamination was detected in the drainage swale east of boring H049, migration via surface runoff to the east appears to be limited. In addition, no PCBs were found in the deeper boring (H301), drilled near boring H049, indicating that the depth of contamination is limited to approximately 1.8 m (6 ft).

BTEX were found in two subsurface soil samples from one boring (H047) between 0.76 and 1.8 m (2.5 and 6 ft) bgs at individual concentrations of 14 to 210 µg/kg, with a maximum total BTEX value of 240 µg/kg. The area impacted is limited to the immediate area around boring H047.

In a few soil samples, metal constituents were detected at levels higher than reference values determined during the Phase I SI. Metals detected above reference values include: chromium, which was found at the surface in Phase I boring H048 at 87,500 µg/kg (reference value of 17,200 µg/kg); copper, which was identified at 42,700 µg/kg at the surface in Phase I boring H049 (reference value of 15,800 µg/kg); lead, identified at the surface in Phase I boring H049 at 35,500J µg/kg (reference value of 30,900 µg/kg); nickel, found at the surface in Phase I boring H048 at a concentration of 52,300J µg/kg (reference value of 21,000 µg/kg); and zinc, found at the surface in Phase I boring H047 at a concentration of 61,600 µg/kg (reference value of 54,400 µg/kg). Metals were not analyzed in Phase II borings H301, H302, H303, H304, H305, and H306.

Uranium-234, ^{238}U, and ^{99}Tc were found in surface soils collected to the south of SWMUs 32 and 33 at sampling stations H048 and H049. Technetium-99 was found in subsurface soils to a depth of 1.8 m (6 ft) in the same locations. Uranium-234 and ^{238}U were found to a depth of 1.8 m (6 ft) at sampling station H049, located immediately south of SWMU 32. The amount of radioactivity found near SWMUs 32 and 33 includes ^{99}Tc at activities up to 56.9 ± 3.3 pCi/g, ^{234}U up to 4.49 ± 0.64 pCi/g, and ^{238}U up to 7.39 ± 0.82 pCi/g. Radionuclide analyses were not performed on samples collected from Phase II sample borings H301 through H305.

Fate and Transport of Contamination

Transport of contaminants at SWMUs 32 and 33 may occur as a result of surface-water runoff from surface soils. Affected media include surface-water runoff and sediments that may be carried by the runoff and deposited downstream. Drainage from the area flows south beneath the railroad tracks to a storm sewer inlet near boring H304 (Fig. 3.59). This storm sewer discharges into Bayou Creek through KPDES Outfall 008.

The presence of BTEX compounds and ^{99}Tc in the subsurface indicates that migration to the groundwater is a possibility. It does appear, however, that the levels identified would not present a threat to off-site receptors.

Summary of Previous Remedial Actions at SWMUs 32 and 33

There have been no previous remedial actions associated with SWMUs 32 and 33 of WAG 23.

3.2.8.3 SWMUs 56 and 80 — C-540-A PCB Waste Staging Area and Spill Site

Location

The C-540-A PCB Waste Staging Area (SWMU 56) and the C-540-A PCB Spill Site lie outside the C-540-A Building in the southeastern part of the plant, north of Nebraska Avenue and west of 22nd Street (Fig. 3.54).

Setting

The C-540-A PCB Waste Staging Area has been used from 1976 to the present for the temporary storage of containerized PCB-contaminated waste oils and solids. This 1.5 × 3 m (5 × 10 ft) diked staging area can hold up to six 55-gal drums. Soil contaminated by PCBs in the vicinity of the C-540 Facility has been designated as SWMU 80 (Fig. 3.60). The area of SWMUs 56 and 80 is irregular, encompassing an area about 30.5 × 30.5 m (100 × 100 ft) around the C-540-A Building and extending about 182.8 m (600 ft) from the facility within the drainage ditches leading from the unit.

Surface-water hydrology, wetlands, and floodplains. Area stormwater flow appears to follow three main pathways (Fig. 3.60). The northern part of the SWMUs drain into a storm sewer located to the northwest, and the western and southern sections drain into a storm sewer located to the west. Both of these storm sewers formerly flowed into KPDES Outfall 011, but are now routed to Outfall 010. The area east of the buildings drains into a swale that used to discharge to Outfall 012. Presently, water that would normally flow into Outfalls 011 and 012 has been re-routed through a lift station to Outfall 010. However, in a heavy rainfall, some water would likely flow past the lift station and enter Outfall 011 or 012 as it had previously. Water flowing through Outfalls 010, 011, or 012 discharges to Little Bayou Creek. No wetlands have been identified in the vicinity of SWMUs 56 and 80 (CDM Federal 1994). No 100-year floodplains are adjacent to SWMUs 56 and 80.

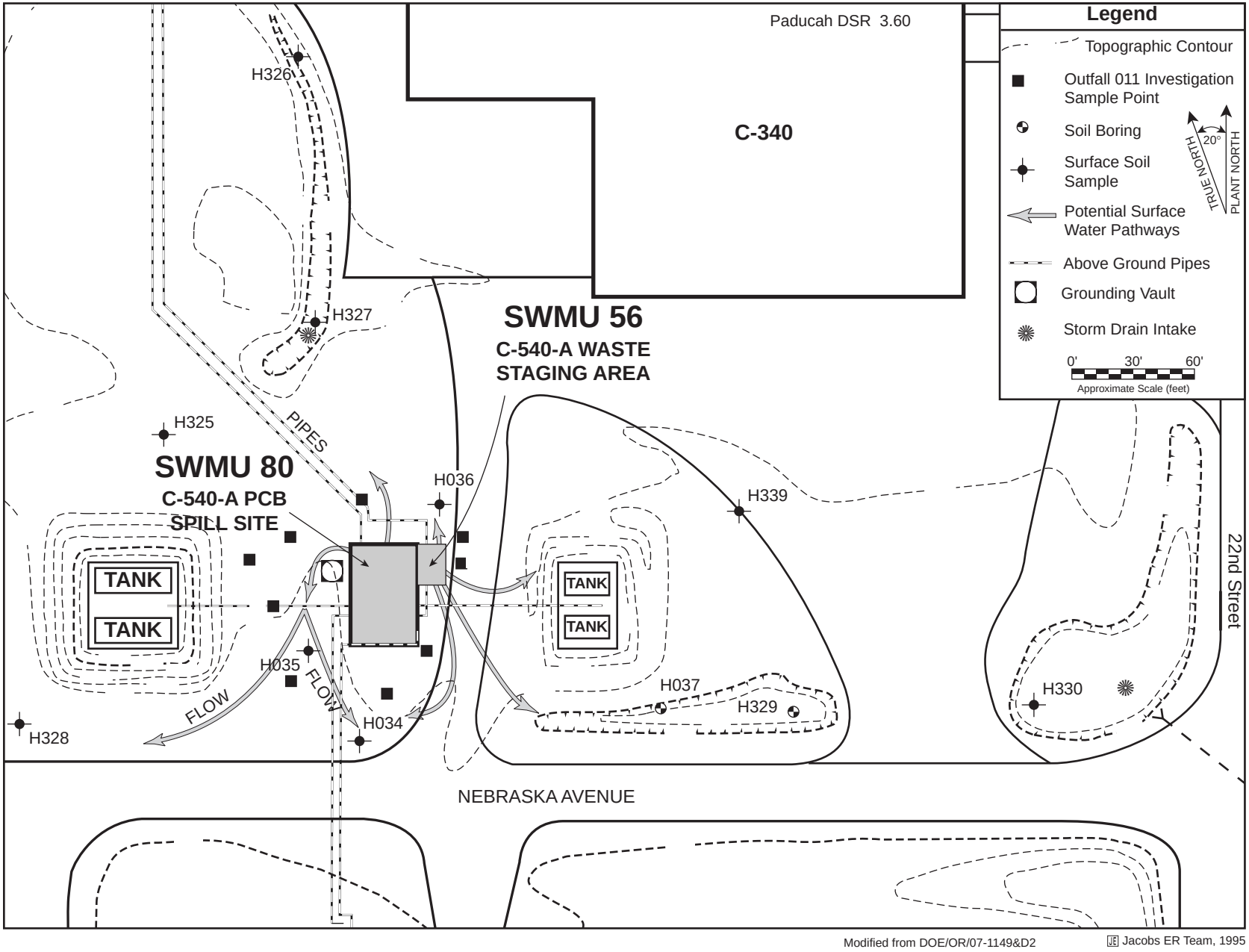


Fig. 3.60. Physical features of SWMUs 56 and 80.

Biological resources. Vegetation inside the fence is mown grass providing very little to no wildlife habitat. No potential habitats for T&E species are present within the fence (CDM Federal 1994).

Soils and prime farmland. Historically, soils within the impacted area of SWMUs 56 and 80 are Henry silt loams. However, the soils associated with these areas have been disturbed by past activities, decreasing the likelihood that any of these areas are prime farmland.

Manufacturing/TSD Processes

In 1970, the old underground piping from the C-540-A Building was abandoned in place because of leaks and maintenance problems. At that time, the underground piping was cut off at the surface and replaced with aboveground piping. In the past, during the summer months, an oily/watery substance has sometimes bubbled up from the ground where the old piping was cut (DOE 1993a). This old, underground piping has been suspected of containing PCB oils that might have contributed to area soil contamination.

Previous actions (separate from previous remedial actions). A spill that occurred at this site during the 1970s resulted in the dredging of contaminated sediments from a ditch south of the C-340 Building. This ditch, formerly called the C-340 Ditch, is now called the Outfall 011 Ditch. The dredging of the C-340 Ditch took place in 1983 and was confined to an area outside the security fence. PCBs in the ditch were removed to below 25 ppm (MMES 1984).

Summary of Previous Investigations

The following describes the sampling performed at SWMUs 56 and 80. Data used to describe soil contamination associated with these units are from four sources: Phase I and Phase II of the PGDP SI, sampling performed in April 1995 to support the Outfall 011 investigation; additional sampling performed March 1996 (reported in an appendix of the FS report); and sampling performed in the ditch to the southeast of SWMUs 56 and 80 near Phase II boring H345 in April 1999. Phase I and Phase II SI data were used in the FS to estimate the nature and extent of contamination, to calculate risks and hazards, and to make appropriate response action decisions. The additional samples were collected from a more defined, gridded area, in March 1996 to supplement Phase I and Phase II SI data. This information was used to refine the area and volume of PCB contamination. The sampling performed in April 1999 was used to determine whether residual PCBs left at SWMUs 56 and 80 following the removal action (discussed in the summary of previous remedial action subsection) were at concentrations that may migrate off-site. A discussion of sampling results is included in the nature and extent of contamination subsection.

Phase I and Phase II Site Investigations. Site investigation activities were conducted to assess potential releases via the surface migration pathway only. One 4.6 m (15 ft) soil boring (H329), one 1.8 m (6 ft) soil boring (H037), and 15 shallow soil borings (H034, H035, H036, H325, H326, H327, H328, H329, H330, H339, H343, H344, H345, H346, and H347) were drilled and sampled at SWMUs 56 and 80 (Fig. 3.61).

Additional sampling performed in April 1995 as part of the Outfall 011 investigation. Shallow (1.2 m or 4 ft) soil samples were collected concentric to the SWMUs in April 1995 (Fig. 3.61) as a result of PCB-contaminated sediments and water detected in the grounding vault on the west side of C-540-A.

Additional sampling to support the Phase I and Phase II Site Investigation in March 1996. As previously mentioned, additional sampling was performed in March 1996 to support Phase I and Phase II SI data. The DOE gridded SWMUs 56 and 80 into 21 – 7.6 × 7.6 m (25 × 25 ft) and 9 – 15.25 × 15.25 m (50 × 50 ft) sections (a total of 31 sections) and 5-point composite sampled (at the four corners and in the middle of the gridded areas) at 0 to 0.3 and 1.5 m (0 to 1 and 5 ft) depth intervals.

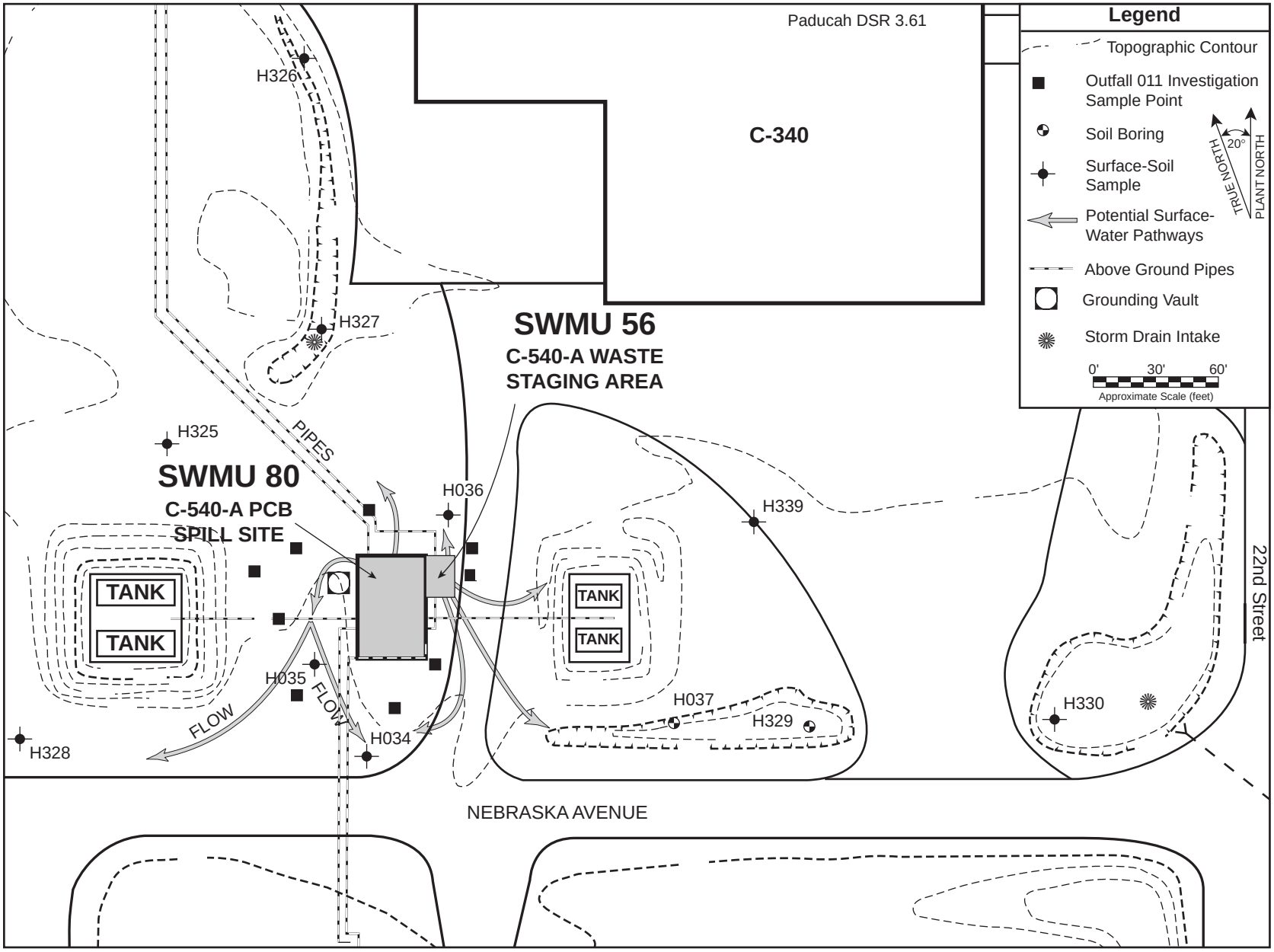


Fig. 3.61. Location of historical samples at SWMUs 56 and 80 at the PGDP.

Additional sampling performed in April 1999. This sampling was performed to provide additional information about the extent of contamination at SWMUs 56 and 80. Two areas near Phase II boring H345 were divided into 7.6 × 7.6 m (25 × 25 ft) grids and 5-point composite samples were collected (one at each corner of the grid and one in the middle) at the surface. One sample included soil from around H345.

Geology/Hydrogeology

At SWMUs 56 and 80, the surface soil consists of silt loam and silty clay loam included in the Henry silt loam soil series. A fragipan layer usually is associated with this type of soil, but is probably not present in the area since the soil was disturbed during dike upgrade construction. The dike upgrade construction took place between November 1993 and April 1994. Permeability of the silt loam would likely be between 4.23×10^{-4} cm/sec (1.98 ft/d) and 1.41×10^{-3} cm/sec (3.99 ft/d) (USDA 1976).

The area west of the C-540-A Pump House has been contoured with 0.15 to 0.30 m (6 to 12 in.) of backfill. This soil covers the dense gravel aggregate, which is approximately 1.22 to 1.83 m (4 to 6 ft) thick, and overlies the grounding mat.

Boring logs H037, H326, H328, H329, and H330 describe the upper 0.15 m (6 in.) of soil to be moist, firm, lean (silty) clay. Boring H328 contained some gravel mixed with the clay. Only at boring H327 was the lean clay described as wet. Dry fill material consisting of gravel and clay was present in the upper 0.15 m (6 in.) at boring H325. Dry, sandy silt and gravel was found in the 0.3-m (1-ft) deep borings, H034 and H035. Boring H036 contained moist, sandy silt and gravel. The deepest boring log, H329, describes the upper 3 m (10 ft) of sediment as lean clay and the interval from 3 to 4.6 m (10 to 15 ft) as lean clay with some fine sand. Borings containing only clay are located in ditches of this area.

During April 1995, shallow soil samples (A through I) were taken around SWMUs 56 and 80 down to a depth of 1.2 m (4 ft) bgs as part of an investigation of contamination in outfalls 011 and 012. In samples E, H, and I, located south of the pump house, groundwater was encountered at a depth of 0.3 m (1 ft) bgs within the sandy silt with gravel fill (DOE 1995b). This anomalously high water level is thought to have resulted from a perched water zone within the surface fill, present only during rainy periods. A clay layer which is approximately 6.1 m (20 ft) thick lies immediately below the surface fill and likely inhibits infiltration of precipitation in the area. The Phase IV boring G-7 provided the closest deep lithologic information and is located about 99 m (325 ft) to the west. This boring shows a limestone gravel fill down to a depth of 1.2 m (4 ft).

A summary of geotechnical testing data for boring H-329 as well as for borings H-344 and H-346 is provided in Table 3.70. These data were used in establishing the soil type present at the unit and were also considered in the selection of remedial alternatives.

Table 3.70. Summary of geotechnical testing data at SWMUs 56 and 80

Boring No.	Sample depth (ft)	Natural moisture content (%)	Atterberg Limits (%)			Grain size analysis			pH in water
			L.L.	P.L.	P.I.	Finer than No. 200 (%)	Finer than No. 40 (%)	Finer than No. 4 (%)	
H329	3 to 5	23.5	42	19	23	94	97	100	"
H329	8 to 10	23.0	39	18	21	92	97	100	"
H329	13 to 15	19.7	34	16	18	85	97	100	"
H344	0 to 0.5	31.9	57	32	25	65	73	83	6.6
H346	0 to 0.5	23.2	37	19	18	73	91	99	6.8

L.L. = Liquid Limit
P.L. = Plastic Limit
P.I. = Plastic Index

Source: CH2M HILL 1992

At a depth of about 6.1 m (20 ft) bgs lie the Upper Continental Deposits. These deposits are approximately 18.3 m (60 ft) thick and consist of sandy clay interfingered with layers of sand. Typically, the Lower Continental Deposits are encountered beneath this formation. In this area, the Lower Continental Deposits are only about 1.5 to 3 m (5 to 10 ft) thick due to the proximity of the terrace slope. These deposits consist of well-rounded chert gravel and sand. Underlying the Lower Continental Deposits is the Porters Creek Clay.

The sandy silt and gravel fill at the surface in the vicinity of these SWMUs was found to have a water level at 0.3 m (1 ft) bgs (DOE 1995b). Since this fill material lies above 6.1 m (20 ft) of clay, it is thought to be a perched zone. Below the surficial sandy silt and gravel layer, the water level in the UCRS sand and gravel would be approximately 9.1 m (30 ft) bgs with a downward gradient from the UCRS to the RGA (DOE 1995b).

The nearest monitoring well water level was in MW255 (AKGWA # 8001-6189) 281.9 m (925 ft) to the northeast. This monitoring well originally was boring P4-E8 drilled during the Phase IV groundwater investigation (DOE 1995b). An RGA water level of 17.1 m (56.1 ft) was taken in MW255 in May 1995, and the screen in this well was set from 27.7 to 29.2 m (91 to 95.7 ft). Flow in the RGA tends to be toward the northeast.

Nature and Extent of Contamination

Phase I and Phase II of the SI identified widespread PCB contamination at these SWMUs. Based on the SI, PCB contamination extended to boring H327 to the north, H328 to the west, and to boring H343 along 22nd Street to the southeast. Analytical results of the April 1995 sampling event confirmed the presence of PCBs in the immediate area surrounding C-540-A. The maximum concentration of PCBs discovered during the Outfall 011 investigation around the C-540-A Building was 3,000 ppm to the immediate west of the SWMUs. Additional samples collected to support the Phase I and Phase II investigation in March 1996 revealed three areas greater than 25 ppm, but none below 0.3 m (1 ft) deep. Grid 7 contained total PCBs at approximately 117 ppm, grid 9 contained PCBs at approximately 79 ppm, and grid 27 revealed total PCBs at about 111 ppm. Migration was believed to be minimal as all other values were below 25 ppm and the drainage swale to the southeast of 22nd street contained only about 2 ppm total PCBs; however, to confirm their hypothesis, the DOE collected additional composite samples near boring H345 in April 1999. The maximum total PCBs detected were about 7 ppm, which substantiated the DOE's belief that the contamination was not migrating in significant concentrations.

A surface sample collected at boring H037 contained dioxins at 2.9 ppb. The extent of dioxin contamination was limited to this area.

The PAHs were found in a surface sample (H037) at levels ranging from 830J µg/kg to 2,400J µg/kg for individual analytes. The total PAH concentration was 9,430J µg/kg.

The TCE was identified in the April 1995 sampling event to the southeast of C-540-A in borehole "H" at 2,000 µg/kg in the soil and 59 µg/L in the perched water. TCA; 1,1-DCA; and 1,1-DCE also were identified in borehole "H" in the soil and perched water. TCA was identified at the highest concentration in the water and soil samples at 5,000 µg/L and 168,000 µg/kg, respectively.

During the April 1995 borehole drilling, a perched water zone was encountered that contained PCBs, TCA, TCE, 1,1-DCA and 1,1-DCE. According to boring logs in the area, a thick clay layer [approximately 6.1 m (20 ft)] lies immediately below the surface fill. The clay is believed to inhibit infiltration of surface water, creating a perched water zone within the surface fill. Fractures to the clay

layer are possible and could lead to the introduction of TCE into the groundwater; however, there is not sufficient information available to determine whether fractures exist at this location. Confirmation of groundwater contamination associated with these SWMUs is difficult due to the lack of groundwater sampling data for the area and contributors to the Northeast Plume being upgradient from SWMUs 56 and 80 (DOE 1995a).

Trace quantities of ^{99}Tc were detected at all three sampling depths (from 0 to 1.8 m or 0 to 6 ft) in boring H037 at values ranging from 0.5J ± 0.1 pCi/g to 1.9J ± 0.2 pCi/g. Metals were not detected at elevated concentrations.

Fate and Transport of Contamination

Transport of contaminants at SWMUs 56 and 80 may occur as a result of surface-water runoff from surface soils; however, historical sampling indicates that, while this may have been a historical pathway, current transport of contamination via surface-water runoff is minimal. Drainage from the area flows in three directions. The area north of the building drains north to a storm sewer inlet near boring H327 (Fig. 3.61). The area south and west of the building drains west to another storm sewer inlet near boring H328 and across Nebraska Avenue to swales near borings H347 and H346. Both storm sewers discharge through Outfall 011, where detectable PCBs have been identified. The area east of the building drains to a grass-covered swale that leads east along Nebraska Avenue, then follows a surface-water drainage line that extends across 22nd Street south to boring H343, and discharges to the Outfall 012 Ditch. Based upon the presence of ^{99}Tc and TCE in the subsurface, migration of contamination from SWMUs 56 and 80 to the groundwater remains a possibility.

Summary of Previous Remedial Actions at SWMUs 56 and 80

In December 1997, the DOE conducted a non-time-critical removal action at SWMUs 56 and 80 to remove PCBs in excess of 25 ppm and dioxins in excess of 1.3 ppb. The DOE identified PCB and dioxin contamination above their cleanup goals at three of four gridded areas.

Three areas were identified during the March 1996 sampling activities with PCB concentrations that exceeded the 25 ppm cleanup level. These three areas had a total volume of approximately 55 m^3 (72 yd^3), with the depth of contamination confined to the upper 0.3 m (1 ft) of soil (Fig. 3.61).

Dioxin contamination exceeding the 1.3 ppb risk-based cleanup levels was present in one of the grids at SMWU 80 (Fig. 3.61). Of the dioxin contamination identified, the congener 2,3,7,8-TCDD was present at 2.9 ppb. Consequently, approximately 18 m^3 (23 yd^3) of dioxin-contaminated soil was excavated at SWMU 80. The depth of contamination was isolated to the top 0.3 m (1 ft) of soil.

3.2.8.4 SWMUs 57 and 81 — C-541-A PCB Waste Staging Area and Spill Site

Location

The C-541-A PCB Waste Staging Area (SWMU 57) and soil contaminated with PCBs in the vicinity of the C-541 Facility (SWMU 81) is located outside the C-541-A Pump House in the north–central part of the plant (Fig. 3.62).

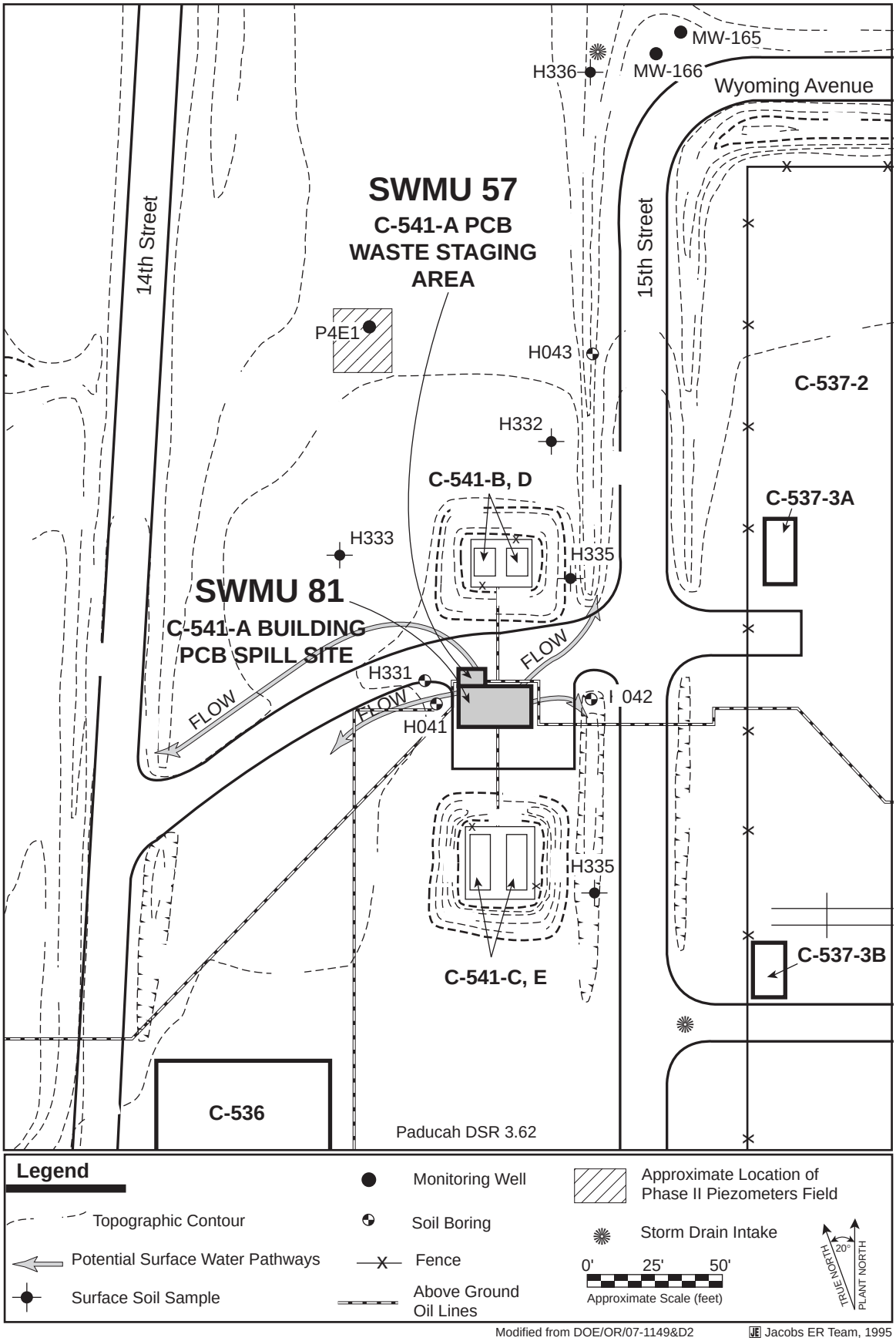


Fig. 3.62. Physical features of SWMUs 57 and 81.

Setting

SWMUs 57 and 81 are located in a fairly flat area that is generally grass covered, except for a gravel drive near the building and the concrete-paved roadways. Together, these units cover approximately 45.7 × 45.7 m (150 × 150 ft) and extend 91.4 m (300 ft) into the drainage swale to the north.

Surface-water hydrology, wetlands, and floodplains. The western part of this area drains to a storm sewer near 14th Street that discharges to KPDES Outfall 001. The remaining area drains north to the NSDD and then through Outfall 003. No wetlands have been identified in the vicinity of SWMUs 57 and 81 (CDM Federal 1994). No 100-year floodplains are adjacent to SWMUs 57 and 81.

Biological resources. Vegetation inside the fence is mown grass providing very little to no wildlife habitat. No potential habitats for T&E species are present within the fence (CDM Federal 1994).

Soils and prime farmland. Historically, soils within the impacted area of SWMUs 57 and 81 are Henry silt loams. However, the soils associated with these areas have been disturbed by past activities, decreasing the likelihood that any of these areas are prime farmland.

Manufacturing/TSD Processes

Since 1976, this 1.5 × 3 m (5 × 10 ft) diked staging area has been used for the temporary storage of containerized PCB-contaminated waste oils and solids. However, the C-541-A PCB Waste Staging Area has not been in use for the last five years, at least.

Former operating procedures resulted in spills and leaks in this area. The C-541 Facility includes a pump house and four aboveground storage tanks that formerly held thermal insulating fluids containing greater than 50 ppm PCBs. Currently, these storage tanks contain dielectric, electrical insulating fluids with detectable concentrations of PCBs (<50 ppm). The C-541-A Pump House has circulated transformer oil to the C-537 and C-535 Switchyards since the 1950s. Originally, underground piping was used to transport the insulating fluids to the switchyards. About 20 years later, as a result of reported leaks and maintenance problems, the underground piping was replaced with aboveground piping. The old underground piping was abandoned in place.

Summary of Previous Investigations

The following describes the sampling conducted at SWMUs 57 and 81. As with SWMU 1, data used to describe soil contamination at these units are from two sources: Phase I and Phase II of the PGDP SI, and additional sampling performed March 1996, reported in an appendix of the FS report. Phase I and Phase II SI data were used in the FS to estimate the nature and extent of contamination, to calculate risks and hazards, and to make appropriate response action decisions. The additional samples were collected from a more defined, gridded area, in March 1996 to supplement Phase I and Phase II SI data. This information was used to refine the area and volume of PCB contamination and, for SWMUs 57 and 81, to confirm whether dioxins were at levels requiring remediation. The results of these investigations are presented in the nature and extent of contamination subsection.

Phase I and Phase II Site Investigations. Site investigation activities were conducted to assess potential releases via the surface migration pathway only. Sampling was conducted at nine locations: one 4.6-m (15-ft) boring (H331), three 1.8-m (6-ft) borings (H041, H042, and H043), and five surface soil samples (H332, H333, H334, H335, and H336). The sampling stations were selected generally because they are within the drainageways leading from the PCB storage and supply building (Fig. 3.63).

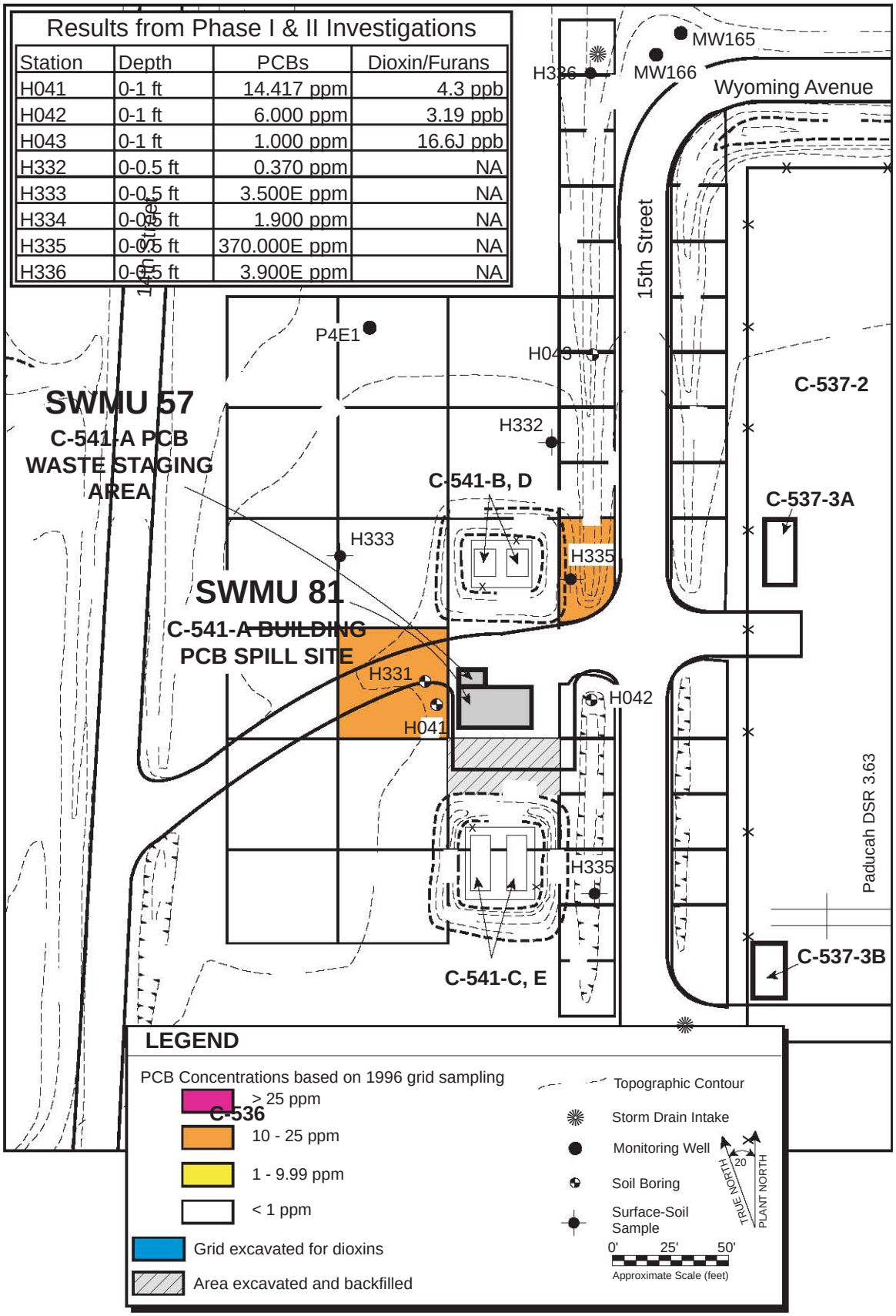


Fig. 3.63. Historical samples collected at SWMUs 57 and 81 at the PGDP.

Additional sampling to support the Phase I and Phase II Site Investigation. As previously mentioned, additional sampling was performed in March 1996 to support Phase I and Phase II SI data. The DOE gridded SWMUs 57 and 81 into 29 – 7.6 × 7.6 m (25 × 25 ft) and 15 – 15.25 × 15.25 m (50 × 50 ft) sections (a total of 44 sections) and sampled at 0 to 0.3 m (0 to 1 and 5 ft) depth intervals (Fig. 3.63).

Geology/Hydrogeology

Silt loam and silty clay loam, which are included in the Henry silt loam soil series, make up the surficial deposits at SWMUs 57 and 81. At depths ranging from 0.3 to 1.2 m (1 to 4 ft) bgs, a low-permeability layer (fragipan) is typically present. The fragipan layer is probably not present at these SWMUs because the soil was disturbed during dike upgrade construction that took place between November 1993 and April 1994. Immediately south of these units is an area of Calloway silt loam (USDA 1976).

Permeability of the silt loam would be between 4.23×10^{-4} cm/sec (1.20 ft/d) and 1.41×10^{-3} cm/sec (3.99 ft/d). If present, the fragipan layer would likely have a permeability of less than 8.4×10^{-5} cm/sec (0.24 ft/d) (USDA 1976).

The 1.8-m (6-ft) deep borings H041, H042, and H043 contained dry to moist silty clay. Boring H331 was 4.6 m (15 ft) deep and contained moist lean clay. Lean clay with some gravel was found in borings H322 (0.15 m or 0.5 ft) and H333 (0.15 m or 0.5 ft). The 0.15-m (0.5-ft) deep borings H334 and H335 contained moist to wet lean clay. A summary of geotechnical testing data for boring H-331 is provided in Table 3.71. These data were used in establishing the soil type present at the unit and were also considered in the selection of remedial alternatives.

Table 3.71. Summary of geotechnical testing data at SWMUs 57 and 81

Boring No.	Sample depth (ft)	Natural moisture content (%)	Atterberg Limits (%)			Grain size analysis			pH in water
			L.L.	P.L.	P.I.	Finer than No. 200 (%)	Finer than No. 40 (%)	Finer than No. 4 (%)	
H331	3 to 5	25.3	39	21	18	93	95	100	4.3
H331	8 to 10	26.4	34	22	12	95	98	100	5.4
H331	13 to 5	21.3	33	17	16	87	95	100	5.3

L.L. = Liquid Limit
P.L. = Plastic Limit
P.I. = Plastic Index

Source: CH2M HILL 1992

At a depth of about 6.1 to 7.5 m (20 to 25 ft) bgs lie the Upper Continental Deposits. These deposits are approximately 10.7 m (35 ft) thick and consist of silty clay interfingered with layers of sand or silt. The Lower Continental Deposits are encountered beneath this formation. In the vicinity of SWMUs 57 and 81, the Lower Continental Deposits are approximately 12 m (40 ft) thick and consist of well-rounded chert gravel and sand. Underlying the Lower Continental Deposits is the McNairy Formation.

At SWMUs 57 and 81, the hydraulic gradient is downward from the UCRS to the RGA. Horizontal flow within the sand lenses of the UCRS is limited, because many of the lenses are not interconnected over large distances. Flow in the RGA is to the northeast.

The monitoring wells, MW165 (AKGWA # 8000-5159) and MW166 (AKGWA # 8000-5160), located to the north are the nearest wells to these SWMUs. The 1994 UCRS water levels in MW166 range from 10.3 to 12.3 m (33.8 to 40.3 ft) bgs, and the screened interval is 10.5 to 11.6 m (33 to 38 ft) bgs. Monitoring Well 165 is screened in the RGA from 19.2 to 20.7 m (63 to 68 ft) bgs. Water levels in 1994 for this well ranged from 13.6 to 16 m (44.5 to 52.5 ft) bgs.

Nature and Extent of Contamination

The results of the SI sampling indicated that PCBs were detected in surface soils surrounding the C-541-A PCB Waste Staging Area and Spill Site and soils in swales leading from the unit. In addition, dioxins and furans also were found in the soils.

The highest PCB concentration was found at the surface in boring H335 (Aroclor-1260 at 370,000 J µg/kg), located next to a swale west of 15th Street. The PCBs also were identified in surface soil samples to the north, as far as Wyoming Avenue, in boring H336 (3,900 µg/kg), and to the south as far as boring H334 (1,900 µg/kg). The PCBs also were detected down to 1.8 m (6 ft) in boring H041 [17,417 µg/kg at the surface and 9,805 µg/kg 1.2 to 1.8 m (4 to 6 ft) bgs], located in a runoff area immediately west of the SWMUs. The PCBs also were detected down to 1.2 m (4 ft) in boring H042 [740 µg/kg at 0.61 to 1.2 m (2 to 4 ft)], located in a ditch immediately east of the SWMUs. Boring H043, located in the ditch on the west side of 15th Street, between H335 and H336, had PCB contamination to a depth of 1.2 to 1.8 m (4 to 6 ft) at 680 µg/kg. The only elevated PCBs identified during the additional March 1996 sampling were found at about 105 ppm in boring 33. No PCBs greater than 25 ppm were detected below 0.3 m (1 ft).

The lone dioxin detection of concern was identified at the surface of boring H043 at 1.7 ppb. Confirmation samples collected from this area during the March 1996 additional sampling revealed the maximum dioxin concentration was less than 1.3 ppb, but results were considered suspect.

PAHs ranged from 50J µg/kg to 100J µg/kg for individual analytes in the surface sample of boring H042. The total PAH concentration in this sample was 250J µg/kg. The 0.61- to 1.2-m (2- to 4-ft) sample from boring H043 contained phenanthrene, a PAH, at a concentration of 400J µg/kg.

The following metals were detected in surface samples H041 and H042 at levels above reference values but less than two times reference values: copper was detected at levels up to 20,800 µg/kg, which is above the reference value of 15,800 µg/kg; silver was detected at levels up to 2,700 µg/kg, which is above the reference value of 1,900 µg/kg; and zinc, which was detected at levels up to 75,300J µg/kg, well above the reference value of 54,400 µg/kg. Uranium-234 and ^{238}U were detected at levels up to 1.7 ± 0.12 pCi/g at sampling stations H041 and H042. Traces of ^{99}Tc were detected in soil samples from H042 and H043 at activities up to $7.7J \pm 6J$ pCi/g.

Fate and Transport of Contamination

Transport of contaminants at SWMUs 57 and 81 may occur as a result of surface runoff from surface soils; however, based upon the levels of contamination identified during the March 1996 sampling event, surface runoff is no longer a concern at these units.

The presence of ^{99}Tc at these units indicates that groundwater contamination is a possibility; however, based on the levels identified, it is not likely. The highest activity was 7.7 pCi/g.

Summary of Previous Remedial Actions at SWMUs 57 and 81

In December 1997, the DOE conducted a nontime-critical removal action at SWMUs 57 and 81 to remove PCBs in excess of 25 ppm and dioxins in excess of 1.3 ppb. At SWMUs 57 and 81, the DOE identified one PCB area of concern and one dioxin area of concern.

PCBs that exceeded the 25 ppm cleanup level were present in the grid located south of the C-541-A Pump House at SWMU 57. The total area of PCB contamination that exceeded the 25 ppm cleanup level

was approximately 24 m^3 (32 yd^3). The depth of contamination was limited to the upper 0.3 m (1 ft) of soil (Fig. 3.63).

Dioxin contamination was identified slightly above its risk-based cleanup level in soil boring H043 (1.7 ppb) completed during the Phase I SI. Consequently, approximately 18 m^3 (23 yd^3) of dioxin-contaminated soil was excavated (Fig. 3.63).

3.2.8.5 3.2.8.5 SWMU 74 — C-340 PCB Spill Site

Location

The C-340 PCB Spill Site (SWMU 74) is located adjacent to the transformer area on the north side of the C-340 Reduction and Metals Facility (Fig. 3.64). The inactive C-340 Facility, which was formerly used for converting uranium powder to metal, is on the east side of the plant.

Setting

SWMU 74 covers a relatively flat area approximately 30.5 × 61 m (100 × 200 ft) and also extends northward approximately 61 m (200 ft) into the drainage swale. The surface on the north and west sides of the unit is covered by gravel. Grass cover is present on the east side of the unit.

Surface-water hydrology, wetlands, and floodplains. The western part of the area drains to a storm sewer that formerly discharged to KPDES Outfall 011. Currently, flow normally directed to Outfall 011 has been rerouted to Outfall 010. The eastern part of this area drains east and north to the Outfall 010 ditch. Also, some stormwater runoff likely would flow north across the road and enter the ditch on the north side of Oklahoma Avenue. Flow in this ditch eventually will reach Outfall 010, which empties into Little Bayou Creek. No wetlands have been identified in the vicinity of SWMU 74 (CDM Federal 1994). No 100-year floodplains are adjacent to SWMU 74.

Biological resources. Vegetation inside the fence is mowed grass providing very little to no wildlife habitat. No potential habitats for T&E species are present within the fence (CDM Federal 1994).

Soils and prime farmland. Historically, soils within the impacted area of SWMU 74 are Henry silt loams. However, the soils associated with these areas have been disturbed by past activities decreasing the likelihood that any of these areas are prime farmland.

Manufacturing/TSD Processes

Releases of unknown quantities of transformer oil occurred from past operations during the 1950s through the 1970s, when the use of PCB oils began to be phased out.

Summary of previous actions (excluding remedial actions). On January 20, 1992, nongasket PCB Spill Report No. PCB-259 was initiated due to water containing detectable PCBs being released from the C-340 transformer dike. Samples taken of this water indicated 8.7 µg/L (ppb) PCBs. As a result of Report No. PCB-259, the dike near the C-340 Building was cleaned and the surrounding soil was excavated in accordance with 40 C.F.R. 761 § G. Following the cleanup, verification samples were taken, as specified in the regulations, which indicated additional PCB contamination (Carson 1992).

Summary of Previous Investigations

The following describes the hazardous substances or pollutants/contaminants detected at SWMU 74. Data used to describe soil contamination at this unit are from Phase I and Phase II of the PGDP SI and the 1993 access control project.

Phase I and Phase II Site Investigation. Site investigation activities were conducted to assess the potential releases via the surface migration pathway only. Samples were taken at 12 sampling locations near SWMU 74 and SWMU 82: one 4.6-m (15-ft) boring (H307), and 11 surface soil samples (H038, H039, H040, H105, H308, H309, H310, H311, H312, H337, and H338). Nine of the sampling locations are SWMU 74 sampling locations, while three are locations associated with SWMU 82. The SWMU 82 locations (Phase I boring H105 and Phase II borings H337 and H338) are included in the discussion since they are in close proximity to some of the SWMU 74 sampling locations and may provide insight into the migration of the contaminants from SWMU 74. The sampling stations were generally selected to be within the drainages leading from the PCB Spill Site (Fig. 3.64).

July 1993 access control sampling event. In June of 1993, at the request of LMUS' Environmental Compliance Department, seven areas surrounding C-340 were sampled in support of the Access Control Project. Four sampling points collected during the 1993 access control project were located in the vicinity of SWMU 74 and were used for the evaluation of contamination at that unit.

Geology/Hydrogeology

Silt loam and silty clay loam, which are included in the Henry silt loam soil series, make up the surficial deposits at SWMU 74 (USDA 1976). The Henry series consists of poorly drained soils that have a fragipan layer. If the soil in the area has been undisturbed, this fragipan is likely to be present at about 0.5 m (1.5 ft) bgs and to be about 0.3 to 1.2 m (1 to 4 ft) thick. Henry silt loam is strongly acidic and commonly forms in thick deposits of loess or alluvium.

Permeability in the silt loam would be approximately 4.23×10^{-4} cm/sec (1.20 ft/d) to 1.41×10^{-3} cm/sec (3.99 ft/d). If present, the fragipan likely would have a permeability of less than 8.4×10^{-5} cm/sec (0.24 ft/d) (USDA 1976).

The 0.3-m (1-ft) deep Phase I borings were described as dry to moist silty gravel. The Phase II borings H307 (4.6 m or 15 ft), H310 (0.15 m or 0.5 ft), H311 (0.15 m or 0.5 ft), and H312 (1.5 m or 5 ft) contained moist lean clay. Lean clay with gravel was found in borings H308 and H309, which were 0.15 m (0.5 ft) deep.

A summary of geotechnical testing data for boring H-307 is provided in Table 3.72. These data were used in establishing the soil type present at the unit and also were considered in the selection of remedial alternatives.

The Upper Continental Deposits are present in this area at a depth of about 4.6 to 6.1 m (15 to 20 ft) bgs. These deposits are approximately 16.8 m (55 ft) thick and consist of sandy clay interfingered with layers of sand. Typically the Lower Continental Deposits are encountered beneath this formation. The Lower Continental Deposits here are about 6.1 to 7.6 m (20 to 25 ft) thick and consist of well-rounded chert and sand. Beneath this sand and gravel layer lies the McNairy Formation.

The UCRS is contained within the loess and the Upper Continental Deposits. Horizontal flow within the UCRS is restricted by the lack of interconnected sand lenses over long distances. Water levels in the UCRS range from approximately 9.1 to 10.7 m (30 to 35 ft) bgs with a downward gradient from the

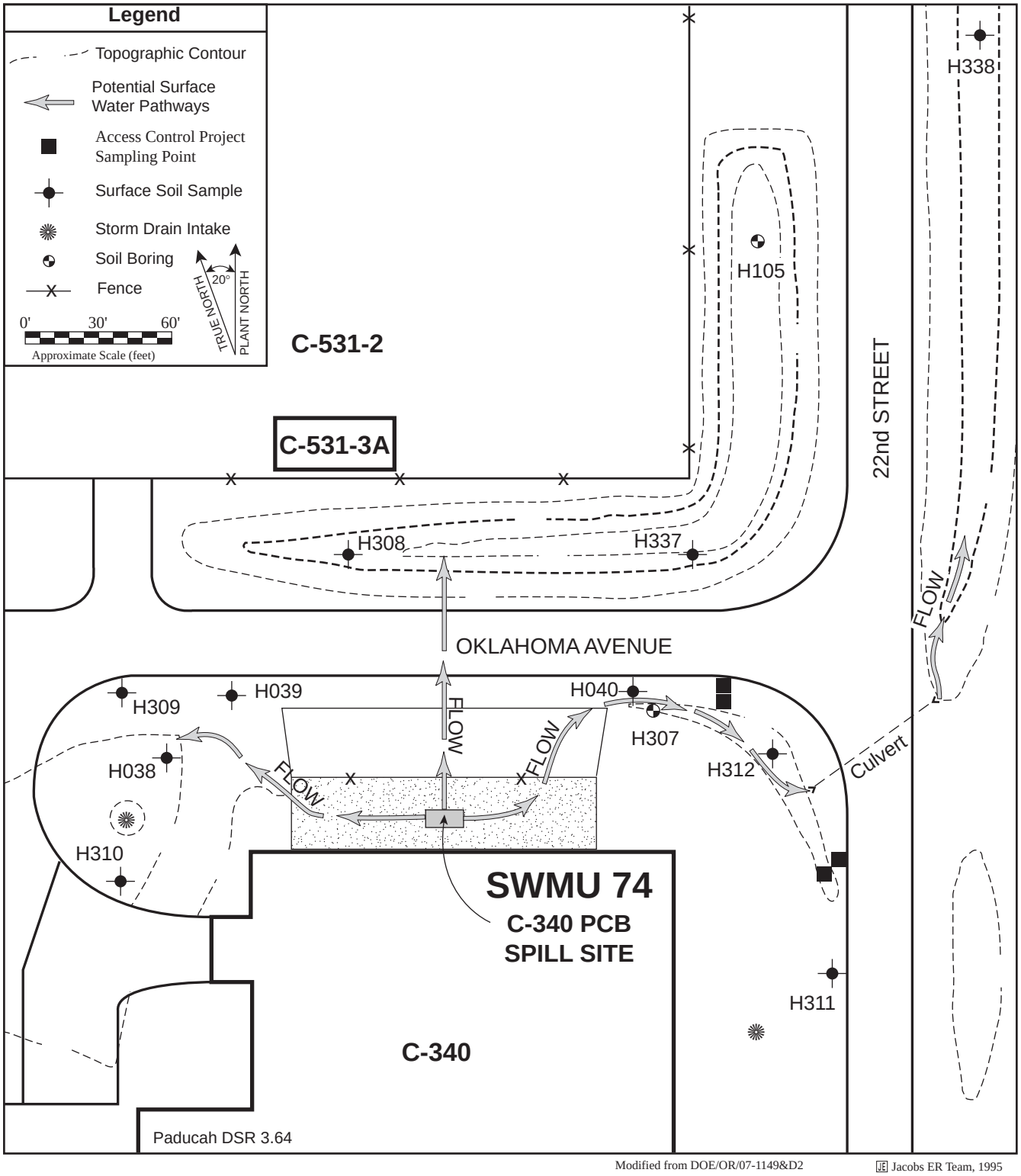


Fig. 3.64. Physical features of SWMU 74.

Table 3.72. Summary of geotechnical testing data at SWMU 74

Boring No.	Sample depth (ft)	Natural moisture content (%)	Atterberg Limits (%)			Grain size analysis			pH in water
			L.L.	P.L.	P.I.	Finer than No. 200 (%)	Finer than No. 40 (%)	Finer than No. 4 (%)	
H307	0 to 5	24.0	50	19	31	87	93	99	—
H307	5 to 10	22.2	37	18	19	94	98	100	—
H307	10 to 15	21.4	39	15	24	91	96	99	—
H307	0 to 0.5	23.6	32	22	10	91	95	100	6.8

L.L. = Liquid Limit
P.L. = Plastic Limit
P.I. = Plastic Index

Source: CH2M HILL 1992

UCRS to the RGA (DOE 1995a). The Phase IV boring F-5, about 60.96 m (200 ft) to the west, has a sand layer from 5.2 to 11.6 m (17 to 38.2 ft) bgs and a gravel layer from 11.6 to 12.5 m (38.2 to 41 ft) bgs. During drilling, a water sample was attempted at 12.2 m (40 ft) bgs in the UCRS, which was unsuccessful as a result of insufficient water. The nearest well to SWMU 74 is MW255, originally Phase IV boring E-8, located about 167.6 m (550 ft) to the northeast. The May 1995 depth of water in MW255 was 17.1 m (56.1 ft) bgs in the RGA. This well was screened from 27.7 to 29.2 m (91 to 95.7 ft). In this area, flow in the RGA is toward the northeast.

Nature and Extent of Contamination

Four sampling points collected during the 1993 access control project (Fig. 3.64) indicated the presence of total uranium from approximately 50 pCi/g to 167 pCi/g. In addition, PCBs (Aroclor-1254, -1260, and total PCBs) were found in these areas from 1,100 to 26,000 µg/kg. Finally, ^{137}Cs was found at concentrations from 0.6 to 0.9 pCi/g (Kennedy 1993).

The PCB contamination at SWMU 74 is greatest adjacent to the transformer pad, and decreases with distance away from the pad within the drainageways. Levels above 1,000 µg/kg are limited to the area characterized by borings H039, H040, H309, and H310, primarily located in the gravel area west of the transformer which drains to Outfall 011.

Dioxin contamination was identified in SWMU 74 samples on each side of the transformer pad at concentrations ranging from 3.4 to 9.9 µg/kg. Technetium-99 activity was detected in the surface sample H038 at 0.6 pCi/g ± 0.5 pCi/g.

Fate and Transport of Contamination

Transport of contaminants at SWMU 74 may occur as a result of surface-water runoff from surface soils. Outfall gravel cover at SWMU 74 is thought to minimize erosion and transport mechanisms. Based upon the contamination present at SWMU 74, migration of contaminants to the groundwater likely is not occurring.

Previous Remedial Actions

There have been no previous remedial actions taken at SWMU 74.

3.2.8.6 SWMU 79 — C-611 PCB Spill Site

Location

SWMU 79 is located near the C-611 Water Treatment Plant on the west side of the plant, adjacent to Water Works Road (Fig. 3.54).

Setting

SWMU 79 covers an area about 45.7 × 45.7 m (150 × 150 ft). Much of the area surface is grass covered except for the roadways that are gravel. Sometime prior to the early 1970s, oils containing PCBs were spilled or leaked from a transformer near the west side of the C-611 Water Treatment Process Building. The soils contaminated by this spill make up SWMU 79.

Surface-water hydrology, wetlands, and floodplains. Surface water from the site drains generally to the south in the ditch along the road west of C-611. At Water Works Road, surface flow turns for a short distance to the west and then flows again to the south crossing under the road. In a heavy rainstorm, sheet flow also likely crosses Water Works Road southeast of the site. Surface flow from SWMU 79 eventually drains into Bayou Creek. No wetlands have been identified in the vicinity of SWMU 79 (CDM Federal 1994). No 100-year floodplains are adjacent to SWMU 79.

Biological resources. Vegetation inside the fence is mown grass providing very little to no wildlife habitat. No potential habitats for T&E species are present within the fence (CDM Federal 1994).

Soils and prime farmland. Historically, soils within the impacted area of SWMU 79 are Calloway silt loam, 0 to 2% slope; Grenada silt loam, 6 to 12% slope; and Fallaya-Collins silt loam. However, the soils associated with these areas have been disturbed by past activities, decreasing the likelihood that any of these areas are prime farmland.

Manufacturing/TSD Processes

There have been no manufacturing or TSD processes at SWMU 79.

Summary of Previous Investigations

The following describes the hazardous substances or pollutants/contaminants detected at SWMU 79. Data used to describe soil contamination at this unit are the Phase I and Phase II of the PGDP SI.

Site investigation activities were conducted to assess the potential releases via the surface migration pathway. Four shallow soil borings were investigated during the Phase I site investigation (H053, H054, H055, and H056). The borings were located adjacent to the transformer pad in low-lying areas or swales that likely would receive runoff from the facility. Borings H053, H054, and H055 were sampled to a depth of 1.8 m (6 ft) and boring H056 was sampled to a depth of 0.6 m (2 ft). Due to the presence of PCBs in these borings, three additional surface soil samples were taken during Phase II. Borings H321 and H322 were located near the facility in low-lying areas that potentially could receive runoff from the area. Boring H320 was located on the northeast side of the facility to determine the boundary of contamination (Fig. 3.65).

Geology/hydrology

Silt loam and silty clay loam in the Calloway silt loam soil series make up the surficial deposits at SWMU 79. This type of soil normally is present where loess deposits are relatively flat. If the area has

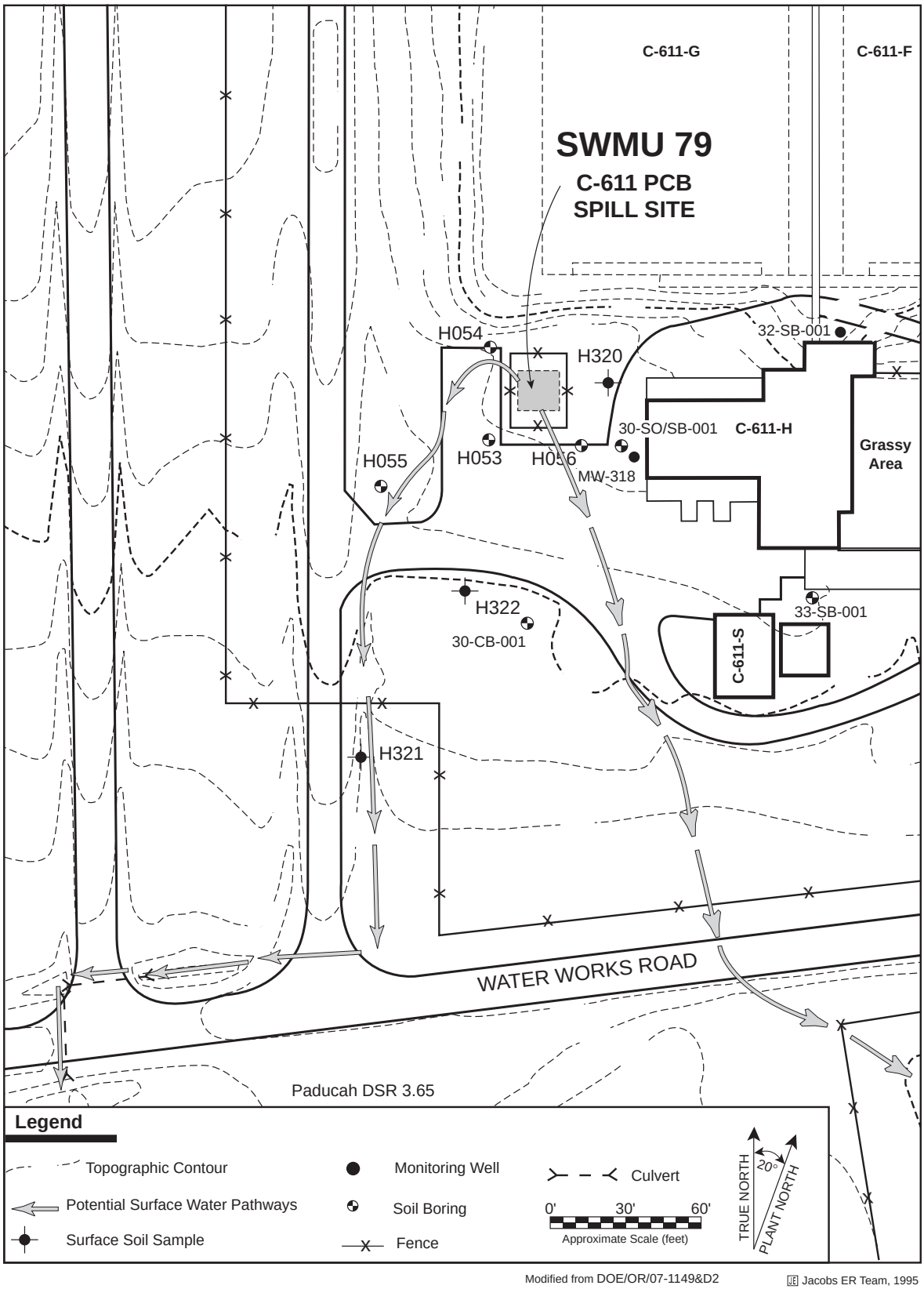


Fig. 3.65. Physical features of SWMU 79.

been undisturbed, a low-permeability layer (fragipan) likely is present at about 0.61 to 0.76 m (2 to 2.5 ft) bgs, which restricts drainage in the surface soils. This Calloway soil usually has a permeability of between 4.23×10^{-4} cm/sec (1.20 ft/d) and 1.41×10^{-3} cm/sec (3.99 ft/d) (USDA 1976).

Three 1.8-m (6-ft) borings, H053, H054, and H055 at SWMU 79, revealed damp to moist silty clay. Boring H056 was only 0.61 m (2 ft) deep and contained gravelly sandy clay.

The Phase II borings H320, H321, and H322 were 0.15 m (0.5 ft) in depth and contained moist lean (silty) clay.

Geotechnical testing data from borings at this site were not available. Taken from the *Soil Survey of Ballard and McCracken Counties, Kentucky*, estimated soil properties for Calloway silt loam or silty clay loam are presented in Table 3.73 (USDA 1976). These data were considered in the selection of remedial alternatives for this unit.

Table 3.73. Estimated geotechnical data for Calloway Series Soil

Soil property	Estimated value(s)
Liquid Limit	25% to 35%
Plasticity Index	2% to 8%
pH	4.5 to 5.5
Percentage passing sieve size	
No. 4 (4.7 mm)	100%
No. 10 (2.0 mm)	100%
No. 40 (0.42 mm)	95% to 100%
No. 200 (0.074 mm)	80% to 100%

SWMU 79 is located on the Porters Creek Clay terrace. At this unit, the Terrace Gravel is present at a depth of about 6.1 m (20 ft) bgs. These terrace deposits are approximately 0.61 to 2.4 m (2 to 8 ft) thick and consist of gravelly sand and clayey gravel. The Lower Continental Deposits are absent in this area.

Groundwater flow in this area would predominately occur within the Terrace Gravel above the Porters Creek Clay. Water within this gravel is thought to discharge to the Upper Continental Deposits or to Bayou Creek. Since this unit is on the terrace, the RGA is not present at SWMU 79. Average water levels at the former sanitary landfill (SWMU 8) near SWMU 79 are about 3.4 to 4.8 m (11 to 15 ft) bgs in the Terrace Gravel. The closest monitoring well to SWMU 79 is MW318, which was screened in the Terrace Gravel from 3.9 to 6.9 m (12.9 to 22.6 ft) bgs. The water level measured in this well in July 1994 was 2.3 m (7.5 ft) bgs.

Nature and Extent of Contamination

Low levels of PCBs were detected in surface soils next to the transformer and soils in swales leading from the unit. In addition, Octachlorodibenzo-p-dioxin was detected in surface samples collected from four borings (H053, H054, H055, and H056) at concentrations ranging from 1.53 µg/kg to 8.69J µg/kg. Other organic compounds (fluoranthene, pyrene, and some pesticides) were detected in borings H055 and H056 at concentrations ranging from 24 µg/kg to 80J µg/kg for individual analytes.

Five metals were detected above reference concentrations in surface samples H053, H054, and H055: (1) arsenic was detected at a concentration of 15,000J µg/kg, which is above the reference value of 11,800 µg/kg; (2) barium was detected at a concentration of 231,000 µg/kg, which is above the reference

concentration of 157,000; (3) copper was detected at a concentration of 17,600 µg/kg; (4) silver was detected at a concentration of 2,900 µg/kg; and (5) zinc was detected at a concentration of 60,200J µg/kg.

Technetium-99 (up to 1.4J pCi/g ± 0.4 pCi/g) was detected in borings H053 and H054. The ^{239}Pu also was detected at 0.36 pCi/g ± 0.17 pCi/g in the surface sample collected from H054. Dioxins, PAHs, metals, and radiological contaminants are not at levels of concern for SWMU 79.

Fate and Transport of Contamination

Transport of contaminants at SWMU 79 may occur as a result of surface-water runoff from surface soils; however, sampling results indicate this not occurring to a significant extent. Based upon the contamination present at SWMU 74, migration of contaminants to the groundwater likely is not occurring.

Summary of Previous Remedial Actions

There have been no previous remedial actions taken at SWMU 79.

Summary of Previous Risk Assessments

The summary presented in this section was taken from the *Remedial Investigation Addendum for Waste Area Grouping 23* (DOE 1994a). Specifically, the risk summary tables of the WAG 23 Addendum contains the pertinent risk information that will be repeated here. The purpose of this activity was to determine the nature and extent of contamination and risks associated with nine following SWMUs.

- SWMU 1 C-747-C Oil Landfarm
- SWMU 32 C-728 Clean Waste Oil Tanks
- SWMU 33 C-728 Motor Cleaning Facility
- SWMU 56 C-540-A PCB Waste Staging Area
- SWMU 57 C-541-A PCB Waste Storage Are
- SWMU 74 C-340 PCB Spill Site
- SWMU 79 C-611 PCB Spill Site
- SWMU 80 C-540-A PCB Spill Site
- SWMU 81 C-541-A PCB Spill Site

Table 3.74 summarizes the risks for these SWMUs calculated in the WAG 23 Addendum. These risks are being compiled from Tables 2-9, 3-5, 4-5, 5-5, 6-4, and 7-3 of the report. Subsequent to the WAG 23 Addendum being completed, several of these SWMUs were remediated. The risk results then were recalculated and presented in *Residual Risk Evaluation Report for Waste Area Grouping WAG 23 and Solid Waste Management Unit 1 of Waste Area Grouping 27 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1999d). Table 3.75 summarizes the residual risk results from the Residual Risk Report. The Residual Risk Report information presented here comes from the Executive Summary. The Residual Risk Report addressed the effectiveness of the PCB, dioxin, and furan cleanup that was undertaken at SWMUs 56, 57, 80, 81, and 1. SWMUs 32, 33, 74, and 79 were determined to require no further action in the WAG 23 FS. The baseline risk results presented in Table 3.75 are taken from the WAG 23 FS.

Table 3.74. Summary of WAG 23 Addendum risk results

SWMU 1			
Direct Contact to Soil (0 to 1 ft bs)	**On-Site Worker (250 day/year)**	**Worker/Intruder (25 day/year)**	**Contaminant Contributing to Risk**
Chemical Cancer Risk Estimate	6×10^{-4}	6×10^{-5}	Be, TCDD, PCBs, As
Chronic HI	8.5	0.85	TCDD
Radiological Cancer Risk Estimate	6×10^{-6}	6×10^{-7}	^{238}U, ^{237}Np
Direct Contact to Soil (0 to 6 ft bs)	**On-Site Worker (250 day/year)**	**Worker/Intruder (25 day/year)**	**Contaminant Contributing to Risk**
Chemical Cancer Risk Estimate	5×10^{-4}	5×10^{-5}	Be, PCBs, As, Dioxins, Furans
Chronic HI	6.0	0.6	TCDD
Radiological Cancer Risk Estimate	3×10^{-5}	3×10^{-6}	^{235}U, ^{238}U, ^{237}Np
Ingestion of Groundwater	**Future Off-Site Resident UCRS**	**Future Off-Site Resident RGA**	**Contaminant Contributing to Risk**
Cancer Risk Estimate	MW162, 5×10^{-4}	MW161, 1×10^{-3}	RGA ñ Be TCE, 1,1-DCE UCRS ñ Vinyl chloride, TCE, As, Be, 1,1-DCE
Chronic HI	5.3	11.2	RGA ñ Mn, Ba, Cr, Carbon disulfide UCRS ñ As, Mn, Cr, V
Radiological Cancer Risk Estimate	MW162, 2×10^{-6}	MW161, —	^{99}Tc
SWMUs 32 and 33			
Direct Contact to Soil	**Future On-Site Worker (25 day/year)**	**Current Worker/Intruder (250 day/year)**	**Contaminant Contributing to Risk**
Cancer Risk Estimate	3×10^{-5}	3×10^{-4}	TCDD, PCBs
Chronic HI	0.12	1.2	TCDD
Radiological Cancer Risk Estimate	2×10^{-7}	2×10^{-6}	^{238}U
SWMUs 56 and 80			
Direct Contact to Soil	**Unrestricted Worker (250 day/year)**	**Worker/Intruder (25 day/year)**	**Contaminant Contributing to Risk**
Cancer Risk Estimate	3×10^{-3}	3×10^{-4}	Dioxins, PCBs, Furans
Chronic HI	35.4	3.5	Dioxins, Furans
SWMUs 57 and 81			
Direct Contact to Soil	**Unrestricted Worker (250 day/year)**	**Worker/Intruder (25 day/year)**	**Contaminant Contributing to Risk**
Cancer Risk Estimate	9×10^{-4}	9×10^{-5}	Dioxins
Chronic HI	1.3	0.13	Dioxins, Furans
SWMU 74			
Direct Contact to Soil	**Unrestricted Worker (250 day/year)**	**Worker/Intruder (25 day/year)**	**Contaminant Contributing to Risk**
Cancer Risk Estimate	2×10^{-5}	2×10^{-6}	PCBs
Chronic HI	0.01	0.001	None
SWMU 79			
Direct Contact to Soil	**Unrestricted Worker (250 day/year)**	**Worker/Intruder (25 day/year)**	**Contaminant Contributing to Risk**
Cancer Risk Estimate	3×10^{-5}	3×10^{-6}	PCBs
Chronic HI	0.05	0.005	None

Table 3.75. Summary of the Residual Risk Report findings for WAG 23

Scenario	SWMU 1	SWMU 56 and 80	SWMU 57 and 81
Baseline risk assessment results for total cancer risk[a]			
Future Industrial Worker	5×10^{-4}	3×10^{-3}	9×10^{-4}
Current Industrial Worker	5×10^{-5}	3×10^{-4}	9×10^{-5}
Residual risk assessment results for total cancer risks			
Future Industrial Worker	4×10^{-5}	3×10^{-5}	8×10^{-5}
Current Industrial Worker	4×10^{-6}	3×10^{-6}	8×10^{-6}
Percent reduction in total cancer risk			
Future Industrial Worker	91%	99%	91%
Current Industrial Worker			

[a] Taken from Table 2.8 of the WAG 23 FS

Table 3.76. List of SWMUs included in UST investigation[a]

Tank number	SWMU designation	Volume (gal)	Construction	Contents	Age
C-746-A1	139				
C-750-A		10,000	Open hearth steel or wrought iron	Gasoline	≈ 41 yrs.
C-750-B		10,000	Open hearth steel or wrought iron	Diesel fuel	≈ 41 yrs.
C-750-C		1,000	Open hearth steel or wrought iron	Waste oil or solvents	≈ 41 yrs.
C-750-D	24			PCB-contaminated waste oil and solvents	
C-200-A		500	Steel	Gasoline	≈ 41 yrs.
C-710-B		200	Steel	Gasoline	≈ 41 yrs.

[a] Modified from Table 1-1 of Martin Marietta Energy Systems 1992b

3.2.9 Underground Storage Tanks

3.2.9.1 Overview of UST Site Investigation

SWMUs evaluated in the UST site investigation at the PGDP include the C-750-A, C-750-B, C-750-C, C-750-D, C-200-A, and C-710-B USTs. A list of all UST SWMUs, including volume estimates, former contents, and probable construction, is provided as Table 3.76. All of the tanks are located within the PGDP security fence in the south–central portion of the facility. These units were investigated due to categorical regulation as underground storage tanks, with the exception of the C-750-D UST. Figure 3.66 shows the location of these units relative to the PGDP facility structures.

The primary references used to summarize the USTs include: the *Final Site Evaluation Report for WAG 15, C-200-A UST and C-710-B UST, Paducah Gaseous Diffusion Plant, Paducah Kentucky* (DOE 1996c); *Corrective Acton Plan for Petroleum Product Underground Storage Tanks Located at the C-750 Garage Facilities, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (MMES 1992b); and *Investigation and Corrective Action Plans for C-750-A and C-750-B Underground Storage Tanks at Paducah Gaseous Diffusion Plant* (MMES 1991).

The C-750-D UST is identified as SWMU 24. The C-746-A1 UST is identified as SWMU 139, and no UST was discovered at SWMU 140.

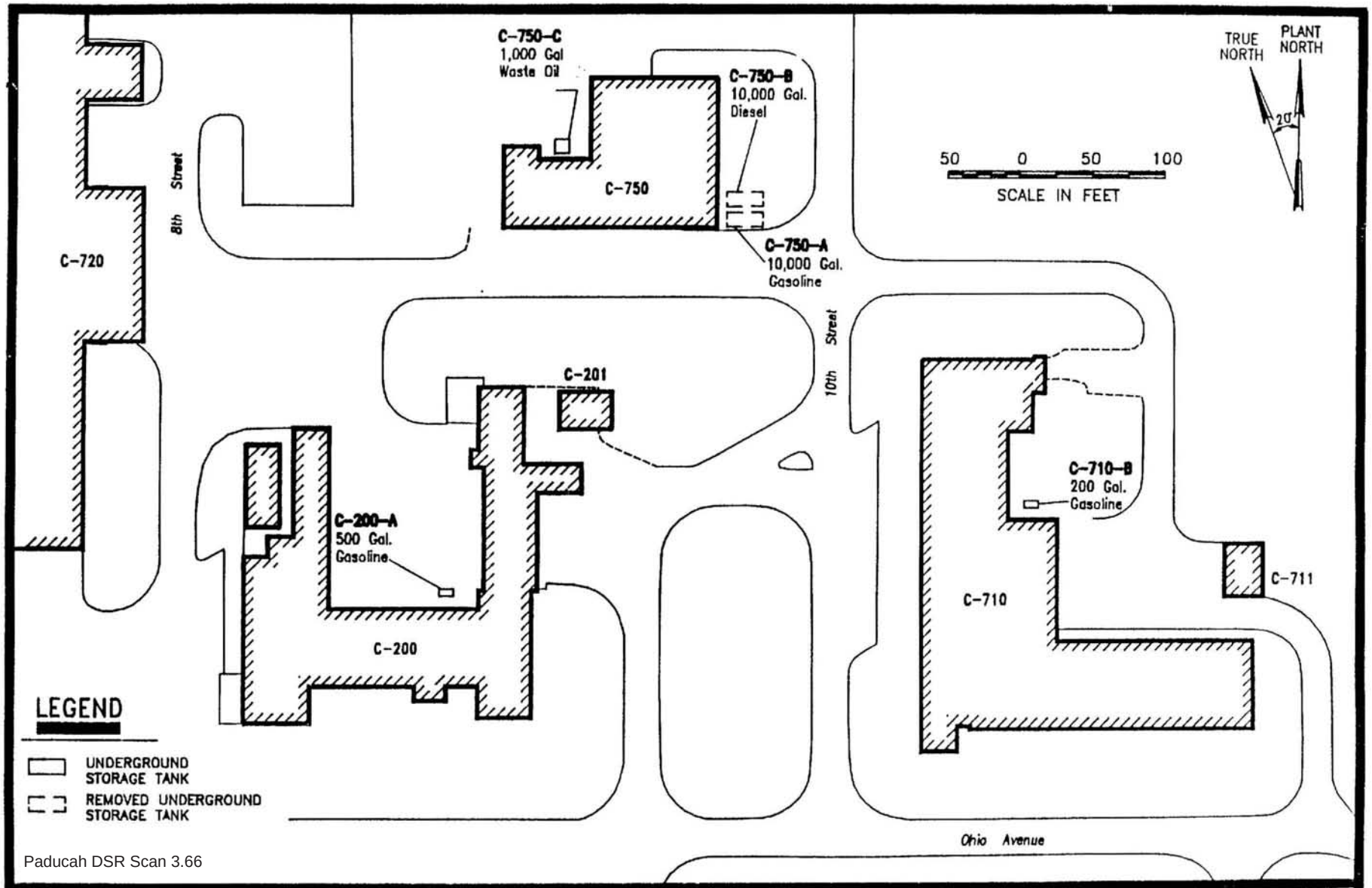


Fig. 3.66. Locations of USTs (Figure 1-2 of UST RI).

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PADUCAH UST SITE INVESTIGATION

PADUCAH, KENTUCKY

3.2.9.2 Description of SWMUs

Location

The C-200, C-710-B, and C-750 USTs are located in the south–central portion of the PGDP security area. The C-200-A UST is located on the north side of the C-200 Building and has a capacity of 110 gal.

The C-710-B UST is located at eastside of the C-710 facility. The C-710-B UST is located at the base of a U-shaped portion of the C-710-B building with parallel air, nitrogen, and steam lines running north/south, perpendicular to the north side and the south side of the building legs enclosing the tank inside the U-shape. The base of the C-710-B tank is located approximately 4 m (12 ft) bgs.

The C-750 USTs surround the C-750 Building. The C-750-A UST is located immediately east of the C-750 Building. The C-750-A UST, SWMU 142, was a 10,000-gal UST that was used to store gasoline. It was removed in 1991. The C-750-B UST, SWMU 143, was a 10,000-gal UST that was also removed in 1991. The C-750-C UST is located west of the main section of the C-750 Building. The C-750-D UST is located 15 m (50 ft) west of the C-750 Building. This UST was used from 1953 to 1982 to accumulate waste oils that were then sold to reclaimers. The C-750-D is buried beneath a concrete pad and is of unknown origin and condition.

Setting

The C-200 facility is the Guard and Fire Headquarters for the plant. This building houses the facilities for the police and fire services personnel. The facility is an irregular, L-shaped structure with a floor area of 1811 m^3 (19,490 ft^2).

The C-710 Technical Services Building provides space for laboratories, offices, a shop, and storage areas. Research and development, troubleshooting, and analytical support personnel are housed in this L-shaped building that has a floor area of 8268 m^2 (88,997 ft^2).

The C-750 Garage houses the service and maintenance of all automotive and heavy mobile equipment used in the plant. This L- shaped one-story structure has a floor area of 110 m^2 (1186 ft^2).

Manufacturing/TSD Processes

The C-200-A UST was constructed in 1957 and was filled with concrete in 1977. The C-200-A UST was used for gasoline storage that fueled emergency generators inside the C-200 Building. The C-710 UST was emptied in 1985 and contained gasoline. The C-750-A and C-750-B USTs were constructed in 1955, closed in 1989, and removed in 1991. The two USTs along with the associated piping, and 365 yd^3 of soil were removed.

Summary of Previous Investigations

Site investigations/remedial investigations. In July 1989, petroleum hydrocarbons were discovered in MW69, located approximately 150 m (500 ft) northeast of the C-750 Building. A preliminary assessment was conducted to determine the source(s) of the contamination. The results of the assessment indicated that six tanks located in the vicinity of the C-750 Building could have contributed to the contamination detected in MW69; C-750-A, C-750-B, C-750-C, C-200-A, C-710-B, and C-750-D. Tank C-750-D was subsequently removed from further remedial investigations because it had been used for the storage of waste oils containing PCBs and uranium, which by the presence of these contaminants exempted the tank from UST regulations and required separate investigation (MMES 1992c).

The C-200 area was investigated in 1991. The tank was filled with grout in 1977; therefore, the contents of the tank could not be sampled but did contain gasoline at one time.

The C-710 UST was sampled in 1996. The sample was analyzed for BTEX and lead. No lead discovered above the quantification limit of 0.25 mg/L.

The C-750-A and C-750-B USTs were investigated in 1989. Readings from a shallow monitoring well 91 m (300 ft) from the USTs showed the presence of organic vapors. Sampling of the soil produce during the drilling of this well also indicated the presence of organic petroleum components. A second phase of the investigation was initiated in 1991.

In 1998 the DOE conducted an RI for the WAG 27 units at the PGDP. The *D1 Remedial Investigation Report for Waste Area Grouping 27, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1998f) was used to evaluate the potential impacts to the groundwater from the C-750 USTs. The investigation included the C-720 facility, which is located near the C-750 garage area. Numerous borings and groundwater samples were taken from this area to evaluate the presence of TCE in the RGA. Based on the findings from the sampling data, the C-720 area is not as significant a source of TCE to the RGA as is the C-400 area.

Sources of Data

Since the results of the preliminary investigation in the C-750 area indicated that the C-750-A and C-750-B had leaked, the primary focus of the subsequent investigation was to determine the extent of contamination that was released from the site. A total of 13 soil borings/monitoring wells were completed near the C-750 facility and surrounding area in 1991. The soil borings and monitoring wells installed as part of this investigation are shown in Fig. 3.67.

The WAG 27 RI included two soil borings within the C-200 area. The borings were located east and northwest of C-200. Based on a decreasing trend of TCE concentrations from the north side of the C-720 Building, and a significant decrease under the C-200 area, the source of TCE appears to be located near the northeast corner of the C-720 Building.

Hydrogeologic Conceptual Site Model

Five stratigraphic units have been identified to evaluate groundwater flow at the PGDP. These five units include:

- Hydraulic Unit (HU) 1: loess;
- HU 2: discontinuous sand and gravel lenses in a clayey silt matrix;
- HU 3: relatively impermeable clay layer that acts as the upper confining layer for the RGA;
- HU 4: predominately continuous sand unit with a clayey silt matrix which directly overlies the RGA; and
- HU 5: gravel, sand, and silt. This is the primary pathway for groundwater transport of contaminant away from the SWMUs and is the uppermost aquifer in the area of the PGDP.

The hydraulic conductivities of the sand comprising the HU 2 and HU 4 are typically two orders of magnitude higher than clays and silts, which make up HU 1 and HU 3.

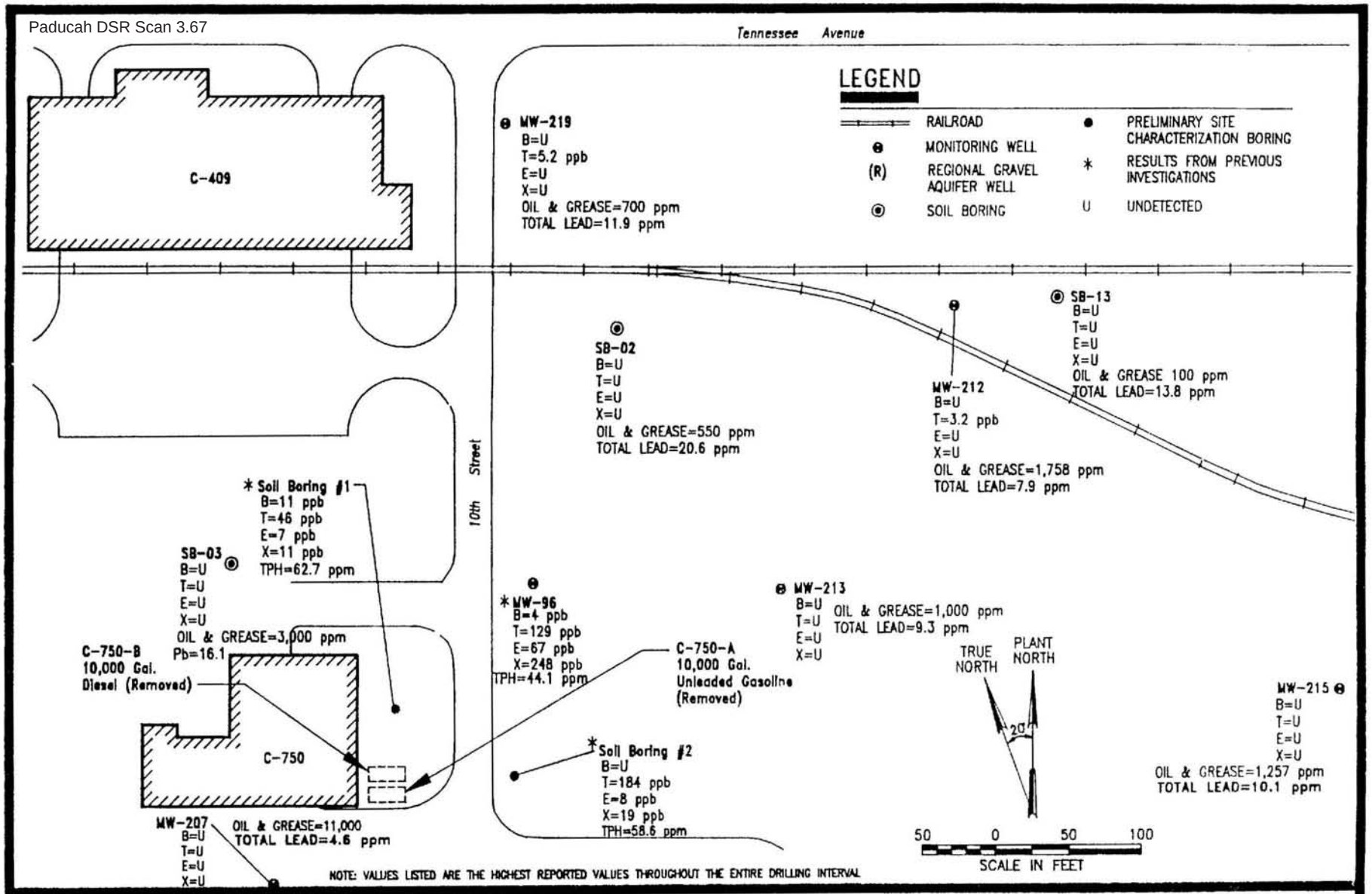

Fig. 3.67. Location of soil borings and monitoring wells.

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Nature and Extent of Contamination

The results of the 1992 site investigation indicate that three of the USTs investigated: C-200-A, C-710, and C-750-C have not leaked. This is based on the results of the sampling in and near the USTs and historical documentation indicating the materials stored in the tanks. The most conclusive evidence to support these conclusions was the soil and groundwater samples associated from MW209, which is located 5 m (15 ft) from C-200-A. These boring and subsequent monitoring well data did not indicate the presence of BTEX, or other contaminants above background levels (DOE 1992).

The sampling locations that were used to evaluate the C-710-B were SB-01 located approximately 1.8 m (6 ft) north of C-710-B and MW210 installed approximately 6 m (20 ft) northeast of C-710-B. In addition to the soil and groundwater samples, a tank sample was collected from C-710-B to characterize the residual contents of the tank and to provide relative concentrations for the constituents found. These results affirm the conclusion that the C-710-B tank has not leaked.

The C-750-A and C-750-B USTs are believed to be the source of the soil contamination detected in the soils and groundwater northeast of the C-750 garage. This soil contamination is bounded to the east by MW213, to the north by soil boring SB-02, to the west by SB-03, and to the south by piping that was utilized with fuel services from these two tanks. A groundwater plume in the UCRS of the BTEX compounds has also been defined. This plume emanates to the northeast from the C-750 USTs and is bounded to the east by MW213, the north by MW69, to the west by SB-03, and to the south by MW207. The vertical extent of the plume has been bounded by data from MWs 68 and 71. Based on sampling data from these wells, and consideration of the conceptual site model, it is determined that the RGA has not been contaminated by the C-750-A and C-750-B USTs.

Contaminant Fate and Transport

The C-750-A and C-750-B USTs have leaked BTEX compound within the UCRS. This plume extends from the UST to the northeast as indicated in Fig. 3.68.

The C-200-A, C-710, and C-750-C USTs are not suspected of leaking and therefore do not require fate and transport assessments.

Previous Remedial Actions

The C-200-A UST was used for gasoline storage from 1957 to approximately 1977. It was then permanently filled with concrete and taken out of service. The C-710-B UST was installed in 1955 and emptied in 1985. Based on the sampling information collected in the area, corrective action for the C-710 UST was not required. The preliminary investigation included testing of the C-750-A and C-750-B USTs and completion of three soil borings in the area. Subequently, the C-750-A and C-750-B USTs were emptied in July 1989 and removed in March 1991.

3.2.9.3 Risk Assessment Summary

The summary presented in this section was taken from *Baseline Risk Assessment for the Underground Storage Tanks at the C-200, C-710, and C-750 Buildings, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (MMES 1992d). Specifically, the risk summary tables of the UST BRA contain the pertinent risk information that will be repeated here. The purpose of this BRA was to present the potential human health risks associated with the PGDP USTs in the absence of any corrective action. The goal of the BRA was to provide a framework for developing the risk information necessary to assist decision making at a remedial site.

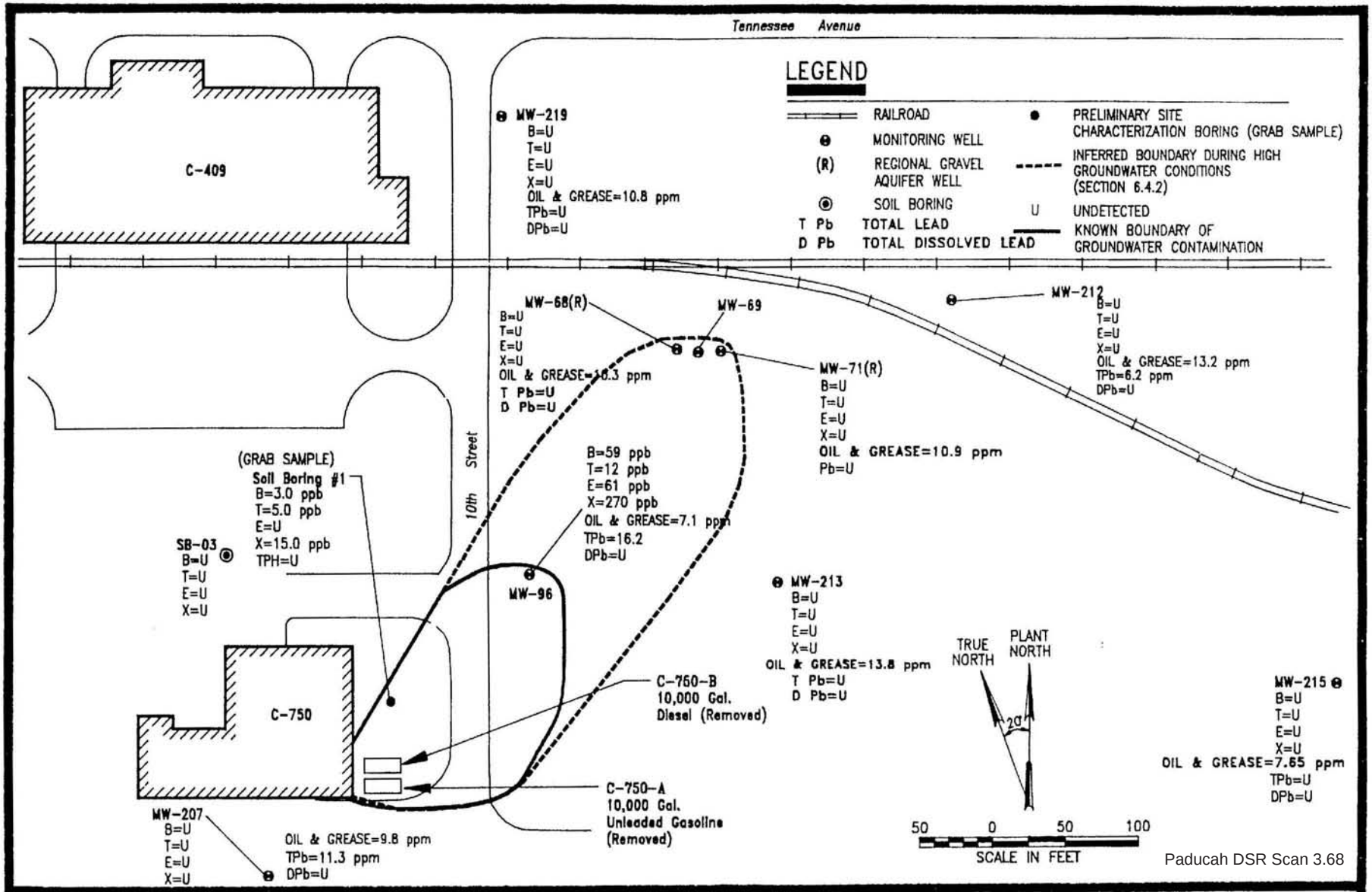

Fig. 3.68. Extent of BTEX contaminations in UCRS.

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Table 3.77 summarizes the risks for these USTs calculated in the UST BRA. These risks are being compiled from Tables 5-1 to 5-4 of the UST BRA. Subsequent to the UST BRA being completed, several of these USTs were remediated.

Table 3.77. Summary risk results from the UST BRA[a]

Scenario (light industrial)	Systemic toxicity	Excess lifetime cancer risk
Site-specific Estimate	0.82	1.5×10^{-4}
Reference Estimates	1.1	7.9×10^{-5}

[a] Taken from Tables 5-1 to 5-4 of the UST BRA (MMES 1992d)

The summary presented in this section was taken from *Baseline Risk Assessment for Underground Storage Tanks 130, 131, 132, 133, and 134 as presented in the WAGs 1&7 RFI/RI, Paducah Gaseous Diffusion Plant, Paducah, Kentucky, UST Facility/Site Identification Number 6319073* (LMES 1996a). Specifically, the Executive Summary and Chapter 7.4 of the WAGs 1 and 7 UST BRA contain the pertinent risk information that will be repeated here. The purpose of this BRA was to present the potential human health risks associated with the WAGs 1 and 7 USTs in order to close the sites.

Table 3.78 summarizes the risks for the USTs calculated in the WAGs 1 and 7 UST BRA (LMES 1996a). These risks are being compiled from Tables ES.1 and ES.2 of the BRA. Note that USTs 130, 131, and 132 had no use scenarios of concern.

Table 3.78. Summary risk results from the WAGs 1 & 7 UST BRA

	UST 133	
Scenario	**Systemic toxicity**	**Excess lifetime cancer risk**
Future adult rural resident	none	9×10^{-5}
Future child rural resident	none	NA
	UST 134	
Future adult rural resident	none	3×10^{-6}
Future child rural resident	none	NA

Notes: NA = ELCR not applicable to child cohort. Values for adult ELCR include exposures as a child.
[a] Taken from Tables ES.1 and ES.2 of the WAGs 1 & 7 UST BRA (LMES 1996a)

The summary presented in this section was taken from *Baseline Risk Assessment for Exposure to Polycyclic Aromatic Hydrocarbons at Underground Storage Tanks C-750 A&B, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (LMES 1996b). Specifically, the Executive Summary and Appendix B of the C-750 A&B UST BRA contain the pertinent risk information that will be repeated here. The purpose of this BRA was to present the potential human health risks associated with PAHs at the C-750 A&B USTs in order to close the sites.

Table 3.79 summarizes the risks for the USTs calculated in the C-750 A&B UST BRA. These risks are being compiled from Tables 9 and 10 from Appendix B.

Table 3.79. Summary risk results from the C-750 A&B UST BRA

Scenario	C-750 A&B UST Systemic toxicity	Excess lifetime cancer risk
Future Excavation Worker	0.00554	4.13×10^{-6}

[a] Taken from Tables 9 and 10 of the C-750 A&B UST BRA (LMES 1996a)

3.2.10 WAG 3

WAG 3 consists of three SWMUs: the C-747 Contaminated Burial Yard (SWMU 4), the C-746-F Classified Burial Yard (SWMU 5), and C-747-B Burial Ground (SWMU 6) (DOE 1998e). All three of these sites are located in the west-central and northwestern portion of the PGDP security area (Fig. 3.69). According to the PGDP Site Management Plan (DOE 1999c), the SWMUs in WAG 3 were grouped as a result of common geographical location, common release mechanisms, and the potential to apply a common remedial technology to each of the units, as necessary. The EPA and KDEP approved an RI/FS for the SWMUs in WAG 3, and field activities were completed in 1999 and early 2000.

3.2.10.1 C-747 Contaminated Burial Yard (SWMU 4)

Location

The C-747 Contaminated Burial Yard (SWMU 4) is located south of the C-749 Uranium Burial Ground (SWMU 2) and the C-404 Low-Level Waste Burial Ground (SWMU 3), in the west–central portion of the PGDP. SWMU 4 is bounded to the north by Virginia Avenue, to the east by 6th Street, to the west by 4th Street, and to the south by an active railroad spur.

A figure depicting the relative location and dimensions of SWMU 4 is provided as Fig. 3.70.

Setting

SWMU 4 primarily is an open grass field consisting of approximately 2 hectares (5 1/3 acres) that was used at one time for the disposal of various waste materials in burial cells. The SWMU is enclosed by a chain-link security fence with limited access to authorized personnel only. A subsurface geophysical survey was completed during the WAG 3 investigation prior to delineating sample locations. The survey identified four distinct anomalous areas within the SWMU. The following subheadings provide information on the setting of SWMU 4, including surface-water hydrology, biological resources, soils, and surface and subsurface features.

Surface-water hydrology, wetlands, and floodplains. Surface-water drainage swales are located along the borders of the SWMU to the north, east, and west. The shallow drainage swales direct surface runoff to the northwest corner, under Virginia Road, and into the KPDES Outfall 015 effluent ditch. Outfall 015 empties into Bayou Creek on the west side of the plant. There are no streams, wetlands, or 100-year floodplain areas within SWMU 4.

Biological resources. SWMU 4 is covered in field grasses and clovers with the exception of a short, narrow, gravel road that enters from 4th Street. The road is rarely used and is nearly completely grass covered. Since the SWMU is located within the security area of the plant, is surrounded by a security fence, and is fairly regularly mowed, it provides limited habitat for wildlife. No T&E are known to be present at SWMU 4.

Soils and prime farmland. Native surface soils at PGDP are part of the Calloway-Henry Association. However, in SWMU 4, it is likely that extensive reworking of the surface [as a result of the burial cell excavations and associated construction activities (e.g., road building)] has resulted in removal of much of the native soil cover. At SWMU 4, it appears that a cap, up to approximately 0.9 m (3 ft) thick, has been placed over the entire area.

Fig. 3.69. Locations of SWMUs within Waste Area Group 3.

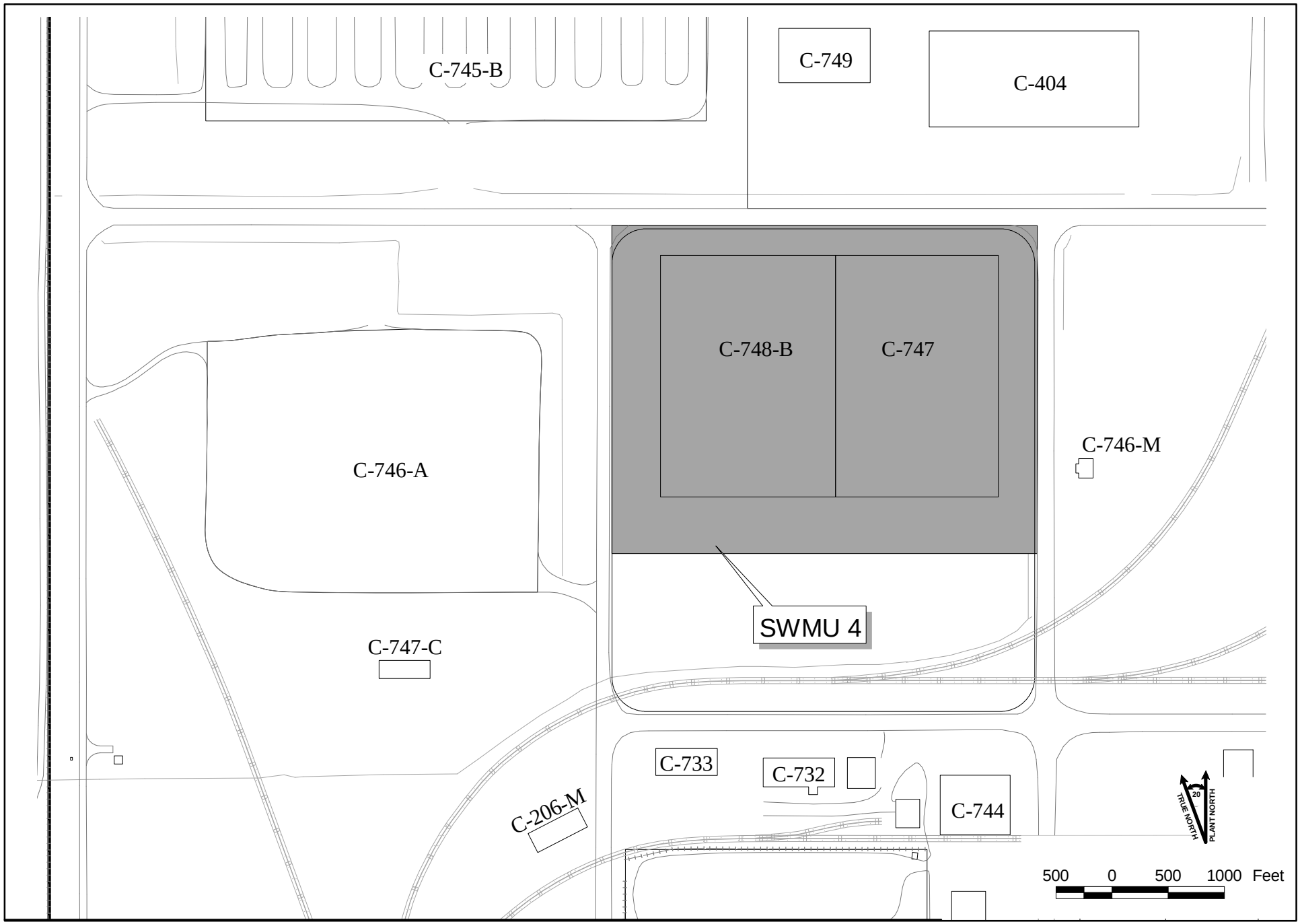

Fig. 3.70. Location of the C-747 Contaminated Burial Yard (SWMU 4).

Underground utilities. No underground utilities are located at SWMU 4. However an underground water line is located to the south and southeast of the SWMU.

Geology/Hydrogeology

The stratigraphy for SWMU 4 has been inferred from a total of 45 soil borings that were placed within the SWMU and along the perimeter of the SWMU boundary. These boreholes include 4 DWRC borings that were drilled into the McNairy Formation, 8 angled HSA borings that were advanced to under the burial cells, and 29 vertical DPT and 4 vertical HSA borings completed at varying depths.

Sandy, silty clays and clayey silts make up the upper 6 m (20 ft) of soil (identified on cross-sections as HU1). The HU2 interval (ranging from silty clay to sandy clay to gravelly, silty clay to gravel) extends from 6-12 m (20-40 ft) bgs with an average thickness of 6 m (20 ft). It is likely that the coarser-grained lithologies form lenses within the HU2. An underlying interval primarily consisting of silt and clay with varying amounts of sand and a few gravels, the HU3, is found at 12-17 m (40-55 ft) bgs. The variable lithology of HU3 in the area of SWMU 4 suggests that the HU3 has a reduced capacity to function as an aquitard relative to other areas of the plant.

The RGA (consisting of HU4 and HU5) was identified at a depth of 17-37 m (55-120 ft) bgs. An upper 1.5 m (5 ft) thick sand makes up the HU4. The HU5 consists of a mixture of medium-grained, well-sorted sand with varying percentages of moderately well-sorted, sub-rounded to subangular chert gravel. A sandy clay found at depths of 32-35 m (105-115 ft) bgs, defines a transition zone between the RGA and McNairy Formation. The dark gray to greenish-gray clay characteristic of the McNairy Formation was encountered at depths ranging from 30 m (100 ft) bgs in the east to 35 m (115 ft) bgs in the west.

The base of the RGA deepens to the west and forms a trough in the McNairy Formation. As compared to the normal thickness of the RGA across the PGDP, 12-14 m (40-45 ft), the total thickness of the RGA under the west end of SWMU 4 is 18-20 m (60-65 ft). This trough is a preferred pathway for groundwater (and contaminants) migrating from SWMU 4, making the SWMU a likely contributor to the Southwest Plume.

Manufacturing/TSD Processes

The C-747 Contaminated Burial Yard operated from 1951 through 1958, and was used for disposal of radiologically contaminated and non-contaminated PGDP waste materials and excess equipment. Some of the material was burned prior to disposal. According to PGDP personnel, a majority of the contaminated material was buried in the northern part of the burial yard. Also, sludges that originally were designated for the C-404 burial area also may have been placed into the C-747 Contaminated Burial Yard; these sludges historically consisted of uranium-contaminated solid waste and ^{99}Tc-contaminated magnesium fluoride. The total quantity of waste buried at the C-747Contaminated Burial Yard is unknown. When the yard was closed, a smaller pit was reported to have been excavated for the disposal of radiologically contaminated scrap metal. In 1982, the entire burial yard was covered with 0.6 to 0.9 m (2 to 3 ft) of soil material and a 15-cm (6-in.) clay cap.

Summary of Previous Investigations

Site Investigations/Remedial Investigations. The C-747 Contaminated Burial Yard was investigated during the CERCLA Phase II Site Investigation (CH2M HILL 1992). This investigation included a geophysical survey, radiation walkover survey, infiltrometer testing, and collection of soil samples from four boreholes.

The WAG 3/SWMU 4 investigation included a geophysical survey, surface radiological walkovers, infiltrometer testing, CPT borings, collection of subsurface soil and groundwater samples from 45 boreholes, and surface soil/sediment samples from five locations.

As part of the geophysical survey during the Phase II SI, an electromagnetic conductivity survey was performed to delineate the location of the site burial pits, followed by a limited magnetometer survey to define selected anomalies. Survey results indicated four main anomalous areas, interpreted to be buried metal and wastes, located in the western two-thirds of the burial yard. The WAG 3 RI geophysical survey confirmed the delineation of the waste cells and identified an additional waste cell in the northeastern corner of the SWMU.

The radiation walkover during the Phase II SI consisted of a low-level gamma radiation survey of the site. Data from the survey indicated elevated readings in the east, north, and west perimeter ditches surrounding the site; readings did not exceed three times the background established for the survey. Localized contamination was detected along the western half of the southern portion of the site, and along the northern portion of the site. Shielded re-scans of the areas resulted in near background readings, indicating beta radiation was being detected. At one location in the southwest corner of the site, unshielded and shielded readings were nearly equivalent, suggesting the presence of gamma-emitting radionuclides.

Additional radiological screening surveys over portions of SWMU 4 were conducted in May and June of 1996 by Lockheed Martin Utility Services. Results indicated two small areas located in the western portion of the SWMU 4 required flagging and demarcation as radiological contamination areas; a small hole located within these areas provided a 399,000 dpm β/α. The ditches surrounding the SWMU also were flagged as radiological contamination areas, with counts as high as 119,700 dpm β/α.

The WAG 3 RI radiation walkover targeted areas twice the established background for further investigation. Two small areas above twice background were noted in the southwestern portion of the SWMU. The maximum activity in this area was approximately 200,000 cpm with a background of 30,000 cpm. In addition, a small area in the southern portion of the SWMU had an activity of 53,00 cpm with the background of 30,000 cpm. In response to the elevated levels, an *in situ* gamma spectrometry investigation was performed. Seven samples were collected in SWMU 4. The results of the *in situ* investigation did not indicate the presence of radioactive contamination.

The geophysical and radiation walkover surveys were used to select locations for four soil borings at the C-747 site during the Phase II SI. Soil borings were located on all four sides of the burial area, and drilled approximately to the top of the HU3 interval [i.e., 13 m (40 ft) bgs].

Infiltrometer tests were conducted at the three surface sampling locations to estimate the infiltration rate during the Phase II SI. The results of the infiltrometer testing indicate the cap placed over the C-747 Contaminated Burial Yard consists of a lean clay with a laboratory permeability in the range of 1×10^{-6} cm/sec. Two additional infiltrometer tests were completed as part of the WAG 3 RI. The soil was classified as Group C soils having minimum infiltration rates in the range of 0.1-0.4 centimeters per hour (0.05-0.15 inches per hour) and consisting of a layer that impedes downward movement of water. In addition, three surface soil samples were collected to evaluate the geotechnical parameters of the cover material placed over buried waste areas of the site.

The WAG 3/SWMU 4 RI subsurface exploration began with three CPT borings used to characterize the depth of the shallow hydrogeologic units at the site. Soil and groundwater samples were collected from 41 UCRS borings (29 DPT, 4 vertical HSA, and 8 angled HSA) throughout the SWMU. Four borings drilled through the RGA and into the underlying McNairy Formation around the perimeter of the

SWMU (DWRC borings) provided deep groundwater samples. Five surface soil/sediment samples were obtained from within the SWMU and from the drainage ditches surrounding the SWMU. Significant levels of VOCs and PCBs were encountered in the soils and groundwater. Elevated levels of radionuclides, SVOCs, and metals also were encountered at SWMU 4 during the WAG 3 RI.

Conceptual Site Model

The preliminary conceptual site model for the human health risk assessment is provided as Fig. 3.71.

Nature and Extent of Contamination

Organics. Soil samples from Phase II sample H227 contained VOCs and SVOCs; however, only VOCs and one occurrence of SVOCs were detected at depth. VOCs also were detected in the bottom interval of the H225 boring.

Samples collected during the WAG 3 RI indicated VOCs are present in the subsurface soil, UCRS groundwater, and RGA groundwater at SWMU 4. Most of the VOCs detected are TCE and its degradation products. The majority of the samples in which TCE was detected in both subsurface soils and UCRS groundwater are beneath or adjacent to the burial cells and generally are below 7 m (23 ft) bgs. This suggests that sources of TCE have been disposed of in the burial cells, and that these sources have been mobilized by precipitation infiltrating through the surface soils, down through the cells, and into the underlying soils.

In the RGA, VOCs are encountered in the three DWRC borings located west of the SWMU (downgradient), while lower levels of VOCs are encountered east of the SWMU (upgradient). Based on available data, groundwater flow in the RGA is generally west at SWMU 4. These data indicate that a small quantity of VOCs are present immediately upgradient of SWMU 4, and a much greater quantity of VOCs are present immediately downgradient of SWMU 4, suggesting that SWMU 4 is a source of VOC contamination to the RGA (specifically the Southwest Plume).

In both soils and groundwater, the highest levels of contamination were detected in the angled borings under the burial cells. Levels of contamination around the periphery of the cells are several orders of magnitude lower or, in some cases, not detected at all.

During the WAG 3 RI, PCBs were detected at SWMU 4 at depths of 0.9–1.8 m (3–6 ft) bgs. Within this horizon, radiological contamination (including gross alpha, beta, and various radioisotopes) also was detected. In several of the borings, gravel (typically used on gravel pads and driveways) was encountered at this interval. The WAG 3 RI report postulates that this horizon represents the original grade at the time the burial cells were in use. Most of the PCB detections were encountered in borings outside but adjacent to the burial cells. A potential explanation relates the contamination to spills on the gravel pad. Spills also might explain the high radiological detects found at this horizon.

Inorganics. Soil samples from the Phase II sample H227 detected metal contamination near the bottom of the boring. Results from the H214, H225, and H226 samples indicated metal contamination in the surface soils and at depth. Metal compounds detected in the sampling include the following: aluminum, arsenic, barium, beryllium, cadmium chromium, lead, magnesium, manganese, mercury, nickel, and vanadium.

During the WAG 3 RI, metals were identified in SWMU 4 at levels that exceeded screening values (however, due to uncertainty of laboratory methods, the actual concentrations of these analytes could be within background ranges). The source of these metals is unknown, but if they do represent contamination, then it is likely originating from material buried at the site.

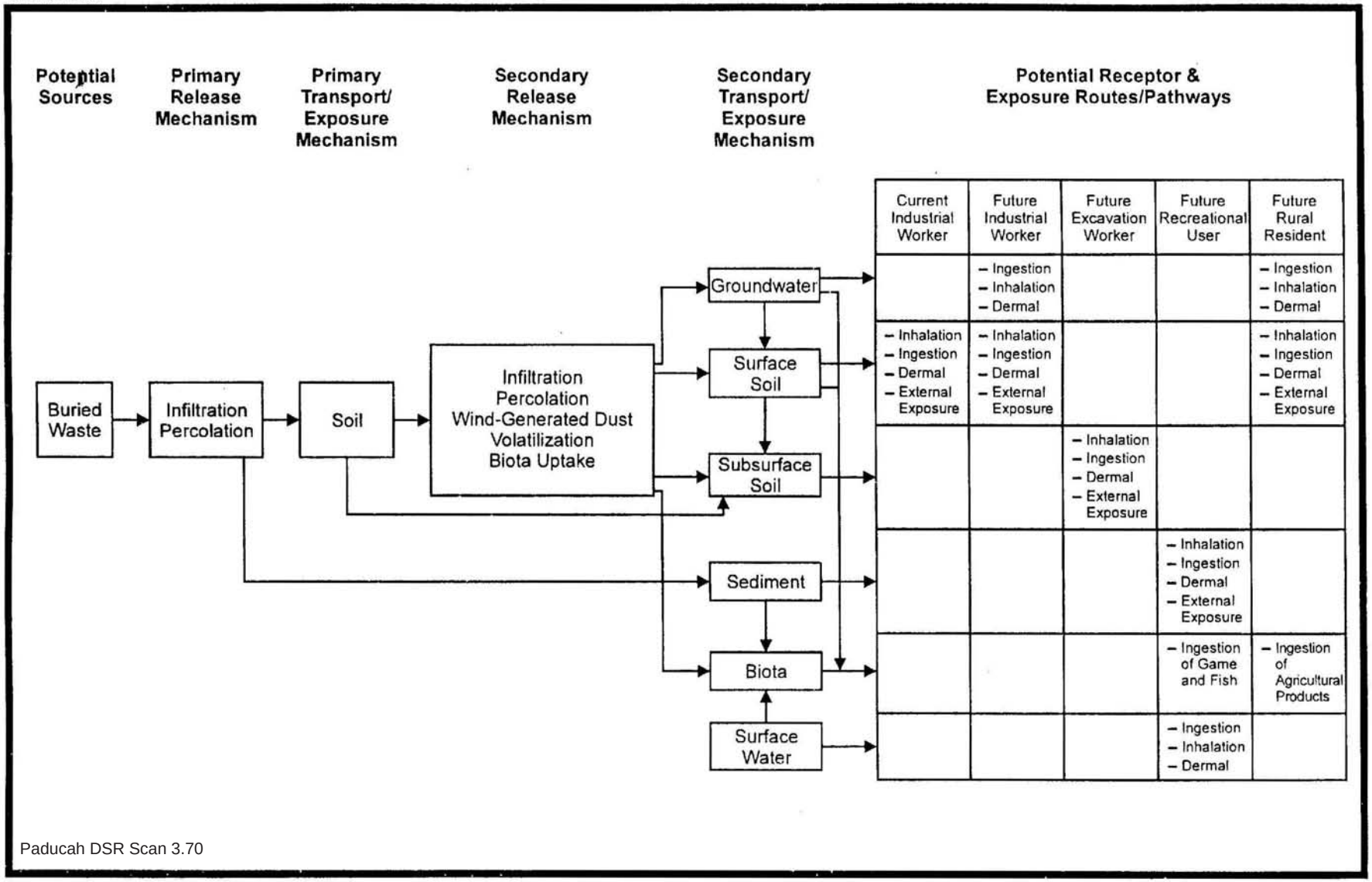

Fig. 3.71. Conceptual site model for the C-747 Contaminated Burial Yard (SWMU 4).

Radionuclides. Radiological contamination was detected during the Phase II Site Investigation in the near surface soil horizon in boring H227. Results from the H214, H226, and H225 borings indicated radionuclide contamination in the near surface soils. Radionuclide compounds detected during the sampling include the following: ^{234}U, ^{235}U, ^{238}U, ^{237}U, and ^{99}Tc.

The WAG 3 RI detected elevated radiological activity, including high levels of various radioactive isotopes, primarily around the southwest burial cell. Radiological contamination also was detected in the burial cell in the northeast corner. WAG 3 RI samples revealed ^{99}Tc was present in the RGA around SWMU 4 and in the UCRS groundwater under SWMU 4. No contamination was identified from the McNairy Formation except for one sample (^{99}Tc was detected at 37 pCi/L at 158 ft bgs in 004-058). Because this boring is located upgradient, SWMU 4 is not considered to be the source.

Contaminant Fate and Transport

Based on soil boring logs, two model layers (one partially saturated and one saturated) were delineated at SWMU 4. These layers correspond to the UCRS [0.3–17 m (1–55 ft bgs)] and the RGA [17–30 m (55–100 ft bgs)]. The travel distances from the source to each downgradient exposure point were 271 m (890 ft) to the PGDP security fence and 882 m (2895 ft) to the DOE property boundary, based on a west to northwestward groundwater flow direction.

Table 3.80 reports model results for selected contaminants detected in the SWMU 4 area. This table lists the maximum concentrations of each source contaminant modeled to reach the two receptor locations. The WAG 3 RI report also includes fate and transport modeling results for 14 metals, one SVOC, two additional VOCs, and 34 additional radionuclides (includes daughter products). Modeling indicates that volatile contaminants in the UCRS will contribute significantly to contaminant levels in groundwater of the RGA. Contributions from radionuclide contaminants in the surface soil to the groundwater in the RGA are negligible. However, the modeling shows that radionuclide contaminants in the UCRS result in groundwater contamination in the RGA, as summarized in the table below.

Table 3.80. Fate and transport modeling results for SWMU 4

	Plant fence		Property boundary	
Constituent	**Max conc. (mg/L) (pCi/L)**	**Time (year)**	**Max conc. (mg/L) (pCi/L)**	**Time (year)**
trichloroethene	2.26×10^{1}	101.6	4.70×10^{0}	110.7
1,1-dichloroethene	2.58×10^{-1}	62.86	5.38×10^{-2}	68.83
vinyl chloride	3.31×10^{-1}	56.6	6.90×10^{-2}	61.96
neptunium-237	4.88×10^{2}	316.4	9.83×10^{1}	380.4
technetium-99	6.34×10^{4}	111.4	1.32×10^{4}	112.7
uranium-234	4.51×10^{3}	4329	8.94×10^{2}	5140
uranium-238	8.33×10^{2}	4330	1.66×10^{2}	5141

Summary of Previous Remedial Actions

No previous remedial actions have been conducted for these units.

3.2.10.2 3.2.10.2 C-746-F Classified Burial Yard (SWMU 5)

Location

The C-746-F Classified Burial Yard (SWMU 5) is located south of the C-746-P Clean Scrap Yard, and west of the C-747-B Burial Yard in the northwestern portion of the PGDP. Unnamed gravel roads parallel the northern and southern extents, while Patrol Road 1 lies to the west. On the east site, a third gravel road connects the other two and has an offshoot at the center to the east. The SWMU has a fenced boundary that limits access to authorized personnel only.

The Classified Burial Yard consists of disposal pits that cover an area of approximately 15,608 m^2 (168,000 ft^2). According to plant personnel, the disposal pits were located on a grid system and consisted of approximately 3 by 3-m (10 by 10-ft) cells excavated to depths of 1.8 to 4.6 m (6 to 15 ft) bgs. A figure depicting the relative location and dimensions of SWMU 5 is provided as Fig. 3.72.

Setting

SWMU 5 is primarily an open grass field of approximately 1.8 hectares (4 1/3 acres) that was used at one time for the burial and disposal of security-classified weapons components, radionuclide-contaminated scrap metal, and slag from nickel and aluminum smelters. The SWMU is enclosed by a chain-link security fence with limited access to authorized personnel only. The following subheadings provide information on the setting of SWMU 5, including surface-water hydrology, biological resources, soils, and surface and subsurface features.

Surface-water hydrology, wetlands, and floodplains. Surface-water drainage swales are located along the borders of the SWMU to the north, west, and south. The shallow drainage swales direct surface runoff along these drainages into Ditch 001, located south of the burial yard. Ditch 001 then flows west into KPDES Outfall 001, which empties into Big Bayou Creek on the west side of the plant. There are no streams, wetlands, or 100-year floodplain areas within SWMU 5.

Biological resources. SWMU 5 is covered in a herbaceous layer dominated with grasses and various flowering plants. Since the SWMU is located within the security area of the plant, is surrounded by a security fence, and is fairly regularly mowed, it provides limited habitat for wildlife. No T&E species are known to be present at SWMU 5.

Soils and prime farmland. Native surface soils at PGDP are part of the Calloway-Henry Association. However, in SWMU 5 it is likely that extensive reworking of the surface as a result of the burial cell excavations has resulted in removal of much of the native soil cover. Previous activities at SWMU 5 placed a cap [up to approximately 1.5 m (5 ft) thick] over the entire SWMU.

Underground utilities. No underground utilities are located at SWMU 5.

Geology/Hydrogeology.

This interpretation of the geology of SWMU 5 has been developed from 16 soil borings that were drilled around the perimeter of the SWMU boundaries. The SWMU is a classified burial area; therefore, no borings were drilled within the SWMU boundary. However, lithologic samples from under the SWMU were collected from angled HSA borings.

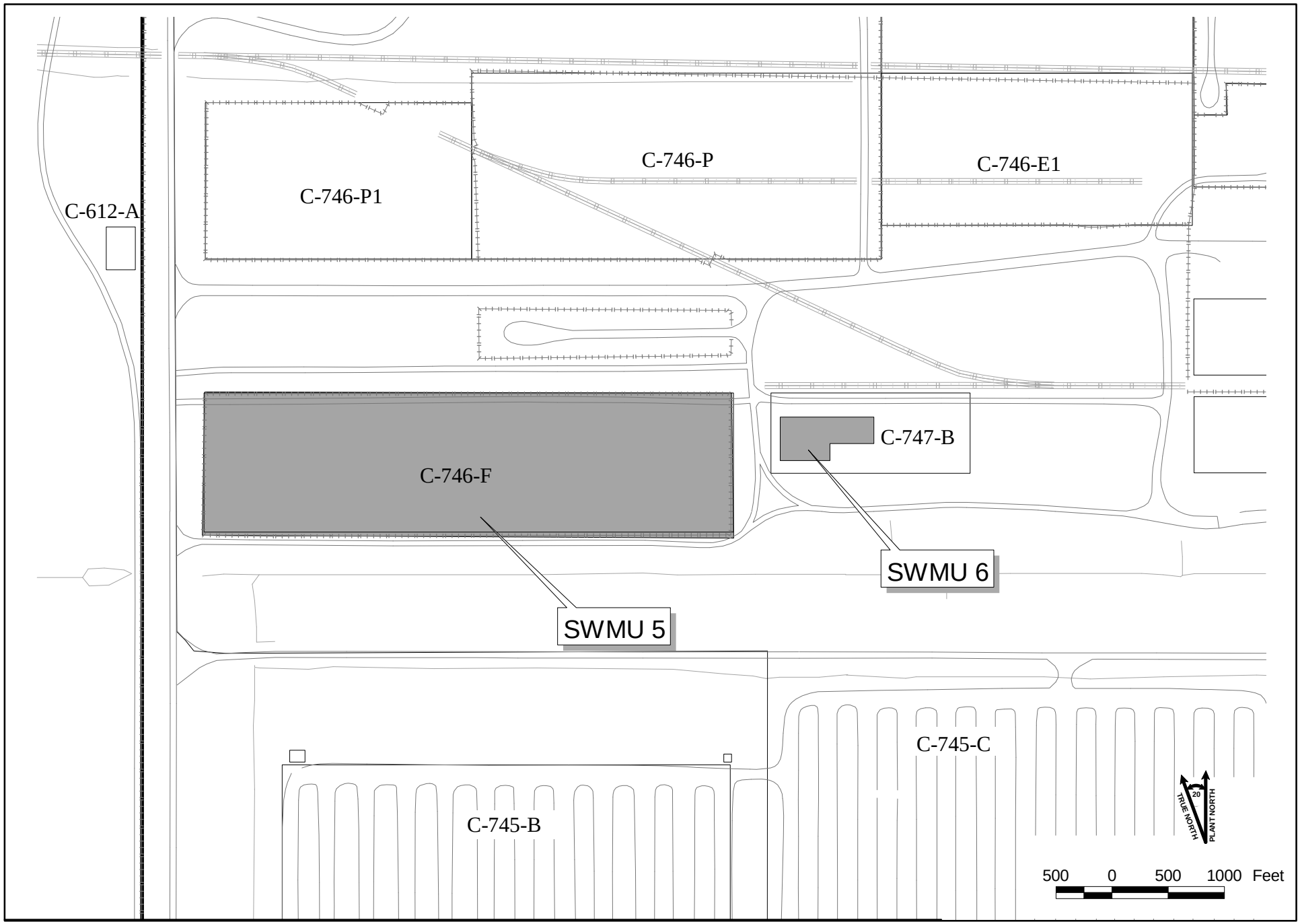

Fig. 3.72. Location of the C-746-F Classified Burial Yard (SWMU 5) and C-747-B Burial Yard (SWMU 6).

The upper 5-6 m (18–20 ft) of soil (HU1) was identified as moist to damp silty clays to clayey silts. A sandy, silty clay is present 6–12 m (20–40 ft) bgs (HU2), with a gravel lens at 5–9 m (18–28 ft) bgs. Both the thickness of the gravel layer and the physical properties of the gravel varied from boring to boring. The HU3 low permeability layer, with up to 80% clay, is found at 12–18 m (40–58 ft) bgs.

The RGA (HU4 and HU5) consists of a 12–15 m- (40–50 ft-) thick mixture of medium-grained, well-sorted sand with varying amounts of coarse, moderately sorted, sub-rounded to sub-angular chert gravel. A transition zone where there is an increasing silt/clay content combined with a decreasing amount of gravel is present at the bottom 1.5–3 m (5–10 ft) of the RGA. The top of the McNairy Formation was identified at 30–32 m (100–105 ft) bgs. At SWMU 5, the McNairy Formation consists of a clay unit that is stiff to firm with low to moderate plasticity.

Manufacturing/TSD Processes

The C-746-F Classified Burial Yard was used from approximately 1965 through 1987 for disposal of security-classified weapons components, some radionuclide-contaminated scrap metals, and slag from nickel and aluminum smelters; records suggest that weapons components containing tritium, ^{60}Co, and ^{182}Ta may have been placed in the burial yard. Wastes placed in the yard disposal pits were covered with 0.6 to 0.9 m (2 to 3 ft) of soil. The far western end of the yard has not been used for disposal.

Chemically unstable or incompatible wastes appear to have been disposed in SWMU 5, as evidenced by an underground fire thought to have occurred in 1975 or 1976 in the southeast corner of the yard. The fire burned for several weeks, and individuals observing the fire reported that the ground surface appeared to be unstable. Neither the source nor the cause of the fire was determined, and the fire extinguished itself without intervention.

Summary of Previous Investigations

Site Investigations/Remedial Investigations. Three groundwater monitoring wells were installed at the site in 1983, prior to sitewide investigations. One of the wells was located along the south side of the site (MW52), with the others (MWs 53 and 54) installed along the north side of the site. All three wells were completed in the RGA.

The C-746-F Classified Burial Yard was included in the Phase I Site Investigation and consisted of collection of soil samples from a borehole (H002) located along the southern edge of the site. The borehole was drilled to a depth of approximately 22 m (72 ft) bgs. Soil samples were collected continuously in 1.8 m (6 ft) intervals over the depth of the boring.

Phase II Site Investigation activities at SWMU 5 consisted of the collection of soil samples from boreholes, and installation and sampling of one groundwater monitoring well. Two boreholes were drilled and sampled at the site: one near the northeastern corner (H263), and one near the southwestern corner (H264). Both boreholes were drilled to an approximate depth of 1.8 m (6 ft) bgs. The Phase II Site Investigation installed groundwater monitoring well (MW190) on the north side of the site, completing the well in the UCRS. Soil samples were collected during the well installation.

The WAG 3/SWMU 5 investigation included a geophysical survey, surface radiological walkovers, infiltrometer testing, CPT borings, collection of subsurface soil and groundwater samples from 12 boreholes, and surface soil/sediment from 10 locations.

Surface geophysical surveys of SWMU 5 identified the areal limits of the waste cell. The surveys verified the presence of the waste cell in the central and eastern portions of the SWMU. However, discrete individual trench-like features were not apparent in the data. The radiological walkover survey completed within the boundary of SWMU 5 did not identify any area with activity greater than twice background. Three samples were collected during an *in situ* gamma spectrometry investigation. These samples did not indicate the presence of radioactive contamination.

An infiltrometer test was completed within the boundary of SWMU 5. The test concluded that the soil consists of Group C soils having a minimum infiltration rate in the range of 0.1-0.4 centimeters per hour (0.05-0.15 inches per hour) and consists of a layer that impedes downward movement of water.

The SWMU 5 RI subsurface investigation began with two CPT borings to characterize the depth of the shallow hydrogeologic units at the site. Subsurface samples (soil and groundwater) were collected from 10 UCRS borings (3 DPT, 2 vertical HSA, and 5 angled HSA) around the perimeter of the SWMU. Groundwater samples were collected from two borings drilled through the RGA and into the underlying McNairy Formation (DWRC borings). Ten surface soil/sediment samples were obtained from within the SWMU and from the drainage ditches surrounding the SWMU. The WAG 3 RI results did not indicate that SWMU 5 currently is contributing any significant contamination to the UCRS or RGA groundwater.

Conceptual Site Model

The preliminary conceptual site model for the human health risk assessment is provided as Fig. 3.73.

Nature and Extent of Contamination

Organics. Results of the Phase II deep boring (H002) reveal the presence of VOC contaminants in the near surface soil horizon, and in an isolated horizon at approximately 12 m (40 ft) bgs. Analytical results for boring H263 determine the presence of SVOCs throughout the depth of the boring, while results from boring H264 indicate the presence of VOC contaminants in the upper 1.2 m (4 ft) of the boring. Sample results from the boring for MW190 identify SVOC contaminants in the near surface soil horizon. In addition, SVOCs and PCBs were found in the surface soil sample collected at H264. The WAG 3 RI results establish the presence of SVOCs (including pesticide/herbicide and PAHs) and PCBs in the surface soils at low concentrations. It is likely the contamination is related to vehicular traffic and to the lawncare maintenance program of the facility.

Results from the groundwater samples collected from MWs 52, 53, 54, and 190 indicate the presence of TCE and bis(2-ethylhexyl)phthalate in the UCRS groundwater. Groundwater samples from the RGA contain VOCs and SVOCs. The analyses of groundwater samples collected from depths near the contact between the UCRS and the RGA during the WAG 3 RI establish the presence of the Northwest Plume under SWMU 5. The available data do not indicate that SWMU 5 is contributing to the plume.

Inorganics. Metal contamination was detected in samples from the Phase II boring H002 at sporadic depth intervals. Results for boring H264 indicate metal contamination throughout the depth of the boring. Additionally, metal contamination was found in the surface soil collected at H264. The WAG 3 RI analyses identified a few areas of low-level metal contamination.

Results from the groundwater samples collected from MWs 52, 53, 54, and 190 determined the presence of metals in the UCRS groundwater. Groundwater samples from the RGA indicated metal contamination present. The WAG 3 RI did not find elevated metals levels in groundwater.

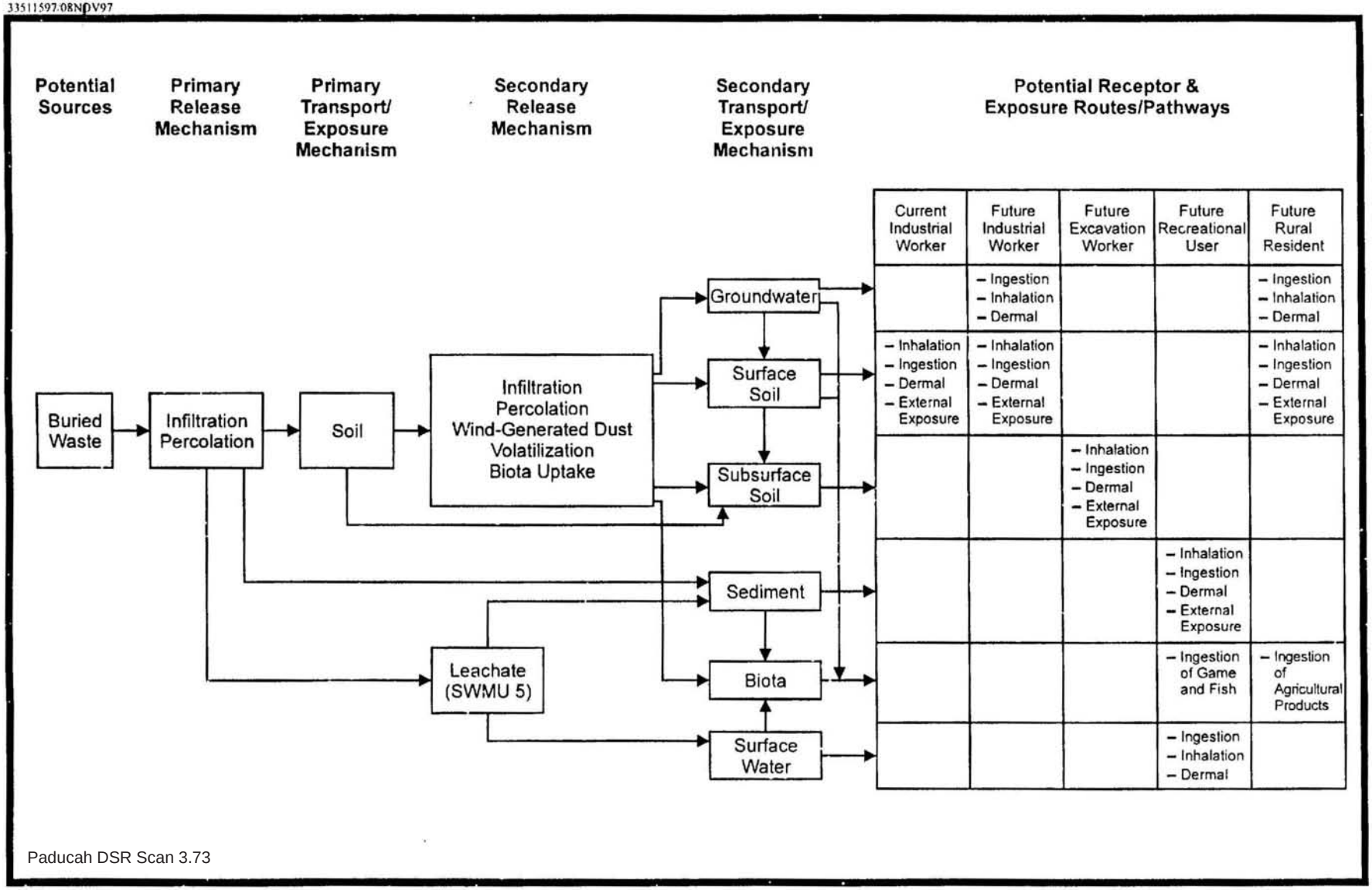

Fig. 3.73. Conceptual Site Model for the C-746-F Classified Burial Yard (SWMU 5).

Radionuclides. Radionuclide contamination was discovered in two horizons located between 1.8 and 9.1 m (6 and 30 ft) bgs in Phase II boring H002. Additionally, radionuclide contamination was detected in the surface soil sample taken at H264. Radionuclides identified included ^{239}Pu, ^{99}Tc, ^{230}Th, ^{234}U, ^{235}U, and ^{238}U.

Results from the groundwater samples collected from MWs 52, 53, 54, and 190 indicated the presence of radionuclide contamination in the UCRS and RGA groundwater. Analyses of the WAG 3 RI revealed the presence of ^{99}Tc in a sample at the McNairy interface with the RGA and could indicate some mixing at this interface. In addition, Radon-222 was detected in four locations and ^{234}U, ^{238}U, and total uranium were identified in one location during the WAG 3 RI.

Contaminant Fate and Transport

Three model layers, two partially saturated and one saturated, were delineated at SWMU 5. The upper partially saturated layer [0–12 m (0–40 ft) bgs] includes the loess deposits making up HU1 and the permeable, but discontinuous, sand and gravel lenses of the UCRS. A lower partially saturated layer represents the silty clay aquitard HU3 [12–18 m (40–60 ft) bgs]. The saturated layer consists of the RGA and extends from 18–30 m (60–100 ft) bgs. The travel distance from the source to each downgradient exposure point is 271 m (890 ft) to the PGDP security fence and 847 m (2780 ft) to the DOE property boundary.

Surface and subsurface soil data provided by the WAG 3 RI and the Site Investigations (CH2M HILL 1991, 1992) were used to develop the source terms and inventories for the fate and transport model. Metals, organic compounds, and radionuclides were identified as present above screening levels in surface soils at SWMU 5.

Table 3.81 reports model results for selected contaminants detected in the SWMU 5 area. This table lists the maximum concentrations of each source contaminant modeled to reach the two receptor locations. The WAG 3 RI also includes fate and transport results for 2 additional metals, 4 SVOCs, 1 VOC, and 10 additional radionuclides (includes daughter products). Contributions to the RGA from other constituents are minor.

Table 3.81. Fate and transport modeling results for SWMU 5

	Plant fence		Property boundary	
Constituent	**Max conc. (mg/L) (pCi/L)**	**Time (year)**	**Max conc. (mg/L) (pCi/L)**	**Time (year)**
		Surface Soil		
Technetium-99	5.78×10^{1}	109.5	9.65	110.7
		UCRS-First Partially Saturated Zone		
Iron	4.98×10^{1}	1411	1.84×10^{1}	1602
Iron (at H263)	1.88×10^{1}	1591	6.61	1871
		UCRS-Second Partially Saturated Zone		
Iron	4.64×10^{2}	1873	8.27×10^{1}	2069
Technetium-99	2.29×10^{2}	130.1	9.96×10^{1}	138.6

Summary of Previous Remedial Actions

No previous remedial actions have been conducted at this site.

3.2.10.3 C-747-B Burial Grounds (SWMU 6)

Location

The C-747-B Burial Grounds are located east of the C-746-F Classified Burial Yard and west of the C-746-Transuranic Storage area, in the northwest section of the PGDP. The SWMU is bounded to the north by a set of abandoned railroad tracks, to the east by a 1.5 m (5 ft) wide by 1.2 m (4 ft) deep drainage ditch, and by unnamed gravel roads to the west and south. The burial ground consists of five separate burial plots (identified as Areas H, I, J, K, and L) that together cover an area of approximately 483 m^2 (5,200 ft^2).

Area H – Magnesium Scrap Burial Area. This disposal site is approximately 17 m^2 (180 ft^2), with dimensions of 3.7 by 4.6 m (12 by 15 ft), and approximately 1.8 m (6 ft) deep.

Area I – Exhaust Fan Burial Area. This discard pit is approximately 26 m^2 (280 ft^2), with dimensions of 2.4 by 10.6 m (8 by 35 ft), and approximately 1.8 m (6 ft) deep.

Area J – Contaminated Aluminum Burial Area. This area is approximately 372 m^2 (4,000 ft^2), with dimensions of 11.2 by 33.5 m (37 by 110 ft), and approximately 1.8 m (6 ft) deep.

Area K – Magnesium Scrap Burial Area. This site is approximately 17 m^2 (180 ft^2), with dimensions of 3.7 by 4.6 m (12 by 15 ft), and approximately 1.8 m (6 ft) deep.

Area L – Modine Trap Burial Area. This area is approximately 55m^2 (600 ft^2), with dimensions of 6 by 9.1 m (20 by 30 ft), and approximately 1.8 m (6 ft) deep.

A figure depicting the relative location and dimensions of SWMU 6 is provided on Fig. 3.72.

Setting

SWMU 6 is primarily an open grass field consisting of approximately 0.1 hectare (1/3 acre) of land. Radioactively contaminated abandoned equipment and materials cover approximately 50% of the surface. These items include, but are not limited to, industrial forklifts, transport carts, flatbed trailers, and concrete pipes. The following subheadings provide information on the setting of SWMU 6, including surface-water hydrology, biological resources, soils, and surface and subsurface features.

Surface-water hydrology, wetlands, and floodplains. A surface drainage ditch is located east of the buried materials and flows southward to discharge into Ditch 001. Ditch 001 flows west past SWMU 5 into KPDES Outfall 001, which empties into Big Bayou Creek on the west side of the plant. There are no streams, wetlands, or 100-year floodplain areas within SWMU 6.

Biological resources. The SWMU 6 ground surface is dominated with medium to tall grasses [up to 0.9 m (3 ft) high] with occasional pockets of young trees and shrubs. Abandoned equipment also is located on the surface of the SWMU. Since the SWMU is located within the security area of the plant and is occasionally mowed, it provides limited habitat for wildlife. No T&E species are known to be present at SWMU 6.

Soils and prime farmland. Native surface soils at PGDP are part of the Calloway-Henry Association. However, in SWMU 6 it is likely that extensive reworking of the surface as a result of the burial cell excavations has resulted in removal of much of the native soil cover. It appears that the excavated material was used to backfill after the waste material was deposited at SWMU 6.

Underground utilities. No underground utilities are located at SWMU 6.

Geology/Hydrogeology

The geology for SWMU 6 has been inferred from 18 soil borings drilled in and around the SWMU. Five angled HSA borings were intended to collect samples and characterize the geology under the burial area. Because of abandoned equipment in the area, two of the five angled borings (006-021 and 006-022) were terminated before reaching the soils beneath the burial cells.

The upper 5-6 m (15-20 ft) of soil (HU1) is comprised mainly of silty clays and clayey silts ranging from dry to moist. A 1.5-3-m- (5-10-ft-) thick layer of gravelly silty clay to sandy silty gravel (HU2) was encountered at a depth of approximately 5-9 m (18–28 ft) bgs. The HU3 consists of a silty sandy clay occurring from 9-18 m (30-60 ft) bgs. The lithology of this unit varies with increasing and decreasing amounts of sand, vertically and horizontally throughout the unit.

A coarse-grained sand layer was encountered at 17-18 m (55 to 60 ft) bgs. This sand unit was not identified in the DWRC borings but is believed to be representative of the HU4 unit. A 14-15 m- (45-50 ft-) thick layer of silty sand and sand and gravel mix (HU5) underlies this layer, extending from approximately 18-32 m (60 to 105 ft) bgs. The top of the McNairy was identified at ~32 m (105 ft) bgs and extends to the total depth [48 m (158 ft) bgs] of the two DWRC borings.

Manufacturing/TSD Processes

This SWMU was used for disposal of miscellaneous metal debris. Disposal in each of the cells is described below.

Area H – Magnesium Scrap Burial Area. Magnesium in various shapes, generated in the PGDP machine shop, is disposed of in this cell. Approximately 10 drums of magnesium scrap were discarded during midsummer 1971. A 1 m (3 ft) cover of soil was placed on the top of the buried drums.

Area I – Exhaust Fan Burial Area. Eight exhaust hood blowers removed from the C-710 Building were discarded into this cell in 1966. Each of the blowers, approximately 38 cm (15 in.) in diameter and 45 kg (100 lb) in weight, is contaminated with perchloric acid. Each blower was placed about 1.2 m (4 ft) apart in the hole and covered with 1.5 m (5 ft) of soil.

Area J – Contaminated Aluminum Burial Area. Approximately 100 to 150 drums of aluminum scrap in the form of nuts, bolts, plates, trimmings, etc., generated by the PGDP converter and compressor shops, were discarded in this cell over a period of 5 years. Final disposal in the cell is believed to have occurred in 1960–1962. After disposal was completed, a 1 m (3 ft) soil cover was placed over the waste in the cell.

Area K – Magnesium Scrap Burial Area. Approximately 20 drums of magnesium scrap were disposed in this cell between September 3, 1968, and December 23, 1969. A 1 m (3 ft) soil cover was placed over the buried drums.

Area L – Modine Trap Burial Area. A single contaminated modine trap was buried in this area. The modine trap was approximately 1.2 m (4 ft) in diameter, 5 m (15 ft) long, and weighed 2,250 kg (5,000 lb). The equipment, which was buried on March 5, 1969, was covered with 1 m (3 ft) of soil.

Summary of Previous Investigations

The WAG 3/SWMU 6 investigation included a geophysical survey, surface radiological walkovers, infiltrometer testing, CPT borings, collection of subsurface soil and groundwater samples from 18 boreholes, and surface soil/sediment from 5 locations.

The surface geophysical survey completed at SWMU 6 identified the areal limits of one waste cell approximately 0.03 hectares (0.07 acres) in size. Due to the presence of contaminated equipment on the surface of the SWMU, the area surveyed was limited. The radiological walkover survey completed in SWMU 6 did not identify any areas of activity greater than twice background. Four samples were collected during an *in situ* gamma spectrometry investigation. These samples indicated the only non-natural radioisotope present was ^{137}Cs, which was measured at all four locations.

An infiltrometer test was completed within the boundary of SWMU 6. The test concluded that the soil consists of Group C soils having a minimum infiltration rate in the range of 0.1-0.4 centimeters per hour (0.05-0.15 inches per hour) and consists of a layer that impedes downward movement of water.

The SWMU 6 RI subsurface exploration began with one CPT boring to characterize the depth of the shallow hydrogeologic units at the site. Subsurface samples (soil and groundwater) were collected from 16 UCRS borings (9 DPT, 2 vertical HSA, and 5 angled HSA around the perimeter of the SWMU). Groundwater samples were collected from two borings advanced through the RGA and into the underlying McNairy Formation (DWRC borings). Five surface soil/sediment samples were obtained from within the SWMU and from the drainage ditches surrounding the SWMU.

Conceptual Site Model

The preliminary conceptual site model for the human health risk assessment is provided as Fig. 3.74.

Nature and Extent of Contamination

Organics. The WAG 3 RI indicated the presence of two VOCs (TCE and acetone in low concentrations) and two SVOCs [di-n-butyl phthalate and bis(2-ethylhexyl)phthalate] in the subsurface soils. It is likely that the acetone and di-n-butyl phthalate are lab contaminants. Trichloroethene was detected in very small concentrations in the two angled borings south of the SWMU. Because the TCE detected was south (generally upgradient) and not under (or very close to) any burial cells, the source of this TCE is not believed to be from SWMU 6. Residual degreasing fluids from the stockpiled equipment at the surface is a potential source.

SWMU 6 is located above the Northwest Plume. Therefore, the presence of TCE in the RGA was expected. However, the fact that TCE was not detected in UCRS groundwater samples from the SWMU 6 RI suggests that the TCE detected in RGA groundwater beneath SWMU 6 is the result of contamination migrating beneath the site in association with the Northwest Plume.

Inorganics. The subsurface soils at SWMU 6 contained several inorganic constituents above screening levels including aluminum, arsenic, barium, beryllium, chromium, cobalt, copper, lead, manganese, nickel, and zinc.

Analyses of the groundwater samples collected from SWMU 6 identified the presence of metals at elevated levels in the UCRS groundwater including aluminum, cobalt, iron, manganese, and zinc. The RGA groundwater samples exhibited high concentrations of several metals due to the presence of suspended

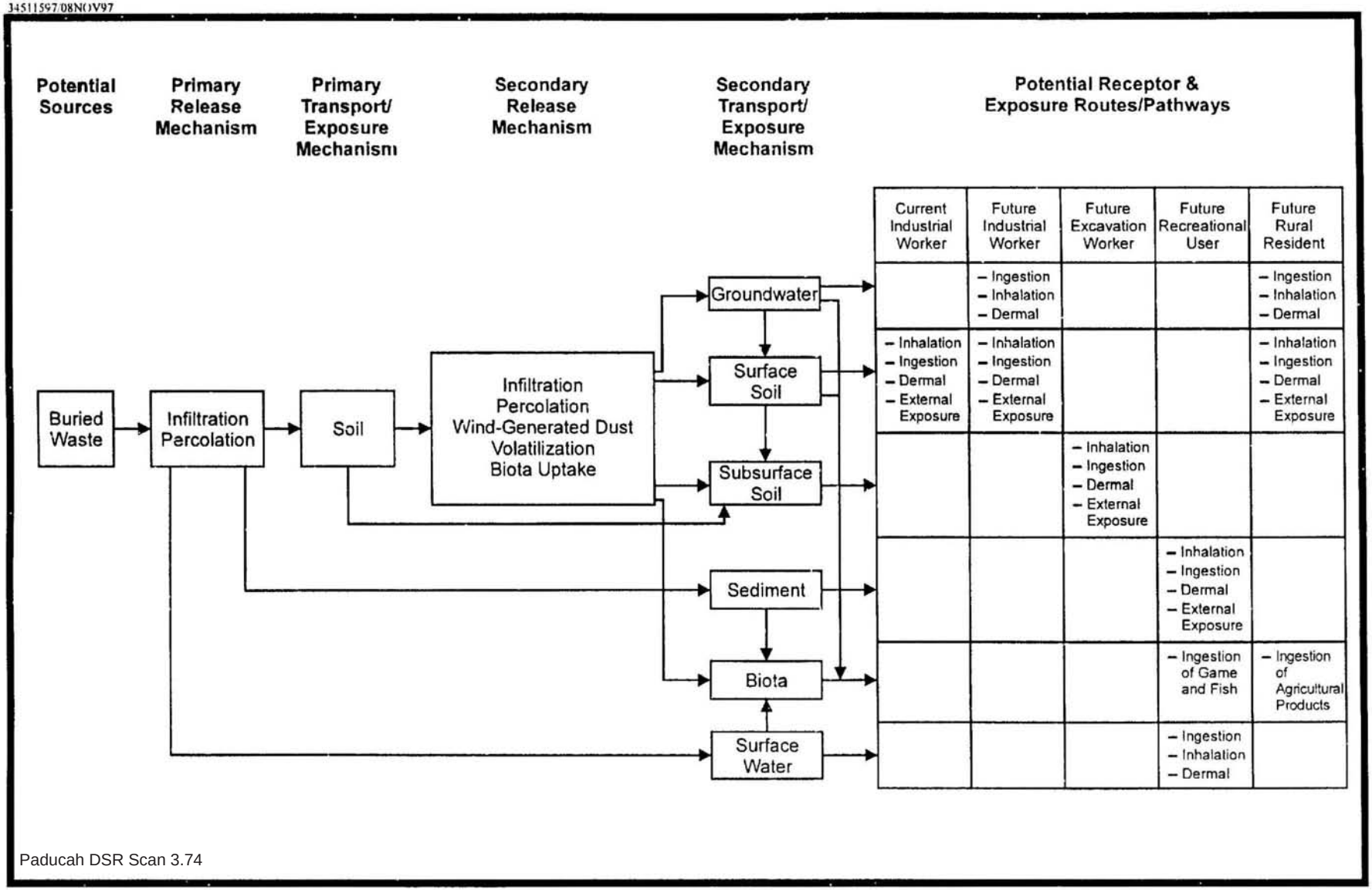

Fig. 3.74. Conceptual site model for the C-747-C Burial Grounds (SWMU 6).

sediments. The only analytical constituent that exceeded screening values in the McNairy groundwater samples was manganese.

Radionuclides. Several radioisotopes were detected in the SWMU 6 samples. The radioisotopes detected most frequently were ^{99}Tc and ^{235}U and ^{238}U. In addition to radiologically contaminated wastes buried in SWMU 6, the equipment stored at the surface has residual surface contamination. It is likely that the radiological contamination in the SWMU 6 samples was derived from both the burial cells and the equipment on the surface.

One liquid sample [collected at a depth of 1.2-2.7 m (4–9 ft) bgs within Burial Cell J] had elevated activities of ^{237}Np and total uranium. The highest beta activity measured in groundwater was encountered in borings that penetrated Burial Cell J.

Contaminant Fate and Transport

Three model layers (two partially saturated and one saturated) were delineated at SWMU 6. The first partially saturated layer extends to a depth of 12 m (40 ft) bgs and includes the loess deposits making up HU1 and the HU2. A second partially saturated layer extends to a depth of 18 m (60 ft) bgs and includes the silty clay aquitard, the HU3. The saturated layer includes the RGA and extends from an average depth of 18-30 m (60 to 100 ft) bgs. In the model, the travel distances from the source to each downgradient exposure point are 280 m (920 ft) to the PGDP security fence and 860 m (2820 ft) to the DOE property boundary. The direction of groundwater flow in the RGA was assumed to be north, based on potentiometric maps of the area.

The WAG 3/SWMU 6 RI soil data were used to develop the source terms and inventories for the SWMU 6 fate and transport model. These results indicate contributions from constituents in surface soil to groundwater in the RGA are negligible.

Table 3.82 reports model results for selected contaminants detected in the SWMU 6 area. This table lists the maximum concentrations of each source contaminant modeled to reach the two receptor locations. The WAG 3 RI also includes fate and transport results for 3 additional metals, 1 SVOC, and 15 additional radionuclides (includes daughter products). Contributions to the RGA from other constituents are minor.

Table 3.82. Fate and transport modeling results for SWMU 6

	Plant fence		Property boundary	
Constituent	**Max conc. (mg/L) (pCi/L)**	**Time (year)**	**Max conc. (mg/L) (pCi/L)**	**Time (year)**
		Surface Soil		
Technetium-99	9.71	105.1	3.15	113.2
		UCRS-First Partially Saturated Zone		
Iron	6.01×10^{1}	1966	2.12×10^{1}	2171
Technetium-99	1.16×10^{1}	118.6	3.86	120.1
		UCRS-Second Partially Saturated Zone		
Iron	3.28×10^{1}	1787	1.19×10^{1}	2076
Iron (from 006-027)	7.77	1787	2.56	2076

Summary of Previous Remedial Actions

No previous remedial actions have been conducted at this site.

WAG 3 Risk Assessment Summary

The summary presented in this section was taken from *Remedial Investigation Report for Waste Area Grouping 3 at the Paducah Gaseous Diffusion Plant* (DOE 2000b). This RI document provides information on the baseline risks posed to human health and the environment from contamination at WAG 3 that will be used to support the need for remedial action in WAG 3 and to assist in the selection of the remedial alternatives.

The following is excerpted from the Executive Summary of the WAG 3 BRA.

> In 1999–2000, the U.S. Department of Energy conducted a Remedial Investigation (RI)/Resource Conservation and Recovery Act Facility Investigation for Waste Area Grouping (WAG) 3. WAG 3 includes Solid Waste Management Units (SWMUs) 4, 5, and 6 at the Paducah Gaseous Diffusion Plant (PGDP) in Paducah, Kentucky. The overall purpose of this remedial investigation was to determine the presence, nature, and extent of contamination at SWMUs 4, 5, and 6. The primary focus of the RI was to collect sufficient information about surface soil, subsurface soil, and the shallow groundwater of the Upper Continental Recharge System contamination to support an assessment of risks to human health and the environment and the selection of remedial actions to reduce these risks. In addition, contamination in the Regional Gravel Aquifer (RGA) and McNairy Formation groundwater was characterized to determine if contamination in the WAG 3 SWMUs acted as a secondary source of contamination to groundwater.

To facilitate data aggregation and to focus results on specific areas, this baseline risk assessment derives hazard and risk estimates for the following SWMUs.

- SWMU 4—C-747 Contaminated Burial Yard
- SWMU 5—C-746-F Classified Burial Yard
- SWMU 6—C-747-B Burial Ground

Consistent with regulatory guidance and agreements contained in the approved human health risk assessment Methods Document (DOE 1996), the BHHRA evaluates land-use scenarios that encompass current use and several hypothetical future uses of the WAG 3 SWMUs and the areas to which contaminants may migrate. The following land-use scenarios and exposure routes are assessed.

Current industrial worker

- incidental ingestion of soil
- dermal contact with soil
- inhalation of vapors and particulates emitted from soil
- external exposure to ionizing radiation emitted from soil

Future industrial worker

- incidental ingestion of soil
- dermal contact with soil
- inhalation of vapors and particulates emitted from soil
- external exposure to ionizing radiation emitted from soil
- ingestion of groundwater
- dermal contact with groundwater while showering
- inhalation of vapors emitted by groundwater while showering

Future excavation worker

- incidental ingestion of soil (soil and waste)
- dermal contact with soil (soil and waste)
- inhalation of vapors and particulates emitted from soil (soil and waste)
- external exposure to ionizing radiation emitted from soil (soil and waste)

Future recreational user

- ingestion of venison grazing on vegetation grown in contaminated soil
- ingestion of rabbit grazing on vegetation grown in contaminated soil
- ingestion of quail grazing on vegetation grown in contaminated soil

Future on-site rural resident

- incidental ingestion of soil
- dermal contact with soil
- inhalation of vapors and particulates emitted from soil
- external exposure to ionizing radiation emitted from soil
- ingestion of groundwater
- dermal contact with groundwater while showering
- inhalation of vapors emitted by groundwater during household use
- inhalation of vapors emitted by groundwater while showering
- ingestion of vegetables grown in contaminated soil

Off-site rural resident (at PGDP security fence)

- ingestion of groundwater
- dermal contact with groundwater while showering
- inhalation of vapors emitted by groundwater during household use
- inhalation of vapors emitted by groundwater while showering

This report also contains a BERA that evaluates risks under both current and potential future conditions to several ecological receptors that may come into contact with contaminated media at or migrating from sources in WAG 3.

Summary tables of the risk assessment done for the WAG 3 BRA follow. Tables 3.83 through 3.86 present the risk results and the quantitative risk summaries found in Exhibits 1.77 through 1.80 of the WAG 3 BRA.

As shown in Table 3.83, default ELCR estimates calculated for the current and future industrial worker exposed to surface soil differ from the lower-bound estimates (final column) by less than one order of magnitude to greater than two orders of magnitude. The sequential changes in ELCR for all three SWMUs are most heavily influenced by the use of EPA Region 4 dermal absorption factors versus KDEP default values. However, even with such cumulative changes in ELCR estimates, it is important to note that the lower-bound ELCRs still exceed *de minimus* levels for each of the SWMUs under consideration at WAG 3.

Table 3.83. Summary of risk results and uncertainties for the current industrial worker - ELCR - for WAG 3

(formerly "Exhibit 1.79. Quantitative summary of uncertainties for exposure to soil by the current and future industrial worker—excess lifetime cancer risk")

SWMU	Default ELCR	Previous ELCR minus EPA Region 4 ABSs	Previous ELCR minus infrequent detects	Previous ELCR minus laboratory contaminants	Previous ELCR minus provisional or withdrawn toxicity values
SWMU 4 (soil)	5.4×10^{-4}	2.5×10^{-5}	2.5×10^{-5}	2.5×10^{-5}	1.4×10^{-5}
SWMU 5 (soil)	4.1×10^{-4}	3.2×10^{-5}	3.2×10^{-5}	3.2×10^{-5}	2.8×10^{-5}
SWMU 6 (soil)	2.4×10^{-4}	8.0×10^{-6}	8.0×10^{-6}	8.0×10^{-6}	3.1×10^{-6}

Table 3.84. Summary of risk results and uncertainties for the future industrial worker - ELCR - for WAG 3

(formerly "Exhibit 1.80. Quantitative summary of uncertainties for the future industrial worker—excess lifetime cancer risk")

SWMU	Default ELCR	Previous ELCR minus infrequent detects	Previous ELCR minus laboratory contaminants	Previous ELCR minus provisional or withdrawn toxicity values
SWMU 4 (RGA)	4.7×10^{-4}	4.7×10^{-4}	4.7×10^{-4}	1.7×10^{-4}
SWMU 4 (McNairy)	3.1×10^{-3}	3.1×10^{-3}	3.1×10^{-3}	5.6×10^{-4}
SWMU 5 (RGA)	5.4×10^{-4}	1.9×10^{-4}	1.9×10^{-4}	6.4×10^{-6}
SWMU 5 (McNairy)	1.2×10^{-3}	1.2×10^{-3}	1.2×10^{-3}	7.2×10^{-4}
SWMU 6 (RGA)	2.3×10^{-4}	2.3×10^{-4}	2.3×10^{-4}	3.9×10^{-5}
SWMU 6 (McNairy)	7.8×10^{-4}	7.8×10^{-4}	7.8×10^{-4}	1.9×10^{-4}

Table 3.85. Summary of risk results and uncertainties for the current industrial worker - systemic toxicity - for WAG 3

(formerly "Exhibit 1.77. Quantitative summary of uncertainties for exposure to soil by the current and future industrial worker—systemic toxicity")

SWMU	Default HI	Previous HI w/o lead	Previous HI minus EPA Region 4 ABSs	Previous HI minus infrequent detects	Previous HI minus laboratory contaminants	Previous HI minus provisional or withdrawn toxicity values
SWMU 4 (soil)	3.6	3.6	<1	<1	<1	<1
SWMU 5 (soil)	<1	<1	<1	<1	<1	<1
SWMU 6 (soil)	<1	<1	<1	<1	<1	<1

Table 3.86. Summary of risk results and uncertainties for the future industrial worker – systemic tocicity- for WAG 3

(formerly "Exhibit 1.78. Quantitative summary of uncertainties for exposure to groundwater by the future industrial worker—systemic toxicity")

SWMU	Default HI	Previous HI w/o lead	Previous HI minus infrequent detects	Previous HI minus laboratory contaminants	Previous HI minus provisional or withdrawn toxicity values
SWMU 4 (RGA)	16,000	33	33	32	6.4
SWMU 4 (McNairy)	220,000	76	76	76	25
SWMU 5 (RGA)	20,000	27	27	26	5.8
SWMU 5 (McNairy)	71,000	63	63	63	10
SWMU 6 (RGA)	23,000	19	19	19	5.5
SWMU 6 (McNairy)	70,000	42	42	42	8.2

Similarly, Table 3.84 shows that the ELCR estimates for the future industrial worker under default and lower-bound conditions differ by less than one to more than two orders of magnitude. The sequential changes in ELCR for all three SWMUs are most heavily influenced by the exclusion of provisional or withdrawn toxicity values when calculating ELCR. However, the resulting lower-bound ELCR estimates still exceed the *de minimus* level at each SWMU.

In Tables 3.85 and 3.86, the HI estimates for both current and future industrial worker exposures calculated using the default exposure rates vary markedly from the lower-bound estimates (final column) for those locations where lead was a COPC and the provisional lead RfD was used. For those locations, omitting lead from the list of COPCs decreases the HIs by about three to four orders of magnitude. By contrast, other uncertainties investigated in both Tables 3.85 and 3.86 have little effect on the HI estimates. For the current industrial worker exposed to surface soil at SWMUs 4, 5 and 6, the lower-bound estimates of HI are all less than the *de minimus* level established in the Methods Document (i.e., HI = 1). For the future industrial worker, the lower-bound HI estimates exceed a HI of 1.0 at all locations in the RGA and McNairy formations.

BHHRA—Principal Findings

For all SWMUs in WAG 3, the cumulative human health systemic toxicity and ELCR exceed the accepted standards of EPA and KDEP for one or more land-use scenarios when assessed using default exposure parameters. The land-use scenarios for which risks exceed *de minimus* levels [i.e., for KDEP, a cumulative hazard index (HI) of 1 or a cumulative ELCR of 1.0E-06 and for EPA, an HI of 1 and a range of 1.0E-04–1.0E-06 for ELCR] are summarized in Table 3.87.

BERA—Principal Findings

The three SWMUs comprising WAG 3 provide a small area of grassy habitat suitable for ecological receptors. The ecological risk assessment evaluates risks from current and potential future exposure of terrestrial plants, soil invertebrates, and terrestrial wildlife to chemicals in WAG 3 surface soil. Chemical and radionuclide contaminants were evaluated for surface soils from SWMUs 4, 5, and 6. Table 3.88 summarizes chemicals of potential ecological concern (COPECs) that were identified based on the results of screening contaminant concentrations against ecological benchmarks. Maximum concentrations of a number of analytes were near background levels or exceeded background levels or benchmarks at only a couple of stations. Radionuclides in surface soil do not present a risk to terrestrial receptors at any of the

Table 3.87. Land uses of concern for WAG 3

(*formerly "Table ES.1. Land use scenarios for which human health risk exceeds de minimus levels*")

Land use scenario	Site		
	SWMU 4	**SWMU 5**	**SWMU 6**
Systemic toxicity[a]			
Current industrial worker			
Exposure to soil	X[b]	–	–
Future industrial worker			
Exposure to soil	X[b]	–	–
Exposure to RGA groundwater	X[c]	X[c]	X[c]
Exposure to McNairy groundwater	X[c]	X[c]	X[c]
Future on-site rural resident[a]			
Exposure to soil	X[b]	X[b]	X[b]
Exposure to RGA groundwater	X[c]	X[c]	X[c]
Exposure to McNairy groundwater	X[c]	X[c]	X[c]
Off-site rural resident			
Exposure to groundwater[e]	X	X	X
Future recreational user[a]			
Exposure to soil	–	–	–
Future excavation worker			
Exposure to soil and waste	X[c]	X[b]	X[c]
Excess lifetime cancer risk			
Current industrial worker			
Exposure to soil	X	X	X
Future industrial worker			
Exposure to soil	X	X	X
Exposure to RGA groundwater	X	X	X
Exposure to McNairy groundwater	X	X	X
Future on-site rural resident[e]			
Exposure to soil	X	X	X
Exposure to RGA groundwater	X	X	X
Exposure to McNairy groundwater	X	X	X
Off-site rural resident[d]			
Exposure to groundwater	X[d]	–	–
Future recreational user[e]			
Exposure to soil	–	X	–
Future excavation worker			
Exposure to soil and waste	X	X	X

Notes:

Land-use scenarios where risk exceeded the benchmark levels (HI of 1/ELCR of 1.0E-06) are marked with an "X."
Land-use scenarios where risk did not exceed a benchmark level are marked with a "–."

[a] Results for a child are presented for systemic toxicity for the future recreational user and the future on-site rural resident.
[b] These land use scenarios are of concern even though lead was not detected.
[c] Lead is present, and the land use scenario is of concern whether or not the element is included in the assessment.
[d] Based on the results of contaminant transport modeling, "X" indicates that the location contains a source of unacceptable off-site contamination.
[e] Values for ELCR for the future recreational user and the future on-site rural resident are for lifetime exposure.

Table 3.88. Chemicals of potential ecological concern for WAG 3

(formerly "Exhibit ES.7. Summary of chemicals with maximum detected concentrations resulting in ecological hazard quotients greater than 1 for one or more nonhuman receptor groups")

Receptor group	Site		
	SWMU 4	SWMU 5	SWMU 6
Plants [a]	Chromium, nickel, vanadium[c], zinc[c]	Aluminum, arsenic[c], chromium, nickel[c], zinc	Nickel[c], zinc[c]
Soil invertebrates [a]	Chromium, copper	Chromium, zinc, fluoranthene, phenanthrene	Zinc[c]
Terrestrial wildlife [b]	Chromium	Aluminum	None

[a] Plant and soil invertebrate results are based on maximum detected concentrations or activities.
[b] Terrestrial wildlife results are based on comparison of maximum exposure estimates to lowest observed adverse effect levels.
[c] Greater than surface soil background concentration at only one station in the SWMU.

SMWUs. Estimated doses from exposure to radionuclides in soil were below recommended dose rate limits for all receptors at all SWMUs.

3.2.11 Other Sources

3.2.11.1 SWMU 58 — North-South Diversion Ditch/Off-site

Description

SWMU 58 includes approximately 1,845 m (6,050 ft) of the NSDD channel between Outfall 003 [located approximately 533 m (1,750 ft) north of the PGDP perimeter security fence] and Little Bayou Creek. Figure 3.75 is a map of the SWMU 58 area. The NSDD served originally as a drain for C-400 Building effluent and runoff from the north–central area of the plant. Beginning in 1977, the DOE constructed a lift station on-site to capture the normal flow in the NSDD and pipe the effluent to the C-616-F Lagoon for treatment. Flow from C-616-F discharges to Bayou Creek. Today, except for storm events, little flow issues from Outfall 003. The annual average flow through Outfall 018 is approximately 70.07 l/sec (1,110 gpm).

Setting

The southern half of the SWMU 58 ditch borders the west and north sides of the C-746-S&T residential/inert landfill complex (now closed) and the south and east sides of the C-746-U Landfill. Construction and maintenance activities have constrained the channel in these areas. The NSDD flows through scrub forests and grasslands downstream of the landfills. Most of the NSDD in SWMU 58 follows the course of an ephemeral stream that drained the land to the north of PGDP prior to construction of the plant. However, the course of the ditch has been moved west at the C-746-S&T Landfill Complex to prevent the stream from undercutting the toe of the landfill. See Fig. 3.75 for an illustration of the SWMU 58 area.

Geology/Hydrogeology

In the area of SWMU 58, the NSDD cuts progressively deeper through UCRS sediments as it flows northward. The base of the ditch is near the top of the HU2 sand and gravel interval at the C-746-S&T Landfill Complex. Surface water and the UCRS must be in close communication. Area monitoring wells measure a vertical hydraulic gradient of approximately 1.25 m/m (ft/ft) downward. Thus, the leakance of the HU3 horizon is the primary factor governing the influence of the NSDD upon the RGA.

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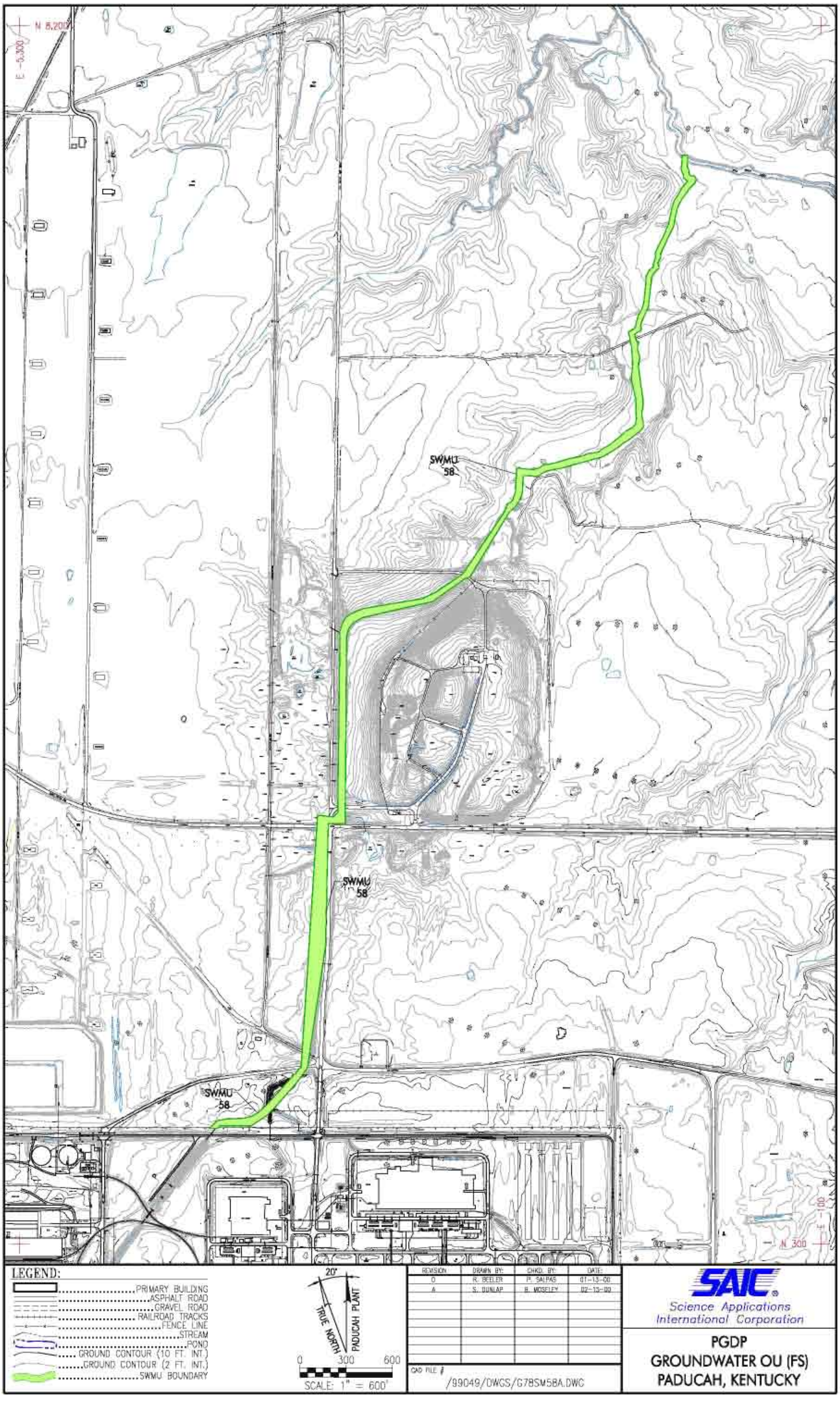


Figure 3.75. Map of the SWMU 58 Area.

In general, the HU3 horizon is a thick interval of silty clay in the area of the off-site NSDD. However, the log of soil boring GB-05D, located on the south side of the C-746-U Landfill, shows that the HU2/HU3 interval can be predominately sand. Contaminants of the NSDD would be expected to impact RGA water quality where these sand facies underlie the ditch.

Nature and Extent of Contamination

The PGDP's SI provides the primary data for the assessment of nature and extent of contamination along the NSDD of SWMU 58. Table 3.89 summarizes the maximum contaminant levels associated with SWMU 58. Analyses of sediments document the presence of the following contaminants at elevated levels: PAHs, antimony, and the radionuclides ^{237}Np, ^{239}Pu, ^{99}Tc, ^{230}Th, ^{234}U, ^{235}U, and ^{238}U. In general, contaminant levels in sediments declined with downstream distance and were below reference levels north of the C-746-S&T Landfill Complex.

Table 3.89. Contaminant levels above reference levels for SWMU 58

Contaminant	Maximum contaminant levels[a]		
	Sediments	Subsurface soils	UCRS groundwater
Fluoranthene		55	
PAHs (total)	2,000		
Antimony	1,400		
Barium			54
Cobalt			43.7
Nickel			166
^{237}Np	0.54	1.97	
^{239}Pu	0.85	4.1	
^{99}Tc	36	160	72
^{230}Th	31	110	2.83
^{234}U	5.6	8.9	131.6
^{235}U	0.16	0.36	6.42
^{238}U	6.5	14	202.4

[a] Organic and metal contaminant levels are presented as µg/kg and µg/L. Radionuclide levels are presented as pCi/g and pCi/L.

The SI also attributed contamination in soil and shallow groundwater at the southwest corner of the C-746-S&T Landfill Complex to the buried channel of the NSDD. Contaminants in soil included TCE; the PAH fluoranthene; the radionuclides ^{237}Np, ^{239}Pu, ^{99}Tc, ^{230}Th; and the common uranium isotopes. The same radionuclides, with the exception of ^{237}Np and ^{239}Pu, as well as the metals barium, cobalt, and nickel, also were found at elevated levels in filtered samples of UCRS groundwater.

The Phase II SI related contamination of RGA groundwater by TCE (max of 58 µg/L), ^{99}Tc (max of 610 pCi/L), ^{234}U (max of 6.1 pCi/L), and ^{238}U (max of 5.9 pCi/L) in the area of the C-746-S&T Landfill Complex to the NSDD. Subsequent compliance monitoring at the C-746-S&T and C-746-U Landfills have detected levels of TCE as high as 32 µg/L and ^{99}Tc as high as 45 pCi/L (disregarding 1 outlier).

3.2.11.2 C-616 Lagoon Complex

Description

The C-616 Lagoon Complex consists of two adjacent impoundments, the C-616-E Sludge Lagoon and the C-616-F Full Flow Lagoon, located north of the plant's perimeter security fence. Both lagoons were constructed in 1977 to support the C-616 Liquid Pollution Abatement Facility, which was used to reduce chromium from wastewaters of the C-635 Cooling Towers and other nearby facilities. C-616-E was a

dewatering basin for the treatment facility sludge. Flow passed from the C-616-E Lagoon to the C-616-F Lagoon and then to Bayou Creek through the Outfall 001 ditch system. Figure 3.76 is a map of the C-616 area.

The C-616-F Lagoon is a settling basin for final polishing of the C-616-E effluent and for flow from the on-site NSDD, pumped to the lagoon by the C-616-C Lift Station. Because the C-616-E Lagoon filled with sediment, walls and baffles of sheet piling were added to the east end of the C-616-F Lagoon and, beginning in 1997, the C-616-F Lagoon began receiving the sludge from the C-616 Liquid Pollution Abatement Facility clarifier.

Both lagoons are constructed with below-grade clay floor and above-grade earth/clay walls. The lagoons share a common wall containing a 0.3-m (12-in.) overflow pipe, to drain the C-616-E Lagoon into the C-616-F Lagoon. The C-616-E Lagoon is an "L"-shaped surface impoundment covering an area of 19,974 m^2 (215,000 ft^2). C-616-F is a rectangular impoundment of 31,587 m^2 (340,000 ft^2). The design depth of water in both lagoons is approximately 3.7 m (12 ft).

Setting

The berms of the C-616 Lagoon complex rise approximately 2.1 m (7 ft) above the surrounding land. An overflow weir on the west end of the C-616-F Lagoon maintains the water level at 0.9 m (3 ft) below the top of the dam. A perimeter security fence, at the base of the berms, prevents public access to the lagoons.

Geology/Hydrogeology

A loess-derived silt deposit underlies the C-616 Lagoon Complex to a depth of 3.0 m (10 ft) bgs. Silt and clay units are locally present, forming a HU1 horizon with a thickness of up to 6.4 m (21 ft). The underlying HU2 horizon is composed of a 1.8 to 3.0-m (6- to 10-ft) thick interval of sand overlying gravel. On the west side of the lagoon complex, the depth of the base of the HU2 horizon is at 7.3 m (24 ft) bgs. Depth to the base of the HU2 horizon on the east side of the lagoons ranges from 6.1 to 8.5 m (20 to 28 ft) bgs.

The HU3 member primarily is silty sand, with thick clay lenses of limited horizontal extent. Thin sand and gravel units occur locally. The cumulative thickness of the HU3 units ranges from 7.0 to 8.8 m (23 to 29 ft) with a base at 14.0 to 16.2 m (46 to 53 ft) bgs.

In the C-616 area, the RGA consists of a HU4 horizon of sand, with a width between 0.6 and 2.1 m (2 and 7 ft), overlying a thick HU5 horizon. The HU5 member primarily is a sandy gravel deposit on the west side of the lagoons but includes an upper gravel unit on the east side of the lagoons.

Nearby wetlands attest to a shallow water table in the area of the C-616 Lagoons. MW173 (screened in the upper RGA) and MW174 (screened in the UCRS) measure a downward hydraulic gradient of approximately 1.5 in the UCRS on the south side of the C-616-F Lagoon. The high hydraulic gradient, in combination with the more permeable texture of the local HU3, likely results in an area of increased recharge to the RGA beneath the lagoons. Local groundwater flow directions are difficult to predict but the overall flow direction must be to the north.

Nature and Extent of Contamination

PGDP operations previously characterized the potential for the C-616-E Lagoon to leach hazardous constituents with sampling events in 1991 and 1993. In the 1991 sample event, 46 sludge samples were collected for analysis of leachable chromium. The average characteristic of the lagoon for chromium was found to be 1.670 ± 0.851 mg/L for the mean at the 80% confidence interval in the TCLP extracts, which

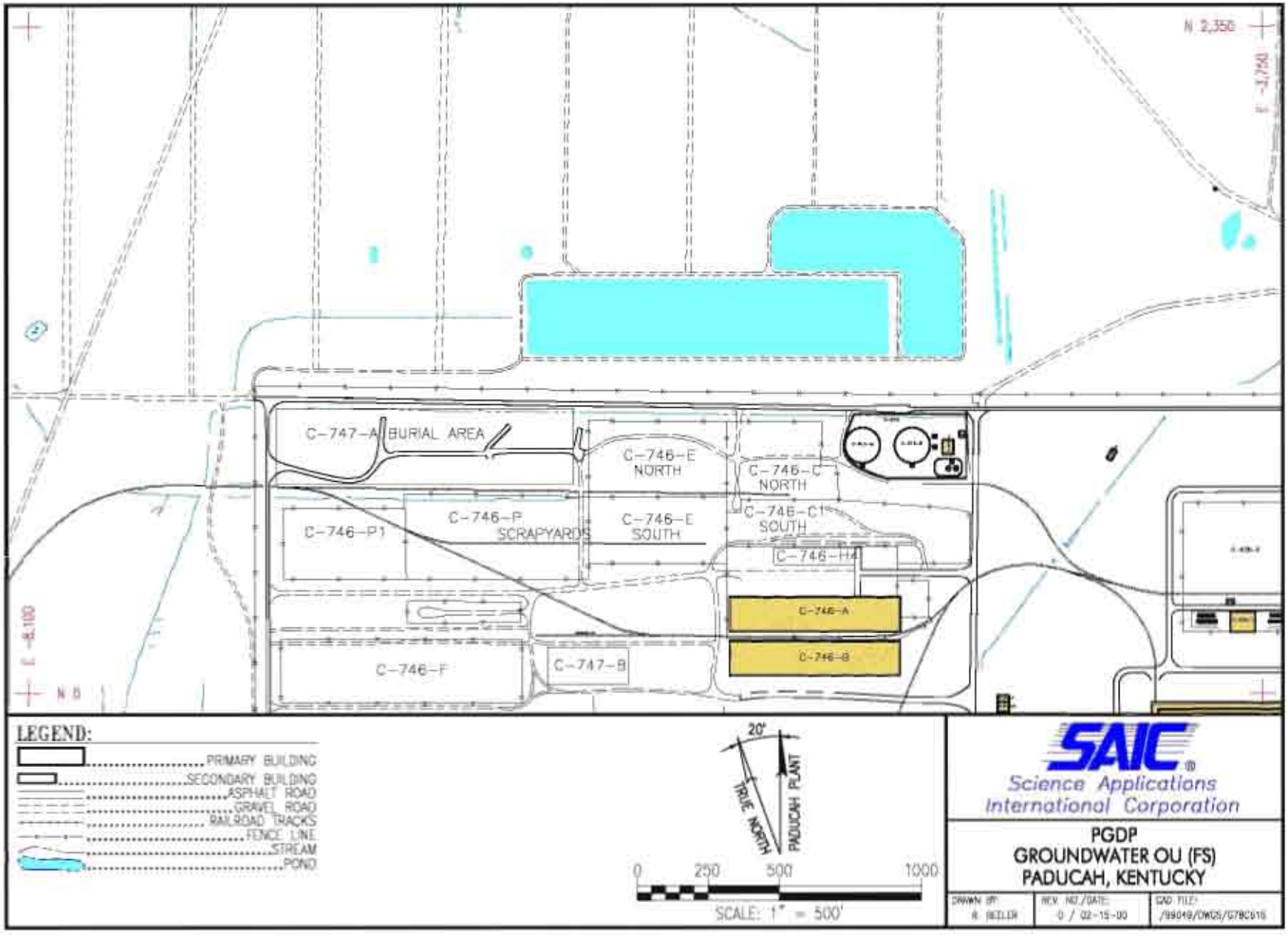


Figure 3.76. Map of the C-616 Lagoon Area.

was well below the regulatory limit of 5.0 mg/L. In the 1993 sample event, 20 sludge samples were collected and analyzed for PCBs, radionuclides, and the full suite of RCRA TCLP parameters. Uranium (up to 69.3 pCi/g) and chromium (up to 1.52 mg/L) were the only detectable analytes.

The SI composited a sample of sludge from three locations in the C-616-E Lagoon and collected a water sample for analysis. Chromium levels of 22,100,000 μg/kg in sediment and 28.9 μg/L in surface water were detected. The metals: antimony (425,000 μg/kg), copper (335,000 μg/kg), iron (132,000,000 μg/kg), nickel (71,700 μg/kg), and zinc (417,000 μg/kg); and the radionuclides: ^{99}Tc (94 pCi/g), ^{230}Th (12 pCi/g), ^{234}U (5.2 pCi/g), and ^{238}U (8.8 pCi/g) were present in the sludge at elevated levels.

The only characterization of the C-616-F Lagoon comes from the SI, a sample of sludge composited from three locations across the lagoon and a water sample from near the center of the lagoon. Chromium levels in the C-616-F Lagoon were 1,960,000 μg/kg in sediment and 10.4 μg/L in surface water. The only other contaminants of the sludge found at elevated levels were beryllium (3,900 μg/kg) and ^{99}Tc (4,700 pCi/g).

MW173 (screened in the upper RGA) and MW174 (screened in the UCRS) provide the closest sampling points for characterization of area groundwater. In both wells, the maximum detected TCE levels are at trace levels (4 μg/L in MW173 and 3 μg/L in MW174), the dissolved chromium analyses are below the method detection limits, and, with the exception of 1 outlier, the maximum detected ^{99}Tc levels are 18 pCi/L (MW173) and 17 pCi/L (MW174).

However, downgradient RGA monitoring wells define a discrete area of elevated ^{99}Tc activity, identified as the Technetium-99 Plume, which may be derived from the C-616 Lagoon Complex. Technetium-99 activity in the core of the plume ranges between 200 and 300 pCi/L. No other contaminants are known to be associated with the Technetium-99 Plume.

3.2.11.3 Outfalls 010, 011, and 012

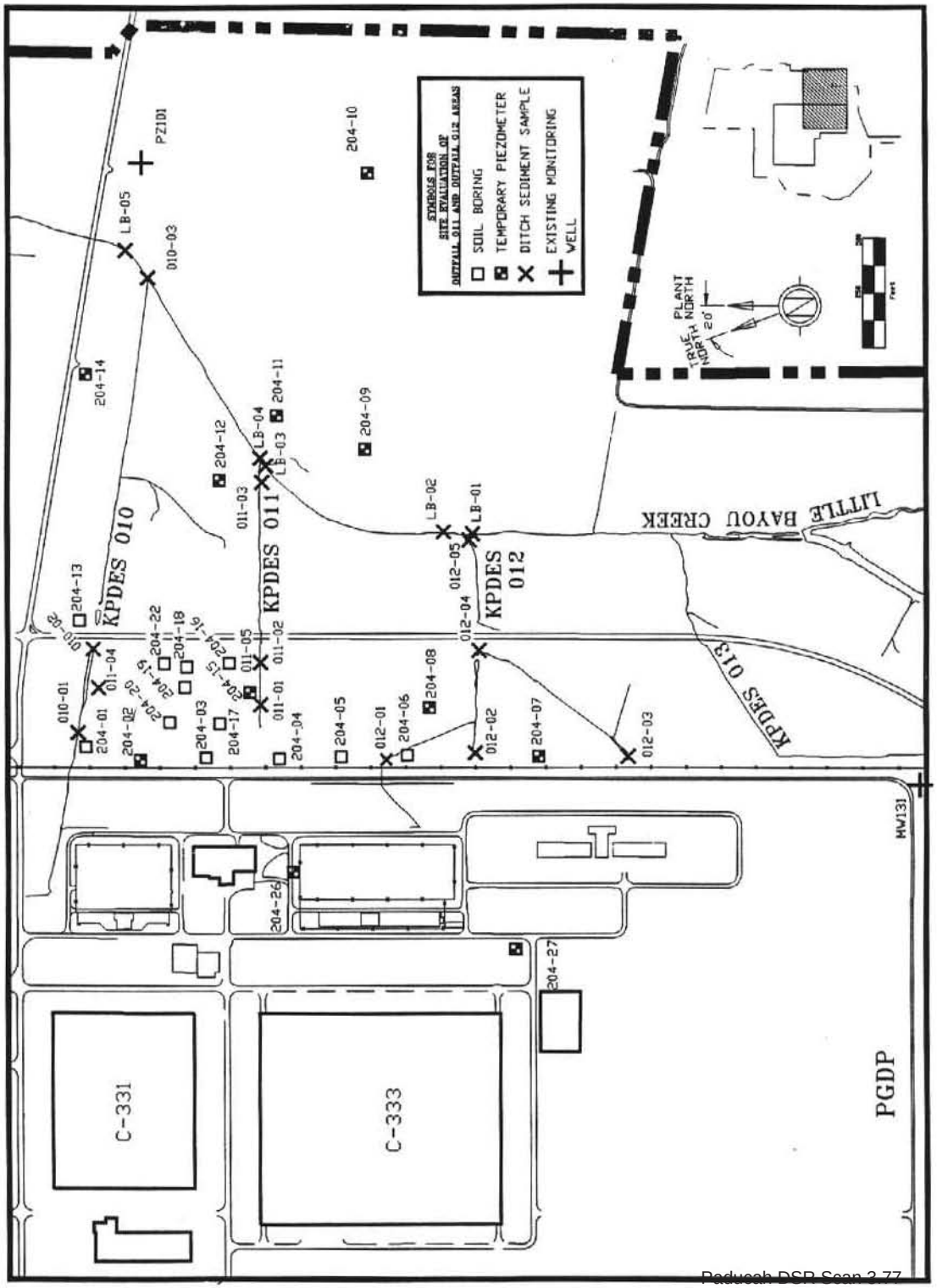
Scope

During September 11, 1995, through October 31, 1995, an evaluation of the area surrounding and downstream of Outfalls 010, 011, and 012 was conducted at the PGDP. The purpose of the investigation was to determine the source of elevated levels of TCE in Outfall 011 detected during June 1995 sampling of the soil and groundwater adjacent to the ditch. The results of the investigation were to determine the necessity of removal or remedial actions at Outfalls 010, 011, and 012, and at AOC 204 (DOE 1995b).

Areas of Investigation

The PGDP received four Notices of Violation (NOVs) from the Kentucky Division of Water for discharge of PCBs at levels exceeding the PGDP Kentucky Pollutant Discharge Elimination System (KPDES) permit limits. In 1994 and 1995, PCBs were detected in effluent from Outfall 012, resulting in one NOV each year. Since the receipt of the NOVs, unusually high concentrations of TCE were detected in Outfall 011 water.

Outfalls 010, 011, and 012 include SWMUs 56, 61, 66, 70, 74, 75, 80, 82, 83, 101, 188, and 191 and AOC 204. The area of study drains to Little Bayou Creek through Outfalls 010 through 012. Plant effluent is diverted from Outfalls 002, 011, and 012 via lift station, and discharged through Outfall 010. During high flow events, drainage exceeding the capacity of the Outfall 002, 011, and 012 lift stations is routed through the respective outfall. Figure 3.77 shows the location of the study area with respect to the PGDP site.



Paducah DSP Scan 3.77

Fig. 3.77. Location of samples, boreholes, and piezometers for the Outfall 010-012 and AOC 204 Investigation.

Method of Investigation

During the Outfalls 010–012 and AOC 204 investigation, a geophysical survey, sediment sampling, soil borings, temporary piezometer installation, and water level measurements were conducted. The following subsections provide a description of each of these activities (DOE 1995b).

Geophysical surveys. Geophysical surveys were conducted between September 11 and September 20, 1995, prior to environmental sample collection. The geophysical survey was performed in the vicinity of AOC 204, between Outfall 010 and Outfall 011, using electromagnetometers. These data were evaluated by comparing the anomalies on the contour maps with the cultural features noted on topographical maps of the area. Results indicated four target areas, potential locations of buried material and debris, for further soil sampling in the vicinity of AOC 204. Figure 3.77 identifies the geophysical survey areas, and locations of electromagnetometer anomalies.

Sediment sample collection. Eighteen ditch sediment samples were collected during the investigation: three from Outfall 010, five from Outfall 011, five from Outfall 012, five from Little Bayou Creek, and two from the ditch which drains AOC 204. Each sediment sample was collected 0.3 m (1 ft) below the top of the sediment within the ditch. Figure 3.77 shows the location of each of the sediment sampling locations conducted for this study.

Soil borings. Twenty-three direct push borings were drilled for subsurface sampling of soil and groundwater; borings were drilled to a maximum depth of 11 m (35 ft) bgs. Soil samples were collected from 18 of the borings, with one soil sample collected at a depth of 0.3 m (1 ft) bgs per boring for PCB analysis. Groundwater samples were collected from 25 locations, including 22 of the boring locations. Fourteen piezometers were installed to collect samples and hydrologic information. Figure 3.77 shows the location of each of the soil borings conducted for the study.

Temporary piezometer installation. Three temporary piezometers were installed in the center of the drainage ditches, one at each sediment sampling location. Temporary piezometers were also installed in 11 of the soil borings. Figure 3.77 identifies the location of the temporary piezometers installed for the investigation.

Water level measurements. Water levels in each of the temporary piezometers were measured on October 23, 1995, and recorded.

Previous Investigations and Remedial Actions

During the early 1980s, Outfall 011 was dredged and excavated to remove PCB contamination to obtain a cleanup level of 25 ppm. Data from this study indicated PCBs detected in the KPDES monitoring stations were the result of PCBs migrating with particulate within the storm and plant effluent discharge system.

During sampling conducted in June 1995, elevated levels of TCE in the vicinity of Outfall 011 were detected during soil and groundwater sampling (DOE 1995b). These elevated levels of TCE prompted the Outfall 010 through 012 and AOC 204 investigation.

Geology/Hydrogeology

Stratigraphy in the area of interest was determined to be similar to that elsewhere at the PGDP. A generalized depiction of the geology in the Outfalls 010 through 012 area is provided as Fig. 3.78.

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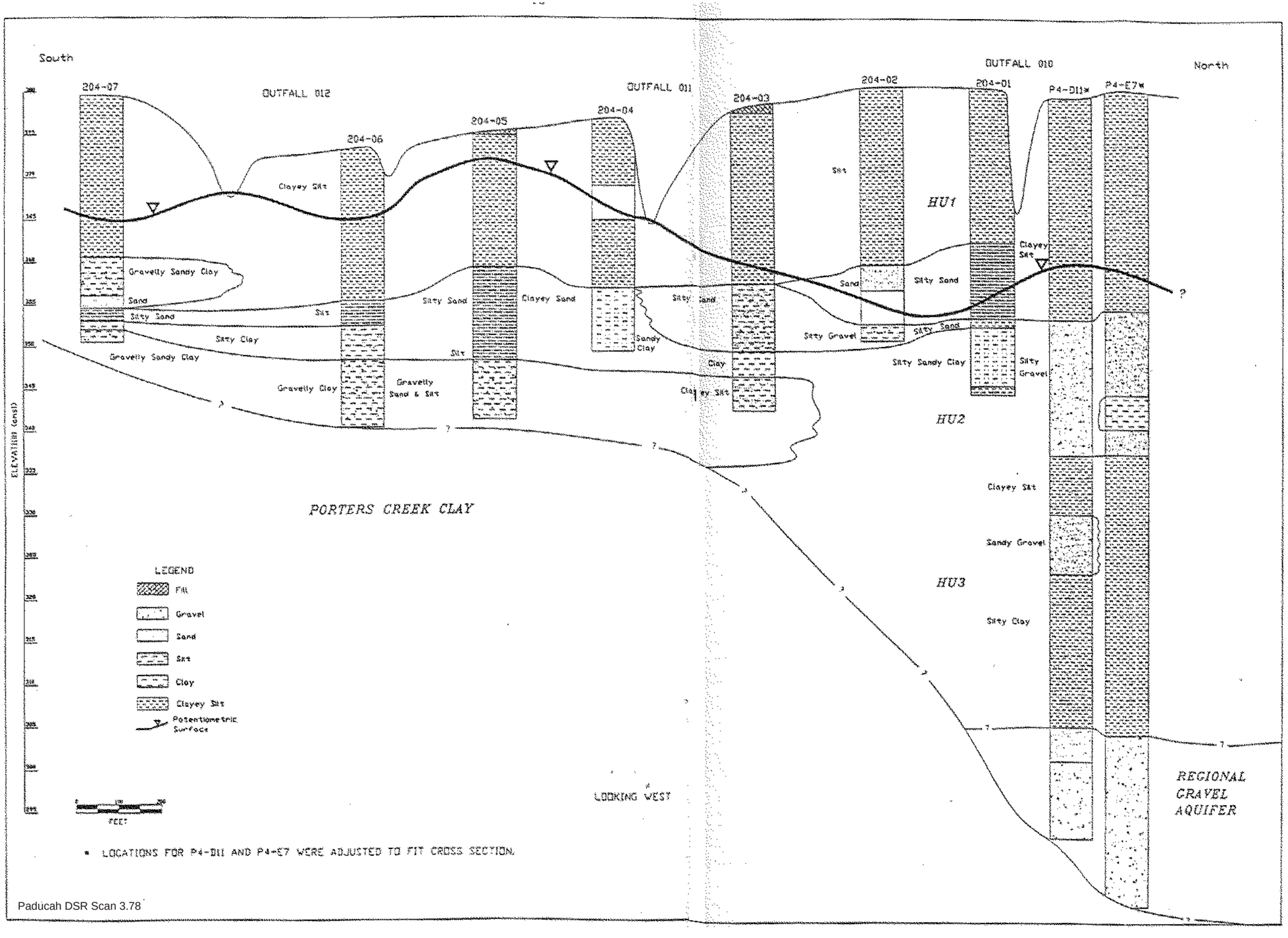


Paducah DSR Scan 3.78

Fig. 3.78. Generalized geology/hydrogeology for the Outfalls 010 through 012 area.

Field data indicate that the HU1 and the underlying Porters Creek Clay confine the HU2 in this area. It is assumed that some leakage occurs between the HU2 and the RGA proceeding north off the Terrace Gravel slope. Geomorphic features, such as the outfall ditches and Little Bayou Creek, influence the local poentimetric surface; potentiometric data suggest that shallow groundwater is recharging the surface at Outfalls 011 and 012. However, temporary piezometer information indicates a section of Little Bayou Creek is a "losing" stream, along with Outfall 010. Gaining or losing reaches of the surface water appears to be dependent upon the degree of hydraulic connectivity to the HU2 unit, which is dependent upon the thickness and permeability of the overlying HU1 unit (DOE 1995b).

Nature and Extent of Contamination

Soil. Seven borings indicated concentrations of VOCs within the subsurface soil. Concentrations of TCE from samples collected during this and previous investigations ranged to 2804 µg/kg (Carter, et al. 1995), and were detected in the soil borings at varying depths. Soil borings 204-15 and 204-19 showed consistent levels of TCE and 1,1,1-TCA (less than 110 µg/kg) throughout the depth of the boring.

PCBs were detected in only one of the soil borings at detectable levels, with the exception being at boring 204-26, located within the PGDP security fence immediately adjacent to a dielectric transfer line and the C-533 switchyard. Operators of the C-540 building indicated that the dielectric fluid lines have been cut and occasionally weep oil in the spring. The oil within the lines contains PCBs. Therefore, it is presumed that the PCB contamination detected in boring 204-26 is related to the dielectric line and is unrelated to the contamination detected in Outfall 011 (DOE 1995b).

Sediments. Data collected from this investigation suggested that the sediments within Outfall 011 are the source of TCE detected in the KPDES sample from the station at Outfall 011. One ditch sediment sample contained elevated TCE concentrations. The lack of TCE in sediments located upstream of the contaminated area indicated TCE is not migrating from upstream sources, such as the plant site; downstream sediment samples did not indicate the presence of TCE, suggesting a localized source of TCE. Further, it was determined to be hydrodynamically improbable for contaminants to migrate from shallow groundwater to Outfall 011, as shallow groundwater flow is downward and flows in a northerly direction from Outfall 011.

Several of the ditch sediment samples contained detectable levels of PCBs (Aroclor-1254 and -1260), with samples in the upper reaches containing the highest concentrations. As the solubility of Aroclor-1254 and 1260 are 40 µg/L and 25 µg/L, respectively, results strongly suggested that PCB contamination is associated with particulate transport (DOE 1995b).

Groundwater. One groundwater sample, collected from boring 204-20 contained TCE at 400 µg/L. Groundwater samples collected from borings 204-06, -08, -15, and -17 contained TCE and 1,1,1-TCA at levels >32 µg/L. None of the other sample locations had detectable levels of TCE. Sampling conducted prior to the Outfalls 010 through 012 and AOC 204 investigation detected TCE groundwater contamination at levels of 35,000 µg/L in the vicinity, which was considered an indicator of DNAPL in the soils. Using previous investigation results and study data, the VOC concentration profile suggested a plume in the HU stratigraphy extending northward from Outfall 011, with downward migration likely occurring.

PCBs were not detected in any of the groundwater samples during the investigation (DOE 1995b).

3.3 PREVIOUS GROUNDWATER INVESTIGATIONS

3.3.1 Groundwater Phase I

The Phase I Groundwater Investigation was initiated in Summer 1986 to provide general lithologic and hydrologic data at three areas located inside the plant security fence. The project consisted of the installation of eight groundwater monitoring wells, six of which were installed in two well clusters of three wells each (completed in the UCRS, Upper RGA, and Lower RGA). These two well clusters were located near the northwest corner of the plant (MWs 63 through 65) and near the center of the plant (MWs 68 through 70). One replacement well (MW70A) was installed to replace Upper RGA well MW70 when it was concluded that mud-induced well damage was preventing water from flowing into the hole. The remaining well (MW67), located at the northern edge of the C-749 Uranium Burial Ground (SWMU 2), was completed in the upper RGA to investigate hydraulic conditions in that area. Grain-size analysis was conducted on representative soil samples collected from each well boring. Two deep [approximately 45.7 m (150 ft) bgs] sample borings (S1 and S2) were drilled to delineate the vertical extent of the RGA and to assist in characterizing the stratigraphy of the upper 15.2 m (50 ft) of the McNairy Formation. Falling head tests were conducted in an attempt to quantify the hydraulic conductivity of the RGA, but due to difficulties encountered during these tests, accurate measurements could not be obtained.

The results of this investigation are briefly presented in a final report issued by MCI Consultants in December 1986 (MCI 1986). As noted there, this investigation was among the first to provide information concerning the total thickness of the RGA inside the PGDP boundaries. In addition, the two deep borings provided new information regarding the lithology of the upper McNairy Formation at the plant. The potentiometric data provided by the project wells were consistent with previously determined RGA flow directions (north/northwest) but suggested that local, anomalous gradients could exist.

3.3.2 Groundwater Monitoring Phase II

The Groundwater Monitoring Phase II project was conducted at the PGDP pursuant to the CERCLA ACO between DOE and EPA. It involved the installation of borings and monitoring wells to provide additional information concerning the hydrogeology of the PGDP, in particular the C-404 Landfill. Ten soil borings were drilled into the McNairy Formation, four RCRA-quality monitoring well clusters were installed around the edges of the C-404 Landfill, and five other plant monitoring wells were plugged and abandoned. In addition, an aquifer pump test was conducted in the RGA near the C-404 Landfill involving the installation of a high-capacity pumping well and five piezometers.

The results of this investigation are detailed in the report *Ground Water Monitoring, Phase 2: Preliminary Hydrogeological Characterization of the DOE Reservation and C-404 Post Closure Compliance Program* (EDGe 1989). This investigation was among the first to recognize the significance of the buried terrace (Porters Creek Terrace) that extends roughly east–west across the southern portion of the site. The terrace slope was believed to act as a transition zone across which the shallow deposits (Terrace Gravels) and the RGA are relatively discontinuous. The investigation concluded that the slope of the terrace influences the amount of recharge into the RGA across the terrace slope and suggested additional hydrogeologic investigations to quantify the flow.

3.3.3 Groundwater Phase III Investigation

In 1991, the Groundwater Phase III Investigation was initiated to address several data gaps existing at that time concerning the site geology and hydrogeology. Field activities for the investigation were conducted between fall 1991 and spring 1992. The investigation involved the following field activities.

- Installation of three RGA monitoring wells to provide perimeter monitoring data.
- Installation of two piezometers in the RGA to provide potentiometric data in areas where little or no data existed.
- Installation of a background monitoring well cluster, with individual monitoring wells completed in the UCRS, the RGA, and the McNairy Formation. The cluster (MWs 102 through 104) was installed near the base of the Porters Creek Terrace between the C-746-K Landfill and the PGDP security fence.
- Installation of soil borings to provide additional lithologic data. Six of these borings were installed to provide a better understanding of several features of the Porters Creek Terrace, in particular the continuity of water-bearing deposits over the terrace slope. Other soil borings were associated with monitoring well and piezometer installation.
- Installation of a high-capacity well, seven piezometers, and three buried pressure transducers for conducting an aquifer pump test in the RGA.

Results

The results of the investigation provided useful information for further characterization of the stratigraphy, groundwater flow properties, and groundwater contaminant distribution at the PGDP. These results are detailed in the November 1992 document, *Report of the Paducah Gaseous Diffusion Plant Groundwater Investigation Phase III* (MMES 1992e). The Phase III report provided an overview of previous hydrogeologic investigations and presented an updated hydrogeologic conceptual model for the PGDP, based on all that was known at that time concerning the stratigraphy, groundwater chemistry, and hydrogeology of the site.

The soil borings installed for the Phase III Groundwater Investigation provided lithologic data to define more accurately the location and slope of the Porters Creek Clay Terrace near the southern boundary of the plant. The boring logs also provided evidence that the shallow deposits are discontinuous across the terrace slope. The steep hydraulic gradient at the terrace slope, as indicated by hydraulic head measurements taken during the investigation, confirms that flow is restricted across the terrace slope. The lithologic data gathered during this investigation provided evidence of the lateral and vertical heterogeneity of the RGA and also provided data to support further characterization of the McNairy Formation. The McNairy was observed to consist of very fine- to medium-grained, well sorted sand with interbedded thin clay layers.

Measurements of contaminant (TCE and ^{99}Tc) concentrations in the downgradient and perimeter wells were useful in further defining the limits of the contaminant plumes at the PGDP. The data suggested that there are five to nine or more distinct groundwater contaminant plumes, three of which extend off-site. Groundwater analyses associated with the pump test suggested the presence of a previously unknown source of TCE contamination in the vicinity of the C-333 Building.

Results of the aquifer pump test conducted for the Phase III Groundwater Investigation provided information concerning the hydraulic properties of the RGA in the area west of the C-333 Building. Detailed information concerning the test and an analysis of the data can be found in the Terran aquifer assessment report (Terran 1992). The results of the test indicated that the hydraulic conductivity of the RGA, which ranged in value from (1,000 to 1,200 ft/d), was higher than previously measured.

A number of data gaps remained after completion of the Phase III Groundwater Investigation. The possible influence of RGA paleochannels on contaminant plume migration was identified as an uncertainty that should be addressed in future investigations. Additional unresolved issues included the effects of transient river conditions on groundwater flow patterns and quantification of the amount of groundwater flow over the terrace slope.

3.3.4 Northeast Plume (Groundwater Phase IV) Investigation

Scope

The *Northeast Plume Preliminary Characterization Summary Report* (DOE 1995a) documents two phases of fieldwork completed between March and December 1994, a Site Evaluation of SWMUs 193 and 194 and a Groundwater Monitoring Phase IV Investigation. Together, these investigations provided much of the key data to support selection of an interim corrective measure for the PGDP's Northeast Plume.

The Site Evaluation of SWMUs 193 and 194 was intended to identify possible sources of contamination associated with some of the staging areas utilized during plant construction. These areas represented potential source areas for the Northeast Plume. The Groundwater Monitoring Phase IV Investigation primarily was an assessment of the nature and extent of contamination and aquifer hydraulic properties associated with the Northeast Plume.

Areas of Investigation

The Site Evaluation of SWMUs 193 and 194 focused on sites located in the south and east sides of the PGDP where fabrication and assembly of plant equipment occurred during the construction of the PGDP. These processes typically used large quantities of TCE, the primary contaminant of the Northeast Plume, as a degreasing and cleaning agent. Figure 3.79 is a map of the areas targeted for investigation as part of the Site Evaluation and the project sample locations.

The Groundwater Monitoring Phase IV Investigation boreholes defined four on-site transects oriented southeast–northwest and four off-site transects to the east and northeast of the PGDP. These transects bisected the Northeast Plume and other areas of groundwater contamination related to the PGDP. Figure 3.80 shows the location of the investigation boreholes.

Investigation Methods

The Site Evaluation of SWMUs 193 and 194 used a cone penetrometer and GeoProbe rig to collect soil and water samples and define the geologic units from 28 boreholes. At two locations within SWMU 193, the Site Evaluation included an electromagnetic survey to locate possible buried objects as an aid in siting the project boreholes.

The Groundwater Monitoring Phase IV Investigation consisted of 48 boreholes drilled to a depth of approximately 46 m (150 ft) using a dual-wall reverse circulation drilling method. Water samples from the UCRS (where possible), the upper, middle, and lower RGA and several depths in the McNairy

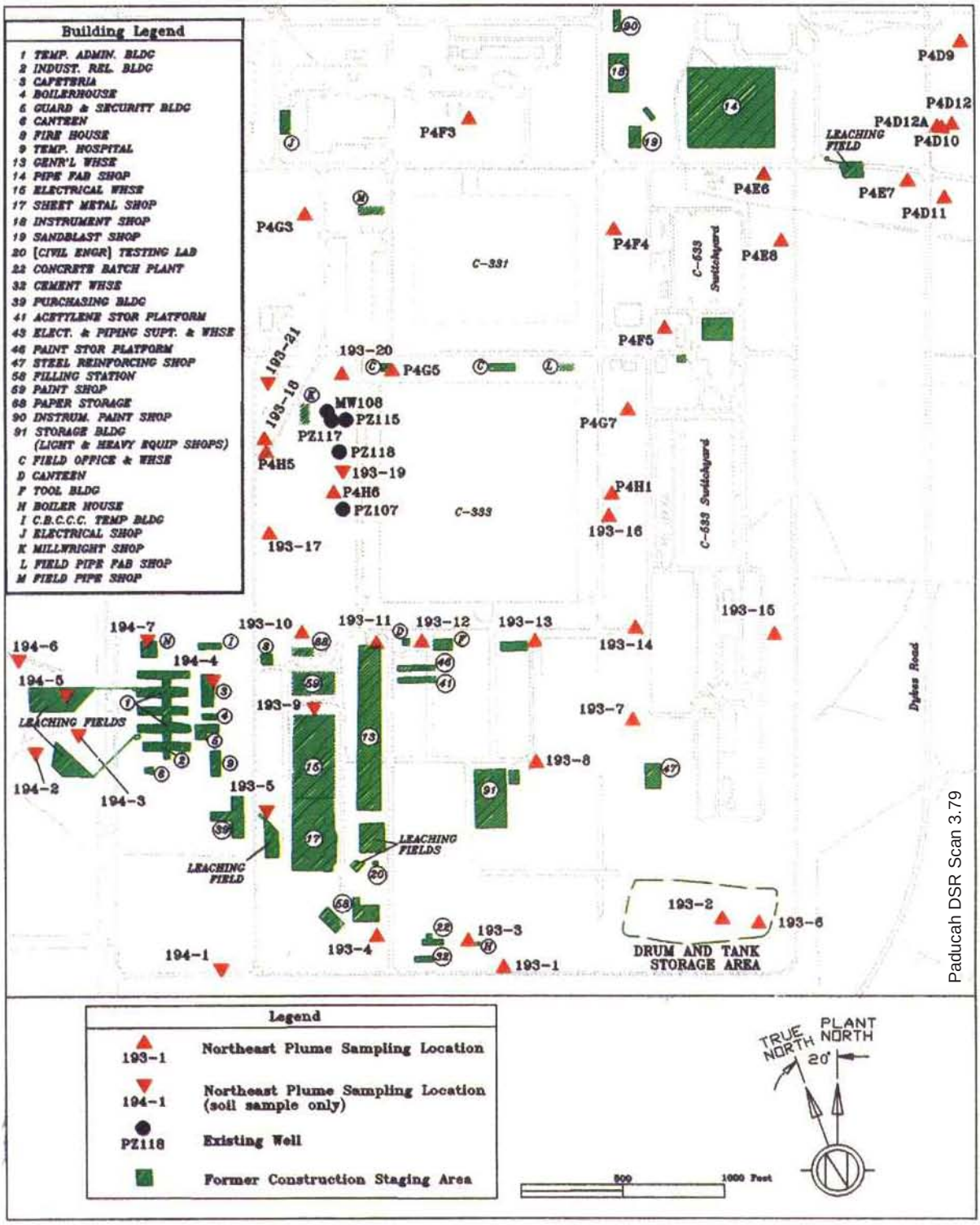


Fig. 3.79. Study area and sample locations of the Site Evaluation of SWMUs 193 and 194.

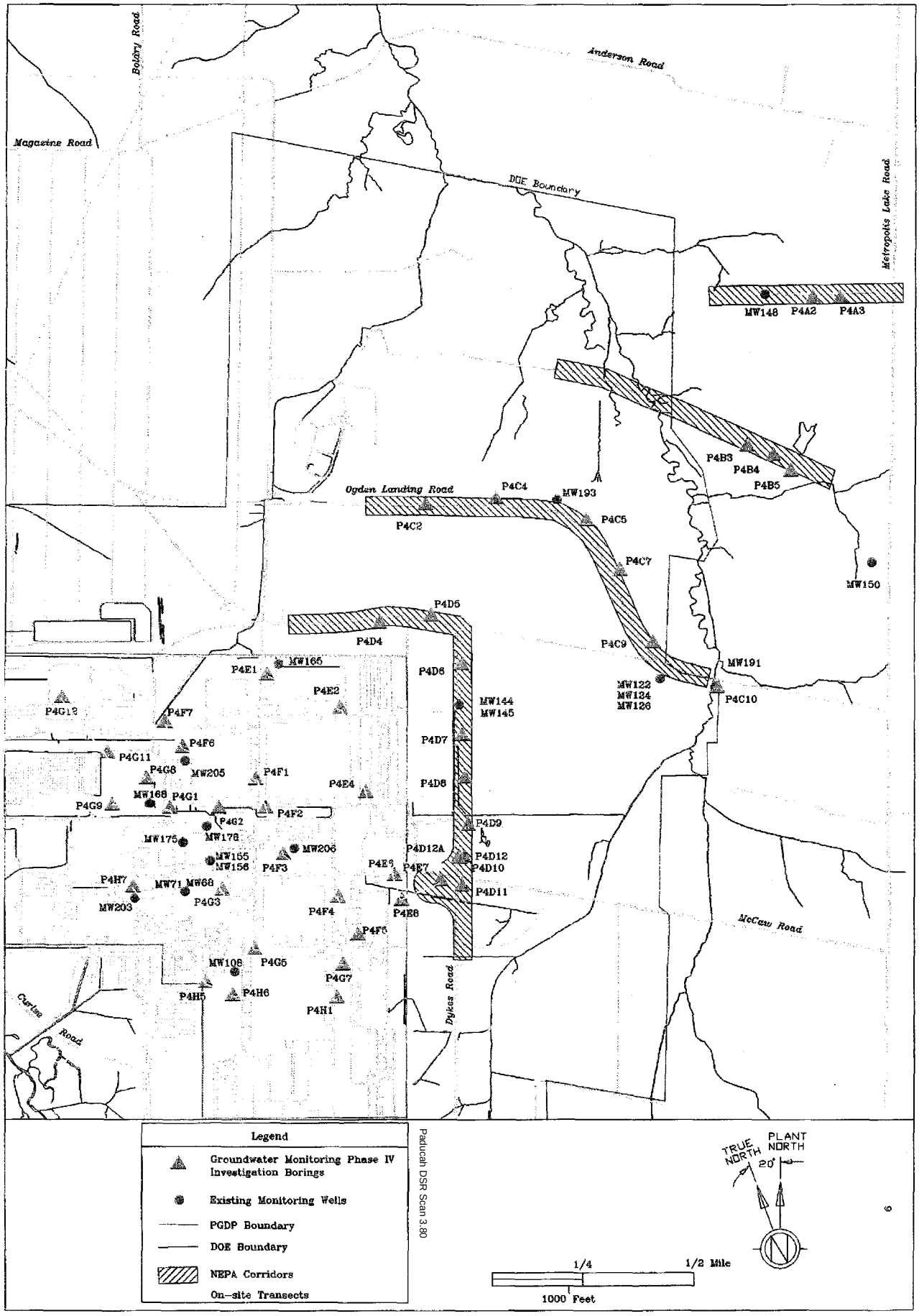


Fig. 3.80. Sample locations of the groundwaer monitoring Phase IV investigation

Formation defined both areal and vertical trends in contaminant levels. Geophysical and sample logs of the boreholes defined the geologic units of the investigation area. In addition, the Groundwater Monitoring Phase IV Investigation constructed RGA wells in nine boreholes to provide for continued monitoring of contaminant levels in critical areas.

Conclusions

The Site Evaluation of SWMUs 193 and 194 and the Groundwater Monitoring Phase IV Investigation provided key data regarding the geologic framework of the PGDP area and the source and distribution of groundwater contamination derived from the PGDP.

Geology/Hydrogeology

The lithologic and geophysical logs of the Northeast Plume Investigation confirmed the conceptual model of the stratigraphy of the PGDP but provided many refinements in the area of the Northeast Plume. Within the lower continental deposits, the geophysical logs defined the textures of distinct depositional units that could then be correlated to hydraulic properties. Several borehole logs indicated the presence of coarse sand and gravel units in the top of the McNairy Formation in contact with basal gravel units of the lower continental deposits. Vertical trends in contaminant levels indicate that these sand and gravel units in the McNairy Formation were in hydraulic connection with the lower continental deposits. Consequently, the basal RGA was redefined to include McNairy Formation sand and gravel units in contact with the lower continental deposits, where they occur.

Most soil borings penetrated approximately 15.25 m (50 ft) into the McNairy Formation. These boreholes were not sufficiently deep to penetrate a middle member of the McNairy Formation, termed the Levings Member in southern Illinois. However, the geophysical log of the one Groundwater Monitoring Phase IV Investigation boring that was drilled to the base of the McNairy Formation indicated that a thick Levings Member is locally present with a top near the depth of the other soil borings.

Nature and Extent of Contamination

The Site Evaluation of SWMUs 193 and 194 and the Groundwater Monitoring Phase IV Investigation detected several potential sources of contamination to the RGA. Table 3.90 summarizes the source zone identifications.

Table 3.90. Potential contaminant source zones identified by the Northeast Plume Investigation

Plume	Location	Contaminant(s)
Northeast	Millwright Shop	TCE
	Septic Tank and Leach Field of the Kellogg Pipe Fabrication Shop	TCE
	C-340 Area	TCE
	C-531 and C-533 Switchyards	TCE
Northwest	C-400	TCE and ^{99}Tc
	Northwest Area (Between Borings P4-G11 and P4-G12)	TCE and ^{99}Tc
?	C-720 Area	TCE

The Northeast Plume Investigation verified that TCE and ^{99}Tc were the primary contaminants associated with the Northeast Plume. Contaminant levels of Northeast Plume samples ranged up to 6,700 µg/L TCE and 712 pCi/L ^{99}Tc. Sample analyses of many on-site RGA water samples (and some McNairy Formation water samples) reported the presence of TCE degradation products, but generally at levels of

secondary importance. Table 3.91 presents the five highest detected levels of the TCE degradation products from the Northeast Plume water samples.

Table 3.91. Summary of highest detected levels of TCE degradation products in RGA water samples of the Northeast Plume

Boring ID	Detected contaminant levels					Location
	1st Highest	2nd Highest	3rd Highest	4th Highest	5th Hghest	
			***Cis*-1,2-Dichloroethene**			
P4-G2	3,097					Top RGA
P4-G7		998				Base RGA
P4-F4			525			Middle RGA
P4-E1				518		Middle RGA
P4-G3					464	Middle RGA
			Carbon Tetrachloride			
P4-G2	402					Top RGA
P4-G7		25				Base RGA
P4-E1			22			Middle RGA
P4-G5				6		Base RGA
P4-E6					3	Base RGA
			1,1-Dichloroethene			
P4-G2	382					Middle RGA
P4-F5		146				Base RGA
P4-G7			50			Base RGA
P4-G3				34		Middle RGA
					23	Base RGA
			1,1,1-Trichloroethane[a]			
P4-F5	21					Base RGA
P4-F4		2				Middle RGA
P4-E6			1			Base RGA

[a] Only 3 detections

Figures 3.81 and 3.82 present the maximum TCE levels in the top and bottom of the RGA as mapped for the Northeast Plume Investigation. In addition, Fig. 3.83 shows the maximum ^{99}Tc levels mapped in the RGA, based on the investigation data. The primary observations of the Northeast Plume Investigation based on the contaminant distribution included these:

- The southern edge of the Northeast Plume is sharply defined;
- The extent of contamination at the top of the RGA differs from the extent of contamination at the base of the RGA; and
- The C-400 area is primarily a source to the Northwest Plume.

The *Northeast Plume Preliminary Characterization Summary Report* (DOE 1995a) concluded that the general presence of the highest dissolved TCE levels at the base of the RGA suggested the presence of a DNAPL source(s) for the Northeast Plume. However, the presence of highest dissolved TCE concentrations at the top of the RGA was an indication of proximity to a UCRS DNAPL source zone.

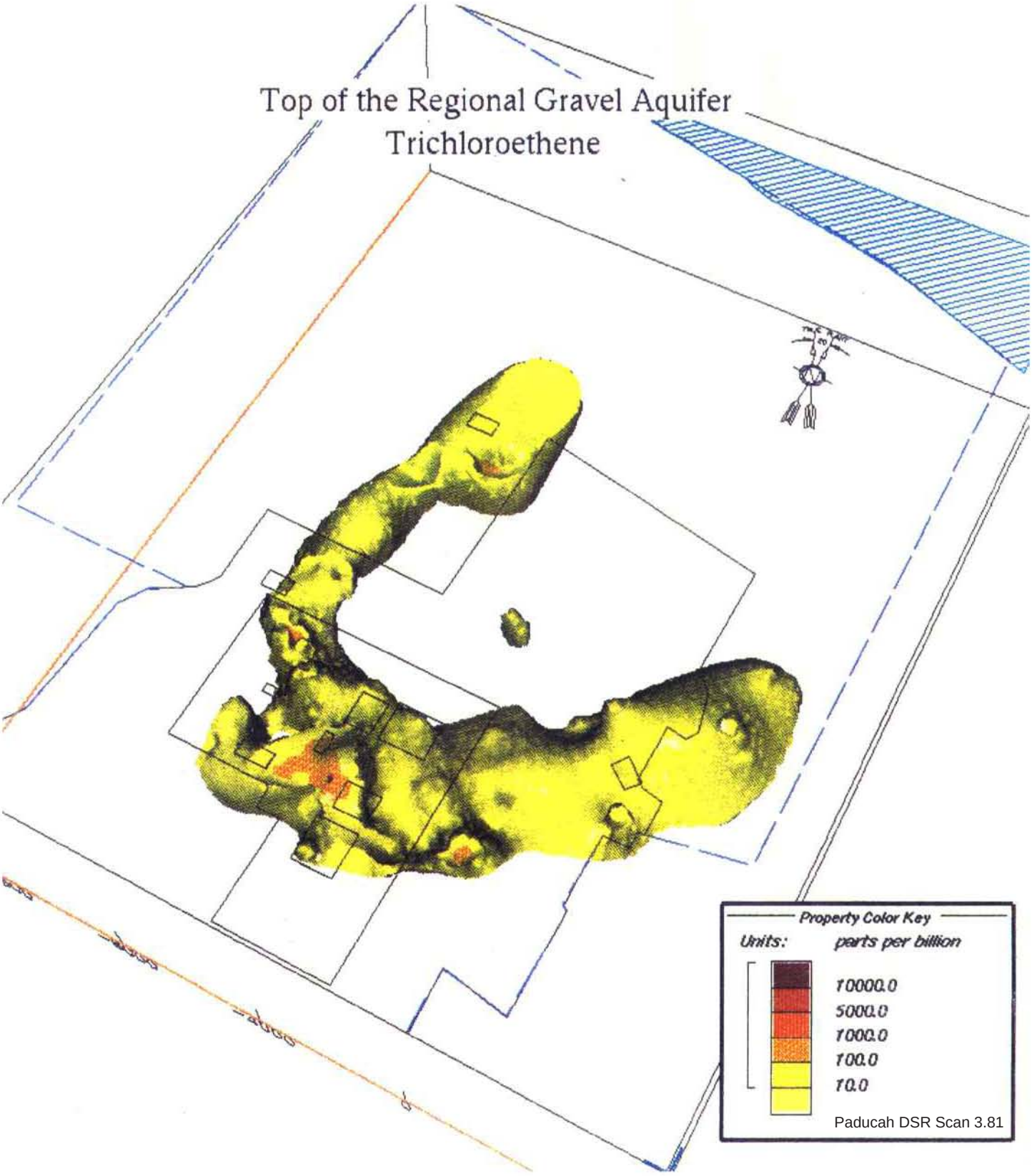


Fig. 3.81. Maximum TCE levels in the top of the RGA.

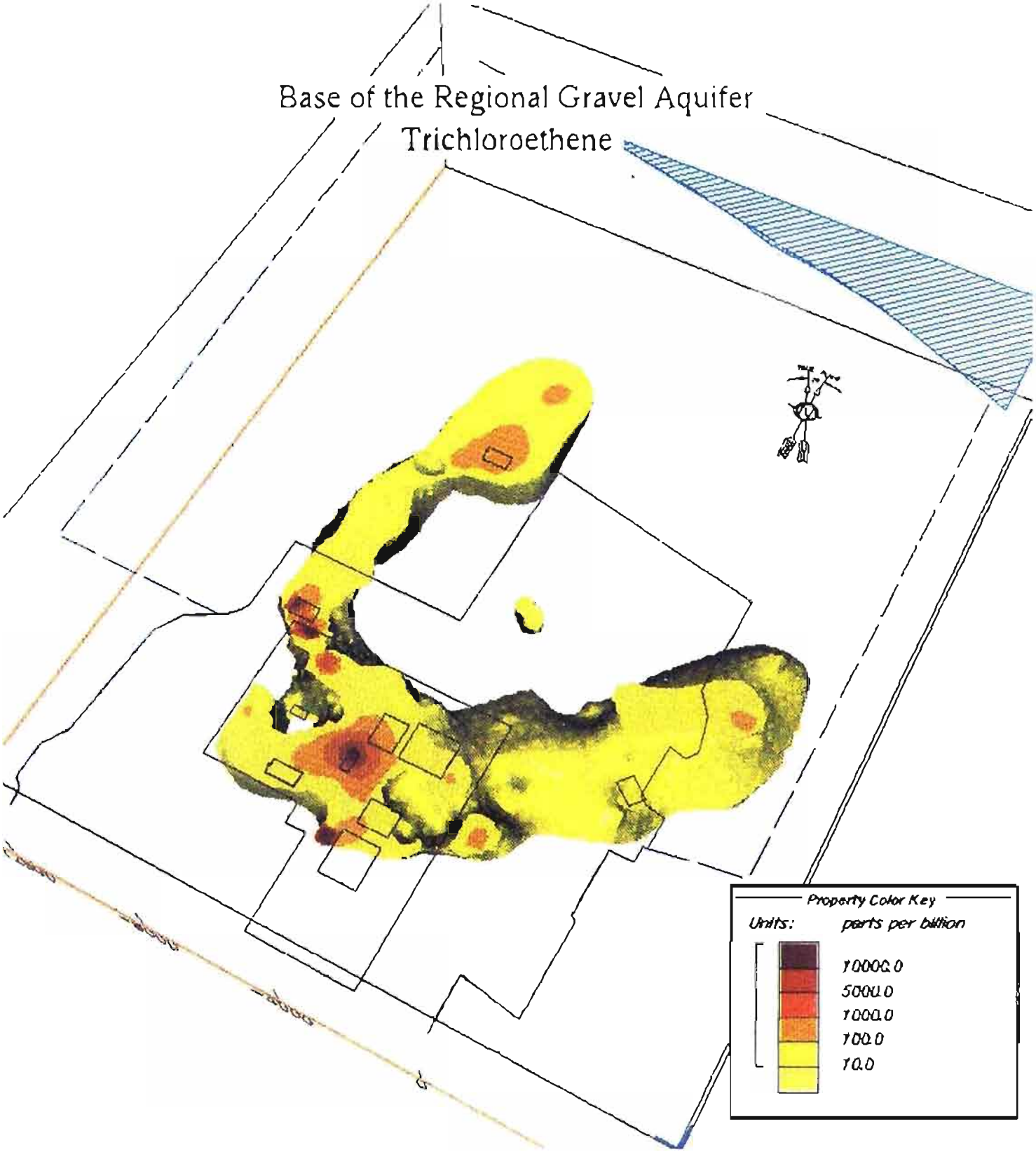
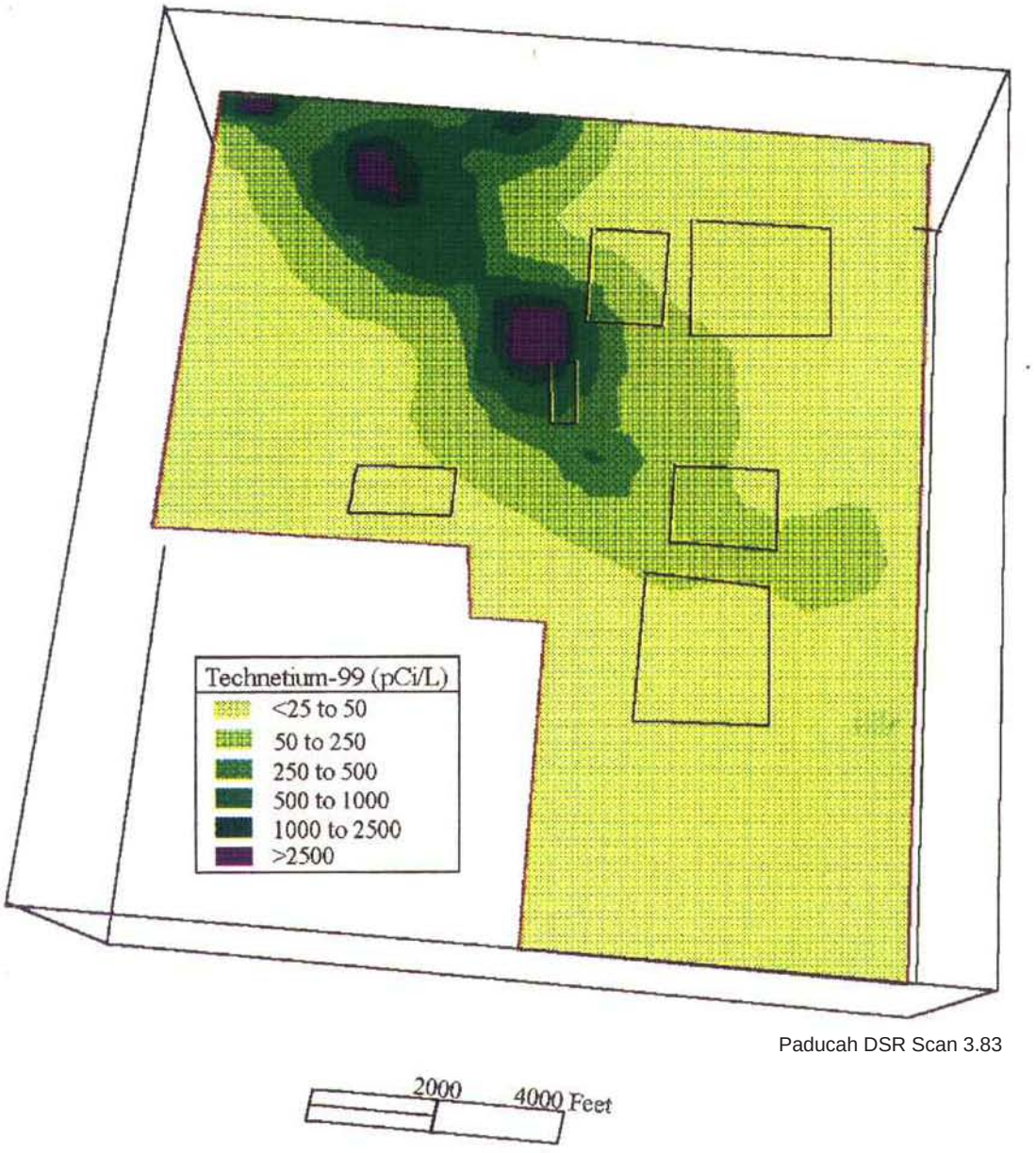


Fig. 3.82. Maximum TCE levels in the bottom of the RGA



This drawing represents a possible interpretation of contaminant conditions based on a limited number of widely-spaced sampling points. The conditions may change with time, and conditions significantly different than those interpreted here may actually exist between sample points.

Fig. 3.83. Maximum ^{99}Tc levels mapped in the RGA.

3.3.5 Northwest Plume Investigation

Scope

The *Final Report on Drive-Point Profiling of the Northwest Plume and Analysis of Related Data* (DOE 1995e) documents two phases of investigation of the Northwest Plume. The focus of the report is the interpretation of data derived from investigations conducted in September through October of 1992 and August 1993 through March 1994. In addition, the report presents existing data from environmental surveillance monitoring and other investigations to support a conceptual model of the physical controls governing contaminant migration in the Northwest Plume.

Areas of Investigation

Both phases of the investigation addressed SWMUs 7 and 30, located in the northwest corner of the plant, and the off-site area overlying the high concentration zone of the Northwest Plume. The second phase investigation also collected water samples on the south side of SWMUs 7 and 30 to characterize upgradient source contributions. Figure 3.84 is a map of the primary sample locations used in the Northwest Plume Investigation.

The soil borings of both phases of fieldwork defined contaminant distribution and the geologic structure of the RGA along six transects across the axis of the Northwest Plume. These transects form the basis for a 3-dimensional model of the RGA and the Northwest Plume.

Investigation Methods

The Northwest Plume Investigation relied upon a hydraulic hammer-drive system coupled with a discrete depth sampler to collect the majority of groundwater samples for the investigation. These water samples represented the UCRS, RGA, and McNairy Formation flow systems. Other soil borings drilled by hollow stem auger and sampled with a Hydropunch™ sampler and existing monitoring wells were also used to collect UCRS and RGA water samples. Logs of previous area soil borings provided the expected depths of the top and base of the RGA. Changes in penetration rate by the hydraulic hammer-drive system determined formation contacts for the log of each soil boring.

Together, both phases of the investigation completed 33 soil borings and collected water samples from 90 discrete depths using the hydraulic hammer-drive system. Traditional drilling, using hollow stem augers, collected an additional seven discrete depth samples from six soil borings at the northern extent of the high-concentration zone of the Northwest Plume. The investigation also sampled 11 monitoring wells in the Northwest Plume area.

Conclusions

The results of the Northwest Plume Investigation are the primary basis for the current maps of lateral and vertical extent of the core of the Northwest Plume. These map revisions were critical to the siting the Northwest Plume Groundwater (pump-and-treat) System.

Geology/Hydrogeology

The soil borings of the Northwest Plume Investigation defined a trough in the top of the McNairy Formation in the area of the high concentration zone of the Northwest Plume. The *Final Report on Drive-Point Profiling of the Northwest Plume and Analysis of Related Data* (DOE 1995e) attributed the

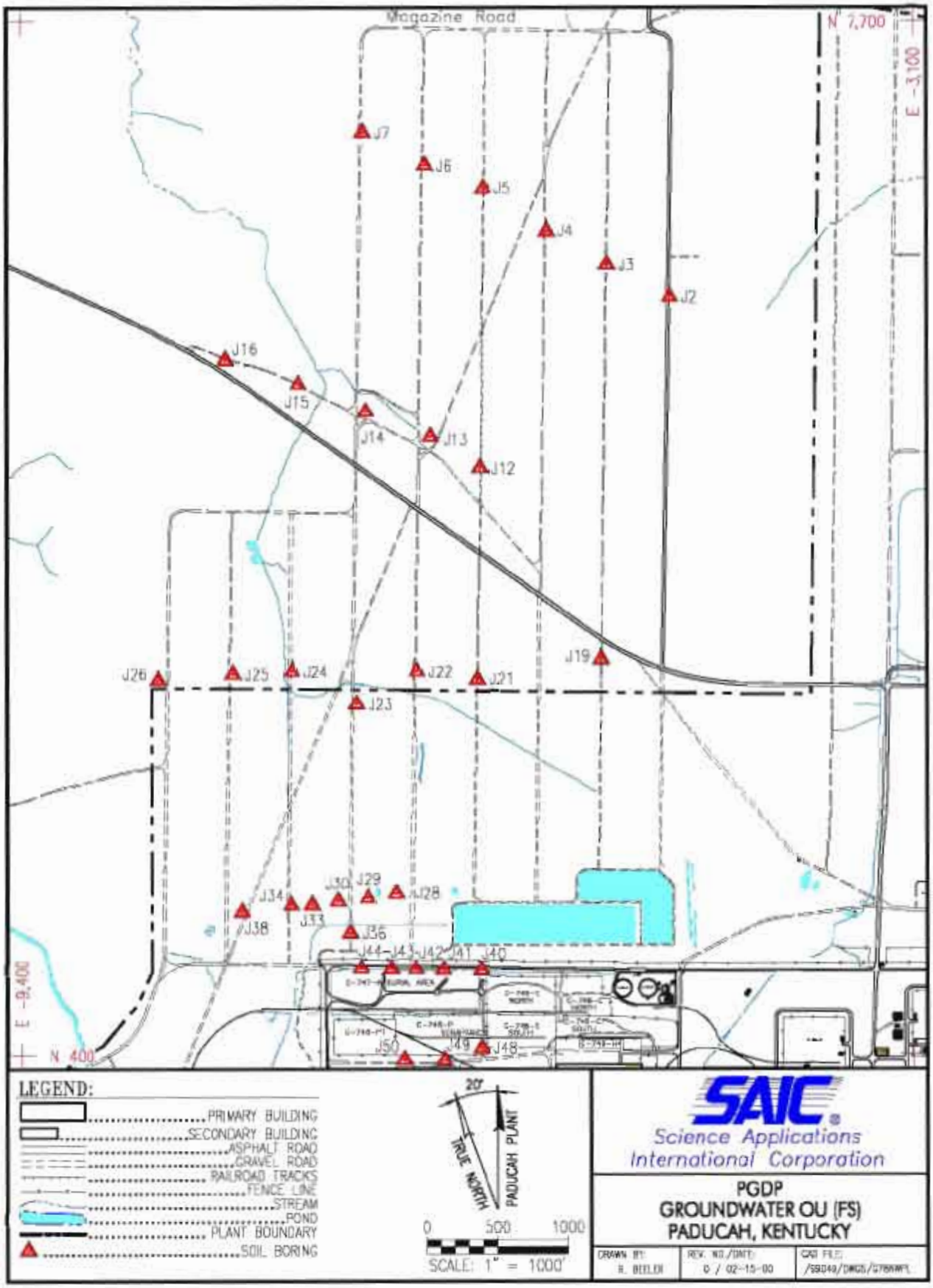


Figure 3.84. Sample Locations of the Northwest Plume Investigation.

orientation of the Northwest Plume, in part, to highly conductive channel deposits along the trough. A topographic high in the top of the McNairy Formation was found near the northern extent of the high-concentration core of the Northwest Plume. Soil borings from this area revealed that the lower continental deposits consisted of finer-grained sediments across this ridge in the top of the McNairy Formation.

The investigation report presents a comparison of hydrographs of RGA wells in the Northwest Plume area versus a hydrograph of the Ohio River. Periods of high hydraulic potential in the RGA apparently correspond (lag behind) periods of high river stage. These trends in hydraulic potential cause groundwater flow directions along the axis of the Northwest Plume to change from north (low river stage) to northeast (high river stage), causing a wobble in the axis of the Northwest Plume. Thus, contaminant levels in Northwest Plume wells can be expected to vary according to previous trends of Ohio River stage. The contaminant level/river stage relationship is dependent upon the location of the monitoring well relative to the core of the Northwest Plume.

Nature and Extent of Contamination

The investigation confirmed that the primary contaminants of the Northwest Plume are TCE (up to 16,000 µg/L) and ^{99}Tc (up to 4,800 pCi/L), with only trace levels of TCE degradation products (1,1-DCE and 1,2-DCE) throughout the RGA plume. (Analyses of the first phase Northwest Plume Investigation reported *cis*-DCE compounds and vinyl chloride in RGA water samples. These detections appear to be misidentifications of freon and bromodichloromethane.) MW186, a UCRS well in SWMU 7, was found to be the only location of elevated degradation products (up to 3,000 µg/L vinyl chloride and 4,800 µg/L 1,2-DCE). Thus, the only significant degradation of TCE appears to occur in localized areas of the UCRS.

The Northwest Plume Investigation measured high levels of TCE and ^{99}Tc in water samples from the upper RGA and UCRS near SWMU 7 (MWs 185 and 187, respectively). However, water samples from soil borings J36 and J43 revealed that the highest contaminant levels were present at the base of the RGA. In addition, the investigation report showed that the ratio of the levels of TCE versus ^{99}Tc was constant within the Northwest Plume. However, the upper RGA samples from near SWMU 7 did not contain the same ratio of contaminants. Thus, two sources to the Northwest Plume were implied. The upgradient samples of the Northwest Plume Investigation and recent samples collected for the Northeast Plume Investigation indicated that the C-400 Cleaning Building was the location of a larger DNAPL zone to the Northwest Plume.

Figures 3.85 through 3.90 are maps of contaminant levels in the upper, middle, and lower RGA as determined by the Northwest Plume Investigation. Table 3.92 summarizes calculations in the investigation report of the area of contamination and contaminant mass and flux for the Northwest Plume.

The investigation report includes a plot of measured contaminant levels versus distance along the axis of the Northwest Plume. This plot defines a consistent dilution curve, suggesting that the mass flux in the Northwest Plume has reached equilibrium. Based on the dilution curve, the 5 µg/L drinking water standard commonly applied for TCE contamination is reached at a distance of 4,270 m (14,000 ft) downgradient of the plant security fence. Because the Ohio River is approximately 5,180 m (17,000 ft) downgradient of the plant security fence, the Northwest Plume is not expected to significantly impact water quality in the Ohio River.

Two reports were previously done for the Northwest Plume. They are discussed separately.

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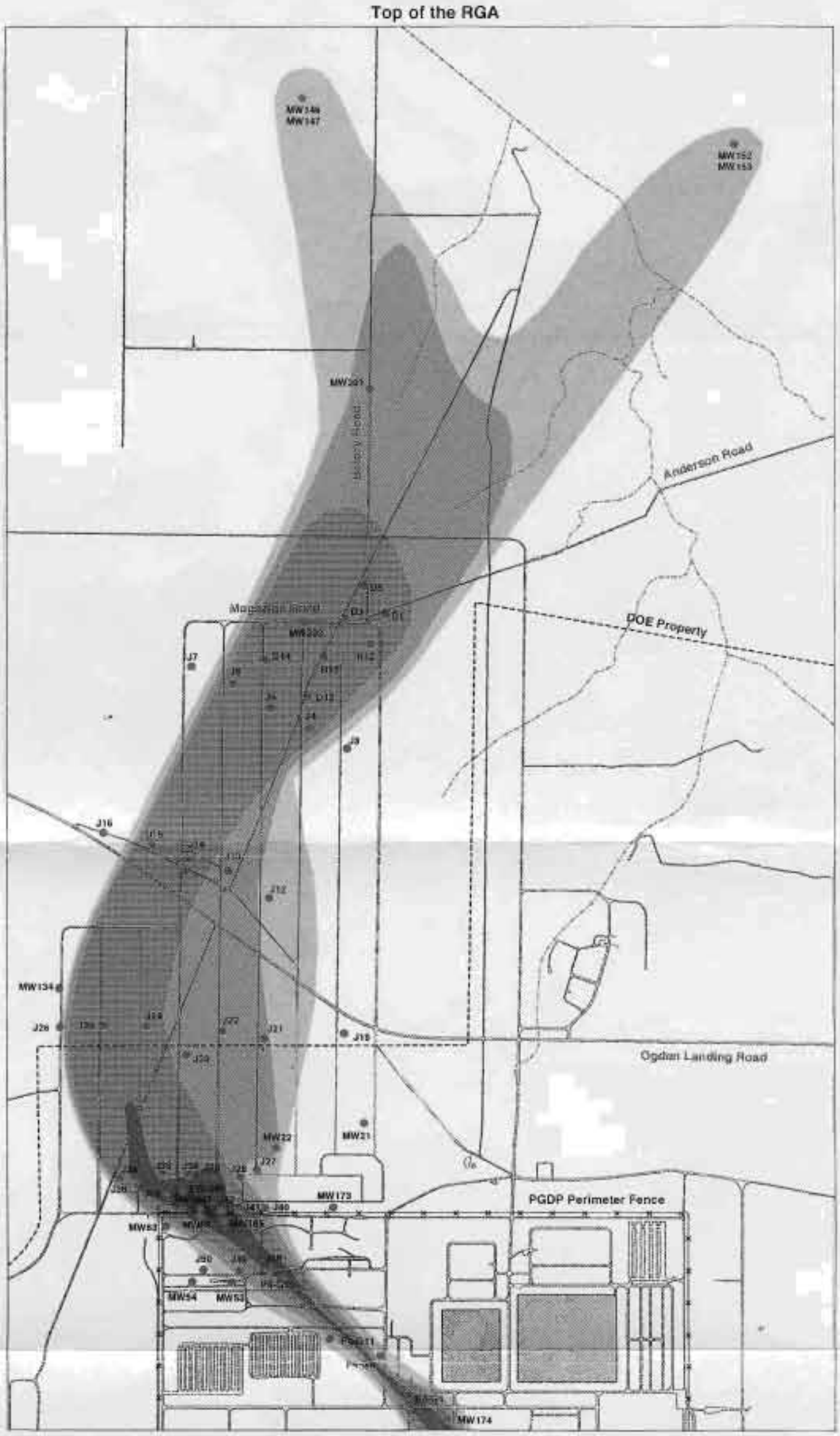

Fig. 3.85. Map of Trichloroethene levels of the Northwest Plume in the Upper RGA

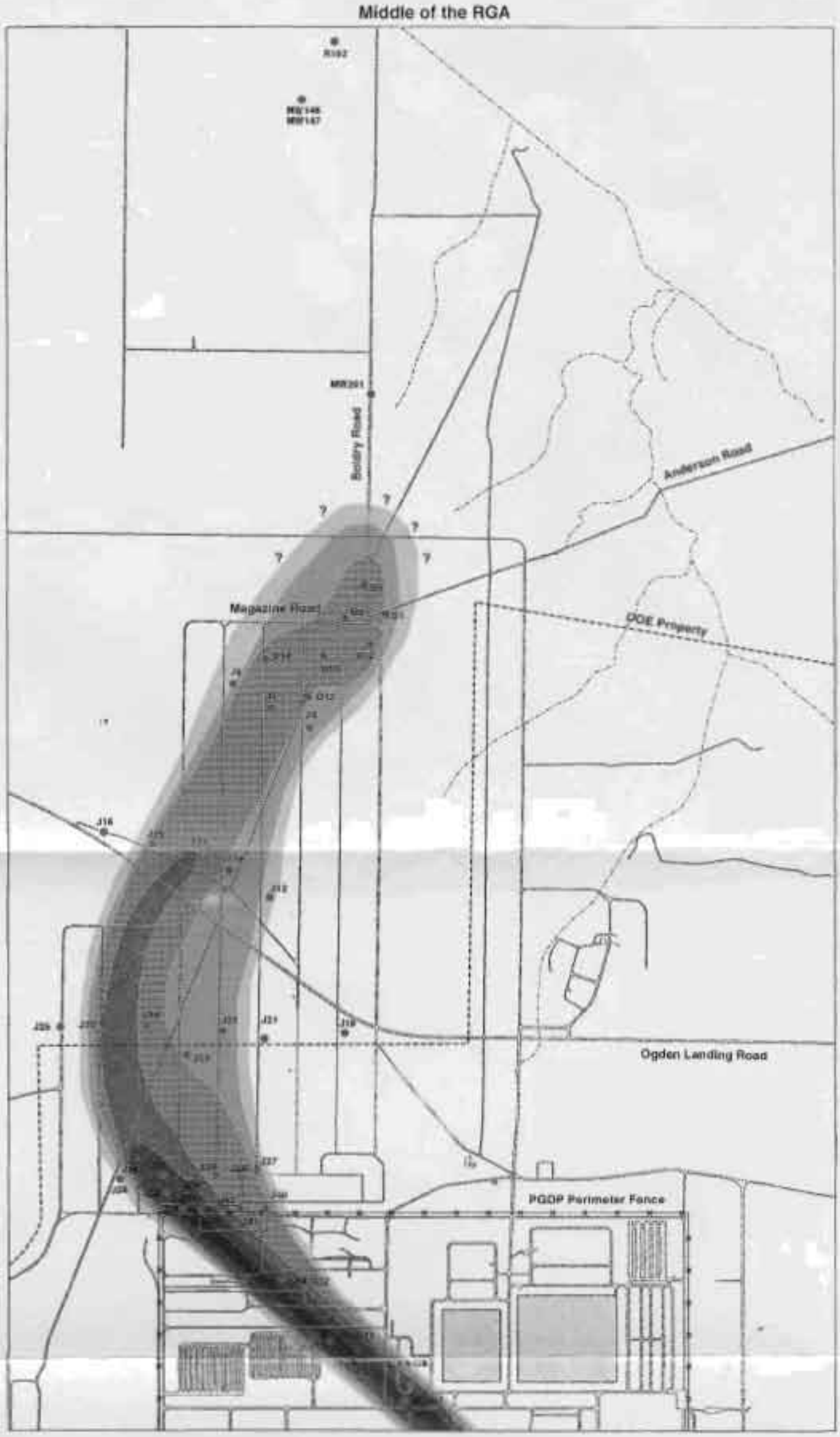

Fig. 3.86. Map of Trichloroethene levels of the Northwest Plume in the Middle RGA

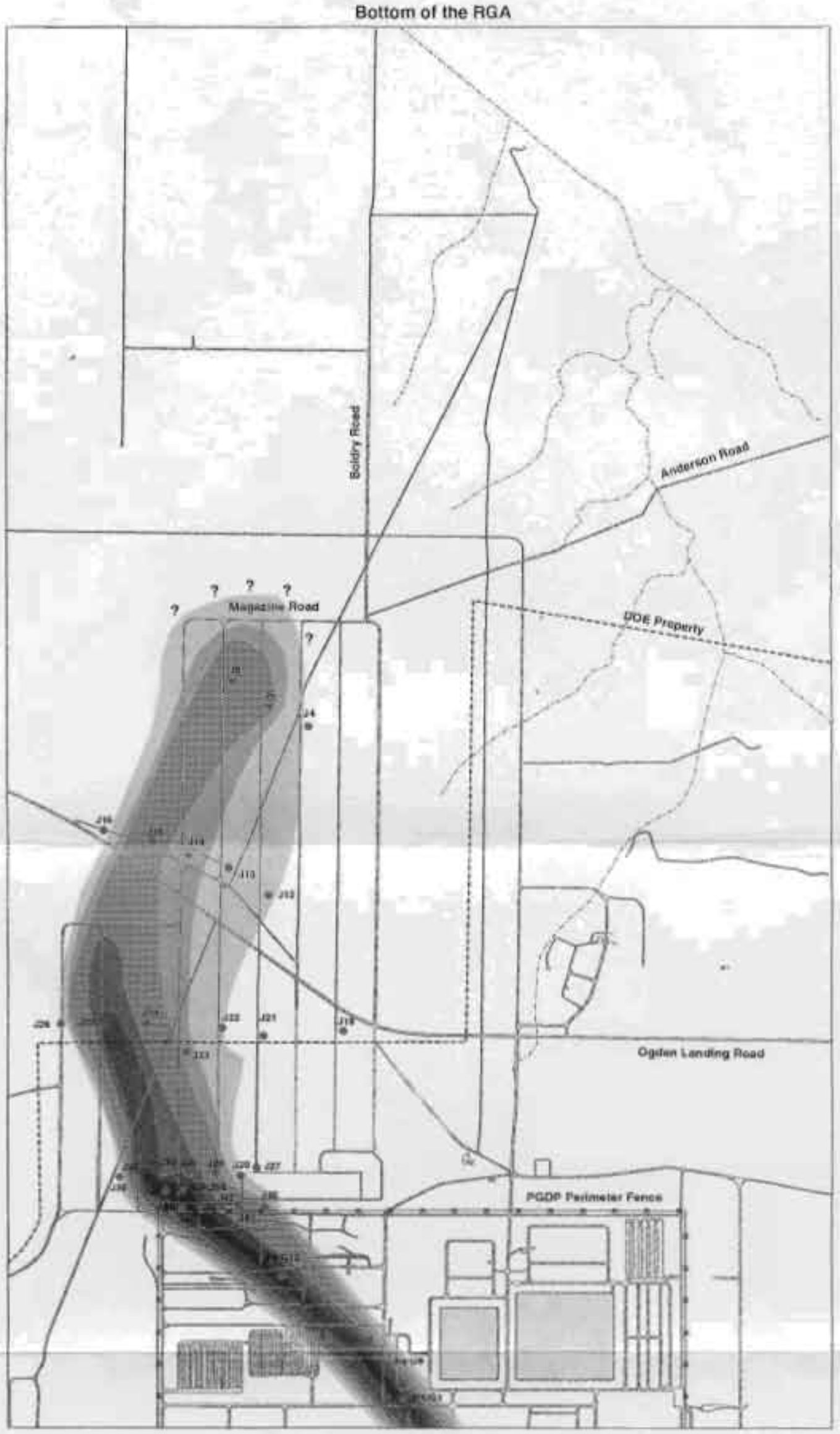

Fig. 3.87. Map of Trichloroethene levels of the Northwest Plume in the Lower RGA

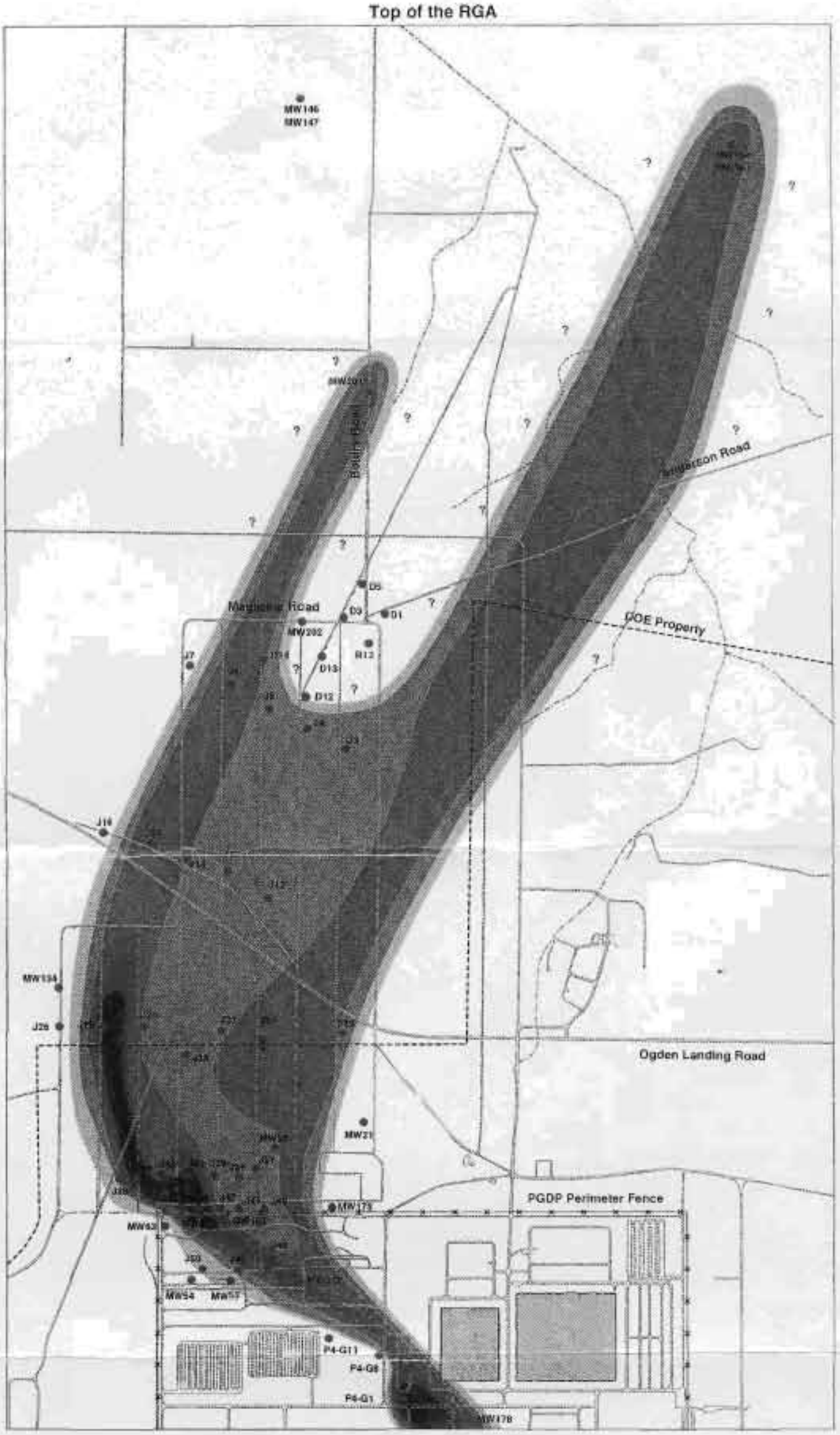

Fig. 3.88. Map of Technetium-99 levels of the Northwest Plume in the Upper RGA

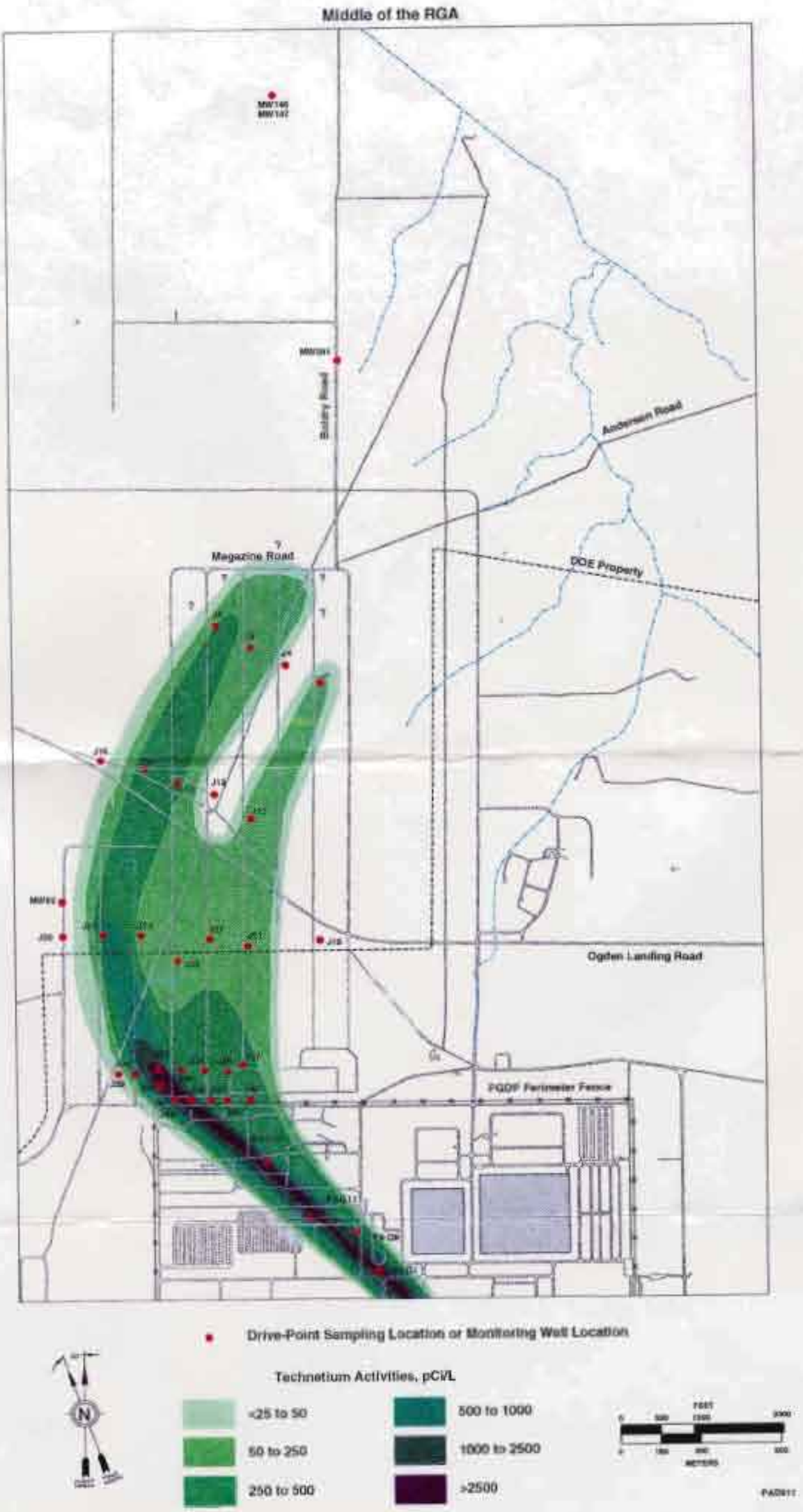

Fig. 3.89. Map of Technetium-99 levels of the Northwest Plume in the Middle RGA

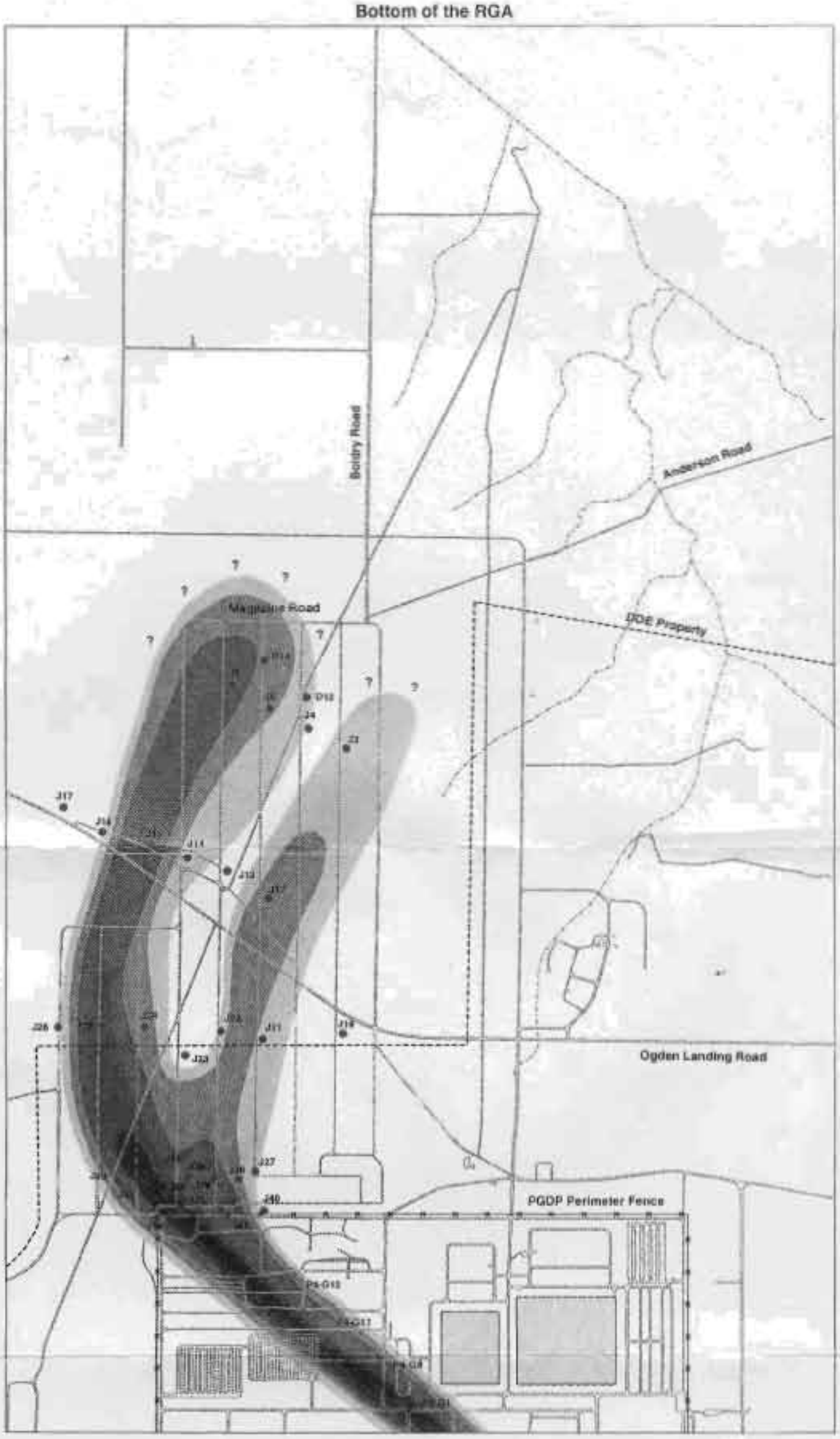

Fig. 3.90. Map of Technetium-99 levels of the Northwest Plume in the Lower RGA

Table 3.92. Calculations of physical properties of the Northwest Plume

Physical property	Calculation result (SI Units)	Calculation result (English Units)
Area Underlain by the Northwest Plume	5 kilometers^2	1,300 acres
Volume of Contaminated Water Contained Within The Northwest Plume	9.2×10^9 to 1.4×10^{10} liters	2.4×10^9 to 3.6×10^9 gallons
Volume of Dissolved TCE Contained Within The Northwest Plume	2,100 to 3,300 liters	400 to 600 gallons
Annual Mass Flux of TCE Within the Northwest Plume	12 to 20 liters	3 to 6 gallons
Volume of Dissolved ^{99}Tc Contained Within the Northwest Plume	1,700 to 2,500 grams (28 to 42 Curies)	4 to 6 pounds
Annual Mass Flux of ^{99}Tc Within the Northwest Plume	0.001 to 0.006 grams (0.4 to 0.7 Curies)	2.2×10^{-6} to 1.3×10^{-5}

The summary presented in this section was taken from *Human Health Baseline Risk Assessment for the Northwest Plume, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1993b). Specifically, Sect. 5 of the Northwest Plume BRA contains the pertinent risk information that will be repeated here. The purpose of this activity was to provide support for the determination of potential remedial action needs and alternatives for the Northwest Plume.

Tables 3.93 and 3.94 summarize the risks for areas of the Northwest Plume calculated in the Northwest Plume BRA. These risks are being compiled from Tables 5.1 through 5.10 of the Northwest Plume BRA. These tables were taken from *Baseline Risk Assessment and Technical Investigation Report for the Northwest Dissolved Phase Plume* (DOE 1994b).

The results of the Northwest Plume Dissolved Phase BRA are presented here and are taken from *Baseline Risk Assessment and Technical Investigation Report for the Northwest Dissolved Phase Plume (*DOE 1994b). This investigation evaluated the nature and extent of off-site contamination in the RGA in the Northwest Plume and determined risk presented by this contamination to groundwater users. However, unlike the earlier investigations, which focused only on risk under current conditions, this assessment focused on both risk under current conditions and risk because of changes in contaminant concentrations over time, assuming that the on-site sources of the Northwest Plume (i.e., those sources that are within the controlled area at PGDP) were contained. The results of the risk assessment of groundwater usage are discussed in Subsection 5.5 of the Northwest Plume Dissolved Phase BRA and tabulated in Tables 5.51 through 5.111 of that report.

Tables 3.95 through 3.98 summarize the risk results and the contaminants contributing to the risk of the Northwest Plume Dissolved Phase BRA.

3.3.6 Natural Attenuation Investigation

Scope

With the support of the Argonne National Laboratory, an evaluation of natural attenuation processes for TCE and ^{99}Tc in the Northeast and Northwest Plumes was conducted at the PGDP in May 1997 (Clausen 1997). Fifteen monitoring wells were sampled for various parameters to document the type of

Table 3.93. Summary of risks for the Northwest Plume at the PGDP

(formerly "Table 5.9a. Hazard indexes and excess lifetime cancer risk associated with exposure to natural occurring metals[a]—DOE 1993b")

Chemical	Ingestion of groundwater	Inhalation of volatiles household water use	Dermal exposure while bathing	Ingestion of vegetables	Ingestion of milk	Ingestion of meat	Sum of HQs across pathways	HI total
High TCE/^{99}Tc								
Arsenic	8.9E-01	NR	2.5E-03	2.9E-01	4.4E-03	2.3E-02	1.22	
Barium	1.1E-01	NR	3.1E-05	4.2E-02	4.5E-03	3.0E-04	0.15	
Cadmium	4.0E-02	NR	1.2E-04	3.5E-02	1.0E-02	9.2E-04	0.09	
Copper	8.3E-02	NR	2.4E-03	8.8E-01	2.5E-01	2.7E-01	1.5[B]	
Cyanide	8.2E-03	NR	2.7E-05	5.7E-01	1.2E-06	6.2E-07	0.58	
Silver	3.5E-02	NR	1.0E-04	2.4E-02	1.4E-01	3.5E-03	0.21	
HI total	1.2E+00		5.2E-03	1.8E+00	4.1E-01	3.0E-01		3.8[c]
TCE/^{99}Tc								
Arsenic	8.3E-01	NR	2.4E-03	2.8E-01	4.1E-03	2.2E-02	1.10	
Barium	1.0E-01	NR	3.0E-04	4.1E-02	4.3E-03	3.0E-04	0.15	
Cadmium	6.2E-02	NR	1.8E-04	5.4E-02	1.6E-02	1.4E-03	0.13	
Copper	4.6E-02	NR	1.3E-04	4.9E-02	1.4E-02	1.5E-02	0.13	
Cyanide	4.8E-03	NR	1.4E-05	3.3E-01	7.0E-07	3.6E-07	0.34	
Silver	1.2E-02	NR	3.5E-05	8.2E-03	4.8E-02	1.2E-03	0.07	
HI total	1.1E+00		3.1E-03	7.6E-01	8.6E-02	3.9E-02		1.9
Outside of Plume								
Arsenic	1.2E-01	NR	3.4E-04	4.0E-02	5.9E-04	3.1E-03	0.16	
Barium	1.3E-01	NR	3.8E-04	5.2E-03	5.5E-03	3.8E-04	0.19	
Cadmium	9.8E-02	NR	2.8E-04	8.6E-02	2.5E-03	2.2E-03	0.21	
Copper	2.3E-02	NR	6.7E-05	2.5E-02	7.1E-03	7.6E-03	0.06	
Cyanide	5.3E-03	NR	1.5E-05	3.7E-01	7.9E-07	4.0E-07	0.37	
Silver	1.1E-02	NR	3.1E-05	7.3E-03	4.3E-02	1.1E-03	0.06	
HI total	3.9E-01		1.0E-03	5.3E-01	5.8E-02	1.4E-02		1.1
Reference								
Arsenic	6.7E-01	NR	1.9E-03	2.3E-01	3.3E-03	1.8E-02	0.92	
Barium	6.4E-02	NR	1.9E-04	2.5E-02	2.7E-03	1.8E-04	0.09	
Cadmium	7.5E-02	NR	2.1E-04	6.5E-02	1.9E-02	1.7E-03	0.16	
Copper	4.4E-02	NR	1.3E-04	4.7E-02	1.3E-02	1.4E-02	0.12	
Cyanide	3.9E-03	NR	1.1E-05	2.7E-01	5.7E-07	2.9E-07	0.27	
Silver	1.6E-02	NR	4.7E-05	1.1E-02	6.7E-02	1.5E-03	0.10	
HI total	8.7E-01		2.5E-03	6.5E-01	1.1E-01	3.5E-02		1.7

NR = No RfD for this pathway

[a] Naturally occurring metals listed on this table were detected only one time above the background UTL (e.g., 1/37 arsenic results were above background), and therefore do not pass the screen for being considered present at background levels. However, these metals were tested to be present at background levels using a nonparametric analysis of variance (Kruskal-Wallis) test. Because of the uncertainty in designating these metals as site-related, risk estimated for them is presented separately.

[b] The value reported in the SAIC BHHRA was 2.24.

[c] The value reported in the SAIC BHHRA was 4.5.

Table 3.93. Summary of risks for the Northwesst Plume at the PGDP (continued)

(formerly "Table 5.9a. Hazard indexes and excess lifetime cancer risk associated with exposure to natural occurring metals[a]—DOE 1993b")

Chemical	Ingestion of groundwater	Inhalation of volatiles household water use	Dermal exposure while bathing	Ingestion of vegetables	Ingestion of milk	Ingestion of meat	Sum across pathways	Total
High TCE/^{99}Tc								
Arsenic	2.0E-04	NC	5.7E-07	6.7E-05	9.9E-07	5.2E-06	2.7E-04	
Total								2.7E-04
TCE/^{99}Tc								
Arsenic	1.9E-04	NC	5.4E-07	6.3E-05	9.2E-07	4.9E-06	2.6E-04	
Total								2.6E-04
Outside of Plume								
Arsenic	2.7E-05	NC	7.7E-08	9.0E-06	1.3E-07	7.0E-07	3.7E-05	
Total								3.7E-05
Reference								
Arsenic	1.5E-04	NC	4.3E-07	5.1E-05	7.5E-07	4.0E-06	2.1E-04	
Total								2.1E-04

NC = Not identified as a carcinogen for this pathway

[a] Naturally occurring metals listed on this table were tested to be present at background levels using a nonparametric analysis of variance (Kruskal-Wallis) test. Because of the uncertainty in designing these metals as site-related, risk estimated for them is presented separately.

Table 3.94. Summary of risks for the Northwest Plume at the PGDP

(formerly "Table 5.9b. Hazard indexes and excess lifetime cancer risks associated with the site-related COCs")

Chemical	Ingestion of groundwater	Inhalation of volatiles household water use	Dermal exposure while bathing	Ingestion of vegetables	Ingestion of milk	Ingestion of meat	Sum of HQs across pathways	HI total
TCE/^{99}Tc—DOE 1993								
cis-1,2-Dichloroethane	1.4E-04	5.8E-05	3.9E-06	9.7E-04	1.2E-07	6.0E-08	0.001	
2-Butanone	3.8E-03	1.8E-04	1.2E-05	3.0E-01	5.2E-07	2.7E-07	0.30	
Bis(2-ethylhexyl)phthalate	2.5E-02	NR	2.4E-03	1.0E-02	3.2E-03	1.6E-03	0.04	
Di-n-butylphthalate	5.5E-04	1.5E-04	5.2E-05	2.3E-04	5.7E-05	2.8E-05	0.00	
Dieldrin	5.9E-02	NR	2.7E-03	3.5E-02	1.0E-01	7.6E-03	0.21	
Diethylphthalate	6.9E-05	1.9E-05	9.5E-07	1.7E-04	6.8E-09	2.9E-09	0.0002	
Phenol	5.3E-04	NR	8.5E-06	8.7E-03	2.4E-07	1.2E-07	0.01	
Toluene	6.8E-04	5.0E-04	8.8E-05	2.3E-03	1.2E-06	5.9E-07	0.004	
Uranium	4.2E-02	NR	1.2E-04	1.4E-02	1.8E-03	9.7E-05	0.06	
Xylene	7.1E-05	3.0E-05	1.6E-05	1.4E-02	2.2E-10	9.3E-08	0.01	
Pathway HIs	1.3E-01	9.4E-04	5.4E-03	3.9E-01	1.1E-01	9.3E-03		
Total HI								0.6
High TCE/^{99}Tc—DOE 1993								
cis-1,2-Dichloroethene	1.4E-03	5.9E-04	4.0E-05	1.0E-02	1.2E-02	6.1E-06	0.01	
Bis(2-ethylhexyl)phthalate	2.7E-03	NR	2.6E-04	1.1E-03	3.5E-04	1.8E-04	0.0027	
Bromodichloromethane	1E-02	NR	2.7E-04	1.5E-01	1.1E-05	5.8E-06	0.17	
Carbon tetrachloride	3.1E-01	NR	2.0E-02	1.0	5.5E-04	2.8E-04	1.3	
Chloroform	2.7E-02	NR	9.5E-04	3.0E-01	2.8E-05	1.4E-05	0.34	
Di-n-butylphthalate	3.7E-03	1.0E-03	3.5E-04	1.5E-03	3.8E-04	1.9E-04	0.007	
Dibromochloromethane	1.0E-03	NDA	NDA	NDA	NDA	NDA	0.001	
Phenol	6.3E-04	NR	1.0E-05	1.0E-02	2.8E-07	1.4E-07	0.01	
Tetrachloroethene	2.7E-03	NR	3.8E-04	1.1E-02	3.8E-06	2.0E-06	0.01	
Uranium	5.7E-02	NR	1.6E-04	1.8E-02	2.5E-03	1.3E-04	0.08	
Pathway HIs	4.0E-01	1.6E-03	2.2E-02	1.5E+00	1.6E-02	8.1E-04		
Total HI								1.9
Outside of Plume—DOE 1993								
Bis(2-ethylhexyl)phthalate	1.2E-02	NR	1.1E-03	5.0E-03	1.6E-03	7.9E-04	0.02	
Uranium	2.5E-01	NR	7.1E-04	7.9E-02	1.0E-02	5.6E-04	0.34	
Pathway HIs	2.6E-01		1.8E-03	8.4E-02	1.2E-02	1.4E-03		
Total HI								0.4
Reference—DOE 1993								
Bis(2-ethylhexyl)phthalate	2.4E-01	NR	2.3E-02	9.8E-02	3.1E-02	1.6E-02	0.41	
Toluene	6.8E-04	5.0E-04	8.8E-05	2.3E-03	1.2E-06	5.9E-07	0.003	
Uranium	1.6E-02	NR	4.7E-05	5.2E-03	7.0E-04	3.7E-05	0.02	
Xylene	8.4E-05	3.6E-05	1.9E-05	1.9E-04	2.2E-07	1.1E-07	0.00	
Pathway HIs	2.6E-01	5.4E-04	2.3E-02	1.1E-01	3.2E-02	1.6E-02		
Total HI								0.4

NR = No RfD available.

Table 3.94. Summary of risks for the Northwest Plume at the PGDP (continued)

Chemical	Ingestion of groundwater	Inhalation of volatiles household water use	Dermal exposure while bathing	Ingestion of vegetables	Ingestion of milk	Ingestion of meat	Sum across pathways	Total
High TCE/^{99}Tc								
Bis(2-chloroethyl)ether	8.3E-05	2.3E-05	5.0E-07	1.3E-03	3.8E-08	2.1E-08	1.4E-03	
Bis(2-ethylhexyl)phthalate	3.3E-07	NC	3.1E-08	1.3E-07	4.2E-08	2.1E-08	5.6E-07	
Bromodichloromethane	8.7E-06	NC	1.5E-07	8.1E-05	6.0E-09	3.1E-09	9.0E-05	
Carbon tetrachloride	1.2E-05	5.5E-06	7.7E-07	3.9E-05	2.2E-08	1.1E-08	5.8E-05	
Chloroform	9.7E-07	4.8E-06	2.5E-08	8.0E-06	7.3E-10	3.7E-10	1.4E-05	
Dibromochloromethane	9.9E-07	NDA	NDA	NDA	NDA	NDA	9.9E-07	
Tetrachloroethane	6.0E-07	2.7E-07	8.3E-08	2.5E-06	8.4E-10	4.3E-10	3.4E-06	
Trichloroethene	1.9E-04	1.2E-04	8.6E-06	7.7E-04	2.6E-07	1.4E-07	1.1E-03	
^{99}Tc	2.0E-05	NC	NC	3.8E-06	9.1E-06	2.3E-06	3.5E-05	
^{234}U	5.7E-07	NC	NC	1.1E-07	1.3E-09	1.1E-10	6.8E-07	
^{235}U	1.7E-08	NC	NC	3.2E-09	3.7E-11	3.1E-12	2.0E-08	
^{238}U	1.0E-06	NC	NC	1.9E-07	1.3E-09	1.1E-10	1.2E-06	
Pathway risk	3.2E-04	1.5E-04	1.0E-05	2.2E-03	9.4E-06	2.4E-06		
Total								3E-3
TCE/^{99}Tc Plume—DOE 1993b								
Bis(2-ethylhexyl)phthalate	3.1E-06	NC	2.9E-07	1.2E-06	3.9E-07	2.0E-07	5.2E-06	
Dieldrin	2.0E-05	5.6E-06	9.3E-07	1.2E-05	3.6E-05	2.6E-06	7.7E-05	
N-nitrosodiphenylamine	1.2E-07	NC	1.2E-08	2.3E-07	3.3E-10	1.7E-10	3.6E-07	
Trichloroethene	4.0E-06	2.6E-06	1.8E-07	1.6E-05	5.5E-09	2.8E-09	2.3E-05	
^{99}Tc	1.8E-06	NC	NC	3.5E-07	8.3E-07	2.1E-07	3.2E-06	
^{238}U	6.5E-07	NC	NC	1.2E-07	8.2E-10	6.8E-11	7.7E-07	
Pathway risk	3.0E-05	8.2E-06	1.4E-06	3.0E-05	3.7E-05	3.0E-06		
Total								1E-4
Outside of Plume—DOE 1993b								
Bis(2-ethylhexyl)phthalate	1.5E-06	NC	1.4E-07	6.0E-07	1.9E-07	9.5E-08	2.5E-06	
N-nitrosodiphenylamine	1.2E-07	NC	1.2E-08	2.3E-07	3.3E-10	1.7E-10	3.6E-07	
^{234}U	2.2E-06	NC	NC	4.1E-07	4.8E-09	4.0E-10	2.6E-06	
^{235}U	1.1E-07	NC	NC	2.2E-08	2.5E-10	2.1E-11	1.3E-07	
^{238}U	5.6E-06	NC	NC	9.7E-07	6.4E-09	5.3E-10	6.6E-06	
Pathway risk	9.5E-06		1.5E-07	2.2E-06	2.0E-07	9.5E-08		
Total								1E-5
Reference—DOE 1993b								
Bis(2-ethylhexyl)phthalate	2.9E-05	NC	2.8E-06	1.2E-05	3.7E-06	1.9E-06	4.9E-05	
N-nitrosodiphenylamine	1.2E-07	NC	1.2E-08	2.3E-07	3.3E-10	1.7E-10	3.6E-07	
^{99}Tc	1.4E-07	NC	NC	2.7E-08	6.5E-08	1.6E-08	2.5E-07	
^{234}U	1.2E-07	NC	NC	2.2E-08	1.5E-10	1.2E-11	1.4E-07	
Pathway total	2.9E-05		2.8E-06	1.2E-05	3.7E-06	1.9E-06		
Total								5E-5

NC = not considered a carcinogen for this pathway.
NDA = Pertinent data not available to calculate risk.

Table 3.95. Excess lifetime cancer risk from chemicals in groundwater–rural residential use

Well Category[a]	Excess Lifetime Cancer Risk					
	Ingestion	Inhalation	Dermal[b]	Vegetables	Biota[c]	Total[d]
Plume Centroid	1×10^{-3}	8×10^{-5}	1×10^{-6}	3×10^{-3}	4×10^{-4}	5×10^{-3}
Dissolved Plume	2×10^{-4}	2×10^{-4}	6×10^{-6}	2×10^{-4}	2×10^{-3}	3×10^{-3}
Outside and West of Plume	9×10^{-6}	NV[e]	1×10^{-6}	2×10^{-5}	7×10^{-6}	4×10^{-5}
Near Shawnee Steam Plant	6×10^{-4}	1×10^{-5}	2×10^{-6}	5×10^{-4}	2×10^{-4}	1×10^{-3}
Near Ohio River	5×10^{-6}	1×10^{-7}	3×10^{-7}	2×10^{-6}	5×10^{-6}	1×10^{-5}

[a] Wells were grouped according to the concentration of trichloroethene found in groundwater samples and according to prominent off-site features. See Table 5.11 in DOE 1994b for a list of wells by group.
[b] Risks presented are the sum of risks from dermal contact while bathing and dermal contact while swimming.
[c] Risks presented are the sum of risks from consumption of milk and meat from cows drinking contaminated groundwater and eating pasture irrigated contaminated groundwater, ingestion of venison from deer drinking contaminated groundwater and eating pasture irrigated with contaminated groundwater, and consumption of fish raised in ponds filled with contaminated groundwater.
[d] Total risks also include risks from ingestion of soil contaminated through irrigation with contaminated groundwater. The soil ingestion risks are not presented separately.
[e] NV indicates no value was reported for the exposure route in the assessment.

Table 3.96. Hazard indices from chemicals in groundwater–rural residential use (child)

Well Category[a]	Hazard Index					
	Ingestion	Inhalation	Dermal[b]	Vegetables	Biota[c]	Total[d]
Plume Centroid	3.0	NV[e]	0.2	0.8	2.0	6.0
Dissolved Plume	6.0	<0.1	0.7	0.4	9.0	20.0
Outside and West of Plume	0.2	NV	<0.1	<0.1	<0.1	0.3
Near Shawnee Steam Plant	20.0	<0.1	2.0	0.7	8.0	30.0
Near Ohio River	<0.1	<0.1	<0.1	<0.1	<0.1	0.1

[a] Wells were grouped according to the concentration of trichloroethene found in groundwater samples and according to prominent off-site features. See Table 5.11 *in* DOE 1994b for a list of wells by group.
[b] Hazard indices presented are the sum of risks from dermal contact while bathing and dermal contact while swimming.
[c] Hazard indices presented are the sum of risks from consumption of milk and meat from cows drinking contaminated groundwater and eating pasture irrigated contaminated groundwater, ingestion of venison from deer drinking contaminated groundwater and eating pasture irrigated with contaminated groundwater, and consumption of fish raised in ponds filled with contaminated groundwater.
[d] Total hazard indices are rounded to one significant digit. This value also includes risks from ingestion of soil contaminated through irrigation with contaminated groundwater. The soil ingestion risks are not presented separately.
[e] NV indicates no value was reported for the exposure route in the assessment.

Table 3.97. Contaminants[a] contributing to excess lifetime cancer risk by well category

Well Category[b]	Excess Lifetime Cancer Risk	
	Contaminants	Total Risk
Plume Centroid	vinyl chloride (81%); bis(2-chloroethyl)ether (9%); trichloroethene (5%); technetium-99 (2%)	5×10^{-3}
Dissolved Phase	dieldrin (72%); trichloroethene (17%); vinyl chloride (5%); 1,1,2-trichloroethane (1%); 1,2-dichloroethane (1%); carbon tetrachloride (1%)	3×10^{-3}
Outside and West of Plume	uranium-238 (66%); bis(2-ethylhexyl)phthalate (24%); uranium-234 (3%)	4×10^{-5}
Near Shawnee Steam Plant	arsenic (50%); vinyl chloride (48%); technetium-99 (2%)	1×10^{-3}
Near Ohio River	1,1,2-trichloroethane (100%)	1×10^{-5}

[a] Contaminants contributing more than 1% of total risk are shown.
[b] Wells were grouped according to the concentration of trichloroethene found in groundwater samples and according to prominent off-site features. See Table 5.11 in DOE 1994b for a list of wells by group.

Table 3.98. Contaminants[a] contributing to hazard index (child) by well category

Well Category[b]	Hazard Index	
	Contaminants	Total Risk[c]
Plume Centroid	carbon tetrachloride (61%); manganese (31%); copper (6%)	6.0
Dissolved Phase	manganese (47%); dieldrin (42%); carbon tetrachloride (6%); 1,1,2-trichloroethane (2%)	20.0
Outside and West of Plume	nitrate as nitrogen (71%); bis(2-ethylhexyl)phthalate (29%)	0.3
Near Shawnee Steam Plant	manganese (82%); arsenic (14%); nickel (2%); barium (1%)	30.0
Near Ohio River	1,1,2-trichloroethane (100%)	0.1

[a] Contaminants contributing more than 1% of total risk are shown.
[b] Wells were grouped according to the concentration of trichloroethene found in groundwater samples and according to prominent off-site features. See Table 5.11 in DOE 1994b for a list of wells by group.
[c] Values are rounded to one significant digit.

natural attenuation mechanisms operating at the site and the rate at which they are operating. The sampling locations include five wells in the Northeast Plume (MWs 100, 108, 124, 193, and 255), six wells in the Northwest Plume (MWs 66, 146, 187, 262, 233, and 248), two wells that are near source areas for both plumes (UCRS MW157 and RGA MW155), and two RGA background wells (MWs 103 and 194). The locations of the sample collection points for the Natural Attenuation Evaluation are shown on Fig. 3.91.

The types of chemical and geochemical data collected included:

- Stable isotope ratios (of carbon and chlorine isotopes of TCE, of dissolved inorganic carbon, of inorganic chlorine, and of oxygen in water);
- Various physical and geochemical parameters (as listed in Table 3.99); and

Chemical data primarily focused on defining the levels of TCE and TCE daughter products (*cis*-1,2-DCE, vinyl chloride, ethylene, ethane, and chloroethene) and ^{99}Tc present in the two plumes.

The purpose of the sampling was to assess if natural attenuation processes are leading to decreasing parent compound concentrations, increasing daughter compound concentrations, decreasing electron acceptors, and/or increasing metabolic byproduct concentrations. Sampling locations and methods were selected following guidance originally developed by the Air Force and also included in EPA Region IV's Technical Guidance Document (AFCEE 1996; EPA 1997). The data were screened following the ranking system presented in EPA Region IV's guidance to assess the potential for biodegradation of TCE at the site (EPA 1997).

Conclusions

The results of this study are detailed in the *Evaluation of Natural Attenuation Processes for Trichloroethylene and Technetium-99 in the Northeast and Northwest Plumes at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (Clausen 1997). As noted in that report, the investigation indicated that several natural attenuation processes are acting on the plumes, although at low rates. There was no clear evidence that biodegradation processes are occurring to any appreciable degree within the study areas.

The study indicated that the RGA is characterized by very low concentrations of native and/or anthropogenic carbon and so likely does not have a sufficient electron donor supply to drive biodegradation. The stable isotopic data are consistent with the conclusion that only minor and slow biodegradation of TCE is occurring. The dissolved oxygen concentrations in the RGA typically were greater than 1.0 mg/L; under these aerobic conditions reductive dechlorination would not occur. The study concluded that anaerobic biodegradation is not occurring in the RGA within the study areas, but that there are some

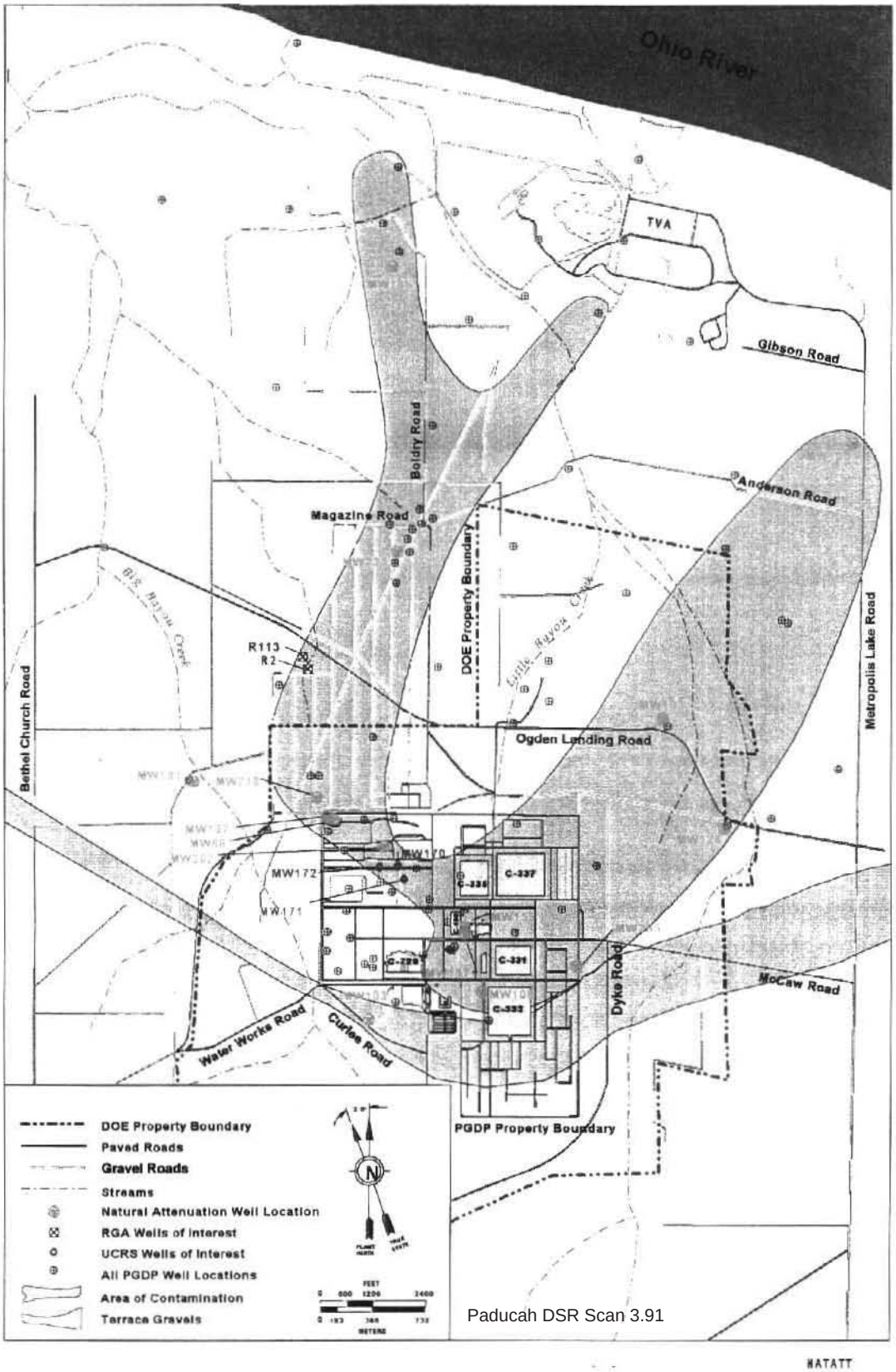

Fig. 3.91. Natural attenuation evaluation of sample collection points.

Table 3.99. Physical and geochemical data collected during the natural attenuation investigation

Parameter	Media	Reporting Limits
Hydrogen	Gas	0.22 ppm
Methane	Gas	0.1 ppm
Argon	Gas	0.018
Dissolved Oxygen	Gas	0.1 ppm
Methane	Gas	0.001 ppm
Nitrogen	Gas	0.013 ppm
Nitrate Nitrogen	Water	1 mg/L
Ammonia	Water	0.10 mg/L
Sulfate	Water	10 mg/L
Hydrogen Sulfate	Water	0.01 mg/L
Total Iron	Water	0.1 mg/L
Ferrous Iron	Water	0.1 mg/L
DOC	Water	1 mg/L
Alkalinity	Water	1.0 mg/L
Chloride	Water	0.1 mg/L
Sulfate	Water	0.1 mg/L
TCE*	Water	0.001 mg/L
cis,1-2-DCE*	Water	0.001 mg/L
1,1-DCE*	Water	0.005 mg/L
Vinyl Chloride*	Water	0.003 mg/L
Chloroethene*	Water	0.005 mg/L
Ethene	Water	0.03 mg/L
Ethane	Water	0.03 mg/L
BTEX*	Water	0.005 mg/L
^{99}Tc	Water	25 pCi/L
PH	Water	NA
Temperature	Water	1°F
D.O.	Water	0.1 mg/L
Eh	Water	NA

*The reporting limit for these compounds varies depending upon the concentration of TCE and the laboratory doing the analysis. The *cis*-1,2-DCE and vinyl chloride were analyzed by two methods to obtain a low quantification limit.

indications (such as increasing chloride concentrations with declining TCE levels) that aerobic degradation of TCE may be occurring, although at a slow rate. Based on the report's calculated biodegradation rate of TCE in the Northwest Plume (between 2.6×10^{-2} to 7.4×10^{-2}/year) TCE concentrations in the RGA downgradient of the extraction system will remain above the MCL for at least 100 years (Clausen 1997). The report concluded that the biodegradation rate is insufficient to support natural attenuation as a remedial option for the Northwest and Northeast Plumes.

The TCE-breakdown products vinyl chloride, ethylene, ethane, and chloroethene were not detected in the samples collected for this study. However, because significant concentrations of some TCE-degradation products (vinyl chloride and DCE) have been found during previous investigations in some limited areas at the PGDP, the study recognized that anaerobic conditions could exist in some "micro-environments" (Clausen 1997). Locally reducing conditions coupled with local carbon sources could have led to the anaerobic degradation of TCE in these micro-environments.

The predominant natural attenuation processes for radionuclides are dilution, sorption reactions (such as precipitation, adsorption on mineral surfaces, or partitioning into organic matter), and radionuclide decay. The slightly to moderately oxidizing conditions in the RGA and the Eh/pH conditions indicate that the likely form of ^{99}Tc is the pertechnetate anion (TcO_4^-), which is not immobilized by sorption to any significant degree. It was concluded that, although sorption of ^{99}Tc was not occurring at the PGDP, advection, dispersion, and dilution are reducing ^{99}Tc levels with increasing distance from the source (Clausen 1997).

3.3.7 Data Gaps

3.3.7.1 Scope

The *Data Report for the Sitewide Remedial Evaluation for Source Areas Contributing to Off-Site Groundwater Contamination at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2000) documents the field investigation informally known as the Data Gaps Project. Conducted from April to October 1999, the purpose of the project was to collect additional data along the plant secured perimeter to identify the width of the current groundwater plumes, identify any new plumes, and gather additional environmental and geotechnical data to support risk assessments and sitewide remedial evaluations. During the course of the investigation, the scope was expanded to address questions resulting from other remedial investigations such as WAG 6 and WAG 27.

A total of 33 temporary borings were drilled and sampled during the project. Six monitoring wells, three RGA wells (MWs 352, 353, 354) and three deep Rubble Zone wells (MWs 345, 346, 347), were also installed as part of the Data Gaps project. Well depths ranged from 21 to 103 m (70 to 338 ft). Four temporary piezometers were installed as two clusters with each cluster consisting of one deep (17 m, 55 ft) piezometer and one shallow (11 m, 35 ft) piezometer.

3.3.7.2 Areas of Investigation

Initially the investigation consisted of thirteen borings and four piezometers to be installed immediately outside the west security fence of the plant secured area and along the north security fence between the Northwest and Northeast Plumes. By the end of the project the 43 borings and wells fell into three major and three minor study areas. The major study areas were as follows:

- the Southwest Plume area (fourteen borings and one monitoring well),
- the C-616 Lagoon area (six borings and four piezometers) and,
- the North-South Diversion Ditch (seven borings and one monitoring well).

The three minor study areas include the following:

- the southeast corner of the C-720 building (three borings),
- the Northeast Plume (two borings and one monitoring well), and
- the deep Rubble Zone (three monitoring wells).

Figure 3.92 shows the sampling locations for the Data Gaps Investigation.

3.3.7.3 Investigation Methods

Direct push technology, hollow stem auger, dual-wall reverse circulation, and Barber rig drilling methods were used for this investigation. Multiple drilling methods were employed at several sampling locations where both soil and groundwater samples were collected.

Since the primary focus of the investigation was the collection of groundwater samples from the RGA and upper McNairy Formation, dual-wall reverse circulation drilling was the primary drilling method. Groundwater sampling using bladder pumps was attempted in the UCRS, at 1.5-m (five-foot) intervals through the RGA, and in the upper McNairy sands. The 21 borings drilled using this method were generally drilled to depths between 43 and 49 m (140 and 160 ft). A total of 203 groundwater samples were collected from these borings. Sampling activities also included collecting drill cuttings for lithologic logs and running borehole geophysical logs.

Hollow stem augers were the drilling method of choice for the collection of geotechnical soil samples and the installation of piezometers and RGA groundwater monitoring wells. The twelve hollow stem auger borings resulted in 30 soil samples, four piezometers and three RGA wells.

Direct-push methods were used to collect shallow soil and groundwater samples from depths above 18m (60 ft) where use of a larger rig was not warranted, primarily along the North-South Diversion Ditch. The seven DPT borings yielded 44 soil samples and four groundwater samples.

Finally, three deep Rubble Zone monitoring wells were installed using a Barber rig. The monitoring wells were drilled to depths ranging from 94 to 103 m (310 to 338 ft).

3.3.7.4 Conclusions

The Data Gaps investigation provided key data regarding the geologic framework of the PGDP area, details on the nature and extent of the Southwest Plume, and identified additional potential source areas of groundwater contamination. The report for this investigation, however, does not present any interpretation of the results.

3.3.7.5 Geology/Hydrogeology

The lithologic and geophysical logs of the Data Gaps investigation provided additional evidence that the contact between the lower continental deposits and the upper McNairy Formation is an irregular surface. The logs indicate possible channels separated by ridges that may help define the shapes of the groundwater plumes. One such channel and ridge sequence appears to help define the Southwest Plume as a distinct plume from the Northwest Plume. Another ridge, resulting in a thinning of the RGA, appears to exist to the north between the plant secured area and the plant's sanitary landfills. This ridge may contribute to the separation between the Northwest and Northeast Plumes.

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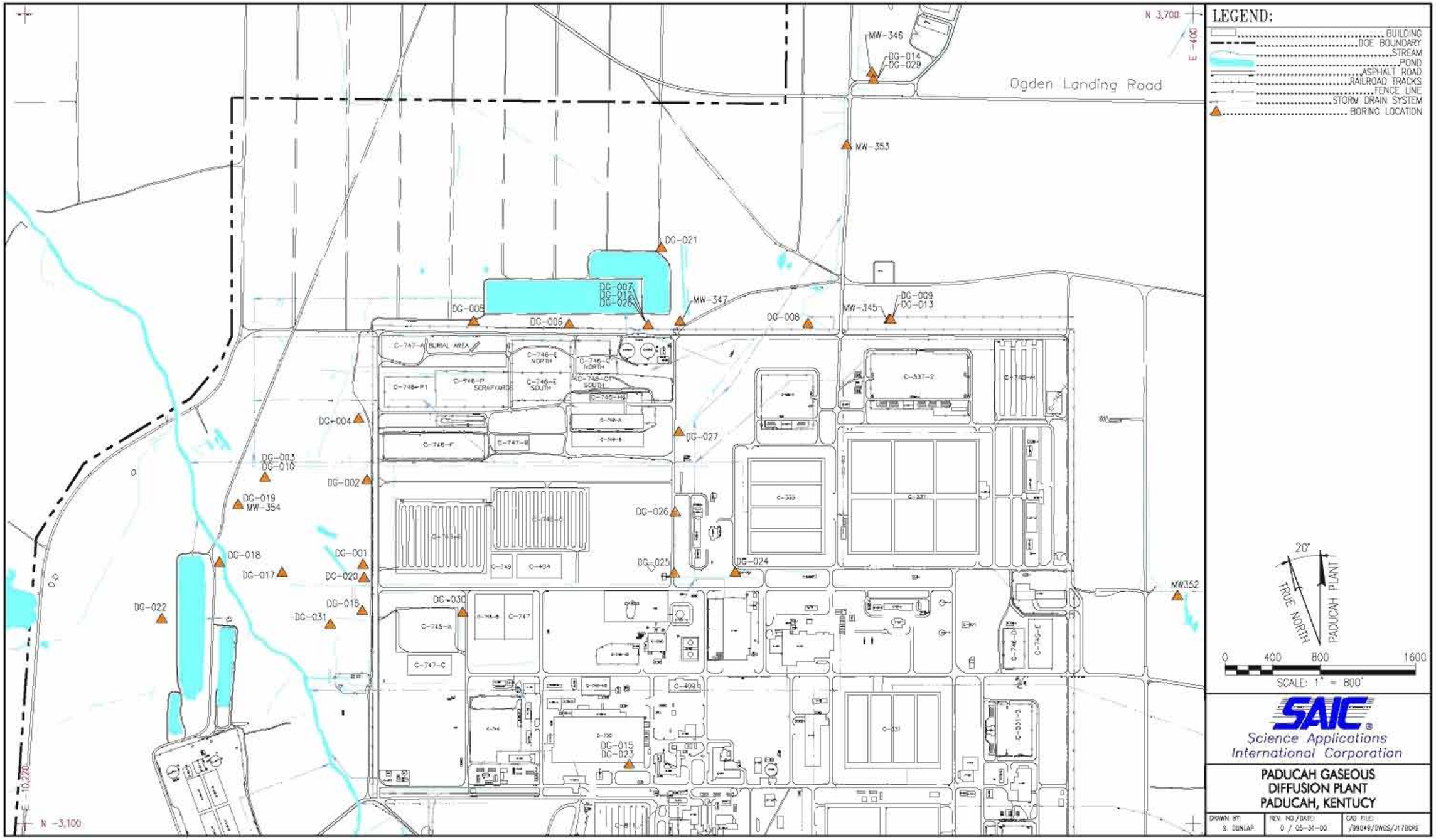

Fig. 3.92. Boring Locations for Data Gaps Investigation

The Data Gaps investigation provided some detail on the structure of the Southwest Plume. The most important impact is a change in the orientation of the core of the plume. After the WAG 27 investigation, the general trend of the plume and groundwater flow direction was interpreted to be northwest. With the additional information from the Data Gaps investigation, the primary core of the Southwest plume appears to be oriented almost due west in the vicinity of the plant secured area.

3.3.7.6 Nature and Extent of Contamination

As mentioned earlier, the report on the Data Gaps investigation does not provide an interpretation of the data collected. However, a brief review of the data provides some new insights to the nature and extent of contamination.

The nature of the Southwest Plume is better defined. The main core of the plume appears to derive from a source north and east of the sources proposed as a result of the WAG 27 investigation. After the WAG 27 investigation, the SWMU 1 area and the C-720 building appeared to be the primary sources for the plume. With the additional information from this investigation, the primary source of both TCE and ^{99}Tc now appears to be in the vicinity of SWMU 4, one of the burial grounds, with the SWMU 1 area and the C-720 building becoming minor sources. The Southwest Plume is clearly separate from the Northwest Plume. It does not appear, however, that the Southwest Plume has migrated beyond the on-site unsecured area.

Near the southeast corner of the C-616 lagoons, a previously unknown area of increased TCE and ^{99}Tc contamination exists between the Northwest and Northeast Plumes. TCE concentrations of 1600 µg/L and ^{99}Tc activities of 1550 pCi/L were detected in the upper RGA, suggesting a nearby source area, perhaps to the south. Additional sampling in the area suggests the direction of migration is possibly northeast as a result of recharge from the lagoons and the thinning of the RGA to the north as noted earlier.

Shallow groundwater data from the DPT borings along the North-South Diversion Ditch suggest that the ditch is acting as a low-level line source of ^{99}Tc. Activities detected along the ditch ranged from 1870 pCi/L at the south end near the C-400 building to 710 pCi/L near the north security fence.

No data from the three Rubble Zone wells are presented in the report, but subsequent sampling results show no contamination in these deep wells.

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4. NATURE AND EXTENT OF CONTAMINATION

4.1 INTRODUCTION

Chapter 3 summarizes the previous groundwater-related investigations of the PGDP. These investigations have both local and regional perspective; thus, the scope and resolution of the investigations vary considerably.

A primary task of the GWOU FS is to aggregate all of the available data from previous investigations and the ongoing environmental surveillance program into a central database. This database then forms the foundation for the next task, a renewed definition of nature and extent of contamination related to the PGDP, on the scale of the area groundwater basins.

Section 4.2 is the documentation of the development of the GWOU database and the inherent limitations of the database. The interpretation of the data, with regards to sources of contamination and nature and extent of contamination, are presented in Sect. 4.3.

4.2 GROUNDWATER OPERABLE UNIT DATABASE

The GWOU database is a filtered residual of the DOE's electronic files for the PGDP known as Paducah's Oak Ridge Environmental Information System (OREIS). In total, the GWOU Database consists of 234,391 records, representing 683 wells, piezometers, and soil borings (428 of them sample the RGA). The data include analyses of groundwater samples spanning the time frame 1993 through September 2000.

The primary filters applied to the OREIS to derive the GWOU database were the adequacy of the sampling and analyses methods. For data to pass into the GWOU database, the related water sample must first have been collected from wells with known quality of construction or soil boreholes created with approved drilling methods and sampled and preserved in accordance with documented collection procedures. The second data filter addresses the analysis process. All samples represented in the GWOU database must be analyzed by approved methods within acceptable holding times.

4.2.1 Data Validation, Data Qualifiers, Data Assessment

Data validation is the process of evaluating and documenting laboratory adherence to analytical method requirements. As part of the analysis and data review processes, findings are qualified, as necessary, to reflect laboratory and data validation results. The GWOU database has been rigorously checked to identify and exclude data with inconsistent data qualifiers. Table 4.1 defines the common laboratory data qualifiers found in the GWOU database.

In addition to laboratory and validation qualifiers, personnel associated with the field investigation have further qualified some of the recent data included within the GWOU database. These data qualifiers are based predominately upon observations of the sample collection and preservation process.

4.2.2 Data Sets

Specific queries of the database are required to select only suitable data because some types of groundwater samples have limited uses. As an example, typical unfiltered grab samples of groundwater from soil borings are inappropriate to be used in an assessment of nature and extent of contamination by metals because entrained soil particles significantly bias the metals concentrations high.

Table 4.1. Common qualifiers used in the GWOU database

Code	Organic	Inorganic	Radionuclide	Dioxin/furan
A			Analyte not detected	
B	Found in blank associated with sample	Value < Required Detection Limit, Value ≥ Instrument Detection Limit		
C	Pesticide confirmed by GC/MS	Constituent in blank > Required Detection Limit		
D	Identified at secondary dilution	Identified at secondary dilution	Identified at secondary dilution	Identified at secondary dilution
E	Concentration > calibration range	Estimated, matrix interference		
H	Analysis performed outside of method or specified maximum holding time	Analysis performed outside of method or specified maximum holding time	Analysis performed outside of method or specified maximum holding time	Analysis performed outside of method or specified maximum holding time
J	Estimated value. (i.e. Tentatively Identified Compound or result < specified Project Quantitation Limit but > 0			
N	Tentatively Identified Compounds identified	Spike recovery not within control limits	poor spike recovery	
Q			No result available or not required because total analyses < Project Quantitation Limit	
R	Rejected by QC. Data not useable	Rejected by QC. Data not useable	Rejected by QC. Data not useable	Rejected by QC. Data not useable
U	Analyzed but not detected at the analyte quantitation limit	Analyzed but not detected at the analyte quantitation limit		
X	Flag defined in comments	Flag defined in comments	Flag defined in comments	Flag defined in comments
!	Database Notation: Result Qualifier contains “<” or “>”	Database Notation: Result Qualifier contains “<” or “>”	Database Notation: Result Qualifier contains “<” or “>”	
<	Analyzed but not detected at the analyte quantitation limit	Analyzed but not detected at the analyte quantitation limit	Analyzed but not detected at the analyte quantitation limit	
>	Beyond instrument scale	Beyond instrument scale	Beyond instrument scale	

The GWOU database consists of distinct data sets for filtered and unfiltered well samples and unfiltered borehole samples. Monitoring wells of both the PGDP and the TVA’s Shawnee Steam Plant as well as residential wells that are sampled by the PGDP as part of its environmental monitoring program are represented in the wells data set. This data set also includes single samples collected from PGDP piezometers of monitoring well construction quality, when available. The boreholes data set presents analyses of groundwater samples collected from soil borings constructed by drilling and direct push methods as well as from direct-push probes, such as those inserted by cone penetrometers.

4.3 DATA INTERPRETATION

The two groundwater contaminants previously known to be associated with the PGDP are TCE and ^{99}Tc. Either separately or collectively, these contaminants are responsible for three large plumes that extend off-site to the north of the plant and a fourth plume contained within the unsecured on-site area. Consequently, these two contaminants have been the primary focus of earlier large-scale groundwater investigations at the PGDP.

Site-specific investigations have frequently identified isolated occurrences of groundwater contaminants other than TCE and ^{99}Tc. From the perspective of the site-specific investigation, it has been difficult to assess whether the incident of an elevated metal or radionuclide level represents a random outlier from its natural distribution or the occurrence is part of a pattern of contamination that defines a groundwater plume.

As a preliminary means of identifying all significant groundwater contaminants associated with the PGDP, the GWOU FS team compiled a list of all priority contaminants defined by risk assessments (specifically for the off-site rural resident) of previous PGDP investigations. Both groundwater analyses and fate and transport models of dissolved contaminant levels derived from soil contamination define the groundwater contaminant levels used in these risk assessments.

In addition, the GWOU FS team performed a well-by-well risk assessment of groundwater for the DOE reservation and adjacent tracts, as well as downgradient areas. Where the groundwater from a well posed a potential excessive risk for a rural resident scenario [i.e., greater than 1×10^{-6} elevated lifetime cancer risk (ELCR) or hazard index (HI) > 1], the GWOU FS team cataloged the primary constituents responsible for the excess risk to be added to the list of priority contaminants. For wells identified by a HI > 1, the primary contaminants were those contributing > 0.1 HI. Table 4.2 presents the list of priority contaminants from previous PGDP investigations and the PGDP-related contaminants identified by the well-by-well risk assessment. This list was developed to assist engineers with their evaluation of potential remedial technologies for groundwater at the PGDP and should not be considered COPCs or COCs. A list of COCs is identified in the BRA for the GWOU FS.

For the purposes of the discussion of nature and extent of PGDP contaminants, the list of contaminants in Table 4.2 was pared down based on professional judgment (reference the footnotes to Table 4.2). The following list defines the contaminants to be assessed for nature and extent:

VOCs

- carbon tetrachloride
- chloroform
- 1,1-DCE
- 1,2-DCE
- *cis*-1,2-DCE
- *trans*-1,2-DCE
- TCE
- vinyl chloride

Other Organic Compounds

- acrylonitrile
- Aroclor-1254
- benzene
- bromodichloromethane
- naphthalene

Table 4.2. Summary of preliminary selection of PGDP-related contaminants

SWMUs/Sources	Contaminants	Risk	Contaminants	Hazard
	Northwest Plume			
Plume Centroid	bis(2-chloroethyl)ether		carbon tetrachloride	
	trichloroethene	5×10^{-3}	copper	6
	vinyl chloride		manganese	
	^{99}Tc			
Dissolved Phase	1,1,2-trichloroethane			
	1,2-dichloroethane		1,1,2-trichloroethane[a]	
	carbon tetrachloride	3×10^{-3}	carbon tetrachloride	20
	dieldrin		dieldrin[b]	
	trichloroethene		manganese	
	vinyl chloride			
Outside and West of Plume	bis(2-ethylhexyl)phthalate		bis(2-ethylhexyl)phthalate[c]	
	^{234}U	4×10^{-5}	nitrate as nitrogen[c]	0.3
	^{238}U			
Near Shawnee Steam Plant	vinyl chloride		arsenic[d]	
	arsenic	1×10^{-3}	barium[d]	30
	^{99}Tc		manganese	
			nickel[d]	
Near Ohio River	1,1,2-trichloroethane	1×10^{-5}	none	NA
	WAG 3[e]			
SWMU 4	arsenic	5×10^{-3}	arsenic	41
	1,1-dichloroethene	3×10^{-2}	cobalt	3
	carbon tetrachloride	4×10^{-6}	copper	12
	trichloroethene	2×10^{-2}	iron	258
	vinyl chloride	2×10^{-2}	manganese	77
	^{237}Np	4×10^{-4}	nickel	0.5
	^{239}Pu	9×10^{-5}	vanadium	0.6
	^{99}Tc	2×10^{-4}	1,1-dichloroethene	14
	total uranium[f]	1×10^{-3}	1,2-dichloroethene	0.1
	uranium-234	5×10^{-4}	carbon tetrachloride	0.5
	uranium-235	6×10^{-6}	trichloroethene	1883
	uranium-238	1×10^{-4}		
SWMU 5			iron	103
			manganese	23
SWMU 6			iron	13
			manganese	0.6
	WAG 6[e]			
Far North Sector	2,4-dinitrotoluene[g]	1×10^{-3}	2,4-dinitrotoluene	4
			copper[c]	0.3
Northeast Sector	n-nitroso-di-n-propylamine[h]	3×10^{-3}	none	NA
Northwest Sector	trichloroethene	2×10^{-6}	antimony	1
RGA	none	NA	iron[j]	18
			manganese[c]	0.8
Southeast Sector	1,1-dichloroethene	3×10^{-4}		
	carbon tetrachloride	2×10^{-6}	carbon tetrachloride[c]	0.2
	trichloroethene	2×10^{-3}	trichloroethene	64
	vinyl chloride	6×10^{-6}		
Southwest Sector	trichloroethene	1×10^{-4}	trichloroethene	3
	vinyl chloride	4×10^{-5}		
West Sector	trichloroethene	5×10^{-6}	1,2-dichloroethene[c]	0.6
			trans-1,2-dichloroethene[c]	0.3
	WAG 27[e]			
SWMU 1 UCRS	trichloroethene	5×10^{-4}	trichloroethene	60
	vinyl chloride	5×10^{-3}	antimony	12
			manganese[c]	0.3

Table 4.2. Summary of preliminary selection of PGDP-related contaminants (continued)

SWMUs/Sources	Contaminants	Risk	Contaminants	Hazard
SWMU 1 RGA	none	NA	antimony	3
SWMU 91 UCRS	trichloroethene[i]	1×10^{-5}	antimony	8
C-720	trichloroethene	9×10^{-4}	*trans*-1,2-dichloroethene	181
Subsurface Soil	vinyl chloride	2×10^{-4}	trichloroethene	106
			antimony	46
			silver[c]	0.8
			vanadium[c]	0.3
C-720 RGA	trichloroethene	5×10^{-4}	trichloroethene	64
		WAG 28[e]		
SWMU 99a			lithium	156
			strontium	0.4
SWMU 193a			chromium	90
SWMU 193c			lithium	127
			manganese	8
			strontium	0.8
SWMU 194			chromium	1720
			lithium	223
			strontium	1
AOC 204	trichloroethene	1×10^{-2}	trichloroethene	1190
		Well-by-Well Analysis[k]		
			1,1-dichloroethane	0.3
	1,1-dichloroethene	4×10^{-2}	1,1-dichloroethene	20
			1,2-dichloroethene	18
			4-methyl-2-pentanone	0.3
	acrylonitrile	3×10^{-4}	acrylonitrile	8
	Aroclor-1254	1×10^{-5}	Aroclor-1254	5
	benzene	7×10^{-6}	benzene	0.6
	bis(2-ethylhexyl)phthalate	2×10^{-6}		
			bromomethane	0.3
	bromodichloromethane	1×10^{-5}	bromodichloromethane	0.2
	carbon tetrachloride	4×10^{-6}	carbon tetrachloride	0.5
	chloroform	1×10^{-5}	chloroform	1
	chloromethane	1×10^{-5}		
			cis-1,2-dichloroethene	108
	dibromochloromethane	3×10^{-6}		
	methylene chloride	3×10^{-6}	methylene chloride	0.2
			naphthalene	35
	tetrachloroethene	4×10^{-6}		
			trans-1,2-dichloroethene	30
	trichloroethene	2×10^{-2}	trichloroethene	25,500
			aluminum	3
			antimony	42
	arsenic	1×10^{-3}	arsenic	19
			barium	0.6
	beryllium	3×10^{-3}	beryllium	1
			boron	0.6
			cadmium	6
			cobalt	0.5
			chromium	286
			fluoride	10
			iron	85
			manganese	34
			molybdenum	4
			nickel	3
			nitrate	1
			silver	2
			uranium	13
			vanadium	9
			zinc	0.2

Table 4.2. Summary of preliminary selection of PGDP-related contaminants (continued)

SWMUs/Sources	Contaminants	Risk	Contaminants	Hazard
	^{241}Am	7×10^{-6}		
	^{239}Pu	2×10^{-6}		
	^{226}Ra	1×10^{-5}		
	^{222}Rn	1×10^{-3}		
	^{99}Tc	9×10^{-5}		
	^{228}Th	5×10^{-6}		
	^{230}Th	2×10^{-6}		
	^{234}U	2×10^{-5}		
	^{235}U	2×10^{-6}		
	^{238}U	7×10^{-5}		

[a] Only detected in 3 of 55 samples. Maximum concentration was 9 μg/L.
[b] Only detected in 2 of 14 samples. Detected in one well only and not associated with plant activities.
[c] Hazard index of less than 1.
[d] Only found in the wells near TVA.
[e] Modeled contaminants.
[f] Assessed as ^{238}U
[g] Large uncertainty associated with the source term. Not identified elsewhere.
[h] Awaiting further disposition from the baseline risk assessment. Not considered a likely PGDP contaminant.
[i] The trichloroethene contamination at SWMU 91 is currently being remediated under the LASAGNA project.
[j] Essential human nutrient found at elevated concentrations in the clayey soil beneath the PGDP.
[k] Maximum risk over all wells outside the PGDP security fence.

Metals

- aluminum
- antimony
- arsenic
- barium
- beryllium
- boron
- cadmium
- chromium
- copper
- fluoride
- iron
- manganese
- nickel
- silver
- uranium
- vanadium

Radionuclides

- ^{241}Am
- ^{237}Np
- ^{222}Rn
- ^{99}Tc
- ^{228}Th
- ^{234}U
- ^{238}U

4.3.1 Main Groundwater Contaminant Plumes

Groundwater contamination is known to extend outside the PGDP security fence within four main plumes: the Northeast Plume, the Technetium-99 Plume, the Northwest Plume, and the Southwest Plume. The main contaminants previously known to be associated with each plume are as follows:

Plume	Principal contaminants
Northeast Plume (Inside security fence)	^{99}Tc and TCE
Northeast Plume (Outside security fence)	TCE
Technetium-99 Plume	^{99}Tc
Northwest Plume	^{99}Tc and TCE
Southwest Plume	^{99}Tc and TCE

Although ^{99}Tc is not listed as a primary contaminant of the off-site Northeast Plume, monitoring wells adjacent to the PGDP in the Northeast Plume have produced water with detectable levels of ^{99}Tc beginning in September 1998. These occurrences appear to be associated with a more recent ^{99}Tc release that is unrelated to the main source of the Northeast Plume.

4.3.1.1 Nature of the primary groundwater contaminants historically attributed to the PGDP

TCE was the primary organic solvent used in degreasing operations at the PGDP from the 1950s through the 1980s. The on-site use of TCE was discontinued in July 1993. Thus, industrial processes can be discounted as continuing sources of groundwater contamination. The remaining sources of TCE to groundwater are mostly secondary accumulations in the subsurface and leaking burial grounds.

TCE is a common DNAPL associated with industrial settings. At the PGDP, the TCE has penetrated into the fine-grained matrix of the unconsolidated sediments that comprise the UCRS. In some places, the dynamics of the TCE spills were sufficient to promote TCE DNAPL migration into the underlying sands and gravels of the RGA. The extreme permeability contrast of the RGA with the fine sand and silt units of the underlying McNairy Formation has been sufficient to retard further downward migration of the DNAPL.

Secondary sources of TCE can be found as residual ganglia and pools in both the UCRS and RGA. Because of the low solubility of TCE and much lower drinking water standard, these secondary sources of TCE pose a continuing threat to off-site groundwater users for centuries if left untreated. Attachment 4 presents a calculation of TCE DNAPL volumes for the PGDP source areas.

Technetium-99 is a fission product impurity of reprocessed uranium derived from spent reactor fuel. The enrichment of recycled uranium at the PGDP occurred during three periods: 1952–1964, 1969–1974, and 1976–1977. Virtually all of the recycled uranium came from plutonium production reactors at Hanford and Savannah River.

Technetium-99 will occur in its most oxidized state, the pertechnate anion (TcO_4) in aerobic settings such as the UCRS and RGA flow systems at the PGDP. The pertechnate anion is highly soluble and has a low affinity to sorb or complex with the unconsolidated sediments that comprise the UCRS and RGA. As a dissolved contaminant, ^{99}Tc will move with the primary groundwater flow path through the RGA. The McNairy groundwater flow system tends to be a reducing environment. Under reducing conditions, ^{99}Tc can be converted to the Tc^{+4} cation that would tend to have low mobility in clay and silty clay soils (CH2M HILL 1989) such as those found in the upper and middle members of the McNairy Formation at the PGDP.

The widespread occurrence of ^{99}Tc at the PGDP facility is a largely a result of historical releases through the air and water pathways. Decontamination processes at the C-400 Cleaning Building continue to produce ^{99}Tc-contaminated water that is treated, as needed, prior to discharge to Bayou Creek through a permitted outfall. The primary source areas to groundwater contamination aare suspected to be sediments of the NSDD, various burial grounds, and undocumented spills of the former Technetium Storage Tank at C-400. Technetium-99 has a long half-life, estimated to be between 212,000 and 250,000 years. Thus, ^{99}Tc will be a persistent groundwater contaminant until the source zones are depleted or remedial actions are undertaken.

4.3.1.2 Extent of main plumes

The PGDP overlies a south embayment of the ancestral (Pleistocene) Tennessee River. A subcrop of the Porters Creek Clay forms the south wall of the buried river valley. The thick sand-and-gravel deposit of the ancestral Tennessee (which forms the main unit of the RGA) fills the ancestral Tennessee River Valley north from the PGDP to the present coarse of the Ohio River, which is the regional groundwater discharge area. Thus, the overall groundwater (and dissolved contaminant) flow direction is northeast towards the Ohio River. However, significant east–west heterogeneities in the sand-and-gravel deposit and leakage from plant water utilities combine to cause groundwater flow (and contaminant plume migration) to spread outward locally from the east and west sides of the PGDP. Thus, in the PGDP vicinity, the Northeast Plume tracks east of the plant and the Southwest Plume tracks west of the plant against the subcrop of the Porters Creek Clay.

Figures 4.1 and 4.2 are maps of the plumes, as they were understood in 1999, showing the maximum contaminant levels observed in the RGA. The contaminant detection limits, 25 pCi/L for ^{99}Tc and 5 μg/L for TCE, define the extent of the plumes. Groundwater contaminant levels vary considerably with depth inside the plumes. In general, the highest dissolved contaminant levels occur near the top of the RGA in the proximity of shallow source zones (i.e., in the UCRS). However, near source zones where contaminants have migrated as a separate phase liquid (e.g., DNAPL) to the base of the RGA, the resulting dissolved contaminant levels may be elevated across the depth of the aquifer. In either case, the core of the downgradient dissolved-phase plume tends to move to the middle or base of the RGA due to area recharge.

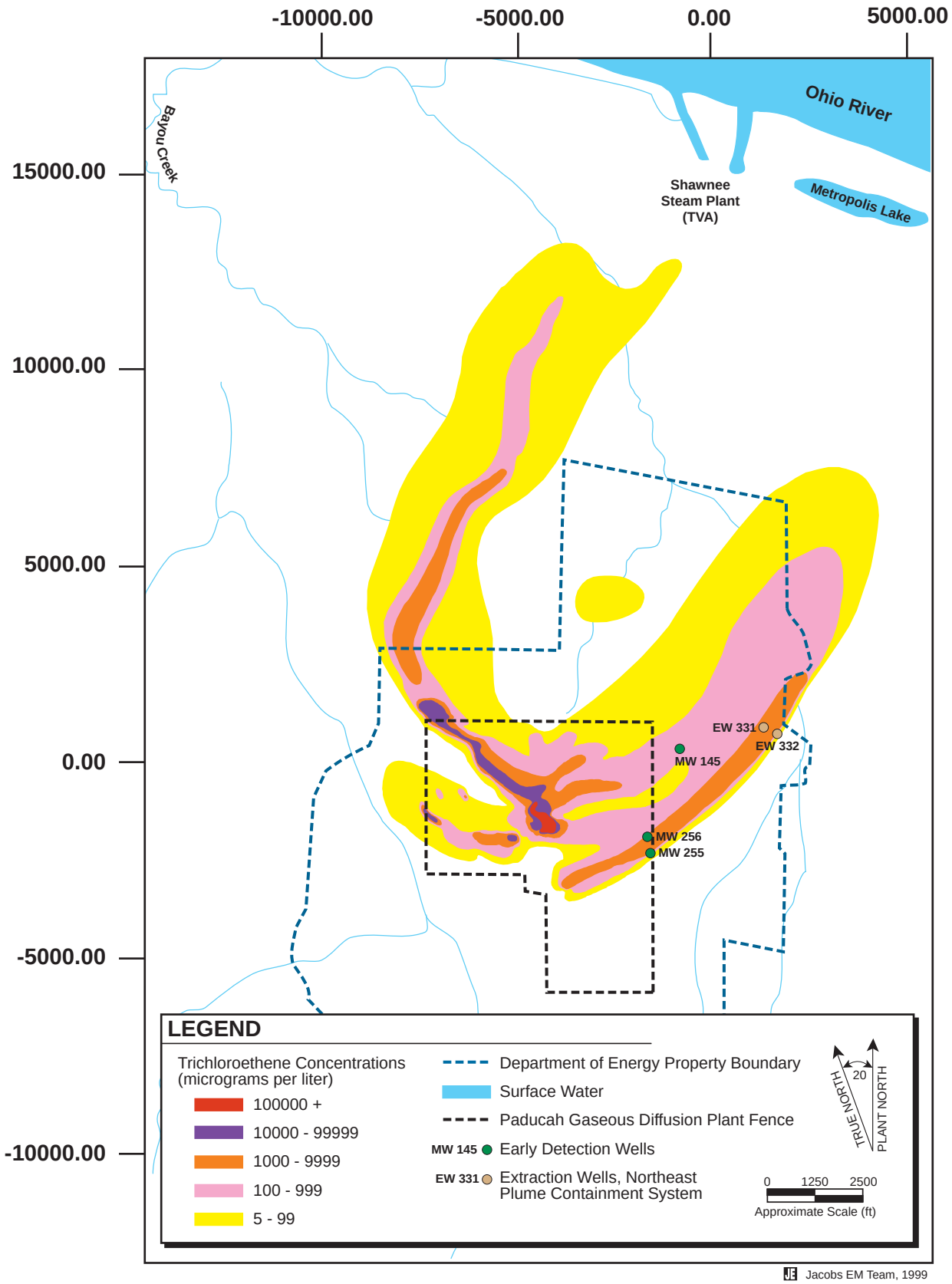

Fig. 4.1. Trichloroethene plumes of the PGDP.

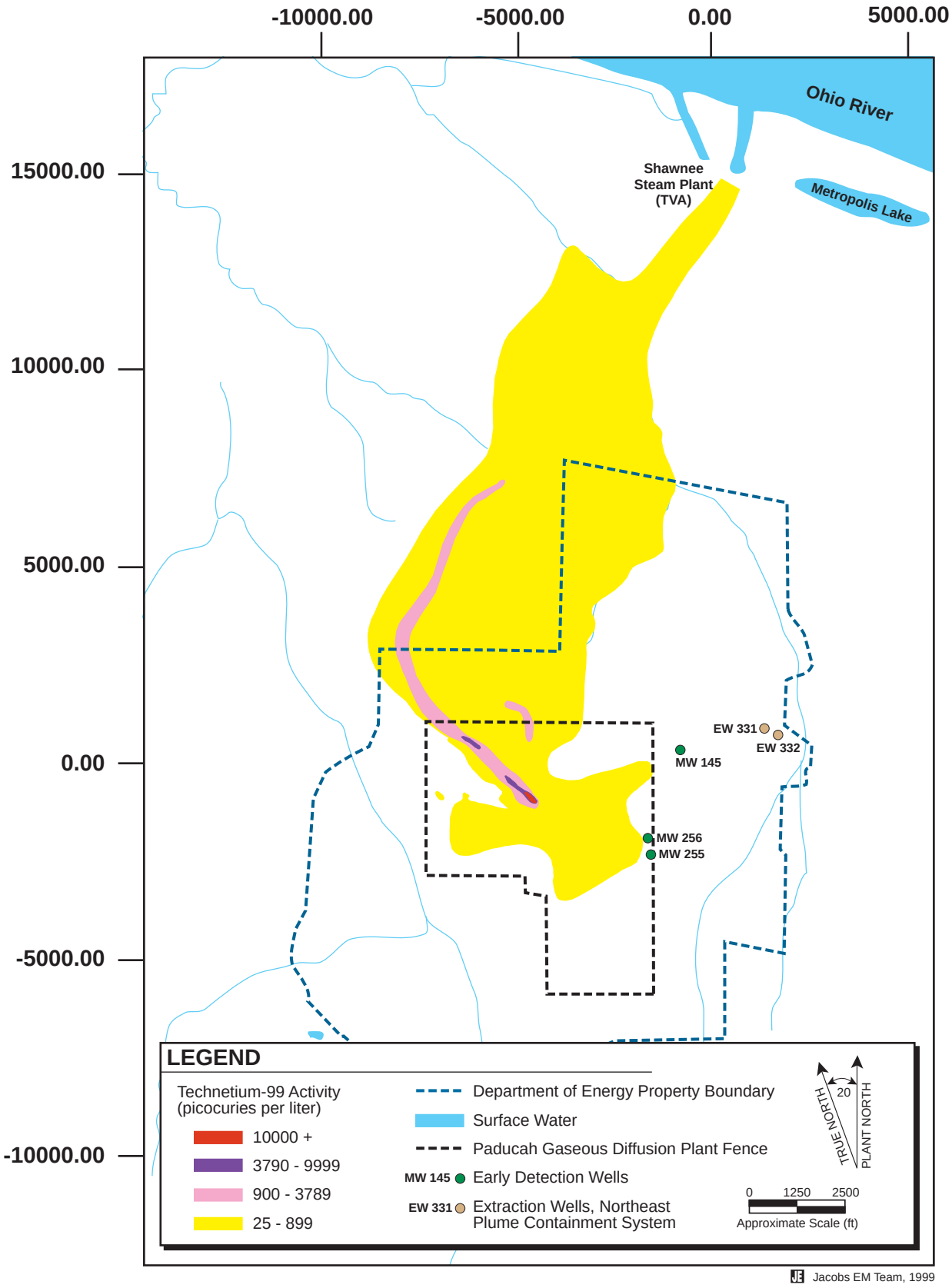

Fig. 4.2. Technetium-99 plumes of the PGDP.

The leading edge of the Northeast Plume has migrated 2,000 m (6,500 ft) north of the PGDP, beyond the DOE property boundary. There are no natural discharge features to intercept the Northeast Plume prior to the Ohio River or its floodplain. Thus, there exists potential for the Northeast Plume to stretch another 2,500 m (8,000 ft) north in the future, absent remedial measures or the plume's growth reaching a state of equilibrium.

The PGDP's Southwest Plume appears to have migrated off-site only recently. This plume's leading edge reaches approximately 750 m (2,500 ft) west of the PGDP and is completely contained within the DOE reservation boundary. Hydraulic potential of the RGA suggests that the plume will grow northward if left unchecked, either merging into the Northwest Plume or paralleling the Northwest Plume to the west.

Both the Northwest Plume and the Technetium-99 Plume extend off-site to near the Ohio River in the area of the TVA's Shawnee Steam Plant. Little Bayou Creek forms the northern limit of the Northwest Plume, where TCE levels in the creek water (up to 50 μg/L) indicate that the plume is discharging to the creek. TCE is largely undetected in monitoring wells to the north of Little Bayou Creek in the Shawnee Steam Plant area. The Technetium-99 Plume tracks to the east of the Northwest Plume and extends past Little Bayou Creek. Local monitoring well sample analyses suggest that ^{99}Tc levels of 200 to 300 pCi/L probably extend to an Ohio River canal at the Shawnee Steam Plant. This contamination would be captured and diluted to non-detectable levels by process water intake pumps of both the steam plant and the PGDP that are located in the canal.

4.3.1.3 Sources of the main plumes

The four main plumes mark preferred groundwater pathways in the RGA. These preferred pathways integrate groundwater flow from broad areas. Thus, on a site such as the PGDP with numerous contaminant source areas, it is expected to find multiple source zones that contribute to the main plumes. The following text summarizes the known and suspected contributing sources to each of the main plumes.

Northeast Plume

The 1999 investigation of source areas to the Northeast Plume (WAG 28 RI) was unable to define a discrete TCE DNAPL source zone for the main high-concentration core of the Northeast Plume. Previously, two of the most likely sources appeared to be associated with former facilities that existed during the construction of the PGDP.

Soil and water samples of the former millwright shop, located west of the C-333 Process Building, revealed only trace levels of TCE. Thus, the occurrence of TCE contamination in the RGA near the northeast corner of C-333 appears to be related to a relatively small DNAPL source zone located beneath the building.

Similarly, samples of soil and water from the former sites of the Kellogg Building (pipe fabrication shop) and its leach field determined that these locations were not current DNAPL source zones. However, monitoring well data confirm the presence of the main high-concentration core of the Northeast Plume immediately east of these facilities. Beginning in 1997, TCE levels in the core of the plume have steadily declined. Thus, it is possible that dissolution has depleted the DNAPL source material.

Another potential source of the Northeast Plume is the currently active C-533 Electrical Switchyard. The subcrop of the Porters Creek Clay, which forms the south boundary of the RGA, underlies the switchyard. TCE contamination in previous shallow groundwater samples collected adjacent to the south end of the switchyard (south of the RGA) may indicate the presence of a local DNAPL zone. WAG 28 RI samples of UCRS soil and water collected around the north end of the switchyard contained only low

levels of TCE. Because groundwater flow in the UCRS above the RGA is primarily vertical, it remains possible that a DNAPL source zone is located in the UCRS immediately below the north end of the switchyard that could not be detected by the perimeter samples.

Water samples of the Groundwater Phase IV Investigation and the WAG 6 RI define a lesser core of dissolved-phase TCE and ^{99}Tc in the Northeast Plume emanating from the northeast corner of the C-400 Cleaning Building. The likely source of both TCE DNAPL and ^{99}Tc is in the area of the C-403 Neutralization Pit located off the northeast corner of C-400.

Southwest Plume

The recent remedial investigations of WAG 3 and WAG 27 and the Data Gaps Investigation have determined several contaminant source zones contributing to the Southwest Plume. Both the C-720 Maintenance and Stores Building and the C-747 Burial Area (SWMU 4) appear to be primary source areas.

Groundwater samples taken from soil borings in the C-720 area and to the northwest define a dissolved phase TCE plume emanating from the east side of the C-720 Building across the width of the RGA. UCRS soil samples from around C-720 indicate the presence of a DNAPL zone associated with the building storm drain system near the southeast corner of the building. This area appears to be the primary source zone to the dissolved phase plume. A lessor DNAPL source zone northeast of C-720 affects the upper RGA only.

The Data Gaps investigation characterized RGA contaminant levels on the west side of the PGDP. Groundwater samples from borings along the security fence delineated a core of dissolved TCE and ^{99}Tc, at levels above those expected from the distal C-720 source zones. Analyses of groundwater from borings located within the plant found similar levels of both contaminants immediately downgradient of SWMU 4. Thus, SWMU 4 appears to be the primary source zone affecting contaminant levels outside the on-site secure area.

Other sources of contamination in the UCRS overlying the Southwest Plume include the following:

- C-747-C Former Oil Landfarm/SWMU 1 (TCE),
- C-749 Uranium Burial Ground/SWMU 2 (TCE),
- C-404 Low-Level Radioactive Waste Burial Ground/SWMU 3 (TCE and ^{99}Tc),
- UF_6 Cylinder Drop Test Area/SWMU 91 (TCE), and
- C-740 TCE Spill Site.

Groundwater investigations and continued monitoring at these locations have shown that these source units have only minimal impact on RGA water quality. An innovative technology, the Lasagna™ process, is being applied as an interim remedial action to the TCE DNAPL zone associated with the UF_6 Cylinder Drop Test Area.

Northwest Plume

Many investigations have been required to determine the multiple sources contributing to the Northwest Plume. The Phase IV Groundwater Investigation established the C-400 area, located near the center of the PGDP, as the primary contaminant source to the high-concentration core of the Northwest Plume.

Several TCE DNAPL and ^{99}Tc source zones occur in the C-400 area. The largest TCE DNAPL zone at the PGDP underlies the southeast corner of the C-400 block, derived from a leaking TCE transfer pump and the SWMU 11 TCE Leak Site, where a sump pump below a large degreasing unit in C-400 was

inadvertently routed into the PGDP storm sewer system. High dissolved-phase TCE concentrations extend to the base of the RGA, indicating that DNAPL has penetrated to the base of the RGA in the area.

Another TCE DNAPL source occurs at the south end of the C-400 Building. TCE-contaminated soils extend from a leak site, where a storm sewer "daylights" from beneath the building, westward along the storm drain to near the perimeter of the C-400 block. At the leak site, DNAPL penetrated downward into the top of the RGA.

The C-400 Technetium Storage Tank Area (SWMU 47) is located on the west side of the C-400 Building. The site previously included a 4,000-gal tank used in the early 1960s to store a waste solution containing ^{99}Tc and other radionuclides, and chromium. Surface and subsurface soils at the site are contaminated by radionuclides. High levels of dissolved ^{99}Tc are found in the RGA in the proximity and downgradient of SWMU 47.

After treatment, many of the former C-400 Building waste streams drained north through the NSDD to Little Bayou Creek. The NSDD also received runoff from the PGDP's C-600 Steam Plant. Over years of operation, the on-site ditch filled with coal fines that readily sorbed and accumulated contaminants from the C-400 effluent. Recent investigations have shown the upper RGA to be contaminated with ^{99}Tc in the vicinity of the NSDD. It appears likely that the NSDD immediately north of the C-400 Building is a source of ^{99}Tc to the Northwest Plume.

An investigation of the C-747-A burial ground (WAG 22, SWMUs 7 and 30 RI) evaluated the site waste pits as a contributing source to the Northwest Plume, where the plume exits from the PGDP at the northwest corner of the facility. Dissolved levels of TCE and its degradation products in UCRS water samples around Waste Pit B (SWMU 7) were suggestive of a small TCE DNAPL source that originated in the burial cell and migrated into the underlying UCRS. The presence of a TCE DNAPL in the RGA could not be determined because high upgradient concentrations from the Northwest Plume mask any local contribution.

Several of the waste pits and area soil in the C-747-A burial ground contained ^{99}Tc contamination at elevated levels. Fate and transport modeling of the SWMUs 7 and 30 RI and draft FS (a final FS was deferred) showed that the contaminated materials likely were contributing ^{99}Tc at levels far below drinking water standards.

Technetium-99 Plume

The Technetium-99 Plume consists of a core of ^{99}Tc contamination, at levels less than drinking water standards, found east of the Northwest Plume. Sporadic on-site detections of RGA groundwater with higher ^{99}Tc levels from the north–central area of the PGDP are also attributed to the Technetium-99 Plume. A definitive source to the core of the plume remains unknown. The on-site NSDD and the C-616-E Sludge Lagoon, located immediately north of the main PGDP-fenced area, have been suspect source zones.

Recent investigations have addressed both suspected source areas. As discussed for the Northwest Plume, the ^{99}Tc contamination associated with the on-site NSDD may account for the core of the Technetium-99 Plume. Moreover, the off-site NSDD appears to provide a line source of lower-level contamination along the east edge of the Technetium-99 Plume. Groundwater samples from both the UCRS and RGA in soil borings at the perimeter of the C-616-E Lagoon contained only trace levels of ^{99}Tc.

4.3.2 Extent of the Priority Contaminants

To evaluate the extent of the priority contaminants for the GWOU, the following sections present maps of RGA sample locations and maps of maximum detected levels of the contaminants in RGA

groundwater as derived from the GWOU database. These figures represent the area impacted by PGDP groundwater contamination and downgradient areas north of the PGDP to the Ohio River. Metropolis Lake Road and Bethel Church Road are convenient landmarks that mark the east and west boundaries of the map area. In addition to major PGDP eastings and northings, the maps include the outlines of the PGDP security area and the PGDP TCE plumes for reference. The TCE plumes define major groundwater flow paths emanating from the PGDP.

Most of the priority contaminants are among three major contaminant groups associated with the PGDP: VOCs, metals, and radionuclides. The priority contaminants also include four other organic compounds.

4.3.2.1 Volatile organic compounds

TCE is the most well-known VOC associated with groundwater contamination at the PGDP. It is the only VOC to be found off-site at levels of 1 ppm or greater. TCE occurs in the Southwest, Northwest, and Northeast Plumes. The extent of the other VOCs is not as widespread.

	On-site SW Plume	On-site NW Plume	On-site NE Plume	Off-site NW Plume	Off-site NE Plume	Off-site C-746-S&T Landfill Area
carbon tetrachloride	√	√	√	—	<5 ppb	—
chloroform	√	√	—	√	—	√
1,1-DCE	√	√	√	—	√	—
1,2-DCE	—	—	—	√	—	<5 ppb
cis-1,2-DCE	√	√	√	—	√	<5 ppb
trans-1,2-DCE	√	√	√	—	—	—
TCE	√	√	√	√	√	√
vinyl chloride	√	—	<5 ppb	—	—	—

Figures 4.3 through 4.18 present the available data for these VOCs. All of these priority contaminants except 1,2-DCE are found on-site. *Trans*-1,2-DCE and vinyl chloride are primarily limited to the immediate PGDP area.

The data are suggestive of a source of dissolved chloroform and vinyl chloride to the RGA located in the northwest corner of the PGDP (likely the burial grounds of SWMUs 7 and 30). Of these contaminants, only chloroform appears to be migrating off-site.

4.3.2.2 Other organic compounds

The other organic compounds that are priority contaminants for the GWOU are largely undetected in RGA groundwater samples. Figures 4.19 through 4.24 show the distribution of samples and measured levels of contaminants. Naphthalene has not been detected. The GWOU database includes singular reports of acrylonitrile and bromodichloromethane (10 and 4 ppb, respectively) and 3 detections of aroclor-1254 (0.2 to 0.9 ppb). Benzene was the most frequently detected of these contaminants (identified in analyses of water samples from 7 soil borings and 3 wells). All benzene analyses but 1 are 5 ppb or less, and most appear to be associated with the Northwest Plume.

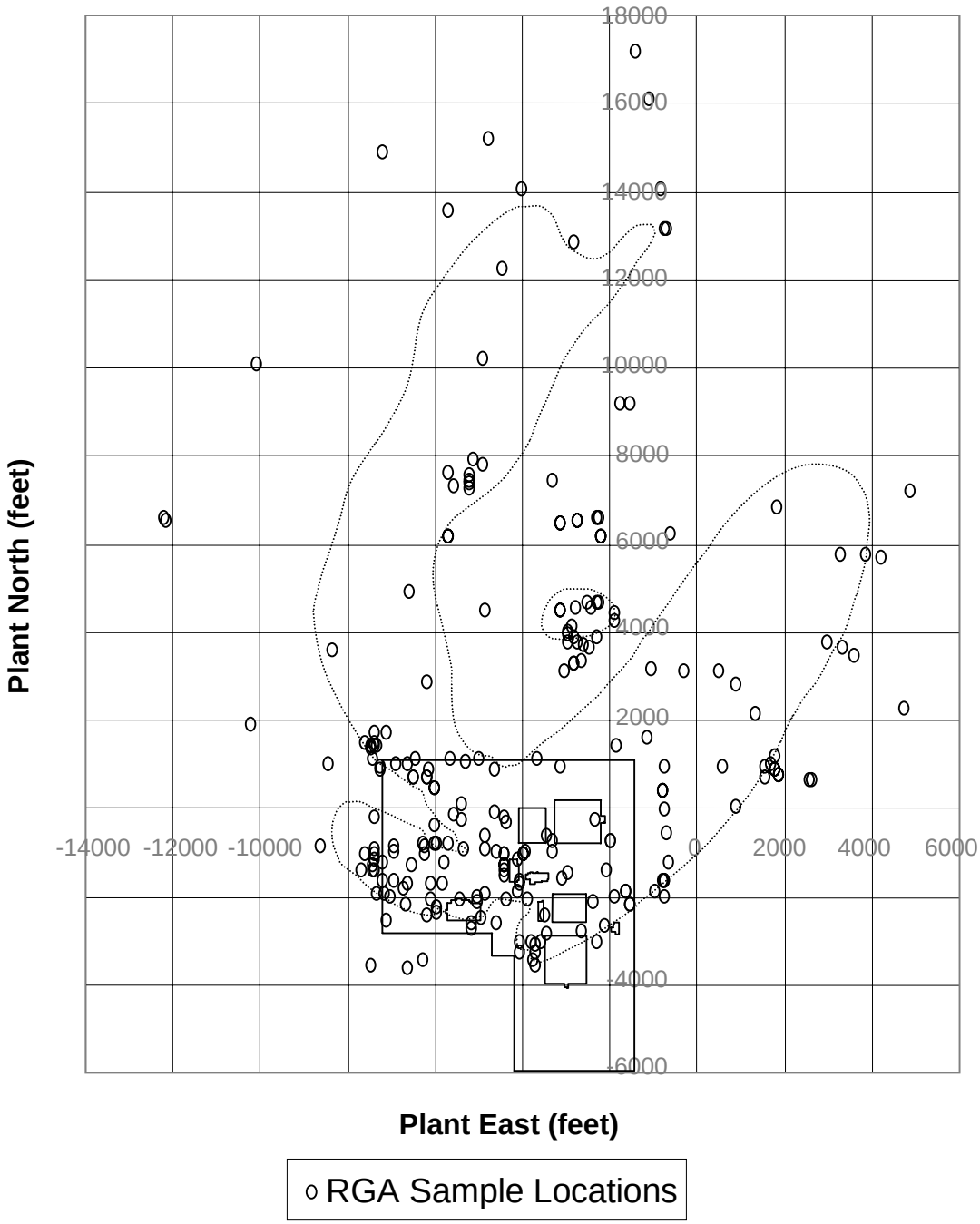

Fig. 4.3. RGA sample locations – trans-1,2-DCE analyses.

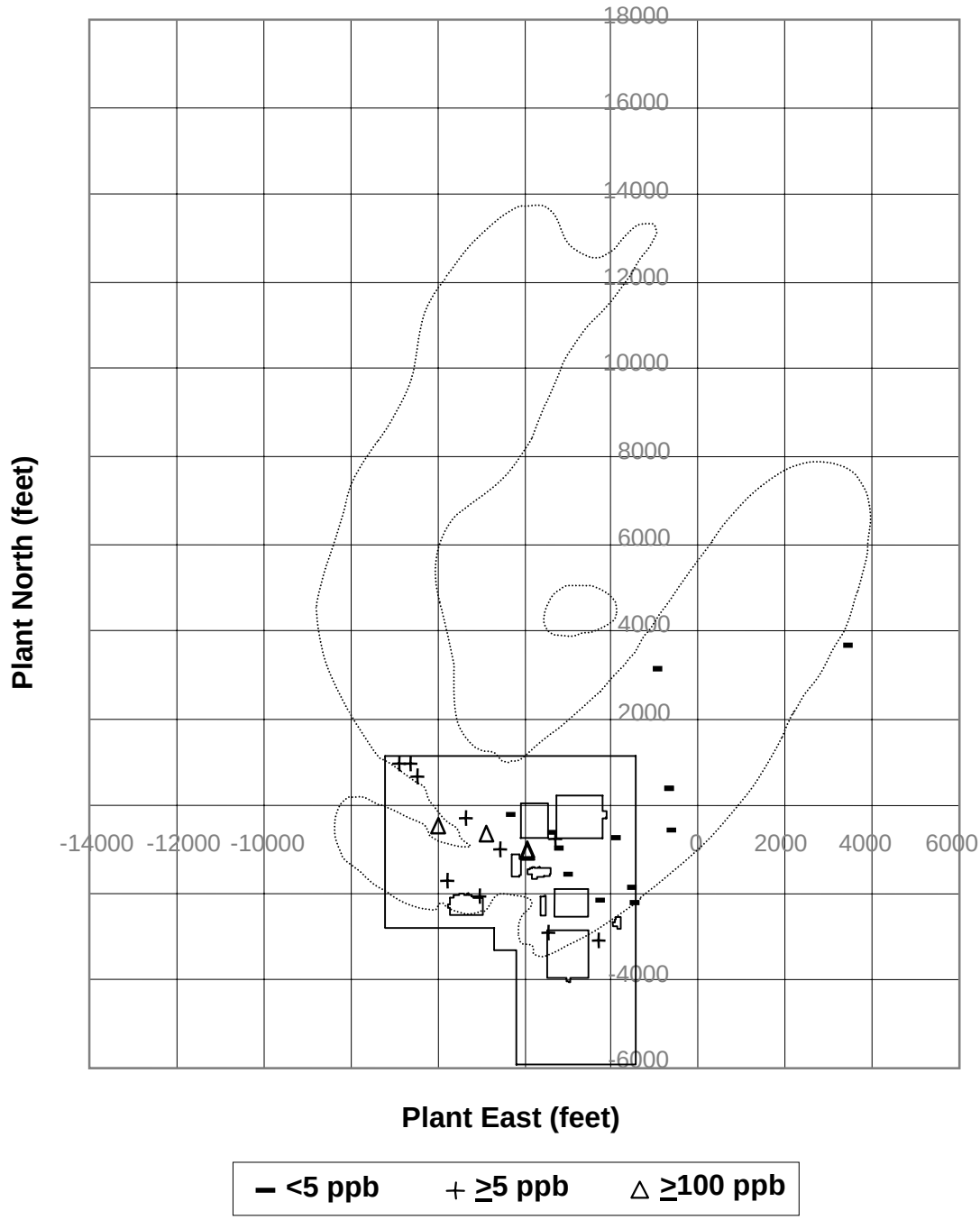

Fig. 4.4. Maximum detected levels of carbon tetrachloride in RGA groundwater.

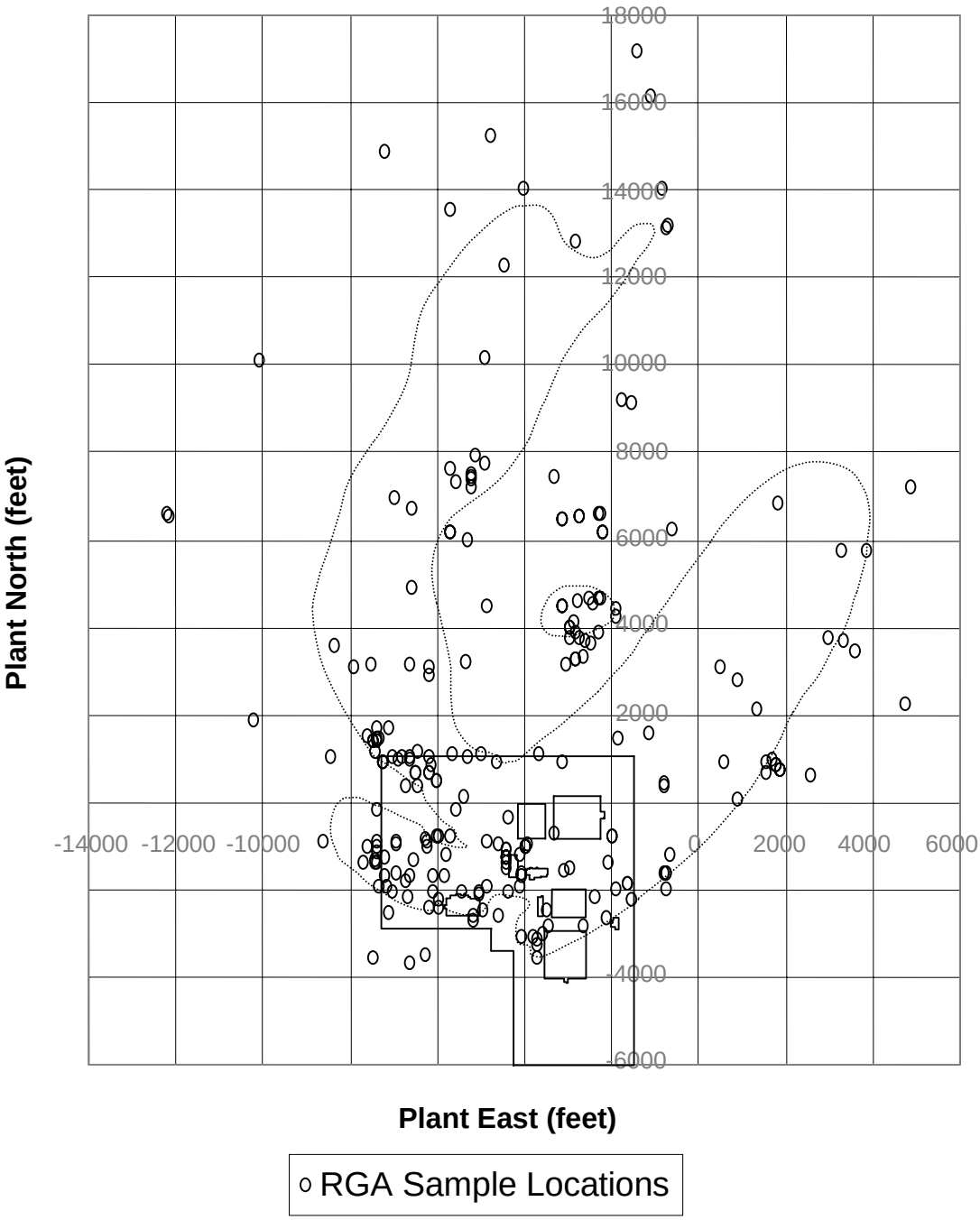

Fig. 4.5. RGA sample locations - chloroform analyses.

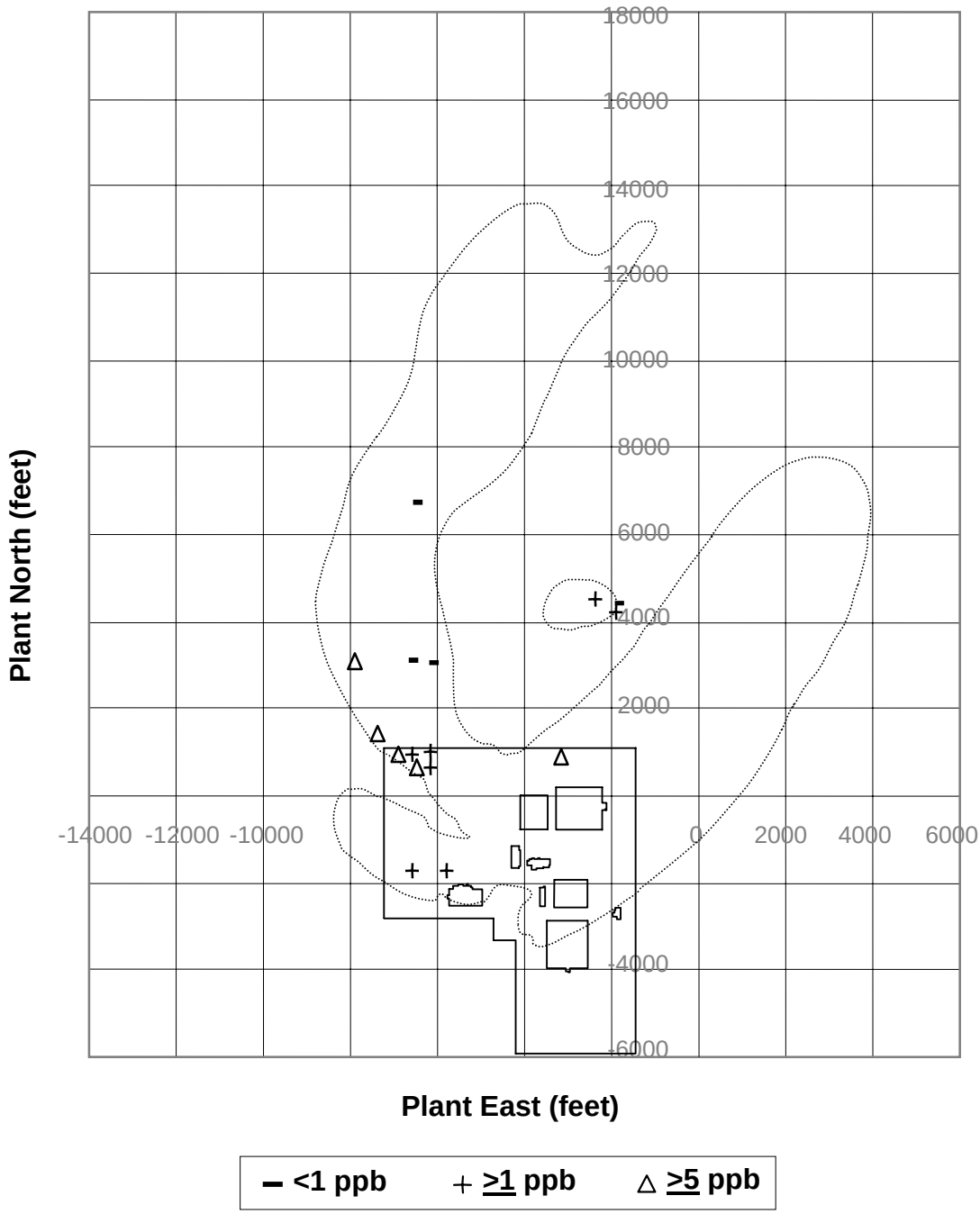

Fig. 4.6. Maximum detected levels of chloroform in RGA groundwater.

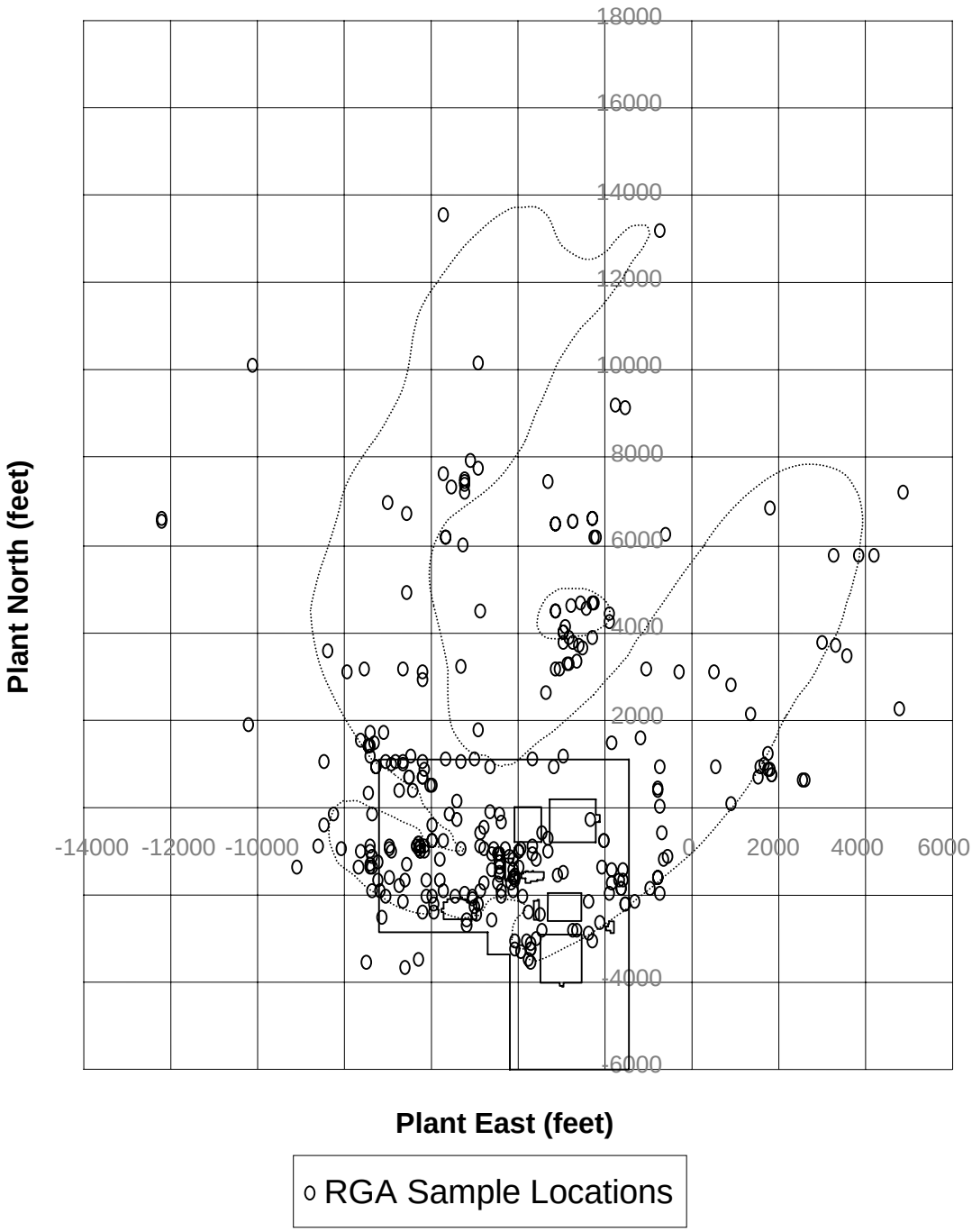

Fig. 4.7. RGA sample locations - 1,1-DCE analyses.

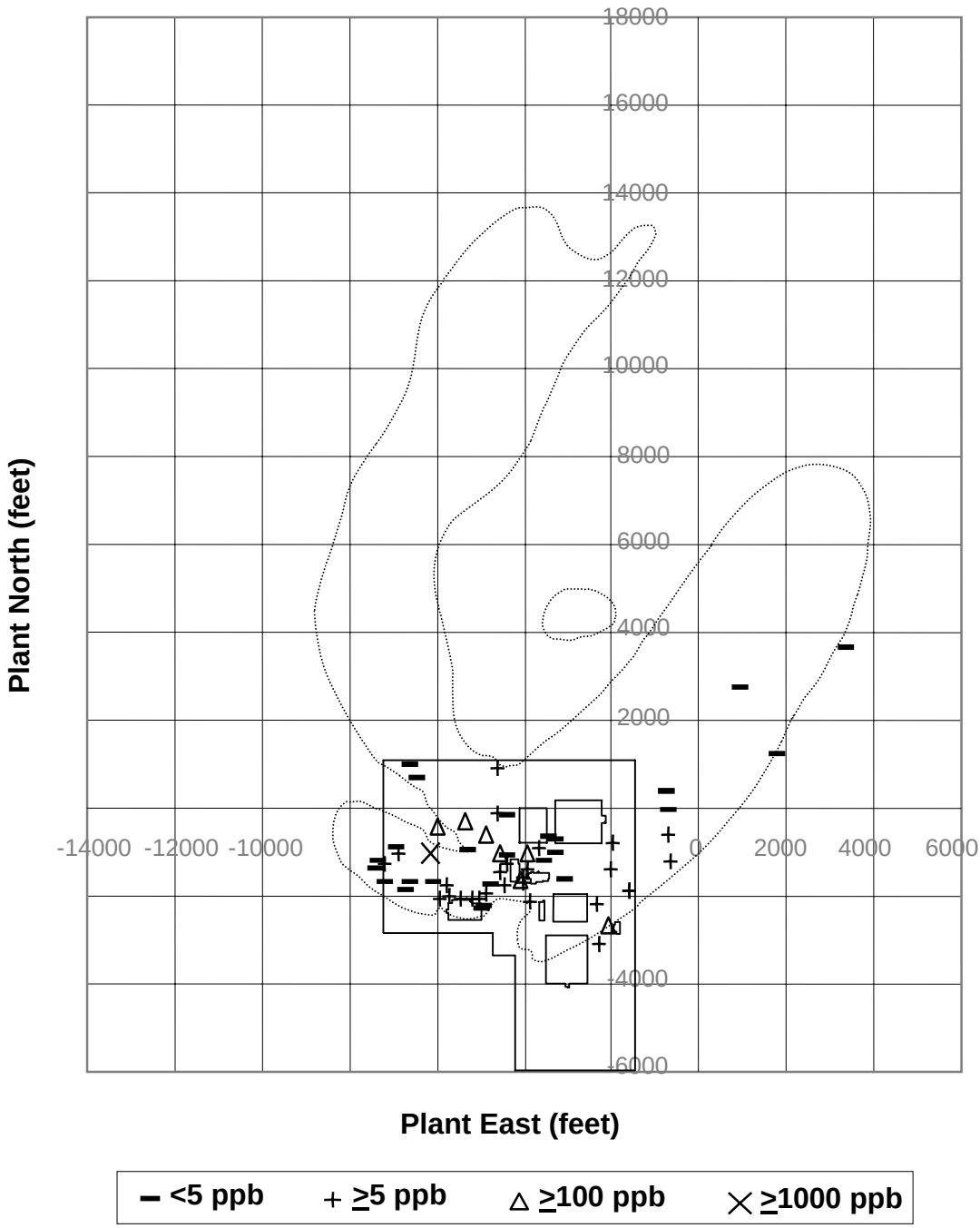

Fig. 4.8. Maximum detected levels of 1,1-DCE in RGA groundwater.

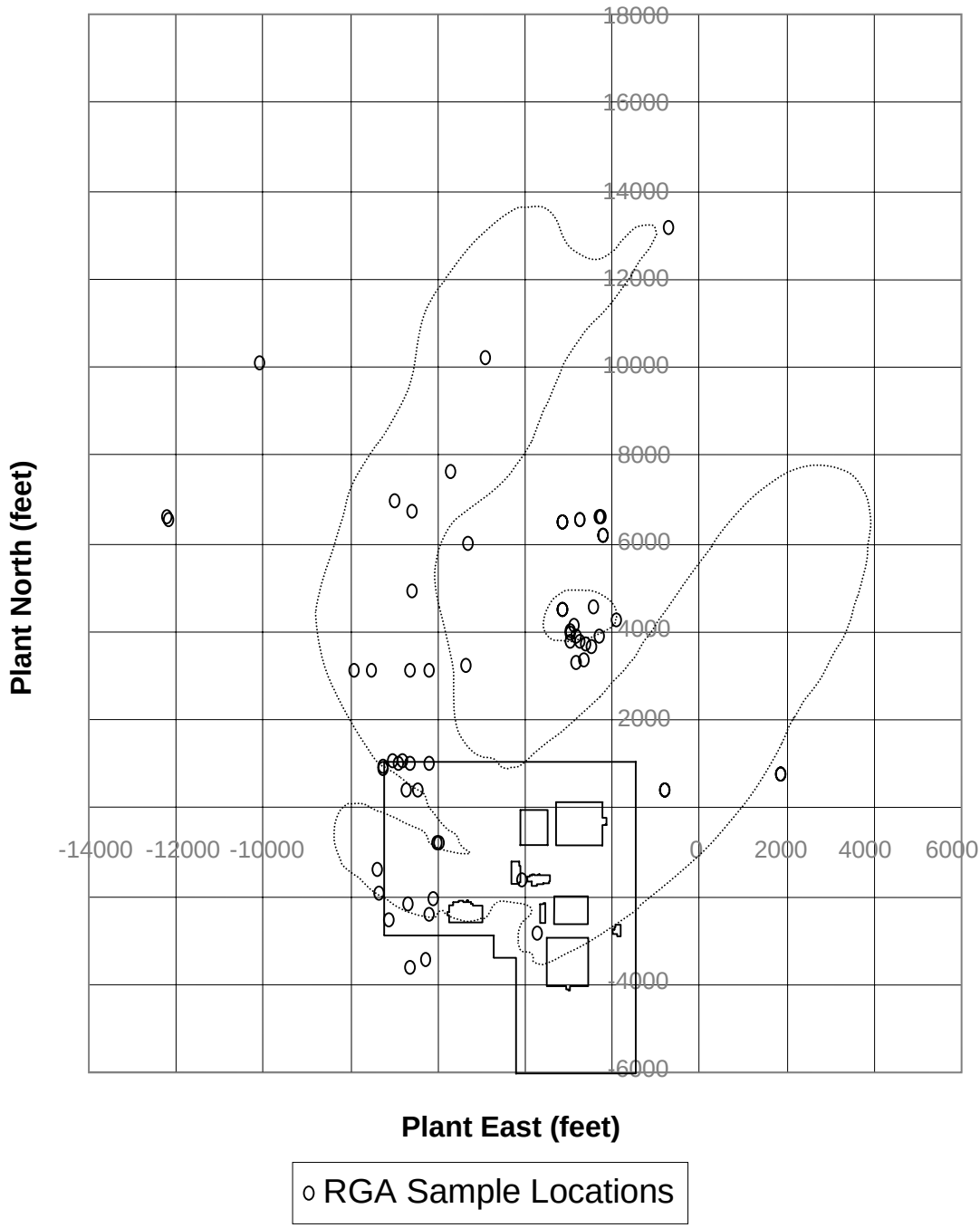

Fig. 4.9. RGA sample locations - 1,2-DCE analyses.

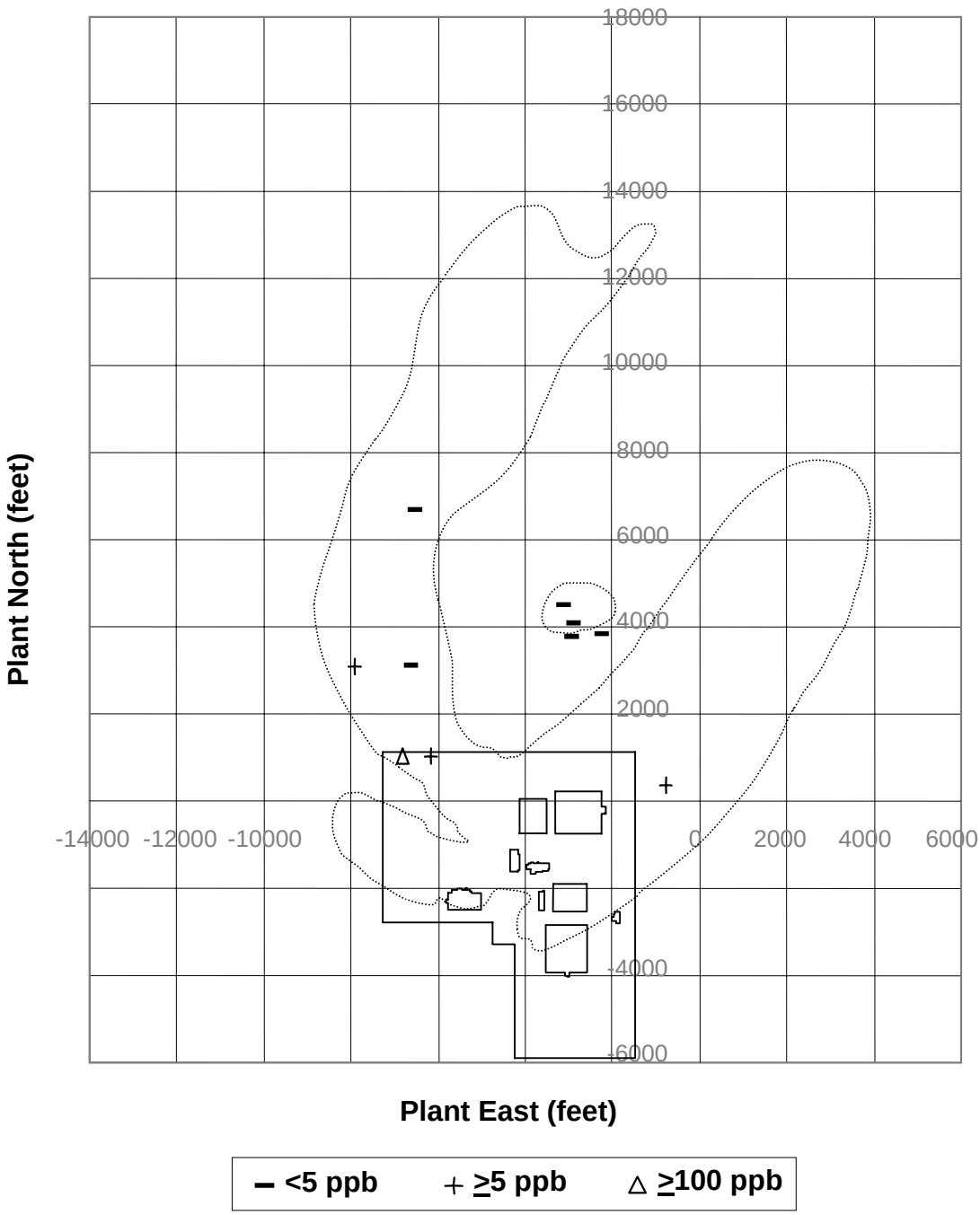

Fig. 4.10. Maximum detected levels of 1,2-dichloroethene in RGA groundwater.

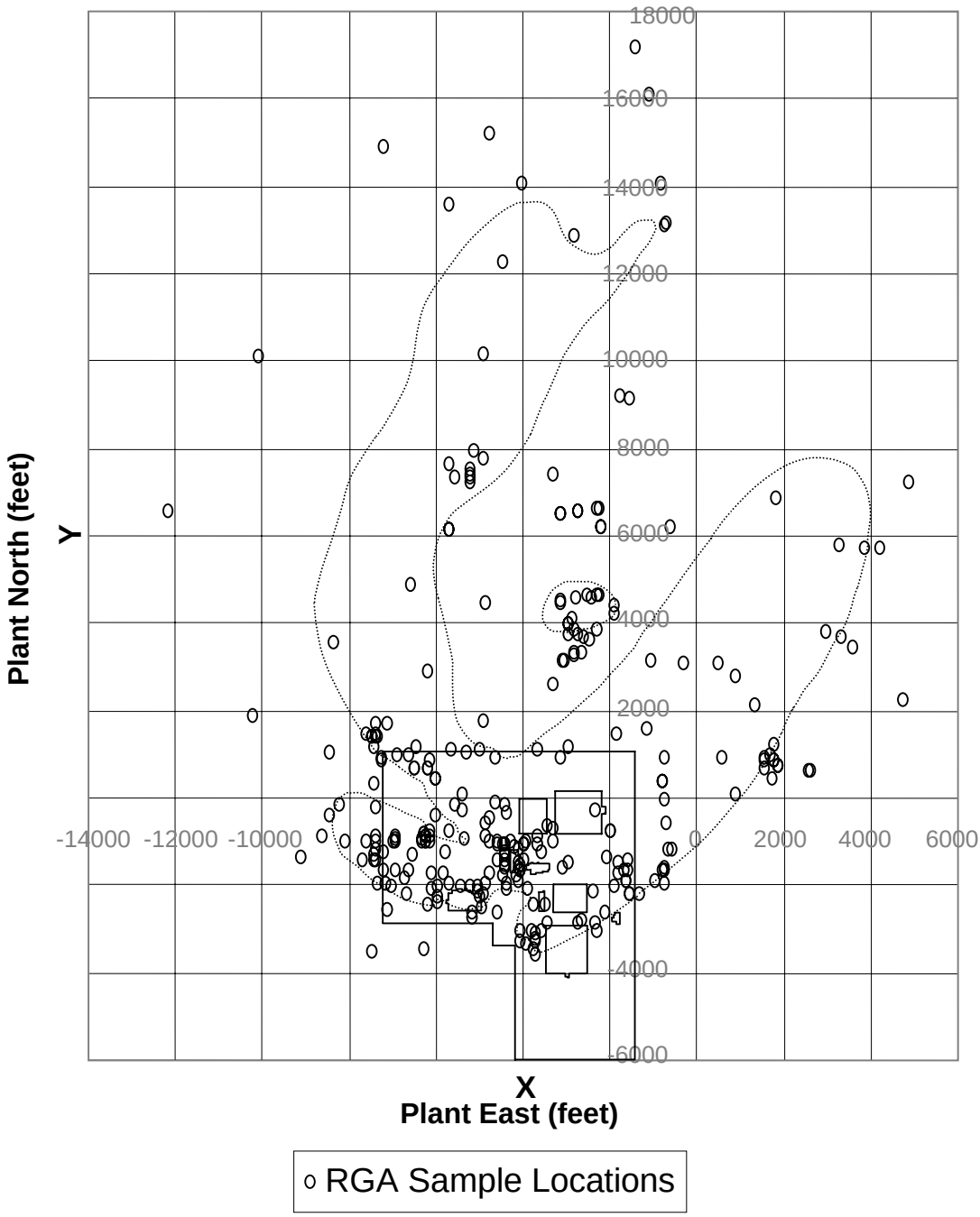

Fig. 4.11. RGA sample locations – cis-1,2-dichlroethene analyses.

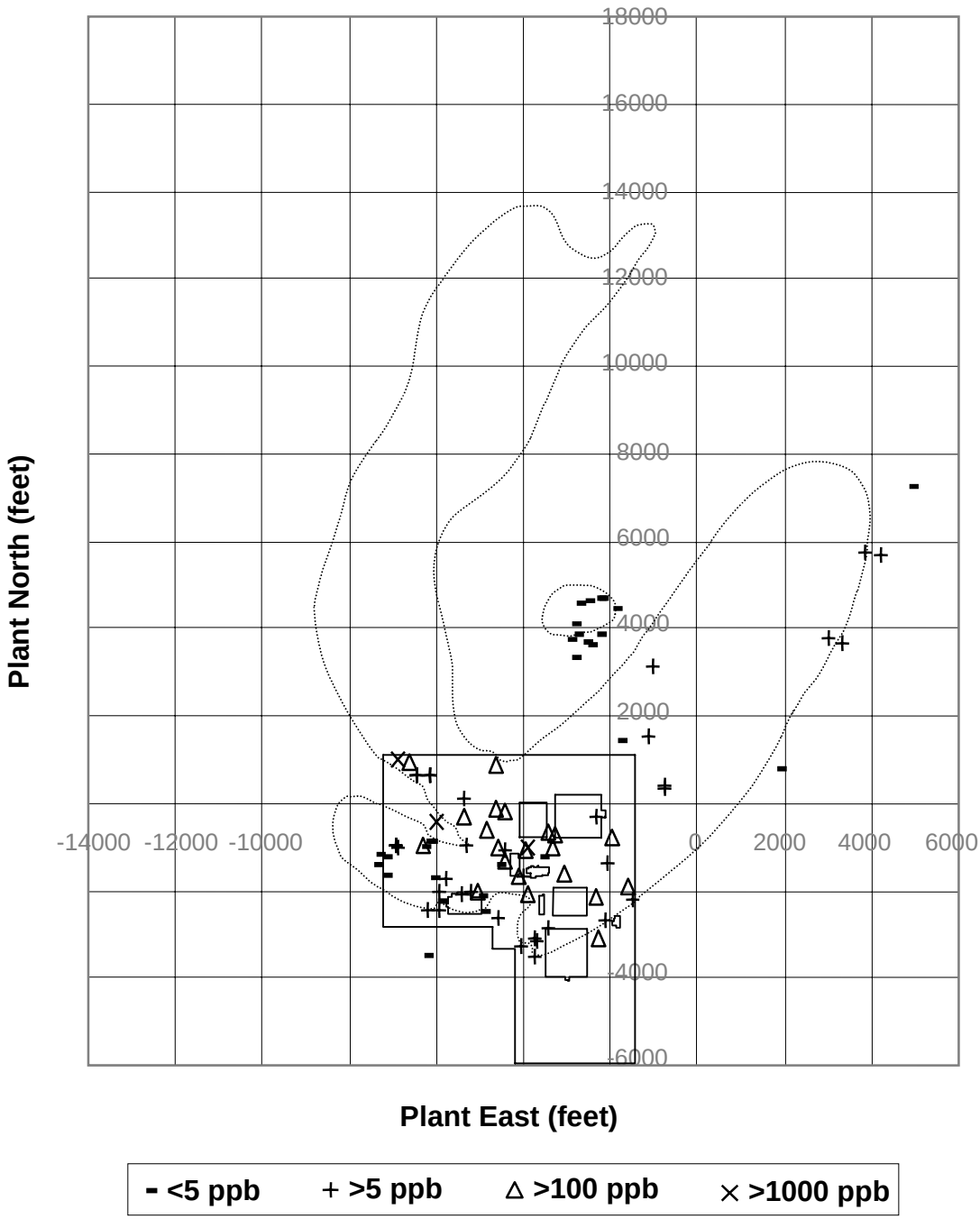

Fig. 4.12. Maximum detected levels of trans-1,2-DCE in RGA groundwater.

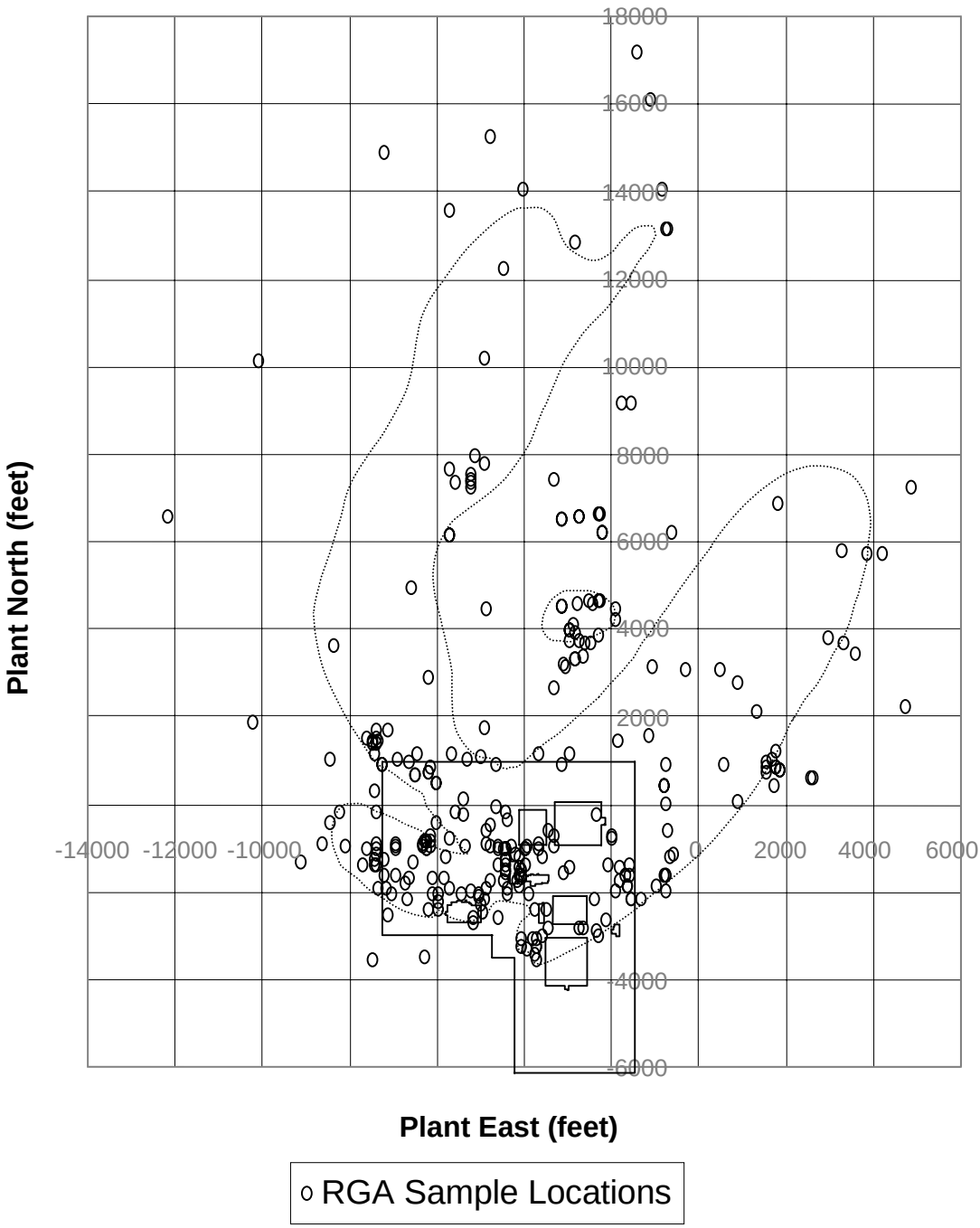

Fig. 4.13. RGA sample locations – carbon tetrachloride analyses.

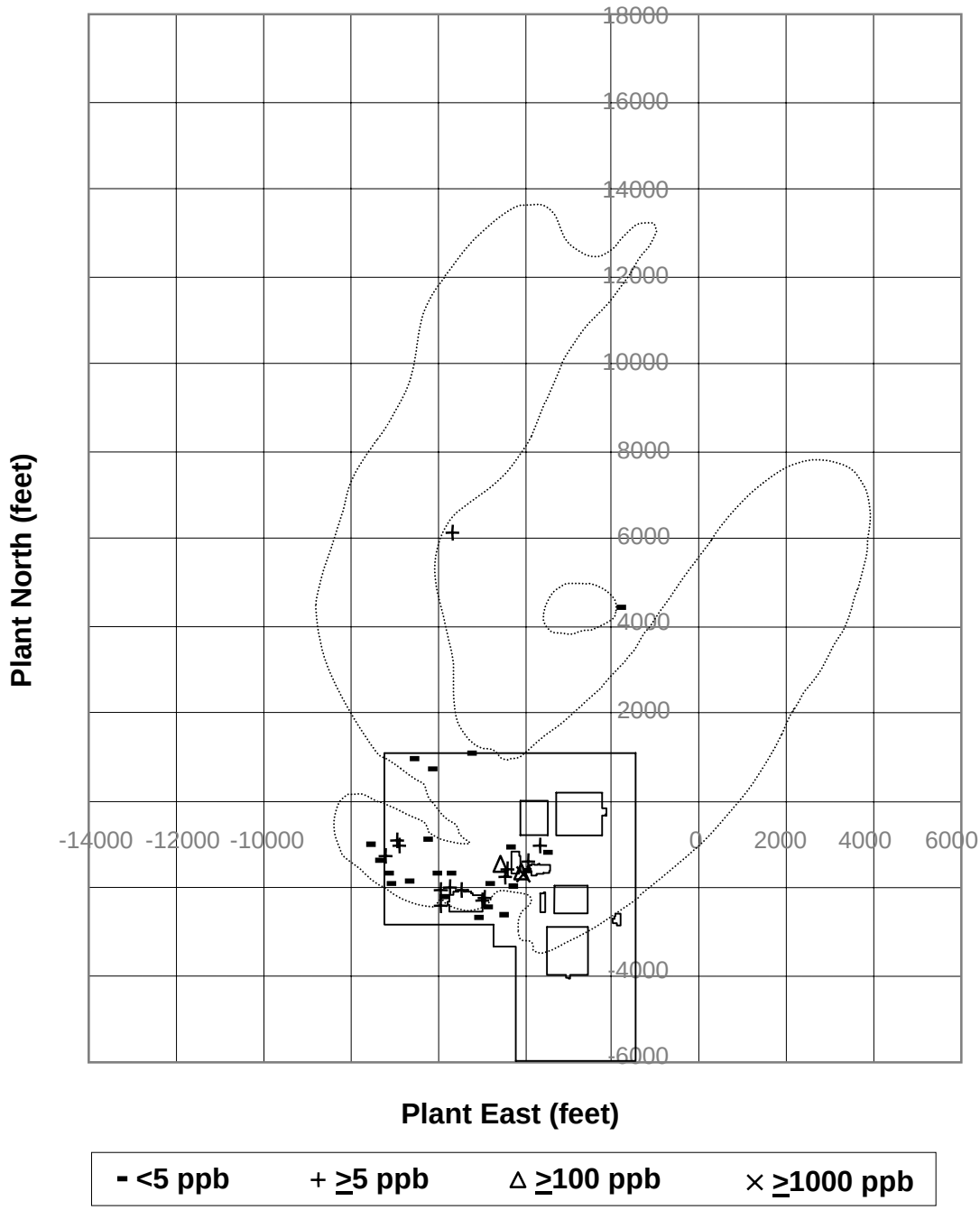

Fig. 4.14. Maximum detected levels of *cis*-1,2-DCE in RGA groundwater.

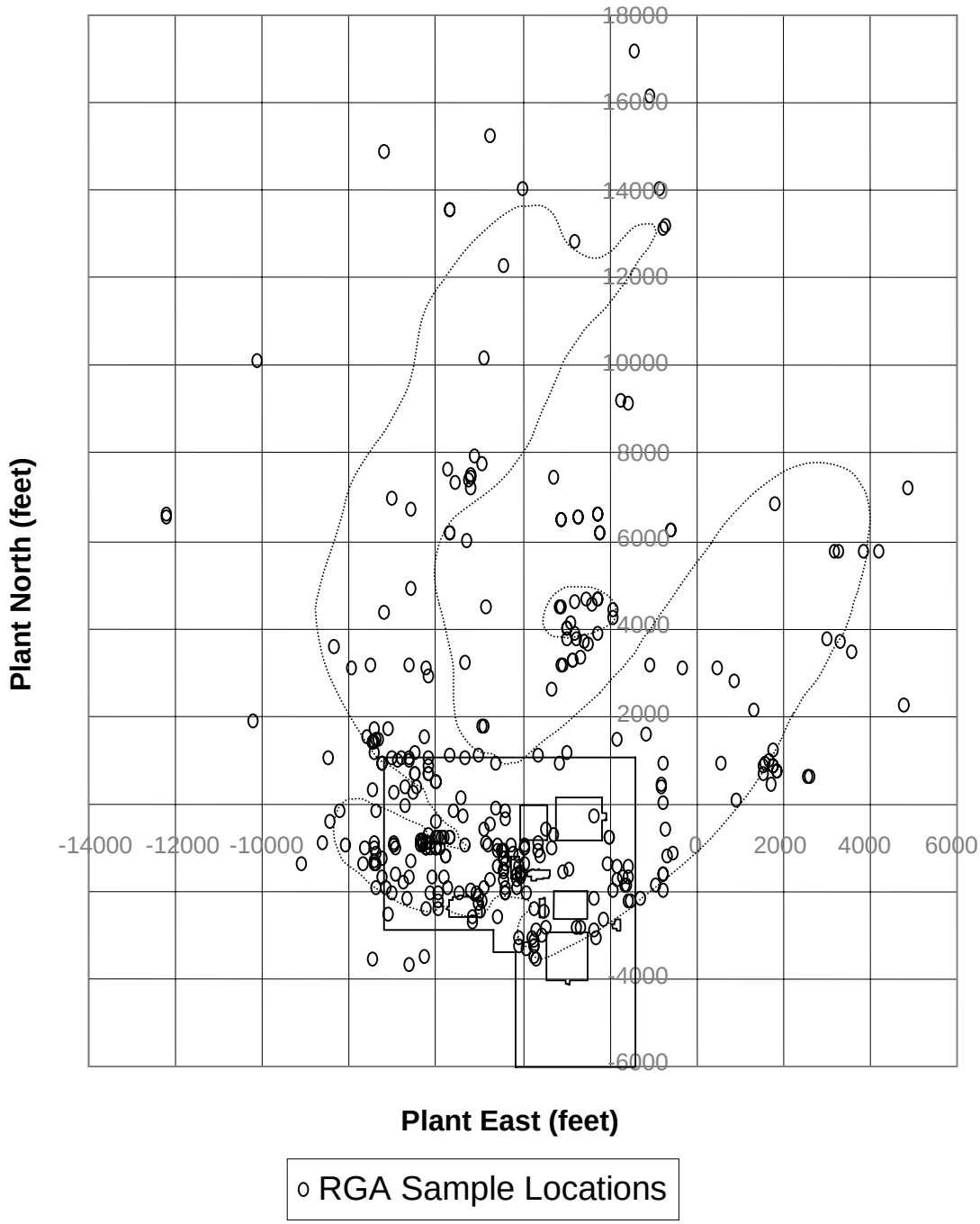

Fig. 4.15. RGA sample locations - trichloroethene analyses.

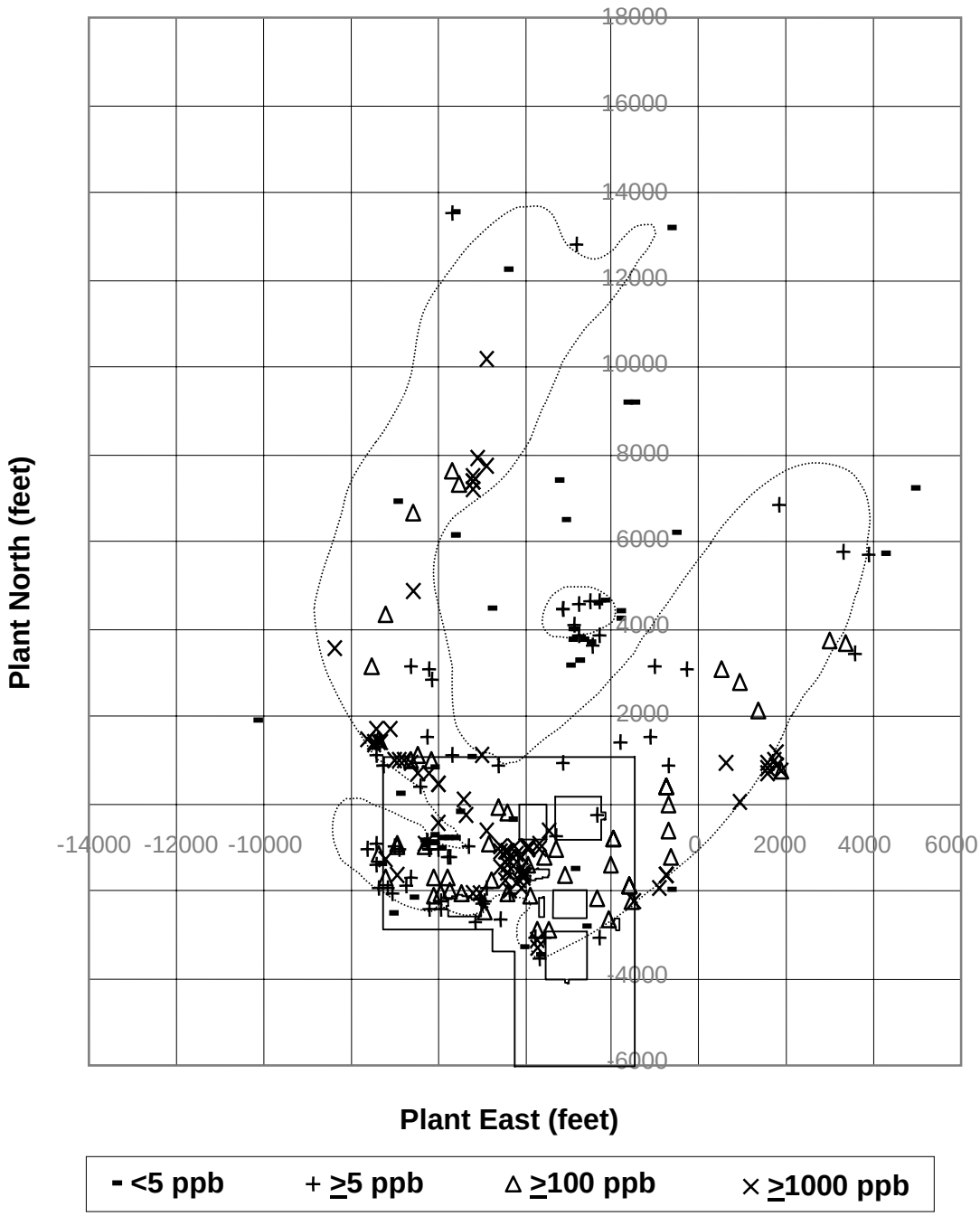

Fig. 4.16. Maximum detected levels of trichloroethene in RGA groundwater.

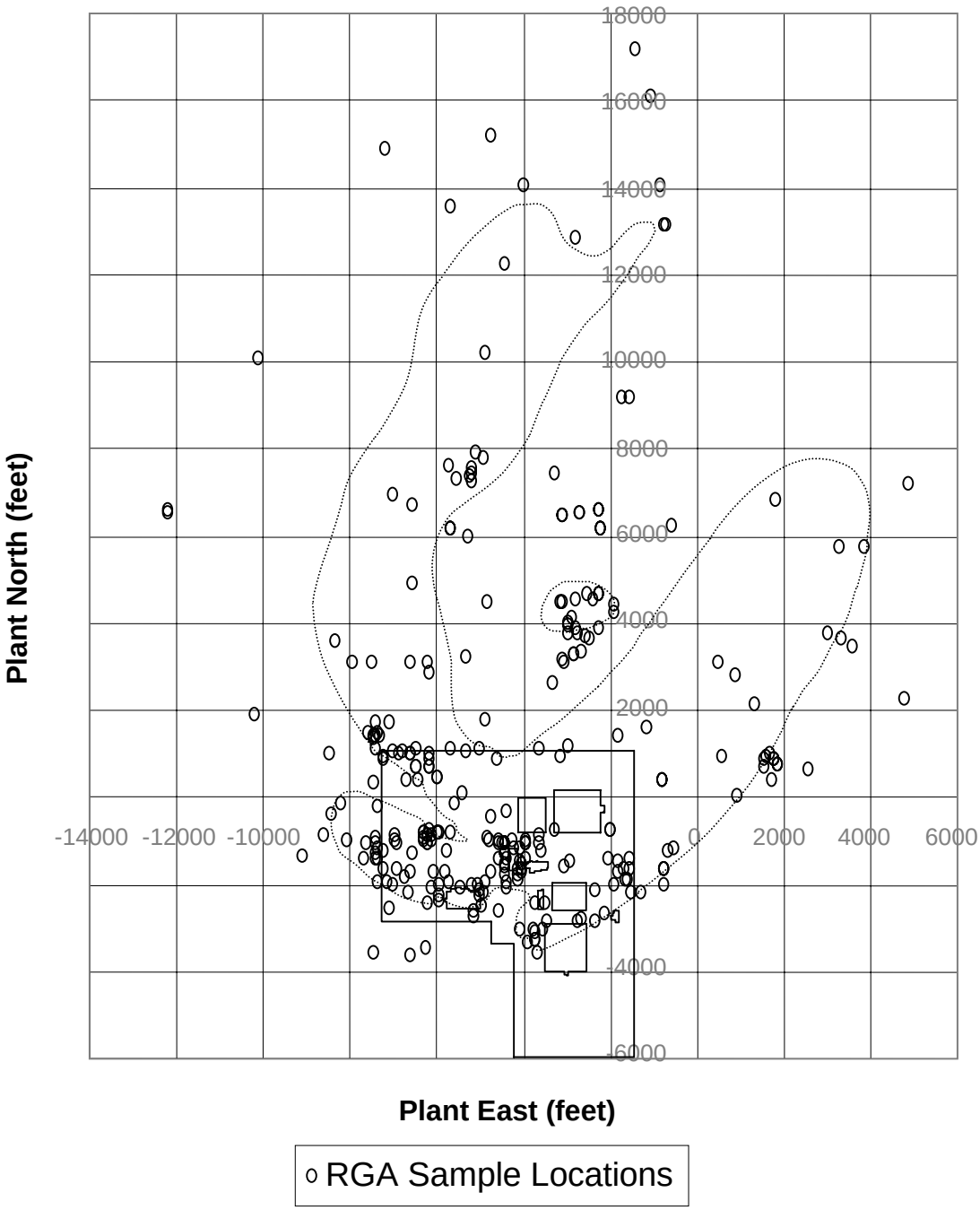

Fig. 4.17. RGA sample locations – vinyl chloride analyses.

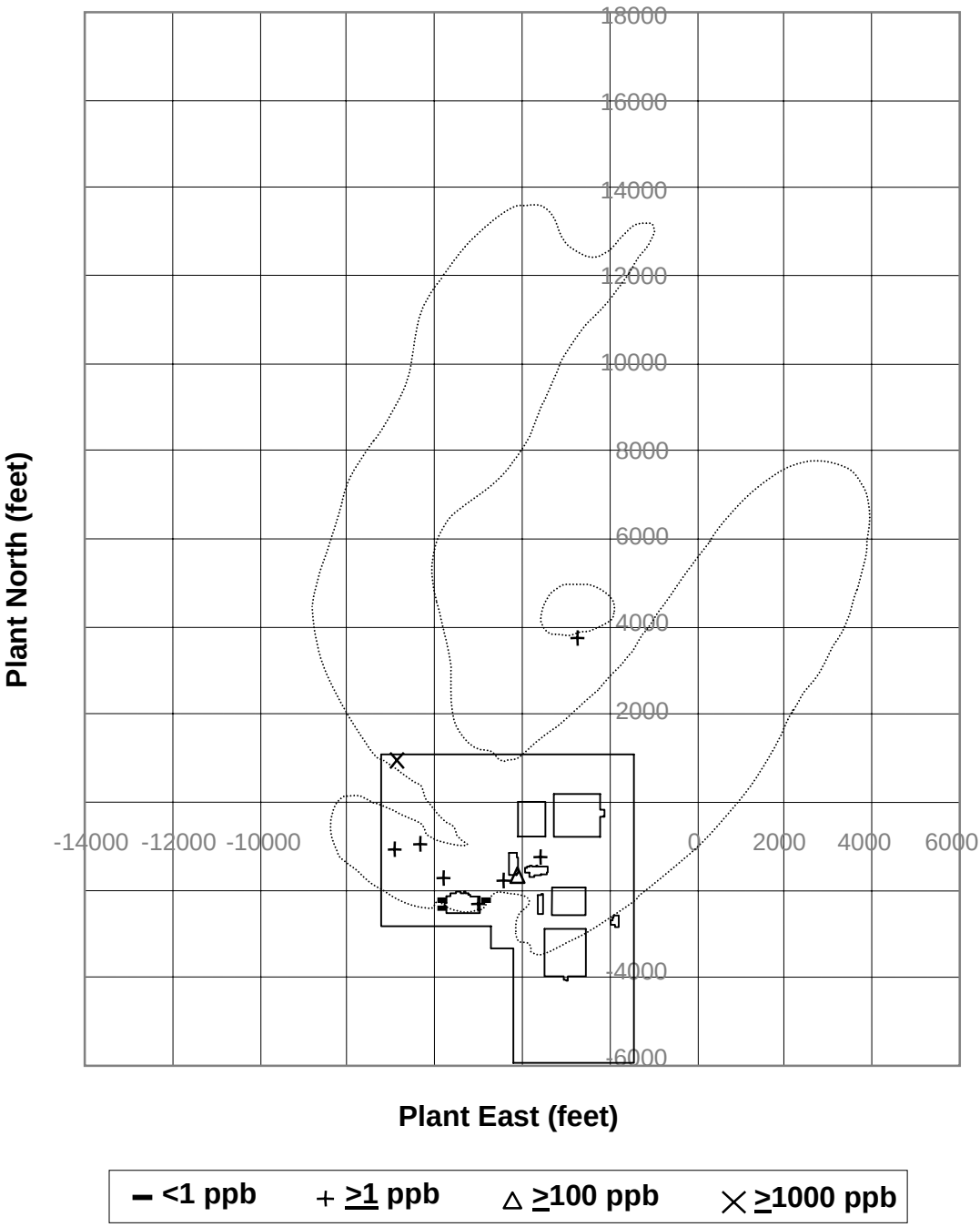

Fig. 4.18. Maximum detected levels of vinyl chloride in RGA groundwater.

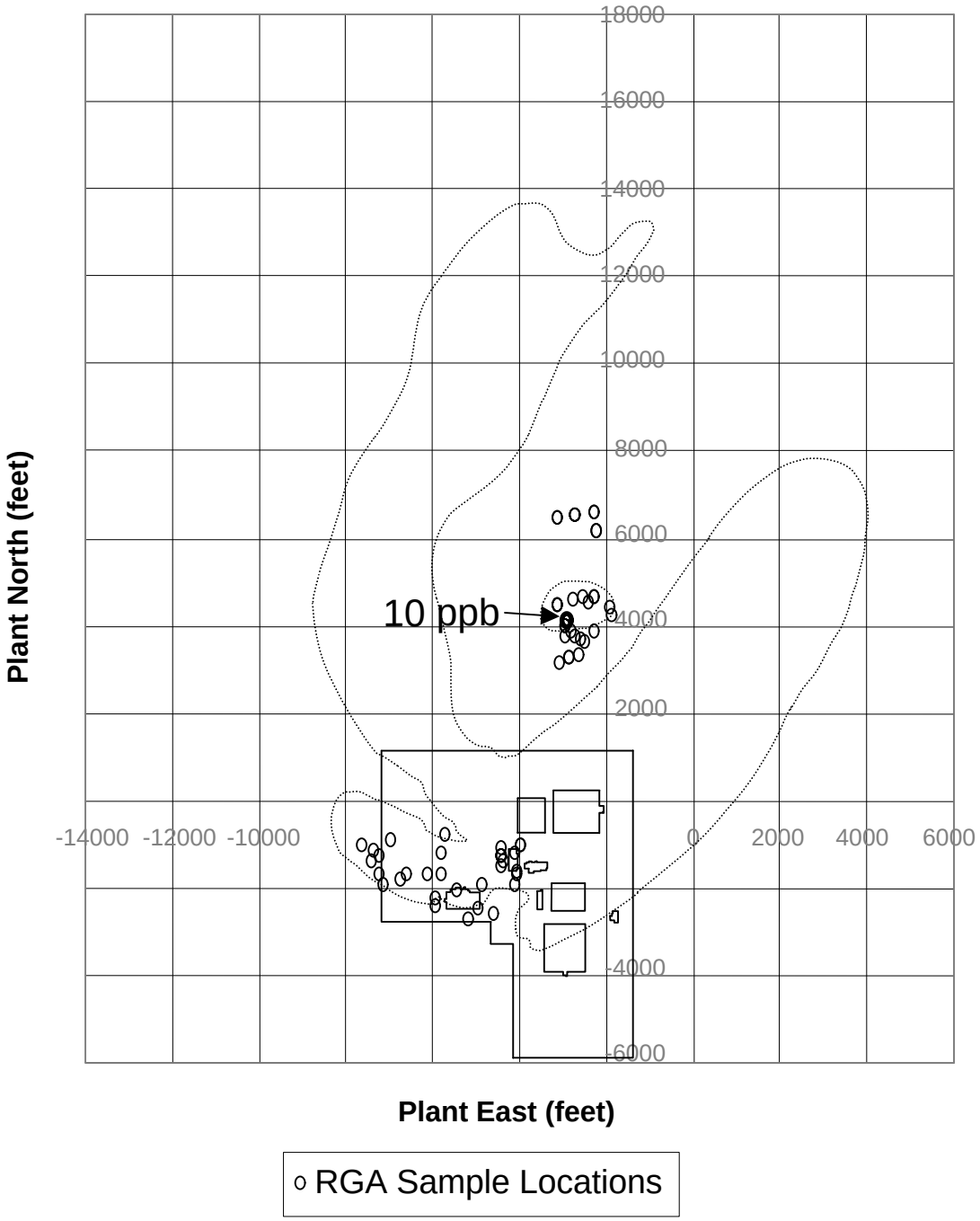

Fig. 4.19. RGA sample locations - acrylonitrile analyses.

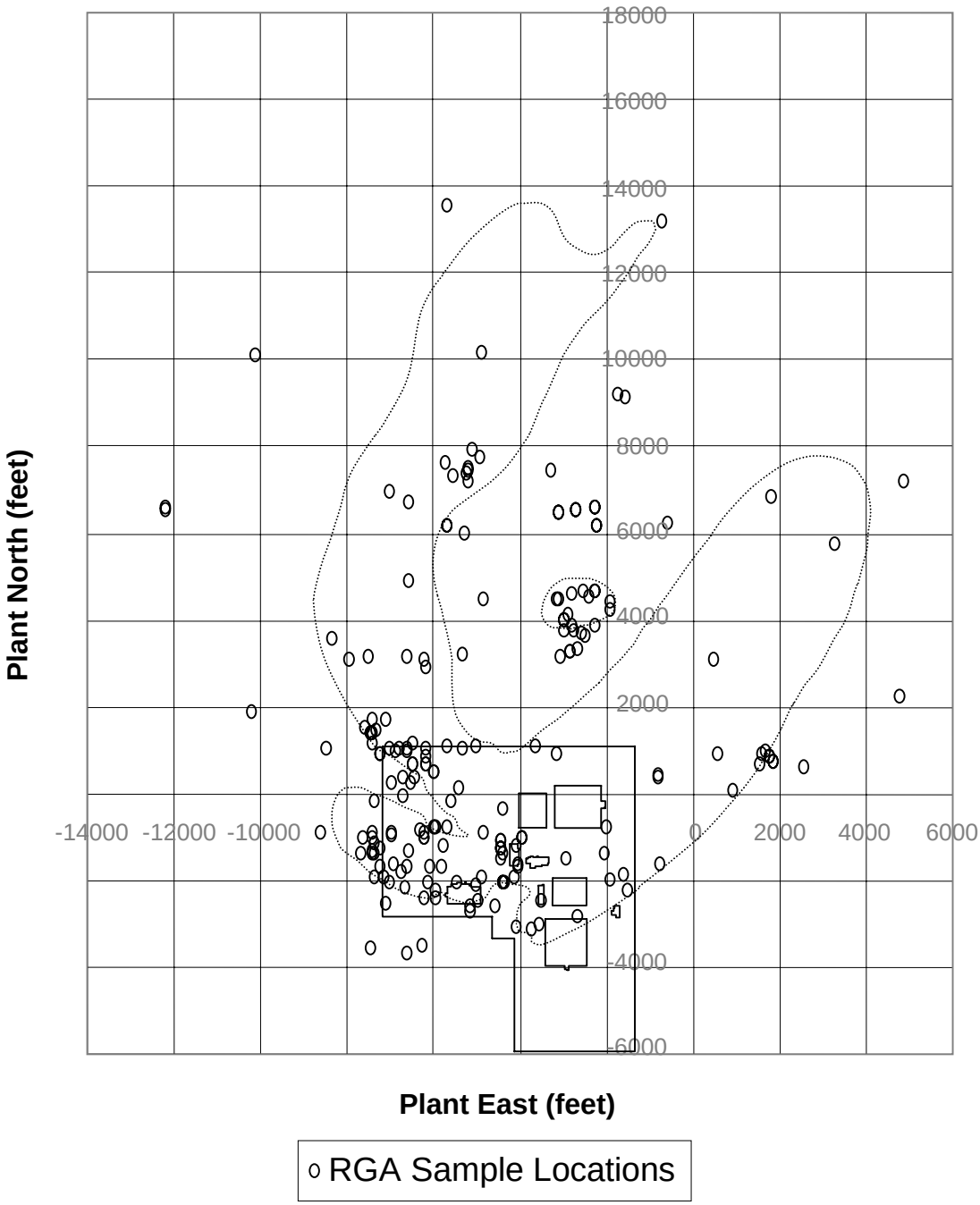

Fig. 4.20. RGA sample locations - benzene analyses.

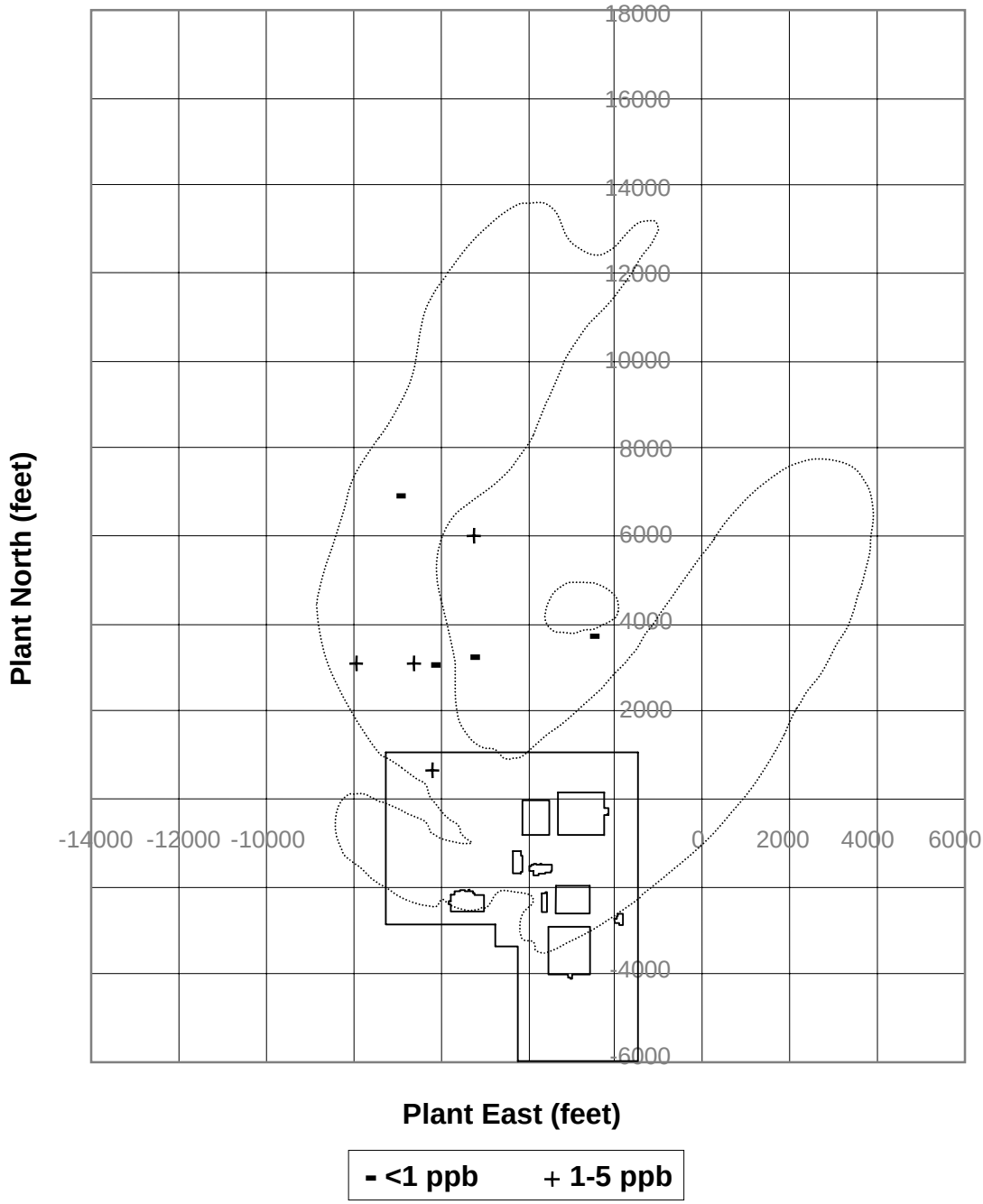

Fig. 4.21. Maximum detected levels of benzene in RGA groundwater.

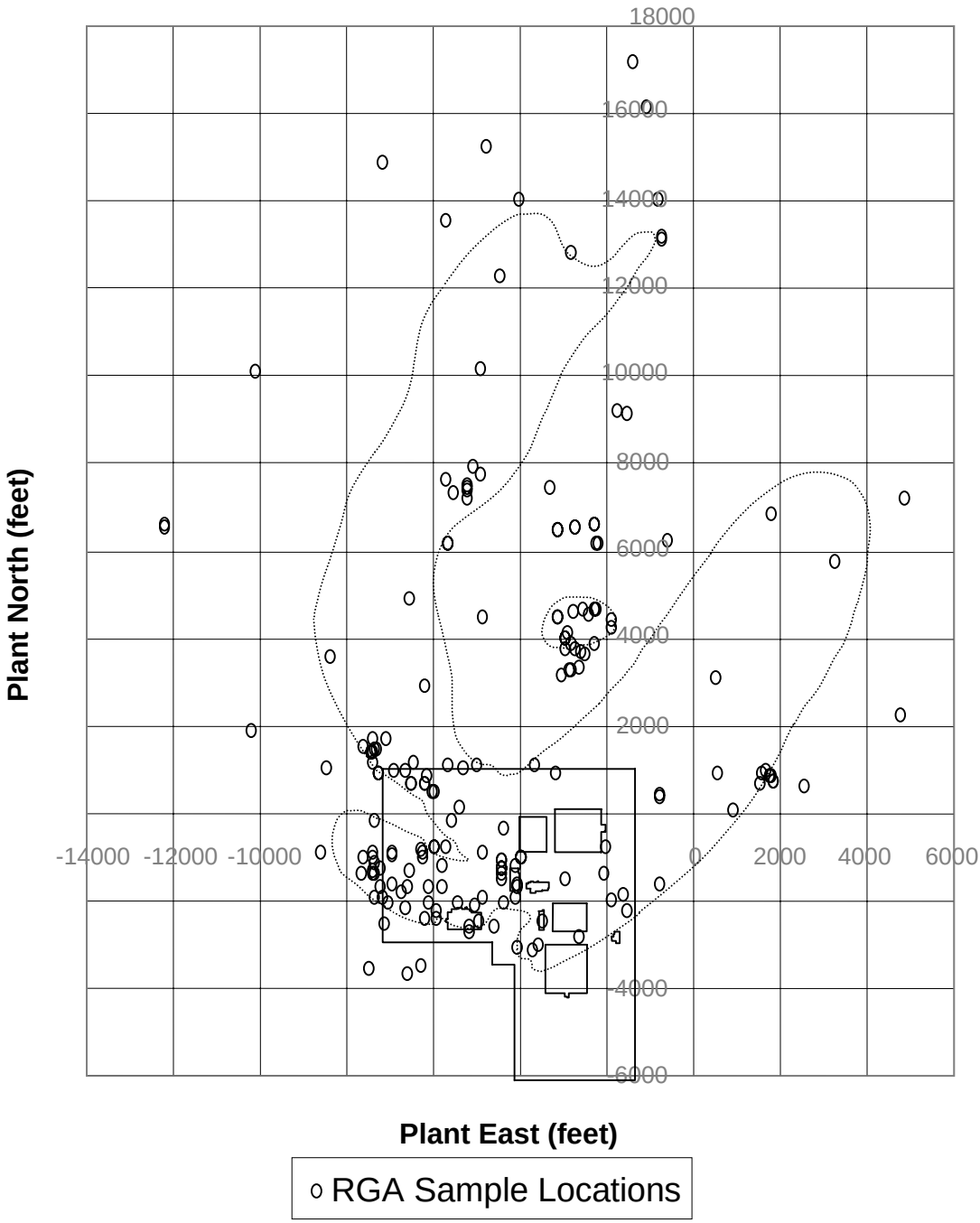

Fig. 4.22. RGA sample locations - bromodichloromethane analyses.

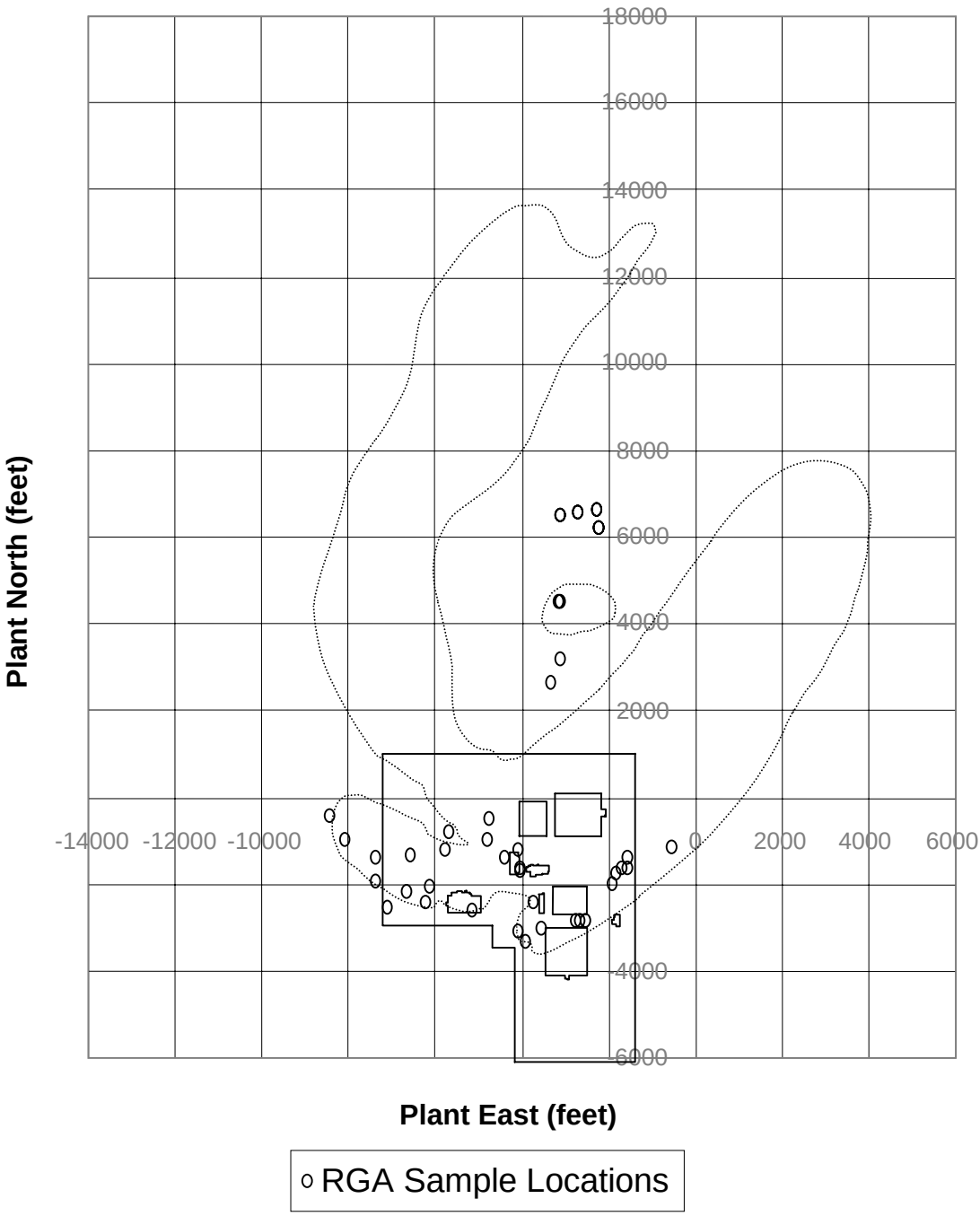

Fig. 4.23. RGA sample locations - naphthalene analyses.

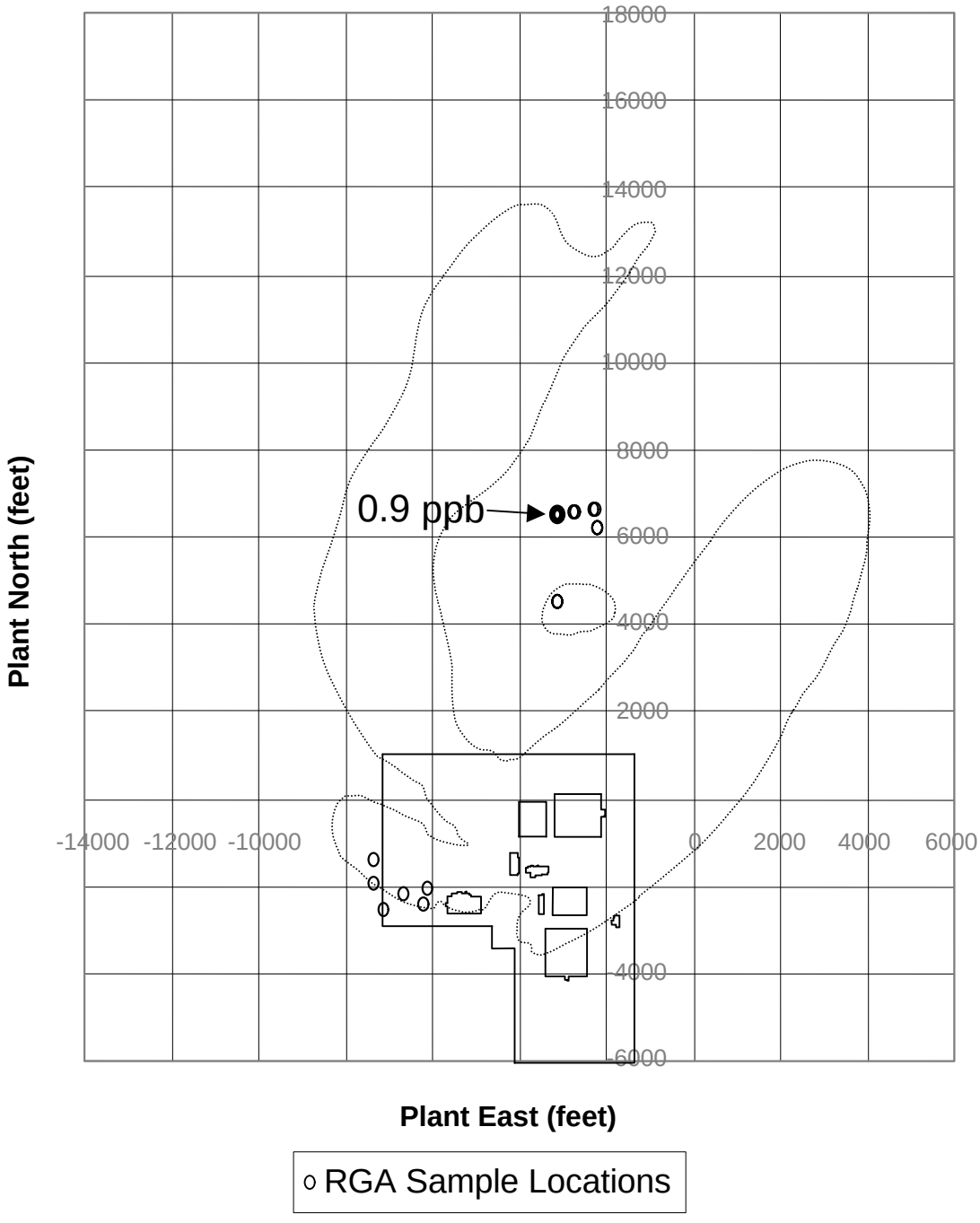

Fig. 4.24. RGA sample locations – PCB-1254 analyses.

4.3.2.3 Metals

Previous human-health risk models have identified 16 metals that have been retained as priority contaminants for the GWOU. As in previous sections, Figs. 4.25 through 4.56 map the density of RGA water sample locations and maximum detected levels. However, with the exception of boron, dissolved metals levels are reported with respect to the PGDP background concentrations that are documented in Appendix D to the GWOU FS. In the absence of an established PGDP background concentration, boron levels are mapped as ppm. The background concentrations determined from filtered water samples were used as a conservative comparison to highlight areal trends in the metals data. Table 4.3 summarizes the reference background concentrations and detected levels for each metal.

Tables 4.4 and 4.5 present comparisons of the metals analyses against background levels derived from total (whole) water samples and against MCLs.

Of the 15 priority contaminant metals, aluminum, chromium, iron, and manganese occur the most frequently (50 to 87% of sample locations) at levels equal to or greater than 5 times background. High levels of iron are evenly distributed across the map area while elevated aluminum and manganese levels off-site appear to be prevalent in the west half of the PGDP. The distribution of elevated chromium levels off-site suggests the contaminant may be associated with the Northeast and Southwest Plumes.

The GWOU FS database contains 68 analyses for chromium from filtered water samples. These samples are more characteristic of dissolved metals levels in groundwater. Of these analyses, 19 (representing 17 wells) report a detection of chromium. (Only two samples contained chromium levels above the MCL.) All but 6 of these analyses (samples from 4 wells) characterize groundwater of the C-746-S&T Landfill. Recent inspection of the monitoring wells at the C-746-S&T Landfill has revealed that the stainless steel well casings are deteriorated. Biodegredation of the well casing is suspected as the cause of the elevated chromium levels. The DOE has a project in place to replace wells at the C-746-S&T Landfill (and neighboring C-746-U Landfill) with more resistant materials upon completion of a study of some of the well casings.

Antimony, beryllium, cadmium, and silver are rarely detected in off-site RGA water samples. Higher arsenic levels occur beneath the PGDP but the contaminant is largely undetected off-site. Barium appears to be associated with the off-site groundwater contaminant plumes, but generally at levels of less than 2 times background concentrations. Likewise, copper levels appear to be related to the off-site groundwater contaminant plumes, with concentrations decreasing offsite.

Fluoride and vanadium are frequently detected in off-site RGA water samples but uniformly below background concentrations. Isolated occurrences of elevated levels of the metals are found on-site. Likewise, nickel and uranium are typically less than 2 times background levels in off-site RGA water samples. Only isolated off-site occurrences of levels of these metals greater than 5 times the background concentrations are evident from the GWOU database.

Boron is the only priority contaminant metal with a poor scattering of sample locations. The distribution of boron in groundwater based on the GWOU database does not define an anomaly that might be associated with a contaminant source. However, a trend of higher levels from the C-746-S/T Landfill area may exist.

The DOE is continuing to assess the nature and extent of metals contamination associated with the PGDP. Results of this assessment will be presented in a forthcoming White Paper.

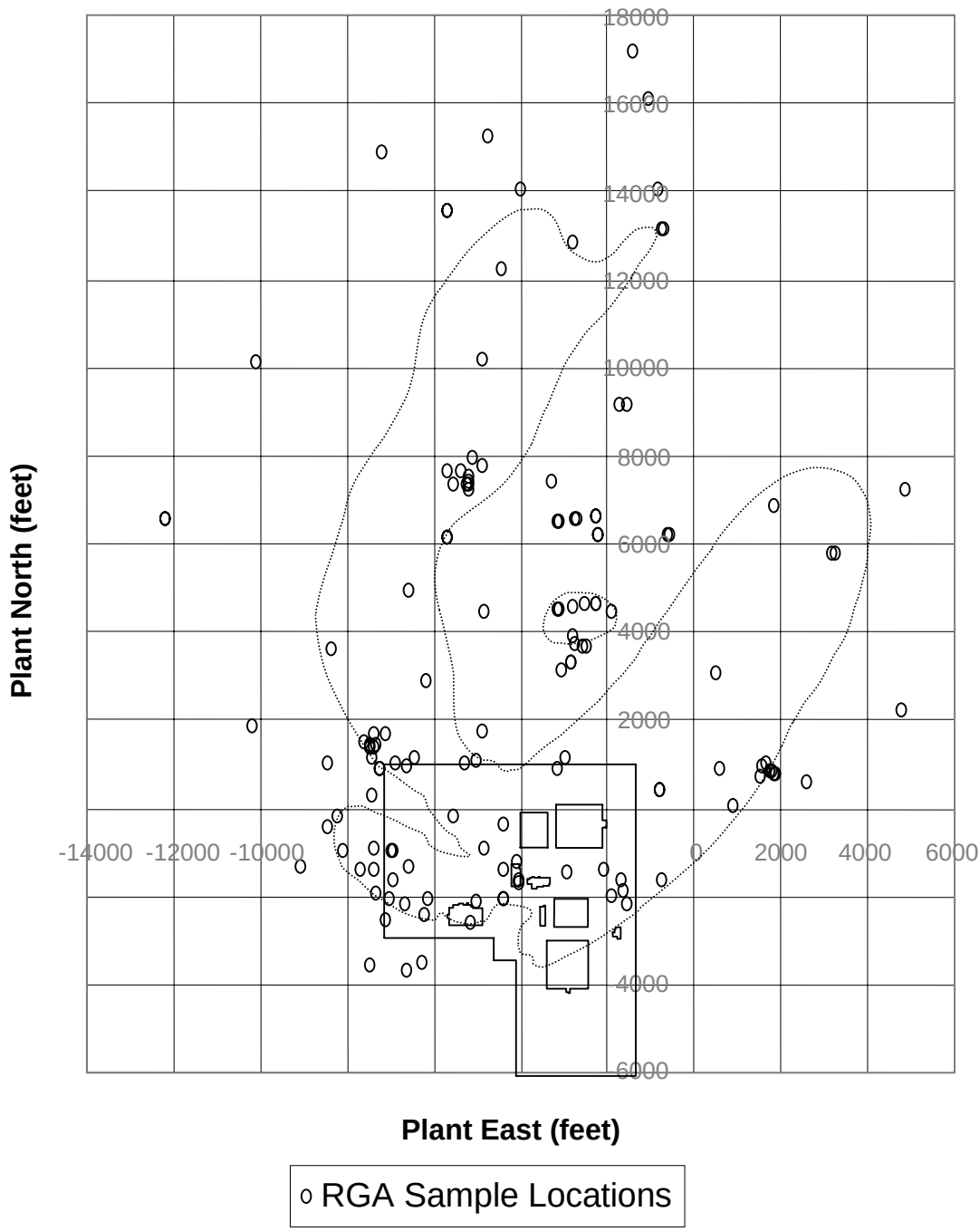

Fig. 4.25. RGA sample locations - aluminum analyses.

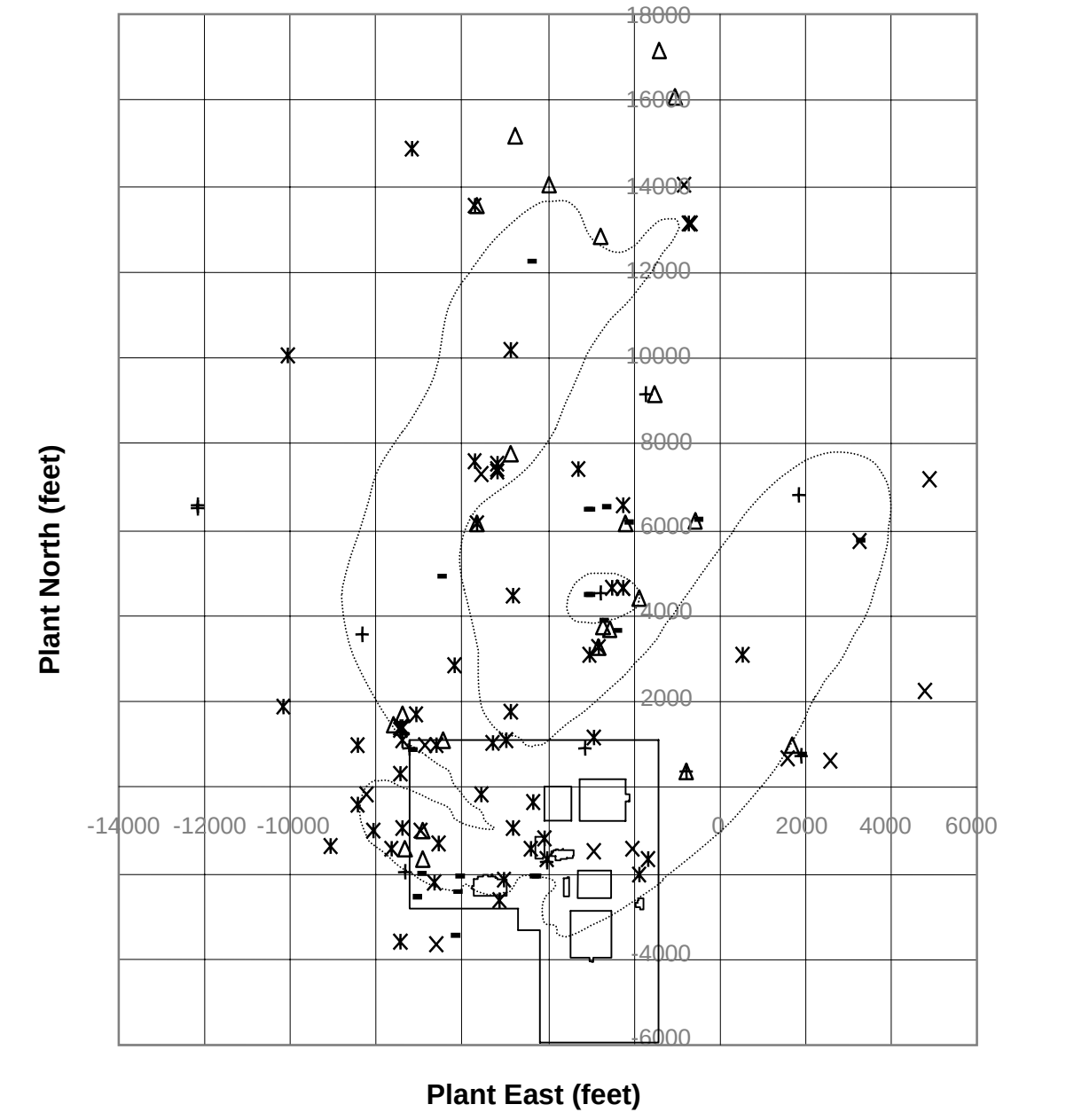

Fig. 4.26. Maximum detected levels of aluminum in RGA groundwater.

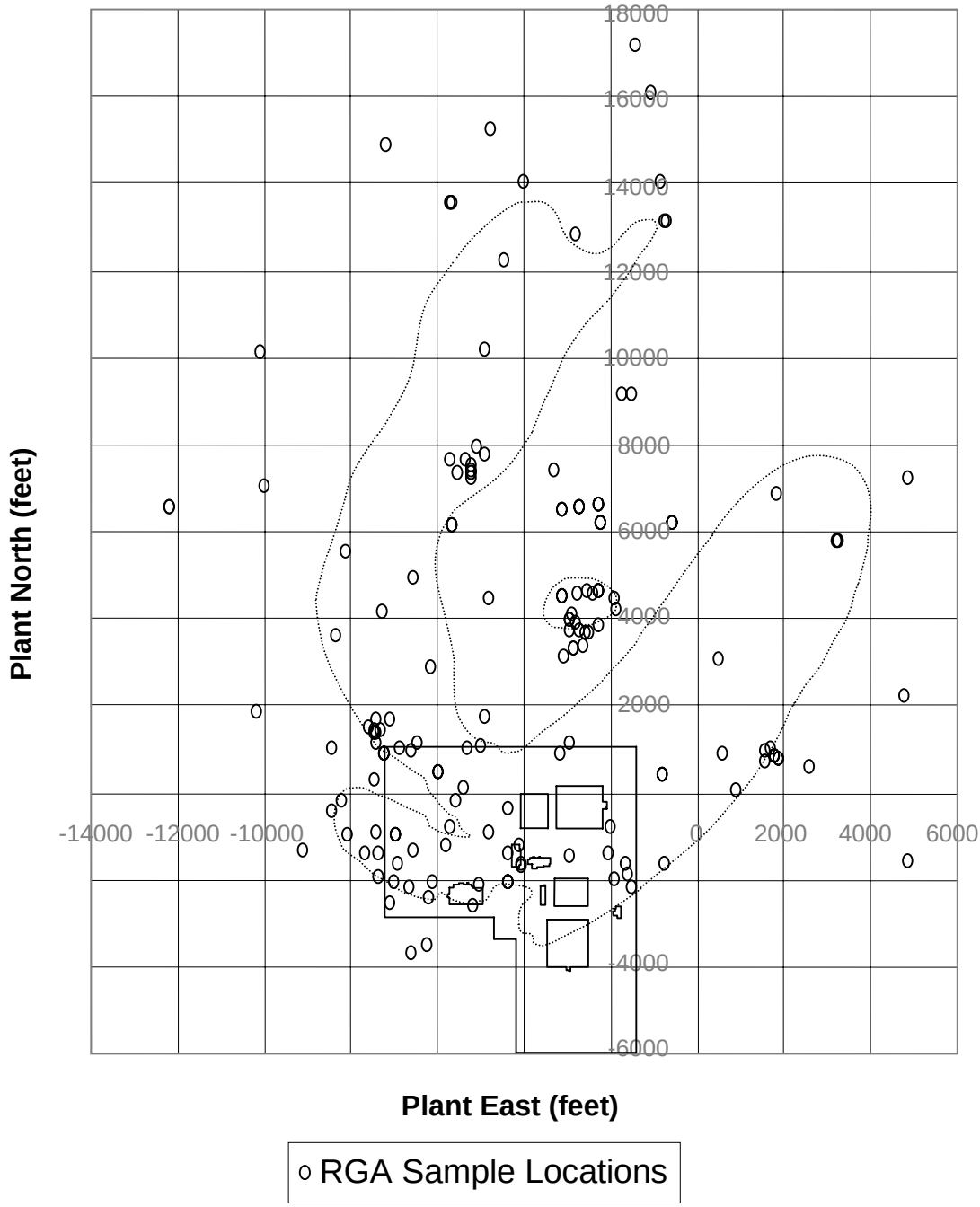

Fig. 4.27. RGA sample locations - antimony analyses.

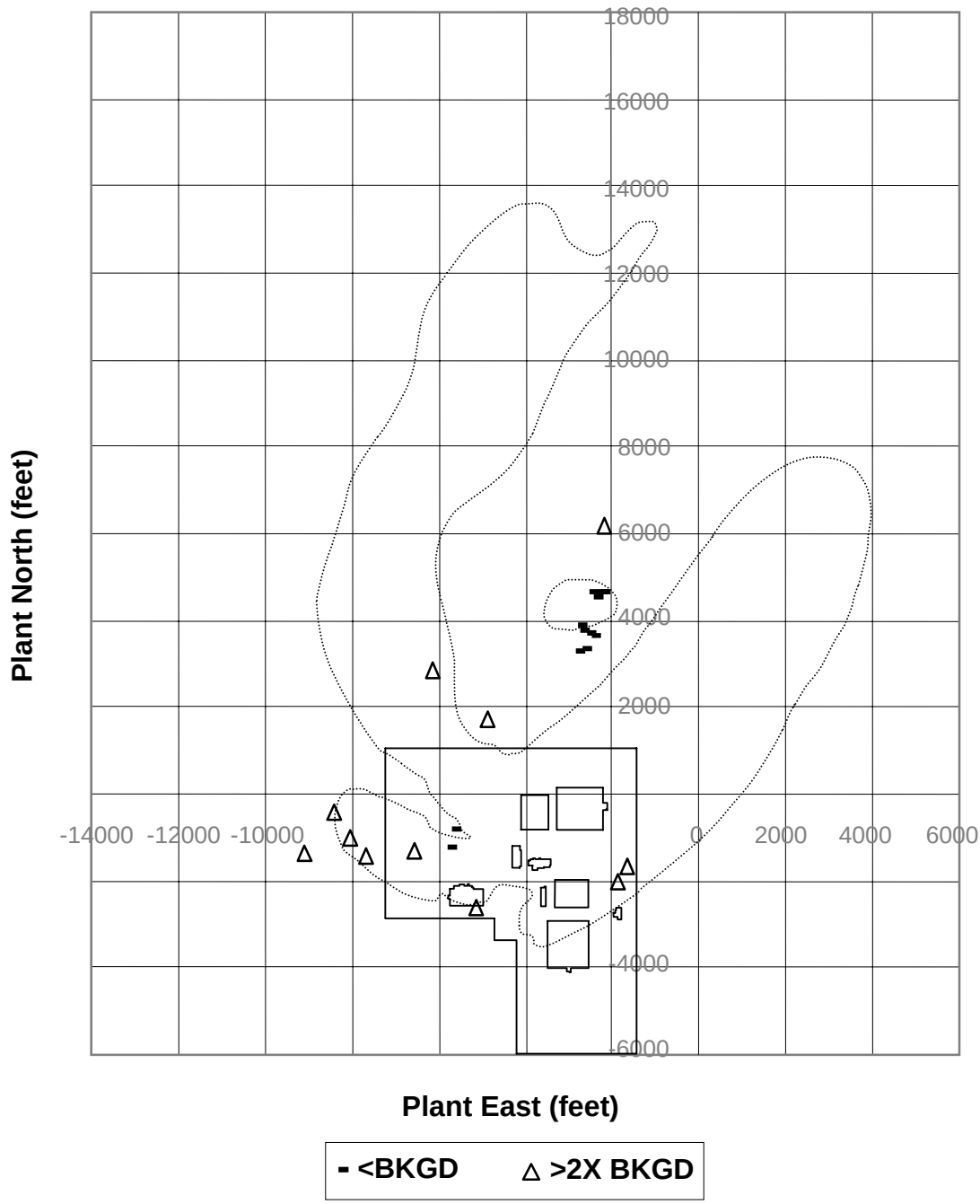

Fig. 4.28. Maximum detected levels of antimony in RGA groundwater.

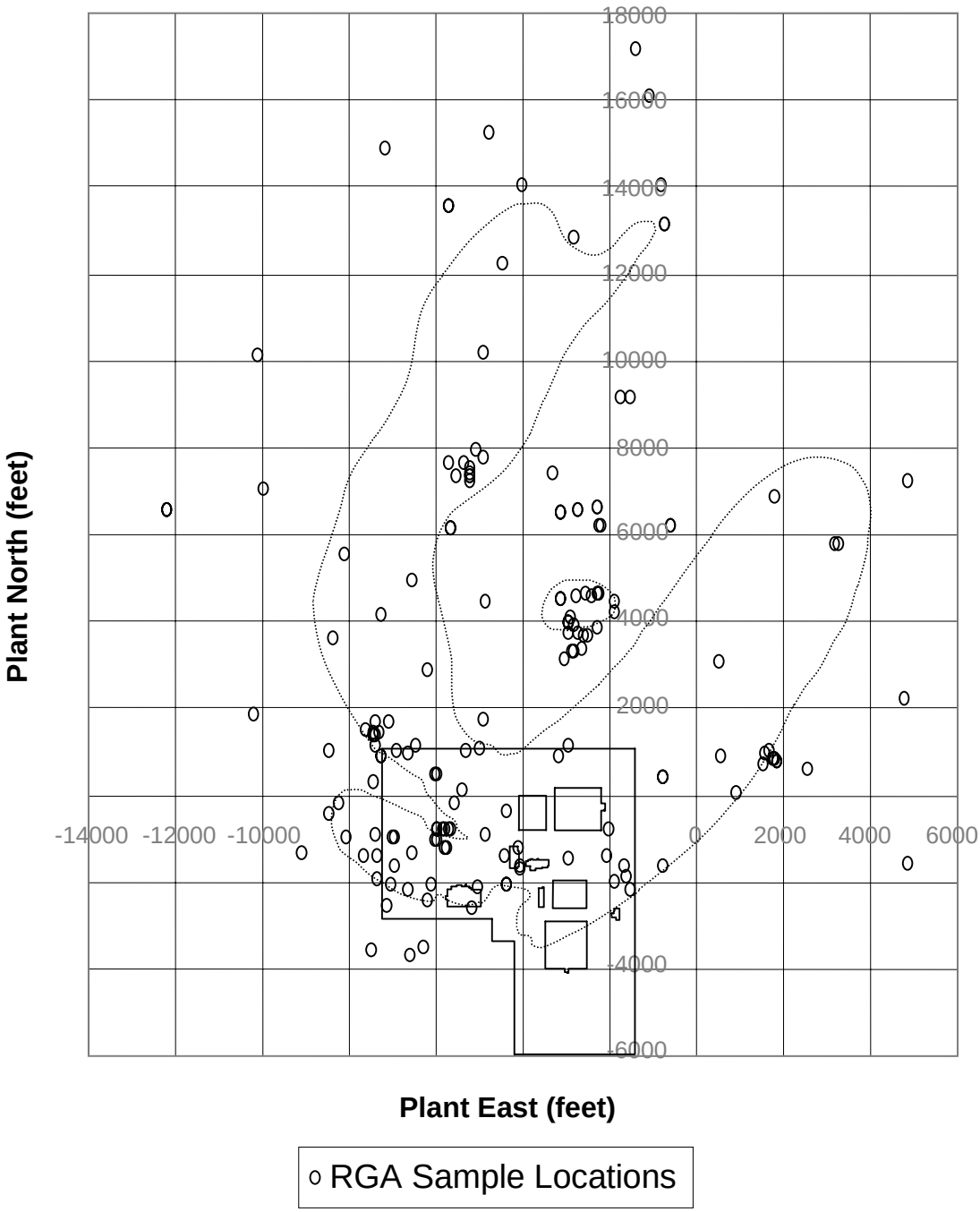

Fig. 4.29. RGA sample locations - arsenic analyses.

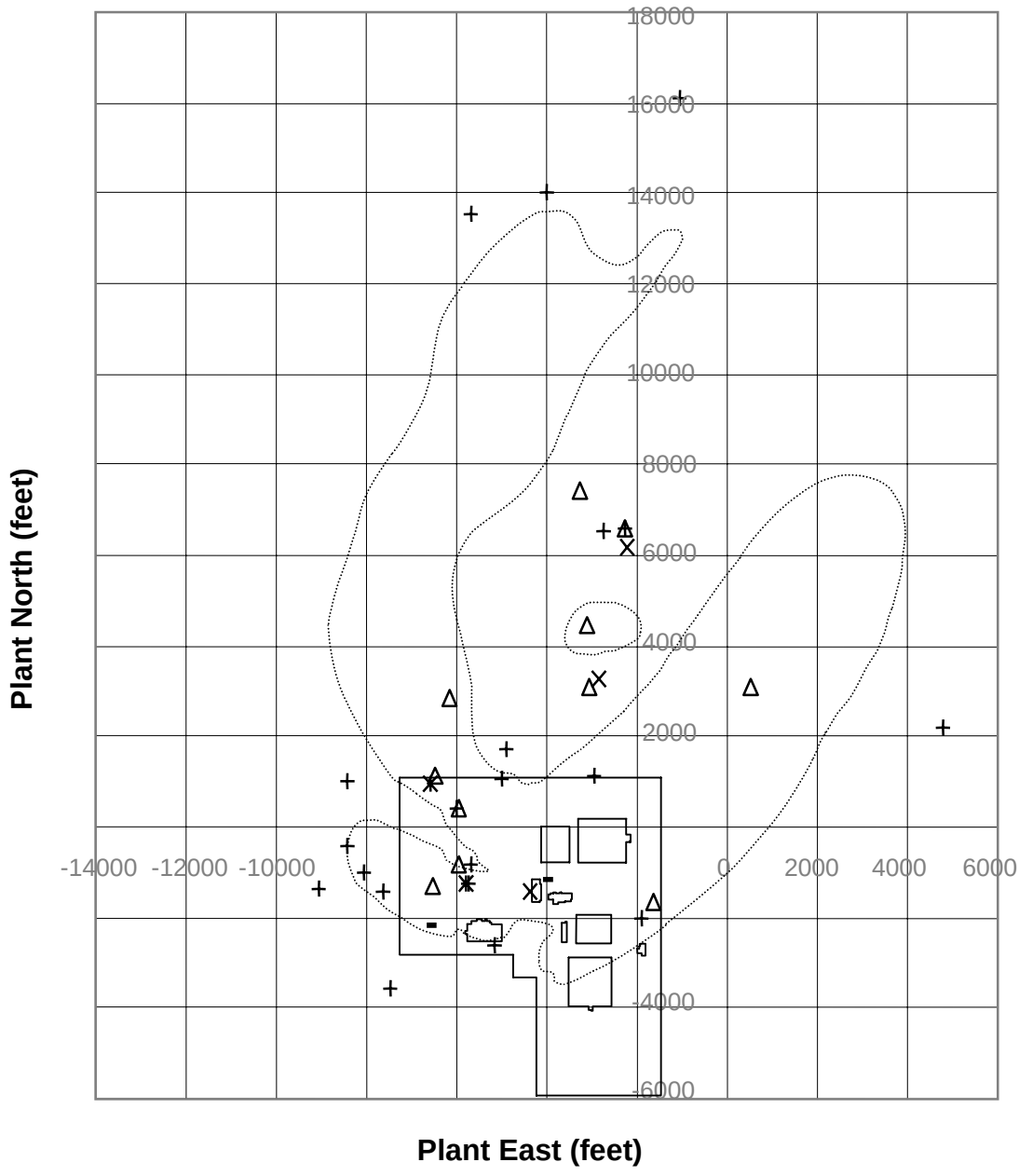

Fig. 4.30. Maximum detected levels of arsenic in RGA groundwater.

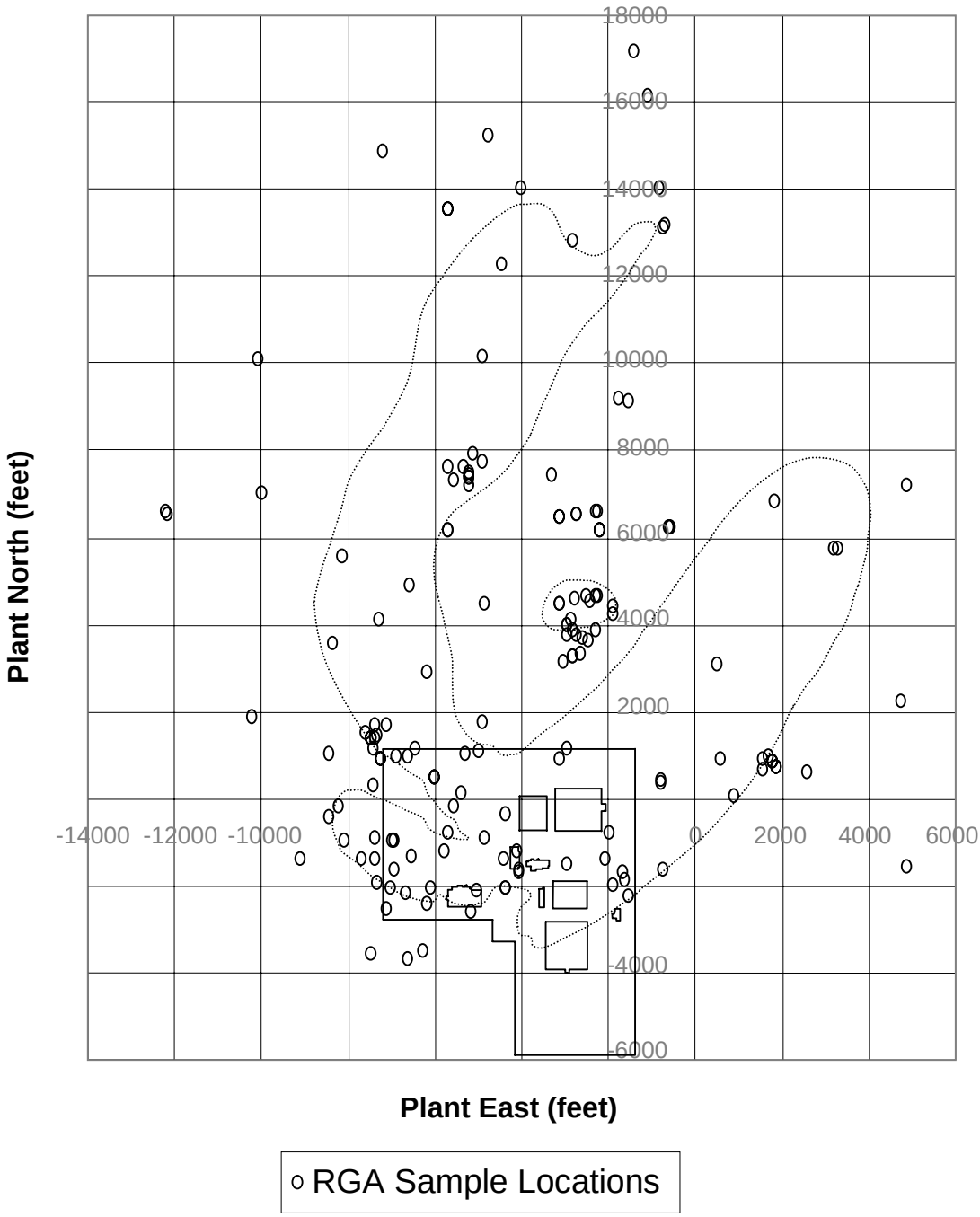

Fig. 4.31. RGA sample locations - barium analyses.

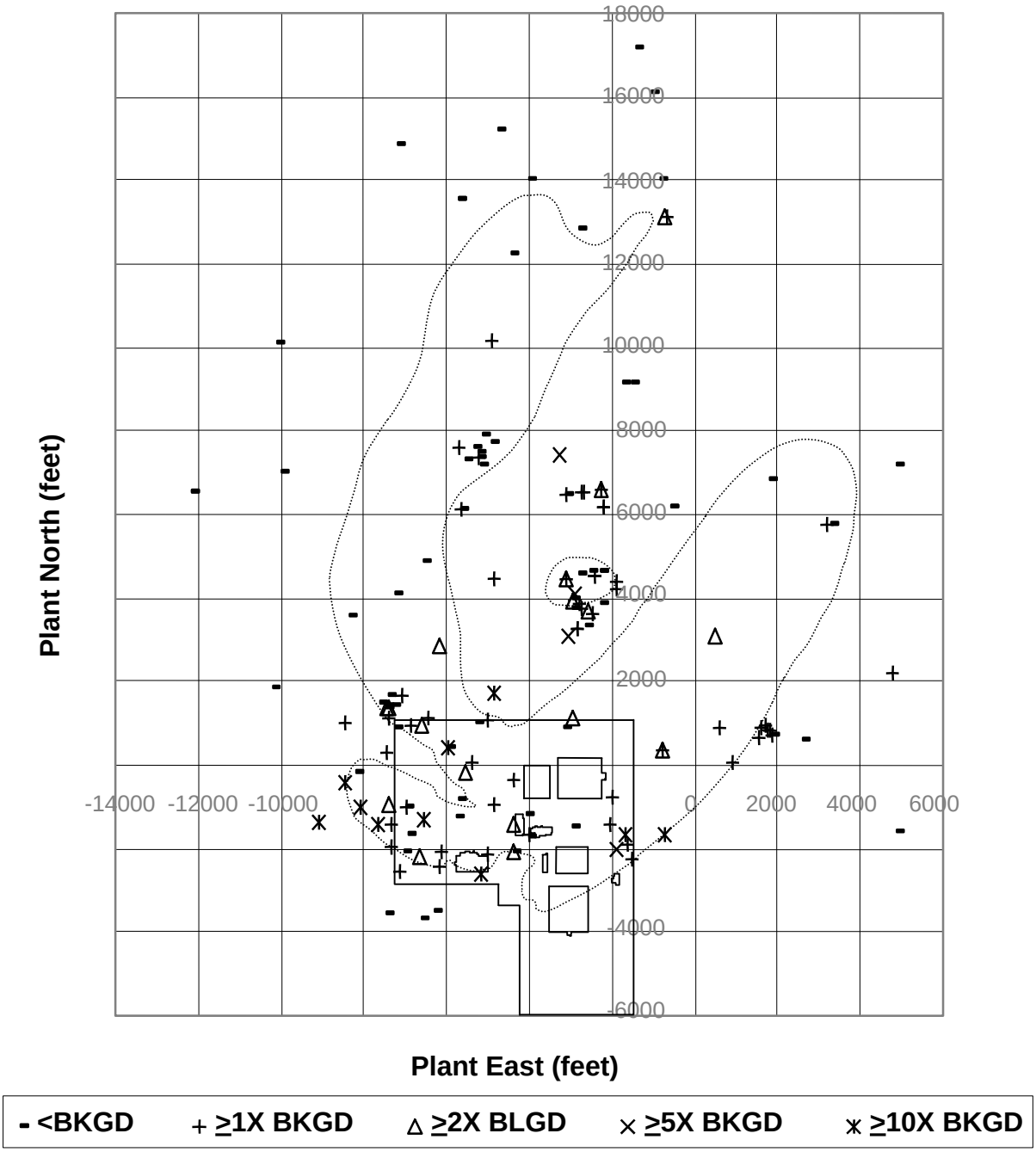

Fig. 4.32. Maximum detected levels of barium in RGA groundwater.

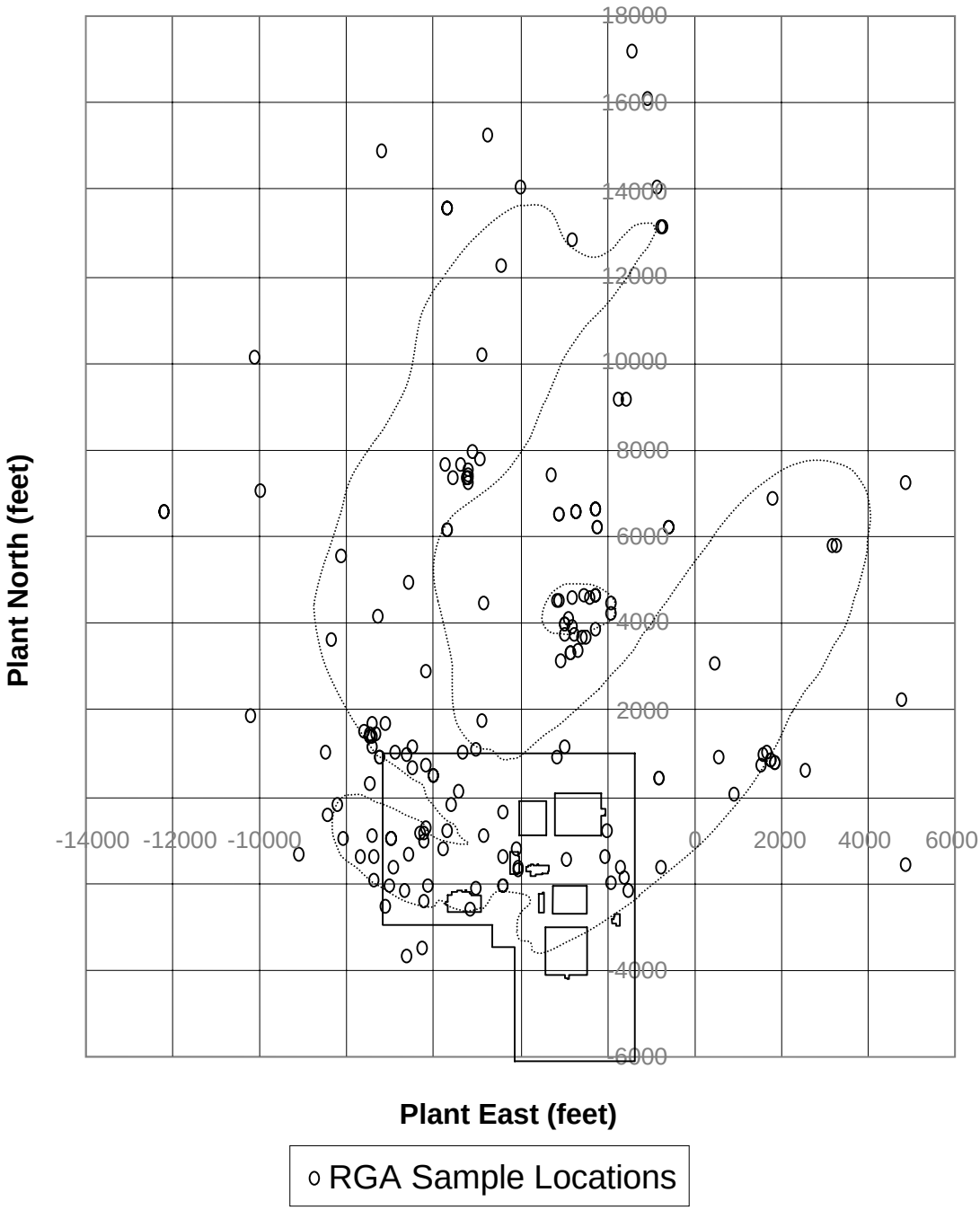

Fig. 4.33. RGA sample locations - beryllium analyses.

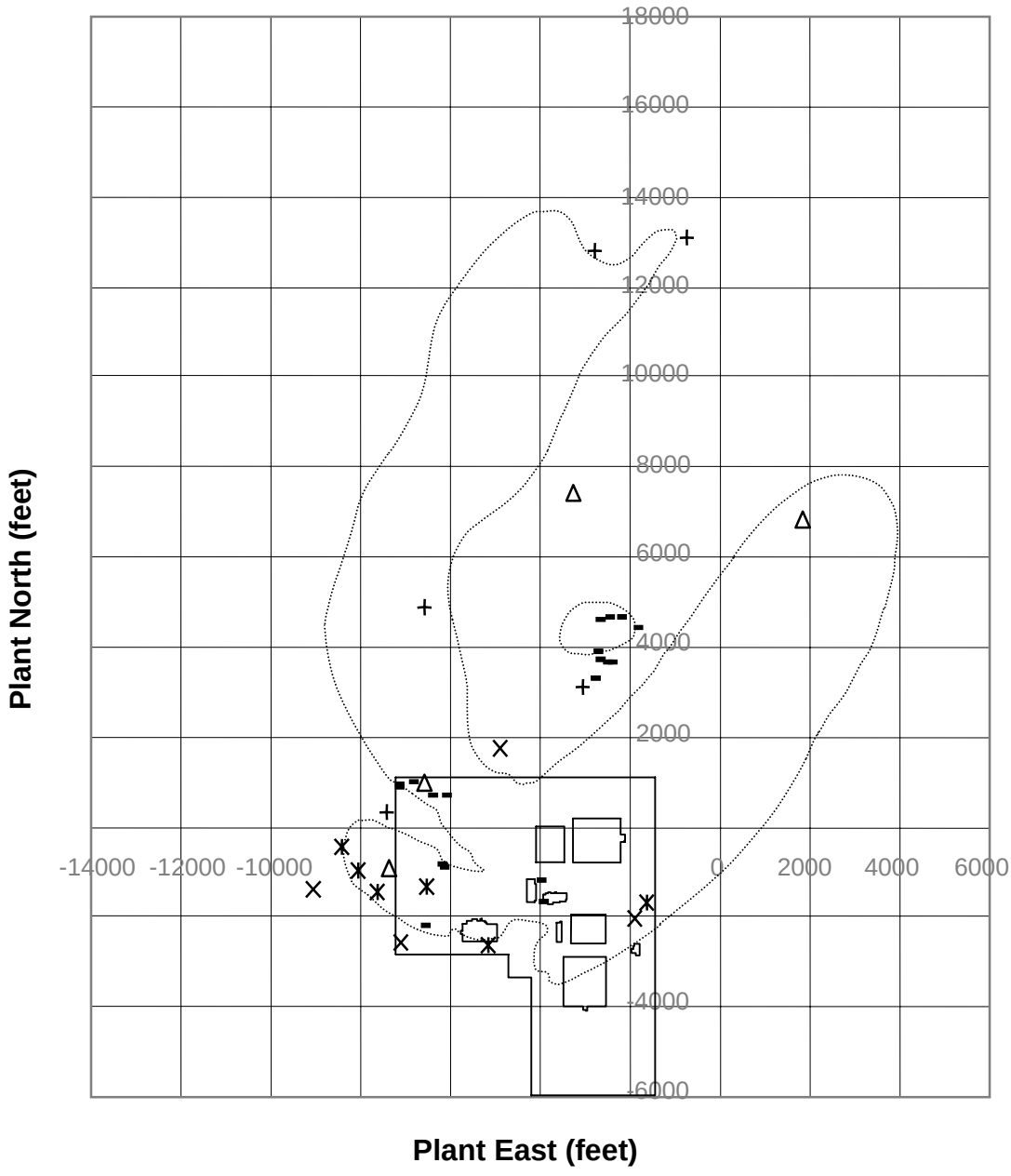

Fig. 4.34. Maximum detected levels of beryllium in RGA groundwater.

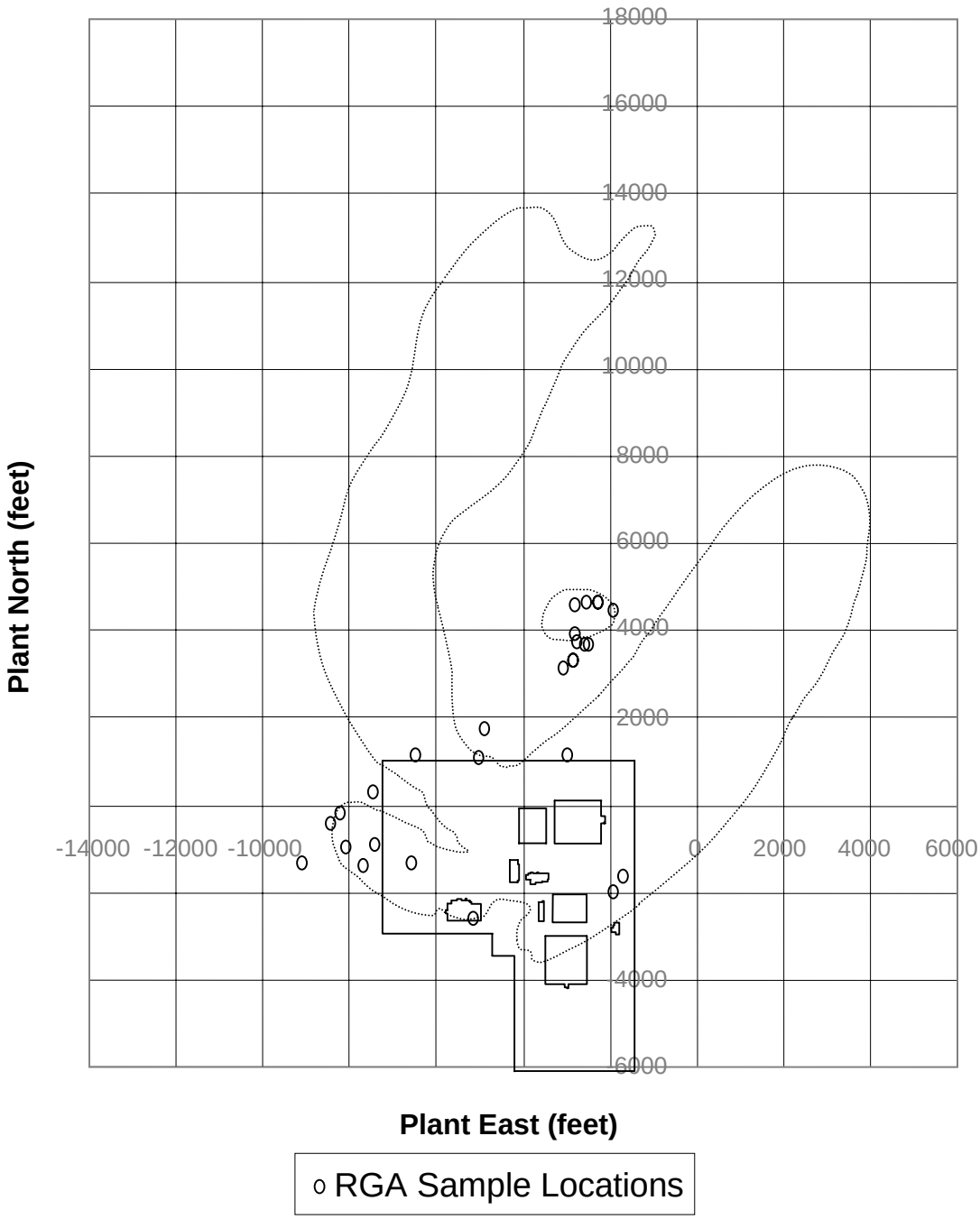

Fig. 4.35. RGA sample locations - boron analyses.

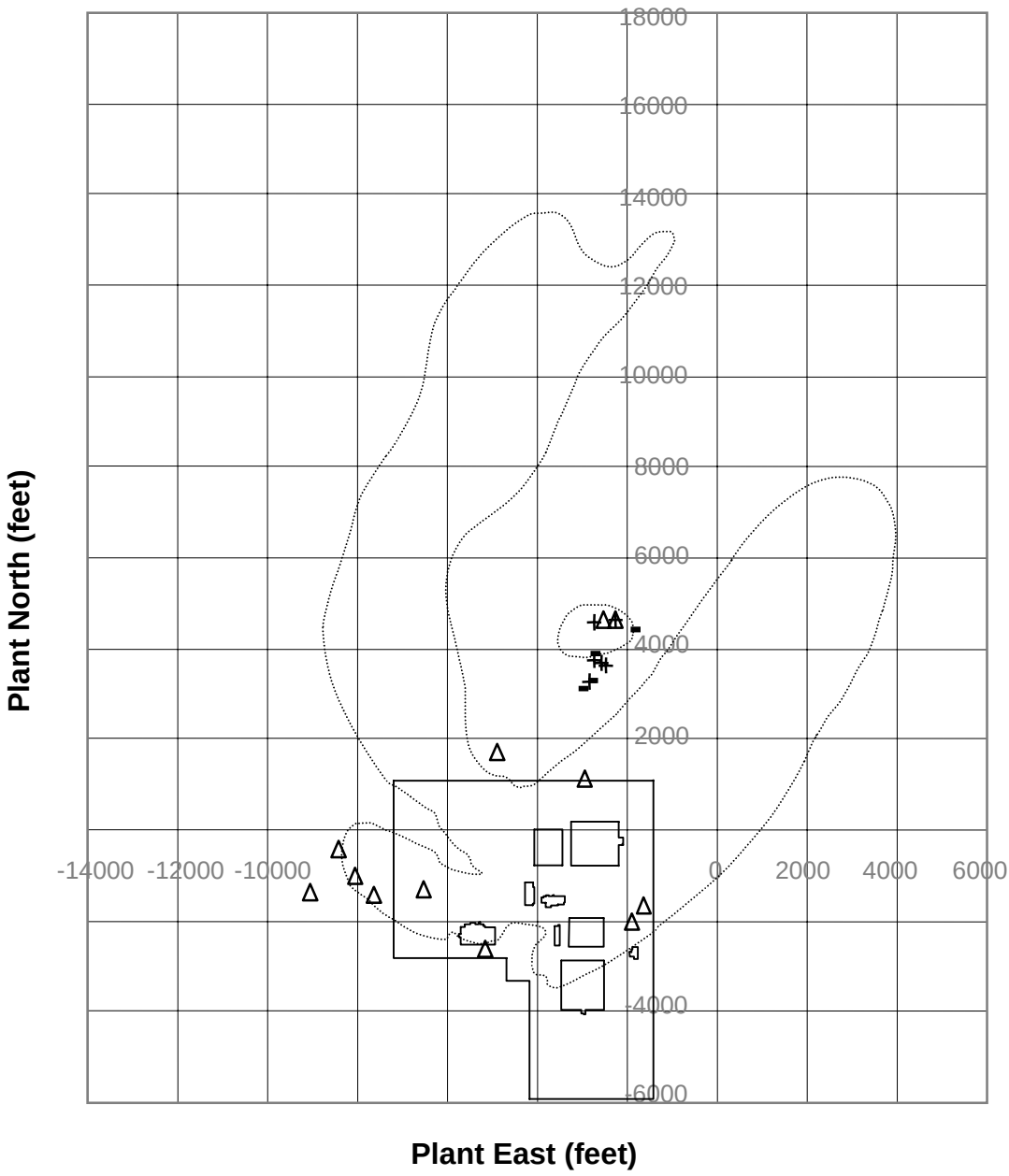

Fig. 4.36. Maximum detected levels of boron in RGA groundwater.

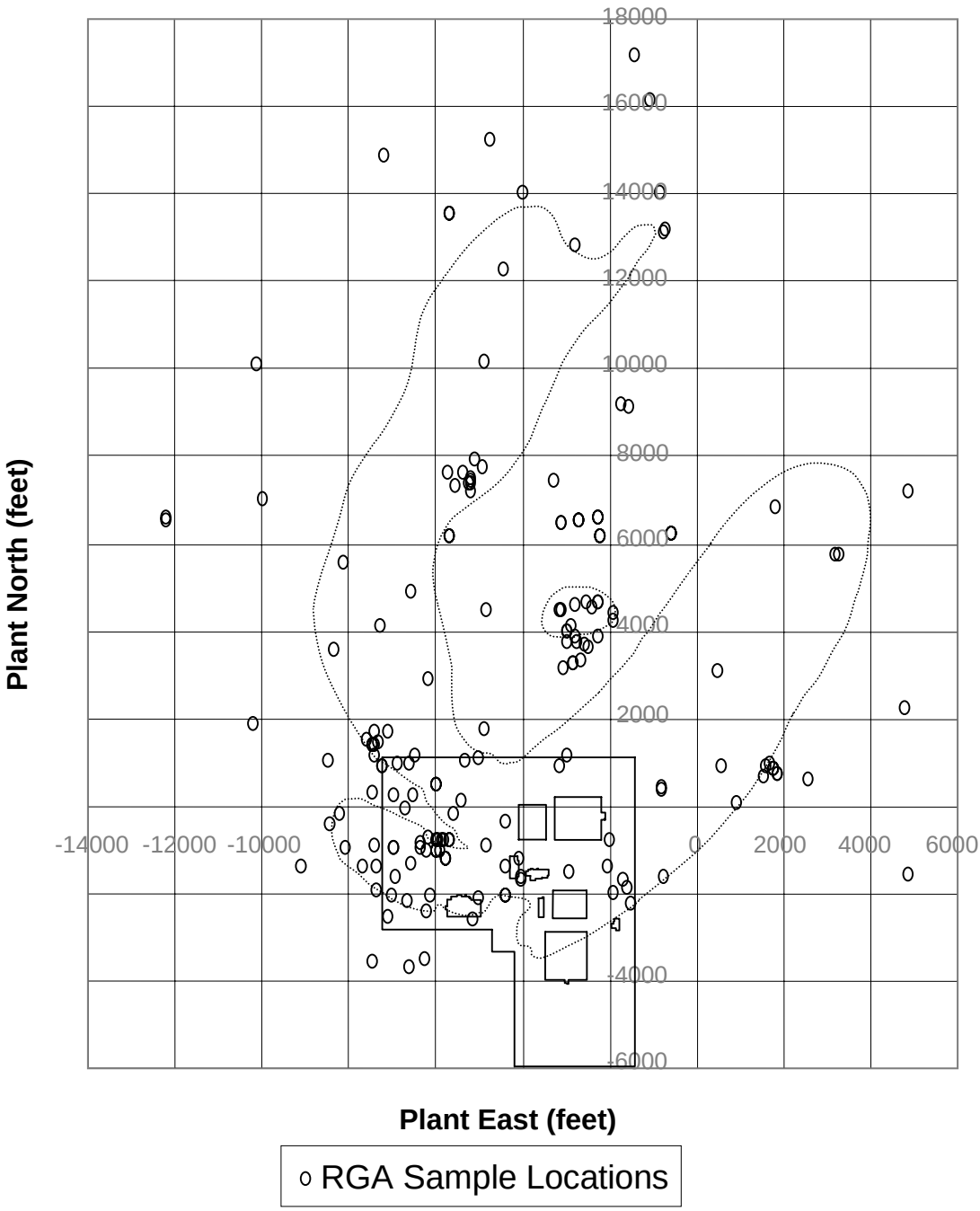

Fig. 4.37. RGA sample locations - cadmium analyses.

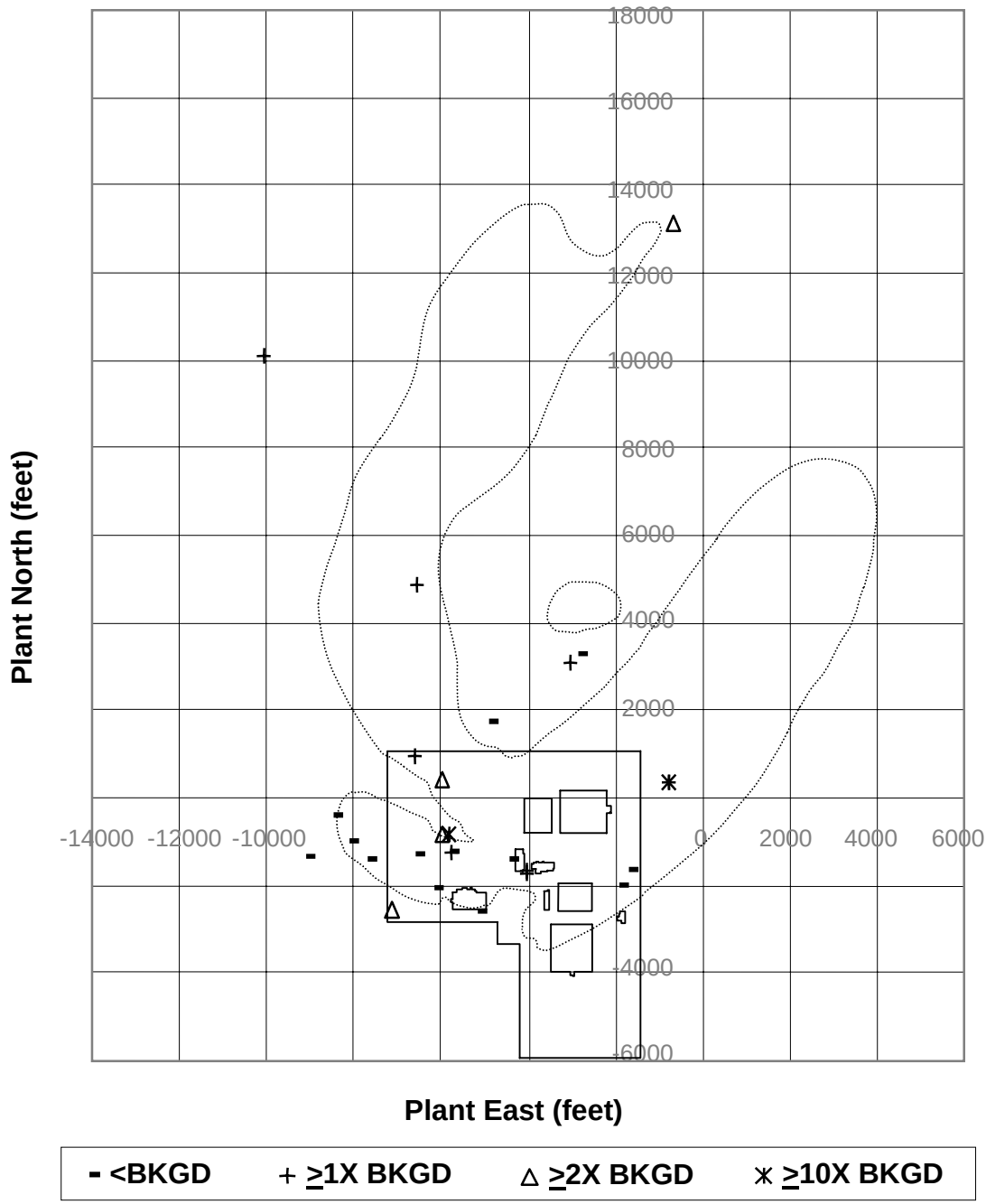

Fig. 4.38. Maximum detected levels of cadmium in RGA groundwater.

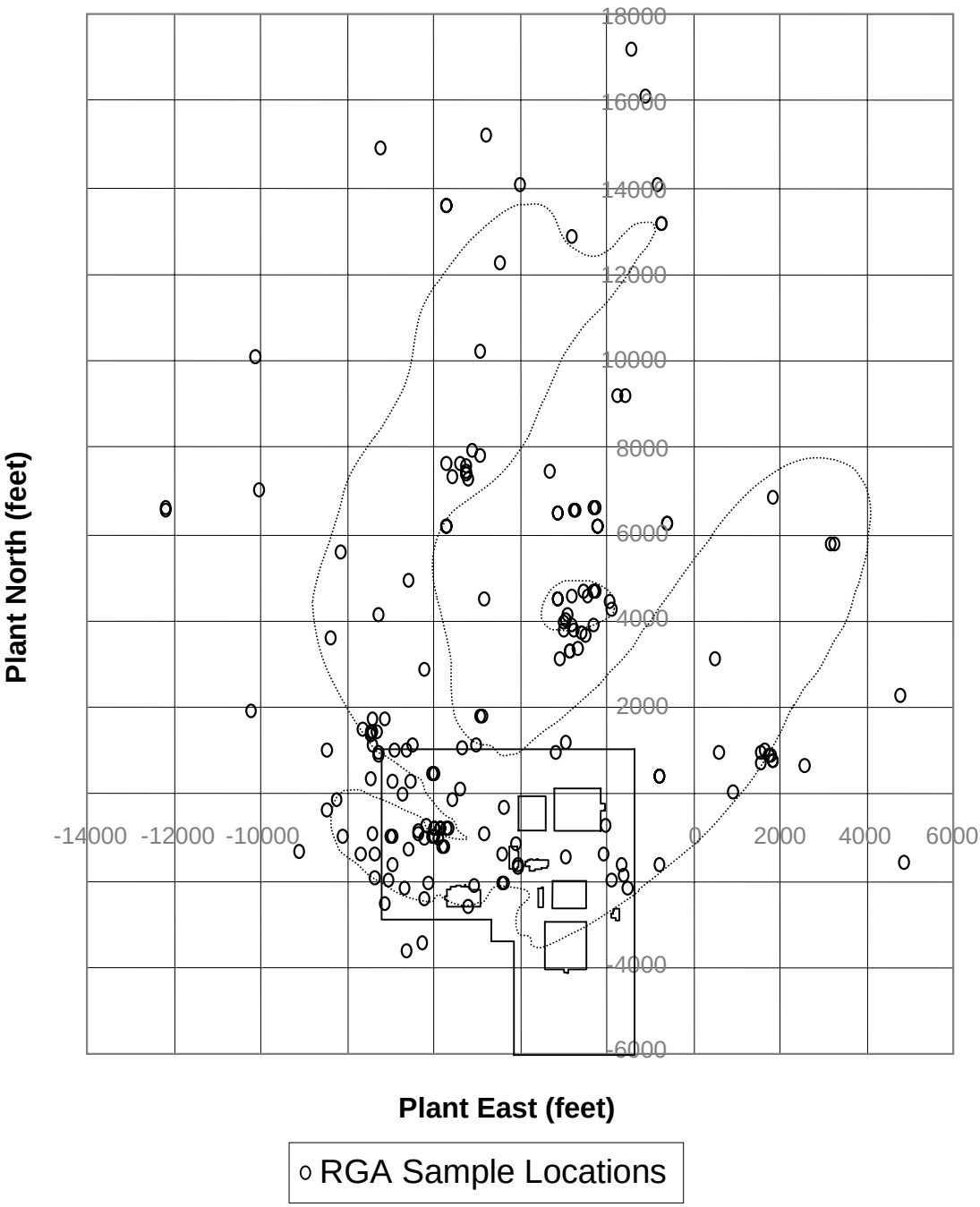

Fig. 4.39. RGA sample locations - chromium analyses.

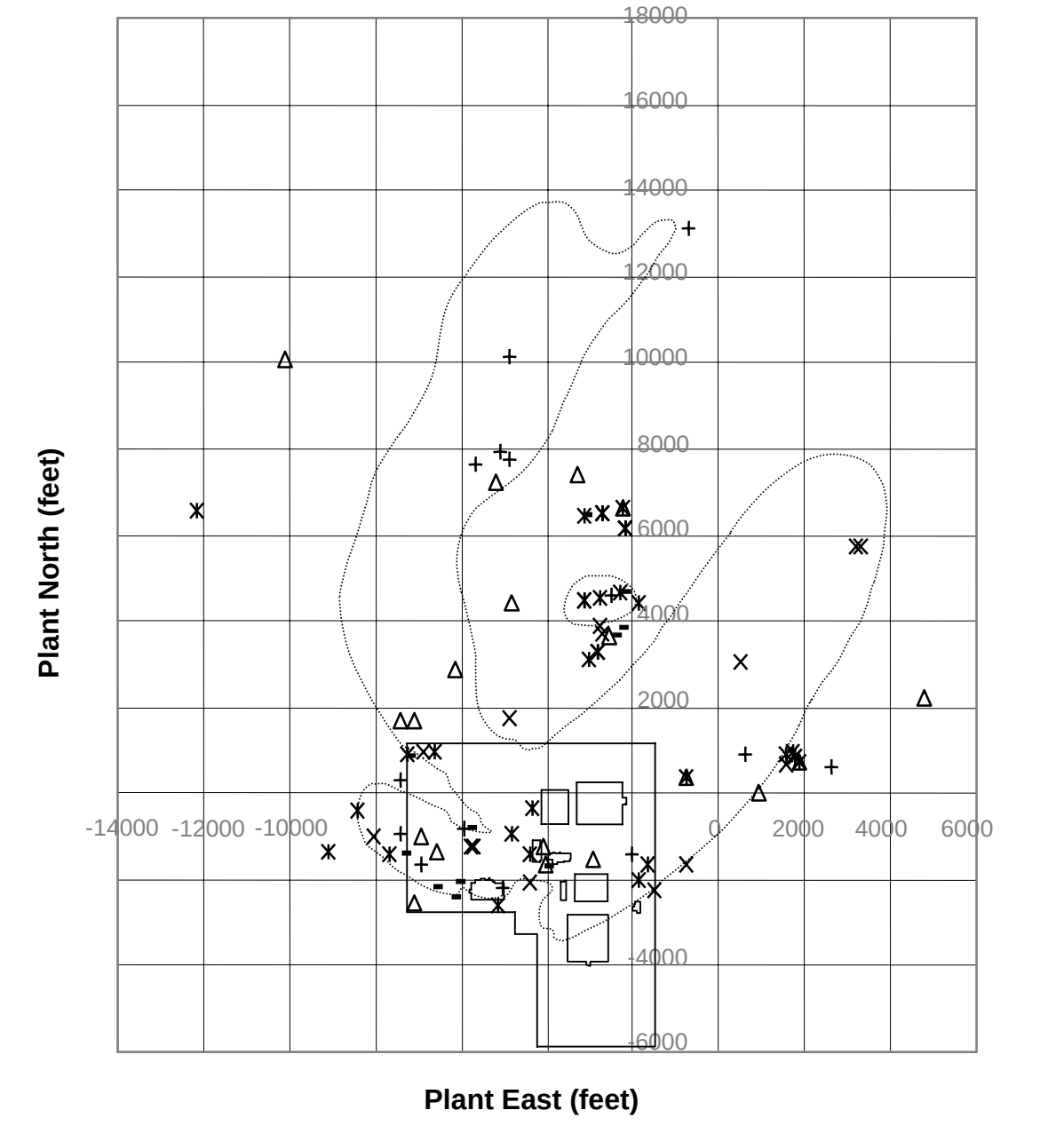

Fig. 4.40. Maximum detected levels of chromium in RGA groundwater.

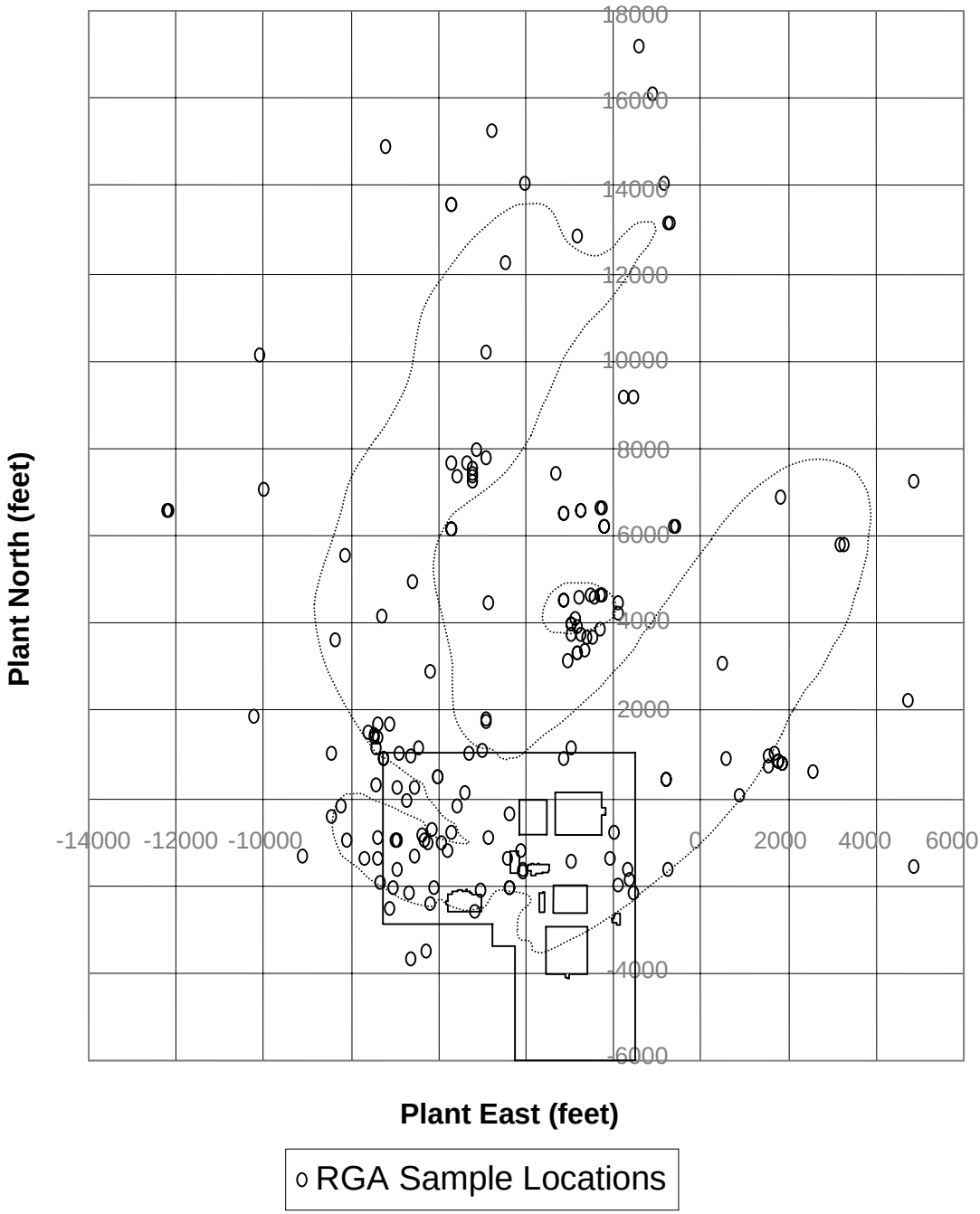

Fig. 4.41. RGA sample locations - copper analyses.

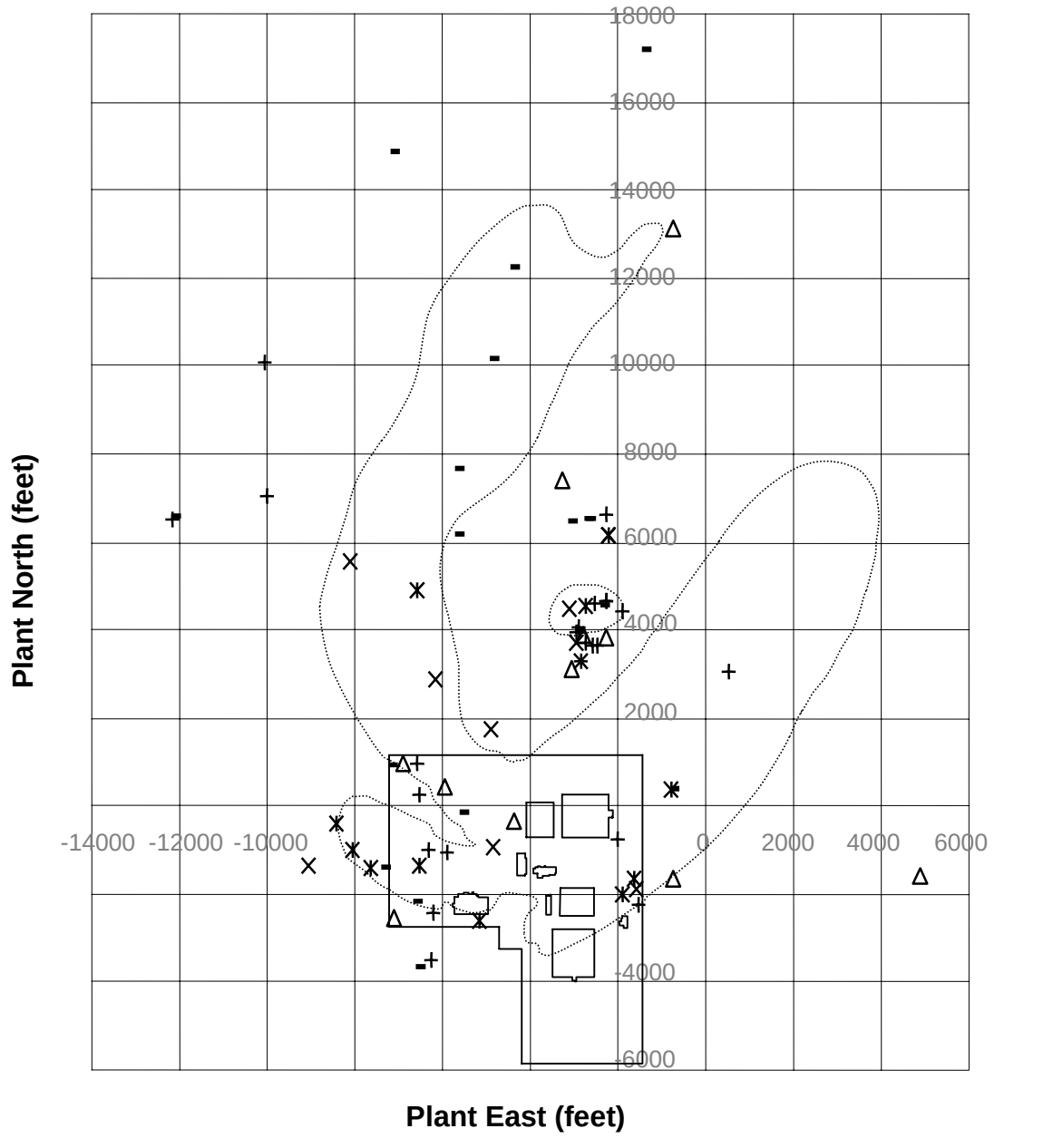

Fig. 4.42. Maximum detected levels of copper in RGA groundwater.

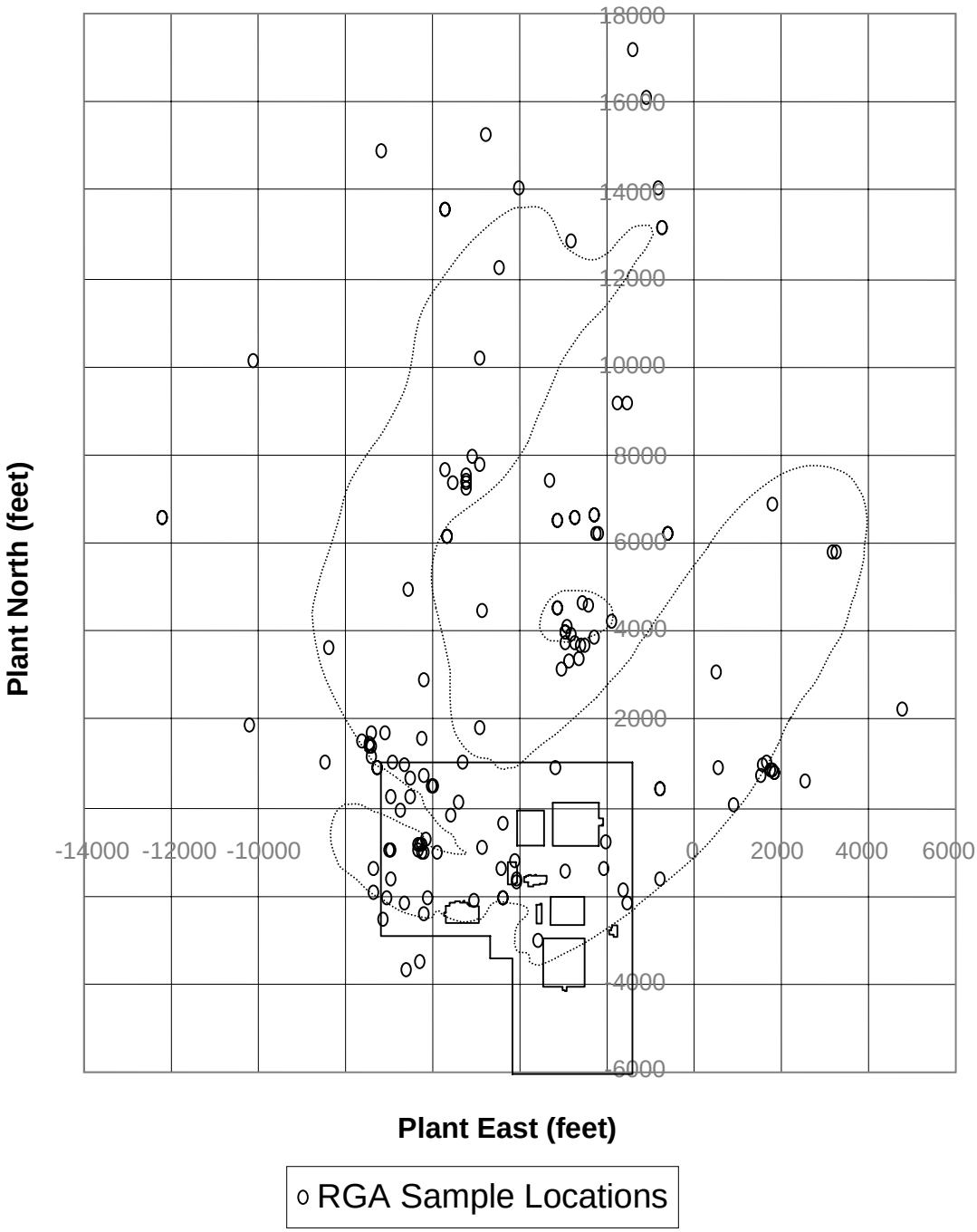

Fig. 4.43. RGA sample locations - fluoride analyses.

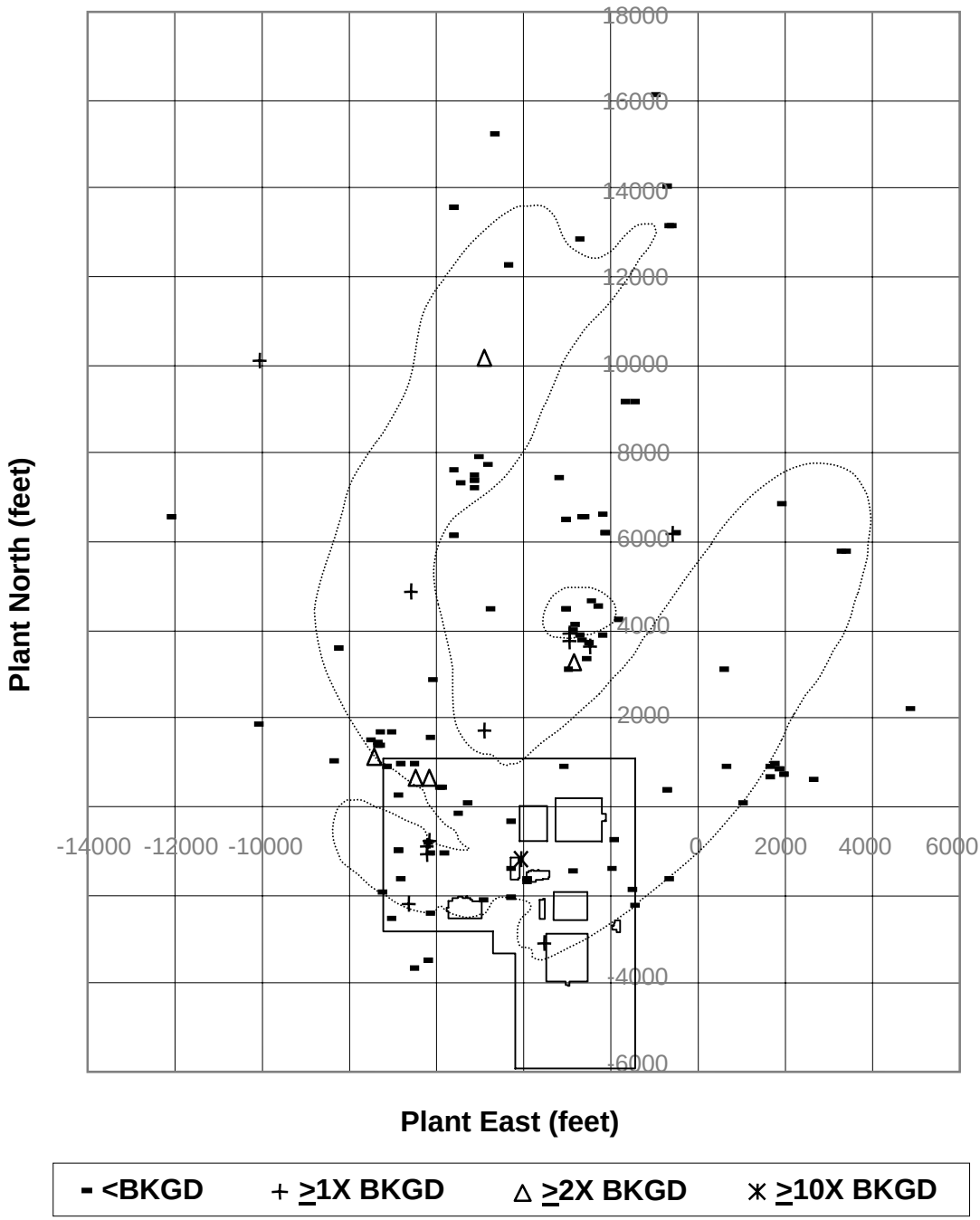

Fig. 4.44. Maximum detected levels of fluoride in RGA groundwater.

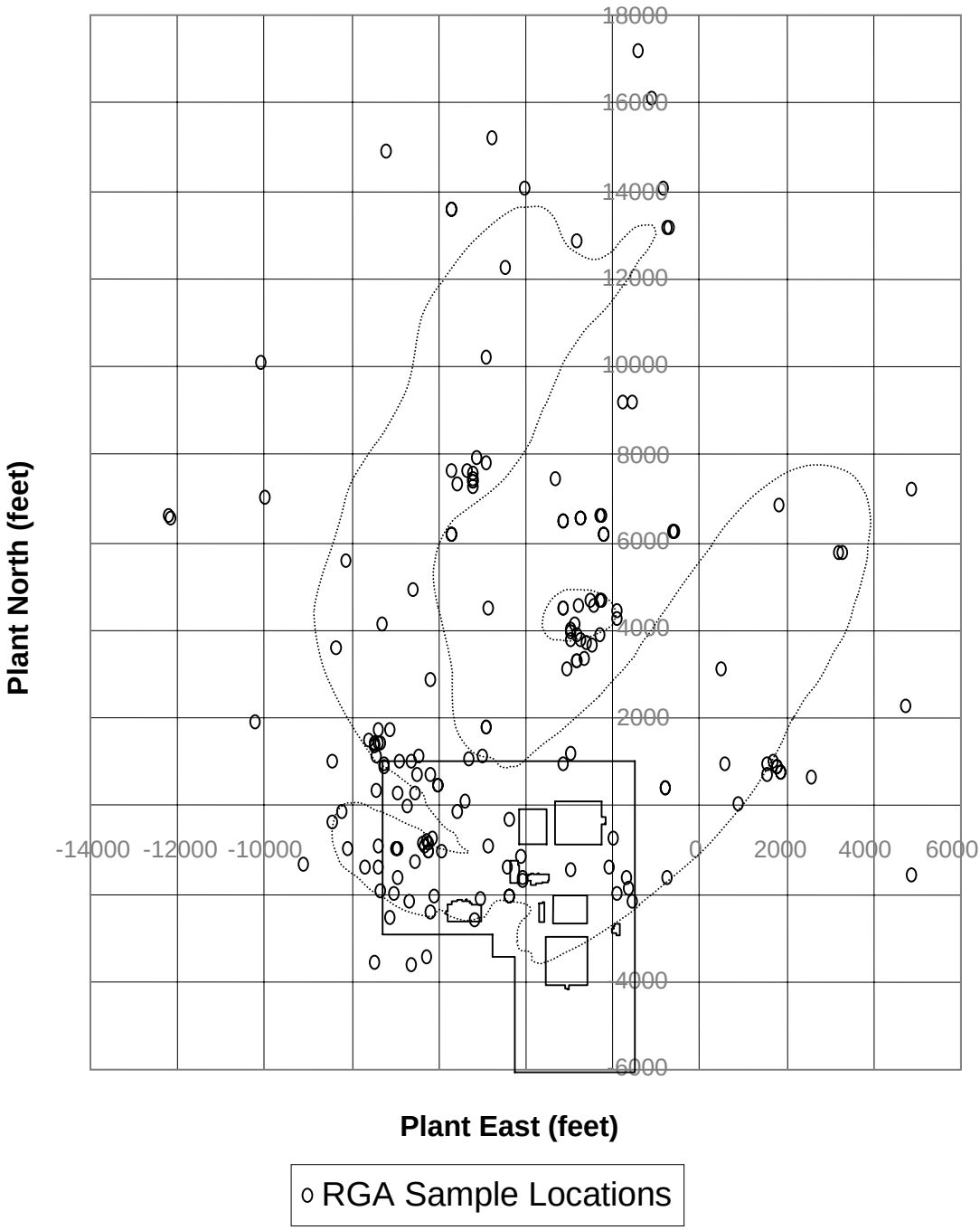

Fig. 4.45. RGA sample locations - iron analyses.

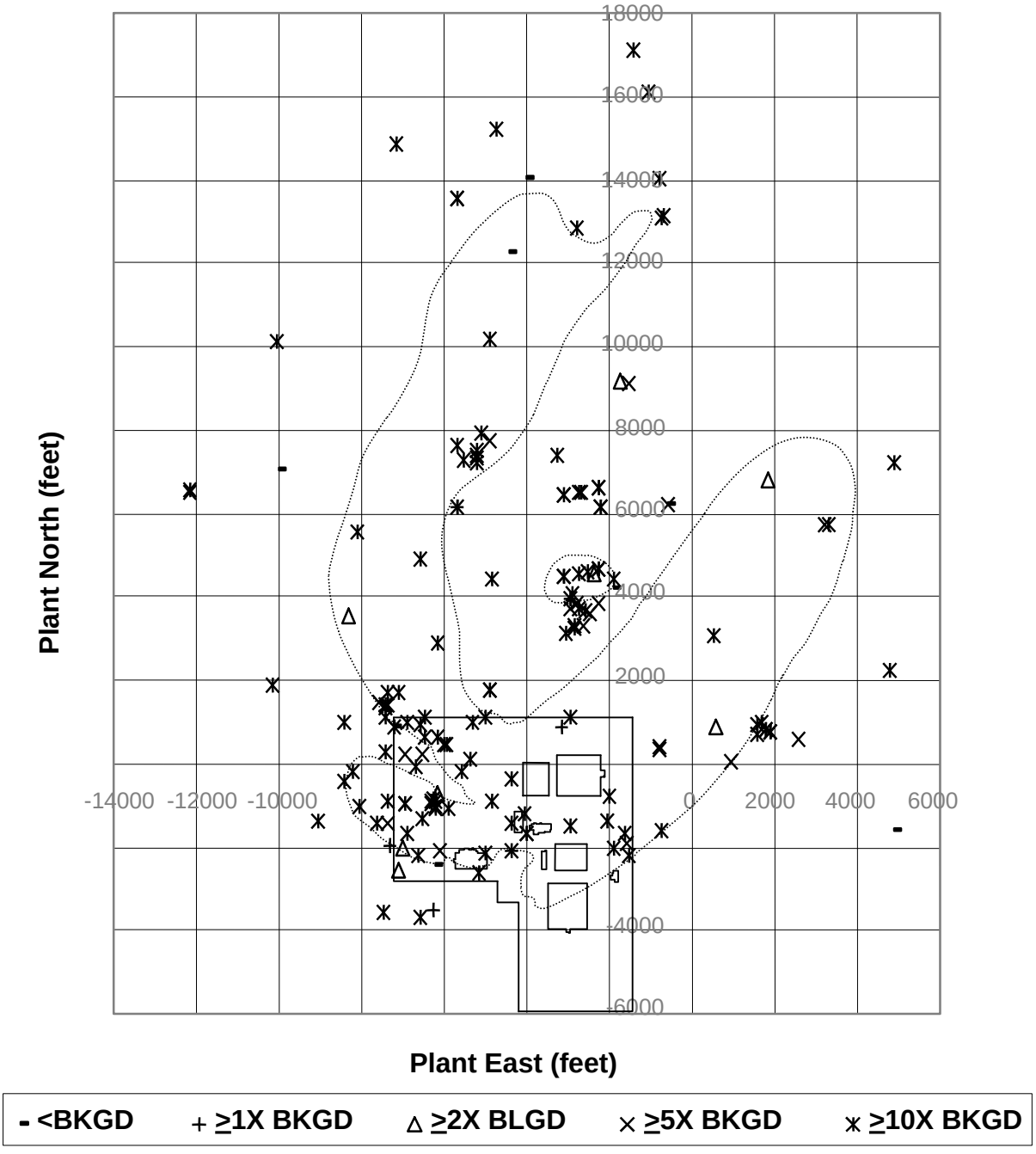

Fig. 4.46. Maximum detected levels of iron in RGA groundwater.

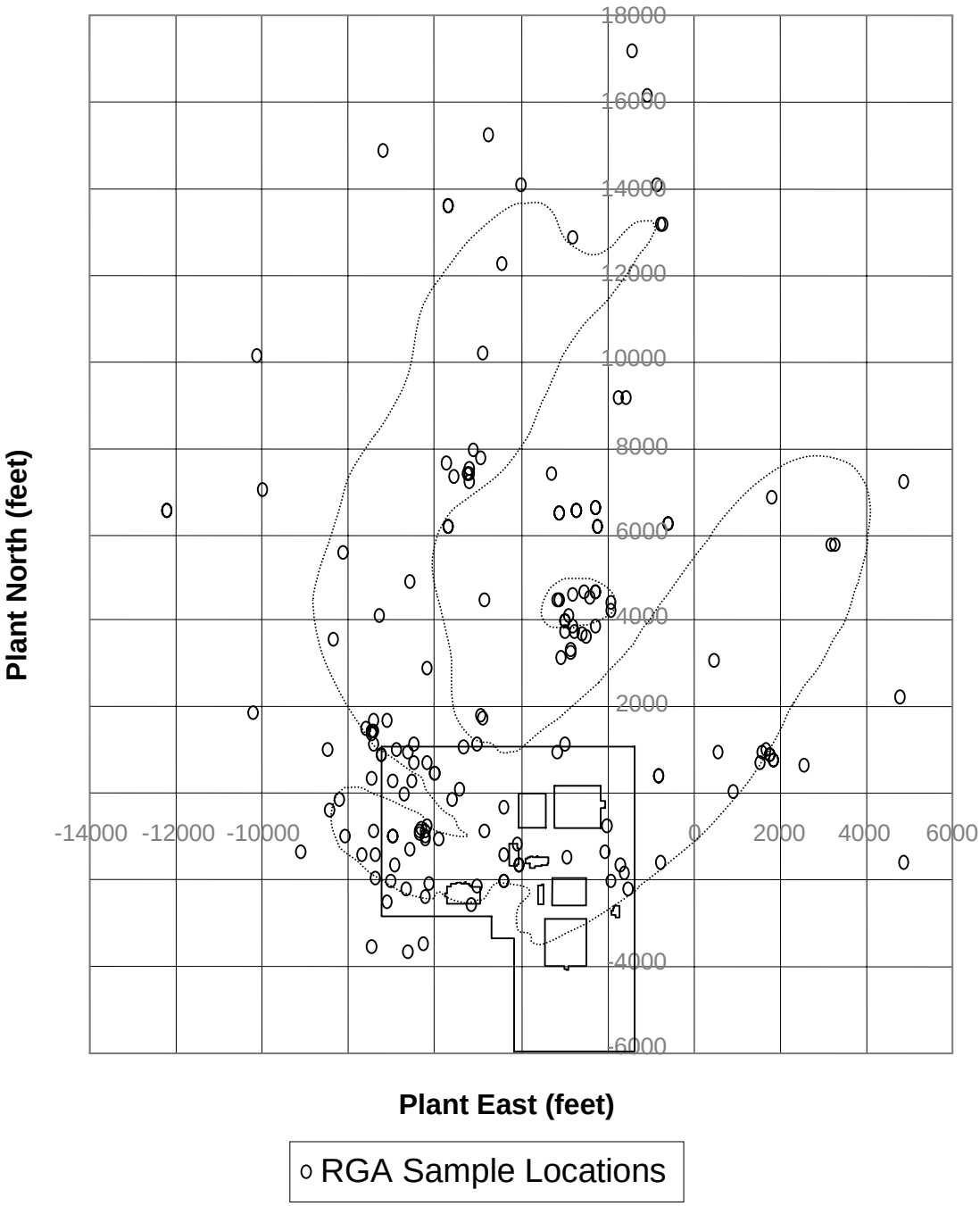

Fig. 4.47. RGA sample locations - manganese analyses.

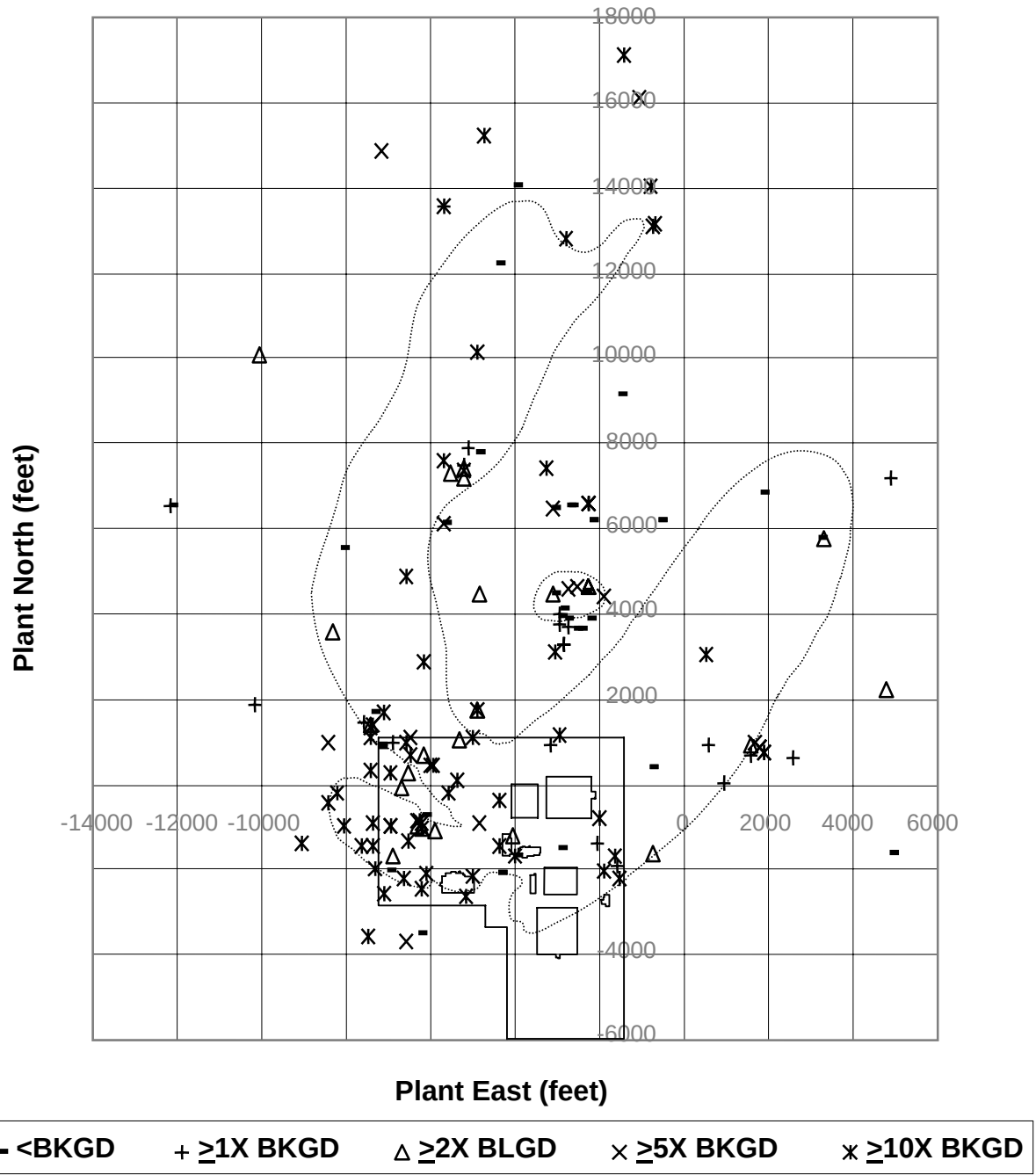

Fig. 4.48. Maximum detected levels of manganese in RGA groundwater.

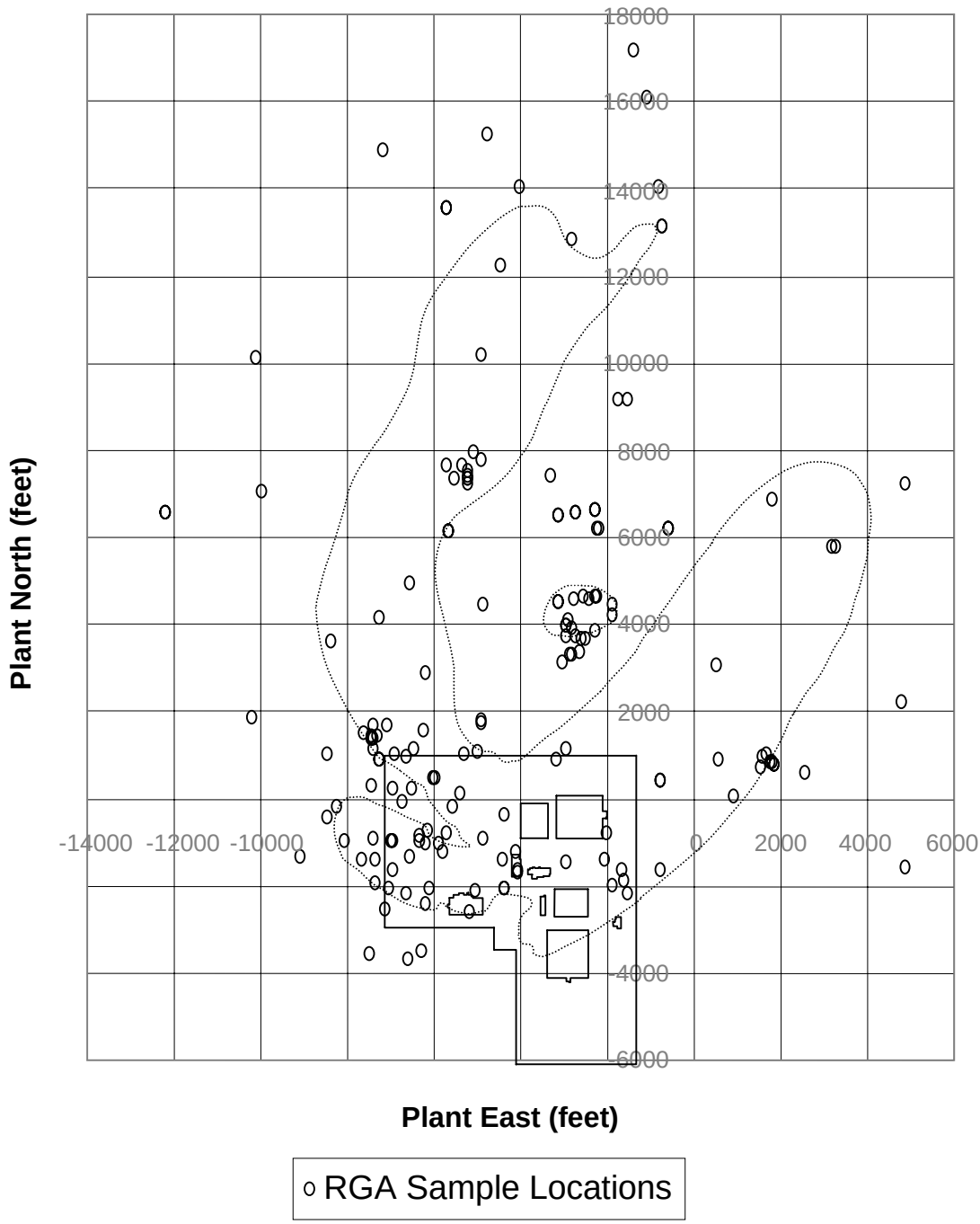

Fig. 4.49. RGA sample locations - nickel analyses.

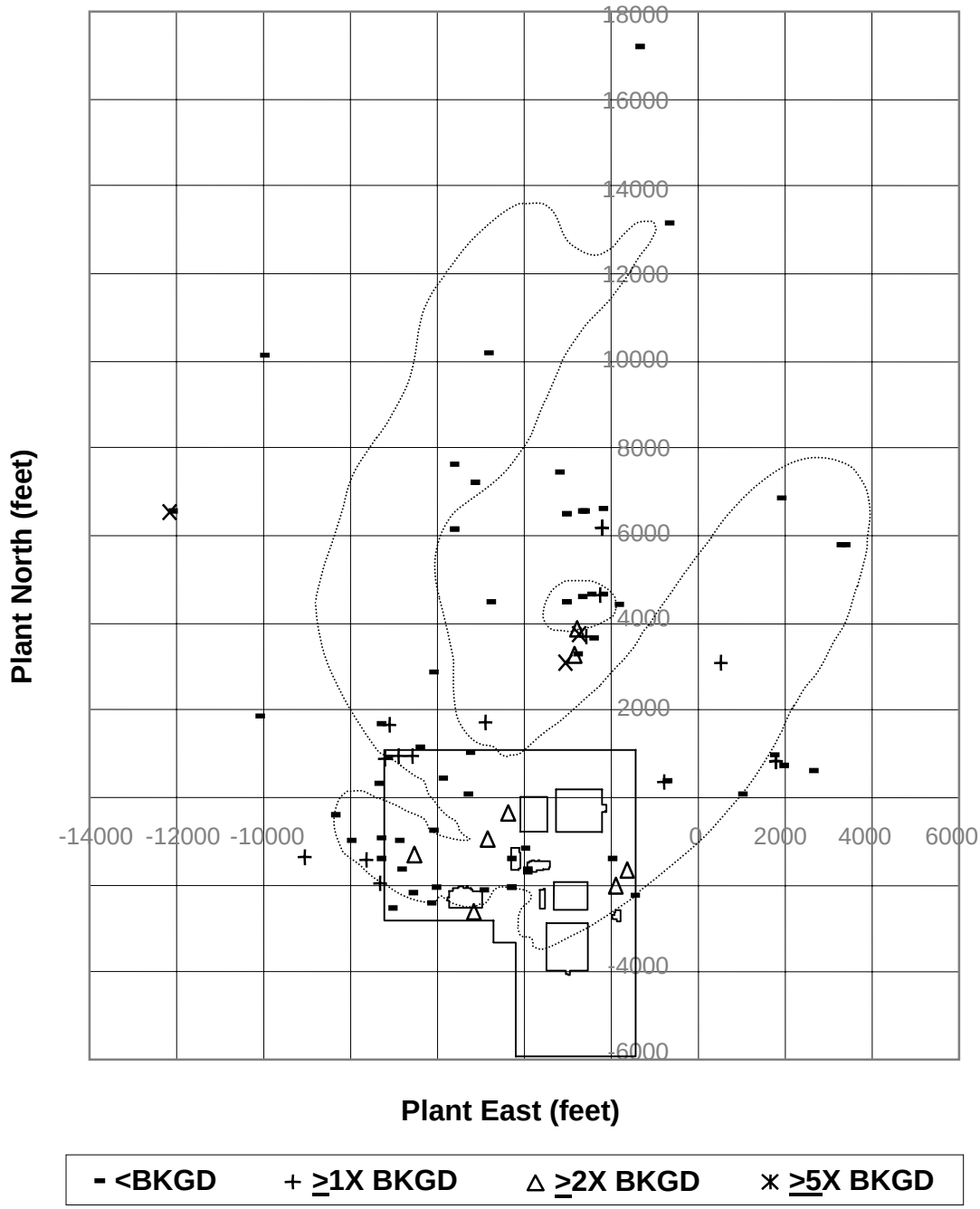

Fig. 4.50. Maximum detected levels of nickel in RGA groundwater.

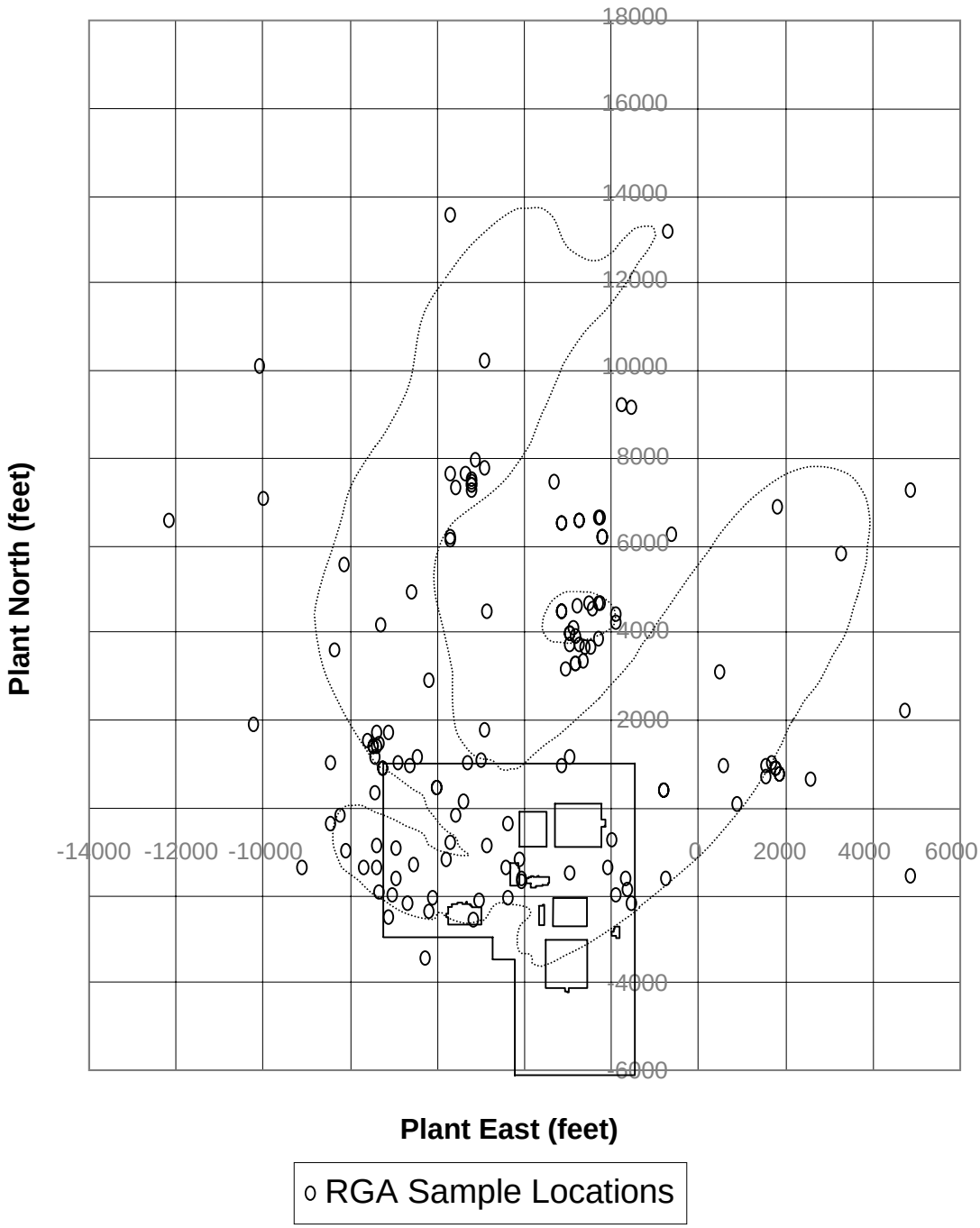

Fig. 4.51. RGA sample locations - silver analyses.

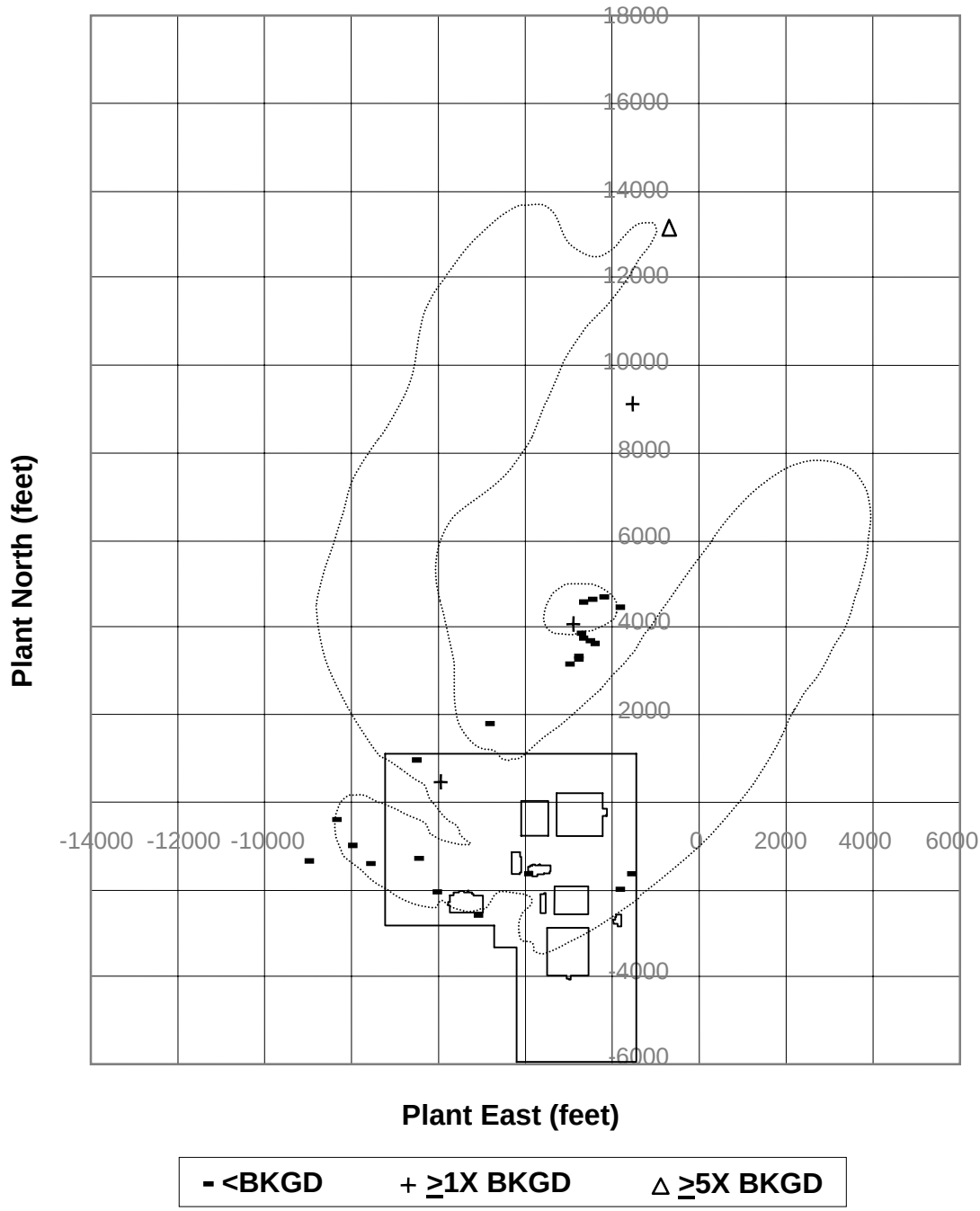

Fig. 4.52. Maximum detected levels of silver in RGA groundwater.

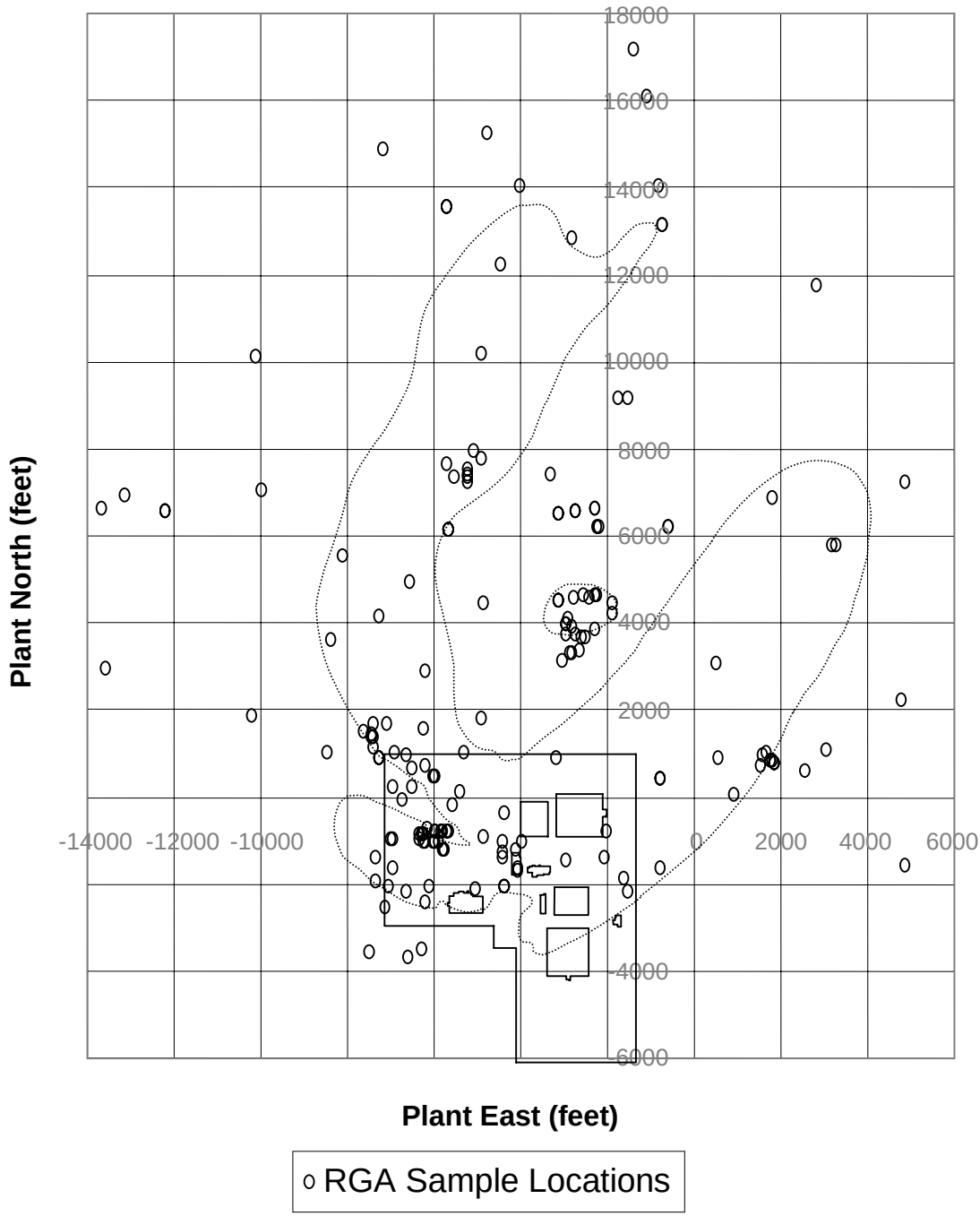

Fig. 4.53. RGA sample locations - uranium analyses.

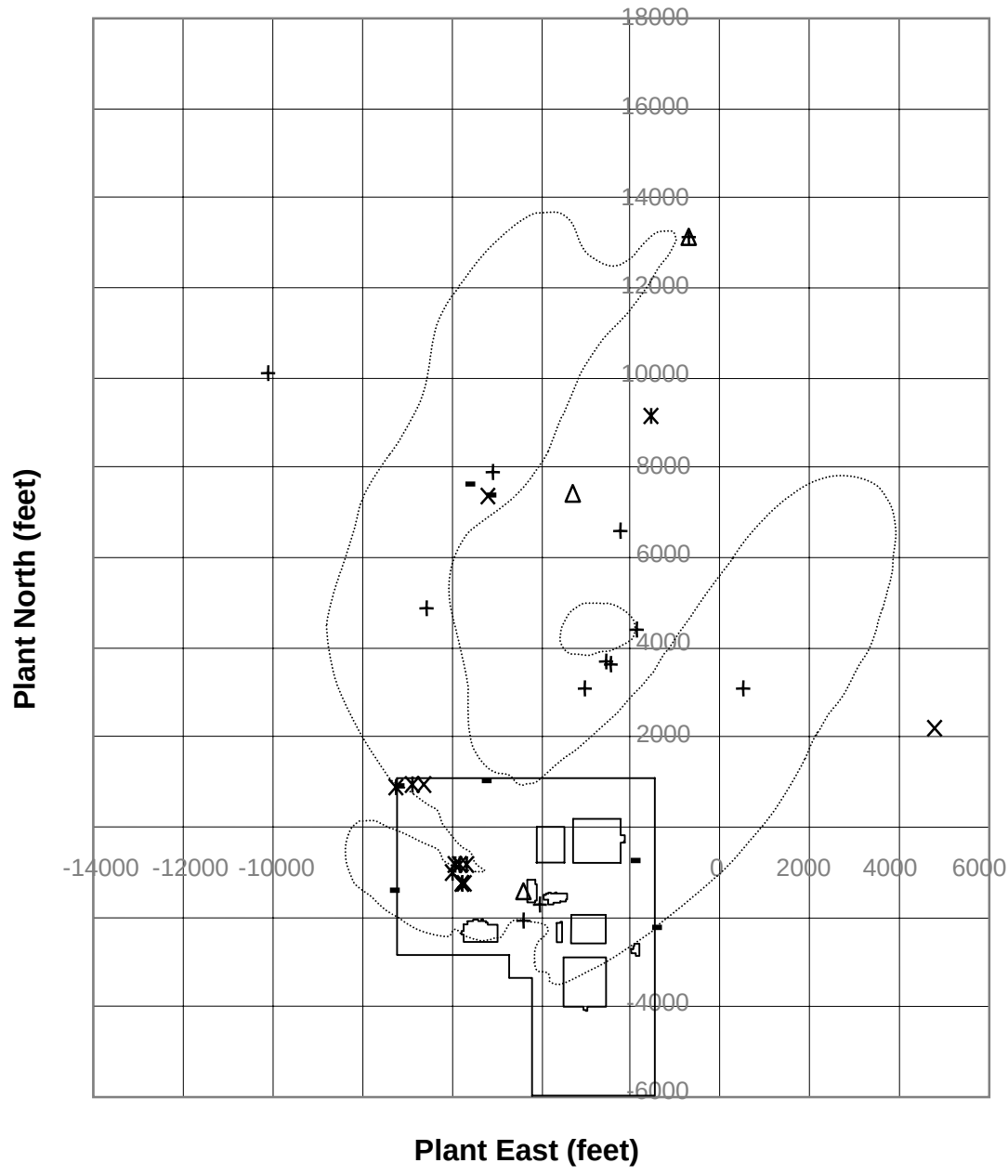

Fig. 4.54. Maximum detected levels of uranium in RGA groundwater.

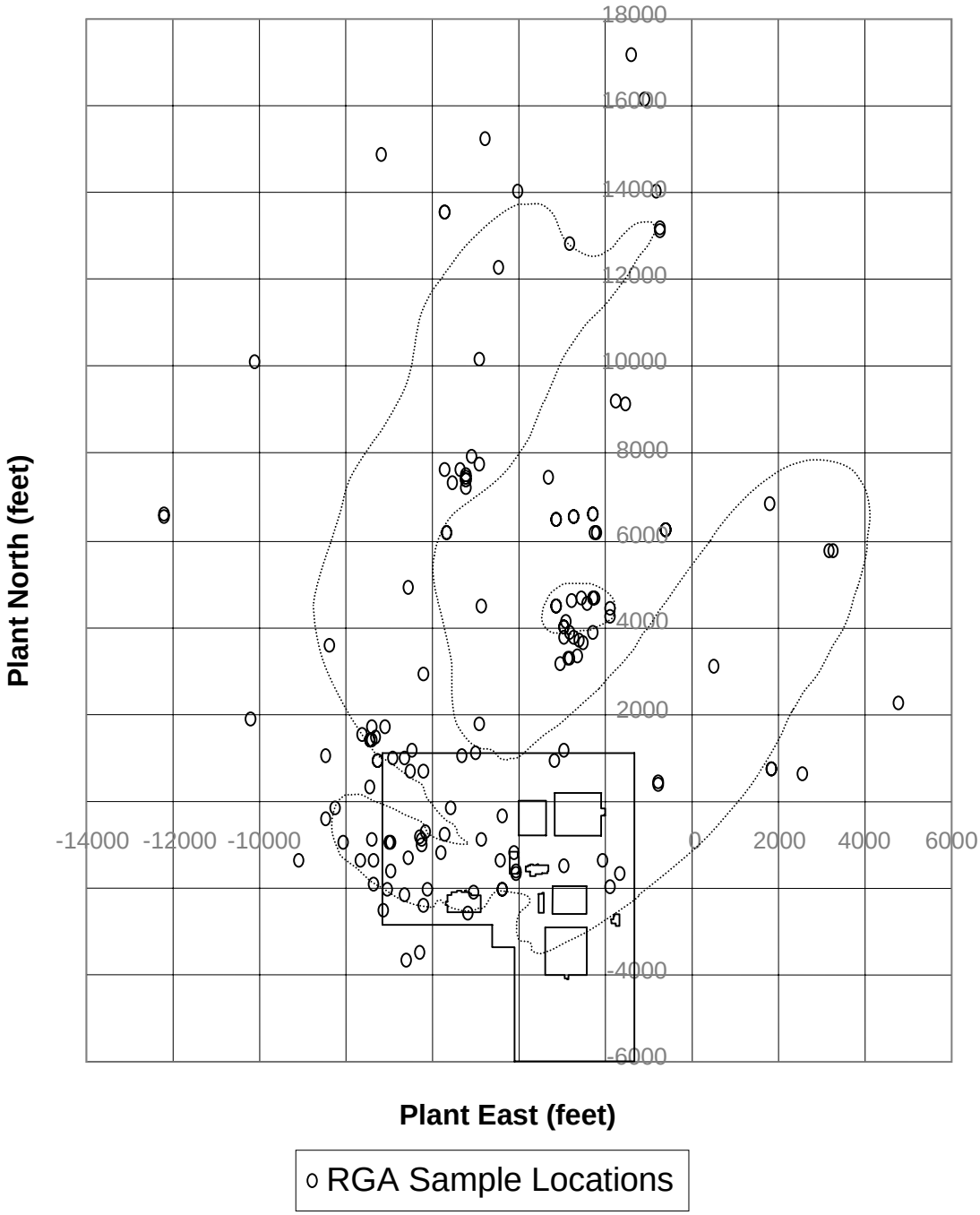

Fig. 4.55. RGA sample locations - vanadium analyses.

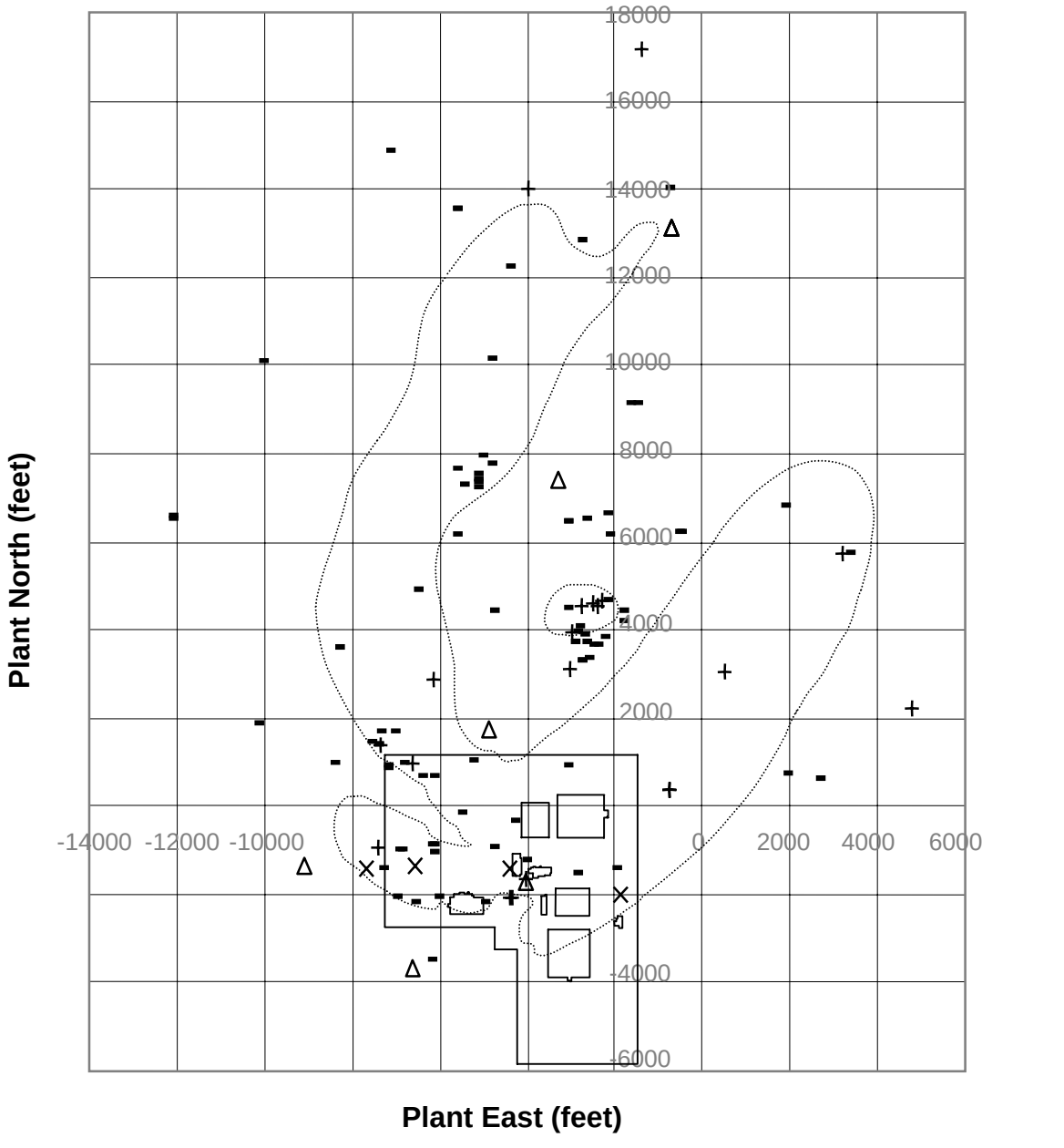

Fig. 4.56. Maximum detected levels of vanadium in RGA groundwater.

Table 4.3. Levels of metals in RGA water samples versus background levels for filtered water samples

	Background (ppm)	# Sample locations with detects	# > 1 × Bkgd[a]	# > 2 × Bkgd	# > 5 × Bkgd	# > 10 × Bkgd
Aluminum	0.311	132	13	23	15	59
Antimony	0.060	15	-	2	0	0
Arsenic	0.005	38	15	12	3	4
Barium	0.200	165	54	18	7	15
Beryllium	0.004	50	8	5	4	12
Boron		13	No Background Values Available			
Cadmium	0.010	23	6	5	—	2
Chromium	0.050	102	13	18	21	37
Copper	0.020	83	25	13	11	16
Fluoride	0.270[b]	131	11	5	—	1
Iron	0.267	173	6	8	23	127
Manganese	0.068	168	20	25	19	67
Nickel	0.305	103	20	12	2	0
Silver	0.060	19	1	-	1	0
Uranium	0.002	36	8	2	6	5
Vanadium	0.134	125	19	6	9	8

[a] Bkgd = Background

[b] 0.270 ppm = value derived from 'total' samples

Table 4.4. Levels of metals in RGA water samples versus background levels for total samples

			Background Based on Total Groundwater Samples			
	Background (ppm)	# Sample locations with detects	# > 1 × Bkgd[a]	# > 2 × Bkgd	# > 5 × Bkgd	# > 10 × Bkgd
Aluminum	2.189	132	16	17	7	29
Antimony	0.060	15	-	2	0	0
Arsenic	0.005	38	15	12	3	4
Barium	0.235	165	48	13	8	14
Beryllium	0.004	50	8	5	4	12
Boron		13	No Background Values Available			
Cadmium	0.010	23	6	5	—	2
Chromium	0.144	102	12	25	11	19
Copper	0.036	83	11	14	6	11
Fluoride	0.270	131	11	5	—	1
Iron	5.030	173	26	34	12	35
Manganese	0.119	168	20	24	20	50
Nickel	0.682	103	7	4	0	0
Silver	0.011	19	-	12	3	1
Uranium	0.002	36	8	2	6	5
Vanadium	0.134	125	19	6	9	8

[a] Bkgd = Background derived from evaluation of total groundwater samples

Table 4.5. Levels of metals in RGA water samples versus MCLs

	MCL[a] (ppm)	# Sample locations with detects	# ≥ 1 × MCL	# ≥ 2 × MCL	# ≥ 5 × MCL	# ≥ 10 × MCL
Aluminum	0.050	132	4	11	14	101
Antimony	0.006	15	5	3	-	2
Arsenic	0.050	38	1	3	0	0
Barium	2.000	165	3	8	4	0
Beryllium	0.004	50	8	5	4	12
Boron	No Value	13				
Cadmium	0.005	23	10	8	3	2
Chromium	0.100	102	13	26	15	22
Copper	1.300	83	3	0	0	0
Fluoride	4.000	131	1	0	0	0
Iron	0.300	173	6	10	26	121
Manganese	0.050	168	16	28	19	72
Nickel	0.100	103	29	30	12	6
Silver	0.100	19	1	2	2	0
Uranium	0.020	36	1	2	2	0
Vanadium	No Value	125				

[a] MCL= Maximum Contaminant Level

4.3.2.4 Radionuclides

Technetium-99 is a widespread groundwater contaminant derived from PGDP. Because it is a well-known concern, the GWOU database contains ^{99}Tc analyses for water samples collected from most wells and soil borings of the PGDP.

In general, analysis for other radionuclides at the PGDP is contingent upon a screening process. Gross alpha and beta activities have been used to determine when isotopic analyses are required. Hence, analyses for most other radionuclides are poorly represented in the GWOU database. Among the other radionuclide priority contaminants, ^{237}Np and ^{222}Rn have the best distribution of RGA water sample locations for evaluation of extent. Americium-241, ^{234}U, and ^{238}U are poorly represented in the database among RGA water samples. There are no RGA water samples in the GWOU database with analysis for ^{228}Th. Figures 4.57 through 4.68 present the radionuclide data for the RGA.

The available data suggest elevated occurrences of ^{241}Am, ^{234}U, and ^{238}U in the RGA are limited to beneath the PGDP and the C-746-S/T Landfill area. The highest off-site activities of ^{99}Tc are located north of the PGDP, associated with the Northwest Plume and the Technetium-99 Plume. Outside of the groundwater contaminant plumes, off-site ^{99}Tc activities are uniformly below the 5 times background level. ^{222}Radon and ^{237}neptunium levels do not define any definitive trends related to the PGDP.

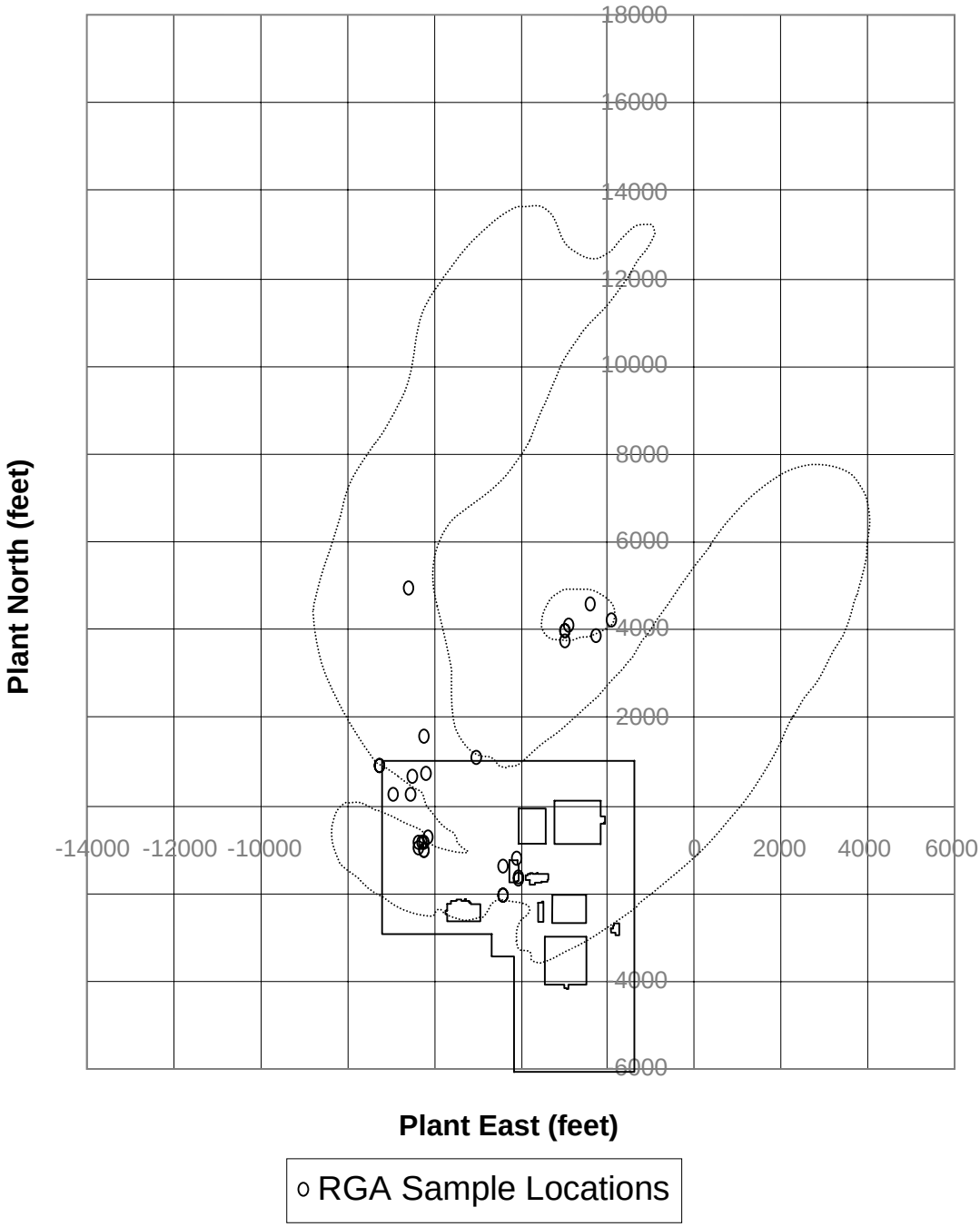

Fig. 4.57. RGA sample locations – americium-241 analyses.

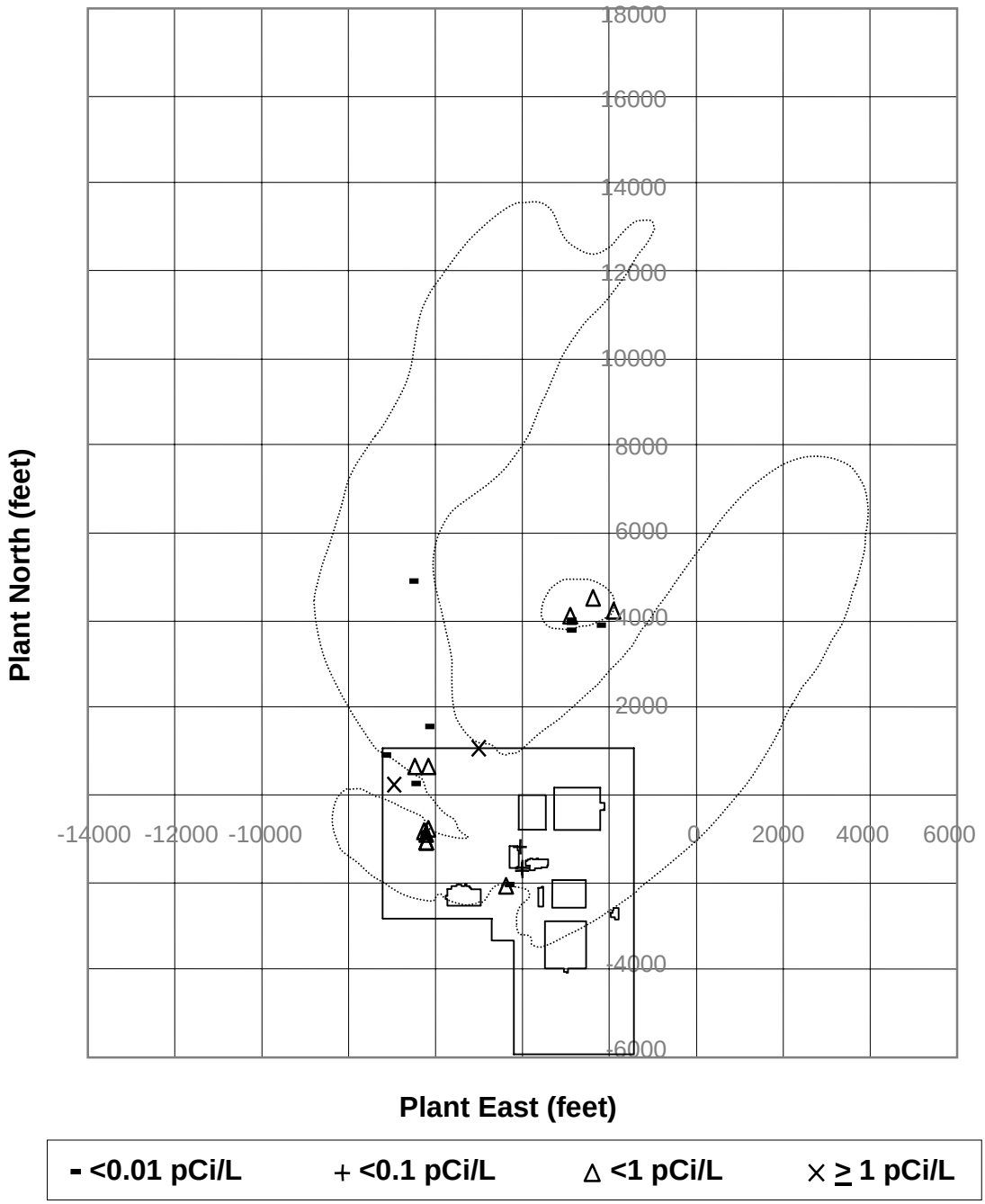

Fig. 4.58. Maximum detected levels of americium-241 in RGA groundwater.

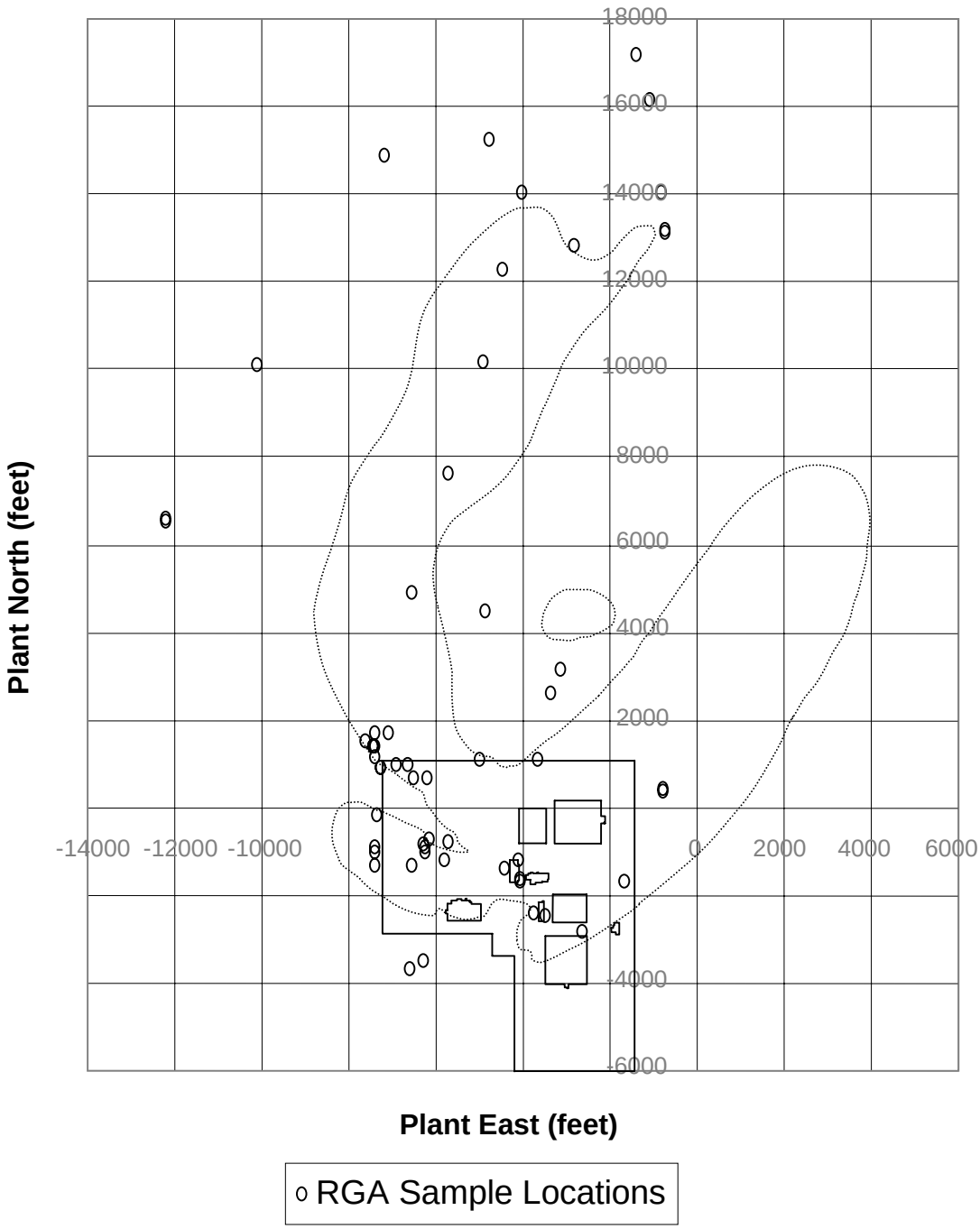

Fig. 4.59. RGA sample locations – neptunium-237 analyses.

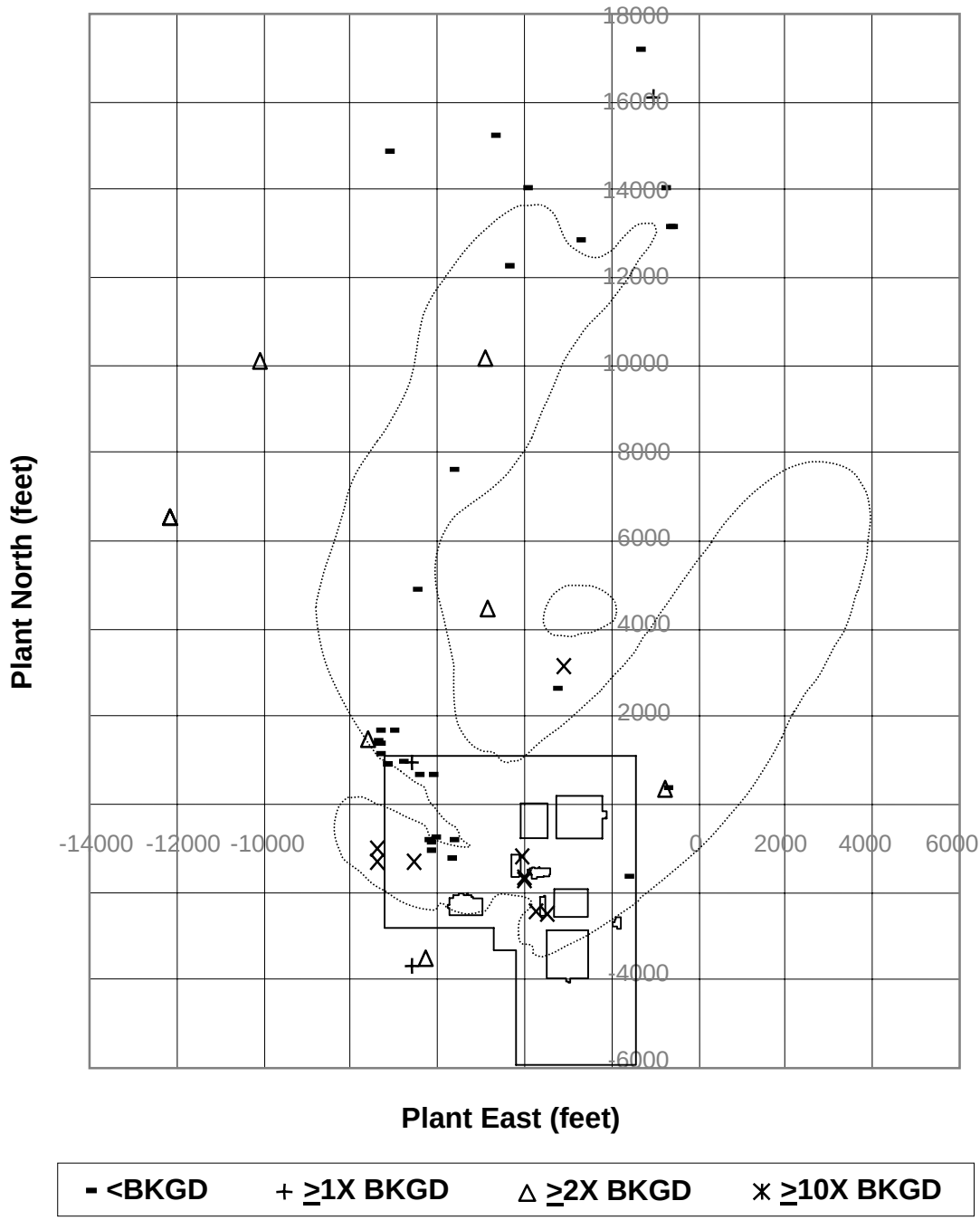

Fig. 4.60. Maximum detected levels of neptunium-237 in RGA groundwater.

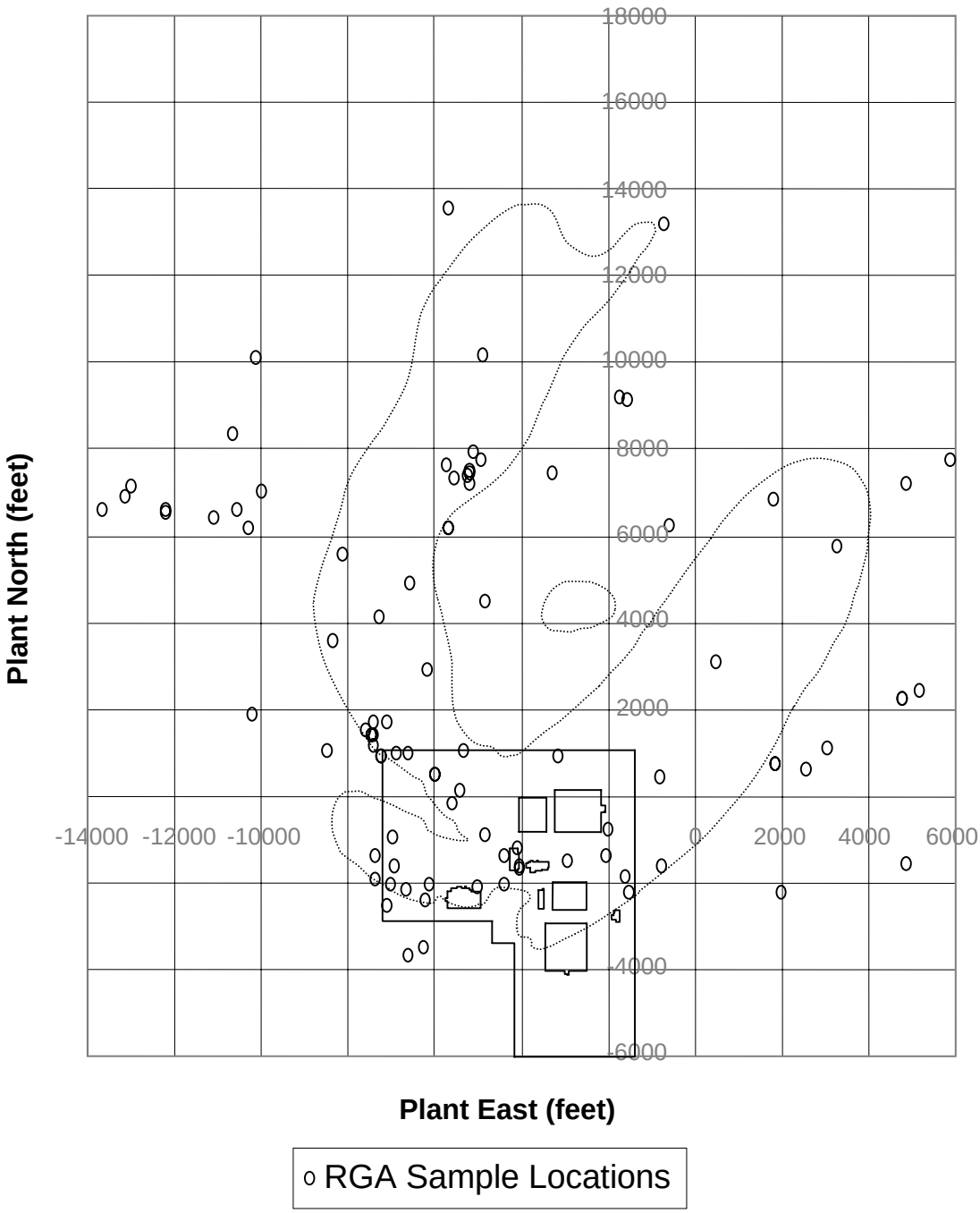

Fig. 4.61. RGA sample locations – radon-222 analyses.

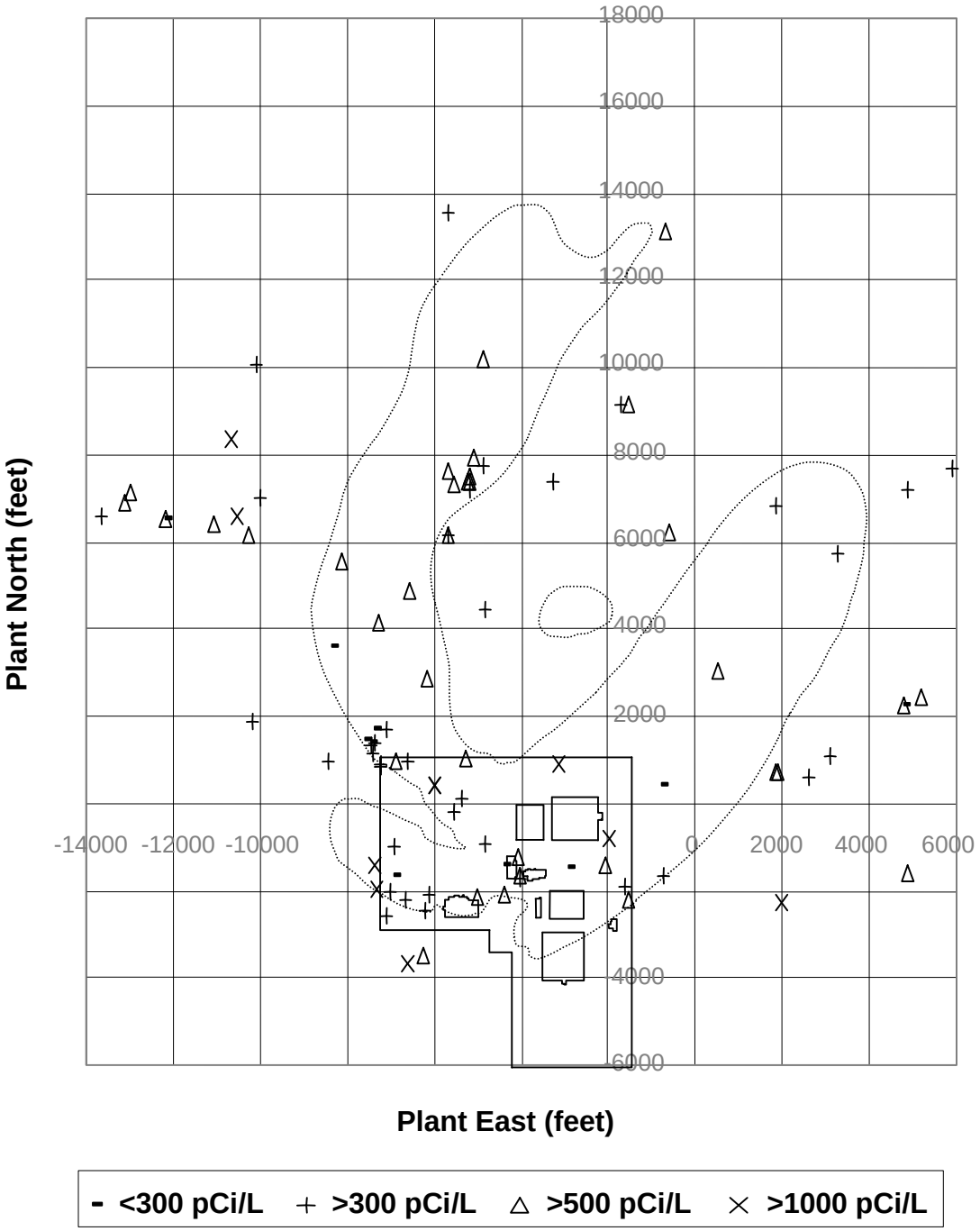

Fig. 4.62. Maximum detected levels of radon-222 in RGA groundwater.

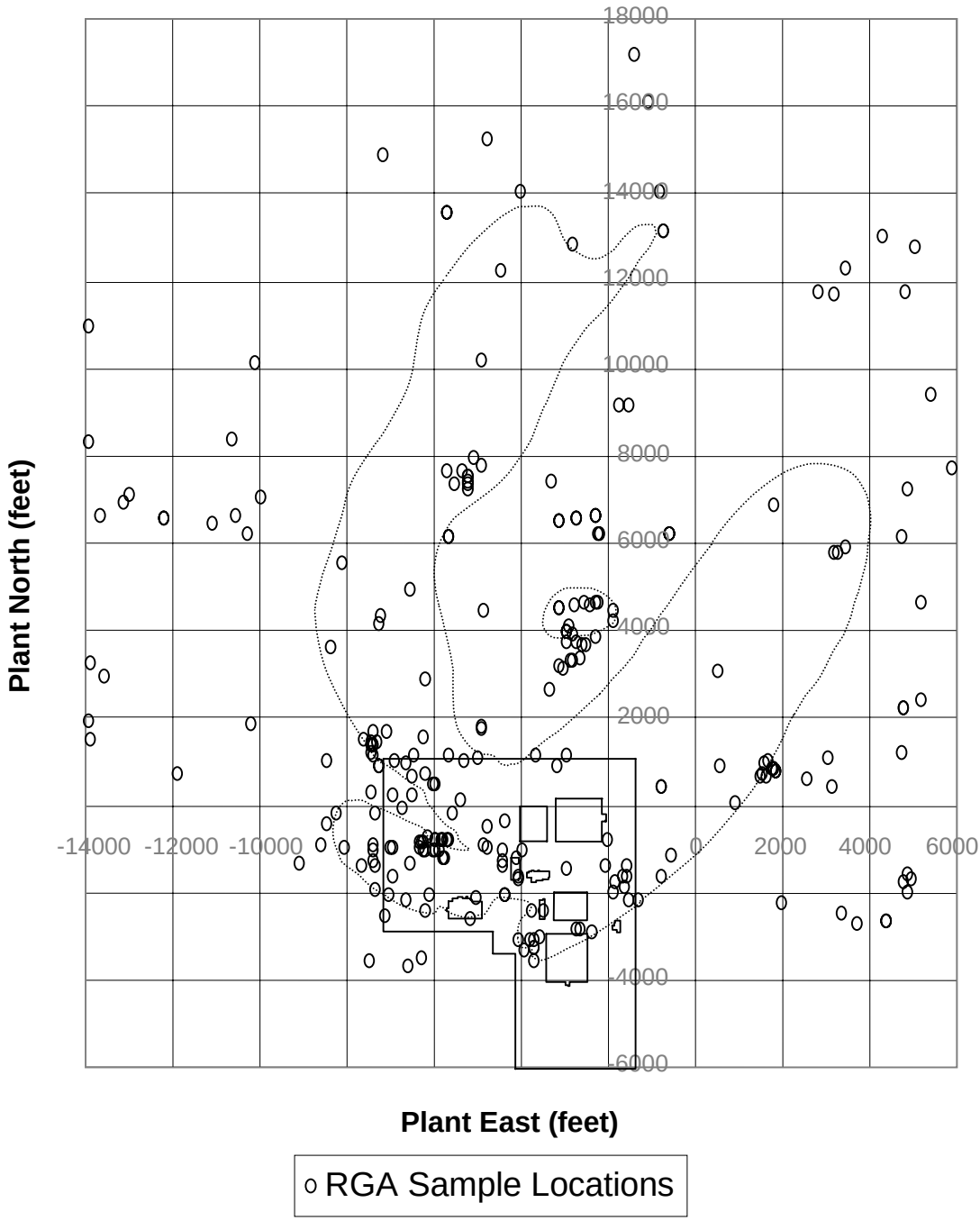

Fig. 4.63. RGA sample locations – technetium-99 analyses.

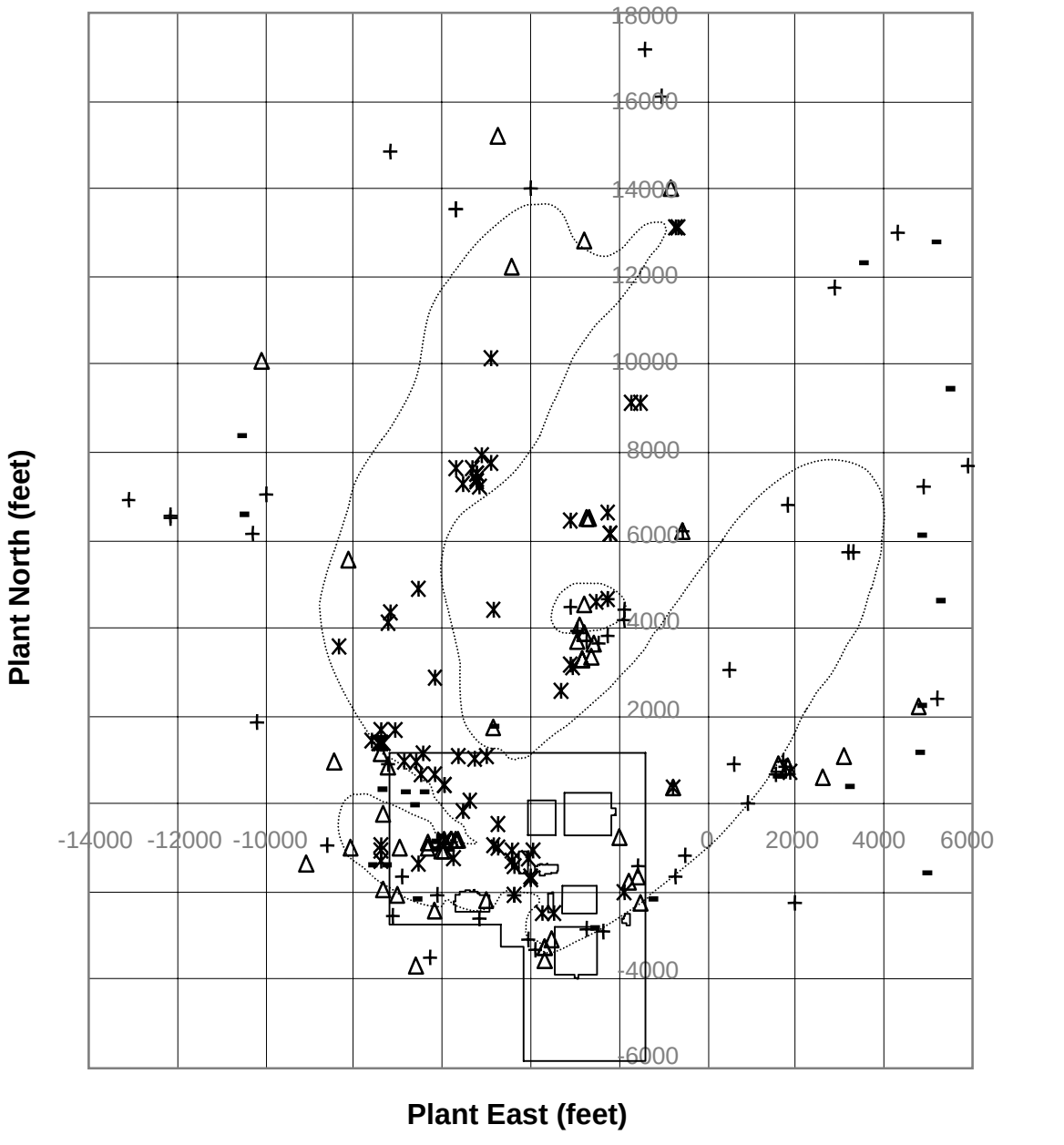

Fig. 4.64. Maximum detected levels of technetium-99 in RGA groundwater.

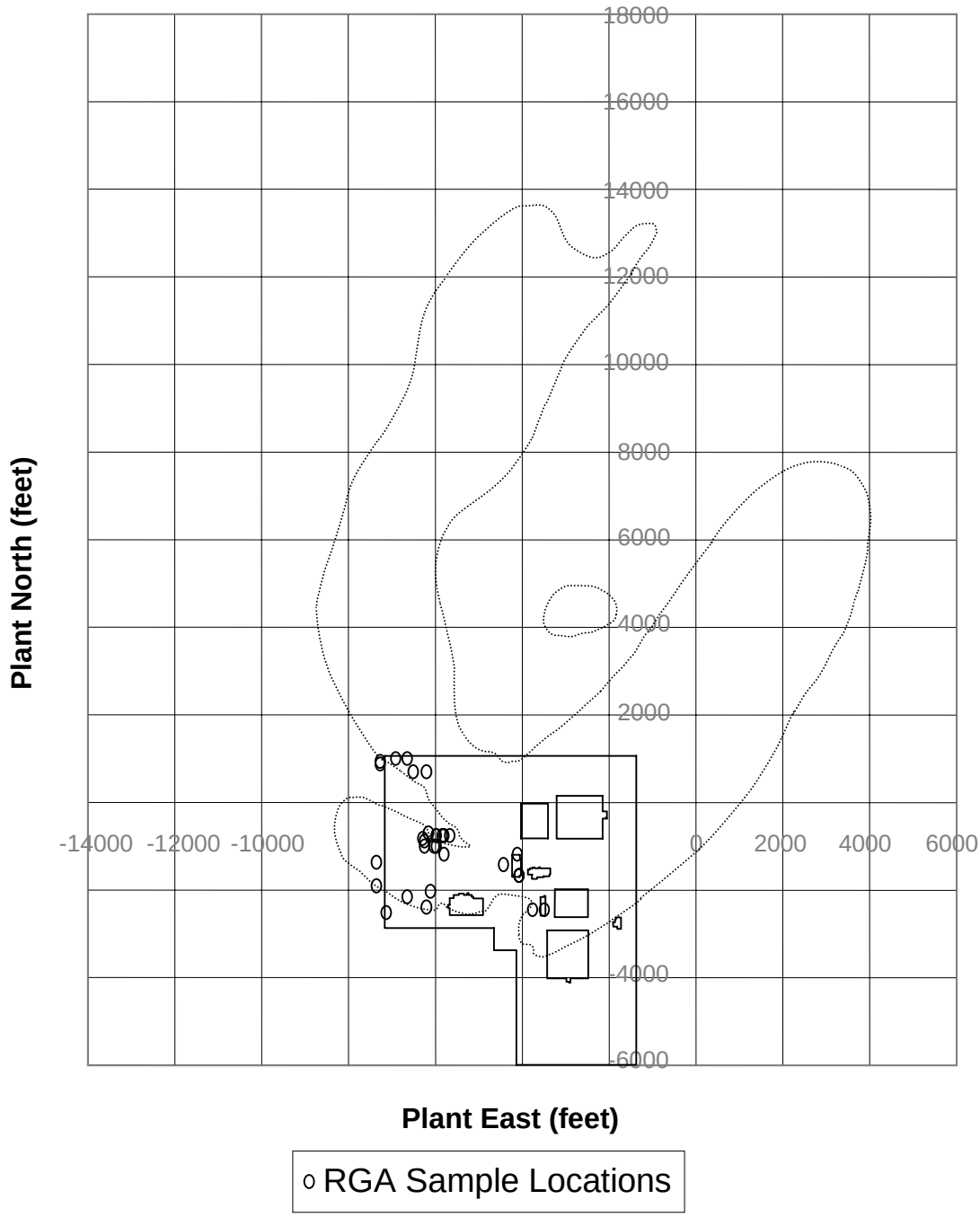

Fig. 4.65. RGA sample locations – uranium-234 analyses.

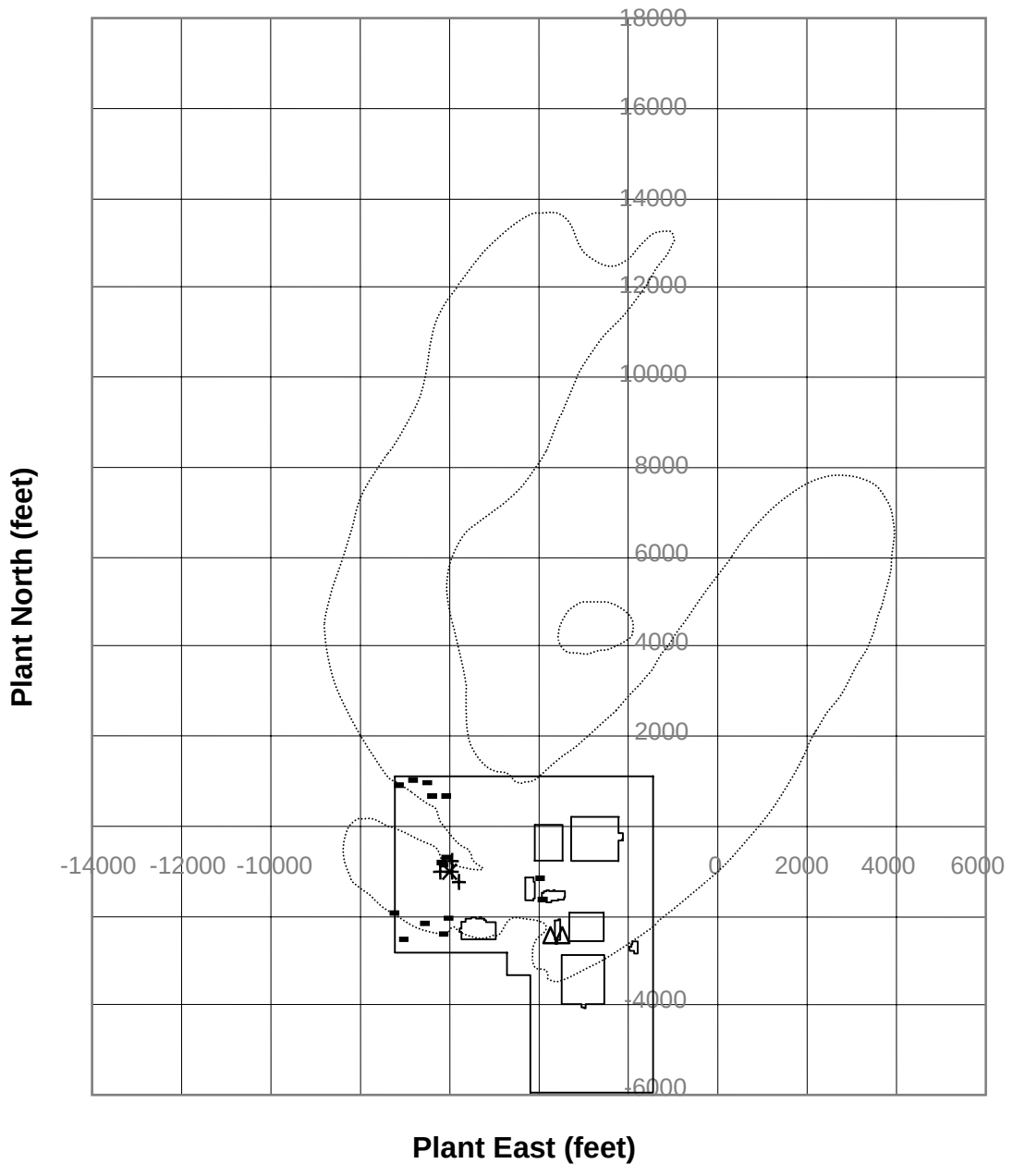

Fig. 4.66. Maximum detected levels of uranium-234 in RGA groundwater.

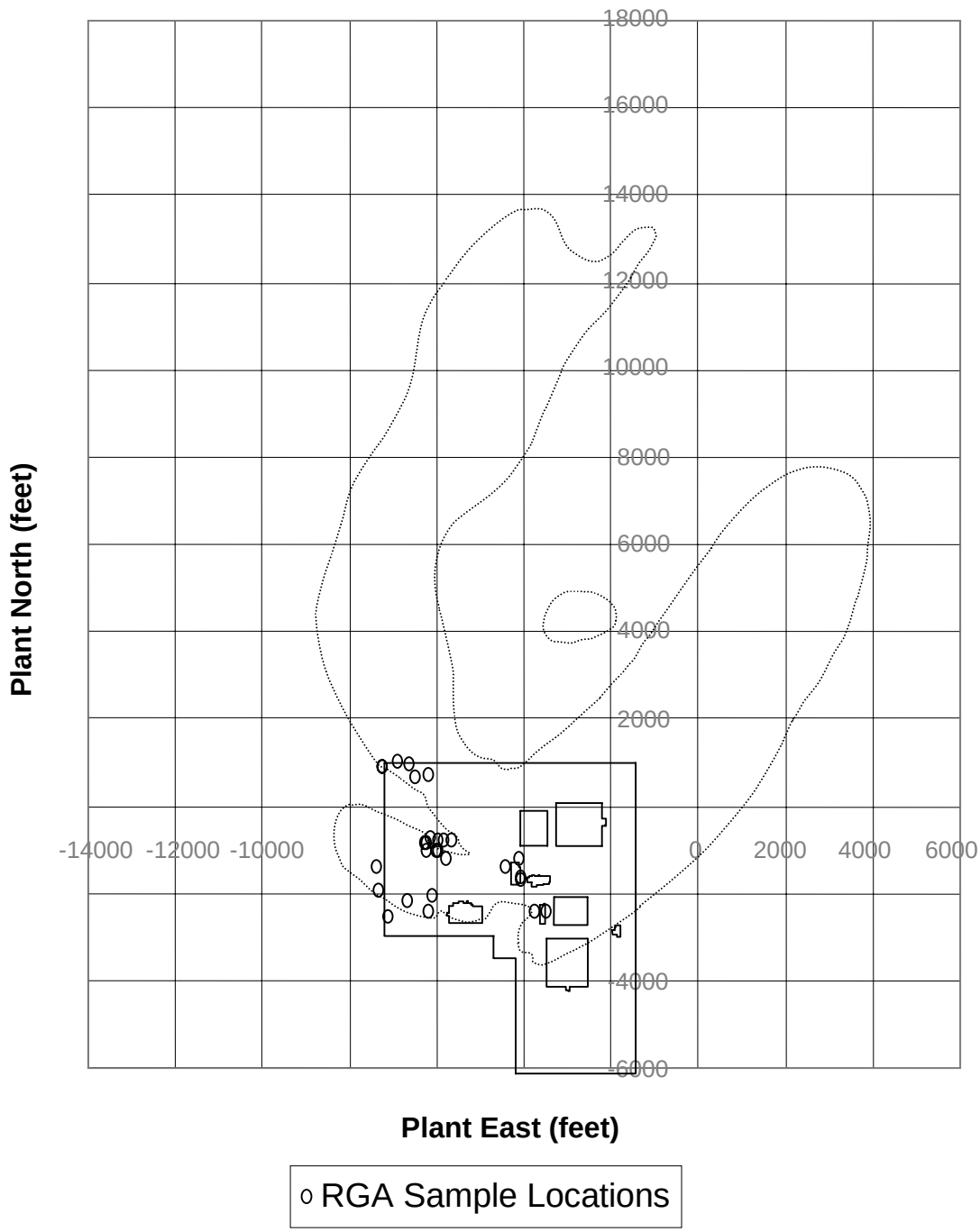

Fig. 4.67. RGA sample locations – uranium-238 analyses.

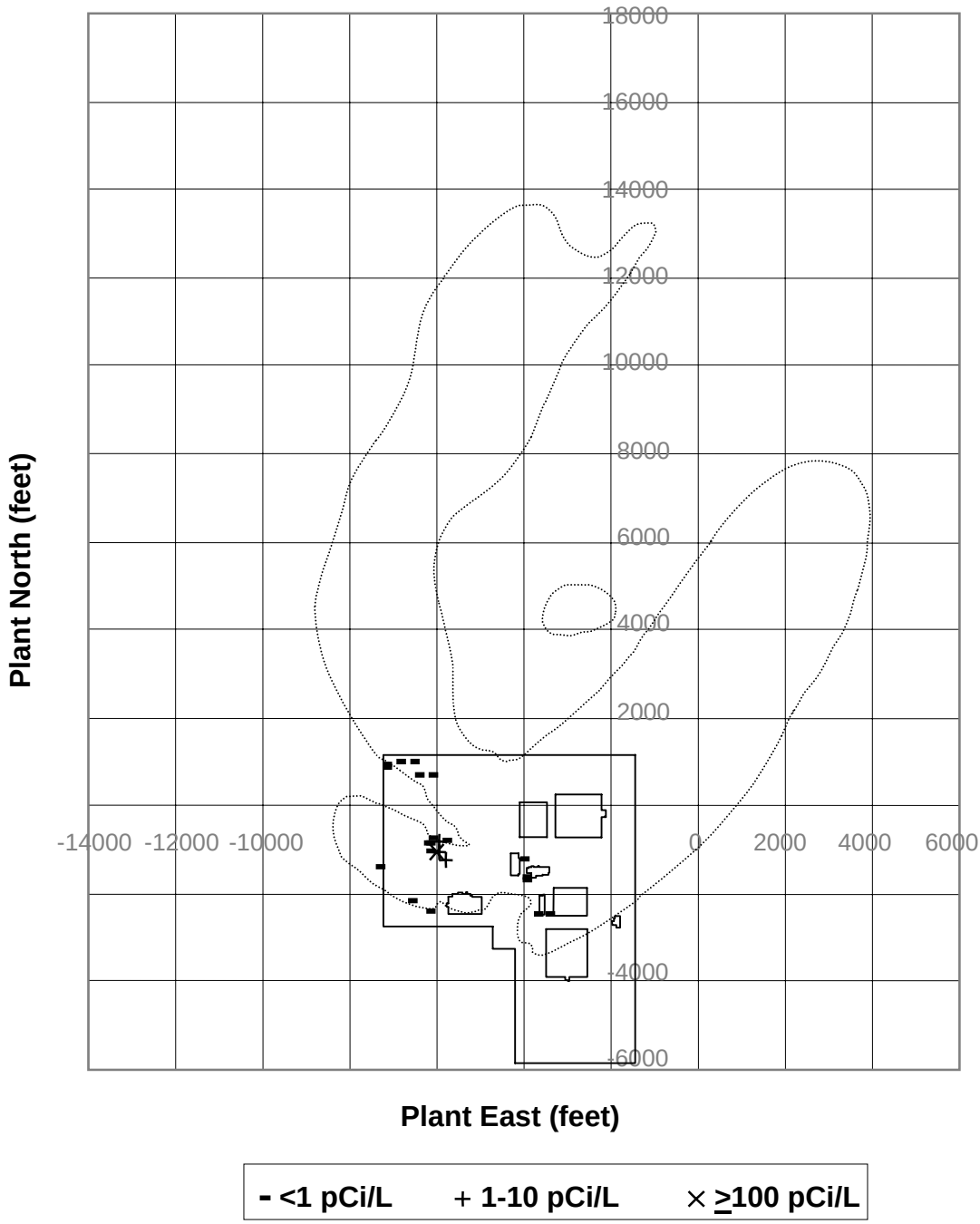

Fig. 4.68. Maximum detected levels of uranium-238 in RGA groundwater.

4.4 REFERENCES

CH2M HILL 1989. *Phase I Site Investigation Work Plan for Paducah Gaseous Diffusion Plant*, CH2M HILL Southeast, Inc., Oak Ridge, TN, March 23, 1989.

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5. CONTAMINANT FATE AND TRANSPORT

5.1 INTRODUCTION

The following subsections provide a summary of the previous fate and transport models of PGDP contaminant sources completed as part of PGDP RIs or other studies. This section includes reviews of modeling performed for WAGs 1 and 7, WAG 22, WAG 6, WAG 27, SWMU 91, and WAG 28.

5.2 SUMMARY OF PREVIOUSLY MODELED SOURCES

Descriptions of source unit investigations in Chap. 3 of this report present the main associated contaminants derived from previous fate and transport modeling. Several fate and transport model codes have been used for the PGDP. The selection of models has been determined by the conceptual models of groundwater/contaminant transport developed for each source unit, the modeled point of exposure, and the amount of available data for source term and transport parameter definition.

5.2.1 WAGs 1 and 7

Fate and transport modeling for WAGs 1 and 7 was completed as part of the *Resource Conservation and Recovery Act Facility Investigation/Remedial Investigation Report for Waste Area Groupings 1 and 7 at Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1996a). After an initial screening of COPCs, the WAGs 1 and 7 RI used the Summer's Model (EPA 1989) to derive a reasonable maximum leachate concentration.

The Summer's Model is a one-dimensional equilibrium/mass-partitioning model that predicts contaminant concentrations in groundwater from soil concentrations. The following assumptions are the basis for the Summers Model:

1. Groundwater is in chemical equilibrium with contaminated soils.

2. The equilibrium relationship between soil and groundwater is approximated by a soil-water partitioning coefficient.

3. No contaminant degradation occurs.

4. Groundwater flow in the vadose zone is vertical.

5. Leachate is not diluted prior to reaching the aquifer.

Fate and transport modeling for WAGs 1 and 7 addressed SWMUs 8, 38, 100, 131, 132, 133, 134, and 136. Tables 5.1 through 5.10 summarize the key hydraulic parameters and calculated results of the WAGs 1 and 7 model.

5.2.2 WAG 22 — SWMU 2

Data Summary and Interpretation Report for Interim Remedial Design at Solid Waste Management Unit 2 of Waste Area Grouping 22 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky (DOE 1997) presented the fate and transport modeling for SWMU 2. Modelers used the MEPAS model (PNL 1989) to

Table 5.1. Source zone areas and transport parameters for WAGs 1 and 7

Multi Media Modeling Summary
Project Name **WAGs 1 and 7**
Model Name Revised Summers Model
Documented *Resource Conservation and Recovery Act Facility Investigation/Remedial Investigation Report for Waste Area Groupings 1 and 7 at Paducah Gaseous Diffusion Plant Paducah, Kentucky*

	SWMU 8	**SWMU 38**	**SWMU 100**	**SWMU 130**	**SWMU 131**	**SWMU 132**	**SWMU 133**	**SWMU 134**	**SWMU 136**
Geologic Units	TSG	RGA	RGA	TSG	TSG	TSG	TSG	TSG	RGA
HYDRAULIC PARAMETERS									
Horizontal Area of Contamination	44,600 m^2	363.25 m^2	719.85 m^2	6.71 m^2	1.5 m^2	10.24 m^2	8.38 m^2	8.38 m^2	17.8 m^2
Perpendicular spill width	213.4 m	12m	13.7 m	2.6 m	1.2 m	3.2 m	2.9 m	2.9 m	3.66 m
Hydraulic Gradient	0.03			0.017	0.017	0.017	0.047	0.017	
Hydraulic Conductivity	8.64E-1 m/d			8.64E-1 m/d	8.64E-1 m/d	8.64E-1 m/d	8.64E-1 m/d	8.64E-1 m/d	
GW flow rate	37.1 m^3/d	9.84 m^3/d	12.169 m^3/d	9.16E-2 m^3/d	1.181E-1 m^3/d	4.28E-1 m^3/d	1.28E-1 m^3/d	2.34E-1 m^3/d	2.94 m^3/d
Darcy flow rate (downward)	3.26E-4 m/d	6.16E-4 m/d	6.16E-4 m/d	5.22E-4 m/d	5.22E-4 m/d	5.22E-4 m/d	5.22E-4 m/d	5.22E-4 m/d	6.16E-4 m/d
Infiltration flow rate	14.54 m^3/d	2.24E-1 m^3/d	4.43E-1 m^3/d	3.5E-3 m^3/d	7.83E-4 m^3/d	5.35E-3 m^3/d	4.37E-3 m^3/d	4.37E-3 m^3/d	1.10E-2 m^3/d
Aquifer Thickness	6.71 m	9.14 m	10.1 m	2.4 m	6.7 m	9.1 m	3 m	5.5 m	9.14 m
Chemical concentration in source (Sc)	attached	attached	attached	attached	attached	attached	attached	attached	attached
Chemical concentration in vadose zone (Cp)	attached	attached	attached	attached	attached	attached	attached	attached	attached
K_d values	attached	attached	attached	attached	attached	attached	attached	attached	attached
Upgradient/background chemical concentration (Ca)	attached	attached	attached	attached	attached	attached	attached	attached	attached
CALCULATED CHEMICAL CONCENTRATION (Cw)	attached	attached	attached	attached	attached	attached	attached	attached	attached

Table 5.2. Distribution coefficients and measured and modeled contaminant levels for SWMU 8

Project Name **WAGs 1 and 7 - SWMU 8**
Model Name Revised Summers Model
Documented *Resource Conservation and Recovery Act Facility Investigation/Remedial Investigation Report for Waste Area Groupings 1 and 7 at Paducah Gaseous Diffusion Plant Paducah, Kentucky*

CHEMICAL PARAMETERS AND CALCULATED RESULTS FOR SWMU 8

Contaminants: Inorganics	**Sc (mg/kg)**	**Kd (sand soils) (L/kg)**	**Cp (sand soils) (mg/L)**	**Kd (clay soils) (L/kg)**	**Cp (clay soils) (mg/L)**	**Ca (mg/L)**	**Cw (sand) (mg/L)**	**Cw (clay) (mg/L)**
Antimony	2.22	45	4.93E-02	250	8.88E-03	0	1.39E-02	2.50E-03
Barium	76.1	60	1.27	60	1.27	0	3.57E-01	3.57E-01
Beryllium	7.47E-01	250	2.99E-03	1300	5.75E-04	0	8.41E-04	1.62E-04
Cadmium	3.81E-01	40	9.53E-03	560	6.80E-04	0	2.68E-03	1.92E-04
Manganese	501	50	10	180	2.78	0	2.82	7.84E-01
Nickel	9.62	300	3.21E-02	650	1.48E-02	0	9.03E-03	4.17E-03
Radionuclides	**(pCi/g)**							
Neptunium-237	1.82E-03	5	3.64E-04	55	3.31E-05	0	1.02E-04	9.32E-06
Plutonium-239	8.69E-05	550	1.58E-07	5100	1.70E-08	0	4.45E-08	4.80E-09
Technetium-99	5.57E-04	0.1	5.57E-03	1	5.57E-04	0	1.57E-03	1.57E-04
Thorium-228	1.65E-09	3200	5.16E-13	5800	2.84E-13	0	1.45E-13	8.01E-14
Thorium-230	2.16E-02	3200	6.75E-06	5800	3.72E-06	0	1.90E-06	1.05E-06
Thorium-232	15	3200	4.69E-03	5800	2.59E-03	0	1.32E-03	7.28E-04
Uranium (total)	44.5	15	2.97	1600	2.78E-02	0	8.35E-01	7.83E-03

Organics	**Sc (mg/kg)**	**Kd_1 (foc=.0002) (L/kg)**	**Cp_1 (mg/L)**	**Kd_2 (foc=.001) (L/kg)**	**Cp_2 (mg/L)**	**Ca (mg/L)**	**Cw_1 (mg/L)**	**Cw_2 (mg/L)**
1,2-Dichloroethene	6.68E-03	1.60E-02	4.18E-01	0.08	8.35E-02	0	1.18E-01	2.35E-02
Benzo(a)pyrene	2.59E-01	1100	2.35E-04	5500	4.71E-05	0	6.63E-05	1.33E-05

	Sc (mg/kg)	**Kd (L/kg)**	**Cp (mg/L)**	**Ca (mg/L)**	**Cw (mg/L)**
Aroclor-1254	1.30E-01	2.63E+04	4.94E-06	0	1.39E-06
Aroclor-1260	2.83E-02	2.63E+04	1.08E-06	0	3.03E-07

Table 5.3. Distribution coefficients and measured and modeled contaminant levels for SWMU 38

Project Name **WAGs 1 and 7 - SWMU 38**
Model Name Revised Summers Model
Documented *Resource Conservation and Recovery Act Facility Investigation/Remedial Investigation Report for Waste Area Groupings 1 and 7 at Paducah Gaseous Diffusion Plant Paducah, Kentucky*

CHEMICAL PARAMETERS AND CALCULATED RESULTS FOR SWMU 38

Contaminants: Inorganics	Sc (mg/kg)	Kd (sand soils) (L/kg)	Cp (sand soils) (mg/L)	Kd (clay soils) (L/kg)	Cp (clay soils) (mg/L)	Ca (mg/L)	Cw (sand) (mg/L)	Cw (clay) (mg/L)
Barium	63.4	60	1.06	60	1.06	0	2.35E-02	2.35E-02
Manganese	473	50	9046	180	2.63	0	2.10E-01	5.84E-02
Radionuclides								
Neptunium-237	1.63E-03	5	3.26E-04	55	2.96E-05	0	7.25E-06	6.59E-07
Plutonium-239	1.28E-06	550	2.33E-09	5100	2.51E-10	0	5.17E-11	5.58E-12
Plutonium-240	5.27E-07	550	9.58E-10	5100	1.03E-10	0	2.13E-11	2.30E-12
Technetium-99	7.64E-05	0.1	7.64E-04	1	7.64E-05	0	1.70E-05	1.70E-06
Thorium-228	1.45E-09	3200	4.53E-13	5800	2.50E-13	0	1.01E-14	5.56E-15
Thorium-230	7.92E-05	3200	2.48E-08	5800	1.37E-08	0	5.50E-10	3.04E-10
Thorium-232	11.6	3200	3.63E-03	5800	2.00E-03	0	8.06E-05	4.45E-05
Uranium (total)	6.65	15	4.43E-01	1600	4.41E-03	0	9.86E-03	9.24E-05

Organics	Sc (mg/kg)	Kd1 (foc=.0002) (L/kg)	Cp1 (mg/L)	Kd2 (foc=.001) (L/kg)	Cp2 (mg/L)	Ca (mg/L)	Cw1 (mg/L)	Cw2 (mg/L)
Benzo(a)pyrene	4.82E-01	1100	4.38E-04	5500	8.76E-05	0	9.74E-06	1.95E-06

	Sc (mg/kg)	Kd (L/kg)	Cp (mg/L)	Ca (mg/L)	Cw (mg/L)
Aroclor-1254	9.65E-02	2.63E+04	3.67E-06	0	8.16E-08
Aroclor-1260	4.56E-02	2.63E+04	1.73E-06	0	3.86E-08

Table 5.4. Distribution coefficients and measured and modeled contaminant levels for SWMU 100

Project Name **WAGs 1 and 7 - SWMU 100**
Model Name Revised Summers Model
Documented *Resource Conservation and Recovery Act Facility Investigation/Remedial Investigation Report for Waste Area Groupings 1 and 7 at Paducah Gaseous Diffusion Plant Paducah, Kentucky*

CHEMICAL PARAMETERS AND CALCULATED RESULTS FOR SWMU 100

Contaminants: Inorganics	Sc (mg/kg)	Kd (sand soils) (L/kg)	Cp (sand soils) (mg/L)	Kd (clay soils) (L/kg)	Cp (clay soils) (mg/L)	Ca (mg/L)	Cw (sand) (mg/L)	Cw (clay) (mg/L)
Barium	105	60	1.75	60	1.75	0	6.15E-02	6.15E-02
Manganese	536	50	10.7	180	2.98	0	3.77E-01	1.05E-01
Radionuclides								
Neptumium-237	2.36E-04	5	4.72E-05	55	4.29E-06	0	1.66E-06	1.51E-07
Plutonium-238	1.76E-09	550	3.20E-12	5100	3.45E-13	0	1.12E-13	1.21E-14
Plutonium-240	1.23E-07	550	2.24E-10	5100	2.41E-11	0	7.86E-12	8.47E-13
Technetium-99	3.78E-05	0.1	3.78E-04	1	3.78E-05	0	1.33E-05	1.33E-06
Thorium-228	1.61E-09	3200	5.03E-13	5800	2.78E-13	0	1.77E-14	9.75E-15
Thorium-230	6.74E-05	3200	2.11E-08	5800	1.16E-08	0	7.40E-10	4.08E-10
Thorium-232	12.4	3200	3.88E-03	5800	2.14E-03	0	1.36E-04	7.51E-05
Uranium (Total)	3.16	15	2.11E-01	1600	1.98E-03	0	7.40E-03	6.94E-05

Table 5.5. Distribution coefficients and measured and modeled contaminant levels for SWMU 130

Project Name **WAGs 1 and 7 - SWMU 130**
Model Name Revised Summers Model
Documented *Resource Conservation and Recovery Act Facility Investigation/Remedial Investigation Report for Waste Area Groupings 1 and 7 at Paducah Gaseous Diffusion Plant Paducah, Kentucky*

CHEMICAL PARAMETERS AND CALCULATED RESULTS FOR SWMU 130

Contaminants: Radionuclides	Sc (mg/kg)	Kd (sand soils) (L/kg)	Cp (sand soils) (mg/L)	Kd (clay soils) (L/kg)	Cp (clay soils) (mg/L)	Ca (mg/L)	Cw (sand) (mg/L)	Cw (clay) (mg/L)
Uranium (Total)	2.84	15	1.89E-01	1600	1.78E-03	0	6.97E-03	6.53E-05

Table 5.6. Distribution coefficients and measured and modeled contaminant levels for SWMU 131

Project Name **WAGs 1 and 7 - SWMU 131**
Model Name Revised Summers Model
Documented *Resource Conservation and Recovery Act Facility Investigation/Remedial Investigation Report for Waste Area Groupings 1 and 7 at Paducah Gaseous Diffusion Plant Paducah, Kentucky*

CHEMICAL PARAMETERS AND CALCULATED RESULTS FOR SWMU 131

Contaminants: Radionuclides	Sc (mg/kg)	Kd (sand soils) (L/kg)	Cp (sand soils) (mg/L)	Kd (clay soils) (L/kg)	Cp (clay soils) (mg/L)	Ca (mg/L)	Cw (sand) (mg/L)	Cw (clay) (mg/L)
Uranium (Total)	2.79	15	1.86E-01	1600	1.74E-03	0	1.23E-03	1.15E-05

Table 5.7. Distribution coefficients and measured and modeled contaminant levels for SWMU 132

Project Name **WAGs 1 and 7 - SWMU 132**
Model Name Revised Summers Model
Documented *Resource Conservation and Recovery Act Facility Investigation/Remedial Investigation Report for Waste Area Groupings 1 and 7 at Paducah Gaseous Diffusion Plant Paducah, Kentucky*

CHEMICAL PARAMETERS AND CALCULATED RESULTS FOR SWMU 132

Contaminants: Radionuclides	Sc (mg/kg)	Kd (sand soils) (L/kg)	Cp (sand soils) (mg/L)	Kd (clay soils) (L/kg)	Cp (clay soils) (mg/L)	Ca (mg/L)	Cw (sand) (mg/L)	Cw (clay) (mg/L)
Technetium-99	4.05E-05	0.1	4.05E-04	1	4.05E-05	0	5.00E-06	5.00E-07
Uranium (Total)	3.31	15	2.21E-01	1600	2.07E-03	0	2.72E-03	2.55E-05

Table 5.8. Distribution coefficients and measured and modeled contaminant levels for SWMU 133

Project Name **WAGs 1 and 7 - SWMU 133**
Model Name Revised Summers Model
Documented *Resource Conservation and Recovery Act Facility Investigation/Remedial Investigation Report for Waste Area Groupings 1 and 7 at Paducah Gaseous Diffusion Plant Paducah, Kentucky*

CHEMICAL PARAMETERS AND CALCULATED RESULTS FOR SWMU 133

Contaminants: Radionuclides	Sc (mg/kg)	Kd (sand soils) (L/kg)	Cp (sand soils) (mg/L)	Kd (clay soils) (L/kg)	Cp (clay soils) (mg/L)	Ca (mg/L)	Cw (sand) (mg/L)	Cw (clay) (mg/L)
Technetium-99	5.50E-05	0.1	5.50E-04	1	5.50E-05	0	4.25E-04	4.25E-05
Uranium (total)	4.03	15	2.69E-01	1600	2.52E-03	0	2.08E-01	1.95E-03

Organics	Sc (mg/kg)	Kd_1 (foc=.0002) (L/kg)	Cp_1 (mg/L)	Kd_2 (foc=.001) (L/kg)	Cp_2 (mg/L)	Ca (mg/L)	Cw_1 (mg/L)	Cw_2 (mg/L)
Benzo(a)pyrene	2.06E+00	1100	1.87E-03	5500	3.75E-04	0	1.45E-03	2.90E-04

Table 5.9. Distribution coefficients and measured and modeled contaminant levels for SWMU 134

Project Name **WAGs 1 and 7 - SWMU 134**
Model Name Revised Summers Model
Documented *Resource Conservation and Recovery Act Facility Investigation/Remedial Investigation Report for Waste Area Groupings 1 and 7 at Paducah Gaseous Diffusion Plant Paducah, Kentucky*

CHEMICAL PARAMETERS AND CALCULATED RESULTS FOR SWMU 134

Contaminants: Radionuclides	Sc (mg/kg)	Kd (sand soils) (L/kg)	Cp (sand soils) (mg/L)	Kd (clay soils) (L/kg)	Cp (clay soils) (mg/L)	Ca (mg/L)	Cw (sand) (mg/L)	Cw (clay) (mg/L)
Neptunium-237	8.13E-05	5	1.63E-05	55	1.48E-06	0	1.06E-05	9.63E-07
Plutonium-238	1.17E-08	550	2.13E-11	5100	2.29E-12	0	1.39E-11	1.49E-12
Technetium-99	3.94E-05	0.1	3.94E-04	1	3.94E-05	0	2.57E-04	2.57E-05
Thorium-228	2.31E-09	3200	7.22E-13	5800	3.98E-13	0	4.70E-13	2.59E-13
Thorium-230	4.59E-05	3200	1.43E-08	5800	7.91E-09	0	9.34E-09	5.51E-09
Thorium-232	22.6	3200	7.06E-03	5800	3.90E-03	0	4.60E-03	2.54E-03
Uranium (total)	2.84	15	1.89E-01	1600	1.78E-03	0	1.23E-01	1.16E-03

Organics	Sc (mg/kg)	Kd_1 (foc=.0002) (L/kg)	Cp_1 (mg/L)	Kd_2 (foc=.001) (L/kg)	Cp_2 (mg/L)	Ca (mg/L)	Cw_1 (mg/L)	Cw_2 (mg/L)
Benzo(a)pyrene	2.08E-01	1100	1.89E-04	5500	3.78E-05	0	1.23E-04	2.46E-05

Table 5.10. Distribution coefficients and measured and modeled contaminant levels for SWMU 136

Project Name **WAGs 1 and 7 - SWMU 136**
Model Name Revised Summers Model
Documented *Resource Conservation and Recovery Act Facility Investigation/Remedial Investigation Report for Waste Area Groupings 1 and 7 at Paducah Gaseous Diffusion Plant Paducah, Kentucky*

CHEMICAL PARAMETERS AND CALCULATED RESULTS FOR SWMU 136

Contaminants: Radionuclides	Sc (mg/kg)	Kd (sand soils) (L/kg)	Cp (sand soils) (mg/L)	Kd (clay soils) (L/kg)	Cp (clay soils) (mg/L)	Ca (mg/L)	Cw (sand) (mg/L)	Cw (clay) (mg/L)
Technetium-99	3.53E-05	0.1	3.53E-04	1	3.53E-05	0	1.32E-06	1.32E-07
Uranium (total)	2.24	15	1.49E-01	1600	1.40E-03	0	5.57E-04	5.22E-06

Organics	Sc (mg/kg)	Kd_1 (foc=.0002) (L/kg)	Cp_1 (mg/L)	Kd_2 (foc=.001) (L/kg)	Cp_2 (mg/L)	Ca (mg/L)	Cw_1 (mg/L)	Cw_2 (mg/L)
1,1-Dichloroethene	4.90E-03	1.60E-02	3.06E-01	0.08	6.13E-02	0	1.14E-03	2.28E-04
Benzo(a)pyrene	2.08E-01	1100	1.89E-04	5500	3.78E-05	0	7.05E-07	1.41E-07
Trichloroethene	4.59E-03	4.28E-02	1.07E-01	2.14E-01	2.14E-02	0	4.00E-04	8.00E-05

simulate fate and transport of contaminants and RESRAD (DOE 1993) for additional modeling of radionuclide contaminants.

The MEPAS model offered a fate and transport and risk computation code that combined source term, transport, and exposure type models. Detailed hydraulic potential measurements at SWMU 2 determined that shallow groundwater flow included a minor lateral discharge component to the adjacent Outfall 15 ditch and a major vertical discharge component to the underlying RGA. Consequently, the SWMU 2 MEPAS model assessed three exposure points:

- groundwater use at Outfall 15 on Bayou Creek,
- groundwater use at the PGDP security fence, and
- groundwater use at the DOE property boundary.

The SWMU 2 RESRAD model assessed the generation of radionuclide daughter products and their transport from the source areas to the RGA directly beneath SWMU 2. Modelers simulated a 12,800-year period to address the long-term threat posed by the radionuclides.

As a conservative measure, the SWMU 2 risk assessment summed contaminant contributions from sources (e.g., surface soil, subsurface soil, and waste), with the exception of a potential secondary source of TCE that was thought to be improbable. The presence of a secondary source of DNAPL at SWMU 2 was not supported by field investigation results and required the catastrophic release of all drummed waste containing TCE at SWMU 2.

Modeling indicated an unacceptable impact upon the Outfall 15 ditch. However, soil and sediment samples at SWMU 2 provided empirical evidence that SWMU 2 had minimal affect upon ditch contaminant levels. Because a previous validation of MEPAS had documented a significant upward bias of contaminant levels in near field simulations, these model results were discounted. With the exception of the simultaneous TCE drum spill scenario, MEPAS modeling showed that contaminant migration from soil and waste cells to the RGA exposure points was not a concern over the 10,000-year model period. RESRAD modeling indicated that the maximum dose of radioactivity from SWMU 2 will arrive in the RGA 100 years into the future. The total contributed dose was expected to be less than the MCL for ionizing radiation. Tables 5.11 through 5.13 present transport parameters of the SWMU 2 model.

5.2.3 WAG 22 — SWMUs 7 and 30

The initial fate and transport models for SWMUs 7 and 30 were documented in *Remedial Investigation Report for Solid Waste Management Units 7 and 30 of Waste Area Grouping 22 at Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1998a). Groundwater model results were generated by the Seasonal Soil Compartment Model (SESOIL) (GSC 1995), for modeling leachate generation and vertical migration from the source units, and the Analytical Transient 1-, 2-, 3-Dimensional Model (AT123D) (Yeh 1981), for simulating horizontal transport in the RGA. Together, the two programs used algorithms similar to those of MEPAS to partition contaminants between soil-sorbed and water-dissolved phases and to transport contaminants to receptor points.

The SWMUs 7 and 30 RI also used the Storm Water Management Model (SWMM) (Huber and Dickinson 1988) to assess the impact of area surface soil contaminants to the PGDP outfall ditch network through ditches that bound the SWMUs on the north and south sides. This model employed soil-water partitioning coefficients and washoff and runoff parameters to derive stormwater contaminant levels.

Table 5.11. Transport parameters for SWMU 2

Multi Media Modeling Summary

Project Name **SWMU 2 of WAG 22**

Model Name Multimedia Environmental Pollutant Assessment System (MEPAS)

Documented *Data Summary and Interpretation Report for Interim Remedial Design at Solid Waste Management Unit 2 of Waste Area Grouping 22 at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*

Geologic Units	UCRS HU2a	UCRS HU2b	HU3	RGA HU4/HU5	McNairy HU6
Hydraulic Parameters					Not Represented
Thickness	7.5 ft	6 ft	9 ft	40 ft	
Conductivity	5E-6 cm/sec	1E-6 cm/sec	5E-6 cm/sec		
Porosity - Total	0.25	0.25	0.38	0.3	
Porosity - Effective				0.25	
Soil Saturation (%)	0	100	100	100	
Bulk Density	2.24 g/cm^3	2.24 g/cm^3	1.96 g/cm^3	2.16 g/cm^3	
TOC	0.1	0.1	0.08	0.03	
Dispersion - Longitudinal	0.75	0.6	0.9		
Dispersion - Transverse	61.9/81.7				
Dispersion - Vertical	0.469/0.619				
Groundwater Velocity				1.17 ft/day	
K_d Values	See attached	See attached	See attached	See attached	
Model Dimension					
VerticaL/Horizontal (2-D only)	1 D	1 D	1 D	1 D	
Source Terms					
Location	SWMU 2	SWMU 2	SWMU 2	SWMU 2	
Area					
Constant/Degrading	Degrading	Degrading	Degrading	Degrading	
Concentration					
Points of Exposure					
Locations	Fence/DOE boundary	Fence/DOE boundary	Fence/DOE boundary	Fence/DOE boundary	

Table 5.12. Distribution coefficients used in the MEPAS model of SWMU 2

Kd Values for: SWMU 2 of WAG 22
Model Name Multimedia Environmental Pollutant Assessment System (MEPAS)
Documented *Data Summary and Interpretation Report for Interim Remedial Design at Solid Waste Management Unit 2 of Waste Area Grouping 22 at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*

CONSTITUENT	UCRS - HU2a	UCRS - HU2b	HU3	RGA HU4/HU5
Aresenic	5.86	5.86	19.4	5.86
Barium	530	530	16000	530
Beryllium	70	70	8000	70
Cadmium	14.9	14.9	567	14.9
Chromium	16.8	16.8	360	16.8
Manganese	16.5	16.5	36.9	16.5
Nickel	12.2	12.2	650	12.2
Silver	0.4	0.4	40	0.4
Thallium	0	0	0.8	0
Uranium	1170	1170	3640	66.8
Vanadium	50	50	100	50
***cis*-1,2-Dichloroethene**	Not in MEPS database	Not in MEPS database	Not in MEPS database	Not in MEPS database
***trans*-1,2-Dichloroethene**	0.007	0.007	0.012	0.0059
Aroclor-1016	134	134	2300	111
Aroclor-1221	4.33	4.33	74.2	3.59
Aroclor-1232	0.575	0.575	9086	0.477
Aroclor-1242	4.7	4.7	80.6	3.89
Aroclor-1248	207	207	3540	171
Aroclor-1254	395	395	6780	328
Aroclor-1260	5000	5000	85700	4140
Trichloroethene	0.094	0.094	1.61	0.0779
Vinyl Chloride	0.0425	0.0425	0.729	0.0352
Am-241	82	82	1000	82
Np-237	3	3	3	3
Pu-239	10	10	250	10
Pu-234	0	0	500	0
Tc-99	3	3	20	3
Th-230	100	100	2700	100
Th-234	100	100	2700	100
U-234	906	906	1580	62.98
U-235	906	906	1580	62.98
U-238	906	906	1580	62.98

Table 5.13. Transport parameters and distribution coefficients used in the RESRAD model of SWMU 2

Multi Media Modeling Summary

Project Name	SWMU 2 of WAG 22
Model Name	RESidual RADioactivity
Documented	*Data Summary and Interpretation Report for Interim Remedial Design at Solid Waste Management Unit 2 of Waste Area Grouping 22 at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*

Geologic Units	**Universal**	**UCRS HU2a**	**UCRS HU2b**	**HU3**	**RGA HU4/HU5**	**McNairy HU6**
Parameters						Not
Thickness		2.29 m	1.83 m	2.74 m		Represented
Bulk Density		2.24 g/cm^3	2.24 g/cm^3	1.96 g/cm^3	2.16 g/cm^3	
Porosity - Total		0.25	0.25	0.38	0.3	
Porosity - Effective		0.13	0.13	0.3	0.25	
Soil-specific b parameter		4.05	4.05	10.4	4.05	
Hydraulic Conductivity		1.58 m/yr	0.32 m/yr	0.16 m/yr	6508 m/yr	
Hydraulic Gradient					0.02	
Water Table Drop Rate					0.001 m/yr	
Source Terms	SWMU 2					
Area	2973 m^2					
Constant/Degrading Concentration	Degrading (decay)					
Point of Exposure	RGA beneath SWMU 2					

Kd Values - cm^3/g				
Am-241	82	82	1000	82
Pb-210	234	234	1830	234
Np-237	3	3	3	3
Pu-239	10	10	250	10
Pa-231	0	0	500	0
Ra-226	24.3	24.3	124	2403
Tc-99	3	3	20	3
Th-229	100	100	2700	100
Th-230	100	100	2700	100
U-233	1170	1170	3640	66.8
U-234	1170	1170	3640	66.8
U-235	1170	1170	3640	66.8
U-238	1170	1170	3640	66.8

SESOIL Modeling. The SESOIL model used for leachate modeling, estimates pollutant concentrations in the soil profile following introduction via direct application and/or interaction with other media. The model defines the soil compartment as a soil column extending from the ground surface through the unsaturated zone and to the upper level of the saturated soil zone. Processes simulated in SESOIL are categorized in three cycles: the hydrologic cycle, sediment cycle, and pollutant cycle. Each cycle is a separate submodule in the SESOIL code. The hydrologic cycle includes rainfall, surface runoff, infiltration, soil-water content, evapotranspiration, and groundwater recharge. The pollutant cycle includes convective transport, volatilization, adsorption/desorption, and degradation/decay. A contaminant in SESOIL can partition in up to four phases (liquid, adsorbed, air, and pure).

Data requirements for SESOIL are not extensive, utilizing a minimum of soil and chemical parameters and monthly or seasonal meteorological values as input. Output of the SESOIL model includes pollutant concentrations at various soil depths and pollutant loss from the unsaturated soil zone in terms of surface runoff, percolation to groundwater, volatilization, and degradation. The simulations using SESOIL were continued until the maximum concentration in groundwater was attained or a simulation time of 1000 years was reached. The model was applied twice: (1) from the Waste Pits (source units) to the HU 2, and (2) from HU 2 to the RGA. Soil contaminant levels determined by the SWMUs 7 and 30 RI and back-calculated soil contaminant levels based on area dissolved-phase levels were used in the SESOIL model of the source units.

Source Areas. Although 27 constituents from Pit A were identified as the initial CMCOPCs based on soil screening, only 7 of them were selected for SESOIL modeling. Similarly, 14 of the 38 initial CMCOPCs from Pits B/C, 4 of 26 initial CMCOPCs from the F Pits, and 7 of 18 initial CMCOPCs from Subsurface Outside of the Pits were selected for SESOIL Modeling. The model was calibrated against the percolation rate by varying the hydraulic conductivity and the disconnectedness index and keeping all other site-specific geotechnical parameters fixed. The final parameter values used in this modeling are as follows: soil bulk dry density of 1.5 g/cm^3, porosity of 0.40, organic carbon content of 0.34%, and a volumetric moisture content of 27.5%. Additional parameter values used in the model included a disconnectedness index of 10.0 and an intrinsic permeability of 9.0×10^{-10} cm^2 which was derived during calibration of the model to a percolation rate of 4.6 in/year.

The SESOIL model was set up using four layers extending from the ground surface to the average water table surface at 12 ft bgs. The first layer of the model extended from ground surface to 1 ft bgs and corresponds to the observed soil cover over the pits. The second layer extended from 1 ft bgs to 5 ft bgs and corresponds to the sampling interval. Therefore, this layer represents the loading zone. The third layer extended from 5 ft bgs to 10 ft bgs, and most of the pit water was collected in this interval that was used to back-calculate to corresponding soil concentrations. Therefore, this layer also represents a loading zone. The fourth layer extended from 10 to 12 ft bgs, formed the leaching zone, and was divided into 5 sublayers for better resolutions. The application parameters for constituents from Pit A, Pits B/C, the F Pits, and Subsurface Outside of the Pits modeled using SESOIL could be found in Appendix D of the RI document. Tables 5.14 through 5.17 present the results of SESOIL modeling for the source areas.

UCRS. SESOIL-predicted maximum leachate concentrations from the individual source areas were compared against the observed maximum groundwater concentrations, and the source term concentrations for transporting the contaminants vertically down to the RGA were developed. However, only 17 of 42 initial CMCOPCs from the UCRS were selected for SESOIL modeling. As before, the model was calibrated against the percolation rate by varying the hydraulic conductivity and the disconnectedness index and keeping all other site-specific geotechnical parameters fixed. The final parameter values used in the modeling from UCRS are as follows: soil bulk dry density of 1.5 g/cm^3, porosity of 0.40, organic carbon content of 0.26%, and a volumetric moisture content of 29.5%. Additional parameter values used in the model included a disconnectedness index of 10.0 and an intrinsic permeability of 1.65×10^{-10} cm^2. Of these

Tables 5.14. Summary of leachate modeling results for the CMCOPCs[1] from the Burial Pit A, WAG 22

COPCs	Exposure Concentration	Predicted $C_{gw,max}$[2] in the UCRS	Predicted T_{max}	Observed $C_{gw,max}$ in the UCRS	Groundwater RGOs	Comment
			Metals[a]			
Cadmium	10.0	0.375	545	N/A	0.005	M
Chromium	55.0	1.95	415	0.91	0.10	M
			Radionuclides[b]			
^{237}Np	1.8	119	338	0.4	1.31	R
^{99}Tc	18	66,441	5	99	276	R
			Volatile Organic Compounds[c]			
Methylene chloride	5.69	12.0	4	N/A	5.00	M
Chlorobenzene	88.31	53.4	12	N/A	12.7	R
Chloromethane	2.19	2.27	4	N/A	1.33	R

[1] These COPCs represent the constituents that were selected for SESOIL modeling.

[2] It should be noted here that the predicted Cgw, max in the UCRS represent the peak leachate concentration before reaching the water table based on contaminant leaching from the existing source concentrations.

[a] Concentations of all inorganic compounds are expressed in mg/kg or mg/L.

[b] Concentrations of radionuclides are expressed as pCi/g or pCi/L.

[c] Concentrations of organic compounds are expressed as µg/g or µg/L.

M = MCL

R = Risk-based

N/A = Not available

Tables 5.15. Summary of leachate modeling results for the CMCOPCs[1] from the Burial Pits B/C, WAG 22

COPCs	Exposure concentration	Predicted $C_{gw,max}$[2] in the UCRS	Predicted T_{max}	Observed $C_{gw,max}$ in the UCRS	Groundwater RGOs	Comments
			Metals[a]			
Arsenic	41	2.48	254	0.28	0.05	M
Barium	232.22	13.61	784	4.3	2	M
Cadmium	165.1	6.96	524	N/A	0.005	M
Chromium	371.08	19.72	391	0.91	0.1	M
Copper	31,933	634	456	0.46	0.602	R
Mercury	2.04	0.009	114	0.0011	0.002	M
			Radionuclides[b]			
^{237}Np	19.0	879	327	0.4	1.31	R
^{99}Tc	656.5	3,555,651	4	99	276	R
			Volatile organic compounds[c]			
Benzene	34.7	62.2	6	12	5	M
Methylene chloride	20.52	60.5	4	N/A	5	M
Toluene	753.4	678.2	9	59	1000	M
			Semivolatile organic compounds[d]			
2,4,6-Trichlorphenol	41	3.25	215	N/A	3.99	R
2,4-Dimethylphenol	5,034	11,390	10	4.4	230	R
Hexachloroethane	34.0	0.8	585	N/A	3.29	R

[1] These COPCs represent the constituents that were selected for SESOIL modeling.

[2] It should be noted that the predicted $C_{gw,max}$ in the UCRS represent the peak leachate concentration before reaching the water table based on contaminant leaching from the existing source concentrations.

[a] Concentrations of all inorganic compounds are expressed as mg/kg or mg/L.

[b] Concentrations of radionuclides are expressed as pCi/g or pCi/L.

[c] Concentrations of organic compounds are expressed as g/g or g/L.

M = MCL

R = Risk-based

N/A = Not available

Table 5.16. Summary of leachate modeling results for the COPCs[1] from the Burial Pit F, WAG 22

COPCs	Exposure concentration	Predicted $C_{gw,max}$[2] in the UCRS	Predicted T_{max}	Observed $C_{gw,max}$ in the UCRS	Groundwater RGOs	Comments
			Radionuclides[a]			
^{237}Np	0.04	1.73	338	0.4	1.31	R
^{99}Tc	4.17	26,430	5	99	276	R
			Semivolatile organic compounds[b]			
4-Methylphenol	0.75	1.69	8	0.21	N/A	

[1] These COPCs represent the constituents that were selected for SESOIL modeling.

[2] It should be noted that the predicted $C_{gw,max}$ in the UCRS represent the peak leachate concentration before reaching the water table based on contaminant leaching from the existing source concentrations.

[a] Concentrations of all inorganic compounds are expressed as mg/kg or mg/L.

[b] Concentrations of radionuclides are expressed as pCi/g or pCi/L.

[c] Concentrations of organic compounds are expressed as g/g or g/L.

M = MCL

R = Risk-based

N/A = Not available

Table 5.17. Summary of leachate modeling results for the COPCs[1] from the Subsurface Soil Outside Pits, WAG 22

COPCs	Exposure concentration	Predicted $C_{gw,max}$ [2] in the UCRS	Predicted T_{max}	Observed $C_{gw,max}$ in the UCRS	Groundwater RGOs	Comments
			Metals[a]			
Arsenic	3.143	1.06	265	0.28	0.05	M
Barium	104.3	8.92	827	4.3	2	M
Cadmium	1.85	0.37	557	N/A	0.005	M
Chromium	21.45	2.37	419	0.91	0.1	M
			Radionuclides[b]			
^{237}Np	2.36	428.58	360	0.4	1.31	R
^{99}Tc	280.0	977,625	5	99	276	R
			Volatile organic compounds[c]			
Methylene chloride	87.1	710.4	4	N/A	5	M

[1] These COPCs represent the constituents that were selected for SESOIL modeling.

[2] It should be noted that the predicted $C_{gw,max}$ in the UCRS represent the peak leachate concentration before reaching the water table based on contaminant leaching from the existing source concentrations.

[a] Concentrations of all inorganic compounds are expressed as mg/kg or mg/L.

[b] Concentrations of radionuclides are expressed as pCi/g or pCi/L.

[c] Concentrations of organic compounds are expressed as g/g or g/L.

M = MCL

R = Risk-based

N/A = Not available

parameters, porosity, density, and disconnectedness index represent default values for silty-clay, and organic carbon content represents average measured value. The volumetric moisture content and the intrinsic permeability were derived during calibration of the model to a percolation rate of 4.3 in./year.

The SESOIL model was set up using three layers extending from the top of the HU 2 to the top of the RGA at 45 ft bgs. The first layer of the model extended from top of the HU 2 to the top of the confining zone and corresponds to the contaminated zone. This layer was divided into five sublayers and contaminant loading was performed in each of these sublayers that represented the back-calculated soil concentrations. The second layer extended from the top of the confining zone to the top of the RGA and formed the leaching zone. This layer also was divided into five sublayers for better resolutions. The third layer of 0.5 ft was used to read the output concentrations at the water table. The application parameters for constituents from UCRS modeled using SESOIL could be found in Appendix D of the RI document. Table 5.18 presents the results of SESOIL modeling.

AT123D Modeling in the RGA. The AT123D is an analytical groundwater pollutant fate and transport model. It computes the spatial-temporal concentration distribution of wastes in the aquifer system and predicts the transient spread of a contaminant plume through a groundwater aquifer. The fate and transport processes accounted for in AT123D are advection, dispersion, adsorption/retardation, and decay. This model can be used as a tool for estimating the dissolved concentration of a chemical in three dimensions in the groundwater resulting from a mass release over a source area (point, line, area, or volume source). The model can handle instantaneous, as well as continuous, source loadings of chemicals of interest at the site.

Six organic compounds and one radionuclide were selected for AT123D modeling in the RGA, based on source loading from UCRS predicted by SESOIL. Contributions from all SWMUs 7 and 30 source units were combined before modeling the expected contributions at the two RGA exposure points, the PGDP security fence, and the DOE property boundary. Maximum concentrations at these two receptor locations were simulated for these constituents. Maximum concentrations at the end of 30 years of simulations also were predicted for these constituents. Table 5.19 presents the results of AT123D modeling.

SWMM Modeling. SWMM model used in the surface-water analysis is a mathematical model for simulating flow and contaminant transport in watershed and in drainage channels. The model was developed by EPA (Huber and Dickinson 1988) and is widely recognized and accepted for simulating runoff quantity and quality due to rainfall. The model simulates time-varying hydrologic conditions, rainfall excess for runoff, infiltration, runoff flows, and movement of contaminants for a specified rainfall period. The conceptual surface-water flow model was used as a basis to form the initial SWMM numerical model for the site. This model was refined using site hydrologic data (specifically, rainfall), site physical characteristics (soil, topography), surface soil geologic characteristics, surface-water drainage patterns, and contaminant concentration data from the field. Washoff and runoff parameters for the surface-water model were determined by calibration with surface-water contaminant levels from the RI database. The simulated peak concentrations at the west drainage ditch due to transport of contaminants through the north and south ditches are shown in Table 5.20. Fate and transport modeling for SWMUs 7 and 30 yielded the following results:

- Technetium-99 contamination derived from the area was a current problem in both groundwater and surface water.

- Uranium isotopes will become the primary groundwater contaminant from the SWMUs over the 1,000-year period modeled.

Table 5.18. Summary of leachate modeling results for the COPCs[1] from the UCRS, WAG 22

COPCs	Exposure concentration	Predicted $C_{gw,max}$[2] in the UCRS	Predicted T_{max}	Observed $C_{gw,max}$ in the UCRS	Groundwater RGOs	Comments
			Metals[a]			
Mercury	0.09	0.0042	405	0.0012	0.002	M
			Radionuclides[b]			
^{99}Tc	355.6	763,627	14	3,670	276	R
			Volatile organic compounds[c]			
1,1,1-Trichloroethane	94.77	27.5	26	1.3	200	M
1,2-Dichloroethane	0.59	0.32	14	3	5	M
1,1-Dichlorethene	3.89	0.31	16	3.7		
1,2-Dichloroethene	1591.9	281.3	18	110	136	R
cis-1,2-Dichloroethene	406.1	133.7	13	140	149	R
4-Methyl-2-2-pentanone	0.09	0.09	10	2.9	N/A	
Acetone	2.54	2.73	9	430	1510	R
Benzene	1.93	0.48	16	N/A	5	M
Chloromethane	0.03	0.01	10	14	1.33	R
Methylene chloride	18.47	9.40	10	N/A	5	M
Trichloroethene	464.4	56.53	20	19,000	5	M
Vinyl chloride	362.7	15.21	12	N/A	2	M
			Semivolatile organic compounds[c]			
2,4-Dimethylphenol	6189.3	1983.42	30	N/A	230	R

[1] These COPCs represent the constituents that were selected for SESOIL modeling.

[2] Predicted $C_{gw,max}$ in the RGA represent the predicted peak leachate concentrations due to contaminant leaching from existing source concentrations or from the contamination already present in the UCRS.

[a] Concentrations of all inorganic compounds are expressed as mg/kg or mg/L.

[b] Concentrations of radionuclides are expressed as pCi/g or pCi/L.

[c] Concentrations of organic compounds are expressed as g/g or g/L.

M = MCL

R = Risk-based

N/A = Not available

Table 5.19. Summary of transport modeling in the RGA based on future contaminant loading from SWMUs 7 and 30

Constituent	Unit	Predicted maximum concentration beneath the source	Predicted GW concentration at the PGDP security fence in the direction of flow		Predicted GW concentration at the DOE property boundary in the direction of flow	
			30 years	100 years	30 years	100 years
1,2-DCE	µg/L	27	16.8	24.3	5.2	5.2
cis-12-DCE	µg/L	12.3	4.6	11.3	1.5	2.7
TCE	µg/L	5.3	3.8	4.6	1.1	1.1
Methylene chloride	µg/L	0.8	0.14	0.8	0.05	0.19
Vinyl chloride	µg/L	1.0	0.15	0.96	0.06	.23
2,4-Dimethylphenol	µg/L	200	174	1.74	4.1	40.7
^{99}Tc	pCi/L	23,580	1996	21,686	1205	5077

Note: All the constituents that were identified as the initial CMCOPCs in the source areas (i.e., SWMUs 7 and 30, and also the UCRS beneath the site) were modeled to the RGA. However, only the constituents that were predicted to arrive at the RGA with concentrations exceeding their groundwater MCLs/RBCs were modeled to the receptors using AT123D and are shown in this table. All the concentrations shown in this table represent only the contributed concentrations and do not account for the existing concentrations that have already contaminated the RGA groundwater.

Table 5.20. Simulated peak concentrations at the west drainage ditch due to contaminant loading from North and South Drainage Ditches

Constituent	Unit	Surface-water concentrations at the intersection of North and West Ditches	Surface water concentrations at the intersection of South and West Ditches
Nickel	mg/L	0.03	0.02
PAH	µg/L	44.84	44.54
PCB	µg/L	6.12	5.57
^{237}Np	pCi/L	0.11	0.07
^{99}Tc	pCi/L	99.88	102.39
^{230}Th	pCi/L	3.73	4.75
^{234}U	pCi/L	12.77	17.71
^{235}U	pCi/L	0.56	0.77
^{238}U	pCi/L	24.39	33.83

- VOCs will persist as a major groundwater contaminant until the area DNAPL source is depleted.
- Several types of surface-water contaminants were associated with the SWMUs.

To support development of the SWMUs 7 and 30 FS, additional modeling of ^{99}Tc sources was performed. The report *Technetium-99 Transport Modeling Results for Sources at SWMUs 7 and 30 at the Paducah Gaseous Diffsuion Plant, Paducah, Kentucky* (DOE 1998b) documented the results. In the later simulations, SESOIL (GSC 1996a) and AT123D (GSC 1996b) were used to model each of five source areas separately from its origin to the receptor points. The revised models showed that the SWMUs 7 and 30 sources would not contribute ^{99}Tc at levels that exceed its current MCL at either exposure point.

5.2.4 WAG 6

The WAG 6 RI, as documented in *Remedial Investigation Report for Waste Area Grouping 6 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1999a), used MEPAS to model fate and transport of area contaminants through the RGA. Exposure was modeled at the same two exposure points used in WAGs 7 and 30: the PGDP security fence and the DOE property boundary. The MEPAS modeling for this WAG was conducted using source terms for eight of nine sectors delineated for this area. The ninth area (Sector 9) had no source delineated. This sector was delineated only for purposes of assessing the presence and location of a dissolved contaminant plume originating from Sector 2. The WAG 6 model addressed all areas within the C-400 block, including: SWMUs 11, 40, 47, and 203; the SWMU 26 abandoned pipeline running from C-400; and an area overlying a TCE and ^{99}Tc plume exiting from the northeast corner of the C-400 complex. For each defined sector within WAG 6, constituents were modeled for both surface and subsurface sources. The source terms for "Surface" and "Subsurface," respectively, apply to topsoil and the UCD (host formation of the UCRS). Modelers identified sources of undissolved contaminants within the lower Continental deposits (host formation of the RGA) for two sectors: Sectors 5 and 7. These source terms were identified as "RGA." Table 5.21 summarizes the main attributes of the conceptual site model for WAG 6.

MEPAS will handle a number of partially saturated zones, but restricts the user to one saturated zone. At the PGDP the primary saturated zone is the RGA, and this is considered the primary groundwater pathway through which contaminants can leave the site. To represent each SWMU within WAG 6 as accurately as possible, available geophysical logs and borings were reviewed and a hydrogeologic conceptual model was developed for the MEPAS simulations. For each of the sectors modeled in WAG 6 two

Table 5.21. Transport parameters used in the model for WAG 6

Multi Media Modeling Summary						
Project Name	**WAG 6**					
Model Name	Multimedia Environmental Pollutant Assessment System (MEPAS)					
Documented	*Remedial Investigation Report for Waste Area Grouping 6 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, Vol. 1 (DOE/OR/07-1727/V1&D2)*					
	Universal	**UCRS HU2a**	**UCRS HU2b**	**HU3**	**RGA HU4/HU5**	**McNairy HU6**
Conceptual Model						
Media Represented (soil, air, water, NAPL)	Partially Saturated Zone			Not Represented	Saturated Zone	Not Represented
Geologic Units						
Hydraulic Parameters						
Thickness	49	ft			45	ft
Conductivity	0.3	ft/day (vert)			1500	ft/day
Porosity	0.3				0.37	
Soil Saturation (%)	0.14				100	
Bulk Density	1.86				1.67	
TOC						
Dispersion	0.4				50	ft
Dispersion					5	ft
Groundwater Velocity					0.6	
Hydraulic Gradient					0.0004	
Model Dimension						
VerticaL/Horizontal (2-D only)	1d				1d	
COCs						
Source Terms	8 source terms				8 source terms	
Constant/Degrading	Degrading					
Points of Exposure	Fence	Plant Boundary			Fence	Plant Boundary
Locations	3300	5500			3300	5500

model layers were used. The first layer was the partially saturated zone (UCRS), and the second was the saturated zone (RGA). A complete description of the hydrogeology of this area may be found in Appendix C of the WAG 6 RI report.

No attempt was made to model a TCE DNAPL zone or a distinct ^{99}Tc source in the RGA for WAG 6. Dissolved-phase levels in the Northwest Plume immediately downgradient of C-400 greatly exceeded risk-based action levels. Moreover, the off-site extent of this plume was well documented. It was felt that no additional insight likely would be gained by fate and transport modeling of these sources with the available definition of the sources.

Instead, the model focused on measured soil contaminant levels and their effect on groundwater contaminant levels at the exposure points. With the exception of Sector 1, which was completely covered by the C-400 Building, distinct source units were modeled for surface soil and subsurface soil to support FS decisions. Over the 10,000-year model period, several VOCs and metals were shown to be the main risk drivers originating from WAG 6. Tables 5.22 through 5.29 present the source term information for each sector for the all the constituents selected for fate and transport modeling from this WAG. The modeling results for WAG 6 are presented in Tables 5.30 through 5.37.

5.2.5 WAG 27

Remedial Investigation Report for Waste Area Grouping 27 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky (DOE 1998c) included fate and transport modeling using MEPAS for four sites in the west and north ends of the PGDP: SWMU 001, SWMU 091, SWMU 196, and the C-720 Complex. The site-specific models were based on a consistent set of hydrogeologic and transport parameters while varying the distance to the two exposure scenarios, the PGDP security fence and the DOE property boundary. Table 5.38 presents the values assigned to key parameters of the conceptual site model for WAG 27. Tables 5.39 through 5.42 presents the transport parameters used for the WAG 27 MEPAS simulations.

Soil contaminant levels provided definition of discrete surface soil, subsurface soil, UCRS, and RGA sources, where present, for each of the four sites. The contaminants to be modeled for WAG 27 were determined based on a screening process (discussion of the screening process is presented in the RI). Tables 5.43 through 5.46 present the source term information for the contaminants that were selected for fate and transport modeling from each SWMU. SWMUs 001 and 091 and the C-720 Complex shared common exposure points within the Southwest Plume, as documented by the WAG 27 RI. The exposure points for SWMU 196 were discrete locations on the north side of the PGDP. Like WAG 6, the fate and transport simulations addressed a +10,000-year time frame. SWMU 196 contained no COPCs for the groundwater pathway. Groundwater COCs from the other three sites principally included VOCs and metals. Radionuclides did not present a significant groundwater risk from WAG 27. The modeling results for WAG 27 are presented in Tables 5.47 through 5.50.

The Modified Universal Soil Loss Equation (MUSLE) was used to calculate sediment yield to the drainage ditches at SWMU 196 in WAG 27. The input parameters for SWMU 196 for the average monthly rainfall (4.19 inches, 720 hours per month) can be found in the Appendix C of the WAG 27 RI Report. The predicted sediment yield of 0.000545 tons/event was used to calculate contaminant loading for the single contaminant exceeding its PRG in surface soil, antimony. The reasonable maximum exposure concentration is 62.2 mg/kg antimony (or 30.8 mg loading/event). The result indicated that contaminant loading from SWMU 196 via overland transport should be minimal.

Table 5.22. MEPAS source terms for Sector 1

Contaminant	Level	X-Axis (ft)	Y-Axis (ft)	Z-Axis (ft)	Notes
			Subsurface Soil		
	y	235	498	39	
Neptunium-237	0.3 pCi/g	Modeled as distributed across sector. Z-axis assumes building backfill extends to 10 ft depth.			Maximum detection

Notes:
No source modeled for the following:
TCE: detections believed to be due to Sector 4 source. Sector 4 source dimensions include contaminated volume beneath Sector 1.
X-axis is east-west; Y-axis is north-south; Z-axis is vertical (thickness).

Table 5.23. MEPAS source terms for Sector 2

Contaminant	Level	X-Axis (ft)	Y-Axis (ft)	Z-Axis (ft)	Notes
			Surface Soil		
Phenanthrene	470 µg/kg	230	210	1	Modeled over entire sector.
Uranium-238	4.6 pCi/g				
			Subsurface Soil		
2,6-Dinitrotoluene	432 µg/kg	182	180	49	Maximum detect of 5 detects (in Borings 400-003, 400-005, 400-006, and 400-008). This contaminant could not be modeled because it was absent from the MEPAS database.
Chromium	54.3 mg/kg	101	41	49	Maximum detect. Area around Boring 400-008.
Dibenzofuran	576µg/kg	51	76	2	From 0-2 ft. This contaminant could not be modeled because it was absent from the MEPAS database.
N-Nitroso-di-n-propylamine	634 µg/kg	80	170	46	Maximum detect of 3 detects (in Borings 040-003 and 400-008).
Phenanthrene	487µg/kg	101	117	6	Average of 2 detects +1/2 of 62 non-detects. Detected in borings in southwestern portion of sector (400-005 and 400-008) in soil samples from 1-7 ft bgs.
Thallium	2.3 mg/kg	58	53	2	Maximum detect (Boring 400-003). Detected in 0-2 ft sample.
Uranium-234	20.1 pCi/g	53	129	38	Maximum detects.
Uranium-235	0.7 pCi/g				Detected in SWMU 40 area (Borings 40-005, 40-007, 40-008) and in southeastern portion of sector (Borings 400-058 and 400-061).
Uranium-238	20.2 pCi/g	210	230	49	Maximum detect.
		Modeled over entire sector			

Notes:
The following detects were excluded from consideration in the subsurface in Sector 2 because they only slightly exceeded the background levels:

- Chromium – detected concentration of 39 mg/kg in Boring 040-002 at 11-15 ft bgs just exceeds background of 38 mg/kg.
- Thallium – detected concentration of 0.9 mg/kg in Boring 400-007 at 1-2 ft bgs just exceeds background of 0.7 mg/kg.
- Thallium – detected concentration of 0.8 mg/kg in Boring 400-008 at 32-42 ft bgs just exceeds background of 0.7 mg/kg
- Thallium – detected concentration of 0.8 mg/kg in Boring 400-059 at 10-14 ft bgs just exceeds background of 0.7 mg/kg.

In addition, ^{237}Np was excluded from consideration because it had only one detect in 11 samples (0.3 pCi/g in Boring 040-005 at 7-11 ft bgs). There was a non-detect at 0.1 pCi/g in the same boring.
X-axis is east-west; Y-axis is north-south; Z-axis is vertical (thickness).

Table 5.24. MEPAS source terms for Sector 3

Contaminant	Level	X-Axis (ft)	Y-Axis (ft)	Z-Axis (ft)	Notes
			Source: Surface Soil		
Arochlor-1260	3,300 µg/kg				Maximum detected values.
Neptunium-237	0.4 pCi/g				Only two surface soil sampling
PCBs	10,000 µg/kg				Locations in Sector 3, so Modeled as distributed across
Phenanthrene	1,200 µg/kg	122	234	1	Entire sector.
Thallium	1.2 mg/kg				
Thorium-230	4.2 pCi/g				
Uranium-234	7.1 pCi/g				
Uranium-235	0.4 pCi/g				
Uranium-238	9.1 pCi/g				
			Source: Subsurface Soil		
Phenanthrene	706.3 µg/kg	70	135	4	Average of 3 detects.
Trichloroethene	1,502 µg/kg	152	234	49	Average of 23 detects. Area includes entire sector plus a small portion of the eastern side of Sector 1.
Neptunium-237	0.3 pCi/g	70	234	49	Average of 8 detects. The area is centered around the 2 borings (011-001 and 011-002) with the 8 detects.

Notes:

No sources were modeled for the following subsurface contaminants because they were detected in only one sample:

- Dibenzofuran (max detect = 50 µg/kg), 1 detect, 43 non-detects.
- N-Nitroso-di-n-propylamine (max detect = 331 µg/kg), 1 detect, 43 non-detects.
- Thallium (maximum detect = 0.8 mg/kg), 1 detect, 29 non-detects. The one detect value was only slightly above the PRG.
- Americium-241 (maximum detect = 0.2 pCi/g), 1 detect, 35 non-detects.

In addition, Uranium-238 was not modeled in a subsurface source because it was only detected once above the 2 times background value in 35 detects. This maximum detect value (2.5 pCi/g) only slightly exceeded 2 times background (2.4 pCi/g).
X-axis is east-west; Y-axis is north-south; Z-axis is vertical (thickness).

Table 5.25. MEPAS source terms for Sector 4

Contaminant	Level	X-Axis (ft)	Y-Axis (ft)	Z-Axis (ft)	Notes
		Source: Surface Soil			
Arochlor-1262	38 µg/kg	196	221	1	Only one surface soil analysis available.
Phenanthrene	70 µg/kg				Modeled as distributed across sector less area covered by concrete apron.
		Source: Subsurface Soil			
1,1,1-Trichloroethane	2,400 µg/kg				Detected in Boring 400-200 only.
Trichlorofluoromethane	1.7 µg/kg	65	65	9	Only at 5-9 ft bgs.
1,1,2-Trichloroethane	530 µg/kg				
1,1-Dichloroethene	950 µg/kg				
Carbon Tetrachloride	710 µg/kg	65	65	49	Detected in Boring 400-200 only.
Chromium	51.6 mg/kg				
Phenanthrene	250 µg/kg				
Tetrachloroethene	690 µg/kg				
Neptunium-237	0.29 pCi/g	196	221	49	Modeled as distributed across sector less area cover by concrete apron.
Cis-1,2-Dichloroethene	2,400 µg/kg				
Trichloroethene	11,000,000 µg/kg	130	63	49	1'-35': 115' × 34'
Trans-1,2-Dichloroethene	34,000 µg/kg				36'-50': 147' × 120'
Vinyl Chloride	130 µg/kg				
Plutonium-239	0.2 pCi/g				

Notes:

No source modeled for the following:

- Chloromethane (max detect = 270 µg/kg) and Iodomethane (max detect = 430 µg/kg): Boring 400-014. Only detected at 45'-49' interval.
- Chromium detections in Boring 400-103 (at 9'-13' interval): detection = 38.3 mg/kg, PRG = 38 mg/kg.
- Cobalt detections in Borings 400-068 (at 13'-17' interval) (14.2 mg/kg) and 400-016 (at 16'-20' interval) (16.1 mg/kg): these detections are only slightly above background (13 mg/kg) and unrelated geographically.
- Cobalt (at 126 mg/kg) and lead (at 82.5 mg/kg) detections in Boring 011-006 (at 36'-40' interval): only low levels of detections of cobalt and lead above and below interval - no local source known.
- Lead in Boring 400-138 (at 4'-8' interval) (24.5 mg/kg): isolated detection only slightly above background (23 mg/kg).
- N-Nitroso-di-n-propylamine (447 µg/kg): singular detection in Boring 400-069 (at 13'-17' interval).
- Thallium detections in Borings 400-066 (at 13'-17' interval) (0.9 mg/kg) and 400-139 (at 4'-8' interval) (1.1 mg/kg): detections only slightly above PRG (0.7 mg/kg) and geographically unrelated.
- Uranium-238: detected above background levels in only 3 of 139 analyses.
- Vinyl chloride in Boring 400-201 (at 4'-8' interval): detection of 3,000 µg/kg is one order of magnitude above all other detections (10).

No water sources were modeled. All water contaminants (TCE and *trans*-1,2-DCE) are subsurface soil contaminants.
X-axis is east-west; Y-axis is north-south; Z-axis is vertical (thickness).

Table 5.26. MEPAS source terms for Sector 5

Contaminant	Level	X-Axis (ft)	Y-Axis (ft)	Z-Axis (ft)	Notes
		Source: Surface Soil			
Acenaphthylene	2924 µg/kg				Average of 1 detect and 1/2 of 4 non-detects
Benz(a)anthracene	7600 µg/kg				Average of 3 detects - no non-detects
Benz(a)pyrene	13,000 µg/kg				1 analysis
Benz(b)fluoranthene	9800 µg/kg				Average of 2 detects - no non-detects
Benz(k)fluoranthene	8751 µg/kg				1 analysis
Chromium	48 mg/kg	350	250	1	1 analysis
Dibenzofuran	429 µg/kg	Modeled as distributed across sector less area covered by concrete apron			Average of 3 detects and 2 non-detects (used max detect level)
Neptunium-237	0.13 pCi/g				Average of 1 detect and 2 non-detects
Phenanthrene	5197 µg/kg				Average of 5 detects
Plutonium-239	0.10 pCi/g				Average of 1 detect and 2 non-detects
Technetium-99	11.8 pCi/g				Average of 3 detects
Thallium	1.2 mg/kg				Average of 2 detects - no non-detects
Uranium-234	4.9 pCi/g				Average of 3 detects
Uranium-235	0.27 pCi/g				Average of 1 detect and 2 non-detects
Uranium-238	7.0 pCi/g				Average of 3 detects
		Source: Subsurface Soil			
Cis-1,2-Dichloroethene	1000 µg/kg				Modeled as discrete source
Trans-1,2-Dichloroethene	15,300 µg/kg	250	85	49	Along storm sewer
Vinyl Chloride	35 µg/kg				
Iodomethane	700 µg/kg	55	45	18	Detected in Boring 400-015 only. Only at 8'-12'. 3 non-detects beginning at 19' depth.
Americium-241	1 pCi/g				Single analysis
Cesium-137	0.31 pCi/g	350	336	49	Average of 29 detects
Thallium	1.6 mg/kg	Modeled as distributed across entire sector			Maximum of 2 analyses
Uranium-235	0.4 pCi/g				Maximum of 2 analyses
Trichloroethene	168,200 µg/kg	59	45	49	Maximum detection
		Modeled as discrete source centered on Boring 400-015			

Notes:

No subsurface source modeled for the following:

- N-Nitroso-di-n-propylamine (582 µg/kg): singular analysis for Boring 400-088 (at 6'-10' interval).
- Tc-99: 2 of 56 detections above background (2.8 pCi/g). 3.1 pCi/g in 400-192 at 16'-20' only slightly above background. 7.3 pCi/g in 400-141 at 0'-4' attributed to surface soils.
- U-234: 1 detection (2.7 pCi/g in 400-141 at 0'-4') of 69 analyses only slightly above background (2.4 pCi/g). Higher activity attributed to surface soils.
- U-238: 2 of 69 detections above background (1.2 pCi/g). 1.4 pCi/g in 400-145 at 4'-8' only slightly above background. 4.6 pCi/g in 400-141 at 0'-4' attributed to surface soils.

No water sources were modeled. Unfiltered water samples yielded detections of the following at levels above the higher of background or PRG reference levels.

Boring 400-017 (at 33' - 43'):
Metals: none
Organics: TCE
Radionuclides: none

Boring 400-018 (at 38' - 40'):
Metals: Al, As, Ba, Be, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Hg, Ni, K, Na, V, Zn
Organics: TCE
Radionuclides: Pb-212, K-40, Th-228, Th-230, Th-232, U-233/234, U-238

X-axis is east-west; Y-axis is north-south; Z-axis is vertical (thickness).

Table 5.27. MEPAS source terms for Sector 6

Contaminant	Level		X-Axis (feet)	Y-Axis (feet)	Z-Axis (feet)	Notes
			Surface Soil			
2-Methylnaphthalene	44	µg/kg				Detected in boring 400-044 only.
Dibenz(a,h)anthracene	3,200	µg/kg	225	200	1	Detected in boring 047-002 only.
Dibenzofuran	942	µg/kg				Average of detect in boring 047-002 and 1/2 non-detect in boring 400-044.
Americium-241	0.2	pCi/g				
Cesium-137	1.5	pCi/g				
Neptunium-237	1	pCi/g	20	20	1	Detections in
Technetium-99	53	pCi/g	Modeled as 20' × 20' bermed			Boring 047-002
Thorium-230	6.4	pCi/g	area. Non-detect and below			
Uranium-234	31.1	pCi/g	background in Boring 400-044.			
Uranium-235	1.9	pCi/g				
Uranium-238	39.5	pCi/g	20	20	1	Activity in boring 047-002. Also detected at 3 pCi/g in 400-044.
			Subsurface Soil			
Americium-241	0.2	pCi/g	225	200	49	Average of 1 detect and 2 non-detects.
Neptunium-237	0.2	pCi/g	20	20	25	Boring 047-002. Non-detect at 26'.
Technetium-99	8.1	pCi/g				Boring 047-002.
Uranium-234	41.7	pCi/g	20	20	7	Non-detects and
Uranium-235	2.2	pCi/g				background
Uranium-238	42.8	pCi/g				levels @ 8'.
trans-1,2-Dichloroethene	2,500	µg/kg	50	200	49	Maximum detect.
Trichloroethene	1,700	µg/kg	X-axis determined by < 5 detects in boring 400-041 of Sector 5.			Maximum detect.

No source modeled for:

- Chromium (49.3 mg/kg): single analysis in boring 400-076 @ 14'-18' interval.
- Benz(a)anthracene (18,000 µg/kg), Benz(a)pyrene (16,000 µg/kg), Benz(b)fluoranthene (17,000 µg/kg), Benz(k)fluoranthene (11,000 µg/kg): single analysis for each contaminant (surface soil sample) in boring 047-002, not expected to be a site contaminant.

X-axis is east-west; Y-axis is north-south.

Table 5.28. MEPAS source terms for Sector 7

Contaminant	Level	X-Axis (ft)	Y-Axis (ft)	Z-Axis (ft)	Notes
			Source: Surface Soil		
Chromium	66 mg/kg	290	195	1	Detected in both surface soil samples.
Uranium-238	3.2 pCi/g	Modeled as distributed over surface of entire sector.			Detected in one surface soil sample.
			Source: Subsurface Soil		
Americium-241	0.4 pCi/g	200	70	21	Maximum detect. Detected in 3 borings in northern portion of sector.
Neptunium-237	0.8 pCi/g	90	110	34	Maximum detect.
Antimony	0.85 mg/kg	290	195	49	Average of 9 detects + 1/2 of 21 non-detects. (Higher value than average of detects.) Modeled over entire sector.
Mercury	0.29 mg/kg	290	195	34	Average of 17 detects + 1/2 of 13 non-detects (Higher value than average of detects.)
Technetium-99	3.16 pCi/g	290	195	34	Average of 17 detects. Modeled over entire sector. Not detected in samples below 32 ft.
Thorium-230	1.2 pCi/g	290	195	49	Average of 18 detects. Modeled over entire sector and entire thickness of UCRS.
Trichloroethene	562 µg/kg	130	160	15	Average of 4 detects + 44 non-detects. Area includes portion of central sector under the NW corner of C-400 Bldg. TCE source area centered around Boring 203-003.
Uranium-234	1.1 pCi/g	290	195	34	Average of 18 detects. Modeled over entire sector. Not detected in samples below 32 ft.
Uranium-235	0.4 pCi/g	150	70	2	Maximum detect. Area defined by two detects in northern portion of sector in shallow soil.
Uranium-238	1.6 pCi/g	290	195	34	Average of 18 detects. Modeled over entire sector. Not detected in samples below 32 ft.

Notes:
Sources were not modeled for the following contaminants because they were detected only once in the subsurface soils:

- N-Nitroso-di-n-propylamine
- Phenanthrene
- Plutonium-239

X-axis is east-west; Y-axis is north-south; Z-axis is vertical (thickness).

Table 5.29. MEPAS source terms for Sector 8

Contaminant	Level	X-Axis (ft)	Y-Axis (ft)	Z-Axis (ft)	Notes
		Source: Surface Soil			
Neptunium-237	0.6 pCi/g	700	150	1	Maximum Detects.
Phenanthrene	700 µg/kg				Contaminated area is
Plutonium-239	0.4 pCi/g				associated with
Technetium-99	17.0 pCi/g				pipeline near Borings
Uranium-238	4.6 pCi/g				400-043 and 400-034.
		Source: Subsurface Soil			
Americium-241	0.6 pCi/g	375	300	49	Maximum detects.
Cesium-137	11.1 pCi/g				Eastern part of pipeline only.
Chromium	140 mg/kg				
Copper	390 mg/kg				
Nickel	467 mg/kg				
Phenanthrene	110 µg/kg				
Plutonium-239	0.8 pCi/g				
Technetium-99	265 pCi/g				
Uranium-235	1.1 pCi/g				
Thorium-230	3 pCi/g	1,500	206	49	Maximum detects. Eastern and central
Neptunium-237	2.6 pCi/g				portion of pipeline area.
2,4-Dinitrotoluene	457 µg/kg	1,125	175	49	Maximum detect. Central portion of pipeline area.
Uranium-234	28.2 pCi/g	675	211	49	Maximum detects.
Uranium-238	53.2 pCi/g				Eastern and western ends of pipeline area.

Notes:
X-axis is east-west; Y-axis is north-south; Z-axis is vertical (thickness).

Table 5.30. MEPAS results for Sector 1

Constituent	Plant Fence Max Conc. (pCi/L)	Plant Fence Time (year)	Property Boundary Max Conc. (pCi/L)	Property Boundary Time (year)
	Source: Subsurface			
^{237}Np	3.77E-06	416	2.44E-06	478
^{233}*Pa*	3.77E-06	416	2.44E-06	478
^{233}*U*	7.11E-09	435	5.16E-09	497
^{229}*Th*	1.50E-10	455	1.19E-10	497
^{225}*Ra*	1.50E-10	455	1.19E-10	497
^{225}*Ac*	1.50E-10	455	1.19E-10	497

Notes:
Bold type denotes constituents which were run from screening.
Italic type denotes daughter product concentrations resulting from constituents listed in bold.

Table 5.31. MEPAS results for Sector 2

Constituent	Plant Fence Max Conc. (mg/L)(pCi/L)	Plant Fence Time (year)	Property Boundary Max Conc. (mg/L)(pCi/L)	Property Boundary Time (year)
Source: Surface				
^{238}U	7.22E-08	5,160	4.51E-08	5,950
^{234}Th	7.22E-08	5,160	4.51E-08	5,950
^{234}U	1.05E-09	5,160	7.55E-10	5,950
^{230}Th	2.41E-11	5,160	2.00E-11	5,950
^{226}Ra	1.12E-11	5,160	1.01E-11	5,950
^{222}Rn	1.12E-11	5,160	1.01E-11	5,950
^{210}Pb	1.12E-11	5,160	9.93E-12	6,180
^{210}Bl	1.12E-11	5,160	9.93E-12	6,180
^{210}Po	1.12E-11	5,160	9.92E-12	6,180
Phenanthrene	4.68E-06	7,560	3.00E-06	7,980
Source: Subsurface				
Chromium[1]	2.56E-53	10,000	0.00E+00	NA
N-Nitroso-di-propylamine	2.17E-02	24	1.37E-02	27
Phenanthrene	8.62E-06	7,810	5.41E-06	8,450
Thallium	8.45E-04	31	4.94E-04	37
^{238}U	6.62E-06	7,380	4.28E-06	8,050
^{234}Th	6.62E-06	7,380	4.28E-06	8,050
^{234}U	1.45E-07	7,870	1.03E-07	8,750
^{230}Th	5.17E-09	8,110	4.02E-09	8,980
^{226}Ra	3.05E-09	8,110	2.49E-09	8,980
^{222}Rn	3.05E-09	8,110	2.49E-09	8,980
^{210}Pb	3.02E-09	8,110	2.47E-09	8,980
^{210}Bl	3.02E-09	8,110	2.47E-09	8,980
^{210}Po	3.02E-09	8,110	2.47E-09	8,980
^{234}U	9.61E-07	6,460	6.08E-07	7,580
^{230}Th	5.93E-08	7,130	4.15E-08	7,820
^{226}Ra	4.13E-08	7,130	3.02E-08	8,050
^{235}U	3.41E-08	6,640	2.16E-08	7,580
^{231}Th	3.41E-08	6,640	2.16E-08	7,580
^{231}Pa	4.67E-09	7,130	3.26E-09	7,810
^{227}Ac	4.65E-09	7,130	3.25E-09	7,810
^{227}Th	4.65E-09	7,130	3.25E-09	7,810
^{223}Ra	4.65E-09	7,130	3.25E-09	7,810

[1]Did not reach maximum during model runs

Notes:

Bold type denotes constituents that were run from screening.

Italic type denotes daughter products resulting from constituents listed in bold.

Table 5.32. MEPAS results for Sector 3

Constituent	Plant Fence Max Conc. (mg/L)(pCi/L)	Plant Fence Time (year)	Property Boundary Max Conc. (mg/L)(pCi/L)	Property Boundary Time (year)
		Source: Surface		
PCB	0.00E+00	10,000	0.00E+00	10,000
Aroclor-1260	0.00E+00	10,000	0.00E+00	10,000
Phenanthrene	7.73E-06	7,560	4.66E-06	7,980
^{235}U	4.06E-09	5,160	2.39E-09	5,950
^{231}Th	4.06E-09	5,160	2.39E-09	5,950
^{231}Pa	4.19E-10	5,160	2.82E-10	5,950
^{227}Ac	4.16E-10	5,160	2.80E-10	5,950
^{227}Th	4.16E-10	5,160	2.80E-10	5,950
^{223}Ra	4.16E-10	5,160	2.80E-10	5,950
^{238}U	9.25E-08	5,160	5.43E-08	5,950
^{234}Th	9.25E-08	5,160	5.43E-08	5,950
^{234}U	1.35E-09	5,160	9.10E-10	5,950
^{230}Th	3.09E-11	5,160	2.41E-11	5,950
^{226}Ra	1.44E-11	5,160	1.21E-11	5,950
^{222}Rn	1.44E-11	5,160	1.21E-11	5,950
^{210}Pb	1.42E-11	5,160	1.20E-11	5,950
^{210}Bl	1.42E-11	5,160	1.20E-11	5,950
^{210}Po	1.41E-11	5,160	1.20E-11	5,950
Thallium	2.09E-03	31	1.17E-03	37
^{230}Th (1)	3.29E-53	10,000	0.00E+00	10,000
^{226}Ra (1)	3.31E-50	10,000	0.00E+00	10,000
^{237}Np	6.55E-08	320	3.75E-08	359
^{233}Pa	6.55E-08	320	3.75E-08	359
^{233}U	9.12E-11	320	5.86E-11	359
^{229}Th	1.36E-12	320	1.07E-12	379
^{225}Ra	1.36E-12	320	1.07E-12	379
^{225}Ac	1.36E-12	320	1.07E-12	379
^{234}U	7.10E-08	5,160	4.16E-08	5,950
^{230}Th	3.25E-09	5,160	2.19E-09	5,950
^{226}Ra	1.97E-09	5,160	1.42E-09	5,950
		Source: Subsurface		
Phenanthrene	7.02E-06	7,560	4.21E-06	8,220
^{237}Np	5.77E-07	455	3.64E-07	497
^{233}Pa	5.77E-07	455	3.64E-07	497
^{233}U	1.21E-09	493	8.41E-10	537
^{229}Th	2.79E-11	512	2.15E-11	537
^{225}Ra	2.79E-11	512	2.15E-11	557
^{225}Ac	2.79E-11	512	2.15E-11	557
TCE	2.91E-02	105	1.85E-02	112

[1]Did not reach maximum during model runs.

Notes:

Bold type denote constituents which were run from screening.

Italic type denote daughter product concentrations resulting from constituents listed in bold.

Table 5.33. MEPAS results for Sector 4

Constituent	Plant Fence Max Conc. (mg/L)(pCi/L)	Plant Fence Time (year)	Property Boundary Max Conc. (mg/L)(pCi/L)	Property Boundary Time (year)
	Source: Surface			
PCB	0.00E+00	10,000	0.00E+00	10,000
Phenanthrene	6.34E-07	7,559	4.03E-07	7,979
TC-99	9.85E-08	2,090	6.13E-08	2,335
U-238	2.23E-08	5,160	1.39E-08	5,951
TH-234	2.23E-08	5,160	1.39E-08	5,951
U-234	3.25E-10	5,160	2.32E-10	5,951
TH-230	7.47E-12	5,160	6.14E-12	5,951
RA-226	3.47E-12	5,160	3.10E-12	5,951
RN-222	3.47E-12	5,160	3.10E-12	5,951
PB-210	3.42E-12	5,160	3.05E-12	5,951
BI-210	3.42E-12	5,160	3.05E-12	5,951
PO-210	3.41E-12	5,160	3.05E-12	5,951
TH-230	2.23E-23	10,000	0.00E+00	10,000
RA-226[1]	2.24E-23	10,000	0.00E+00	10,000
RN-222[1]	2.24E-23	10,000	0.00E+00	10,000
PB-210[1]	2.24E-23	10,000	0.00E+00	10,000
BI-210[1]	2.24E-23	10,000	0.00E+00	10,000
PO-210[1]	2.24E-26	10,000	0.00E+00	10,000
U-234	2.00E-08	5,160	1.24E-08	5,950
TH-234	9.17E-10	5,160	6.53E-10	5,950
RA-226	5.55E-10	5,160	4.22E-10	5,950
	Source: Subsurface			
1,1-Dichloroethene	4.14E-03	62	2.50E-03	67
Carbon Tetrachloride	4.87E-04	386	2.94E-04	406
Chromium[1]	2.69E-53	10,000	0.00E+00	10,000
Phenanthrene	6.36E-06	10,280	3.89E-06	10,830
^{237}Np	1.47E-06	455	9.08E-07	497
^{233}Pa	1.47E-06	455	9.08E-07	497
^{233}U	3.08E-09	493	2.09E-09	537
^{229}Th	7.07E-11	493	5.31E-11	557
^{225}Ra	7.07E-11	493	5.31E-11	557
^{225}Ac	7.07E-11	493	5.31E-11	557
^{239}Pu	1.22E-08	10,200	7.00E-09	11,960
Tetrachloroethene	6.44E-04	285	3.89E-04	298
CS-137	0.00E+00	10,000	0.00E+00	10,000
TCE	5.00E+01	105	3.17E+01	112
Vinyl Chloride	1.14E-03	54	7.27E-04	61

Notes:
Bold type denotes constituents which were run from screening.
Italic type denotes daughter product concentrations resulting from constituents listed in bold.
[1]Did not reach maximum during model runs.

Table 5.34. MEPAS results for Sector 5

Constituent	Plant Fence Max Conc. (mg/L)(pCi/L)	Plant Fence Time (yr)	Property Boundary Max Conc. (mg/L)(pCi/L)	Property Boundary Time (yr)
	Source: Surface			
Acenaphthylene	2.66E-04	1,336	1.71E-04	1,419
Benz(a)anthracene	0.00E+00	10,000	0.00E+00	10,000
Benz(a)pyrene	0.00E+00	10,000	0.00E+00	10,000
Benz(b)fluoranthene	0.00E+00	10,000	0.00E+00	10,000
Benz(k)fluoranthene	0.00E+00	10,000	0.00E+00	10,000
Chromium	0.00E+00	9,799	0.00E+00	10,000
^{237}Np	5.43E-08	320	3.41E-08	359
^{233}Pa	5.43E-08	320	3.41E-08	359
^{233}U	7.57E-11	320	5.50E-11	379
^{229}Th	1.13E-12	320	9.73E-13	379
^{225}Ra	1.13E-12	320	9.72E-13	379
^{225}Ac	1.13E-12	320	9.72E-13	379
Phenanthrene	8.57E-05	7,559	5.66E-05	7,979
^{239}Pu	9.91E-10	10,200	6.02E-10	11,750
^{99}Tc	7.44E-07	2,088	4.80E-07	2,335
Thallium	5.35E-03	31	3.29E-03	37
^{234}U	1.25E-07	5,162	8.04E-08	5,953
^{230}Th	5.73E-09	5,162	4.24E-09	5,953
^{226}Ra	3.47E-09	5,162	2.74E-09	5,953
^{235}U	7.00E-09	5,163	4.51E-09	5,951
^{231}Th	7.00E-09	5,163	4.51E-09	5,951
^{231}Pa	7.22E-10	5,163	5.31E-10	5,951
^{227}Ac	7.18E-10	5,163	5.29E-10	5,951
^{227}Th	7.18E-10	5,163	5.29E-10	5,951
^{223}Ra	7.18E-10	5,163	5.29E-10	5,951
^{238}U	1.82E-07	5,163	1.17E-07	5,951
^{234}Th	1.82E-07	5,163	1.17E-07	5,951
^{234}U	2.65E-09	5,163	1.96E-09	5,951
^{230}Th	6.08E-11	5,163	5.19E-11	5,951
^{226}Ra	2.83E-11	5,163	2.62E-11	5,951
^{227}Rn	2.83E-11	5,163	2.62E-11	5,951
^{210}Pb	2.78E-11	5,163	2.58E-11	5,951
^{210}Bi	2.78E-11	5,163	2.58E-11	5,951
^{210}Po	2.78E-11	5,163	2.58E-11	5,951
	Source: Subsurface			
^{241}Am	1.38E-21	10,000	5.82E-24	14,900
^{137}Cs	0.00E+00	10,000	0.00E+00	10,000
Th-230	1.94E-50	10,000	0.00E+00	10,000
RA-226	1.95E-50	10,000	0.00E+00	10,000
TCE	2.53E-01	105	1.59E-01	112
Thallium	4.74E-01	34	2.99E-01	39
^{235}U	7.95E-07	5,160	5.10E-07	5,950
^{231}Th	7.95E-07	5,160	5.10E-07	5,950
^{231}Pa	8.20E-08	5,160	6.01E-08	5,950
	Source: RGA			
^{237}Np	6.17E-07	435	4.06E-07	478
^{233}Pa	6.17E-07	435	4.06E-07	478
^{233}U	1.20E-09	455	8.75E-10	517
^{229}Th	2.60E-11	474	2.10E-11	517
	Source: RGA			
^{225}Ra	2.60E-11	474	2.10E-11	517
^{225}Ac	2.60E-11	474	2.10E-11	517

Notes:
Bold type denotes constituents that were run from screening.
Italic type denotes daughter product concentrations resulting from constituents listed in bold.

Table 5.35. MEPAS results for Sector 6

Constituent	Plant Fence Max Conc. (mg/L)(pCi/L)	Plant Fence Time (year)	Property Boundary Max Conc. (mg/L)(pCi/L)	Property Boundary Time (year)
	Source: Surface			
2-Methylnaphthalene	1.27E-06	2,390	7.90E-07	2,530
^{241}Am	1.54E-24	13,500	1.80E-27	14,900
^{137}Cs	0.00E+00	10,000	0.00E+00	10,000
Dibenz(a,h,)anthracene	0.00E+00	10,000	0.00E+00	10,000
^{237}Np	2.26E-09	320	1.34E-09	359
^{233}Pa	2.26E-09	320	1.34E-09	359
^{233}U	3.15E-12	320	2.16E-12	379
^{229}Th	4.71E-14	320	3.81E-14	379
^{225}Ra	4.71E-14	320	3.81E-14	379
^{225}Ac	4.70E-14	320	3.81E-14	379
^{99}Tc	1.81E-08	2,090	1.10E-08	2,340
^{230}Th	0.00E+00	10,000	0.00E+00	10,000
^{234}U	4.32E-09	5,160	2.61E-09	5,950
^{230}Th	1.97E-10	5,160	1.38E-10	5,950
^{226}Ra	1.19E-10	5,160	8.90E-11	5,950
^{235}U	2.67E-10	5,160	1.63E-10	5,950
^{231}Th	2.67E-10	5,160	1.63E-10	5,950
^{231}Pa	2.75E-11	5,160	1.92E-11	5,950
^{227}Ac	2.74E-11	5,160	1.91E-11	5,950
^{227}Th	2.74E-11	5,160	1.91E-11	5,950
^{223}Ra	2.74E-11	5,160	1.91E-11	5,950
^{238}U	5.54E-09	5,160	3.37E-09	5,950
^{234}Th	5.54E-09	5,160	3.37E-09	5,950
^{234}U	8.07E-11	5,160	5.64E-11	5,950
^{230}Th	1.85E-12	5,160	1.49E-12	5,950
^{226}Ra	8.61E-13	5,160	7.52E-13	5,950
^{227}Rn	8.61E-13	5,160	7.52E-13	5,950
^{210}Pb	8.48E-13	5,160	7.42E-13	5,950
^{210}Bi	8.48E-13	5,160	7.42E-13	5,950
^{210}Po	8.47E-13	5,160	7.41E-10	5,950
	Source: Subsurface			
1,2-Dichloroethene	7.64E-02	21	4.78E-02	23
^{241}Am	4.51E-22	13,500	4.65E-25	14,900
^{237}Np	8.79E-09	378	5.41E-09	438
^{233}Pa	8.79E-09	378	5.41E-09	438
^{233}U	1.45E-11	397	1.03E-11	438
^{229}Th	2.68E-13	397	2.11E-13	438
^{225}Ra	2.68E-13	397	2.11E-13	438
^{225}Ac	2.68E-13	397	2.11E-13	438
^{99}Tc	2.24E-11	2,090	1.36E-08	2,340
^{230}Th[1]	2.62E-50	10,000	0.00E+00	10,000
^{226}Ra[1]	2.64E-50	10,000	0.00E+00	10,000
Trichloroethene	9.58E-03	105	6.03E-03	112
^{234}U	4.55E-08	5,410	2.74E-08	6,190
^{230}Th	2.18E-09	5,410	1.50E-09	6,190
^{226}Ra	1.35E-09	5,410	9.87E-10	6,190
^{235}U	2.43E-09	5,410	1.47E-09	6,190
^{231}Th	2.43E-09	5,410	1.47E-09	6,190
^{231}Pa	2.62E-10	5,410	1.80E-10	6,190
^{227}Ac	2.61E-10	5,410	1.79E-10	6,190
^{227}Th	2.61E-10	5,410	1.79E-10	6,190
^{223}Ra	2.61E-10	5,410	1.79E-10	6,190
^{238}U	5.54E-09	5,160	3.37E-09	5,950
^{234}Th	5.54E-09	5,160	3.37E-09	5,950

Table 5.35. (continued)

Constituent	Plant Fence Max Conc. (mg/L)(pCi/L)	Plant Fence Time (year)	Property Boundary Max Conc. (mg/L)(pCi/L)	Property Boundary Time (year)
	Source: Subsurface (continued)			
^{234}U	8.07E-11	5,160	5.64E-11	5,950
^{230}Th	1.85E-12	5,160	1.49E-12	5,950
^{226}Ra	8.61E-13	5,160	7.52E-13	5,950
^{227}Rn	8.61E-13	5,160	7.52E-13	5,950
^{210}Pb	8.48E-13	5,160	7.42E-13	5,950
^{210}Bi	8.48E-13	5,160	7.42E-13	5,950
^{210}Po	8.47E-13	5,160	7.41E-13	5,950

Notes:
Bold type denotes constituents that were run from screening.
Italic type denotes daughter products resulting from constituents listed in bold.
[1]Did not reach maximum during model runs.

Table 5.36. MEPAS results for Sector 7

Constituent	Plant Fence Max Conc. (mg/L)(pCi/L)	Plant Fence Time (yr)	Property Boundary Max Conc. (mg/L)(pCi/L)	Property Boundary Time (yr)
	Source: Surface			
Chromium	0.00E+00	10,000	0.00E+00	10,000
^{238}U	5.65E-08	5,160	3.57E-08	5,950
^{234}Th	5.65E-08	5,160	3.57E-08	5,950
^{234}U	8.22E-10	5,160	5.99E-10	5,950
^{230}Th	1.89E-11	5,160	1.58E-11	5,950
^{226}Ra	8.77E-12	5,160	7.98E-12	5,950
^{227}Rn	8.77E-12	5,160	7.98E-12	5,950
^{210}Pb	8.63E-12	5,160	7.87E-12	5,950
^{210}Bi	8.63E-12	5,160	7.87E-12	5,950
^{210}Po	8.63E-12	5,160	7.87E-12	5,950
	Source: Subsurface			
^{241}Am	2.85E-22	13,500	2.91E-25	14,900
Antimony	5.73E-03	707	3.58E-03	824
Mercury	0.00E+00	NA	0.00E+00	NA
^{237}Np	9.07E-07	397	5.69E-07	458
^{233}Pa	9.07E-07	397	1.13E-09	458
^{233}U	1.61E-09	416	2.49E-11	478
^{229}Th	3.13E-11	416	2.49E-11	478
^{225}Ra	3.12E-11	416	2.49E-11	478
^{225}Ac	3.12E-11	416	2.49E-11	478
^{99}Tc	5.35E-06	2,090	3.37E-06	2,460
^{230}Th	0.00E+00	10,000	0.00E+00	10,000
Trichloroethene	3.84E-03	84	2.10E-03	96
^{234}U	3.91E-07	6,640	2.55E-07	7,350
^{235}U	3.33E-09	5,160	2.01E-09	5,950
^{231}Th	3.33E-09	5,160	2.01E-09	5,950
^{231}Pa	3.44E-10	5,160	2.37E-10	5,950
^{227}Ac	3.42E-10	5,160	2.36E-10	5,950
^{227}Th	3.42E-10	5,160	2.36E-10	5,950
^{223}Ra	3.42E-10	5,160	2.36E-10	5,950
^{238}U	5.80E-07	6,640	3.79E-07	7,350
^{234}Th	5.80E-07	6,640	3.79E-07	7,350
^{234}U	1.10E-08	6,880	8.02E-09	7,580
^{230}Th	3.37E-10	7,130	2.75E-10	7,810
^{226}Ra	1.87E-10	7,130	1.60E-10	7,810
^{227}Rn	1.87E-10	7,130	1.60E-10	7,810
^{210}Pb	1.85E-10	7,130	1.58E-10	7,810
^{210}Bi	1.85E-10	7,130	1.58E-10	7,810
^{210}Po	1.85E-10	7,130	1.58E-10	7,810
	Source: RGA			
Chromium[1]	6.91E-05	10,000	1.71E-13	10,000
Cobalt	2.74E-02	224	1.33E-02	374
Iron	8.18E+01	377	3.96E+01	631
Manganese	5.71E-01	633	2.77E-01	1,060

Notes:
Bold type denotes constituents that were run from screening.
Italic type denotes daughter products resulting from constituents listed in bold.
[1]Did not reach maximum during model runs.

Table 5.37. MEPAS results for Sector 8

Constituent	Plant Fence Max Conc. (mg/L)(pCi/L)	Plant Fence Time (yr)	Property Boundary Max Conc. (mg/L)(pCi/L)	Property Boundary Time (yr)
	Source: Surface			
^{237}Np	2.16E-07	320	1.50E-07	359
^{233}Pa	7.99E-09	416	1.50E-07	359
^{233}U	3.00E-10	320	2.44E-10	379
^{229}Th	4.49E-12	320	4.31E-12	379
^{225}Ra	4.49E-12	320	4.31E-12	379
^{225}Ac	4.49E-12	320	4.31E-12	379
Phenanthrene	9.92E-06	7,560	7.29E-06	7,980
^{239}Pu	3.40E-09	10,200	2.30E-09	11,800
^{99}Tc	9.24E-07	2,090	6.61E-07	2,340
^{238}U	1.03E-07	5,160	7.37E-08	5,950
^{234}Th	1.03E-07	5,160	7.37E-08	5,950
^{234}U	1.50E-09	5,160	1.24E-09	5,950
^{230}Th	3.44E-11	5,160	3.26E-11	5,950
^{226}Ra	1.60E-11	5,160	1.65E-11	5,950
^{227}Rn	1.60E-11	5,160	1.65E-11	5,950
^{210}Pb	1.57E-11	5,160	1.63E-11	6,180
^{210}Bi	1.57E-11	5,160	1.63E-11	6,180
^{210}Po	1.57E-11	5,160	1.63E-11	6,180
	Source: Subsurface			
2,4-Dinitrotolune	1.07E-01	47	3.73E-02	50
^{241}Am[1]	2.97E-21	13,500	3.21E-24	14,900
^{137}Cs	0.00E+00	10,000	0.00E+00	10,000
Chromium[1]	1.59E-26	10,000	0.00E+00	10,000
Copper	4.00E-01	9,505	2.56E-01	11,100
^{237}Np	9.41E-05	455	5.82E-05	497
^{233}Pa	9.41E-05	455	5.82E-05	497
^{233}U	1.97E-07	493	1.34E-07	537
^{229}Th	4.51E-09	493	3.40E-09	557
^{225}Ra	4.51E-09	493	3.40E-09	557
^{225}Ac	4.51E-09	493	3.40E-09	557
Nickel	1.25E-02	9,814	8.41E-03	10,840
Phenanthrene	5.40E-05	10,500	3.63E-05	10,800
^{239}Pu	5.67E-07	10,200	3.46E-07	11,960
^{99}Tc	1.14E-03	2,213	7.48E-04	2,463
^{230}Th[1]	3.99E-50	10,000	0.00E+00	10,000
^{234}U	4.90E-05	5,162	3.48E-05	5,953
^{230}Th	2.08E-06	5,162	1.83E-06	5,953
^{226}Ra	1.36E-06	5,162	1.19E-06	5,953
^{235}U	2.04E-06	5,163	1.32E-06	5,951
^{231}Th	2.04E-06	5,163	1.32E-06	5,951
^{231}Pa	2.10E-07	5,163	1.56E-07	5,951
^{227}Ac	2.09E-07	5,163	1.55E-07	5,951
^{227}Th	2.09E-07	5,163	1.55E-07	5,951
^{223}Ra	2.09E-07	5,163	1.55E-07	5,951
^{238}U	9.37E-05	5,163	6.67E-05	5,951
^{234}Th	9.37E-05	5,163	6.67E-05	5,951
^{234}U	1.36E-06	5,163	1.12E-06	5,951
^{230}Th	3.13E-08	5,163	2.96E-08	5,951
^{226}Ra	1.46E-08	5,163	1.49E-08	6,184
	Source: Subsurface			
^{227}Rn	1.46E-08	5,163	1.49E-08	6,184
^{210}Pb	1.46E-08	5,163	1.47E-08	6,184
^{210}Bi	1.46E-08	5,163	1.47E-08	6,184
^{210}Po	1.46E-08	5,163	1.47E-08	6,184

Bold type denotes constituents remaining after screening and run with MEPAS.
Italic type denotes daughter products resulting from constituents listed in bold.
[1]Did not reach maximum during model runs.

Table 5.38. Transport parameters used in the model for WAG 27

Multi Media Modeling Summary

Project Name: WAG 27

Model Name: Multimedia Environmental Pollutant Assessment System (MEPAS)

Documented: *Remedial Investigation Report for Waste Area Grouping 27 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, Vol. 4 (DOE/OR/07-1777&D1)*

	Universal	UCRS HU2a	UCRS HU2b	HU3		RGA HU4/HU5		McNairy HU6
Conceptual Model		Partially						
Media Represented (soil, air, water, NAPL)		Saturated		Partially Saturated		Saturated		
Geologic Units		Zone	Units	Zone	Units	Zone	Units	Not Represented
Hydraulic Parameters								
Thickness		40	ft	15	ft	50	ft	
Conductivity		0.08	ft/day (vert)	2.00E-03		1500	ft/day	
Porosity		0.45		0.45		0.37		
Soil Saturation (%)		0.4		0.45		100		
Bulk Density		1.46		1.46		1.67		
TOC		0.08		0.06		0.0002		
Dispersion		0.39		0.15		50	ft	
Dispersion						5	ft	
Groundwater Velocity						0.6		
Hydraulic Gradient						0.0004		
Model Dimension								
VerticaL/Horizontal (2-D only)		1d				1d		
Source Terms						8 source terms		
Constant/Degrading		Degrading						
Points of Exposure		Fence	Plant Boundary			Fence		Plant Boundary
Locations						3300		5500

Table 5.39. MEPAS transport parameters for Solid Waste Management Unit 1

Input parameter description	Parameter name	Value	Reference
	Top soil parameters (wt)		
Textural classification	WT-CLASS	silt	McCracken Co. Soil Survey (USDA 1976)
Sand (%)	WT-SAND	15	McCracken Co. Soil Survey: conservative estimate (highest % sand)
Silt (%)	WT-SILT	80	Maximum % silt for soil type
Clay (%)	WT-CLAY	5	= 100% -% sand - % silt
Organic matter (%)	WT-OMC	0.05	CERCLA Phase II Site Investigation (CH2M HILL 1992), Table 5-1
Iron and aluminum(%)	WT-IRON	4	DOE 1995a (Background Concentrations and Human Health Risk-Based Screening Criteria for Metals in Soil at the PGDP)
pH of topsoil	WT-pH	5.0	McCracken Co. Soil Survey
Percent vegetative cover of the site (%)	WT-VEGCOV	95	Mostly grass-covered
Topsoil water capacity	WT-AVAILW	4.4	McCracken Co. Soil Survey. = Available water capacity (.20 in/in) × root zone depth (23 in) × vegetative cover (95%)
SCS curve number	WT-SCSN	71	Antecedent moisture condition = II (normal moisture); Group C hydrologic soil group; vegetated surface, well vegetated
	Properties of the partially saturated zones (WP)		
Thickness (ft)	WP-THICK	WP1: 39 WP2: 15	1–40 ft (HU 1 & HU 2) Boring logs at 40–55 ft (HU 3) SWMU 1
Textural classification	WP-CLASS	WP1 loam WP2 silty clay	Boring logs at SWMU 1
Sand (%)	WP-SAND	WP1 35.9 WP2 8	Sieve analysis, 25–26.5 ft, H210 SWMU 2 Geotechnical data (1,000 ft NE of SWMU 1)
Silt (%)	WP-SILT	WP1 50 WP2 38	Maximum % silt for soil type SWMU 2 geotechnical data
Clay (%)	WP-CLAY	WP1 14 WP2 54	= 100 - % sd - % silt
Organic matter content in soil (%)	WP-OMC	WP1 0.08 WP2 0.06	Average, WAG 27 RI, 7–40 ft Average, WAG 27 RI, 40–50 ft
Iron + aluminum in soil (%)	WP-IRON	4	DOE, 1995a
pH of pore water in partially saturated zone	WP-pH	6.0	DOE 1995b
Bulk density(g/cm^3)	WP-BULKD	WP1 1.46 WP2 1.46	Table 2.1 of MEPAS Guidance, [(2.65) (1-Porosity)]
Total porosity (%)	WP-TOTPOR	WP1 45 WP2 45	Table 2.1 of MEPAS Guidance, based on soil type; maximum porosity of 45% measured in some UCRS samples at WAG 6 was used as upper limit of total porosity
Field capacity (%)	WP-FIELDC	WP1 27.8 WP2 27.8	Table 2.1 of MEPAS Guidance, based on soil type
Longitudinal dispersivity (ft)	WP-LDISP	WP1 0.39 WP2 0.15	MEPAS Guidance: $D_L = 0.01$ (Th)

Table 5.39. MEPAS transport parameters for Solid Waste Management Unit 1 (continued)

Input parameter description	Parameter name	Value	Reference
	Properties of the partially saturated zones (WP)		
Saturated hydraulic conductivity (ft/day)	WP-CONDUC	ft/day cm/sec WP1 0.08 3E-5 WP2 2E-3 7.2E-7	Slug tests at SWMU 1 (Phase I, 1992) Slug tests at MW128 (NW of SWMU 1)
Moisture content for release site soils (%)	WS-MOISTC	WP1: 40 WP2: 45	Shallow water table - moisture content approximates total porosity in WP1, equals total porosity in WP2.
	Properties of the saturated zone (WZ)		
Textural classification	WZ-CLASS	sand (gravelly)	RGA geotechnical data for SWMU 1
Sand (%)	WZ-SAND	96	Average, SWMU 1 geotechnical data
Silt (%)	WZ-SILT	3	Average, SWMU 1 geotechnical data
Clay (%)	WZ-CLAY	1	Average, SWMU 1 geotechnical data
Organic matter in soil(%)	WZ-OMC	0.02	Average, WAG 6 RGA soil data
Iron + aluminum in soil(%)	WZ-IRON	3	Average, WAG 6, 62 – 78 ft samples
pH of pore water in saturated zone	WZ-pH	6.2	Average pH of RGA groundwater at SWMU 1 (1998 sampling data).
Total porosity (%)	WZ-TOTPOR	37	Conservative, based on WAG 6 measurement
Effective porosity (%)	WZ-EFFPOR	30	Conservative estimate
Darcy velocity (ft/day)	WZPVELOC	0.6	Conservative estimate, uses conductivity of 1,500 ft/d and gradient of 4E-4
Thickness (ft)	WZ-THICK	50	RGA interval: 55–105 ft bgs
Bulk density (ft)	WZ-BULKD	1.67	(2.65 g/cm^3 × 0.63)
Travel distance (ft)	WZ-DIST	500 ft security fence 3,300 ft DOE property boundary	Distance to PGDP security fence and DOE property boundary (both west of SWMU 1)
Longitudinal dispersivity (ft)	WZ-LDISP	50.0	(reference: Bioscreen groundwater model)
Transverse dispersivity (ft)	WZ-TDISP	5.0	(reference: Bioscreen groundwater model)
Vertical dispersivity (ft)	WZ-VDISP	0.1	- near zero
Total flux to aquifer (%)	WZ-FRACT	100	Conservative estimate
Perpendicular distance from groundwater flow to receptor (ft)	WZ-YDIST	0	(plume centerline concentrations)
Vertical distance below groundwater table (ft)	WZ-AQDEPTH	0	(most conservative result)

Table 5.40. MEPAS transport parameters for Solid Waste Management Unit 91

Input parameter description	Parameter name	Value	Reference
		Top soil parameters (WT)	
Textural classification	WT-CLASS	silt	McCracken Co. Soil Survey (USDA 1976)
Sand (%)	WT-SAND	15	McCracken Co. Soil Survey: conservative estimate (highest % sand)
Silt (%)	WT-SILT	80	Maximum % silt for soil type
Clay (%)	WT-CLAY	5	= 100% -% sand - % silt
Organic matter (%)	WT-OMC	0.05	CERCLA Phase II Site Investigation (CH2M HILL 1992), Table 5-1
Iron and aluminum (%)	WT-IRON	4	DOE 1995a (Background Concentrations and Human Health Risk-Based Screening Criteria for Metals in Soil at the PGDP)
pH of topsoil	WT-pH	5.0	McCracken Co. Soil Survey
Percent vegetative cover of the site (%)	WT-VEGCOV	20	Mostly gravel cover, some grass cover.
Topsoil water capacity	WT-AVAILW	0.92	McCracken Co. Soil Survey = Available water capacity (.20 in/in) × root zone depth (23 in) × vegetative cover (0–20%)
SCS curve number	WT-SCSN	86	Antecedent Moisture Condition = II (normal moisture); Group C hydrologic soil group; bare soil, hard surface, 0-20% vegetated
		Properties of the partially saturated zones (WP)	
Thickness (ft)	WP-THICK	WP1 19 WP2 15 WP3 13	1-20 ft (HU 1 + fill) 20-35 ft (HU 2) 35-48 ft (HU 3) — Boring logs at SWMU 91
Textural classification	WP-CLASS	WP1 clay loam WP2 sand WP3 silty clay	Boring logs and sieve analysis at SWMU 91
Sand (%)	WP-SAND	WP1 33 WP2 94.4 WP3 8	Sieve analysis, Geotek G-15 @ 15 ft (700 ft NW of SWMU 91) Average, HU 2A at SWMU 91 SWMU 2 Geotechnical data
Silt (%)	WP-SILT	WP1 37 WP2 5 WP3 38	Hydrometer, Geotek G-15 @ 15 ft Maximum % silt for soil type SWMU 2 Geotechnical data
Clay (%)	WP-CLAY	WP1 30 WP2 0.6 WP3 54	Hydrometer, Geotek G-15 @ 15 ft = 100 - % silt - % sand SWMU 2 Geotechnical data
Organic matter content in soil (%)	WP-OMC	WP1 0.09 WP2 0.07 WP3 0.06	Average, WAG 27 RI, 4–20 ft Average, WAG 27 RI, 20–35 ft Average, WAG 27 RI, 35–50 ft
Iron + aluminum in soil (%)	WP-IRON	4	DOE 1995a
pH of pore water in partially saturated zone	WP-pH	6.0	DOE 1995b
Bulk density(g/cm^3)	WP-BULKD	WP1 1.59 WP2 1.7 WP3 1.46	Table 2.1 of MEPAS Guidance, [(2.65)(1-Porosity)]
		Properties of the partially saturated zones (WP)	
Total porosity (%)	WP-TOTPOR	WP1 40 WP2 36 WP3 45	WP1: Monsanto, 1996 Lasagna™ study; WP2: Mean total porosity of UCRS sands & gravels based on WAG 6 measurements; WP3: Maximum porosity of 45% measured in some UCRS samples at WAG 6 was used as upper limit of total porosity for clay rich layers
Field capacity (%)	WP-FIELDC	WP1 24 WP2 9 WP3 27.8	Table 2.1 of MEPAS Guidance, based on soil type

Table 5.40. MEPAS transport parameters for Solid Waste Management Unit 91 (continued)

Input parameter description	Parameter name	Value	Reference
Properties of the partially saturated zones (WP) (continued)			
Longitudinal dispersivity (ft)	WP-LDISP	WP1 0.19 WP2 0.15 WP3 0.13	MEPAS Guidance: D_L = 0.01 (Th)
Saturated hydraulic conductivity (ft/day)	WP-CONDUC	ft/day / cm/sec WP1 0.017 / 6.2E-6 WP2 0.11 / 4E-5 WP3 2E-3 / 7.2E-7	WP1: MEPAS Guidance, based on soil type WP2: maximum value, pump test - well W1 WP3: slug tests at MW128 (NW of SWMU 91)
Moisture content for release site soils (%)	WS-MOISTC	WP1: 35 WP2: 36 WP3: 45	WP1: Shallow water table- moisture content approaches porosity value WP2 & WP3: Moisture content equals total porosity of soil
Textural classification	WZ-CLASS	sand (gravelly)	RGA geotechnical data for SWMU 1
Sand (%)	WZ-SAND	83.0	Average, SWMU 91 geotechnical data
Silt (%)	WZ-SILT	10.3	Average, SWMU 91 geotechnical data
Clay (%)	WZ-CLAY	6.8	Average, SWMU 91 geotechnical data
Organic matter in soil (%)	WZ-OMC	0.02	Average, WAG 6 RGA soil data
Iron + aluminum in soil (%)	WZ-IRON	3	Average, WAG 6, 62 - 78 ft samples
pH of pore water in saturated zone	WZ-pH	6.5	Average pH of RGA groundwater at SWMU 91 (1998 sampling data).
Total porosity (%)	WZ-TOTPOR	37	Conservative, based on WAG 6 measurement
Effective porosity (%)	WZ-EFFPOR	30	Conservative estimate
Darcy velocity (ft/day)	WZPVELOC	0.6	Conservative estimate, uses conductivity of 1,500 ft/d and gradient of 4E-4
Thickness (ft)	WZ-THICK	58	RGA (HU 4 + HU 5) interval: 48–106 ft
Bulk density (ft)	WZ-BULKD	1.67	(2.65 g/cm^3 × 0.63)
Travel distance (ft)	WZ-DIST	350 ft –fence 2,500 ft – DOE property boundary	Distance to PGDP security fence and DOE property boundary NW of SWMU 91
Longitudinal dispersivity (ft)	WZ-LDISP	50.0	(reference: Bioscreen groundwater model)
Transverse dispersivity (ft)	WZ-TDISP	5.0	(reference: Bioscreen groundwater model)
Vertical dispersivity (ft)	WZ-VDISP	0.1	- near zero
Total flux to aquifer (%)	WZ-FRACT	100	Conservative estimate
Perpendicular distance from groundwater flow to receptor (ft)	WZ-YDIST	0	(plume centerline concentrations)
Vertical distance below groundwater table (ft)	WZ-AQDEPTH	0	(most conservative result)

Table 5.41. MEPAS transport parameters for Solid Waste Management Unit 196

Input parameter description	Parameter name	Value	Reference	
		Top soil parameters (WT)		
Textural classification	WT-CLASS	silt	McCracken Co. Soil Survey (USDA 1976)	
Sand (%)	WT-SAND	15	McCracken Co. Soil Survey: conservative estimate (highest % sand)	
Silt (%)	WT-SILT	80	Maximum % silt for soil type	
Clay (%)	WT-CLAY	5	= 100% –% sand – % silt	
Organic matter (%)	WT-OMC	0.05	CERCLA Phase II Site Investigation (CH2M HILL 1992), Table 5-1	
Iron and aluminum(%)	WT-IRON	4	DOE 1995a (Background Concentrations and Human Health Risk-Based Screening Criteria for Metals in Soil at the PGDP)	
pH of topsoil	WT-pH	5.0	McCracken Co. Soil Survey	
Percent vegetative cover of the site (%)	WT-VEGCOV	10	Mostly building, pavement, some grass cover at NW side	
Topsoil water capacity	WT-AVAILW	0.46	McCracken Co. Soil Survey = Available Water Capacity (.20 in/in) × root zone depth (23 in) × vegetative cover (20%)	
SCS curve number	WT-SCSN	86	Antecedent Moisture Condition = II (normal moisture); Group C hydrologic soil group; bare soil, hard surface, 0-20% vegetated	
		Properties of the partially saturated zones (WP)		
Thickness (ft)	WP-THICK	WP1 17 WP2 17 WP3 14	1–18 ft (HU 1 + fill) 18–35 ft (HU 2) 35–49 ft (HU 3)	Boring logs at SWMU 196
Textural classification	WP-CLASS	WP1 silt WP2 loam WP3 silty clay	Boring logs at SWMU 196 (HU 2: silt and sand)	
Sand (%)	WP-SAND	WP1 20 WP2 52 WP3 5	MEPAS Table 2.1, maximum % sand, based on soil texture observed at SWMU 196	
Silt (%)	WP-SILT	WP1 79 WP2 43 WP3 45	Maximum % silt for soil type	
Clay (%)	WP-CLAY	WP1 1 WP2 7 WP3 50	=100 - % silt - % sand	
Organic matter content in soil (%)	WP-OMC	WP1 0.09 WP2 0.07 WP3 0.06	Average, WAG 27 RI, 4–20 ft Average, WAG 27 RI, 20–35 ft Average, WAG 27 RI, 35v50 ft	
Iron + aluminum in soil (%)	WP-IRON	4	DOE 1995a	
pH of pore water in partially saturated zone	WP-pH	6.0	DOE 1995b	
Bulk density (g/cm^3)	WP-BULKD	WP1 1.48 WP2 1.7 WP3 1.46	Table 2.1 of MEPAS Guidance, [(2.65)(1-Porosity)]	
		Properties of the partially saturated zones (WP)		
Total porosity (%)	WP-TOTPOR	WP1 44.2 WP2 36 WP3 45	WP1: Table 2.1 of MEPAS Guidance, based on soil type; WP2: Mean total porosity of UCRS sands & gravels based on WAG 6 measurements; WP3: Maximum porosity of 45% measured in some UCRS samples at WAG 6 was used as upper limit of total porosity for clay rich layers	
Field capacity (%)	WP-FIELDC	WP1 28 WP2 9 WP3 27.8	Table 2.1 of MEPAS Guidance, based on soil type and porosity	

Table 5.41. MEPAS transport parameters for Solid Waste Management Unit 196 (continued)

Input parameter description	Parameter name	Value		Reference
Properties of the partially saturated zones (WP) (continued)				
Longitudinal dispersivity (ft)	WP-LDISP	WP1 0.17 WP2 0.17 WP3 0.14		MEPAS Guidance: D_L = 0.01 (Th)
Saturated hydraulic conductivity (ft/day)	WP-CONDUC	ft/day	cm/sec	
		WP1 3.7E-1	1.3E-4	MEPAS Guidance, based on soil type
		WP2 1.05	3.7E-4	MEPAS Guidance, based on soil type
		WP3 9.6E-5	3.4E-8	Permeameter Test: HU 3 sample at MW339
Moisture content for release site soils (%)	WS-MOISTC	WP1 36		Shallow water table - moisture content between field capacity and porosity value.
Properties of the saturated zone (WZ)				
Textural classification	WZ-CLASS	sand (gravelly)		Deep boring logs-surrounding area
Sand (%)	WZ-SAND	83.0		Average, WAG 6 geotechnical data
Silt (%)	WZ-SILT	10.3		Average, WAG 6 geotechnical data
Clay (%)	WZ-CLAY	6.8		Average, WAG 6 geotechnical data
Organic matter in soil(%)	WZ-OMC	0.02		Average, WAG 6 RGA soil data
Iron + aluminum in soil(%)	WZ-IRON	3		Average, WAG 6, 62–78 ft samples
pH of pore water in saturated zone	WZ-pH	6.5		Average pH of RGA groundwater
Total porosity (%)	WZ-TOTPOR	37		Conservative, based on WAG 6 measurement
Effective porosity (%)	WZ-EFFPOR	30		Conservative estimate
Darcy velocity (ft/day)	WZPVELOC	0.6		Conservative estimate, uses conductivity of 1,500 ft/d and gradient of 4E-4
Thickness (ft)	WZ-THICK	50		RGA (HU 4 + HU 5) interval: 48– 98 ft
Bulk density (ft)	WZ-BULKD	1.67		(2.65 g/cm^3 × 0.63)
Travel distance (ft)	WZ-DIST	800 ft		Distance to PGDP security fence (northwest)
		2,800 ft		Distance to DOE property boundary (northwest)
Longitudinal dispersivity (ft)	WZ-LDISP	50.0		(reference: Bioscreen groundwater model)
Transverse dispersivity (ft)	WZ-TDISP	5.0		(reference: Bioscreen groundwater model)
Vertical dispersivity (ft)	WZ-VDISP	0.1		- near zero
Total flux to aquifer (%)	WZ-FRACT	100		Conservative estimate
Perpendicular distance from groundwater flow to receptor (ft)	WZ-YDIST	0		(plume centerline concentrations)
Vertical distance below groundwater table (ft)	WZ-AQDEPTH	0		(most conservative result)

Table 5.42. MEPAS transport parameters for the C-720 Area

Input parameter description	Parameter name	Value	Reference
		Top soil parameters (WT)	
Textural classification	WT-CLASS	silt	McCracken Co. Soil Survey (USDA 1976)
Sand (%)	WT-SAND	15	McCracken Co. Soil Survey: conservative estimate (highest % sand)
Silt (%)	WT-SILT	80	Maximum % silt for soil type
Clay (%)	WT-CLAY	5	= 100% - % sand - % silt
Organic matter (%)	WT-OMC	0.05	CERCLA Phase II Site Investigation (CH2M HILL 1992), Table 5-1
Iron and aluminum (%)	WT-IRON	4	DOE 1995a (Background Concentrations and Human Health Risk-Based Screening Criteria for Metals in Soil at the PGDP)
pH of topsoil	WT-pH	5.0	McCracken Co. Soil Survey
Percent vegetative cover of the site (%)	WT-VEGCOV	10	Area mainly covered by pavement but some small patches of grass
Topsoil water capacity	WT-AVAILW	0.46	McCracken Co. Soil Survey = Available Water Capacity (0.20 in/in) × root zone depth (23 in) × vegetative cover (0.10)
SCS curve number	WT-SCSN	86	Antecedent Moisture Condition = II (normal moisture); Group C hydrologic soil group; bare soil, hard surface
		Properties of the partially saturated zones (WP)	
Thickness (ft)	WP-THICK	WP1: 16 WP2: 25 WP3: 18	1–17 ft (HU 1) Boring logs at C-720 17–42 ft (HU 2) 42–60 ft (HU 3)
Textural classification	WP-CLASS	WP1 silty clay WP2 sandy loam WP3 silty clay	Boring logs at C-720 Area
Sand (%)	WP-SAND	WP1 8 WP2 67 WP3 20	Geotechnical data, HU 1, boring H 301 Geotechnical data, HU 2, boring COE 17 Maximum % sand based on soil type
Silt (%)	WP-SILT	WP1 52 WP2 19 WP3 40	Geotechnical data, HU 1, boring H 301 Geotechnical data, HU 2, boring COE 17 Maximum % silt
Clay (%)	WP-CLAY	WP1 40 WP2 14 WP3 40	Geotechnical data, HU 1, boring H 301 Geotechnical data, HU 2, boring COE 17 Minimum % clay based on soil type
Organic matter content(%)	WP-OMC	WP1 0.09 WP2 0.07 WP3 0.06	Average, WAG 27 RI, 7-18 ft Average, WAG 27 RI, 18-38 ft Average, WAG 27 RI, 38-50 ft
Iron and aluminum (%)	WP-IRON	4	DOE 1995a
pH of pore water in partially saturated zone	WP-pH	6.5	OHM 1992 (pH of shallow groundwater at C-750 UST site)
Bulk density(g/cm^3)	WP-BULKD	WP1 1.46 WP2 1.8 WP3 1.46	Table 2.1 of MEPAS Guidance, [(2.65)(1-Porosity)]
Total porosity (%)	WP-TOTPOR	WP1 45 WP2 36 WP3 45	WP2: Mean total porosity of UCRS sands & gravels based on WAG 6 measurements; WP1 & WP3: Maximum porosity of 45% measured in some UCRS samples at WAG 6 was used as upper limit of total porosity for clay rich layers
		Properties of the partially saturated zones (WP)	
Field capacity (%)	WP-FIELDC	WP1 27.8 WP2 9 WP3 27.8	Table 2.1 of MEPAS Guidance, based on soil type and porosity
Longitudinal dispersivity (ft)	WP-LDISP	WP1 0.16 WP2 0.25 WP3 0.18	MEPAS Guidance: $D_L = 0.01$ (Th)

Table 5.42. MEPAS transport parameters for the C-720 Area (continued)

Input parameter description	Parameter name	Value		Reference
Properties of the partially saturated zones (WP) (continued)				
Saturated hydraulic conductivity (cm/sec)	WP-CONDUC	ft/day	cm/sec	Table 2.1 of MEPAS Guidance, based on soil type slug test at MW218, Table 2.1 of MEPAS Guidance
		WP1 7.4E-2	2.6E-5	
		WP2 8.8	3.1E-3	
		WP3 7.4E-2	2.6E-5	
Moisture content for release site soils (%)	WS-MOISTC	WP1 36		Shallow water table - moisture content between field capacity and porosity value for WP1, set equal to porosity for deeper layers.
		WP2 36		
		WP3 45		
Textural classification	WZ-CLASS	sand (gravelly)		Boring Log descriptions
Properties of the saturated zone (WZ)				
Sand (%)	WZ-SAND	74		Average, WAG 6 geotechnical data
Silt (%)	WZ-SILT	17		Average, WAG 6 geotechnical data
Clay (%)	WZ-CLAY	9		Average, WAG 6 geotechnical data
Organic matter (%)	WZ-OMC	0.02		WAG 6 geotechnical data
Iron and aluminum (%)	WZ-IRON	3		Average of WAG 6, 62–78 ft samples
pH	WZ-pH	6.2		Average pH of RGA groundwater at C-720 Area (1998 sampling data).
Total porosity (%)	WZ-TOTPOR	37		Conservative, based on WAG 6 measurement
Effective porosity (%)	WZ-EFFPOR	30		Conservative estimate
Darcy velocity (ft/day)	WZPVELOC	0.6		Conservative estimate, uses conductivity of 1,500 ft/d and gradient of 4E-4
Thickness (ft)	WZ-THICK	40		RGA interval: 60–100 ft bgs
Bulk density (ft)	WZ-BULKD	1.67		(2.65 g/cm^3 × 0.63)
Travel distance (ft)	WZ-DIST	1,800 ft		PGDP security fence (west)
		4,600 ft		DOE property boundary (west)
Longitudinal dispersivity (ft)	WZ-LDISP	50.0		(reference: Bioscreen groundwater model)
Transverse dispersivity (ft)	WZ-TDISP	5.0		(reference: Bioscreen groundwater model)
Vertical dispersivity (ft)	WZ-VDISP	0.1		- near zero
Total flux to aquifer (%)	WZ-FRACT	100		Conservative estimate
Perpendicular distance from groundwater flow to receptor (ft)	WZ-YDIST	0		(plume centerline concentrations)
Vertical distance below groundwater table (ft)	WZ-AQDEPTH	0		(most conservative result)

Table 5.43. MEPAS source terms for Solid Waste Management Unit 1

Contaminant	Level	East-West Axis (ft)	North-South Axis (ft)	Thickness (ft)	Notes
			Inorganics		
Antimony	5 mg/kg	290	200	28	Unsaturated Layer 1; in boring H 208 (10-15) and 8 recent RI borings from 5–33 ft bgs
		100	75	10	Unsaturated Layer 2; in boring H 209 (45–50 ft) and one recent RI boring 001-179 (40–43 ft)
		50	50	3	RGA in boring H 210 (57–60)
Beryllium	10 mg/kg	50	50	5	Unsaturated Layer 1; in boring H 210 (15–20 ft)
		175	75	10	Unsaturated Layer 2 (HU 3); in recent RI borings 001-179 and 001-166 (40-50 ft)
Cadmium	6 mg/kg	525	210	3	Found over most of the SWMU 1 area in 7–10 ft samples
Manganese	2,160 mg/kg	85	80	3	Found in recent RI boring 001-137 (7–10 ft)
			Organics		
bis(2-ethylhexyl) phthalate	2,400 µg/kg	50	75	31	Unsaturated Layer 1; found throughout boring H 009 (1–32 ft)
Trichloroethene	439,000 µg/kg	175	115	50	Unsaturated Layers 1 and 2; found in large area in northern part of unit, in and around the CDM test pit 5; not found above screening levels in RGA soil samples (Phase I CERCLA SI)
	66,000	175	115	10	
Vinyl Chloride	4,800 µg/kg	150	80	9	Unsaturated Layer 1; found in same general area as TCE, smaller area and confined to 1–10 ft interval
Xylene	12 µg/kg	50	50	4	Unsaturated Layer 1; in boring H 052, 2–6 ft bgs
		100	75	5	Unsaturated Layer 2 (HU 3) in boring H 208, 50–55 ft bgs

Most contaminants were detected in fewer than five samples above the screening levels, so maximum concentration were used to estimate contaminant inventory for most constituents. The exception for SWMU 1 was TCE, for which the source term was developed using the average concentration of 88 samples.

The following constituents present above screening levels were not modeled for the subsurface soils because they were detected only in one sample location at concentrations above screening levels.

2-Hexanone
4,4-DDT
Arsenic
Benzene 1,2,4-trimethyl
Butyl benzyl phthalate
cis-1,2-dichloroethene
Decane, 6-ethyl-2-methyl
Di-*n*-butylphthalate
Hexadecane
Lead
Nonane 2,6-dimethyl
Octacosane
Octadecene
Phenanthrene
Phthalate
Tetrachloro 1,1-biphenyl iso

Table 5.44. MEPAS source terms for Solid Waste Management Unit 91

Contaminant	Level		East-west axis (ft)	North-south axis (ft)	Thickness (ft)	Notes
				Subsurface soil		
Antimony	5	mg/kg	300	125	25	Detected above screening levels in boring H 202, 5–30 ft and boring H 203, 5–10 ft
Lead	133	mg/kg	200	75	5	Detected above screening levels in boring H 203, 25–30 ft
Phenanthrene	220J	µg/kg	275	75	6	Detected above PRGs in boring H-003, 18–24 ft
Di-*n*-butylphthalate	84J	µg/kg	200	75	81	Detected above screening levels in H 203 from 25 to 75 ft bgs; source defined to include entire thickness of RGA (to 106 ft bgs)

All sources defined using maximum detected concentrations.

The following constituent was detected above screening levels at the site but was not modeled. Uranium (2,400 mg/kg) detected once above screening level in one sample in one Lasagna™ Phase I boring (LAG11).

Source terms for the RGA were developed using deep-soil sampling data collected at the site for the CERCLA Phase I and II Site Investigations (CH2M HILL 1992).

Table 5.45. MEPAS source terms for Solid Waste Management Unit 196

Contaminant	Level		East-West Axis (ft)	North-South Axis (ft)	Thickness (ft)	Notes
				Surface soil		
Antimony	62.2	mg/kg	175	160	2	Detected above screening level in 7 surface soil samples (0–2 ft); surface source covers unpaved areas at northeastern and northwestern corners of building
				Subsurface soil		
Antimony	58.9	mg/kg	175	160	8	Detected above screening level in same 7 borings having surface sample hits Northeast: four borings (196-008, 196-010, 196-011, & 196-013), 2–10 ft; and Northwest: three borings (196-001 & 196-002 and 196-004), 2–10 ft
Barium	389	mg/kg	75	50	2	Detected in one borings (196-015) in 4–6 ft interval
Beryllium	113	mg/kg				Detected above screening levels in only one soil boring (196-013, located near northeast tank) in 4–6 ft interval
Cobalt	112	mg/kg				
Copper	112	mg/kg	60	50	2	
Lead	116	mg/kg				
Silver	65.4	mg/kg				
Thallium	114	mg/kg				
Cadmium	116	mg/kg	140	50	4	Detected above screening level in 2 borings (196-013 and 196-014, in 4–6 & 6–8 ft intervals, respectively)
Manganese	1,980J	mg/kg	75	40	2	Detected above screening level in one soil boring, 196-011, 4–6 ft
Nickel	587	mg/kg	75	80	4	Detected above screening level in two soil borings, 196-014 and 196-015, in 2–4 and 4–6 ft intervals, respectively

All sources were defined using maximum detected concentrations.
No deep soil or groundwater sampling was conducted, so no RGA groundwater source terms were modeled.

Table 5.46. MEPAS source terms for the C-720 Area

Contaminant	Level		East-west axis (ft)	North-south axis (ft)	Thickness (ft)	Notes
			Inorganics and radionuclides			
Antimony	87.2	mg/kg	200	120	20	Two source areas were defined for antimony and beryllium: one
	1.59	mg/kg	300	275	8	centered around 720-024 (35–50 ft samples) at the SW corner of the C-720 Building - assumed it extends an additional 5 ft into HU 3 (to 55 ft); another one centered around 720-027
Beryllium	107	mg/kg	200	120	20	(20–28 ft) at the NE corner
	1.99	mg/kg	300	275	8	
Cadmium	102	mg/kg				These six metals were detected
Cobalt	103	mg/kg				above screening levels in only
Copper	106	mg/kg	200	120	20	one boring (720-024) from 35–50 ft; Used maximum
Silver	94.8	mg/kg				detected values and assumed
Thallium	94.4	mg/kg				it extends an additional 5 ft
Vanadium	128	mg/kg				into HU 3 (to 55 ft)
Lead	139	mg/kg	200	140	4	Detected above screening levels in only one boring (720-002) from 12–16 ft
			Organics			
bis(2-ethylhexyl)phthalate	1,100	µg/kg	200	120	40	Detected above PRG (880 µg/kg) in one boring (720-024) from 15–50 ft; extended source 5 additional ft into HU 3 (to 55 ft bgs)
trans-1,2-Dichloroethene	450,000	µg/kg	200	150	4	2 detections above the PRG in one boring (720-002) in the 12–16 ft interval
Trichloroethene	2,641	µg/kg	1050	225	20	2 large source areas defined: Northern source, defined by three
	13,069	µg/kg	825	150	20	borings (720-007, 720-008, and 720-027) and Southern source defined by three borings (720-002, 720-004, and 720-005).
Vinyl Chloride	400	µg/kg	200	150	2	3 detections above the PRG in 2 soil borings (720-001 in 22–23 ft
	400	µg/kg	200	150	5	interval (HU 2) and 720-002 in 5–10 ft interval (HU 1)

The following constituents present above screening levels were not modeled for the subsurface soils:

- Mercury - one detect (0.96 mg/kg) slightly above screening levels (0.81 mg/kg PRG) in soil boring 720-027 at 15–18 ft;
- 1,1-Dichloroethene - one detect (200 µg/kg) above PRG (20 µg/kg). It was not modeled because it was in only the 31.5–32 ft sample of just one boring (720-008); and
- 4-Chloro-3-methylphenol - one isolated detect (40J µg/kg) in soil boring 720-006 in 15–18 ft interval.

Maximum concentrations were used for each discrete source area for all constituents except TCE, for which the average concentration in each source area was used to develop the source term inventories.

Four additional detections of antimony (in borings 720-003, 720-020, 720-009, and 720-001) and one detection of beryllium (720-020) were not used in the development of the subsurface soil antimony and barium source terms. These detections (maximum 0.61 mg/kg antimony and 1.4 mg/kg beryllium) were only slightly above the screening level (two times background = 0.42 mg/kg antimony and 1.38 mg/kg beryllium) and were in isolated sample intervals in these borings.

Table 5.47. MEPAS results for Solid Waste Management Unit 1

		PGDP security fence		DOE property boundary	
Source	Constituent	Maximum concentration (mg/L)	Time (yr)	Maximum concentration (mg/L)	Time (yr)
UCRS	Antimony	6.43E-2	794	1.31E-2	862
	Beryllium[a]	0	10,000	0	10,000
	bis(2-ethylhexyl)phthalate[a]	0	10,000	0	10,000
	Cadmium[b]	6.456E-33	9,946 to 15,696	1.543E-34	9,974 to 15,696
	Manganese	1.73E-1	2,334	2.63E-2	2,643
	Trichloroethene	20.44	120	3.4	122
	Vinyl chloride	8.19E-2	57	1.29E-2	63
	Xylenes	1.193E-4	159	1.86E-5	171
RGA	Antimony	1.67E-2	7	8.22E-4	54

[a]Receptor concentrations are zero over the given time range.
[b]Concentrations vary by less than 1/100th of 1% of the maximum concentration over the given time range (steady state).

Table 5.48. MEPAS results for Solid Waste Management Unit 91

		PGDP security fence		DOE property boundary	
Source	Constituent	Maximum concentration (mg/L)	Time (yr)	Maximum concentration (mg/L)	Time (yr)
UCRS	Antimony	4.2E-2	498	5.7E-3	615
	Di-*n*-butylphthalate[a,b]	2.23E-29	10,001	0	10,000
	Lead[a,b]	1.76E-31	9,821 to 11,821	0	10,000
	Phenanthrene	3.85E-5	4,877	5.6E-6	5,377
RGA	Di-*n*-butylphthalate[a]	5.380E-6	4,609 to 10,055	7.878E-7	10,001

[a]Concentrations vary by less than 1/100th of 1% of the maximum concentration over the given time range (steady state).
[b]Receptor concentrations are zero over the given time range.

Table 5.49. MEPAS results for Solid Waste Management Unit 196

		PGDP security fence		DOE property boundary	
Source	Constituent	Maximum concentration (mg/L)	Time (yr)	Maximum concentration (mg/L)	Time (yr)
Surface soil	Antimony	4.81E-4	6,539	1.519E-4	6,546
Subsurface soil	Antimony	1.826E-03	6,543	5.768E-4	6,544
	Barium[a]	0	10,000	0	10,000
	Beryllium[a]	0	10,000	0	10,000
	Cadmium[a,b]	1.401E-39	9,881 to 12,381	0	10,000
	Cobalt	1.416E-9	9,804	3.529E-10	9,805
	Copper[b]	3.105E-17	9,925 to 10,675	5.50E-18	9,933 to 10,675
	Lead[b]	6.963E-29	9,961 to 14,211	1.026E-35	9,821 to 14,211
	Manganese	5.91E-4	9,952	1.591E-4	9,953
	Nickel[b]	1.004E-23	9,868 to 10,368	2.664E-24	9,876 to 10,368
	Silver	1.814E-5	9,771	5.289E-6	9,772
	Thallium	1.541E-03	394	4.401E-4	395

[a]Receptor concentrations are zero over the given time range.
[b]Concentrations vary by less than 1/100th of 1% of the maximum concentration over the given time range (steady state).

Table 5.50. MEPAS results for the C-720 Area

		PGDP security fence		DOE property boundary	
Source	**Constituent**	**Maximum concentration (mg/L)**	**Time (yr)**	**Maximum concentration (mg/L)**	**Time (yr)**
Subsurface soil	Antimony	2.55E-1	229	8.73E-2	361
	bis(2-ethylhexyl)phthalate[b]	3.67E-12	9,930 to 11,180	5.14E-21	9,996 to 11,180
	Beryllium[b,a]	0	10,000	0	10,000
	Cadmium[b]	4.075E-6	9,973 to 10,723	1.13E-19	9,959 to 10,723
	Cobalt	1.3E-2	4,252	5.6E-3	4,301
	Copper	7.88E-3	7,931	3.24E-3	9,974
RGA	Lead[a]	0	10,000	0	10,000
	Silver	6.3E-2	847	3.0E-2	976
	Thallium	1.935	31	8.026E-1	38
	trans-1,2-Dichloroethene	7.22	25	2.83	30
	Trichloroethene	12.7E-1	72	5.35E-1	82
	Vanadium	2.39E-2	3,797	7.7E-3	6,039
	Vinyl chloride	3.63E-3	54	1.50E-3	60
	Trichloroethene	7.66E-2	9.2	2.56E-1	20.7

[a]Receptor concentrations are zero over the given time range.
[b]Concentrations vary by less than 1/100th of 1% of the maximum concentration over the given time range (steady state).

5.2.6 SWMU 91

SWMU 91 was the site of an innovative technology demonstration for the *in situ* removal of TCE known as the Lasagna™ process. The fate and transport models SESOIL and AT123D were used to determine the level of TCE that could remain in the soil after completion of the Lasagna™ process and not leach unacceptable dissolved contaminant levels to the RGA. *Preliminary Site Characterization/Baseline Risk Assessment/Lasagna™ Technology Demonstration at Solid Waste Management Unit 91 of the Paducah Gaseous Diffusion Plant, Paducah Kentucky* (DOE 1996b) reported on the development of the model and the model results.

The SWMU 91 model addressed four possible exposure scenarios: the SWMU boundary, the PGDP security fence, the DOE property boundary, and the Ohio River. Tables 5.51 and 5.52 summarize the main attributes of the source term and the SESOIL and AT123D transport parameters. Based on the model results, the target residual level of TCE in SWMU 91 soils was set at 5.6 mg/kg.

5.2.7 WAG 28

Results of the MEPAS fate and transport modeling for WAG 28 are presented in *Remedial Investigation Report for Waste Area Grouping 28 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1999b). The modeling addressed the impact of three SWMUs, 99, 193, and 194, and AOC 204 on groundwater contamination in the RGA. Because all four sites overlie the Northeast Plume, the models share common exposure points at the PGDP security fence and DOE property boundary. The soil and aquifer transport parameters that were input into the MEPAS model for SWMU 99, SWMU 193, SWMU 194, and AOC 204 are presented in Tables 5.53 through 5.56.

The WAG 28 RI developed source terms in surface soil and the UCRS for the fate and transport modeling. Tables 5.57 through 5.60 present the source term information for all the constituents selected for fate and transport modeling from each SWMU. Suspected DNAPL sources to the Northeast Plume were not confirmed by the WAG 28 RI and could not be assessed with MEPAS. Model results indicated that SWMUs 099, 193, and 194 yielded excess dissolved metals levels in the RGA at the exposure points and that TCE was a groundwater contaminant of concern for AOC 204. The modeling results for WAG 28 are presented in Tables 5.61 through 5.64.

5.2.8 WAG 3

The WAG 3 RI, as documented in *Remedial Investigation Report for Waste Area Grouping 3 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2001), used MEPAS to model fate and transport of area contaminants through the RGA. Exposure was modeled at the same two exposure points used in WAGs 7 and 30: the PGDP security fence and the DOE property boundary. The MEPAS modeling for this WAG was conducted using source terms for the three SWMUs (SWMU 4, SWMU 5, and SWMU 6) delineated for this area. Contaminant source concentrations and source inventories were derived from soil and groundwater sampling results. The sampling data used included the 2000 WAG 3 RI data as well as historical sampling conducted at the sites in support of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site investigation (SI) (CH2M HILL 1992). The data gaps investigation provided additional data used at SWMU 4. The soil and aquifer transport parameters that were input into the MEPAS model for SWMU4, SWMU 5, and SWMU 6 are presented in Tables 5.65 through 5.67.

Table 5.51. Source zone and transport parameters used in the SESOIL model of SWMU 91

Multi Media Modeling Summary

Project Name	SWMU 91 – "Lasagna"
Model Name	RISKPRO (SESOIL)
Documented	*DNAPL Site Characterization and LASAGNA Technology Demonstration at Solid Waste Management Unit 91 of the Paducah Gaseous Diffusion Plant, Kentucky*

	Universal	HU1	UCRS HU2	HU3	RGA HU4
Hydraulic Parameters					
Conductivity		1.0E-7 cm/s	1.1E-5 cm/s	4.2E-7 cm/s	3.8E-5 cm/s
Intrinsic Permeability	1.25E1 cm^2				
Porosity	0.48				
Soil Saturation (%)	0.18				
Bulk Density	1.77 g/cm^3				
TOC		0.2			
Infiltration	86 cm/y				
Evapotranspiration	73 cm/y				
Groundwater recharge	14 cm/y				
Surface runoff	41 cm/y				
Disconnectedness Index	7.5				
Layer thickness		609.6 cm	243.8 cm	426.7 cm	231.5 cm
Freundlich exponent	1				
Model Dimension	1 D				
Source Terms					
Source depth	3 - 7.5 bgs				
Source area	6000 ft^2				
Constant/Degrading	constant			Constant	Constant
Points of Exposure					
Locations	SWMU 91 boundary				
	PGDP perimeter fence				
	boundary				
	DOE property boundary				

Table 5.52. Transport parameters used in the AT123D model of SWMU 91 and modeled TCE concentrations at exposure points

Multi Media Modeling Summary				
Project Name	SWMU 91 – "Lasagna"			
Model Name	RISKPRO (AT123D)			
Documented	*DNAPL Site Characterization and LASAGNA Technology Demonstration at Solid Waste Management Unit 91 of the Paducah Gaseous Diffusion Plant, Kentucky*			
Geologic Units	**RGA HU4/HU5**	**UCRS HU2a**	**UCRS HU2b**	**HU3**
Hydraulic Parameters		Not represented	Not represented	Not represented
Aquifer Thickness	9.144 m			
Aquifer Width	Infinite			
Conductivity	6.35 m/hr			
Effective Porosity	0.25			
Hydraulic Gradient	0.0006			
Bulk Density	1770 kg/m^3			
Longitudal Dispersivity	3.048 m			
Lateral Dispersivity	0.3048 m			
Vertical Dispersivity	0.3048 m			
Time Interval Size For Desired Solution	730 hr			
Discharge Time	87600 hr			
Model Dimension	3 D			
COCs	TCE			
Constant/Degrading Concentration	Degrading			
Points of Exposure Locations	SWMU 91 boundary			
	PGDP perimeter			
	fence boundary			
	DOE property boundary			

Groundwater Concentrations Protective of HH&E (TCE)			26 ug/L	6 ug/L	5 ug/L	3.2 ug/L
Location	**Distance from Source**	**Year Max GW Concentration**	**Target Soil Remediation Level for TCE (mg/kg)**			
SWMU 91 Boundary	0 ft	41	13.3	3.08	2.56	1.64
PGDP Perimeter Fence	2100 ft	53	28.9	6.66	5.55	3.55
DOE Property	4000 ft	64	39	9.01	7.51	4.8

Table 5.53. MEPAS transport parameters for SWMU 99

Input parameter description	Parameter name	Value	Reference
	Topsoil parameters (WT)		
Textural classification	WT-CLASS	Silt	McCracken Co. Soil Survey (USDA 1976)
Percent sand (%)	WT-SAND	15	McCracken Co. Soil Survey: conservative estimate (highest % sand)
Percent silt (%)	WT-SILT	80	Maximum % silt for soil type
Percent clay (%)	WT-CLAY	5	= 100% -% sand - % silt
Percent organic matter (%)	WT-OMC	0.05	CERCLA Phase II Site Investigation (CH2M HILL 1992), Table 5.1
Percent iron and aluminum (%)	WT-IRON	4	DOE 1995a (Background Concentrations and Human Health Risk-Based Screening Criteria for Metals in Soil at PGDP)
pH of topsoil	WT-pH	5.0	McCracken Co. Soil Survey
Percent vegetative cover of site (%)	WT-VEGCOV	0	Covered by concrete or gravel
Topsoil water capacity	WT-AVAILW	0.0	McCracken Co. Soil Survey = available water capacity (0.20 in./in.) × root zone depth (23 in.) × vegetative cover (0%)
SCS curve number	WT-SCSN	86	Antecedent Moisture Condition = II (normal moisture); Group C hydrologic soil group; bare soil, hard surface, 0–20%vegetated
	Properties of the partially saturated zones (WP)		
Thickness (ft)	WP-THICK	WP1 42 WP2 17	1–43 ft (HU 1 + HU 2) 43–60 ft (HU 3) Boring logs at SWMU 99
Textural classification	WP-CLASS	WP1 silty clay loam WP2 silty clay	Boring logs and sieve analyses from Corps of Engineers boring COE-38
Sand (%)	WP-SAND	WP1 5 WP2 8	Boring logs, sieve analyses for boring COE-38 SWMU 2 geotechnical data
Silt (%)	WP-SILT	WP1 65 WP2 38	Boring logs, sieve analyses for boring COE-38 SWMU 2 geotechnical data
Clay (%)	WP-CLAY	WP1 30 WP2 54	Boring logs, sieve analyses for boring COE-38 SWMU 2 geotechnical data
Organic matter content in soil (%)	WP-OMC	WP1 0.08 WP2 0.06	Average, WAG 27 RI, 7–40 ft Average, WAG 27 RI, 40–50 ft
Iron + aluminum in soil (%)	WP-IRON	4	**DOE 1995b**
pH of pore water in partially saturated zone	WP-pH	6.0	**DOE 1995a**
Bulk density(g/cm^3)	WP-BULKD	WP1 1.46 WP2 1.46	Table 2.1 of MEPAS Guidance, [2.65 × (1-Porosity)]
	Properties of the partially saturated zones (WP)		
Total porosity (%)	WP-TOTPOR	WP1 45 WP2 45	Table 2.1 of MEPAS Guidance, based on soil type; maximum porosity of 45% measured in UCRS samples at WAG 6 was used as upper limit of total porosity for clay-rich layers
Field capacity (%)	WP-FIELDC	WP1 37.5 WP2 42	Table 2.1 of MEPAS Guidance, based on soil type
Longitudinal dispersivity (ft)	WP-LDISP	WP1 0.42 WP2 0.17	Estimated based on MEPAS guidance: $D_L = 0.01 \times$ thickness
Saturated hydraulic conductivity (ft/day)	WP-CONDUC	ft/day / cm/sec WP1 1.86 / 6.54E-4 WP2 1.1E-1 / 3.78E-5	WP1: Slug test at MW164 (NW of SWMU 99) WP2: Slug test at MW204 (Phase II Site Investigation)

Table 5.53. MEPAS transport parameters for SWMU 99 (continued)

Input parameter description	Parameter name	Value	Reference
Properties of the partially saturated zones (WP) (continued)			
Moisture content (%)	WS-MOISTC	WP1 43 WP2 45	WP1: Shallow water table—moisture content between field capacity and porosity value WP2: Moisture content = total porosity
Properties of the saturated zone (WZ)			
Textural classification	WZ-CLASS	Sand (gravelly)	Deep boring logs surrounding area
Sand (%)	WZ-SAND	75	Average, WAG 6 geotechnical data and SWMU 99 boring logs
Silt (%)	WZ-SILT	15	Average, WAG 6 geotechnical data and SWMU 99 boring logs
Clay (%)	WZ-CLAY	10	Average, WAG 6 geotechnical data and SWMU 99 boring logs
Organic matter in soil (%)	WZ-OMC	0.02	Average WAG 6 RGA soil data
Iron + aluminum in soil (%)	WZ-IRON	2	Average, SWMU 99, 51–60 ft samples
pH of pore water in saturated zone	WZ-pH	6.4	Average pH of RGA groundwater (WAG 27 data)
Total porosity (%)	WZ-TOTPOR	37	Conservative, based on WAG 6 measurement
Effective porosity (%)	WZ-EFFPOR	30	Conservative estimate
Darcy velocity (ft/day)	WZPVELOC	0.6	Conservative estimate; uses conductivity of 1500 ft/d and gradient of 0.0004
Thickness (ft)	WZ-THICK	40	RGA (HU 4 + HU 5) interval: 60–100 ft bgs
Bulk density (ft)	WZ-BULKD	1.67	(2.65 g/cm^3 × 0.63)
Travel distance (ft)	WZ-DIST	Outside sources: 10 ft to PGDP fence 4500 ft to DOE property boundary	Sources at SWMU 99 are located inside or outside the PGDP security fence. For sources located near or outside the fence, the distance to PGDP fence was assumed to be 10 ft (model does not accept zero value). The distance to the property boundary was 4500 ft. The distances were measured along the groundwater flow direction to the eastern DOE property boundary
		Inside sources: 700 ft to PGDP fence 4800 ft to DOE property boundary	Those located inside the fence were modeled using a distance of 700 ft to the fence and 4800 ft to the DOE property boundary.
Longitudinal dispersivity (ft)	WZ-LDISP	50.0	Reference: Bioplume groundwater model
Transverse dispersivity (ft)	WZ-TDISP	5.0	Reference: Bioplume groundwater model
Vertical dispersivity (ft)	WZ-VDISP	0.1	Near zero
Percent of total flux to aquifer (%)	WZ-FRACT	100	Conservative
Perpendicular distance from groundwater flow to receptor (ft)	WZ-YDIST	0	(Plume centerline concentrations)
Vertical distance below groundwater table (ft)	WZ-AQDEPTH	0	(Most conservative result)

Table 5.54. MEPAS transport parameters for SWMU 193

Input parameter description	Parameter name	Value	Reference
		Topsoil parameters (WT)	
Textural classification	WT-CLASS	Silt	McCracken Co. Soil Survey (USDA 1976)
Percent sand (%)	WT-SAND	15	McCracken Co. Soil Survey: conservative estimate (highest % sand)
Percent silt (%)	WT-SILT	80	Maximum % silt for soil type
Percent clay (%)	WT-CLAY	5	= 100% -% sand - % silt
Percent organic matter (%)	WT-OMC	0.05	CERCLA Phase II Site Investigation (CH2M HILL 1992), Table 5.1
Percent iron and aluminum (%)	WT-IRON	4	DOE 1995a (Background Concentrations and Human Health Risk-Based Screening Criteria for Metals in Soil at PGDP)
pH of topsoil	WT-pH	5.0	McCracken Co. Soil Survey
Percent vegetative cover of site (%)	WT-VEGCOV	18	Mostly covered by concrete or gravel
Topsoil water capacity	WT-AVAILW	0.83	McCracken Co. Soil Survey = available water capacity (0.20 in./in.) × root zone depth (23 in.) × vegetative cover (18%)
SCS curve number	WT-SCSN	86	Antecedent Moisture Condition = II (normal moisture); Group C hydrologic soil group; bare soil, hard surface, 0–20%vegetated
		Properties of the partially saturated zones (WP)	
Thickness (ft)	WP-THICK	WP1 67	1–68 ft (HU 1 + HU 2 + HU 3) Boring logs from Groundwater Phase IV Investigation
Textural classification	WP-CLASS	WP1 silty clay loam	Boring logs and sieve analyses from nearby Corps of Engineers boring COE-35
Sand (%)	WP-SAND	WP1 17	Sieve analyses from boring COE-35
Silt (%)	WP-SILT	WP1 63	Sieve analyses from boring COE-35
Clay (%)	WP-CLAY	WP1 20	Sieve analyses from boring COE-35
Organic matter content in soil (%)	WP-OMC	WP1 0.07	Average, WAG 27 RI, 7–50 ft
Iron + aluminum in soil (%)	WP-IRON	4	**DOE 1995b**
pH of pore water in partially saturated zone	WP-pH	6.0	**DOE 1995a**
Bulk density(g/cm^3)	WP-BULKD	WP1 1.46	Table 2.1 of MEPAS Guidance [2.65 × (1-Porosity)]
Total porosity (%)	WP-TOTPOR	WP1 45	Table 2.1 of MEPAS Guidance, based on soil type; maximum porosity of 45% measured in UCRS samples at WAG 6 was used as upper limit of total porosity for clay-rich layers
Field capacity (%)	WP-FIELDC	WP1 37.5	Table 2.1 of MEPAS Guidance, based on soil type
Longitudinal dispersivity (ft)	WP-LDISP	WP1 0.67	MEPAS Guidance: $D_L = 0.01 \times (Th)$
Saturated hydraulic conductivity (ft/day)	WP-CONDUC	ft/day cm/sec WP1 1.5E-1 5.20E-5	Slug test at MW131
Moisture content (%)	WS-MOISTC	WP1 43	WP1: Shallow water table—moisture content between field capacity and porosity value
		Properties of the saturated zone (WZ)	
Textural classification	WZ-CLASS	Sand (gravelly)	Deep boring logs in surrounding area
Sand (%)	WZ-SAND	75	Average, WAG 6 geotechnical data and SWMU 193 boring logs
Silt (%)	WZ-SILT	15	Average, WAG 6 geotechnical data and SWMU 193 boring logs
Clay (%)	WZ-CLAY	10	Average, WAG 6 geotechnical data and SWMU 193 boring logs
Organic matter in soil (%)	WZ-OMC	0.02	Average WAG 6 RGA soil data

Table 5.54. MEPAS transport parameters for SWMU 193 (continued)

Input parameter description	Parameter name	Value	Reference
Properties of the saturated zone (WZ) (continued)			
Iron + aluminum in soil (%)	WZ-IRON	3	Average, WAG 6, 62–78 ft samples
pH of pore water in saturated zone	WZ-pH	6.4	Average pH of RGA groundwater (WAG 27 data)
Total porosity (%)	WZ-TOTPOR	37	Conservative, based on WAG 6 measurement
Effective porosity (%)	WZ-EFFPOR	30	Conservative estimate
Darcy velocity (ft/day)	WZPVELOC	0.6	Conservative estimate; uses conductivity of 1500 ft/d and gradient of 0.0004
Thickness (ft)	WZ-THICK	25	RGA (HU 4 + HU 5) interval: 68–93 ft bgs
Bulk density (ft)	WZ-BULKD	1.67	($2.65\ g/cm^3 \times 0.63$)
Travel distance (ft)	WZ-DIST	3000 ft – PGDP fence	Minimum distance to eastern PGDP fence along groundwater flowpath
		7400 ft – DOE property boundary	Minimum distance to DOE property boundary along groundwater flowpath
Longitudinal dispersivity (ft)	WZ-LDISP	50.0	Reference: Bioplume groundwater model
Transverse dispersivity (ft)	WZ-TDISP	5.0	Reference: Bioplume groundwater model
Vertical dispersivity (ft)	WZ-VDISP	0.1	Near zero
Percent of total flux to aquifer (%)	WZ-FRACT	100	Conservative
Perpendicular distance from groundwater flow to receptor (ft)	WZ-YDIST	0	(Plume centerline concentrations)
Vertical distance below groundwater table (ft)	WZ-AQDEPTH	0	(Most conservative result)

Table 5.55. MEPAS transport parameters for SWMU 194

Input parameter description	Parameter name	Value	Reference
	Topsoil parameters (WT)		
Textural classification	WT-CLASS	Silt	McCracken Co. Soil Survey
Percent sand (%)	WT-SAND	15	McCracken Co. Soil Survey: conservative estimate (highest % sand)
Percent silt (%)	WT-SILT	80	Maximum % silt for soil type
Percent clay (%)	WT-CLAY	5	= 100% -% sand - % silt
Percent organic matter (%)	WT-OMC	0.05	CERCLA Phase II Site Investigation (CH2M HILL 1992), Table 5.1
Percent iron and aluminum (%)	WT-IRON	4	DOE 1995a (Background Concentrations and Human Health Risk-based Screening Criteria for Metals in Soil at PGDP)
PH of topsoil	WT-pH	5.0	McCracken Co. Soil Survey
Percent vegetative cover of site (%)	WT-VEGCOV	100	Covered by vegetation
Topsoil water capacity	WT-AVAILW	4.6	McCracken Co. Soil Survey = available water capacity (0.20 in./in.) × root zone depth (23 in.) × vegetative cover (100%)
SCS curve number	WT-SCSN	71	Antecedent Moisture Condition = II (normal moisture); Group C hydrologic soil group; well vegetated
	Properties of the partially saturated zones (WP)		
Thickness (ft)	WP-THICK	54	1–55 ft bgs Average based on boring logs in vicinity of SWMU 194
Textural classification	WP-CLASS	Silty, clayey sand	Boring logs (silty sand) and sieve analyses for nearby Corps of Engineers boring COE-20
Sand (%)	WP-SAND	72	Sieve analyses at boring COE-20 for silty sand sample at 38 ft bgs
Silt (%)	WP-SILT	16	Sieve analyses at boring COE-20
Clay (%)	WP-CLAY	12	=100 - % silt - % sand
Organic matter content in soil (%)	WP-OMC	0.07	WAG 27 RI average for UCRS
Iron + aluminum in soil (%)	WP-IRON	4	DOEb 1995
PH of pore water in partially saturated zone	WP-pH	6.45	Average pH, SWMU 193
Bulk density(g/cm^3)	WP-BULKD	1.49	Table 2.1 of MEPAS Guidance, [2.65 × (1-Porosity)]
Total porosity (%)	WP-TOTPOR	43.7	Table 2.1 of MEPAS Guidance, based on soil type
Field capacity (%)	WP-FIELDC	12	Table 2.1 of MEPAS Guidance, based on soil type
Longitudinal dispersivity (ft)	WP-LDISP	0.54	Estimate based on MEPAS guidance: $D_L = 0.01 \times$ thickness
Saturated hydraulic conductivity (ft/day)	WP-CONDUC	ft/day 5.39 cm/sec 1.9E-3	Table 2.1 of MEPAS Guidance, based on soil type.
Moisture content (%)	WS-MOISTC	20	Measured value at boring COE-20
	Properties of the saturated zone (WZ)		
Textural classification	WZ-CLASS	Silty sand/gravel	Boring log description for RGA in nearby boring AH209
Sand (%)	WZ-SAND	74	Average, WAG 6 RGA geotechnical data
Silt (%)	WZ-SILT	17	Average, WAG 6 RGA geotechnical data
Clay (%)	WZ-CLAY	9	Average, WAG 6 RGA geotechnical data
Organic matter in soil (%)	WZ-OMC	0.02	Average, WAG 6 RGA data
Iron + aluminum in soil (%)	WZ-IRON	3	Average, WAG 6 RGA data
PH of pore water in saturated zone	WZ-pH	6.2	Average pH of RGA groundwater at WAG 6
Total porosity (%)	WZ-TOTPOR	37	Conservative, based on WAG 6 measurement
Effective porosity (%)	WZ-EFFPOR	30	Conservative estimate
Darcy velocity (ft/day)	WZPVELOC	0.6	Conservative estimate; uses conductivity of 1500 ft/d and gradient of 0.0004
Thickness (ft)	WZ-THICK	30	RGA (HU 4 + HU 5) interval: 55–85 ft bgs

Table 5.55. MEPAS transport parameters for SWMU 194 (continued)

Input parameter description	Parameter name	Value	Reference
	Properties of the saturated zone (WZ) (continued)		
Bulk density (ft)	WZ-BULKD	1.67	($2.65\ g/cm^3 \times 0.63$)
Travel distance (ft)	WZ-DIST	10 ft to fence	Distance to fence along groundwater flowpath: SWMU 194 is outside the fence (model does not accept zero value, so small value was used)
		8,700 ft to DOE property boundary	Minimum distance to DOE property boundary along groundwater flowpath
Longitudinal dispersivity (ft)	WZ-LDISP	50.0	Reference: Bioplume groundwater model
Transverse dispersivity (ft)	WZ-TDISP	5.0	Reference: Bioplume groundwater model
Vertical dispersivity (ft)	WZ-VDISP	0.1	Near zero
Percent of total flux to aquifer (%)	WZ-FRACT	100	
Perpendicular distance from groundwater flow to receptor (ft)	WZ-YDIST	0	(Plume centerline concentrations)
Vertical distance below groundwater table (ft)	WZ-AQDEPTH	0	(Most conservative result)

Table 5.56. MEPAS transport parameters for AOC 204

Input parameter description	Parameter name	Value	Reference
		Topsoil parameters (WT)	
Textural classification	WT-CLASS	Silt	McCracken Co. Soil Survey (USDA 1976)
Percent sand (%)	WT-SAND	15	McCracken Co. Soil Survey: conservative estimate (highest % sand)
Percent silt (%)	WT-SILT	80	Maximum % silt for soil type
Percent clay (%)	WT-CLAY	5	= 100% -% sand - % silt
Percent organic matter (%)	WT-OMC	0.05	CERCLA Phase II Site Investigation (CH2M HILL 1992), Table 5.1
Percent iron and aluminum (%)	WT-IRON	4	DOE 1995a (Background Concentrations and Human Health Risk-Based Screening Criteria for Metals in Soil at PGDP)
PH of topsoil	WT-pH	5.0	McCracken Co. Soil Survey
Percent vegetative cover of site (%)	WT-VEGCOV	100	Covered with heavy vegetation
Topsoil water capacity	WT-AVAILW	4.6	McCracken Co. Soil Survey = available water capacity (0.20 in./in.) × root zone depth (23 in.) × vegetative cover (100%)
SCS curve number	WT-SCSN	71	Antecedent Moisture Condition = II (normal moisture); Group C hydrologic soil group; vegetated surface, well vegetated
		Properties of the partially saturated zones (WT)	
Thickness (ft)	WP-THICK	WP1 51 WP2 15	1–52 ft (HU 1 + HU 2) 52–67 ft (HU 3) Boring logs at AOC 204, NE Plume Study, and Phase II SI
Textural classification	WP-CLASS	WP1 silty clay loam WP2 silty clay	Boring logs at AOC 204 and sieve analyses from Corps of Engineers Boring COE-38
Sand (%)	WP-SAND	WP1 5 WP2 8	Boring logs, sieve analyses for boring COE-38 SWMU 2 geotechnical data
Silt (%)	WP-SILT	WP1 65 WP2 38	Boring logs, sieve analyses for boring COE-38 SWMU 2 geotechnical data
Clay (%)	WP-CLAY	WP1 30 WP2 54	Boring logs, sieve analyses for boring COE-38 SWMU 2 geotechnical data
Organic matter content in soil (%)	WP-OMC	WP1 0.08 WP2 0.06	Average, WAG 27 RI, 7–40 ft (HU 1 + HU 2) Average, WAG 27 RI, 40–50 ft (HU 3)
Iron + aluminum in soil (%)	WP-IRON	4	**DOE 1995b**
PH of pore water in partially saturated zone	WP-pH	6.0	**DOE 1995a**
Bulk density (g/cm^3)	WP-BULKD	WP1 1.46 WP2 1.46	Table 2.1 of MEPAS Guidance, [2.65 × (1-Porosity)]
Total porosity (%)	WP-TOTPOR	WP1 45 WP2 45	Table 2.1 of MEPAS Guidance, based on soil type; maximum porosity of 45% measured in some UCRS samples at WAG 6 was used as upper limit for clay-rich layers
Field capacity (%)	WP-FIELDC	WP1 37.5 WP2 42	Table 2.1 of MEPAS Guidance, based on soil type
Longitudinal dispersivity (ft)	WP-LDISP	WP1 0.51 WP2 0.15	MEPAS guidance: $D_L = 0.01 \times (Th)$
Saturated hydraulic conductivity (ft/day)	WP-CONDUC	ft/day / cm/sec WP1 1.86 / 6.54E-4 WP2 1.1E-1 / 3.78E-5	WP1: Slug test at MW164 (NW of SWMU 99) WP2: Slug test at MW204 (Phase II Site Investigation)
Moisture content (%)	WS-MOISTC	WP1 43 WP2 45	WP1: Shallow water table—moisture content between field capacity and porosity value WP2: Moisture content = total porosity
		Properties of the saturated zone (WZ)	
Textural classification	WZ-CLASS	Sand (gravelly)	Deep boring logs from the surrounding area
Sand (%)	WZ-SAND	75	Average, WAG 6 geotechnical data and AOC 204 boring logs

Table 5.56. MEPAS transport parameters for AOC 204

Input parameter description	Parameter name	Value	Reference
	Properties of the saturated zone (WZ)		
Silt (%)	WZ-SILT	15	Average, WAG 6 geotechnical data and AOC 204 boring logs
Clay (%)	WZ-CLAY	10	Average, WAG 6 geotechnical data and AOC 204 boring logs
Organic matter in soil (%)	WZ-OMC	0.02	Average WAG 6 RGA soil data
Iron + aluminum in soil (%)	WZ-IRON	2	Average, SWMU 99, 51–60 ft samples
PH of pore water in saturated zone	WZ-pH	6.4	Average pH of RGA groundwater (WAG 27 data)
Total porosity (%)	WZ-TOTPOR	37	Conservative, based on WAG 6 measurement
Effective porosity (%)	WZ-EFFPOR	30	Conservative estimate
Darcy velocity (ft/day)	WZPVELOC	0.6	Conservative estimate; uses conductivity of 1500 ft/d and gradient of 0.0004
Thickness (ft)	WZ-THICK	28	RGA (HU 4 + HU 5) interval: 67–95 ft bgs
Bulk density (ft)	WZ-BULKD	1.67	($2.65\ g/cm^3 \times 0.63$)
Travel distance (ft)	WZ-DIST	10 ft to PGDP fence	Distance to PGDP eastern fence along groundwater flowpath – AOC 204 is outside the fence (model does not accept zero value, so small value was used)
		4500 ft to DOE property boundary	Minimum distance to DOE property boundary along groundwater flowpath
Longitudinal dispersivity (ft)	WZ-LDISP	50.0	Reference: Bioplume groundwater model
Transverse dispersivity (ft)	WZ-TDISP	5.0	Reference: Bioplume groundwater model
Vertical dispersivity (ft)	WZ-VDISP	0.1	Near zero
Percent of total flux to aquifer (%)	WZ-FRACT	100	Conservative
Perpendicular distance from groundwater flow to receptor (ft)	WZ-YDIST	0	(Plume centerline concentrations)
Vertical distance below groundwater table (ft)	WZ-AQDEPTH	0	(Most conservative result)

Table 5.57. MEPAS source terms for SWMU 99

Contaminant	Initial source concentration		Length Parallel to flow direction (ft)	Width perpendicular to flow direction (ft)	Thickness (ft)	Contaminant inventory calculation for MEPAS			Notes
						Volume (cm^3)	Bulk density (g/cm^3)	Inventory (g or Ci)	
					Surface soil				
Aluminum	14,100	mg/kg	305	190	1	1.64E+9	1.48	3.42E+7	Detected above screening levels in one boring, 099- 005, in 0–3 ft sample
Barium	2,470	mg/kg	205	215	1	1.25E+9	1.48	4.56E+6	Detected above screening levels in 0–1 ft sample from one boring, 099-014
Benzo(*b*)fluoranthene	5.7	mg/kg	300	115	1	9.77E+8	1.48	8.24E+3	Detected above screening levels in 0–1 ft sample from one boring, 099-004
Chromium	45.7	mg/kg	150	110	1	4.67E+8	1.48	3.16E+4	Detected above screening levels in 0–1 ft sample in one boring, 099-016
Lithium	11.6	mg/kg	315	375	1	3.34E+9	1.48	5.74E+4	Detected in western portion of SWMU
Strontium	514	mg/kg						2.54E+6	99 (No screening levels available for lithium or strontium)
Neptunium-237	12.8	pCi/g	90	190	1	4.84E+8	1.48	9.173E-3	Detected above screening levels in
Uranium-234	16.4	pCi/g						1.175E-2	surface soils from one boring, 082-014
Uranium-238	51.7	pCi/g						3.705E-2	
Technetium-99	49.4	pCi/g	315	331	1	2.95E+9	1.48	2.159E-1	Detected above screening levels in two
	2650	pCi/g	90	190	1	4.84E+8	1.48	1.899E+0	surface soil source areas located inside the fence. The smaller source was centered around boring 082-014 and had a maximum concentration of 2650 pCi/g. The second source encompasses two borings: 099-001 and 099-004.
					Subsurface soil—partially saturated zone 1 (WP1)				
Aluminum	18400	mg/kg	550	185	37	1.07E+11	1.46	2.86E+9	Total of two source areas centered around 11 borings, detected between 1–38 ft bgs
Chromium	79.1	mg/kg	415	150	6	1.06E+10	1.46	1.22E+6	Total of 2 source areas centered around two borings: 099-019 in the 22–25 ft bgs sample and 099-06 in the 35–38 ft bgs sample
Cobalt	27.3	mg/kg	440	500	3	1.87E+10	1.46	7.45E+5	Detected above screening levels in the 14–17 ft bgs sample from boring 099-001
Lithium	13.8	mg/kg	315	375	40	1.34E+11	1.46	2.70E+6	Detected in western portion of SWMU
Strontium	22.2	mg/kg						4.34E+6	99 (No screening levels available for lithium or strontium)

Table 5.57. MEPAS source terms for SWMU 99 (continued)

Contaminant	Initial source concentration		Length Parallel to flow direction (ft)	Width perpendicular to flow direction (ft)	Thickness (ft)	Contaminant inventory calculation for MEPAS			Notes
						Volume (cm^3)	Bulk density (g/cm^3)	Inventory (g or Ci)	
Subsurface soil—partially saturated zone 1 (WP1) (continued)									
Neptunium-237	0.0049	pCi/g	125	190	19	1.28E+10	1.46	9.141E-5	Detected in historical samples from H217 and H218 from 1–20 ft bgs.
Plutonium-239	0.006	pCi/g						1.119E-4	
Uranium-238	2.4	pCi/g						4.477E-2	
Subsurface soil—partially saturated zone 2 (WP2)									
Aluminum	12,700	mg/kg	140	145	3	1.72E+9	1.46	3.20E+7	Detected above screening levels in 099-010 from 51–54 ft bgs
Lithium	6.14	mg/kg	315	375	17	5.69E+10		5.10E+5	Detected in western portion of SWMU 99 from 43–60 ft bgs. (No screening levels available for lithium or strontium)
Strontium	24	mg/kg						1.99E+6	

All sources were defined using maximum detected concentrations.

Table 5.58. MEPAS source terms for SWMU Unit 193

Contaminant	Initial source concentration		Length parallel to flow direction (ft)	Width perpendicular to flow direction (ft)	Thickness (ft)	Contaminant inventory calculation for MEPAS			Notes
						Volume (cm^3)	Bulk density (g/cm^3)	Inventory (g)	
Surface soil									
Chromium	88.7	mg/kg	250	250	1	1.77E+9	1.48	2.32E+5	Chromium detected above background in one boring (193-023) from 0–1 ft bgs.
Lithium	12.5	mg/kg	1970	2360		1.32E+11		2.44E+6	Lithium and strontium source assumed to cover entire SWMU area
Strontium	391	mg/kg						7.62E+7	
Subsurface soil—partially saturated zone (WP1)									
Aluminum	15,500	mg/kg	1970	2360	60	7.90E+12	1.46	1.79E+11	Aluminum, lithium, and strontium sources assumed to encompass entire SWMU area and full thickness of WP1
Lithium	11.2	mg/kg						1.29E+8	
Strontium	195	mg/kg						2.25E+9	
Cadmium	13.2	mg/kg	440	440	1	5.48E+9		1.06E+5	Cadmium detected above screening levels in one boring, 193-2, at depth of 15.5 ft
Chromium	398	mg/kg	2400	1960	8	1.07E+12		6.19E+8	Chromium detected above screening levels in three borings, 193-1, 193-5, and 193-049, at depths between 15–23 ft
Cobalt	86.1	mg/kg	240	260	3	5.3E+9		6.66E+5	Cobalt detected above screening levels in one boring, 193-036, at a depth of 2–5 ft bgs
Manganese	2270	mg/kg	920	640	8	1.33E+11		4.42E+8	Manganese detected above screening levels in two borings, 193-033 and 193-036, at depths between 2–10 ft bgs

Notes: All sources were developed using the maximum detected concentrations within each model layer.
Benzo(*h*,*g*,*i*)perylene was also detected above screening levels in surface soils. It could not be modeled because the MEPAS model does not include it in its contaminant list.

Table 5.59. MEPAS source terms for SWMU 194

Contaminant	Initial source concentration		Length parallel to flow direction (ft)	Width perpendicular to flow direction (ft)	Thickness (ft)	Contaminant inventory calculation for MEPAS			Notes
						Volume (cm^3)	Bulk density (g/cm^3)	Inventory (g)	
					Subsurface soil				
Aluminum	14500	mg/kg	250	250	16	2.83E+10	1.49	6.12E+8	Three detections above screening levels between 2–15 ft bgs in boring 194-010. Extended source from top of layer to top of first clean sample (1–17 ft bgs).
Chromium	103	mg/kg	650	710	29	3.79E+11	1.49	5.82E+7	Detected above screening levels in five samples between 15–30 ft bgs in four borings: 194-02, 194-03, 194-10, and 194-11. Source extends from base of nearest clean sample to top of HU3 (11–40 ft bgs).
Lithium	9	mg/kg	1730	1050	39	2.01E+12	1.49	2.69E+7	Detected in 15 of 20 samples throughout the SWMU at depths between 2–30 ft. Source encompasses entire SWMU area (1,816,452 ft^2) and extends from top of layer to average depth of top of HU3 (from 1 to 40 ft bgs)
Strontium	26	mg/kg	1730	1050	39	2.01E+12	1.49	7.77E+7	Detected in 16 of 20 samples throughout SWMU at depths between 2–30 ft. Source encompasses entire SWMU area (1,816,452 ft^2) and extends from top of layer to average depth of top of HU3 (from 1 to 40 ft bgs)

Notes:

All sources were defined using the maximum detected concentrations within the model layer.
The bulk density value used was for the partially saturated zone because all sources are located within the Model Layer WP1
Iron was detected above screening values in only one sample and so was not modeled.

Table 5.60. MEPAS source terms for AOC 204

Contaminant	Initial source concentration		Length parallel to flow direction (ft)	Width perpendicular to flow direction (ft)	Thickness (ft)	Contaminant inventory calculation for MEPAS			Notes
						Volume (cm^3)	Bulk density (g/cm^3)	Inventory (g)	
Subsurface soil									
Trichloroethene	0.123	mg/kg	445	345	30	1.3E+11	1.46	2.34E+4	Detected in three historical borings: 204-15, 204-19, and 204-20 at depths between 5 –35 ft bgs.

Notes:

No contaminants passed initial screening from the WAG 28 Remedial Investigation sampling data. The trichloroethene source was defined using historical data. The source was developed using the maximum detected concentration within the model layer.

Table 5.61. MEPAS results for SWMU 99

Source	Constituent (Daughter products are denoted with an asterisk)	PGDP security fence		DOE boundary property		Source location relative to plant fence
		Potential maximum conc. (mg/L or pCi/L)	Time (years)	Potential maximum conc. (mg/L or pCi/L)	Time (years)	
Surface soil	Aluminum	0	10001–20002	0	10001–20002	Outside
	Barium	0	10001–20002	0	10001–20002	Outside
	Benzo(*b*)fluoranthene	0	10001–20002	0	10001–20002	Inside
	Chromium	2.08E-18	9904–15654	1.081E-27	9950–15654	Outside
	Lithium	5.632E+0	78.1	1.715E-2	89.7	Outside
	Neptunium-237	4.985E+0	249	8.428E-1	356	Inside
	*Protactinium-233	4.985E+0	249	8.428E-1	356	Inside
	*Uranium-233	5.405E-3	249	1.306E-3	356	Inside
	*Thorium-229	6.675E-5	266	2.168E-5	356	Inside
	*Radium-225	6.673E-5	266	2.168E-5	356	Inside
	*Actinium-225	6.671E-5	266	2.167E-5	356	Inside
	Strontium	2.214E+0	8952.5	3.581E-4	9898.6–11953	Outside
	Technetium-99	1.81E+2	1570	2.736E-1	2247	Inside
	Uranium-234	0	7880–17881	0	8387–17881	Inside
	*Thorium-230	0	7880–17881	0	8387–17881	Inside
	*Radium-226	0	7880–17881	0	8387–17881	Inside
	Uranium-238	0	7861–17862	0	8367–17862	Inside
	*Thorium-234	0	7861–17862	0	8367–17862	Inside
	*Uranium-234	0	7861–17862	0	8367–17862	Inside
	*Thorium-230	0	7861–17862	0	8367–17862	Inside
	*Radium-226	0	7861–17862	0	8367–17862	Inside
	*Radon-222	0	7861–17862	0	8367–17862	Inside
	*Lead-210	0	7861–17862	0	8367–17862	Inside
	*Bismuth-210	0	7861–17862	0	8367–17862	Inside
	*Polonium-210	0	7861–17862	0	8367–17862	Inside
UCRS	Aluminum	0	10001–20002	0	10001–20002	Outside
	Chromium	9.397E-20	9904–15655	2.039E-26	9997–15655	Inside
	Cobalt	3.612E-5	9890–13140	2.433E-6	9919–13140	Inside
	Lithium	4.686E+1	67	7.217E-1	95.5	Outside
	Neptunium-237	3.86E-2	300	6.887E-3	393	Inside
	*Protactinium-233	3.86E-2	300	6.887E-3	393	Inside
	*Uranium-233	5.052E-5	300	1.179E-5	393	Inside
	*Thorium-229	7.087E-7	300	2.162E-7	393	Inside
	*Radium-225	7.085E-7	300	2.162E-7	393	Inside
	*Actinium-225	7.083E-7	300	2.161E-7	393	Inside
	Plutonium-239	1.229E-10	9948–13948	2.410E-19	9904–13948	Inside
	Strontium	3.782E+0	8952.5	6.118E-4	9899–15655	Outside
	Uranium-238	0	7861–17862	0	8367–17862	Inside
	*Thorium-234	0	7861–17862	0	8367–17862	Inside
	*Uranium-234	0	7861–17862	0	8367–17862	Inside
	*Thorium-230	0	7861–17862	0	8367–17862	Inside
	*Radium-226	0	7861–17862	0	8367–17862	Inside
	*Radon-222	0	7861–17862	0	8367–17862	Inside
	*Lead-210	0	7861–17862	0	8367–17862	Inside
	*Bismuth-210	0	7861–17862	0	8367–17862	Inside
	*Polonium-210	0	7861–17862	0	8367–17862	Inside

If source is located inside fence, distances of 700 ft and 4800 ft, respectively, were used for the fence and the property boundary.
If outside fence, distances of 10 ft and 4500 ft were used.

Table 5.62. MEPAS results for SWMU 193

		PGDP security fence		DOE boundary property	
Source	Constituent	Potential maximum concentration (mg/L)	Time (years)	Potential maximum concentration (mg/L)	Time (years)
Surface Soil	Chromium	2.018E-3	5929	1.194E-3	7961
	Lithium	2.085E+0	45.8	1.169	60.3
	Strontium	2.524E-1	9854–10834	1.546E-4	9846–13283
UCRS	Aluminum	0	1–10,001	0	1–10,001
	Cadmium	0	879–10001	0	9990–10001
	Chromium	3.803E+0	5929	2.133	7744
	Cobalt	3.562E-2	939	2.083E-2	1281
	Lithium	3.805E+1	48.8	38.09	69.8
	Manganese	5.11E+0	2655	3.651	3624
	Strontium	7.453E+0	9854–10834	4.565E-3	9846–13283

Table 5.63. MEPAS results for SWMU 194

		PGDP security fence		DOE boundary property	
Source	Constituent	Potential maximum concentration (mg/L)	Time (years)	Potential maximum concentration (mg/L)	Time (years)
UCRS	Aluminum	0	0–10,001	0	0–10,001
	Chromium	7.24E+1	3,783	1.7E-1	7728
	Lithium	6.7E+1	19.7	7.57E+0	52
	Strontium	1.05E+1	55.81	5.167E-4	9924–11832

Table 5.64. MEPAS results for AOC 204

		PGDP security fence		DOE boundary property	
Source	Constituent	Potential maximum concentration (mg/L)	Time (years)	Potential maximum concentration (mg/L)	Time (years)
UCRS	Trichloroethene	1.428E+1*	110.5	3.66E-3	163

* At the security fence, the computed maximum concentration is greater than the designated initial concentration at the source of 1.428E-07 g/mL. The current receptor is located too close to the source, creating a near-field condition that cannot be properly assessed by a flux boundary condition model. Concentrations have been truncated to the initial dissolved concentration because of near-field conditions.

Table 5.65. MEPAS transport parameters for SWMU 4

Input parameter description	Parameter name	Value	Reference
		Topsoil parameters (wt)	
Textural classification	WT-CLASS	Silt loam	McCracken Co. Soil Survey (USDA 1976)
Percent sand (%)	WT-SAND	15	McCracken Co. Soil Survey: conservative estimate (highest % sand)
Percent silt (%)	WT-SILT	80	Maximum % silt for soil type
Percent clay (%)	WT-CLAY	5	= 100% -% sand - % silt
Percent organic matter (%)	WT-OMC	0.05	CERCLA Phase II Site Investigation (CH2M HILL 1992)
Percent iron and aluminum (%)	WT-IRON	4	Background Concentrations and Human Health Risk-Based Screening Criteria for Metals in Soil at PGDP (DOE 1995a)
pH of topsoil	WT-pH	7.32	WAG 3 RI data
Percent vegetative cover of site (%)	WT-VEGCOV	100	SWMU Maps
Topsoil water capacity	WT-AVAILW	0.33	McCracken Co. Soil Survey = available water capacity (0.20 in./in.) × root zone depth (1.65 in.) × vegetative cover (100%)
SCS curve number	WT-SCSN	71	Antecedent Moisture Condition = II (normal moisture); Group C hydrologic soil group; vegetated surface, well vegetated, 60–100%
		Properties of the partially saturated zones (wp)	
Thickness (ft)	WP-THICK	WP1 54	1–55 ft (HU 1 + HU 2 + HU 3) Boring logs at SWMU 4
Textural classification	WP-CLASS	WP1 sandy loam	Boring logs at SWMU 4
Sand (%)	WP-SAND	38	Boring logs at SWMU 4
Silt (%)	WP-SILT	41	Boring logs at SWMU 4
Clay (%)	WP-CLAY	21	Boring logs at SWMU 4
Organic matter content in soil (%)	WP-OMC	0.05	WAG 6 geotechnical data
Iron + aluminum in soil (%)	WP-IRON	4	**DOE 1995a**
pH of pore water in partially saturated zone	WP-pH	6.0	**DOE 1995a**
Bulk density(g/cm^3)	WP-BULKD	1.82	WAG 3 geotechnical data
Total porosity (%)	WP-TOTPOR	31.28	WAG 3 geotechnical data
Field capacity (%)	WP-FIELDC	14	Table 2.1 of MEPAS Guidance, based on soil type
Longitudinal dispersivity (ft)	WP-LDISP	0.54	Estimated based on MEPAS guidance: $D_L = 0.01 \times$ thickness
Saturated hydraulic conductivity (ft/day)	WP-CONDUC	ft/day 0.3 cm/sec 1.06E-4	WAG 3 Work Plan
Moisture content (%)	WS-MOISTC	31.28	WP1: Moisture content = total porosity
		Properties of the saturated zone (wz)	
Textural classification	WZ-CLASS	Loamy sand	WAG 3 Work Plan
Sand (%)	WZ-SAND	74	WAG 3 Work Plan
Silt (%)	WZ-SILT	17	WAG 3 Work Plan
Clay (%)	WZ-CLAY	9	WAG 3 Work Plan
Organic matter in soil (%)	WZ-OMC	0.02	WAG 3 Work Plan
Iron + aluminum in soil (%)	WZ-IRON	3	WAG 3 Work Plan
pH of pore water in saturated zone	WZ-pH	6.36	WAG 3 RI data
Total porosity (%)	WZ-TOTPOR	37	WAG 3 Work Plan
Effective porosity (%)	WZ-EFFPOR	30	Conservative estimate
Darcy velocity (ft/day)	WZPVELOC	0.6	Conservative estimate; uses conductivity of 1500 ft/day and gradient of 0.0004
Thickness (ft)	WZ-THICK	45	RGA (HU 4 + HU 5) interval: 55–100 ft bgs
Bulk density (g/cm^3)	WZ-BULKD	1.67	WAG 3 Work Plan
Travel distance (ft)	WZ-DIST	890 ft to PGDP fence 2985 ft to DOE property boundary	Distances measured along the groundwater flow direction from the northern perimeter of the SWMU to the PGDP fence and to the DOE property boundary

Table 5.65. MEPAS transport parameters for SWMU 4 (continued)

Input parameter description	Parameter name	Value	Reference
	Properties of the saturated zone (wz) (continued)		
Longitudinal dispersivity (ft)	WZ-LDISP	50.0	Reference: Bioplume groundwater model
Transverse dispersivity (ft)	WZ-TDISP	5.0	Reference: Bioplume groundwater model
Vertical dispersivity (ft)	WZ-VDISP	0.1	Conservative estimate
Percent of total flux to aquifer (%)	WZ-FRACT	100	Conservative estimate
Perpendicular distance from groundwater flow to receptor (ft)	WZ-YDIST	0	(Plume centerline concentrations)
Vertical distance below groundwater table (ft)	WZ-AQDEPTH	0	(Most conservative result)

Table 5.66. MEPAS transport parameters for SWMU 5

Input parameter description	Parameter name	Value	Reference
		Topsoil parameters (wt)	
Textural classification	WT-CLASS	Silt loam	McCracken Co. Soil Survey (USDA 1976)
Percent sand (%)	WT-SAND	15	McCracken Co. Soil Survey: conservative estimate (highest % sand)
Percent silt (%)	WT-SILT	80	Maximum % silt for soil type
Percent clay (%)	WT-CLAY	5	= 100% -% sand - % silt
Percent organic matter (%)	WT-OMC	0.05	CERCLA Phase II Site Investigation (CH2M HILL 1992)
Percent iron and aluminum (%)	WT-IRON	4	Background Concentrations and Human Health Risk-Based Screening Criteria for Metals in Soil at PGDP (DOE 1995a)
pH of topsoil	WT-pH	8.25	WAG 3 RI data
Percent vegetative cover of site (%)	WT-VEGCOV	100	SWMU Maps
Topsoil water capacity	WT-AVAILW	2.44	McCracken Co. Soil Survey = available water capacity (0.20 in./in.) × root zone depth from Table 2.1 MEPAS Guidance (12.2 in.) × vegetative cover (100%)
SCS curve number	WT-SCSN	71	Antecedent Moisture Condition = II (normal moisture); Group C hydrologic soil group; vegetated surface, well vegetated, 60–100% vegetated
		Properties of the partially saturated zones (wp)	
Thickness (ft)	WP-THICK	WP1 39 WP2 20	WP1= 1–40 ft (HU 1 + HU 2) WP2 = HU 3 Boring logs at SWMU 5
Textural classification	WP-CLASS	WP1 sandy clay loam WP2 clay loam	Boring logs at SWMU 5
Sand (%)	WP-SAND	WP1 = 38 WP2 = 10	Boring logs at SWMU 5
Silt (%)	WP-SILT	WP1 = 27 WP2 = 30	Boring logs at SWMU 5
Clay (%)	WP-CLAY	WP1 = 35 WP2 = 60	Boring logs at SWMU 5
Organic matter content in soil (%)	WP-OMC	0.05	WAG 6 geotechnical data
Iron + aluminum in soil (%)	WP-IRON	4	**DOE 1995a**
pH of pore water in partially saturated zone	WP-pH	WP1 = 6 WP2 = 6.56	**DOE 1995a and WAG 3 RI data for WP2**
Bulk density(g/cm^3)	WP-BULKD	WP1 = 1.76 WP2 = 2.25	WAG 3 geotechnical data available for WP1; 2.65 × (1-Porosity)
Total porosity (%)	WP-TOTPOR	WP1 = 33.7 WP2 = 15	WAG 3 geotechnical data available for WP1; SWMU 6 boring logs used as estimate for WP2
Field capacity (%)	WP-FIELDC	WP1 = 24 WP2 = 10	Table 2.1 of MEPAS Guidance, based on soil type for WP1; SWMU 5 boring logs used as estimate for WP2
Longitudinal dispersivity (ft)	WP-LDISP	WP1 = 0.39 WP2 = 0.20	Estimated based on MEPAS guidance: D_L = 0.01 × thickness
Saturated hydraulic conductivity (ft/day)	WP-CONDUC	ft/day: 0.3 Cm/sec: 1.06E-4	WAG 3 Work Plan
Moisture content (%)	WS-MOISTC	WP1 = 33.7 WP2 = 15	Moisture content = total porosity
		Properties of the saturated zone (wz)	
Textural classification	WZ-CLASS	Loamy sand	WAG 3 Work Plan
Sand (%)	WZ-SAND	74	WAG 3 Work Plan
Silt (%)	WZ-SILT	17	WAG 3 Work Plan
Clay (%)	WZ-CLAY	9	WAG 3 Work Plan
Organic matter in soil (%)	WZ-OMC	0.02	WAG 3 Work Plan
Iron + aluminum in soil (%)	WZ-IRON	3	WAG 3 Work Plan

Table 5.66. MEPAS transport parameters for SWMU 5 (continued)

Input parameter description	Parameter name	Value	Reference
	Properties of the saturated zone (wz) (continued)		
pH of pore water in saturated zone	WZ-pH	6.47	WAG 3 RI data
Total porosity (%)	WZ-TOTPOR	37	WAG 3 Work Plan
Effective porosity (%)	WZ-EFFPOR	30	Conservative estimate
Darcy velocity (ft/day)	WZPVELOC	0.6	Conservative estimate; uses conductivity of 1500 ft/day and gradient of 0.0004
Thickness (ft)	WZ-THICK	40	RGA (HU 4 + HU 5) interval: 60–100 ft bgs
Bulk density (ft)	WZ-BULKD	1.67	WAG 3 Work Plan
Travel distance (ft)	WZ-DIST	890 ft to PGDP fence 2780 ft to DOE property boundary	Distances measured along the groundwater flow direction from the northern perimeter of the SWMU to the PGDP fence and to the DOE property boundary
Longitudinal dispersivity (ft)	WZ-LDISP	50.0	Reference: Bioplume groundwater model
Transverse dispersivity (ft)	WZ-TDISP	5.0	Reference: Bioplume groundwater model
Vertical dispersivity (ft)	WZ-VDISP	0.1	Conservative estimate
Percent of total flux to aquifer (%)	WZ-FRACT	100	Conservative estimate
Perpendicular distance from groundwater flow to receptor (ft)	WZ-YDIST	0	(Plume centerline concentrations)
Vertical distance below groundwater table (ft)	WZ-AQDEPTH	0	(Most conservative result)

Table 5.67. MEPAS transport parameters for SWMU 6

Input parameter description	Parameter name	Value	Reference
		Topsoil parameters (wt)	
Textural classification	WT-CLASS	Silt loam	McCracken Co. Soil Survey (USDA 1976)
Percent sand (%)	WT-SAND	15	McCracken Co. Soil Survey: conservative estimate (highest % sand)
Percent silt (%)	WT-SILT	80	Maximum % silt for soil type
Percent clay (%)	WT-CLAY	5	= 100% -% sand - % silt
Percent organic matter (%)	WT-OMC	0.05	CERCLA Phase II Site Investigation (CH2M HILL 1992)
Percent iron and aluminum (%)	WT-IRON	4	Background Concentrations and Human Health Risk-Based Screening Criteria for Metals in Soil at PGDP (DOE 1995a)
pH of topsoil	WT-pH	7.98	WAG 3 RI Data
Percent vegetative cover of site (%)	WT-VEGCOV	90	SWMU Maps
Topsoil water capacity	WT-AVAILW	2.20	McCracken Co. Soil Survey = available water capacity (0.20 in./in.) × root zone depth from Table 2.1 MEPAS Guidance (12.2 in.) × vegetative cover (100%)
SCS curve number	WT-SCSN	71	Antecedent Moisture Condition = II (normal moisture); Group C hydrologic soil group; vegetated surface, well vegetated, 60–100% vegetated
		Properties of the partially saturated zones (wp)	
Thickness (ft)	WP-THICK	WP1 39 WP2 20	WP1= 1–40 ft (HU 1 + HU 2) WP2 = HU 3 Boring logs at SWMU 6
Textural classification	WP-CLASS	WP1 sandy clay loam WP2 clay loam	Boring logs at SWMU 6
Sand (%)	WP-SAND	WP1 = 38 WP2 = 10	Boring logs at SWMU 6
Silt (%)	WP-SILT	WP1 = 27 WP2 = 30	Boring logs at SWMU 6
Clay (%)	WP-CLAY	WP1 = 35 WP2 = 60	Boring logs at SWMU 6
Organic matter content in soil (%)	WP-OMC	0.05	WAG 6 geotechnical data
Iron + aluminum in soil (%)	WP-IRON	4	DOE 1995a
pH of pore water in partially saturated zone	WP-pH	WP1 = 6.76 WP2 = 6.29	WAG 3 RI data
Bulk density(g/cm^3)	WP-BULKD	WP1 = 1.66 WP2 = 2.25	WAG 3 geotechnical data available for WP1; 2.65 × (1-Porosity)
Total porosity (%)	WP-TOTPOR	WP1 = 37.19 WP2 = 15	WAG 3 geotechnical data available for WP1; SWMU 6 boring logs used as estimate for WP2
Field capacity (%)	WP-FIELDC	WP1 = 24 WP2 = 10	Table 2.1 of MEPAS Guidance, based on soil type for WP1; SWMU 6 boring logs used as estimate for WP2
Longitudinal dispersivity (ft)	WP-LDISP	WP1 = 0.39 WP2 = 0.20	Estimated based on MEPAS guidance: D_L = 0.01 × thickness
Saturated hydraulic conductivity (ft/day)	WP-CONDUC	ft/day Cm/sec 0.3 1.06E-4	WAG 3 Work Plan
Moisture content (%)	WS-MOISTC	WP1 = 37.19 WP2 = 15	Moisture content = total porosity
		Properties of the saturated zone (wz)	
Textural classification	WZ-CLASS	Loamy sand	WAG 3 Work Plan
Sand (%)	WZ-SAND	74	WAG 3 Work Plan
Silt (%)	WZ-SILT	17	WAG 3 Work Plan
Clay (%)	WZ-CLAY	9	WAG 3 Work Plan
Organic matter in soil (%)	WZ-OMC	0.02	WAG 3 Work Plan
Iron + aluminum in soil (%)	WZ-IRON	3	WAG 3 Work Plan
pH of pore water in saturated zone	WZ-pH	6.275	WAG 3 RI data

Table 5.67. MEPAS transport parameters for SWMU 6 (continued)

Input parameter description	Parameter name	Value	Reference
Properties of the saturated zone (wz) (continued)			
Total porosity (%)	WZ-TOTPOR	37	WAG 3 Work Plan
Effective porosity (%)	WZ-EFFPOR	30	Conservative estimate
Darcy velocity (ft/day)	WZ-PVELOC	0.6	Conservative estimate; uses conductivity of 1500 ft/day and gradient of 0.0004
Thickness (ft)	WZ-THICK	40	RGA (HU 4 + HU 5) interval: 60–100 ft bgs
Bulk density (g/cm^3)	WZ-BULKD	1.67	WAG 3 Work Plan
Travel distance (ft)	WZ-DIST	920 ft to PGDP fence 2820 ft to DOE property boundary	Distances measured along the groundwater flow direction from the northern perimeter of the SWMU to the PGDP fence and to the DOE property boundary
Longitudinal dispersivity (ft)	WZ-LDISP	50.0	Reference: Bioplume groundwater model
Transverse dispersivity (ft)	WZ-TDISP	5.0	Reference: Bioplume groundwater model
Vertical dispersivity (ft)	WZ-VDISP	0.1	Conservative estimate
Percent of total flux to aquifer (%)	WZ-FRACT	100	Conservative estimate
Perpendicular distance from groundwater flow to receptor (ft)	WZ-YDIST	0	(Plume centerline concentrations)
Vertical distance below groundwater table (ft)	WZ-AQDEPTH	0	(Most conservative result)

MEPAS will handle a number of partially saturated zones, but restricts the user to one saturated zone. At the PGDP the primary saturated zone is the RGA, and this is considered the primary groundwater pathway through which contaminants can leave the site. To represent each SWMU within WAG 3 as accurately as possible, available geophysical logs and borings were reviewed and a hydrogeologic conceptual model was developed for the MEPAS simulations. For each of the SWMUs modeled in WAG 3 two or three model layers were used. The first two layers were the partially saturated zone (UCRS), and the third was the saturated zone (RGA). A complete description of the hydrogeology of this area may be found in the WAG 3 RI report (DOE 2001).

The WAG 3 RI developed source terms in surface soil and the UCRS for the fate and transport modeling. Tables 5.68 through 5.70 present the source term information for all the constituents selected for fate and transport modeling from each SWMU. Over the 10,000-year model period, several VOCs, metals and radionuclides were shown to be the main risk drivers originating from WAG 3. The modeling results for WAG 3 are presented in Tables 5.71 through 5.73.

Table 5.68. Development of source terms for SWMU 4

Contaminant	Initial source concentration[a]		Length parallel to flow direction (ft)	Width perpendicular to flow direction (ft)	Thickness (ft)	Contaminant inventory calculation for MEPAS			Notes
						Volume (cm^3)	Bulk density (g/cm^3)	Inventory (g or Ci)	
					Surface soil				
PCB-1260	115	µg/kg	35	600	1	5.95E+8	1.46	9.98E+01	Contaminants are found in the sediments along the ditch running parallel to the northern edge of the SWMU. The area encompasses samples from 004-001 and 004-002.
Uranium-234	12.8	pCi/g						1.11E-02	
Uranium-238	35.9	pCi/g						3.12E-02	
Chromium	296	mg/kg	370	70	1	7.33E+08	1.46	3.17E+05	Detected above screening levels in 004-033.
	42.3	mg/kg			1	6.24E+08	1.46	3.86E+04	Detected above screening levels in 004-034.
Iron	30700	mg/kg			1	6.24E+08	1.46	2.80E+07	Detected above screening levels in only 004-034.
Nickel	153	mg/kg			1	6.24E+08	1.46	1.39E+05	Detected above screening levels in only 004-034.
Copper	19.5	mg/kg	130	180	1	6.63E+08	1.46	1.89E+04	Copper was detected above screening level in two samples from 004-001 and 004-007.
	30.1	mg/kg	80	165	1	3.74E+08	1.46	1.64E+04	
PCB-1260	41	µg/kg	450	35	1	4.46E+08	1.46	2.67E+01	Contaminants are found in the sediments along the ditch running parallel to the eastern edge of the SWMU. The area encompasses samples from just downstream of 004-002 to 004-003 and the SWMU boundary.
Uranium-234	6.59	pCi/g						4.29E-03	
Uranium-238	26.4	pCi/g						1.72E-02	
4-Methyl-3-penten-2-one	180	µg/kg	50	50	1	7.08E+07	1.46	1.86E+01	Contaminant detected in one historic location, H214.
Neptunium-237	0.266	pCi/g	80	165	1	3.74E+08	1.46	1.45E-04	Detected above screening levels in one location, 004-007.
Plutonium-239	0.0644	pCi/g	55	445	1	6.93E+08	1.46	6.52E-05	Plutonium detected above screening level as Pu-239 in H214 and as Pu-239/240 in 004-001. Pu-239/240 used for modeling purposes.
PCB-1260	61	µg/kg	185	205	1	1.07E+09	1.46	9.56E+01	Contaminants are found in the sediments along a drainage ditch running southwest at the southwest corner of the SWMU. The area encompasses samples from 004-004, 004-006, and 004-007. PCB-1260 was detected only in 004-004.
Uranium-234	30.1	pCi/g						4.72E-02	
Uranium-238	87.3	pCi/g						1.37E-01	

Table 5.68. Development of source terms for SWMU 4 (continued)

Contaminant	Initial source concentration[a]		Length parallel to flow direction (ft)	Width perpendicular to flow direction (ft)	Thickness (ft)	Contaminant inventory calculation for MEPAS			Notes
						Volume (cm^3)	Bulk density (g/cm^3)	Inventory (g or Ci)	
Subsurface soil—partially saturated zone (UCRS Soils)									
Aluminum	26400	mg/kg	470	610	54	4.38E+11	1.82	2.11E+10	Entire area and thickness of SWMU used for modeling.
Cobalt	31.6	mg/kg						2.52E+07	
Iron	34500	mg/kg						2.75E+10	
Copper	1130	mg/kg	470	610	34	2.76E+11	1.82	5.68E+08	Entire area of SWMU, 1-35 ft bgs used for modeling.
Chromium	77.3	mg/kg	470	365	20	9.72E+10	1.82	1.37E+07	Area roughly half the SWMU used to model contaminant found in 3 borings between the depths of 22 and 30 ft bgs.
Lead	62.5	mg/kg	470	175	20	4.66E+10	1.82	5.30E+06	Contaminant detected above screening levels in H225, 004-027, and 004-037.
Manganese	2920	mg/kg	470	640	24	2.04E+11	1.82	1.09E+09	Entire area of SWMU, 1-25 ft bgs used for modeling.
Nickel	593	mg/kg	75	75	39	6.21E+09	1.82	6.70E+06	Detected above sl in 004-008 worst case assumed 16-55 ft bgs.
Lithium	0.148	mg/kg	75	80	10	1.70E+09	1.82	4.58E+02	Detected only in DG-030 in a 48-ft water sample. No screening values for lithium or strontium.
Strontium	0.639	mg/kg					1.82	1.98E+03	
Octachloro-dibenzo[b,e][1,4]dioxin	8.2	mg/g	80	100	5	1.13E+09	1.82	1.69E+01	One detection of contaminant in H227.
PCB-1016	2500	µg/kg	470	610	19	1.54E+11	1.82	7.02E+05	Entire area of SWMU from 1–20 ft in depth used for modeling PCBs.
PCB-1248	800	µg/kg						2.25E+05	
PCB-1254	27000	µg/kg						7.58E+06	
PCB-1260	500	µg/kg						1.40E+05	
PCBs, Total	4300	µg/kg						1.21E+06	
Cesium-137	1.48	pCi/g	210	610	10	3.63E+10	1.82	9.77E-02	Contaminants detected in two borings, 004-030 and 004-056, at 6 and 3 ft bgs, respectively. Area roughly ½ the length of the SWMU and the entire width used for modeling.
Neptunium-237	5.78	pCi/g	470	610	19	1.54E+11	1.82	1.62E+00	Entire area of SWMU from 1–20 ft in depth used for modeling.
Plutonium-239	4.17	pCi/g						1.17E+00	
Radium-226	2.51	pCi/g						7.05E-01	
Technetium-99	269	pCi/g						7.55E+01	
Thorium-230	68.7	pCi/g						1.93E+01	
Uranium-234	69	pCi/g						1.94E+02	
Uranium-235	7.2	pCi/g						2.02E+00	
Uranium-238	126	pCi/g						1.76E+03	

Table 5.68. Development of source terms for SWMU 4 (continued)

Contaminant	Initial source concentration[a]		Length parallel to flow direction (ft)	Width perpendicular to flow direction (ft)	Thickness (ft)	Contaminant inventory calculation for MEPAS			Notes
						Volume (cm^3)	Bulk density (g/cm^3)	Inventory (g or Ci)	
Total Uranium	6260	pCi/g	282	110	15	1.32E+10	1.82	1.50E+02	Source term is area of the waste cell from which sample was taken. Waste cell is in an "L" shape, thus the two areas.
			110	292		1.36E+10		1.55E+02	
4-Methyl-3-penten-2-one	670	µg/kg	80	100	5	1.13E+09	1.82	1.38E+03	One detection of contaminant in 5–10 ft sample from H225.
6-(Acetyloxy)-2-hexanone	2000	µg/kg	80	100	29	6.57E+09	1.82	2.39E+04	Detected only in H225 in samples from 1–30 ft.
bis(2-Methoxyethyl)phthalate	450	µg/kg	80	100	5	1.13E+09	1.82	9.28E+02	One detection of contaminant in 25–30 ft sample from H225.
Ethanol, 2,2'-oxybis-, diacetate	2000	µg/kg	80	100	5	1.13E+09	1.82	4.12E+03	One detection of contaminant in 15–20 ft sample from H225.
Pentachlorophenol	210	µg/kg	80	100	5	1.13E+09	1.82	4.33E+02	One detection of contaminant in 10–15 ft sample from H227.
1,2-Dichloroethene	63	µg/kg	80	100	15	3.40E+09	1.82	3.90E+02	Detected only in H227 in samples from 10–25 ft.
Diethyl ether	9	µg/kg	70	45	54	4.82E+09	1.82	7.89E+01	Detected only in H226 in samples from 5–40 ft.
Carbon tetrachloride	170	µg/kg	165	95	12	5.33E+09	1.82	1.65E+03	Detected in one sample from 004–024.
Trichloroethene	48000	µg/kg	470	610	45	3.65E+11	1.82	3.19E+07	Entire area of SWMU from 10–55 ft in depth used for modeling.
Vinyl chloride	400	µg/kg						2.66E+05	
1,1-Dichloroethene	340	µg/kg						2.26E+05	
2-Propanol	100	µg/kg	75	130	5	1.38E+09	1.82	2.51E+02	One detection of contaminant in 35–40 ft sample from H214.
2-Butanone	2	µg/kg						5.02E+00	
	31	µg/kg	65	105	5	9.66E+08	1.82	5.45E+01	One detection of contaminant in 14–19 ft water sample from 004–008, waste cell.
cis-1,2-Dichloroethene	1500	µg/kg	245	610	24	1.02E+11	1.82	2.77E+05	Area roughty ½ the length of the SWMU and the entire width used for modeling. The first source term spans the depth 1–25 ft bgs; the second is 25–55 ft bgs.
	11000	µg/kg	245	610	19	8.04E+10	1.82	1.61E+06	

[a]All sources were defined using maximum detected concentrations.

Table 5.69. Development of source terms for SWMU 5

Contaminant	Initial Source Concentration		Length parallel to flow direction (ft)	Width perpendicular to flow direction (ft)	Thickness (ft)	Contaminant inventory calculation for MEPAS: Volume (cm^3)	Bulk density (g/cm^3)	Inventory (g)	Notes
					Surface soil				
Aluminum	13800	mg/kg	235	840	1	5.59E+09	1.46	1.13E+08	Entire SWMU boundary chosen as source term.
2-Methylnaphthalene	150	µg/kg						1.22E+03	
3-Nitrobenzenamine	9450	µg/kg						7.71E+04	
Acenaphthylene	9450	µg/kg						7.71E+04	
Benz(a)anthracene	19000	µg/kg						1.55E+05	
Benzo(a)pyrene	24800	µg/kg						2.02E+05	
Benzo(b)fluoranthene	49200	µg/kg						4.02E+05	
Benzo(ghi)perylene	14600	µg/kg						1.19E+05	
Dibenzofuran	3520	µg/kg						2.87E+04	
Pentachlorophenol	357	µg/kg						2.91E+03	
PCB-1260	306	µg/kg						2.50E+03	
Phenanthrene	34600	µg/kg						2.82E+05	
Technetium-99	5.85	pCi/g	235	775	1	5.16E+09	1.46	4.40E-02	Entire length of SWMU chosen as source term for Tc-99 and approximately 3/4 width.
*Bulk density of 1.46 used in SWMU 1 MEPAS modeling									
					Subsurface soil partially saturated zone WP1 (HU1 + HU2 Soils)				
Aluminum	12400	mg/kg	235	840	39	2.18E+11	1.76	4.76E+09	Entire area and thickness of SWMU used for modeling.
Chromium	296	mg/kg	175	215	14	1.49E+10	1.76	7.77E+06	Metals values detected above screening levels at 005-017 in a 20–23 ft sample.
Iron	29200	mg/kg						7.67E+08	
Cobalt	24.7	mg/kg	90	240	3	1.83E+09	1.76	7.98E+04	Metals detected above screening levels
Iron	33100	mg/kg			7	4.28E+09		2.49E+08	at H263 in shallow samples.
Manganese	975	mg/kg						7.35E+06	
Benzo(ghi)perylene	260	µg/kg	90	240	7	4.28E+09	1.76	1.96E+03	Semivolatiles detected above screening levels at H263 in shallow samples.
Dibenzofuran	87	µg/kg						6.56E+02	
Phenanthrene	1300	µg/kg						9.80E+03	
Radium-226	2.2	pCi/g	235	370	20	4.92E+10	1.76	1.91E-01	Just over 1/2 width of SWMU used for source term delineation and entire length.
Uranium-238	2	pCi/g	235	370	31	7.63E+10	1.76	2.69E-01	
					Subsurface soil partially saturated zone WP2 (HU3 Soils)				
Aluminum	16400	mg/kg	235	840	20	1.12E+11	2.25	4.13E+09	Entire SWMU boundary chosen as source term.
Cobalt	19.4	mg/kg						4.88E+06	

Table 5.69. Development of source terms for SWMU 5 (continued)

Contaminant	Initial Source Concentration		Length parallel to flow direction (ft)	Width perpendicular to flow direction (ft)	Thickness (ft)	Contaminant inventory calculation for MEPAS			Notes
						Volume (cm^3)	Bulk density (g/cm^3)	Inventory (g)	
Iron	29400	mg/kg						7.40E+09	
Manganese	1750	mg/kg						4.40E+08	
Toluene	7	ug/kg	110	310	6	5.79E+09	2.25	9.12E+01	Detected only at H002 in 36–42 ft sample.
Radium-226	1.73	pCi/g	235	370	20	4.92E+10	2.25	1.92E-01	Just over 1/2 width of SWMU used for
Technetium-99	3.89	pCi/g	235	370	20	4.92E+10	2.25	4.31E-01	source term delineation and entire
Uranium-238	1.71	pCi/g	235	630	20	8.38E+10	2.25	3.23E-01	length.

Table 5.70. Development of source terms for SWMU 6

Contaminant	Initial source concentration		Length parallel to flow direction (ft)	Width perpendicular to flow direction (ft)	Thickness (ft)	Contaminant inventory calculation for MEPAS			Notes
						Volume (cm^3)	Bulk density (g/cm^3)	Inventory (g)	
Surface Soil									
Copper	21.3	mg/kg	65	80	1	1.47E+08	1.46	4.58E+03	Detected above screening levels in 006-001.
Benzo(ghi)perylene	124	µg/kg						2.67E+01	
Phenanthrene	461	µg/kg						9.91E+01	
Technetium-99	18.8	pCi/g	115	85	1	2.77E+08	1.46	7.60E-03	Area for modeling encompasses 006-016 and 006-017.
SWMU 6 Waste Cells									
Aluminum	18,800	mg/kg	40	100	10	1.13E+09	1.66	3.53E+07	Source term is waste cell "J."
PCB-1016	255	µg/kg						4.79E+02	
Neptunium-237	0.219	pCi/g						4.12E-04	
Technetium-99	43.3	pCi/g						8.14E-02	
Uranium-238	1.52	pCi/g						2.86E-03	
Subsurface soil partially saturated zone WP1 (HU1 + HU2 Soils)									
Chromium	116	mg/kg	45	60	17	1.30E+09	1.66	2.50E+05	Area for modeling surrounds 006-027, the area of a relatively high detection of chromium.
	56.8	mg/kg	90	150	25	9.56E+09	1.66	9.01E+05	Area for modeling is entire area of SWMU
Aluminum	12,100	mg/kg			39	1.49E+10		2.99E+08	
Cobalt	17.9	mg/kg			12	4.59E+09		1.36E+05	
Copper	20.9	mg/kg			28	1.07E+10		3.71E+05	
Iron	58,700	mg/kg			39	1.49E+10		1.45E+09	
Lead	35.4	mg/kg			9	3.44E+09		2.02E+05	
Manganese	1550	mg/kg			12	4.59E+09		1.18E+07	
Technetium-99	8.51	pCi/g	50	45	11	7.01E+08	1.66	9.90E-03	Detected above screening levels at 006-010.
Neptunium-237	0.125	pCi/g						1.45E-04	
Uranium-238	1.72	pCi/g						2.00E-03	
Subsurface soil partially saturated zone WP2 (HU3 Soils)									
Aluminum	22,500	mg/kg	80	185	20	8.38E+09	2.25	4.24E+08	Area for modeling is entire area of SWMU, less southeastern portion.
Cobalt	156	mg/kg						2.94E+06	
Iron	32,900	mg/kg						6.20E+08	
Lead	25.2	mg/kg						4.75E+05	
Iron	36,900	mg/kg	45	60	20	1.53E+09	2.25	1.27E+08	Detected above screening level at 006-027, outside SWMU boundary.

Table 5.71. MEPAS results for SWMU 4

Source	Constituent (Daughter products are denoted with an asterisk)	PGDP security fence		DOE property boundary	
		Potential maximum concentration (mg/L or pCi/L)	Time (years)	Potential maximum concentration (mg/L or pCi/L)	Time (years)
Surface Soil	Chromium	2.81E-40	10,000	1.95E-52	10,000
	Copper	4.40E-04	8039	1.40E-04	9585
	Iron	1.97E+00	1337	6.41E-01	1525
	Nickel	2.53E-03	5044	8.45E-04	6107
	PCB-1260	0	10,000	0	10,000
	Neptunium-237	5.33E-02	275.5	1.64E-02	314.6
	*Protactinium-233	5.33E-02	275.5	1.64E-02	314.6
	*Uranium-233	6.39E-05	275.5	2.35E-05	336.5
	*Thorium-229	8.24E-07	275.5	3.69E-07	336.5
	*Radium-225	8.24E-07	275.5	3.69E-07	336.5
	*Actinium-225	8.23E-07	275.5	3.69E-07	336.5
	Plutonium-239	4.16E-04	8717	1.44E-04	10,260
	Uranium-234	1.37E+00	4355	4.16E-01	5166
	*Thorium-230	5.32E-02	4355	1.90E-02	5166
	*Radium-226	2.99E-02	4605	1.16E-02	5414
	Uranium-238	2.67E+00	4356	8.08E-01	5167
	*Thorium234	2.67E+00	4356	8.08E-01	5167
	*Uranium-234	3.28E-02	4356	1.18E-02	5167
	*Thorium-230	6.63E-04	4606	2.79E-04	5415
	*Radium-226	2.87E-04	4606	1.33E-04	5415
	*Radon-222	2.87E-04	4606	1.33E-04	5415
	*Lead-210	2.82E-04	4606	1.31E-04	5415
	*Bismuth-210	2.82E-04	4606	1.31E-04	5415
	*Polonium-210	2.82E-04	4606	1.31E-04	5415
UCRS-WP1	Aluminum	0	10,000	0	10,000
	Chromium	1.15E-37	10,000	9.22E-53	10,000
	Cobalt	3.29E+00	787.5	6.46E-01	961.3
	Copper	7.32E+00	7992	1.46E+00	9539
	Iron	1.16E+03	1738	2.41E+02	2055
	Lead	8.45E-42	10,000	7.54E-53	10,000
	Lithium	1.76E-03	29.91	5.06E-04	36.29
	Manganese	5.13E+01	2248	9.46E+00	2566
	Nickel	1.45E-01	5019	4.29E-02	6081
	Strontium	2.54E-05	8661	7.44E-06	10,450
	1,1-Dichloroethene	2.58E-01	62.86	5.38E-02	68.83
	1,2-Dichloroethene	2.24E-03	18.18	6.64E-04	20.75
	Carbon Tetrachloride	5.94E-04	300.6	1.85E-04	307.2
	PCB-1016	0	10,000	0	10,000
	PCB-1248	0	10,000	0	10,000
	PCB-1254	0	10,000	0	10,000
	PCB-1260	0	10,000	0	10,000
	PCBs	0	10,000	0	10,000
	Pentachlorophenol	3.35E-18	10,790	6.06E-19	12,910
	Trichloroethene	2.26E+01	101.6	4.70E+00	110.7
	Vinyl Chloride	3.31E-01	56.6	6.90E-02	61.96
	Cesium-137	0	12,920	0	12,920
	Neptunium-237	4.88E+02	316.4	9.83E+01	380.4
	*Protactinium-233	4.88E+02	316.4	9.83E+01	380.4
	*Uranium-233	6.74E-01	337.5	1.63E-01	380.4
	*Thorium-229	1.06E-02	337.5	2.89E-03	380.4
	*Radium-225	1.06E-02	337.5	2.89E-03	380.4
	*Actinium-225	1.06E-02	337.5	2.89E-03	380.4
	Plutonium-239	1.09E+01	8665	2.05E+00	10,210
	Radium-226	2.21E-01	8208	2.16E-02	9765

Table 5.71. MEPAS results for SWMU 4 (continued)

Source	Constituent (Daughter products are denoted with an asterisk)	PGDP security fence		DOE property boundary	
		Potential maximum concentration (mg/L or pCi/L)	Time (years)	Potential maximum concentration (mg/L or pCi/L)	Time (years)
UCRS-WP1 (cont.)	Technetium-99	6.34E+04	111.4	1.32E+04	112.7
	Thorium-230	3.56E-28	10,000	1.30E-43	10,000
	*Radium-226	3.58E-28	10,000	1.31E-43	10,000
	Uranium-234	4.51E+03	4329	8.94E+02	5140
	*Thorium-230	1.74E+02	4329	4.09E+01	5388
	*Radium-226	9.72E+01	4579	2.52E+01	5388
	Uranium-235	4.75E+01	4330	9.45E+00	5141
	*Thorium-231	4.75E+01	4330	9.45E+00	5141
	*Protactinium-231	4.14E+00	4330	9.71E-01	5389
	*Actinium-227	4.11E+00	4330	9.65E-01	5389
	*Thorium-227	4.11E+00	4330	9.65E-01	5389
	*Radium-223	4.11E+00	4330	9.65E-01	5389
	Uranium-238	8.33E+02	4330	1.66E+02	5141
	*Thorium-234	8.33E+02	4330	1.66E+02	5141
	*Uranium-234	1.02E+01	4330	2.41E+00	5389
	*Thorium-230	2.05E-01	4580	5.77E-02	5389
	*Radium-226	8.83E-02	4580	2.75E-02	5389
	*Radon-222	8.83E-02	4580	2.75E-02	5389
	*Lead-210	8.67E-02	4580	2.71E-02	5389
	*Bismuth-210	8.67E-02	4580	2.71E-02	5389
	*Polonium-210	8.67E-02	4580	2.71E-02	5389
	Total Uranium[1]	6.46E+03	4330	2.13E+03	5141
	*Thorium-234	6.46E+03	4330	2.13E+03	5141
	*Uranium-234	7.94E+01	4580	3.09E+01	5141
	*Thorium-230	1.62E+00	4580	7.38E-01	5389
	*Radium-226	6.99E-01	4580	3.52E-01	5389
	*Radon-222	6.99E-01	4580	3.52E-01	5389
	*Lead-210	6.87E-01	4580	3.46E-01	5389
	*Bismuth-210	6.87E-01	4580	3.46E-01	5389
	*Polonium-210	6.86E-01	4580	3.46E-01	5389

[1] Total uranium was analyzed as an activity for the WAG 3 Investigation and not as a concentration. MEPAS does not contain a provision for total uranium as activity in its chemical database, so total uranium activities were modeled as uranium-238.

Table 5.72. MEPAS results for SWMU 5

Source	Constituent (Daughter products are denoted with an asterisk)	PGDP security fence		DOE property boundary	
		Potential maximum concentration (mg/L or pCi/L)	Time (years)	Potential maximum concentration (mg/L or pCi/L)	Time (years)
Surface Soil	Aluminum	0	10,000	0	10,000
	PCB-1260	0	20,000	0	20,000
	2-Methylnaphthalene	3.88E-05	4650	7.00E-06	4659
	Acenaphthylene	4.35E-03	2620	8.05E-04	2658
	Benz(a)anthracene	0	20,000	0	20,000
	Benzo(a)pyrene	0	20,000	0	20,000
	Benzo(b)fluoranthene	0	20,000	0	20,000
	Pentachlorophenol	1.08E-27	20,650	1.25E-28	22,420
	Phenanthrene	2.62E-03	13,600	3.69E-04	13,600
	Technetium-99	5.78E+01	109.5	9.65E+00	110.7
UCRS-WP1	Aluminum	0	10,000	0	10,000
	Chromium	0	10,000	0	10,000
	Cobalt	2.51E-05	14,940	7.61E-06	14,940
	Iron	4.98E+01	1411	1.84E+01	1602
	Iron (at H263)	1.88E+01	1591	6.61E+00	1871
	Manganese	2.32E-01	3870	8.44E-02	4245
	Phenanthrene	6.09E-05	13,600	1.64E-05	13,600
	Radium-226	5.59E-03	12,380	1.13E-03	13,130
	Uranium-238	5.14E-19	19,830	2.13E-19	20,590
	*Thorium-234	5.14E-19	19,830	2.13E-19	20,590
	*Uranium-234	2.81E-20	19,830	1.21E-20	20,590
	*Thorium-230	2.40E-21	20,080	1.07E-21	20,590
	*Radium-226	1.93E-21	20,080	8.61E-22	20,590
	*Radon-222	1.93E-21	20,080	8.61E-22	20,590
	*Lead-210	1.92E-21	20,080	8.58E-22	20,590
	*Bismuth-210	1.92E-21	20,080	8.58E-22	20,590
	*Polonium-210	1.92E-21	20,080	8.58E-22	20,590
UCRS-WP2	Aluminum	0	20,000	0	20,000
	Cobalt	1.89E-03	14,940	2.81E-04	14,940
	Iron	4.64E+02	1873	8.27E+01	2069
	Manganese	1.56E+01	4097	2.76E+00	4481
	Toluene	2.78E-05	321.2	1.19E-05	344.4
	Technetium-99	2.29E+02	130.1	9.96E+01	138.6
	Radium-226	5.33E-03	12,380	1.04E-03	13,130
	Uranium-238	9.95E-19	19,830	1.91E-19	20,590
	*Thorium-234	9.95E-19	19,830	1.91E-19	20,590
	*Uranium-234	5.45E-20	19,830	1.09E-20	20,590
	*Thorium-230	4.64E-21	19,830	9.57E-22	20,590
	*Radium-226	3.71E-21	19,830	7.72E-22	20,590
	*Radon-222	3.71E-21	19,830	7.72E-22	20,590
	*Lead-210	3.69E-21	19,830	7.69E-22	20,590
	*Bismuth-210	3.69E-21	19,830	7.69E-22	20,590
	*Polonium-210	3.69E-21	19,830	7.69E-22	20,590

Table 5.73. MEPAS results for SWMU 6

Source	Constituent (Daughter products are denoted with an asterisk)	PGDP security fence		DOE property boundary	
		Potential maximum conc. (mg/L or pCi/L)	Time (years)	Potential maximum conc. (mg/L or pCi/L)	Time (years)
Surface Soil	Copper	2.56E-12	17,920	2.11E-14	17,920
	Phenanthrene	9.78E-07	13,470	2.71E-07	13,470
	Technetium-99	9.71E+00	105.1	3.15E+00	113.2
UCRS-Waste Cells	Aluminum	0	20,000	0	20,000
	PCB-1016	0	20,000	0	20,000
	Technetium-99	9.15E+01	118.6	3.18E+01	120.1
	Neptunium-237	1.68E-01	330.2	5.53E-02	387.1
	*Protactinium-233	1.68E-01	330.2	5.53E-02	387.1
	*Uranium-233	2.45E-04	348.9	9.33E-05	387.1
	*Thorium-229	3.99E-06	348.9	1.69E-06	387.1
	*Radium-225	3.99E-06	348.9	1.68E-06	387.1
	*Actinium-225	3.99E-06	348.9	1.68E-06	387.1
	Uranium-238	4.80E-19	20,040	1.42E-19	20,790
	*Thorium-234	4.80E-19	20,040	1.42E-19	20,790
	*Uranium-234	2.66E-20	20,040	8.12E-21	20,790
	*Thorium-230	2.28E-21	20,040	7.22E-22	20,790
	*Radium-226	1.83E-21	20,040	5.84E-22	20,790
	*Radon-222	1.83E-21	20,040	5.84E-22	20,790
	*Lead-210	1.82E-21	20,040	5.82E-22	20,790
	*Bismuth-210	1.82E-21	20,040	5.82E-22	20,790
	*Polonium-210	1.82E-21	20,040	5.82E-22	20,790
UCRS-WP1	Aluminum	0	20,000	0	20,000
	Chromium	0	20,000	0	20,000
	Cobalt	8.06E-05	14,720	2.33E-05	14,720
	Copper	3.13E-11	17,920	2.44E-13	17,920
	Iron	6.01E+01	1966	2.12E+01	2171
	Lead	0	20,000	0	20,000
	Manganese	4.08E-01	3690	1.41E-01	4057
	Technetium-99	1.16E+01	118.6	3.86E+00	120.1
	Neptunium-237	5.97E-02	330.2	1.95E-02	387.1
	*Protactinium-233	5.9E-02	330.2	1.95E-02	387.1
	*Uranium-233	9.02E-05	348.9	3.29E-05	387.1
	*Thorium-229	1.47E-06	348.9	5.95E-07	387
	*Radium-225	1.47E-06	348.9	5.95E-07	387
	*Actinium-225	1.47E-06	348.9	5.95E-07	387
	Uranium-238	3.49E-19	20,040	1.00E-19	20,790
	*Thorium-234	3.49E-19	20,040	1.00E-19	20,790
	*Uranium-234	1.93E-20	20,040	5.75E-21	20,790
	*Thorium-230	1.66E-21	20,040	5.11E-22	20,790
	*Radium-226	1.33E-21	20,040	4.13E-22	20,790
	*Radon-222	1.33E-21	20,040	4.13E-22	20,790
	*Lead-210	1.33E-21	20,040	4.12E-22	20,790
	*Bismuth-210	1.33E-21	20,040	4.12E-22	20,790
	*Polonium-210	1.33E-21	20,040	4.12E-22	20,790
UCRS-WP2	Aluminum	0	20,000	0	20,000
	Cobalt	1.66E-03	14,720	4.96E-04	14,720
	Iron	3.28E+01	1787	1.19E+01	2076
	Iron (from 006-027)	7.77E+00	1787	2.56E+00	2076
	Lead	0	20,000	0	20,000

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6. SUMMARY AND CONCLUSIONS

This Data Summary Report is intended to provide sufficient background information to support the development and assessment of remedial alternatives in the FS. The primary supporting documentation of the Data Summary Report is derived from the RIs and environmental monitoring programs of the PGDP.

6.1 CONCEPTUAL SITE MODEL

A conceptual site model is the framework for the development of models of fate and transport of contaminants. Fate and transport modeling provides a means for assessing future risk related to a contaminant source. Under CERCLA, an unacceptable current or future risk presented by a SWMU is the basis for taking a remedial action. The GWOU FS assesses the maximum cumulative risk from the PGDP by integrating the results of fate and transport modeling for each SWMU at specific exposure points that are defined, in part, by the main off-site groundwater plumes.

Because of the diversity of SWMU types and hydrogeologic settings of the PGDP area, each RI requires a specific conceptual site model to support its risk assessment. The following subsections and Fig. 6.1 present the average conditions that prevail at the PGDP.

6.1.1 Hydrogeology

The PGDP is set upon a complex geologic framework that arose from multiple depositional events. From the perspective of contaminant transport, the geologic units of primary interest are a surface blanket of loess and the basin fill deposits of the Pleistocene Tennessee River Valley.

Excluding the south end of the industrial complex, the shallow aquifer under most of the PGDP is developed primarily in a 9-m (30-ft) thick sand-and-gravel deposit of the ancestral Tennessee River. This aquifer, known as the RGA, occurs at depths of approximately 18 to 27 m (60 to 90 ft) bgs at the PGDP. Where sand lenses in the underlying McNairy Formation are located adjacent to the sand and gravel deposit, they, too, are included in the RGA.

The RGA extends north of the PGDP to the Ohio River, where the river cuts down into the McNairy Formation. Overall, groundwater flow in the RGA is north to discharge into the Ohio River. However, the primary east–west orientation of the sand and gravel lenses in the RGA and leakage from plant water utilities causes local groundwater flow directions to diverge to the east and west at the PGDP.

A thick silt and clay interval overlying the RGA sand and gravel deposit attests to a subsequent period of lake and loess deposition in the ancestral Tennessee River basin. At least two horizons of sand and gravel lenses occur within the lake deposits. Large downward hydraulic gradients that force groundwater flow vertically to the RGA are prevalent across the silt and clay units. The horizons of sand and gravel lenses support lateral groundwater flow over limited distances. In total, this groundwater flow system is called the UCRS.

A buried subcrop of the Porters Creek Clay beneath the south end of the PGDP marks the southern-most advance of the ancestral Tennessee River and forms the south boundary of the RGA. The Porters Creek Clay is a confining unit to groundwater flow south of the PGDP. A shallow water table flow system is developed in Pliocene gravel deposits where they overlie the Porters Creek Clay south of the PGDP. Discharge from the water table flow system provides baseflow to Bayou Creek and throughflow to the UCRS to the east and west of the PGDP.

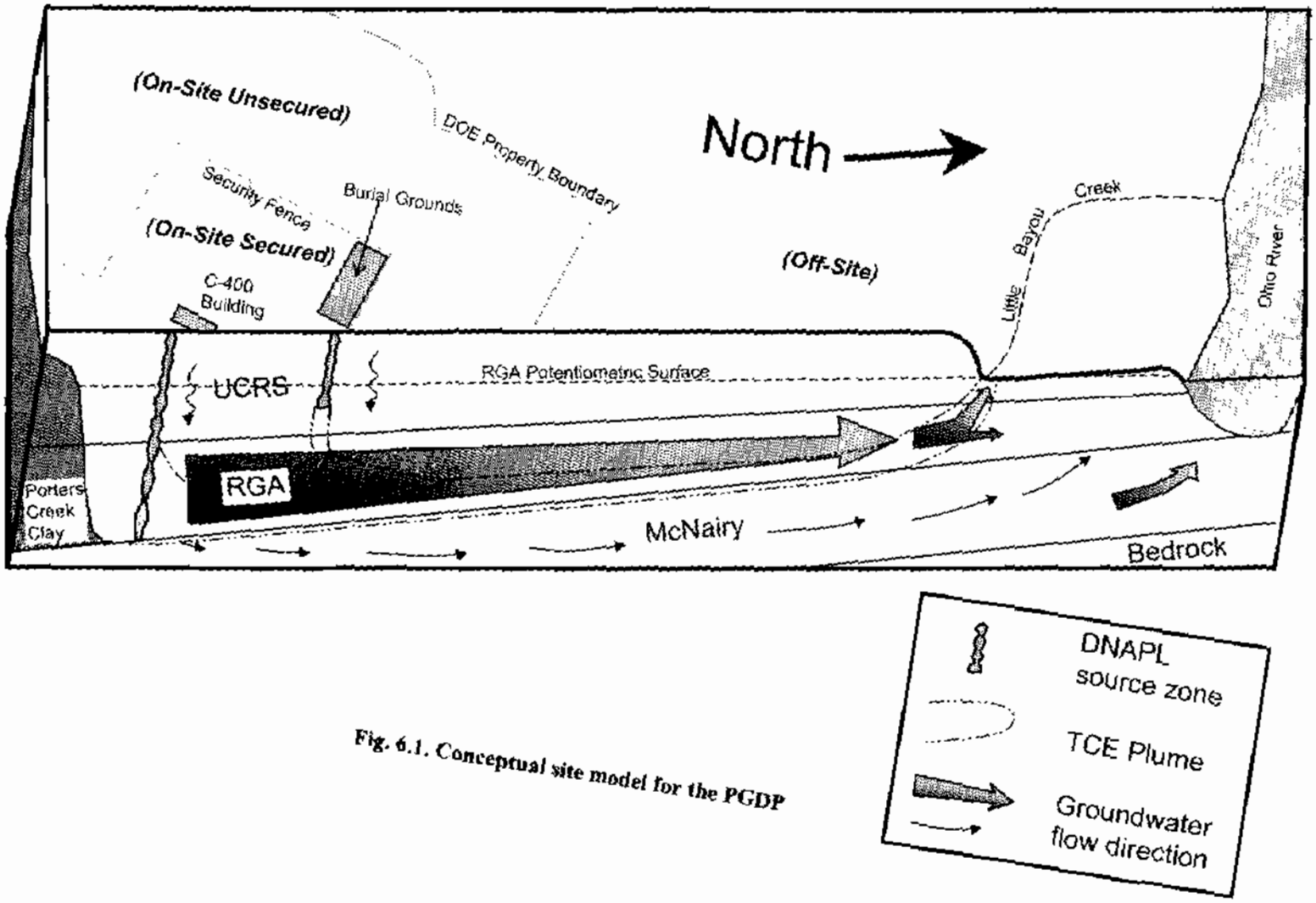

Fig. 6.1. Conceptual site model for the PGDP

The fine sand, silt, and clay lenses that are typical of the upper and middle members of the McNairy Formation form a sharp hydraulic conductivity contrast with the highly conductive sand and gravel deposits of the RGA. Thus, although a downward hydraulic potential gradient exists from the RGA to the McNairy Formation beneath the PGDP, the vast majority of flow in the RGA is lateral. Hydraulic potential gradients between the RGA and McNairy reverse near the Ohio River, where the McNairy Formation flow system also discharges.

Figure 6.2 illustrates the structural relationships of the main geologic units beneath the PGDP. In summary, the primary groundwater flow paths at the PGDP are downward through an upper 18-m (60-ft) interval of silt and clay (the UCRS) and laterally north in the underlying sand and gravel deposit (RGA) to discharge into the RGA. The UCRS receives some throughflow from a shallow water table flow system located south of the PGDP. A small percentage of the water that enters the RGA flows down into the McNairy Formation beneath the PGDP. Near the Ohio River, McNairy Formation groundwater flows up into the RGA.

The PGDP's groundwater plumes mark the local main groundwater flow paths in the RGA. Hydraulic gradient and conductivity of the RGA are two of the primary controls that determine groundwater flow rate towards the Ohio River. In general, flow velocities along the main groundwater flow paths marked by the PGDP groundwater contaminant plumes are on the order of 1.7×10^{-4} to 7.1×10^{-4} cn/s (0.5 to 2 ft/d). Figure 6.3 presents the average hydraulic potential of the RGA, relative to mean sea level, for the PGDP area. Hydraulic gradients measured from hydraulic potential maps of the RGA range from 10^{-4} m/m beneath the PGDP to 10^{-3} m/m near the Ohio River.

Pumping tests of a previous groundwater investigation and the groundwater extraction well fields located in the Northeast and Northwest Plumes provide analyses of hydraulic conductivity in each of the two main groundwater pathways at the PGDP. The following summarizes the results of the hydraulic conductivity tests:

Test Area	Units of Hydraulic Conductivity	Low	High
	Northeast Plume		
C-333	cm/sec	3.53×10^{-1}	4.23×10^{-1}
(Terran 1992)	ft/day	1,000	1,200
Northeast Plume Well Field	cm/sec	1.87×10^{-1}	4.28×10^{-1}
(DOE 1997)	ft/day	529	1,213
	Northwest Plume		
Northwest Plume North Well Field	cm/sec	9.5×10^{-1}	2.01
(LMES 1996)	ft/day	2,686	5,700

6.1.2 Groundwater Contaminants

The primary groundwater contaminants known to be associated with the PGDP are TCE and ^{99}Tc. Of these two contaminants, TCE is the dominant source of risk from off-site groundwater to human health and the environment.

Previous RIs of SWMUs at the PGDP have identified many associated contaminants. This Data Summary Report accepted 34 of these for further assessment of nature and extent, including organic chemicals, metals, and radionuclides. Of the 34 assessed contaminants, only boron was inadequately represented in the spatial distribution of samples included in the GWOU database. The summary of these investigations and the sitewide assessment of nature and extent of contaminants are presented in Chpts. 3 and 4, respectively, of this Data Summary Report.

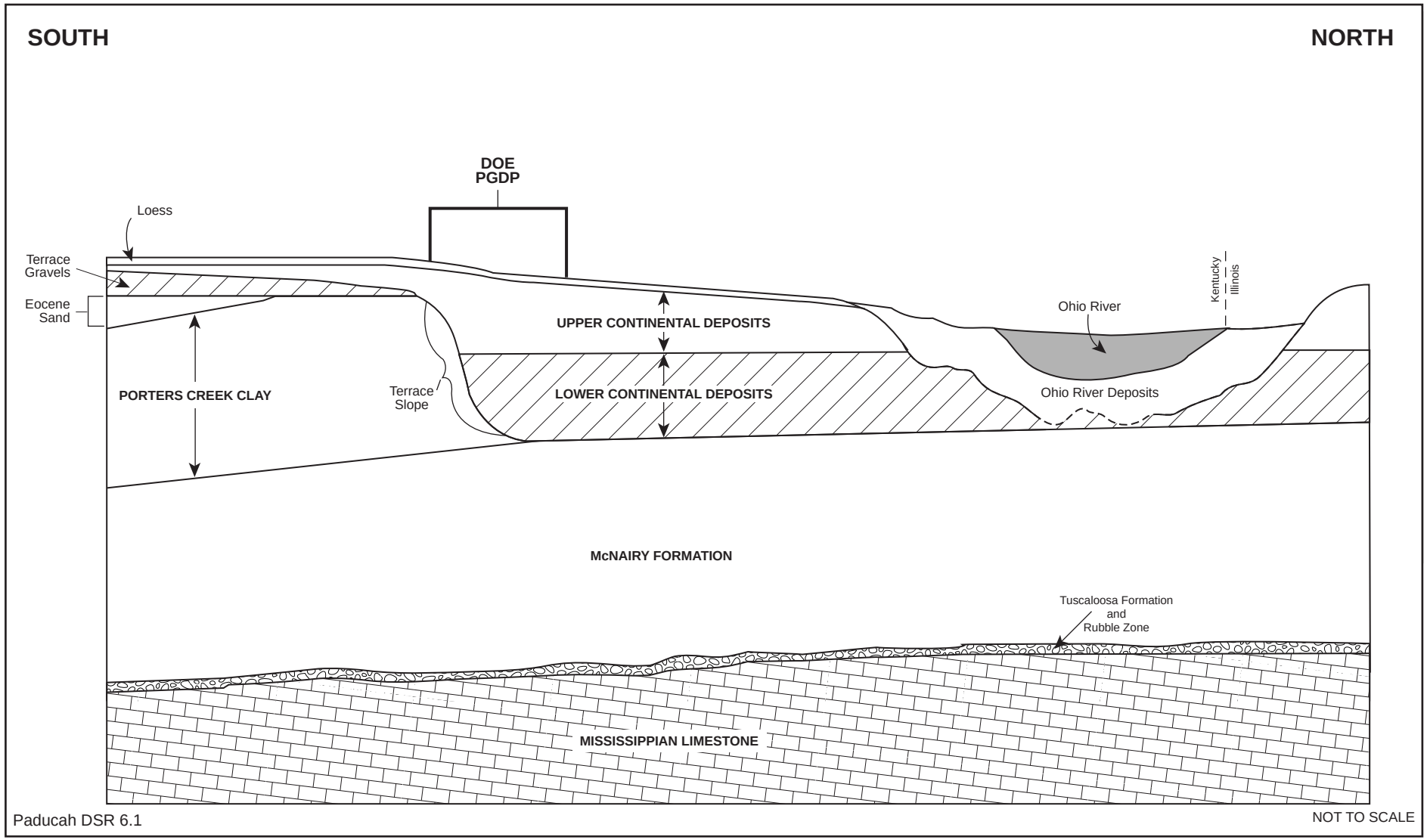

Fig. 6.2. Schematic of stratigraphic and structural relationships near the P GDP.

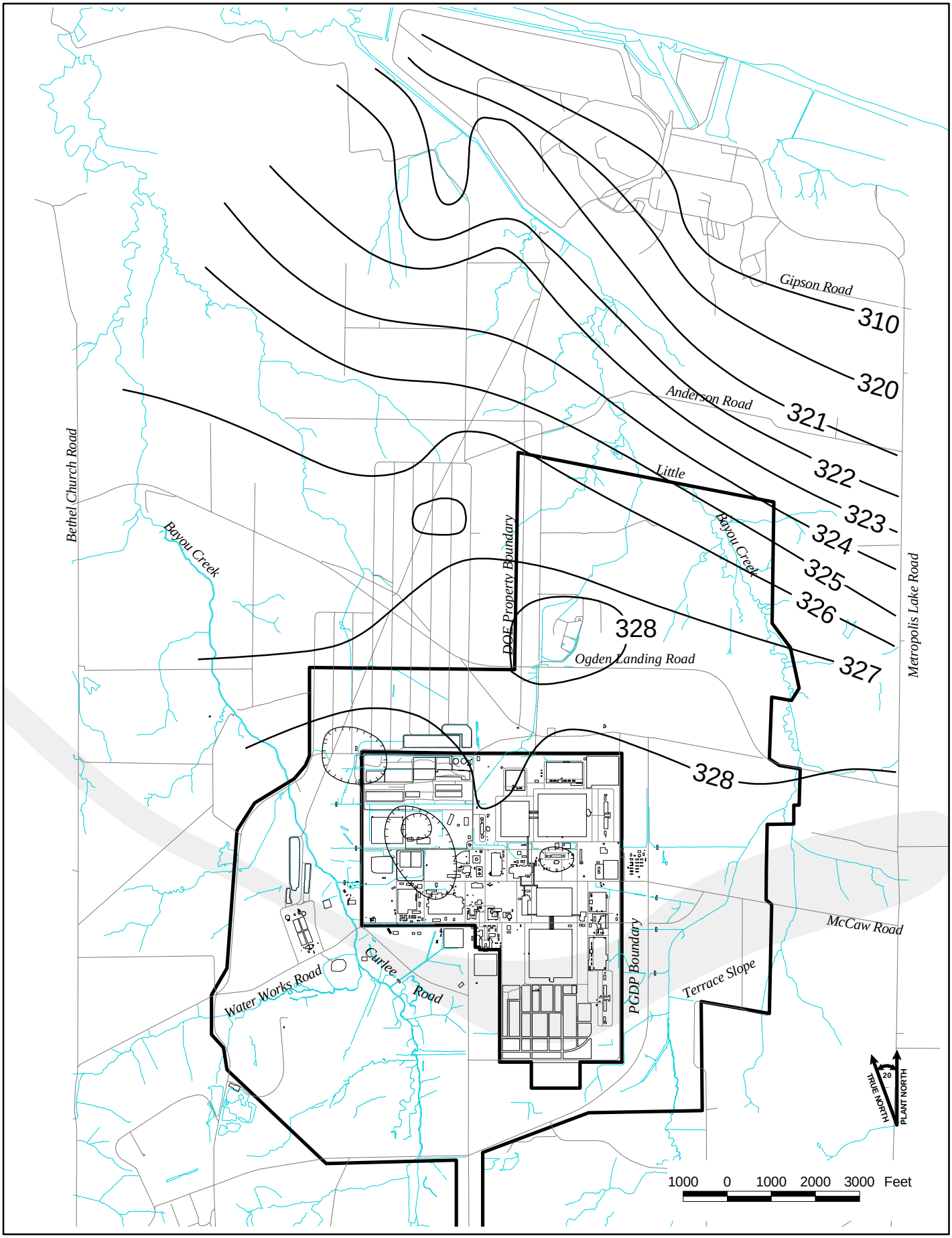

Fig. 6.3. Average potentiometric surface for RGA

The contaminants in each plume that are likely associated with the PGDP are as follows.

Northeast Plume	Northwest Plume	Southwest Plume
carbon tetrachloride	chloroform	TCE
1,1-DCE	1,2-DCE	^{99}Tc
cis-1,2-DCE	TCE	
TCE	benzene	
barium	barium	
chromium	beryllium (?)	
nickel (?)	chromium	
vanadium	copper	
^{99}Tc	uranium	
	^{99}Tc	

Aluminum, iron, and manganese appear to be ubiquitous in concentrations above background levels across the area. The occurrences of these contaminants are likely due to bias created by the collection of the groundwater samples rather than the PGDP.

The conclusions of the BRA of the GWOU FS provide a basis for the selection of contaminants that must be addressed in the ROD. As a practical measure, the alternatives of the FS can be designed around TCE and ^{99}Tc with the understanding that these actions likely will remediate the other PGDP-related groundwater contaminants.

6.1.3 Contaminant Source Terms

The SWMUs contributing significant contamination to the GWOU largely consist of former spill and leak sites, waste burial grounds, and former and operational manufacturing facilities. Many of the sources are associated with below ground utilities. With the exception of DNAPL sites, the thick silt-dominated intervals of the Upper Continental Deposits (averaging approximately 18 m (60 ft), thick beneath the PGDP) typically affords significant protection to water quality in the shallow aquifer (RGA). Table 6.1 provides a summary of the types of release and primary contaminants of the SWMUs assigned to the GWOU.

6.1.4 Contaminant Exposure Route

Current exposure to groundwater contaminants within the secured area of the PGDP is relatively easily controlled through administrative rules and actions and source removal. With the existing land use patterns around the PGDP, the chief area of concern regarding current and near-term exposure to groundwater are the off-site residences overlying the groundwater plumes and ecological and recreational receptors in Little Bayou Creek north of the PGDP, where it gains flow from the discharge of the RGA. The DOE has instituted a Water Policy and well capping and locking program to mitigate the current residential exposure pathway.

For either potential receptor, current human or ecological, the exposure pathway relies upon the transport of dissolved contamination in the RGA from the SWMU area to the off-site exposure point. The dissolved contamination may be leached by infiltrating rainwater or by shallow groundwater from within the primary SWMU boundaries and transported through the UCRS to the RGA. In this case, the attenuation capacity of the Upper Continental Deposits reduces and delays the impact of the contaminant source. Alternatively, where DNAPL exists, secondary sources of contamination such as free-phase TCE may be found in the deep UCRS or RGA. For these secondary source terms, the Upper and Lower Continental Deposits offer little sorptive capacity and advection within the RGA is the primary means of natural attenuation.

Table 6.1. Summary of GWOU contaminant sources

Waste Area Group	Solid Waste Management Unit	Description	Type(s) of Release	Primary Contaminants Present (TCE or ^{99}Tc)
Northeast Plume (AOC 202)				
6	SWMU 40	C-403 Neutralization Pit	leak from former waste treatment facility (including UCRS DNAPL zone)	TCE ^{99}Tc
28	SWMU 99	C-745 Kellogg Building Site	leaching of contamination from materials storage yard	^{99}Tc
28	SWMU 183	McGraw Underground Storage Tank	former materials storage tank	none
28	SWMU 193	McGraw Construction Facilities	former buildings and utilities	none
28	SWMU 194	McGraw Construction Facilities	former buildings and utilities	potential
28	AOC 204	Dykes Road Historical Staging Area	TCE leak into drainage ditch (including shallow soils DNAPL zone)	TCE
Northwest Plume (AOC 201)				
6	SWMU 11	C-400 TCE Leak Site	leak from break in storm sewer	TCE
6	SWMU 26	C-400 to C-404 Underground Transfer Line	former effluent pipeline	none
6	SWMU 47	C-400 Technetium Storage Tank Area	leak/spill from former waste storage tank	^{99}Tc
6	SWMU 203	C-400 Waste Discard Sump	effluent pipeline sump	TCE
22	SWMU 7	C-747-A Burial Ground	leaching from waste burial cells (including UCRS DNAPL zone)	TCE ^{99}Tc
22	SWMU 30	C-747-A Burn Area	leaching from waste burial cells and foundation of former incinerator	^{99}Tc
25	SWMU 59	North-South Diversion Ditch (inside plant security fence)	leaching from contaminated sediments	^{99}Tc
Southwest Plume (AOC 210)				
27	SWMU 1	C-747-C Oil Landfarm	former oil landfarm (including UCRS DNAPL zone)	TCE
27	SWMU 91	C-745-B Cylinder Drop Test Area	former TCE dip tank (including UCRS DNAPL zone)	TCE
27	SWMU 209	C-720 Compressor Shop Pit	former waste liquids sump	TCE
27	AOC 211	C-720 TCE Spill Site – Northeast	raw materials storage shed	TCE
27	C-720	Maintenance and Stores Building	leaks from floor drain/storm sewer system	TCE

6.2 CONCLUSIONS

Trichloroethene and ^{99}Tc are the primary contaminants associated with the PGDP in off-site groundwater. Of these two, only TCE typically occurs at levels exceeding drinking water standards. Numerous other contaminants, including VOCs, metals, and radionuclides are found in the RGA beneath the PGDP. For the most part, these contaminants either are not migrating off-site or are migrating off-site at levels only slightly above background conditions.

By far, the highest levels of TCE in off-site groundwater are migrating along the axes of three main groundwater plumes: the Northeast, Northwest, and Southwest Plumes. Both the Northeast and Northwest Plumes extend beyond the DOE reservation and into residential areas. The Southwest Plume is still contained within the DOE land boundaries.

The DOE has undertaken interim actions on the cores of the Northeast and Northwest Plumes to prevent the further spreading of the contamination and has employed two administrative actions, the Water Policy and well capping and locking, to limit exposure via a residential pathway. In addition to residential scenarios, the Northwest Plume poses potential exposure to groundwater contamination to recreational and ecological users of Little Bayou Creek. Both the GWOU FS and the upcoming SWOU RI will assess the need for an action for Little Bayou Creek, related to discharge of the Northwest Plume.

6.3 REFERENCES

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