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Primary Document

Five-Year Review for Remedial Actions at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

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Five-Year Review for Remedial Actions at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

Date Issued—November 2008

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

Prepared by
PADUCAH REMEDIATION SERVICES, LLC
managing the
Environmental Remediation Activities at the
Paducah Gaseous Diffusion Plant
under contract DE-AC30-06EW05001

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ACRONYMS

ALARA	as low as reasonably achievable
AOC	Area of Concern
AR	Administrative Record
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
BGOU	Burial Ground Operable Unit
CA	contamination area
CAB	Citizens Advisory Board
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
CFR	*Code of Federal Regulations*
COC	contaminant of concern
CSOU	Comprehensive Site Operable Unit
D&D	decontamination and decommissioning
DCE	dichloroethene
DNAPL	dense nonaqueous-phase liquid
DOE	U.S. Department of Energy
EIC	Environmental Information Center
EPA	U.S. Environmental Protection Agency
EQ	equalization
ERH	electrical resistance heating
EW	extraction well
FFA	Federal Facility Agreement
FS	Feasibility Study
FY	fiscal year
GWOU	Groundwater Operable Unit
HSWA	Hazardous and Solid Waste Amendments of 1984
ICM	Interim Corrective Measure
IRA	interim remedial action
KAR	*Kentucky Administrative Regulations*
KDEP	Kentucky Department for Environmental Protection
KDWM	Kentucky Division of Waste Management
KNREPC	Kentucky Natural Resources and Environmental Protection Cabinet
KPDES	Kentucky Pollutant Discharge Elimination System
LUC	Land Use Control
LUCAP	Land Use Control Assurance Plan
LUCIP	Land Use Control Implementation Plan
MIP	membrane interface probe
MOA	Memorandum of Agreement
MCL	maximum contaminant level
MDL	method detection limit
MW	monitoring well
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NOV	Notice of Violation
NPL	National Priorities List
NSDD	North-South Diversion Ditch
O&M	operation and maintenance
OSWER	Office of Solid Waste and Emergency Response
OU	operable unit

Paducah OREIS	Paducah Oak Ridge Environmental Information System
PCB	polychlorinated biphenyl
pH	hydrogen-ion concentration notation
PGDP	Paducah Gaseous Diffusion Plant
POE	point of exposure
PRG	preliminary remediation goal
PRS	Paducah Remediation Services, LLC
RA	remedial action
RAO	remedial action objective
RAWP	Removal Action Work Plan
RDR	Remedial Design Report
RDSI	remedial design support investigation
RCRA	Resource Conservation and Recovery Act of 1976
RGA	Regional Gravel Aquifer
ROD	record of decision
SMP	Site Management Plan
SOU	Soils Operable Unit
SWMU	solid waste management unit
SWOU	Surface Water Operable Unit
TBC	to be considered guidance
^{99}Tc	technetium-99
TCE	trichloroethene
TSCA	Toxic Substances Control Act
TVA	Tennessee Valley Authority
UCRS	Upper Continental Recharge System
USCA	*United States Code Annotated*
USEC	United States Enrichment Corporation
VOC	volatile organic compound
WAG	waste area group
WKWMA	West Kentucky Wildlife Management Area

EXECUTIVE SUMMARY

The cleanup strategy under the *Federal Facility Agreement for the Paducah Gaseous Diffusion Plant* (FFA) establishes four operable units (OUs): the Groundwater OU (GWOU), the Surface Water OU (SWOU), the Soils OU (SOU), and the Burial Grounds OU (BGOU) (EPA 1998). A fifth OU has been established for decontamination and decommissioning (D&D) activities (i.e., the D&D OU). Each OU is scoped to remediate areas and media associated with the Paducah Gaseous Diffusion Plant (PGDP). The specific scopes and further discussions for each OU are addressed in the Site Management Plan (DOE 2008a).

This Five-Year Review encompasses the response actions that the U.S. Department of Energy (DOE) has taken under the respective OUs, plus the Water Policy removal action. The FFA for PGDP includes requirements for combining Five-Year Reviews of remedial actions (Section XXX). The U.S. Environmental Protection Agency (EPA) has defined two types of Five-Year Reviews, statutory and policy. This document is a combination of statutory and policy reviews because the site implemented both removal and remedial actions. The triggering action for this review is the five-year anniversary of the first and second five-year reviews conducted at this site [i.e., *Five-Year Review (Type I) Paducah Gaseous Diffusion Plant Northwest Plume, Interim Remedial Action Record of Decision* (DOE 1998a), and *Five-Year Review for Remedial Actions at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*,(DOE 2003a)]. A form summarizing the site, issues from the review, recommendations, and protectiveness statements is presented as Exhibit ES.1. This form is from Appendix F of the EPA guidance document *Comprehensive Five-Year Review* (EPA 2001).

The assessments of this Five-Year Review find that DOE has implemented and operated the remedies in accordance with the requirements of the Records of Decision (RODs). Continuing and completed response actions by project and OU at PGDP include the following:

Site or Project	Operable Unit
Northwest Plume	GW
Northeast Plume	GW
Cylinder Drop Test Area or Lasagna™	GW
Water Policy	GW
North-South Diversion Ditch Source Control	SW
North-South Diversion Ditch Sections 1 and 2	SW
C-746-K Landfill	SW
Fire Training Area	SW
Surface Water Interim Corrective Measures	SW
C-749 Uranium Burial Ground	BG
C-402 Lime House	D&D
C-405 Incinerator	D&D
GWOU C-400 Electrical Resistance Heating	GW
D&D OU C-410 Infrastructure Removal	D&D

The response actions are functioning as intended by the decision makers who were responsible for the implementation of the specified actions. Each of these projects had specific remedies cited in each applicable ROD. In some cases, the continuation of some of these actions was considered environmentally advantageous; therefore, some of actions have continued past the estimated endpoint. This Five-Year Review indicates that additional actions are not required to meet the remedial action objectives of the decision documents with the exception of the Northwest Plume Interim Remedial Action (IRA).

Exhibit ES.1. Five-Year Review Summary Form

SITE IDENTIFICATION		
Site name *(from WasteLAN)*: Paducah Gaseous Diffusion Plant		
EPA ID *(from WasteLAN)*: KY8890008982		
Region: 4	**State: KY**	**City/County: Paducah/McCracken**
SITE STATUS		
NPL status: Final		
Remediation status (choose all that apply): Under Construction Operating		
Multiple OUs?* YES	**Construction completion date: ___ / ___ / _____**	
Has site been put into reuse? NO		
REVIEW STATUS		
Lead agency: U.S. Department of Energy		
Author name: Kelly Layne		
Author title: Senior Engineer Scientist	**Author affiliation: Paducah Remediation Services, LLC**	
Review period: 01/17/2008 to 03/21/2008		
Date(s) of site inspection: 03/05/2008 through 03/11/2008		
Type of review: Post-SARA Options: Post-SARA; Pre-SARA; NPL-Removal only; Non-NPL Remedial Action Site; NPL State/Tribe-lead; Regional Discretion		
Review number: 3 (third)		
Triggering action: Previous Five-Year Review Report Options: Actual RA On-site Construction at OU #____; Actual RA Start at OU#____; Construction Completion Other (specify)		
Triggering action date *(from WasteLAN)*: 12/20/2003		
Due date *(five years after triggering action date)*: 12/20/2008		

* "OU" refers to operable unit.
** Review period should correspond to the actual start and end dates of the Five-Year Review in WasteLAN.
NPL = National Priorities List

Exhibit ES.1. Five-Year Review Summary Form (Continued)

Issues:

Groundwater Operable Unit

- Northwest Plume—Although the remedy remains protective, the action could be optimized by ascertaining whether the high-concentration core of trichloroethene (TCE) of the Northwest Plume at the North Extraction Well Field has migrated eastward of the capture zone of the well field.
- Northeast Plume—None.
- Lasagna™ [Solid Waste Management Unit (SWMU) 91] or Cylinder Drop Test Area —None.
- Water Policy— None.

Surface Water Operable Unit

- North-South Diversion Ditch (NSDD) Source Control—None.
- NSDD Sections 1 and 2—None.
- C-746-K Landfill—None.
- Fire Training Area—None.
- Surface Water Interim Corrective Measures—Signs were erected under the scope of another project. Although the message content between the signs does not conflict with each other, an evaluation of the sign program is needed.

Burial Ground Operable Unit

- C-749 Uranium Burial Ground—None.

Decontamination and Decommissioning Operable Unit

- C-402 Lime House—None.
- C-405 Incinerator—None.

Projects Currently Underway

- GWOU—C-400 Electrical Resistance Heating—None.
- D&D OU—C-410 Infrastructure Removal—None.

Exhibit ES.1. Five-Year Review Summary Form (Continued)

Recommendations and Follow-up Actions:

Groundwater Operable Unit

- Northwest Plume—Evaluate preferential pumping of high-concentration wells. Assess contaminant trends at the current locations of the core of the downgradient plume.
- Northeast Plume—None.
- Lasagna™ or Cylinder Drop Test Area—None.
- Water Policy—None.

Surface Water Operable Unit

- NSDD Source Control—None.
- NSDD Sections 1 and 2— Perform a residual risk calculation to determine if the remedy can be optimized (e.g., risks are at a level that would support modification of institutional controls and/or cessation of five-year reviews).
- C-746-K Landfill—None.
- Fire Training Area—None.
- Surface Water Interim Corrective Measures—Evaluate whether interim corrective measures signs should be removed or replaced with new signs with language approved for the Environmental Indicator signs.

Burial Ground Operable Unit

- C-749 Uranium Burial Ground—None.

Decontamination and Decommissioning Operable Unit

- C-402 Lime House—None.
- C-405 Incinerator—None.

Projects Currently Underway

- GWOU—C-400 Electrical Resistance Heating—None.
- D&D OU—C-410 Infrastructure Removal—None.

Exhibit ES.1. Five-Year Review Summary Form (Continued)

Protectiveness Statement(s):

Groundwater Operable Unit

Northwest Plume–The remedy for the Northwest Plume is protective of human health and the environment. Exposure pathways that could result in unacceptable risk are being controlled.

Northeast Plume–The remedy for the Northeast Plume is protective of human health and the environment. Exposure pathways that could result in unacceptable risk are being controlled.

Water Policy–The remedy for the Water Policy box currently protects human health and the environment by institutional controls; however, additional actions under the dissolved-phase plume need to be evaluated for long-term protection.

Surface Water Operable Unit

The remedy for the surface water interim corrective measures currently protects human health and the environment by institutional controls; however, additional actions under the SWOU need to be evaluated for long-term protection.

Projects under Construction

- The remedy at C-400 involving Electrical Resistance Heating is expected to be protective of human health and the environment upon completion, and, in the interim, exposure pathways that could result in unacceptable risks are being controlled.

- The D&D of C-410 is in the preliminary stages. The non-time-critical removal action of C-410 is expected to be protective of human health and the environment upon completion, and, in the interim, exposure pathways that could result in unacceptable risks are being controlled.

Remainder of Projects

The remedies for the following projects are protective of human health and the environment. Exposure pathways that could result in unacceptable risk are being controlled.

- Cylinder Drop Test Area or Lasagna™
- NSDD Source Control
- NSDD Sections 1 and 2
- C-746-K Landfill
- Fire Training Area
- C-749 Uranium Burial Ground
- C-402 Lime House
- C-405 Incinerator

These projects are not final actions and were not designed to return the areas to unrestricted use.

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1. INTRODUCTION

The purpose of this Five-Year Review is to ensure that the remedial actions (RAs) taken to date at the Paducah Gaseous Diffusion Plant (PGDP) remain protective of human health and the environment and continue to function as designed. The methods, findings, and conclusions of reviews of several projects are documented in this report and issues found during the review are identified. Also, recommendations are made to address them. This Five-Year Review is part of the Administrative Record (AR) at PGDP.

The U.S. Department of Energy (DOE) has conducted this Five-Year Review pursuant to the Federal Facility Agreement (FFA) (EPA 1998) as well as the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) [42 *USCA* § 9621(c)]; the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) [40 *CFR* § 300.400(f)(4)(ii)]; and the U.S. Environmental Protection Agency (EPA) Office of Solid Waste and Emergency Response (OSWER) Directive 9355.7-03B-P (EPA 540-R-01-007) (EPA 2001). Additionally, this document meets guidance set forth in the CERCLA Five-Year Review Guide, Office of Environmental Management, U.S. Department of Energy, March 2002 (unnumbered). Per this guidance, DOE presented the Citizens Advisory Board (CAB) with information that the Five-Year Review had been initiated. No documented comments were recorded in the meeting minutes.

CERCLA requires that reviews be conducted no less often than once every five years at sites that have undergone an environmental response and contamination remains above concentrations that allow unlimited use and unrestricted exposure. Additionally, DOE has made commitments in the North-South Diversion Ditch (NSDD) Record of Decision (ROD), the ROD for the C-749 Uranium Burial Ground, the C-746-K Landfill, the Northwest Plume ROD, the Northeast Plume ROD, and the Cylinder Drop Test ROD to perform Five-Year Reviews of those respective actions (DOE 1994a; DOE 1995a; DOE 1998a; DOE 1993a; DOE 1995b; and DOE 1998b).

This review encompasses all of the above-mentioned interim remedial actions (IRAs) and also addresses the Water Policy action and the Surface Water Interim Corrective Measures. The FFA includes provisions for combining Five-Year Reviews of remedial actions as stated in Section XXX:

> Consistent with Section 121(c) of CERCLA, 42 *USC* § 9621 (c), and in accordance with this Agreement, DOE agrees that if the selected, final RAs for any operable unit, including selected alternatives entailing institutional controls with remedial action, result in Hazardous Substances, pollutants or contaminants, or Hazardous Wastes and Hazardous Constituents remaining at the Site above levels that allow for unlimited use and unrestricted exposure in accordance with Section 300.430(f) (4) (ii) of the NCP, DOE will submit to EPA and KNREPC [Kentucky Natural Resources and Environmental Protection Cabinet, now known as Kentucky Environmental and Public Protection Cabinet] a review of the RAs no less often than once every five (5) years (Five Year Review) after the initiation of such RAs (i.e., date of issuance of final-ROD) for as long as the site remains on the NPL to assure that human health and the environment are being protected by the RAs being implemented. To facilitate the Five Year Review process for multiple OUs, the Five Year Reviews shall be synchronized as follows: reviews which are required for RA OUs will be conducted every five years starting from the initiation of the RA for the first OU. Every five years thereafter, all subject OU RAs which were started prior to the next Five Year Review date, shall be included in the next Five Year Review. For OU RAs which started after the most recent Five Year Review, the level of the review shall be commensurate to the completeness of the RA and the quantity of operation and maintenance data collected.

> If, based on the Five-Year Review, it is the judgment of EPA or KNREPC that additional action or modification of a RA is appropriate in accordance with Sections 104, 106 or 120 of CERCLA, 42 *USC* § 9604, 9606, or 9620, the RCRA Permits or *KRS* 224 Subchapter 46, then EPA or KNREPC shall require DOE to submit a proposal to implement such additional or modified actions, which shall be subject to review and approval by EPA and KNREPC.

DOE is the lead agency for these response actions, and EPA and the Kentucky Department for Environmental Protection (KDEP) provide regulatory oversight pursuant to the FFA. This Five-Year Review contains reviews of completed projects as well as summaries of projects currently underway. The triggering action for this review is the five-year anniversary of the second Five-Year Review conducted at this site [*Five-Year Review for Remedial Actions at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2003a)].

This Five-Year Review is used to accomplish the following:

1. Evaluate whether the remedy is operational and functional;

2. Evaluate those assumptions critical to the effectiveness of remedial measures or the protection of human health and the environment (e.g., land use, site conditions, applicable standards) made at the time of the remedial decision to determine, given current information, whether these assumptions are still valid;

3. Determine what corrective measures are required to address any identified deficiencies; and

4. Evaluate whether there are opportunities to optimize the long-term performance of the remedy or reduce life-cycle costs.

The evaluations of the completed response actions were conducted during January through March 2008. DOE and its prime remediation contractor, Paducah Remediation Services, LLC, (PRS) conducted the reviews. Chapter 4 of this report identifies the locations of the actions that were reviewed.

2. SITE CHRONOLOGY

In August 1988, trichloroethene (TCE), an organic solvent, and technetium-99 (^{99}Tc), a beta-emitting radionuclide, were detected in four private wells north of the PGDP facility. DOE placed affected residences/businesses on alternate water supplies and began an intensive monitoring and investigation program to define the extent and temporal variations of the groundwater contaminant plumes. Since that time, several investigations and response actions have taken place. Those included in this review are listed in the table below, along with other dates that are important to the environmental response program of PGDP.

Table 2.1. Chronology of Significant Site Events at PGDP

Date of Action	Response Description	Site/ Project name	OU	WAG	SWMU	Media	Response Type
1952	PGDP begins enriching uranium for nuclear fuel reactors.	N/A	N/A	N/A	N/A	N/A	N/A
1964-1965, 1979	PGDP conducts cylinder drop tests using TCE pit (later to be designated SWMU 91).	N/A	GW	N/A	N/A	N/A	N/A
Aug-88	Off-site groundwater contaminants are discovered in neighboring residential wells. DOE immediately provided a temporary water supply. Initiated construction activities to supply municipal water.	N/A	GW	N/A	N/A	N/A	N/A
Nov-88	Agreed Consent Order is signed.	N/A	N/A	N/A	N/A	N/A	N/A
Aug-91	Kentucky Hazardous Waste Management Permit and EPA HSWA Permit are first effective.	N/A	N/A	N/A	N/A	N/A	N/A
May-93	PGDP applies for listing on NPL.	N/A	N/A	N/A	N/A	N/A	N/A
Jul-93	Institutional controls (fencing/posting) for off-site contamination in surface water, outfalls, and lagoons.	Exterior drainage ditches	SW	18 and 25	N/A	surface water	IRA
Jul-93	Issued ROD for hydraulic containment and treatment of high concentrations of off-site TCE contamination in the Northwest Plume.	Northwest Plume	GW	26	201	ground-water	ICM
Mar-94	Instituted action to treat certain plant effluent and control the migration of contaminated sediment associated with the NSDD.	North-South Diversion Ditch	SW	25	59	surface water	IRA
May-94	PGDP is placed on NPL.	N/A	N/A	N/A	N/A	N/A	N/A
Aug-94	Action memorandum approved for extended municipal water line to residents affected by off-site groundwater contamination.	Water Policy	GW	26	NA	ground-water	Removal action
Jun-95	Issued ROD for hydraulic containment and treatment of high concentrations of off-site TCE contamination in the Northeast Plume begins.	Northeast Plume	GW	26	202	ground-water	IRA
Aug-95	Northwest Plume Groundwater System begins operation.	Northwest Plume	GW	26	201	ground-water	IRA
Feb-98	FFA is signed with the EPA and KDEP.	N/A	N/A	N/A	N/A	N/A	N/A

Table 2.1. Chronology of Significant Site Events at PGDP (Continued)

Date of Action	Response Description	Site/ Project name	OU	WAG	SWMU	Media	Response Type
Feb-97	Northeast Plume Groundwater System begins operation.	Northeast Plums	GW	26	202	ground-water	IRA
Jul-98	First Five-Year Review is completed for Northwest Plume Action.	NW Plume	GW	N/A	N/A	N/A	IRA
Aug-98	First Five-Year Review is completed for Water Policy.	Water Policy	GW	N/A	N/A	N/A	IRA
Aug-98	Issued ROD for *in situ* treatment of TCE-contaminated soils using the LASAGNA™ technology.	Cylinder Drop Test Area	GW	N/A	91	soil	IRA
Aug-98	Issued ROD for installation of rip-rap along creek bank to prevent direct contact, implementation of institutional controls, and long-term monitoring and enhancement of existing cap to reduce leachate migration from surface infiltration.	C-746-K Landfill	SW	1 & 7	8	surface water and sediment	IRA
Aug-00	First Five-Year Review is completed for BGOU.	Burial Ground	N/A	N/A	N/A	N/A	N/A
Aug-00	First Five-Year Review is completed for SWOU.	Surface Water	SW	N/A	N/A	N/A	N/A
Dec-01	Lasagna™ or Cylinder Drop Test Area remedial operations are completed.	Cylinder Drop Test Area	GW	N/A	91	soil	IRA
Aug-02	Initiated removal of process equipment and piping	C-410 Infrastructure Removal	D&D	N/A	478	building structures	Non-time-critical removal action
Sep-02	Remedial action for Sections 1 and 2 of the NSDD	North-South Diversion Ditch	SW	N/A	59	sediment and soil	IRA
Dec-03	Five-Year Review is issued.	All applicable projects	NA	NA	NA	NA	NA
Aug-05	*In situ* treatment of TCE source areas in the UCRS and RGA located in the southeast and southwest corners of the C-400 building using electrical resistance heating technology.	C-400 Electrical Resistance Heating	GW	N/A	11 & 533	ground-water	IRA
Dec-05	Initiate removal, characterization, and disposal of building structure and contents.	C-402 Lime House, C-405 Incinerator, C-746-A West End Smelter	D&D		480, 55, & 464	building structures	Non-time-critical removal action

BGOU = Burial Grounds OU
D&D = decontamination and decommissioning
EPA = U.S. Environmental Protection Agency
FFA = Federal Facility Agreement
GW = Groundwater
GWOU = Groundwater OU
HSWA = Hazardous and Solid Waste Amendments of 1984
IRA = Interim Remedial Action
KDEP = Kentucky Department for Environmental Protection
N/A = not applicable
NSDD = North-South Diversion Ditch
NPL = National Priorities List
OU = operable unit
PGDP = Paducah Gaseous Diffusion Plant
RGA = Regional Gravel Aquifer
ROD = record of decision
SW Surface Water
SWMU = solid waste management unit
SWOU = Surface Water OU
TCE = trichloroethene
UCRS = Upper Continental Recharge System
WAG = waste area group

3. BACKGROUND

3.1 PHYSICAL CHARACTERISTICS

PGDP is located in northwestern Kentucky, approximately 10 miles west of the city of Paducah, and approximately 3.5 miles south of the Ohio River (Figure 3.1). The total acreage of land held by DOE at the Paducah Site is 3,556 acres. The industrial portion of PGDP is 748 acres located within a fenced security area. Surrounding the industrial portion of the reservation is the West Kentucky Wildlife Management Area (WKWMA).

3.2 LAND AND RESOURCE USE

PGDP is an active uranium enrichment plant. The plant is owned by DOE and currently is leased to and operated by the United States Enrichment Corporation (USEC). Enrichment operations began in 1952, and the plant became fully operational in 1955. Hazardous, nonhazardous, and radioactive wastes have been generated, stored, and disposed of at PGDP. The industrial portion of PGDP, designated as secured (i.e., fenced and patrolled) industrial land use, includes numerous buildings and offices, support facilities, equipment storage areas, and active and inactive waste management units.

DOE currently holds a lease agreement with USEC for the production facilities at PGDP and a license with Kentucky Department of Fish and Wildlife Resources for certain portions of the WKWMA. Portions of both the DOE Reservation and WKWMA occupy land that once was part of the Kentucky Ordnance Works, a trinitrotoluene production facility in operation between 1942 and 1946. The entire WKWMA covers approximately 6,823 acres. The land licensed to the WKWMA is designated as recreational and is used extensively for outdoor recreation such as hunting and fishing. DOE property not leased to the WKWMA and outside the security area is classified as on-site, unsecured (i.e., not fenced) industrial.

North of the DOE Reservation and WKWMA is the Shawnee Steam Plant, operated by the Tennessee Valley Authority (TVA). This TVA property is designated as industrial.

Private property surrounds the DOE Reservation, WKWMA, and TVA. This property is mostly rural and agricultural.

As noted above, the site is located approximately 10 miles west of Paducah, Kentucky, (population approximately 26,000) in the western part of McCracken County. The total population within a 50-mile radius of PGDP is approximately 500,000. Approximately 50,000 people live within 10 miles of PGDP and homes are scattered along rural roads around the plant. The population of Paducah, based on the 2000 U.S. Census, is 26,307; the total population of McCracken County (251 mi^2) is approximately 65,000. The closest communities to PGDP are the unincorporated towns of Grahamville (1 mile) to the east and Heath about 1 mile southeast. The nearest schools are Heath Elementary, Middle, and High Schools. These are 1.86 miles southeast of the plant near the Heath community. The nearest hospitals are located in Paducah. The site is near the following major roads: U.S. Highway 60 and Kentucky Highways 358, 725, and 996. Additional major roads at great distance are Interstate 24 and U.S. Highway 62. A rail spur serves PGDP and connects to the Illinois Central Gulf Railroad. The nearest airport is Barkley Regional Airport located approximately 3.7 miles southeast of the site. The Ohio River is navigable along its entire length and, near the site, has a downstream connection to the Mississippi River and an upstream connection to the Tennessee River. Dams (i.e., Lock and Dams No. 52 and 53) are located on the Ohio River, both upstream and downstream of the site. In addition, the Kentucky Lock and Dam is

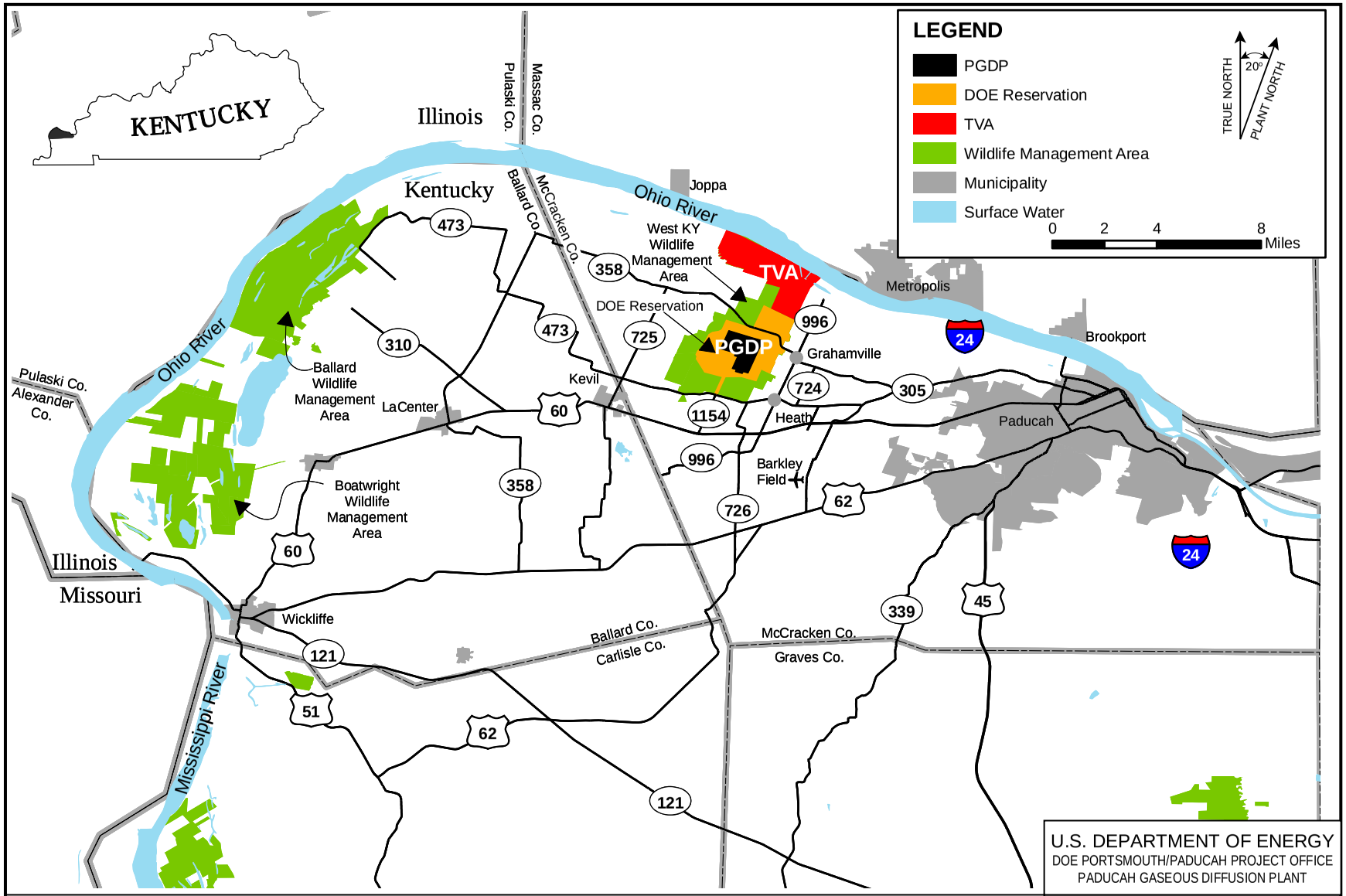

Figure 3.1 PGDP Site Location

located on the Tennessee River near its confluence with the Ohio River. Figure 3.2 is a map showing the land use areas surrounding PGDP.

Several water-bearing zones are present in the PGDP area. The primary water-bearing units, in order of increasing depth, are the Upper Continental Recharge System (UCRS), the Regional Gravel Aquifer (RGA), and the McNairy Formation (Figure 3.3). The RGA has been identified as the uppermost aquifer at PGDP (MMES 1992). The RGA is the dominant groundwater flow system at PGDP and contains the on-site and off-site contaminant plumes.

Groundwater flow is predominately vertically downward in the UCRS, providing recharge to the RGA. Rainfall infiltration and leakage from PGDP water utilities account for most of the recharging water. In general, the depth to the UCRS water table is less than 20 ft in the western half of PGDP and as much as 40 ft in the northeastern corner.

The RGA typically has a relatively high hydraulic conductivity and serves as the dominant flow system in the area. Hydraulic gradients direct groundwater flow in the RGA laterally to the north where the regional groundwater systems discharge into the Ohio River. Additionally, discharges of contaminated groundwater to surface water occur at seeps in Little Bayou Creek. The groundwater in these seeps contains contaminants associated with the Northwest Plume.

Silts and fine sands of the McNairy Formation, found beneath the RGA sediments, form the lower confining unit to the shallow aquifer system. The regional groundwater flow direction in the McNairy Formation is toward the Ohio River. Vertical hydraulic gradients in the McNairy Formation are downward beneath PGDP, but upward near the Ohio River.

PGDP is located in the western portion of the Ohio River basin, approximately 15 miles downstream of the confluence of the Ohio River with the Tennessee River and approximately 35 miles upstream of the confluence of the Ohio River with the Mississippi River. Locally, PGDP is within the drainage areas of the Ohio River, Bayou Creek (also known as Big Bayou Creek), and Little Bayou Creek.

The plant is situated on the divide between Little Bayou and Bayou Creeks (Figure 3.4). Bayou Creek is a perennial stream on the western boundary of the plant that flows generally northward to the Ohio River. Little Bayou Creek becomes a perennial stream at the east outfalls of PGDP and extends northward to the Ohio River. Most of the flow within Bayou and Little Bayou Creeks is from process effluents or surface water runoff from PGDP. Contributions from PGDP comprise approximately 85% of flow within Bayou Creek and 100% of flow within Little Bayou Creek.

3.3 HISTORY OF CONTAMINATION

Historical activities at PGDP have generated various nonhazardous, hazardous, and radioactive wastes that have been managed, stored, and/or disposed of by different methods. These activities have, in some cases, resulted in the release of contaminants to the environment. The primary contaminants of concern (COCs) at PGDP are ^{99}Tc, TCE, polychlorinated biphenyls (PCBs), and uranium. In August 1988, contamination was found in an off-site drinking water well north of PGDP. The contaminants included ^{99}Tc, which is a man-made radionuclide created as a byproduct of the fission of uranium. Initially, ^{99}Tc was introduced to PGDP in 1953 as a contaminant in feed material during a program in which spent nuclear reactor fuel was fed into the plant processes.

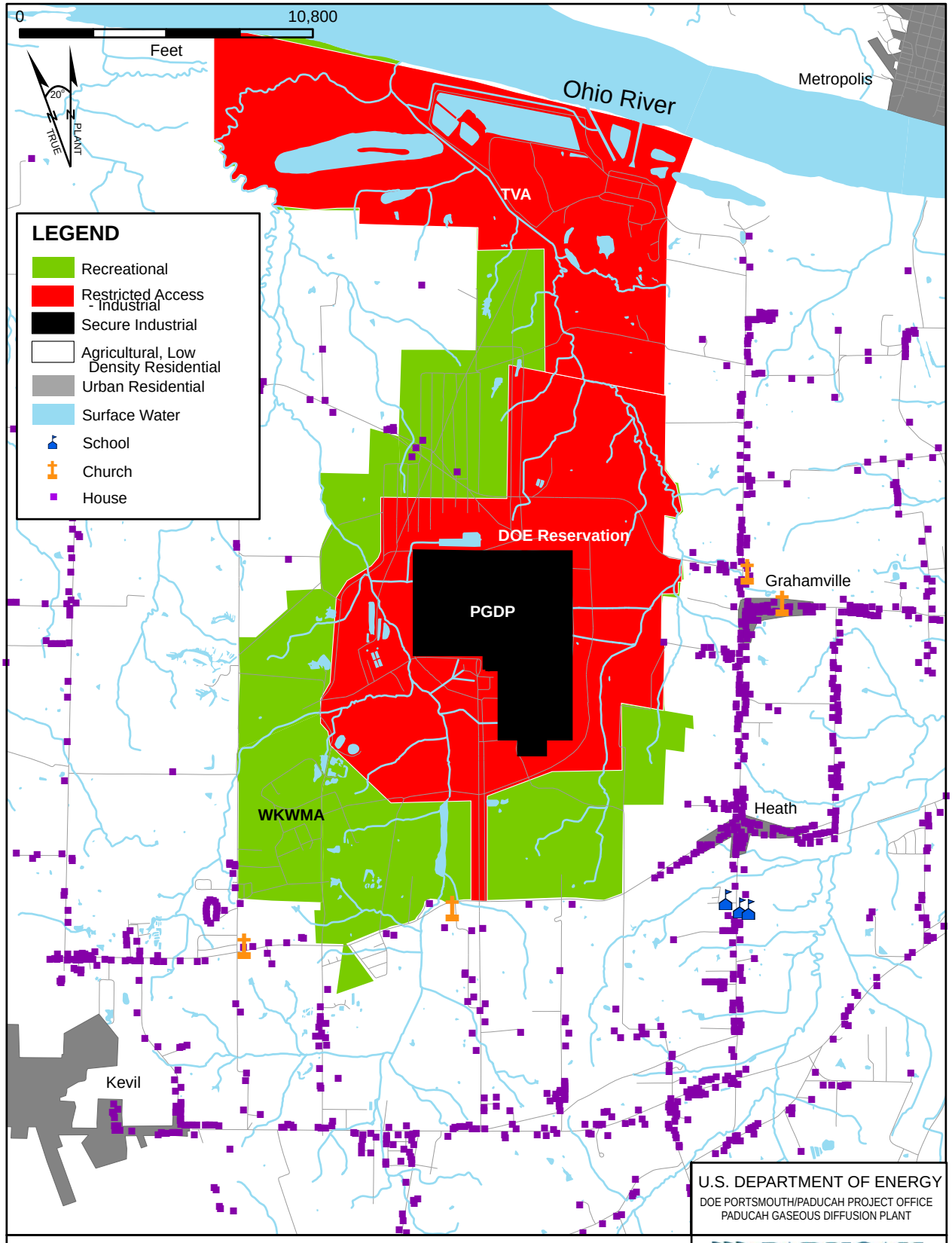

Figure 3.2. Land Use in Proximity to PGDP

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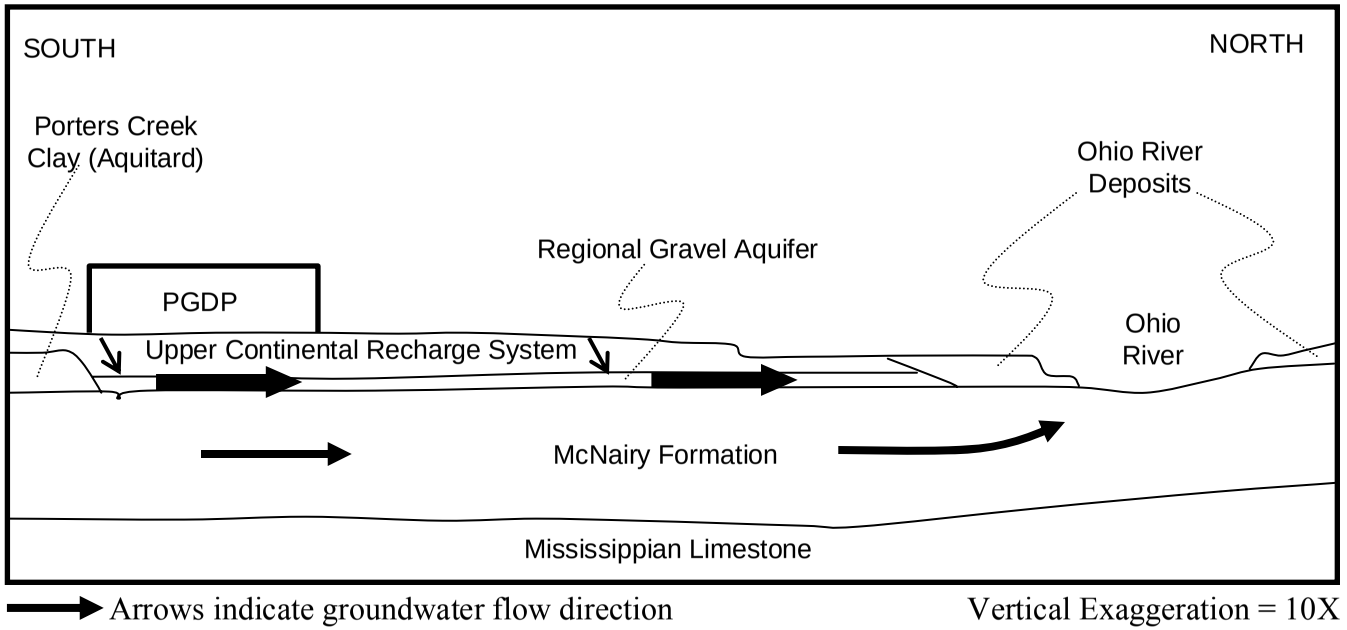

Figure 3.3. Water-Bearing Zones in the PGDP Area

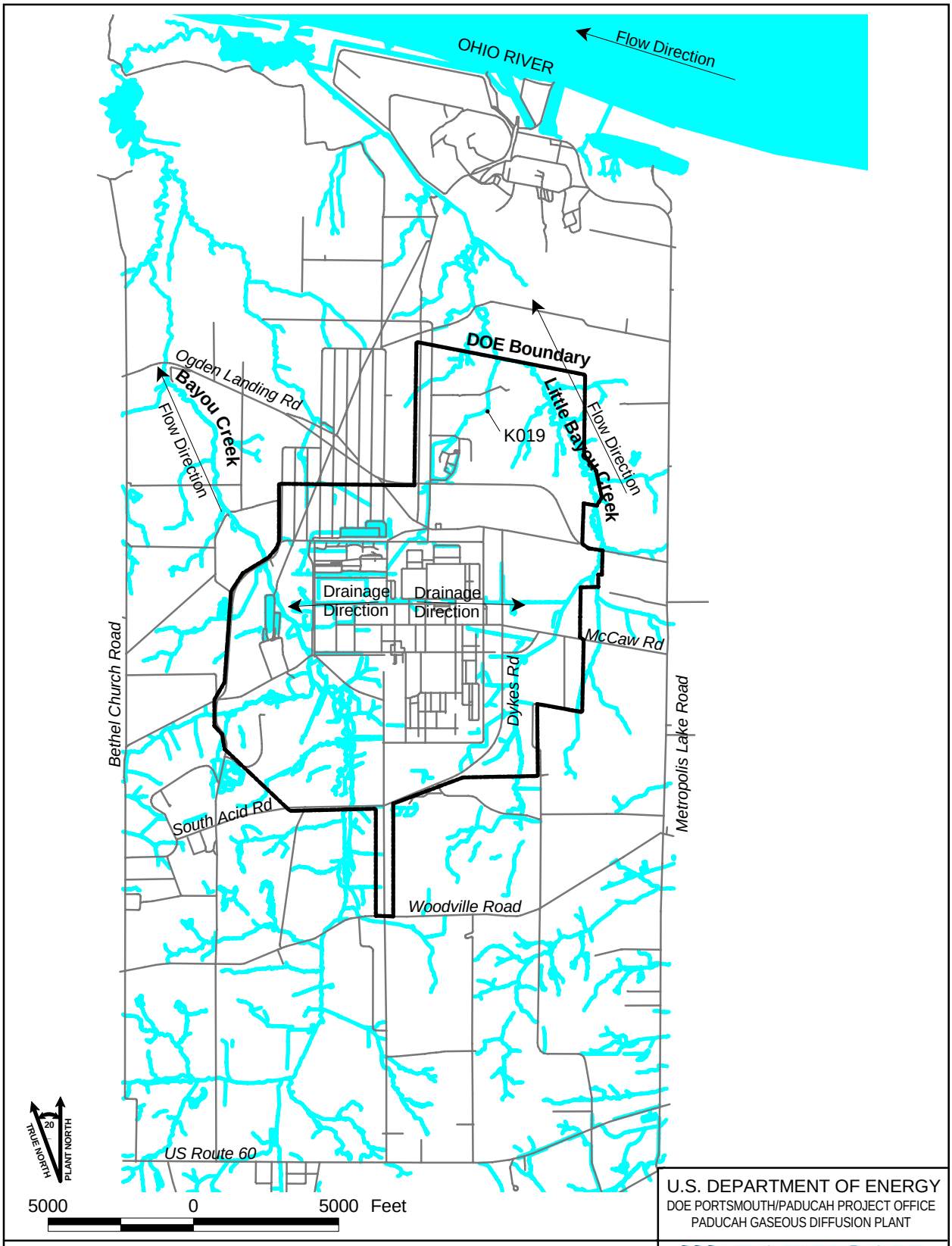

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Figure 3.4. Surface Water Features in the Vicinity of the DOE Site

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Further sampling showed that a commonly used solvent, TCE, also was present in off-site wells. TCE had been used as a cleaning solvent at PGDP since its construction, but has not been used since 1993 (DOE 2001). In the C-400 Building, process piping and equipment from the cascade system were cleaned with TCE. In 1986, TCE was found to have been discharging inadvertently (apparently for many years) from a sump pump in the degreaser area to a storm sewer and was found to have leaked into the soil. Other sources of TCE releases at PGDP are the TCE degreaser at the C-720 Building, and switchyard transfer equipment that was washed with TCE. Reportedly, TCE also was used in the plant processes of the Kellogg Building. Waste TCE was disposed of in on-site landfills and in a historical landfarming operation. TCE was placed into a pit and used as a refrigerant in tests to determine cylinder integrity. The estimated volume of TCE, with consideration given as C-400 being the source zone, is approximately 75,000 gal.

PCBs have been found in sediment and fish downstream of the plant. PCBs have been used extensively as an insulating, nonflammable, thermally conductive fluid in electrical capacitors and transformers at PGDP. The large switchyards that service the process buildings included PCB-filled transformers. PCBs also have been used as flame retardants (on the gaskets of diffusion cascades in other sections of the plant), as a hydraulic fluid, and are used in paints on equipment that is subject to high temperatures. PCBs have been released to the environment from spill sites throughout the plant that resulted from specific transformer ruptures and as part of general operations over the years.

Uranium, thorium, and transuranic elements (i.e., plutonium and neptunium) were detected in off-site sediments near PGDP in 1988. Sources of uranium releases are historic landfills where it was buried, such as the C-749 Uranium Burial Ground, as well as general plant operations where uranium was washed into ditches and creeks.

At the PGDP, site cleanup includes a series of prioritized response actions through which short-term protection goals, intermediate performance goals, and long-term final cleanup goals will be attained. Within this approach, the short-term protection goals are to control risks to humans and the environment; intermediate-term performance goals are to reduce, control, or minimize contaminants found in source areas; and long-term goals are to evaluate and pursue additional actions determined necessary to achieve the contaminant level reductions to provide long-term protectiveness. To achieve these goals, DOE and the regulatory agencies have agreed to use five media-specific OUs to evaluate and implement response actions. These five OUs, which include response actions in the near- and intermediate-term that will be completed without disrupting ongoing uranium enrichment plant operations, are as follows (DOE 2008a):

- Decontamination and Decommissioning (D&D) OU,
- GWOU,
- BGOU,
- SWOU, and
- Soils OU.

In addition to the response actions, each OU includes site characterization activities to support future response action decisions. Once the gaseous diffusion plant ceases operation, D&D of the plant will occur. These D&D activities will be followed by the Comprehensive Site Operable Unit (CSOU), which will address any residual contamination not addressed earlier. The timing and sequencing for implementation of activities associated with the OUs and gaseous diffusion plant D&D are based on a combination of factors including risk, compliance, and technical considerations associated with plant operations as outlined in the FFA. Both the FFA and the Site Management Plan (SMP) (DOE 2008a) document the schedule of actions for the OUs and gaseous diffusion plant D&D.

In accordance with the FFA, all SWMUs and areas of concern (AOCs) requiring investigation and/or potential response actions under the FFA have been assigned to one of the five media-specific OUs listed here. The objective of grouping the sources and areas of contamination into these OUs is to provide a more comprehensive framework to assess sitewide risks, identify and prioritize response actions, and develop integrated cleanup solutions that will reduce any unacceptable risk across the primary exposure pathways through which human health and the environment may be affected. To support implementation of this strategy, the source areas and affected media within each OU have been subjected to a screening process to further segregate the source areas into various categories, including candidate areas designated as a high priority for a response action, areas requiring additional characterization/risk evaluation, and source areas associated with plant operations. Current examples of actions for high-priority areas include these: the excavation of Sections 1 and 2 of PGDP's NSDD and scrap metal removal, both of which were performed as part of the SWOU; the ongoing implementation of the Water Policy; and the source action for TCE and other volatile organic compound (VOC) contamination at the C-400 Cleaning Building area, which is part of the GWOU.

3.4 INITIAL RESPONSE

After the discovery of groundwater contamination in 1988, DOE placed affected residences and businesses on an alternate water supply and began an intensive monitoring and investigation program to define the extent of contamination. DOE's first objective was to reduce immediate risks to off-site residents. DOE implemented plume control actions at the Northwest Pump-and-Treat Facility and the Northeast Containment System, and surface water institutional controls to reduce further the risks posed to human health and environment by releases from PGDP.

After addressing immediate off-site risks, DOE identified potential areas of contamination at the site (e.g., burial grounds, spill sites, and container storage areas) as SWMUs and AOCs. DOE then grouped most of the SWMUs and AOCs into Waste Area Groups (WAGs), based upon common characteristics such as similar contaminants or type of media affected and gave highest priority to those WAGs with the greatest potential for contributing to off-site contamination. Subsequently, DOE began conducting response activities to address the contamination.

In order to keep residents and the community informed of the remedial efforts taking place at PGDP, DOE established a CAB in September 1996. This board is composed of people who reflect the diversity of gender, race, and interests of persons surrounding PGDP. The mission statement of the CAB is as follows:

> The Paducah Gaseous Diffusion Plant (PGDP) Citizens Advisory Board (CAB) is an independent, nonpartisan, broadly representative organization consisting of a balanced mix of the diverse interests with concerns related to PGDP environmental management (EM) activities. The mission does not apply to ongoing production activities at the plant. The Site CAB's primary mission is to provide informed recommendations and advice on major policy issues regarding environmental restoration, waste management and related PGDP activities to the U.S. Department of Energy (DOE).

The CAB meets monthly to hear from persons working on relevant environmental efforts, listen to and discuss input from concerned citizens, form advice and recommendations to submit to DOE, and formulate recommendations to DOE about how to conduct clean-up actions. All meetings are open to the public in accordance with the organization's bylaws.

3.5 BASIS FOR TAKING ACTION

In August 1998, DOE, EPA, and the Commonwealth of Kentucky agreed to restructure the remedial strategy for PGDP. This restructuring reflects the accomplishment of sitewide remedial objectives through an OU approach with consideration to exposure levels. Exposures to soil, sediment surface water, and groundwater are associated with risks that exceed EPA's risk management criteria either for industrial or residential exposure scenarios. The risks were highest for exposures to contaminants in private drinking wells. Other risks were due to recreational exposures in creek sediments and industrial exposures to process drainages. Additional information regarding the risks associated with potential areas of contamination at the site is included in the following sections.

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4. RESPONSE ACTIONS

Twelve completed or operating response actions and two recently initiated response actions are included in this report. The previous Five-Year Review used the WAG or SWMU under which a site was investigated instead of the site's name (DOE 2003a). In order to be able to refer to sites by names used in other CERCLA documents, this report will refer to sites by their individual names, instead of the grouping under which they were investigated. The 12 response actions that require Five-Year Reviews, the OU with which they are associated, and the name used in the previous Five-Year Review are listed in Table 4.1. The location of the discussion of each action within this document is shown on Figure 4.1, the latest approved plume map, which shows the TCE plume based on 2005 data.

Table 4.1. Response Actions Taken at PGDP

Chapter	Site or Project Name Used in This Report	Operable Unit	Project Name Used in Previous Five-Year Reviews
5.	Northwest Plume	GW	Northwest Plume
6.	Northeast Plume	GW	Northeast Plume
7.	Cylinder Drop Test Area or Lasagna™	GW	SWMU 91
8.	Water Policy	GW	Water Policy
9.	NSDD Source Control	SW	NSDD Source Control
10.	NSDD Sections 1 and 2	SW	New to Five-Year Review
11.	C-746-K Landfill	SW	WAGs 1 and 7, SWMU 8
12.	Fire Training Area	SW	WAGs 1 and 7, SWMU 100
13.	Surface Water Interim Corrective Measures	SW	Surface Water Interim Corrective Measures
14.	C-749 Uranium Burial Ground	BG	WAG 22, SWMU 2
15.	C-402 Lime House	D&D	New to Five-Year Review
16.	C-405 Incinerator	D&D	New to Five-Year Review
17.	GWOU C-400 Electrical Resistance Heating	GW	New to Five-Year Review, currently underway
18.	D&D OU C-410 Infrastructure Removal	D&D	New to Five-Year Review, currently underway

BG = Burial Grounds
D&D = decontamination and decommissioning
GW = Groundwater
NSDD = North-South Diversion Ditch
OU = operable unit
SW = Surface Water
SWMU = Surface Water Operable Unit

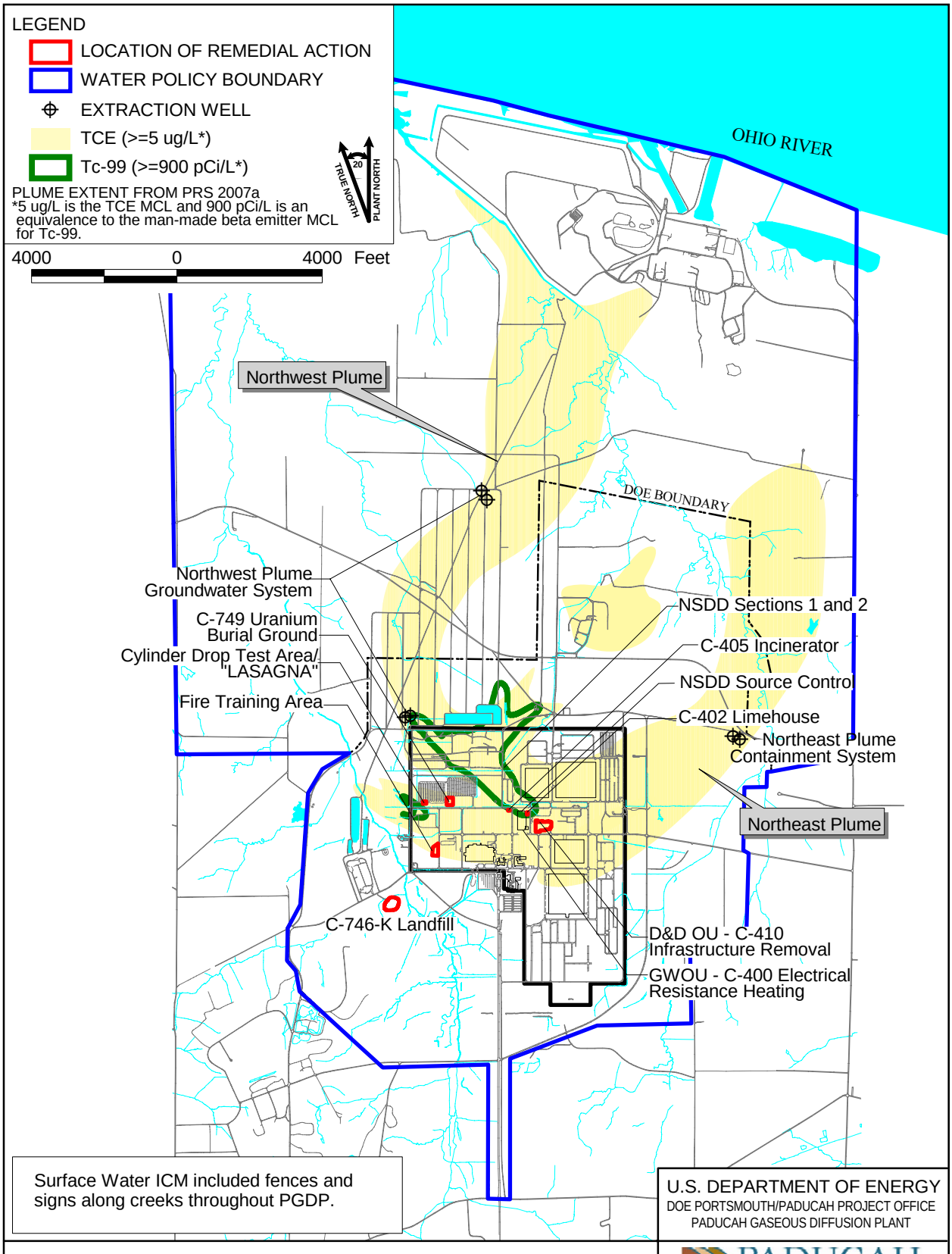

Figure 4.1. Locations of Remedial Actions Taken at PGDP

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5. NORTHWEST PLUME

After discovery of off-site contamination, DOE conducted a site investigation to identify the nature and extent of the contamination. The investigation determined that the groundwater contamination is spreading generally northward toward the Ohio River in multiple plumes. The most prominent of the plumes, containing both TCE and ^{99}Tc, is the Northwest Plume. Figure 5.1 illustrates the extent of the off-site plumes and the two extraction well (EW) fields installed for the Northwest Plume Groundwater System. Figure 5.2 is a comparison of the plumes between 1994 and 2005, which is the latest available plume map (PRS 2007a). The downgradient limit of the Northwest Plume is near the Ohio River and at seeps in Little Bayou Creek.

The 1998 Five-Year Review for this action included the following statements of protectiveness (DOE 1998a):

> The GWOU response actions taken to date at the PGDP are protective of human health and the environment. The combination of these actions minimizes the potential for local residents to be exposed to the contaminated groundwater and controls further migration of contaminants until a final remedial action for the GWOU is developed and implemented. These actions also generate valuable information and data that is being used to develop a final action for the GWOU.
>
> The Northwest Plume IRA is protective of human health and the environment. Since the action has controlled and limited migration of the high concentration portions of the Northwest Plume. The action also provides additional data needed to evaluate a final action for the Groundwater OU (GWOU). Although the Water Policy minimizes the potential threat to nearby residents by providing an alternate water supply, the Northwest Plume action further reduces threats by controlling off-site migration of the high concentration portions of the plume.

The 2003 Five-Year Review had the following statements of protectiveness for the Northwest Plume IRA (DOE 2003a):

> The operational data and the site inspection indicate that the mechanical components of the remedy are functioning as intended by the ROD. Persistent contaminant levels of approximately 100 µg/L TCE and 100 pCi/L ^{99}Tc in water samples from the east downgradient MW indicates that some dissolved contamination is bypassing the South EW Field. Moreover, 2002 contaminant level trends suggest that the high-concentration core of the Northwest Plume has persisted in migrating eastward and is now significantly bypassing the capture zone of the North EW Field. Continued monitoring over a period of one to two additional years is likely to provide a clear basis for assessing the effectiveness of the North EW Field. It should be noted, however, that this is an interim action that is working within the capabilities of the system, as it was designed. The assessment of the effectiveness of the EW Fields will be taken into consideration once a final remedy is decided.

The 2003 Five-Year Review also had a statement about the protectiveness of the Northwest Plume IRA that noted that the remedy was not effective. This appeared to be based on the fact that the northern part of the high concentration plume had migrated outside of the North EW field.

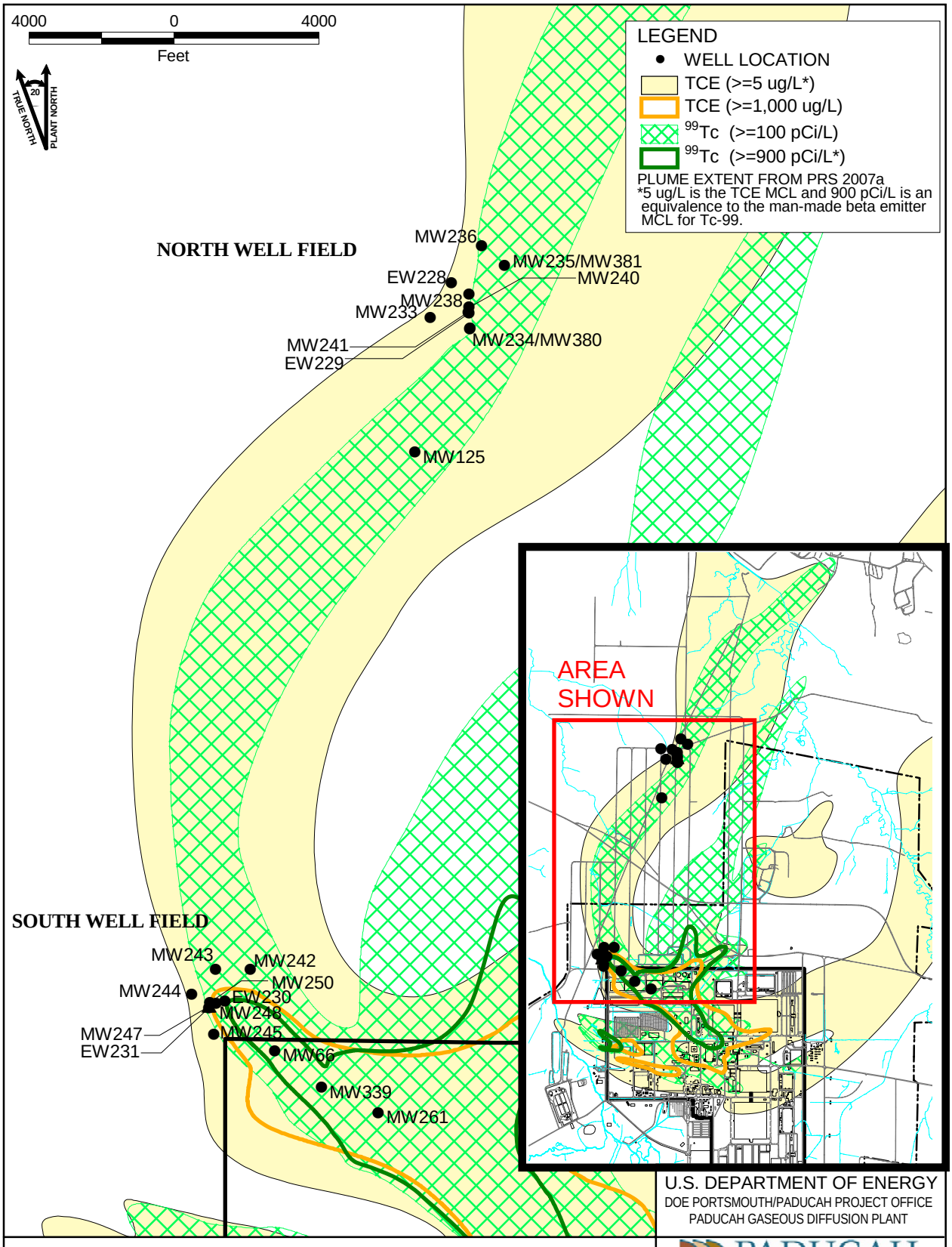

Figure 5.1. NW Plume EW Fields

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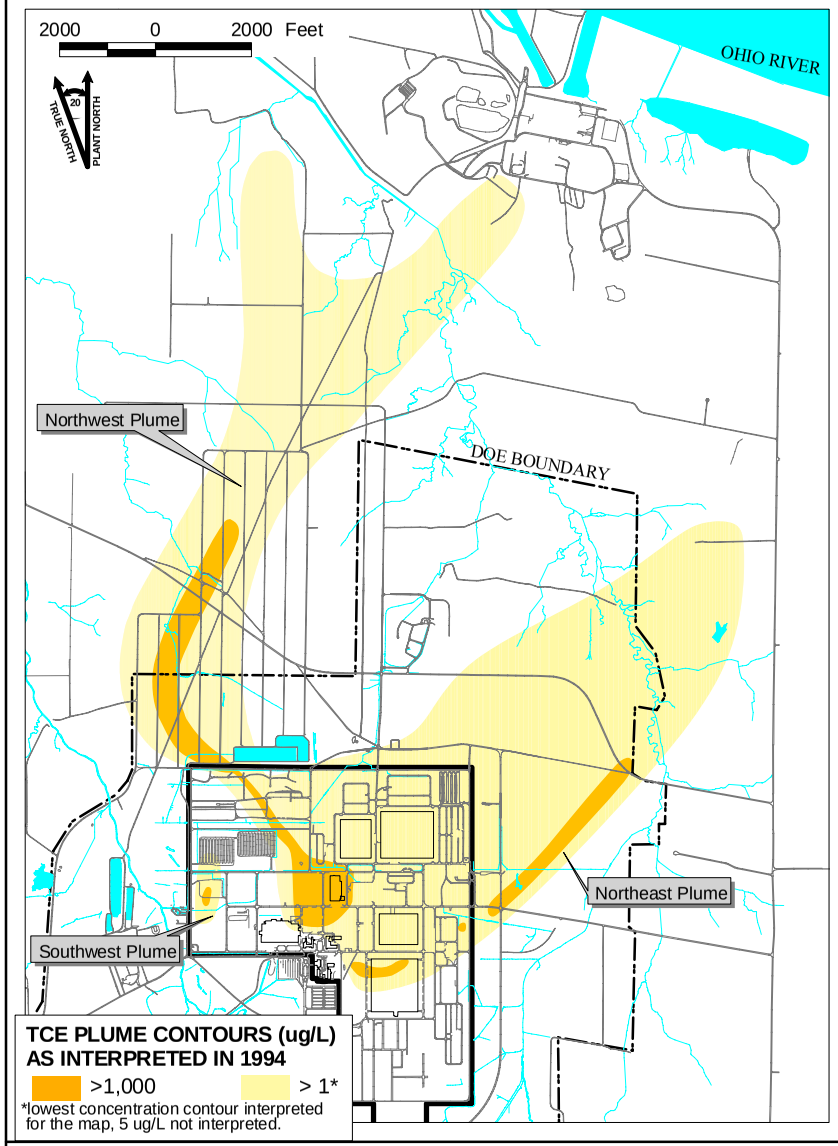

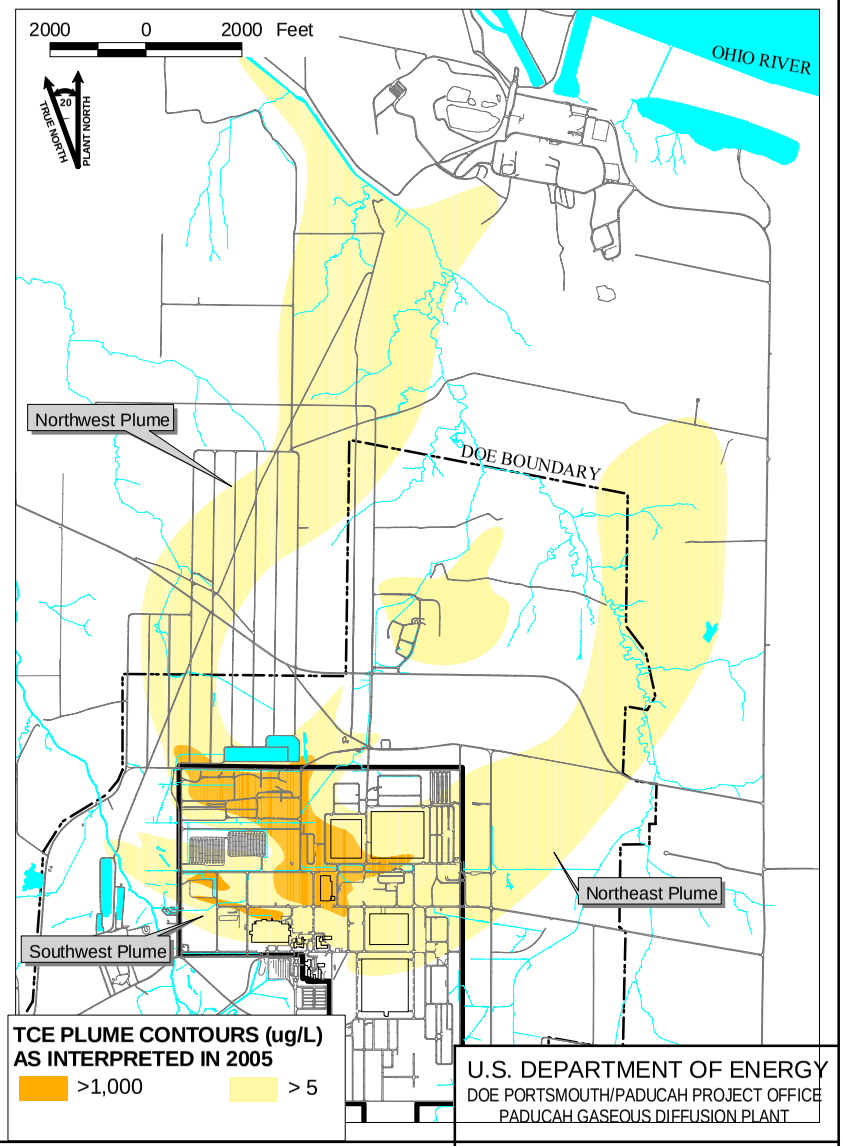

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Figure 5.2. TCE Plumes as Interpreted for 1994 and 2005

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5.1 REMEDY SELECTION

EPA and DOE, with the concurrence of the Commonwealth of Kentucky, agreed to a ROD for an IRA for the Northwest Plume on July 22, 1993 (DOE 1993a). This IRA consisted of the installation and maintenance of two EW fields for a period of two years to initiate control of the high-concentration zone of TCE and ^{99}Tc in the Northwest Plume. A water treatment facility was constructed to treat effluent from the EWs. The Northwest Plume Groundwater System has continued to operate since August 1995.

The *Record of Decision for Interim Remedial Action of the Northwest Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1993a) delineated the remedial action as follows:

> The contaminated groundwater will be extracted at two locations. The first location, immediately north of the plant on DOE property, is intended to control the source. The second groundwater extraction location is off-site of the DOE reservation at the northern tip of the most contaminated portion of the plume [greater than 1,000 µg/L of trichloroethylene (TCE)]. The contaminated groundwater will be pumped at a rate to reduce further contribution to contamination northwest of the plant without changing hydraulic gradients enough to mobilize dense nonaqueous-phase liquids (DNAPLs) or significantly affect other plumes. This pumping rate may be modified during operation to optimize hydraulic containment by adjusting flow from the extraction wells and to support subsequent actions.
>
> The extracted groundwater will be collected in a manifold and piped to the treatment system, which will consist of two ion exchange units in parallel followed by an air stripper with treatment for off-gas emissions. This technology provides the treatment to the COCs (TCE and ^{99}Tc). The target level for treatment of TCE is 5 ppb and 900 pCi/l for ^{99}Tc.
>
> The amount of treated water discharged will be limited by the flow capacity of the skid mounted treatment units. The treated water will be discharged through Kentucky Pollution Discharge Elimination System (KPDES) permitted Outfall 001.
>
> The interim action also includes implementation of a treatability study to evaluate an innovative technology. The innovative technology to be studied involves the potential utilization of iron filings as a viable alternative to pump-and-treat technology for groundwater treatment.
>
> The remedy does not address source remediation, however; the remedy will address continuing release from a DNAPL principal threat source area.

5.2 REMEDY IMPLEMENTATION

DOE signed the ROD for the Northwest Plume action on July 15, 1993, and EPA signed on July 22, 1993. The remedial action work plan and remedial design for the construction and implementation were completed January 18, 1994. The construction of the facility was performed in two phases. The first phase

was the installation of monitoring wells (MWs) and EW fields. The second phase of work was the installation of the treatment facility and all internal equipment, as well as subsurface pipelines to transport the contaminated water through the WKWMA to the treatment system. All of the construction was completed in May 1995, with calibration and operational preparedness through August 27, 1995. The Northwest Plume Groundwater System began pump-and-treat operations on August 28, 1995.

The interim action, as installed, includes the following:

- Four EWs and associated monitoring network with two EWs located at the north end of the high concentration zone and two EWs located immediately north of the plant;

- Double-walled subsurface pipelines with leak detection equipment to transport the contaminated water to the treatment facility;

- Active treatment equipment located in the facility including an equalization (EQ) tank, dual sand filter unit, low-profile air stripper, two double ion exchange units, and on-line volatile organic analyzer; and

- Support equipment installed in the facility including backwash, settling tank, sludge handling equipment, air compressor, and filter press.

DOE issued an *Explanation of Significant Differences for the Interim Remedial Action of the Northwest Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/06-1481&D2, in August 1996 that proposed modifying the original remedial action (DOE 1996a). The three propositions in the document were as follows: (1) elimination of the activated carbon filters, (2) reversal of the sequence of the two treatment units (ion exchange unit and air stripper), and (3) elimination of the iron filings treatability study (DOE 1996a). At that time, DOE determined that the remedy would remain protective of human health and the environment and would meet the applicable or relevant and appropriate requirements (ARARs) identified in the ROD and additional ARARs introduced by the modifications. Although removing the carbon filters would not result in violation of Clean Air Act standards, DOE withdrew its proposal to eliminate the carbon filters in response to public comments. The additional ARARs triggered by the reversal of the treatment units are identified in the Explanation of Significant Differences document, approved by EPA on November 18, 1996. The Northwest Plume remedial action continues to comply with these ARARs.

5.3 SYSTEMS OPERATIONS/OPERATIONS AND MAINTENANCE

Operations and maintenance (O&M) for the Northwest Plume Groundwater System are conducted in accordance with the *Operations and Maintenance Plan for the Northwest Plume Groundwater System Interim Remedial Action at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2005a). Routine and preventive maintenance is conducted in accordance with the *Paducah Plumes Operations Maintenance, Calibration, and Testing Plan* (PRS 2008).

Since initial operations, the frequency of repair to the system has been normal and routine. The Northwest Plume treatment system had processed 1,250,734,157 gal of water, as of December 31, 2007. Mass balance evaluations indicate that the treatment system has removed approximately 25,895 pounds (2,216 gal) of TCE at an operation cost of $25,143,194 by the end of December 2007.

The costs associated with the O&M of the Northwest Plume Groundwater System and the Northeast Plume Containment System (separate GWOU discussed in Chapter 6) are tracked jointly and have been

since Fiscal Year (FY) 2002. The cost for both systems for the five-year reporting period is $7,698,457, or an average of $1,539,691 per year. This cost is a total project cost that includes, but is not limited to, the following items:

- O&M of the systems
- Sampling and analysis
- Health and safety oversight
- Data management
- Technical reporting
- Financial tracking
- Groundwater model recalibration and reporting
- Regulatory document preparation

No major modifications to the treatment system were made during this reporting period (i.e., replacement of primary equipment). The activated carbon units are changed routinely due to contaminant loading. The pump and motors in EW228 and EW230 were replaced in 2004 and 2006, respectively. Additionally, the south extraction wells (EW230 and EW231) underwent well rehabilitation in 2005 to increase their pumping efficiency.

Concentrations of TCE and ^{99}Tc in both influent and effluent continue to be met as indicated from the latest semiannual reporting period of January 2007 to June 30, 2007 (see Table 5.1). The target concentrations for these contaminants are 5 ppb for TCE and 900 pCi/L for ^{99}Tc.

Table 5.1. Northwest Plume Groundwater System Influent and Effluent Concentrations

	TCE (µg/L)			^{99}Tc (pCi/L)		
	High	**Low**	**Average[a]**	**High**	**Low**	**Average[a]**
Influent	3,000	930	1,280	243	123	195
Effluent	3.3	ND[b]	1.9	27.8	ND	5.8

Data is taken from the DOE PGDP FFA Semiannual Progress Report for Fiscal Year 2007 (DOE 2007).
<MDL = Less than method detection limit and is used as 1 µg/L for calculations.
[a] Average is calculated as an arithmetic average, using the laboratory reporting limit for nondetects.
[b] Nondetect

On March 5, 2008, the Northwest Plume Pump-and-Treat Facility was inspected for this Five-Year Review. The facility includes the C-612 Treatment Facility, the South EW Field, and the North EW Field. The treatment facility and the South EW Field are located just outside the northwest corner of the perimeter fence of PGDP, but within the security buffer zone around the plant. The North EW Field is located approximately one mile north of the treatment facility within the WKWMA.

The C-612 Treatment Facility is a pre-engineered metal building with one vehicular entrance and two pedestrian entrances. The exterior of the building appears in good condition with no signs of damage, rust, or deterioration. The area around the building is maintained well, including mowing and weed trimming. A chain-link security fence that is in good condition encloses the building.

All treatment process equipment is located within the building. Groundwater treatment equipment inside includes a sand filter unit, an air stripper and carbon filtration unit, and four ion exchange columns. The interior of the building is clean, free of clutter and debris, and maintained well. Access-controlled areas within the building are clearly marked and identified. Process piping in the facility is identified properly as to content and flow direction, adequately supported, and in a well-maintained condition. There were no signs of leaks or deterioration. Process control panels are maintained well with all components clearly

identified and labeled. All electrical power and control panels are labeled properly. The building contains a wet-type fire sprinkler system that is inspected and tested regularly by the PGDP Fire Services Department, as evidenced by the system inspection tags.

The Northwest Plume IRA treatment system has continued to operate as intended during the 2002-2007 period. This ROD action is reducing contaminant concentrations in the Northwest Plume, but could be more effective by idling the North EW Field while increasing the pump rate of the South EW Field. The action described in the ROD is not intended or expected to return groundwater quality to maximum contaminant levels (MCLs).

5.4 TECHNICAL ASSESSMENT

The primary objective of the Northwest Plume IRA is to initiate an action to mitigate the spread of contamination in the Northwest Plume.

5.4.1 Question A: Is the Remedy Functioning as Intended by the Decision Documents?

Reviews of documents, applicable or relevant and appropriate requirements (ARARs), risk assumptions, groundwater monitoring data, and the results of the site inspection all indicate the following about the Northwest Plume Extraction System:

- The South EW Field is functioning as was intended in the ROD;
- The North EW field is capturing contaminants as was intended in the ROD; however, there is a possibility that the high TCE concentration of the Northwest Plume may have migrated.
- The treatment system is functioning as designed.

The North and South EW Fields have continued to operate nearly continuously since the start of pumping on August 28, 1995. Influent and effluent monitoring of the aboveground groundwater treatment system shows that the treatment system is reducing the contaminant levels of the extracted water to levels that are approved for release to surface water.

The primary concern with regard to the EW fields is the extent of the zones of capture. For the South EW Field (EW230 and EW231) (see Figure 5.1), groundwater analyses for TCE and ^{99}Tc from the MW system demonstrate that the EWs have reduced contaminant levels in the RGA and that these reduced levels persist. Table 5.2 summarizes contaminant analyses for late 1995, when groundwater extraction began, compared with 2007 levels.

Table 5.2. Summary of Contaminant Levels at the South EW Field

	TCE Concentration (µg/L)		Reduction in	^{99}Tc Activity (pCi/L)		Reduction in
Well	Late 1995	2007	Concentration	Late 1995	2007	Activity
MW242	530	96-150	Yes	202	58-110	Yes[a]
MW243	13,500	100-590	Yes	1,948	ND[b]	Yes
MW244	3,600	2-71	Yes	1,948	54	Yes
MW248	14,000	110-2,100	Yes	3,500	ND-303	Yes
MW250	13,300	5-8	Yes	3,358	ND-48	Yes
MW245[c]	28	120-140	No	26	ND	Yes

[a] ^{99}Tc levels have declined; however, the association of the decline and groundwater extraction is not obvious.
[b] Nondetect
[c] Upgradient well

For the years 1998 through 2007, MW261 and MW339, located in the core of the Northwest Plume and far upgradient of the South EW Field, continued to yield water with elevated levels of TCE (10,000 to 40,000 µg/L) and ^{99}Tc (1,500 to 6,000 pCi/L) (see Figure 5.3). During the same period, MW244 and MW250, located proximally to the south EWs at crossgradient and downgradient positions, experienced greatly reduced contaminant levels (typically 30 µg/L or less TCE and 60 pCi/L or less ^{99}Tc (Figure 5.4). Meanwhile, contaminant levels in the remote downgradient wells (MW242 and MW243, located approximately 350 ft north of the south EWs) (see Figure 5.5) persisted at higher levels than those of MW244, and MW250, but at levels significantly reduced from those of upgradient MW261 and MW339. Moreover, the current contaminant levels in MW242 and MW243 are significantly less than those that were present prior to the initiation of pump-and-treat. These data trends suggest that the south EWs are reducing contaminant levels in the core of the Northwest Plume, as intended by the ROD.

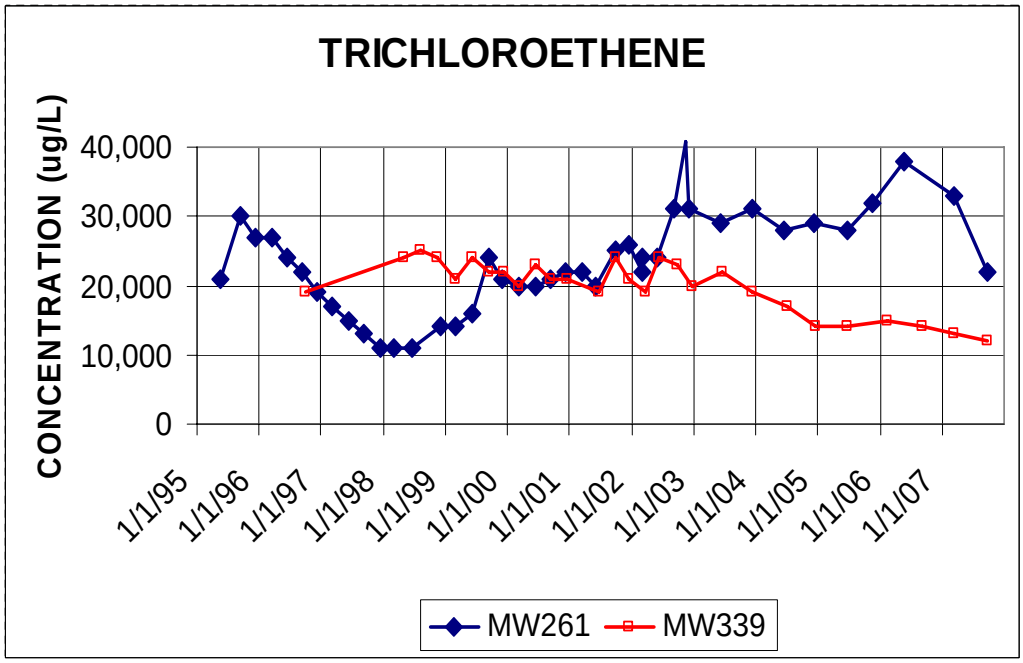
Contaminant levels in MW248, located midway between the two south EWs, are significantly less than those of upgradient MW261 and MW339. Enough data now exist to show that MW248 monitors the same groundwater flow path as upgradient MW66 (Figure 5.6). MW66 is thought to monitor contamination leaching from the C-747-A Burial Ground (SWMU 7) and the C-747-A Burn Area (SWMU 30). This contamination is not related to the high concentration core of the Northwest Plume, which originates from the C-400 Cleaning Building. Monitoring data for the North EW Field (pumping wells EW228 and EW229) (see Figure 5.1) show evidence of two distinct periods of contaminant level trends. Both TCE and ^{99}Tc trends for the period late 1995 through 1997 demonstrate that the North EW Field was reducing the high-concentration core of the Northwest Plume. Contaminant trends for the 1997 through 2007 period are less consistent (Table 5.3).

Table 5.3. Summary of Contaminant Levels in the Area of the North EW Field

Well	Late 1995[a] (Start of Pumping) TCE (µg/L)	Late 1995[a] (Start of Pumping) ^{99}Tc (pCi/L)	Trends 1995-1997	Trends 1998-2007	Calendar Year 2007 TCE (µg/L)	Calendar Year 2007 ^{99}Tc (pCi/L)
MW235/ MW381	900	570	Sharp decline with start of pumping.	Abrupt rise mid-1998–2002 followed by near- steady decline	47-83	ND[b]–26
MW236	1,470	936	Sharp decline with start of pumping.	Abrupt rise mid-1998–2002 followed by near- steady decline	21-72	ND–29
MW238	1,500	948	Sharp decline with start of pumping.	Continuation of overall decline	7-21	ND
MW240	1,400	846	Overall decline (started before pumping).	Continuation of overall decline	4-13	ND
MW233[c]	810	320	Spike in early 1996, then decline.	Sharp drop in early 1998 followed by near-steady decline	5-6	ND
MW234/ MW380[c]	610	394	Overall rise.	Abrupt rise mid-1998–2002 followed by near-steady decline	45-87	ND–45

[a] **Maximum contaminant levels during September through December 1995 period**
[b] ND = nondetect
[c] Upgradient

Contaminant trends in the upgradient MWs are the opposite of trends in the east well (MW234) and west well (MW233) at the North EW Field (Figure 5.7). The range of contaminant levels was approximately equal on the east and west sides from 1995 through 1997. In early 1998, contaminant levels rapidly increased on the east side of the North EW Field and declined on the west side. These trends suggest that a possible migration of the high-concentration core of the Northwest Plume may have begun.



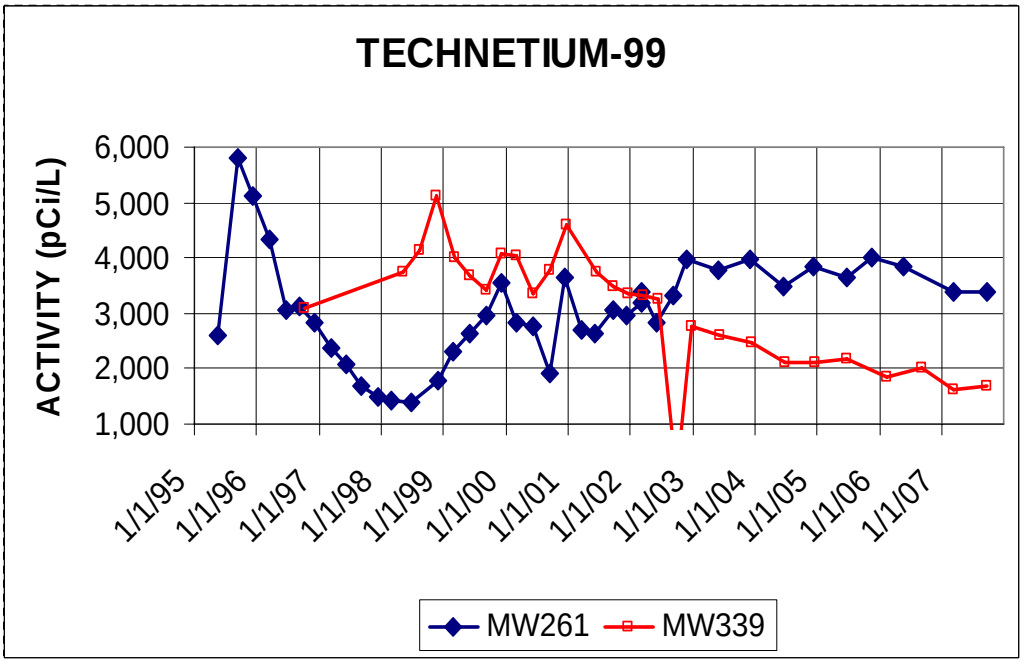


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Figure 5.3. Contaminant Trends in Far Upgradient MW261 and MW339

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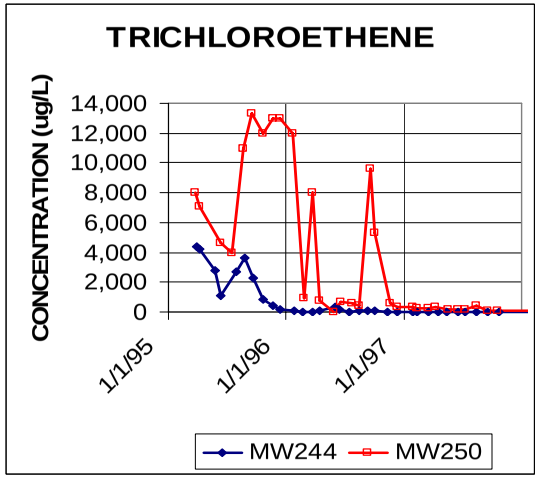

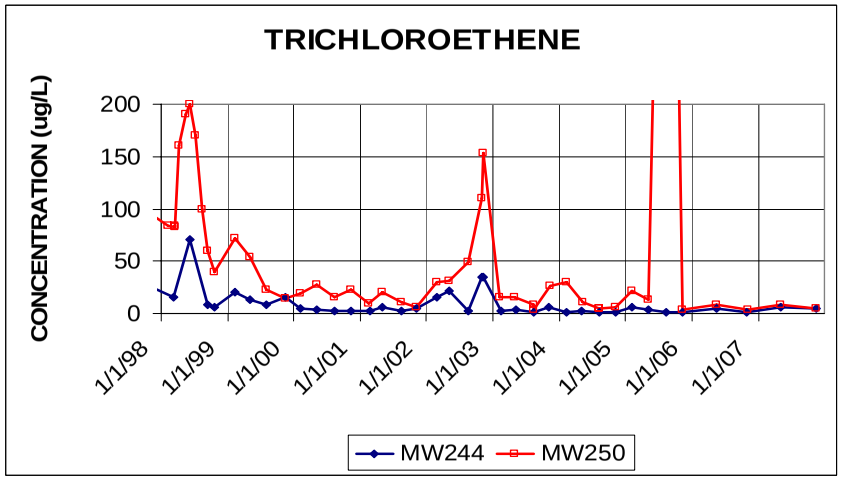

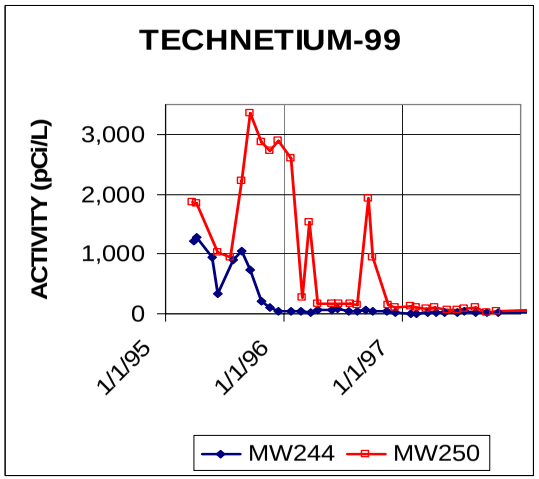

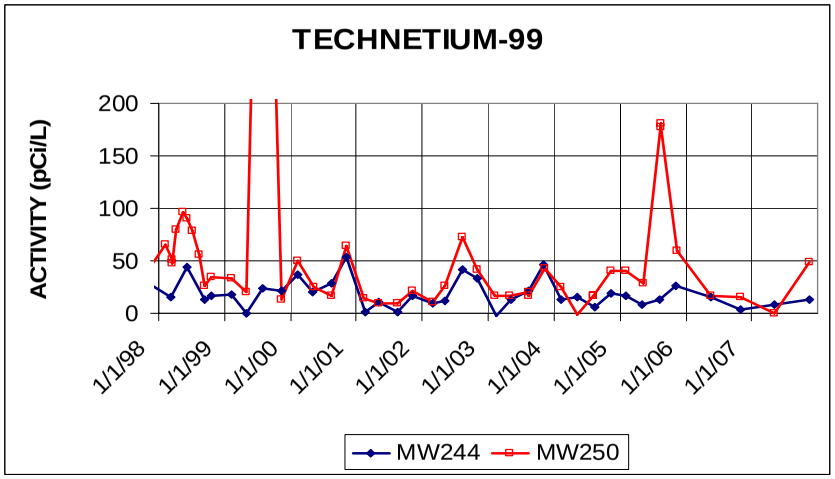

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Figure 5.4. Contaminant Trends in Proximal MW244 and MW250

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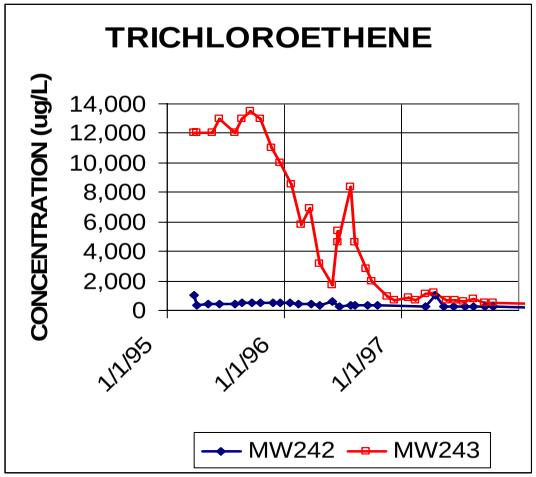

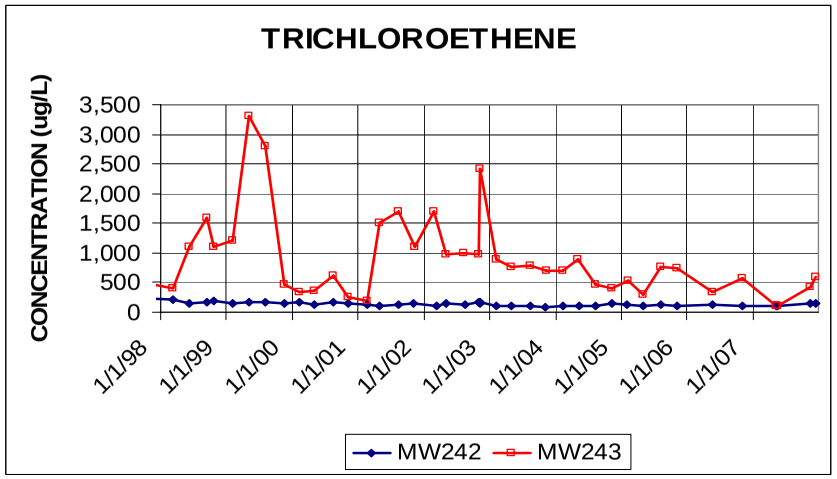

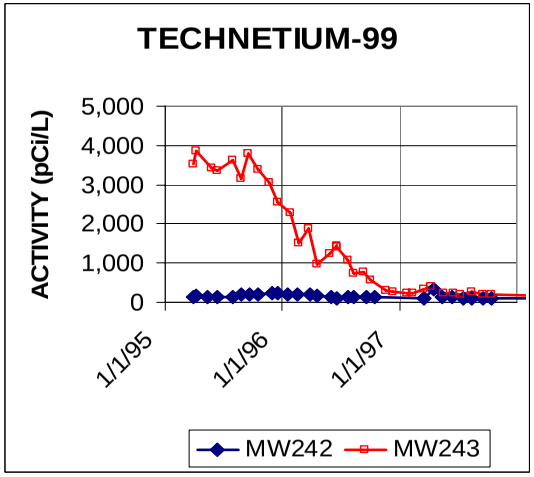

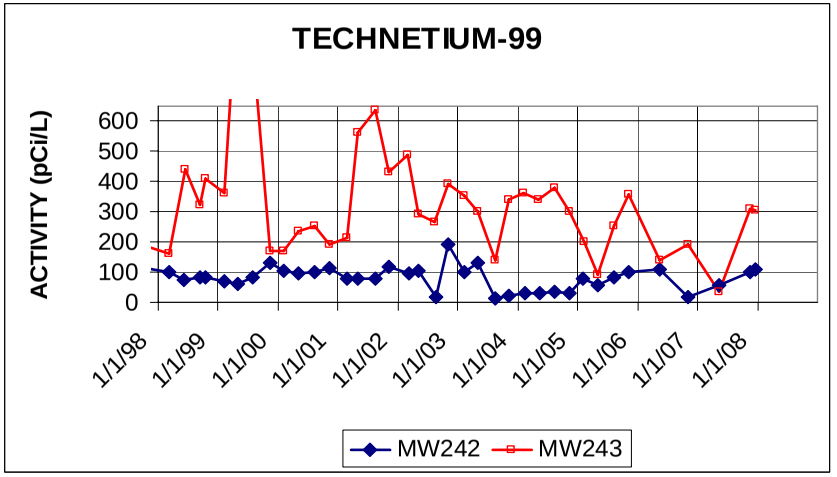

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Figure 5.5. Contaminant Trends in Distal Downgradient MW242 and MW243

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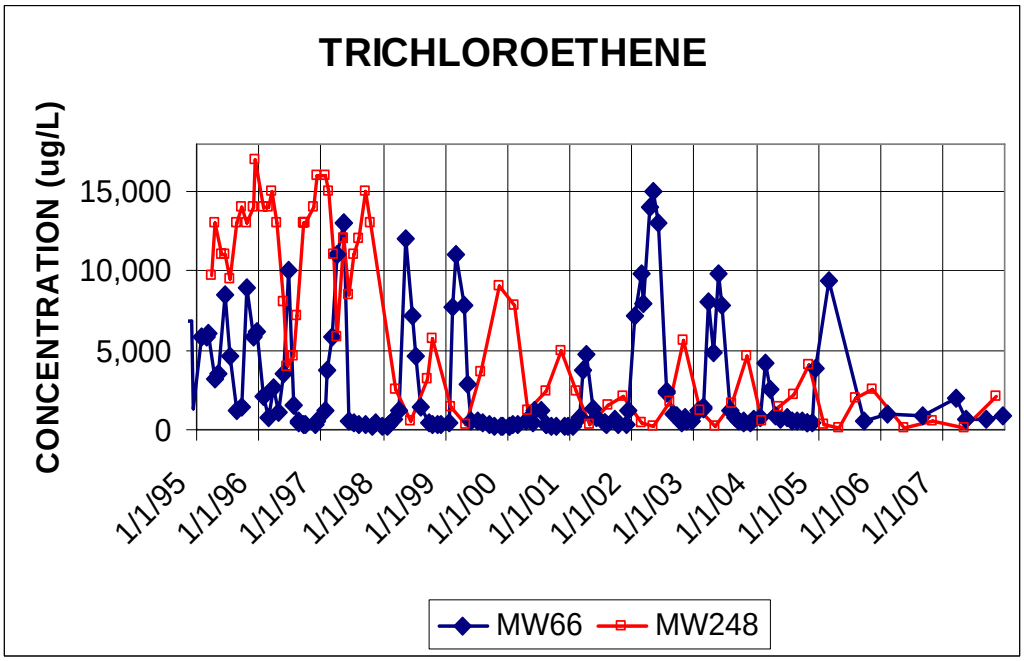

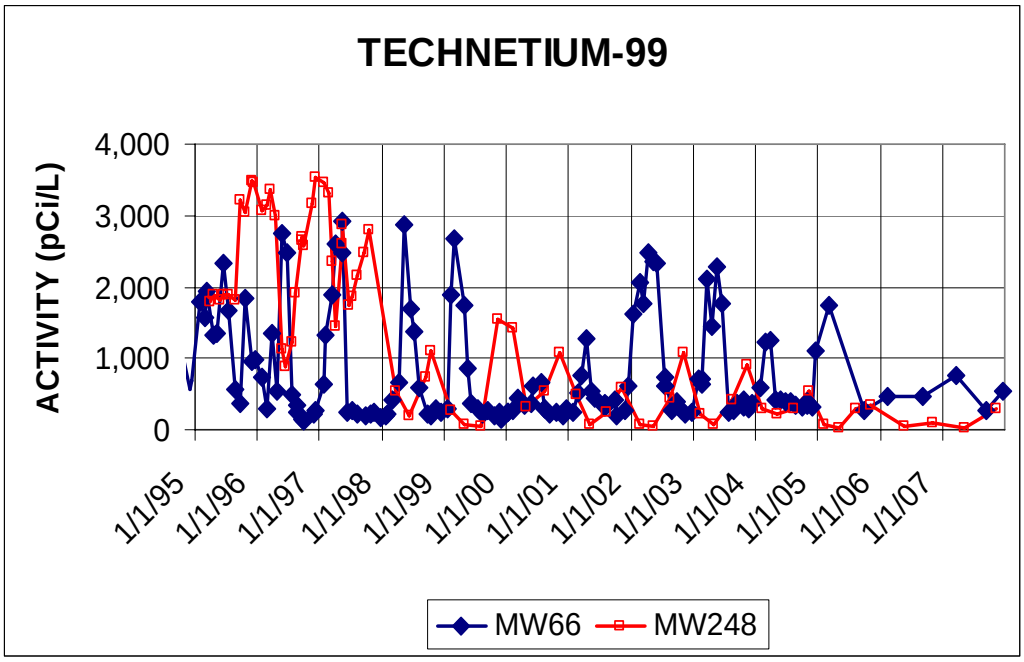

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Figure 5.6. Contaminant Trends in Upgradient MW66 and MW248

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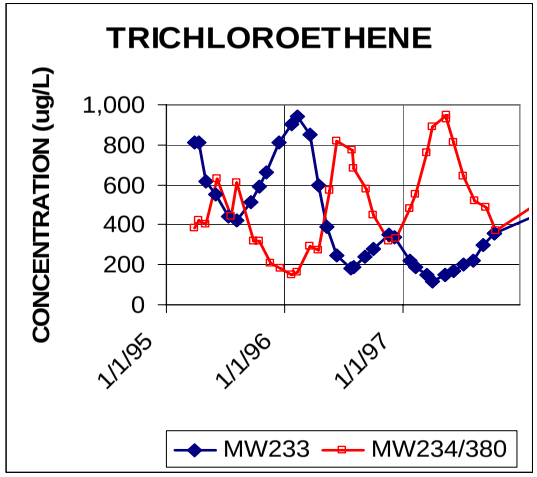

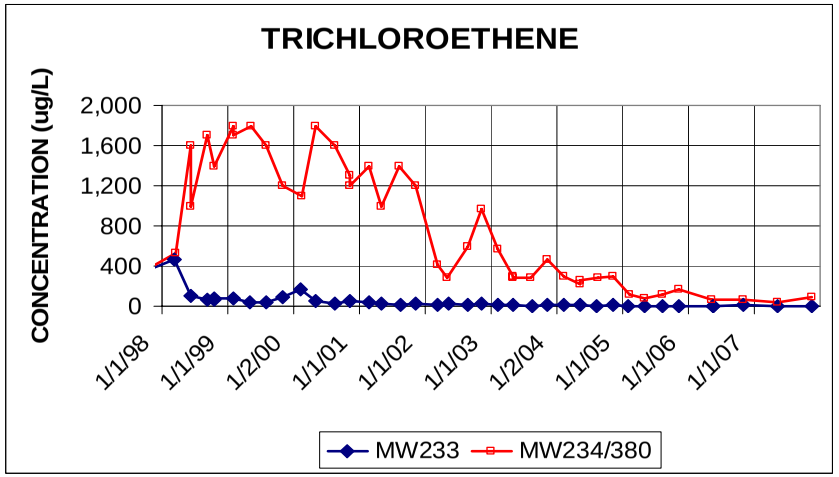

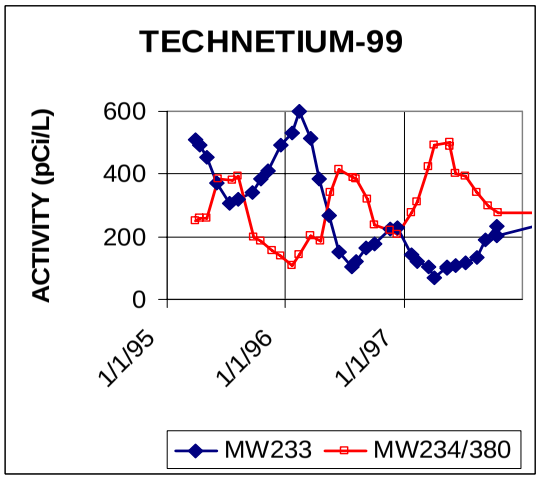

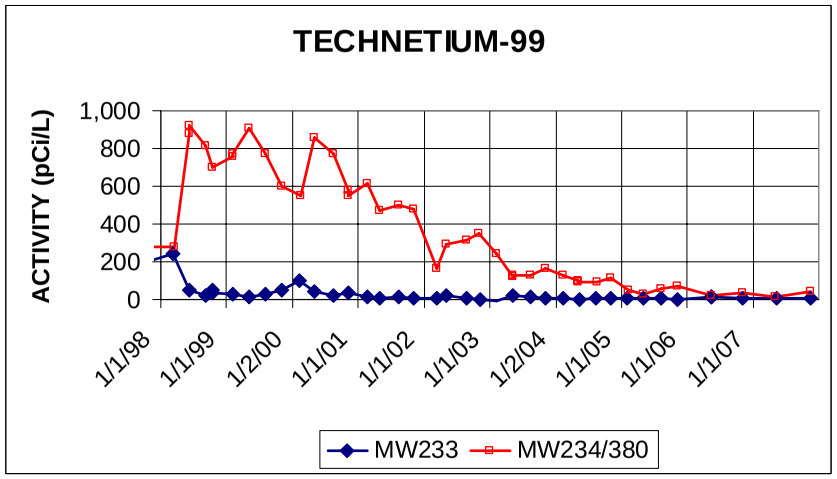

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Figure 5.7. Contaminant Trends in Upgradient MW233 and MW234

A comparison of contaminant trends for the period early 1998 through 2001 between upgradient MW234 (1,000 to 1,800 µg/L TCE and 473 to 924 pCi/L ^{99}Tc) and downgradient MW238 and MW240 (83 to 1,200 µg/L TCE and 33 to 693 pCi/L ^{99}Tc) (see Figure 5.8) demonstrates a significant reduction in contaminant levels due to the EWs. For the same period, comparable contaminant levels in MW234 and remote downgradient MW235 and MW236 (600 to 1,800 µg/L TCE and 150 to 816 pCi/L ^{99}Tc) (Figure 5.9) indicate that at least part of the high-concentration core of the Northwest Plume was bypassing the North EW Field on the east side; thus, while the North EW Field continued to capture some of the core of the Northwest Plume, it was allowing some groundwater with TCE concentrations greater than 1,000 µg/L to continue to migrate northward.

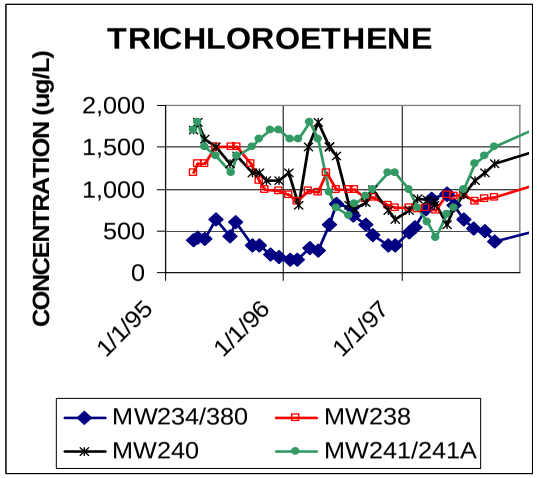
Contaminant levels of the North EW Field during 2002 experienced a significant decline in upgradient MW234/380, proximal downgradient MW238 and MW240, and remote downgradient MW235/381 and MW236, while remaining very low (below 25 µg/L TCE and 25 pCi/L ^{99}Tc) in MW233. During the same year, TCE and ^{99}Tc levels rose in MW125 (located approximately 1,300 ft to the southwest of the North EW Field) to comparable levels observed in MW234/380, MW235/381, and MW236 (Figure 5.10). The overall trend since 2002 has been a continuous decline of contaminant levels in MW234/380, MW235/381, and MW236 and sustained high levels in MW125. These trends (and trends in other wells of the downgradient Northwest Plume) document the possible eastward migration of the core of the Northwest Plume. The core of the Northwest Plume no longer passes through the North EW Field. The highest levels of contamination observed in the MWs of the North EW Field in 2007 were 87 µg/L TCE and 45 pCi/L ^{99}Tc (both in groundwater samples of upgradient well MW234/380). Meanwhile, contaminant levels in the core of the off-site Northwest Plume during 2007 were as high as 700 µg/L TCE and 220 pCi/L ^{99}Tc, as measured in samples from MW125.

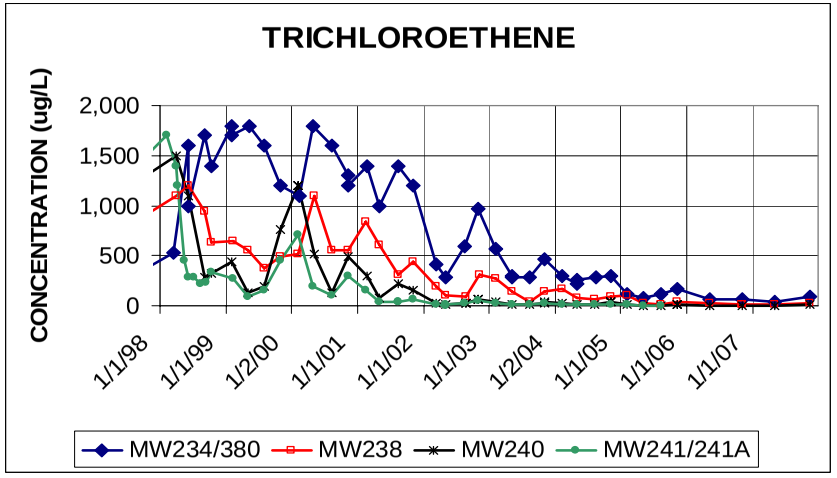
5.4.2 Question B: Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and RAOs Used at the Time of the Remedy Selection Still Valid?

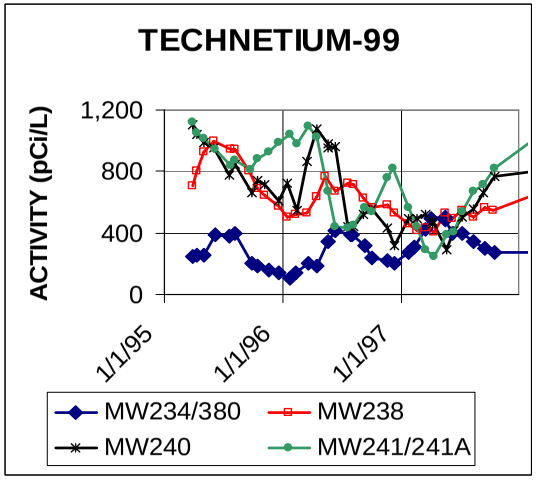
The Northwest Plume ROD does not document or reference specific exposure assumptions, toxicity data, cleanup levels, or remedial action objectives (RAOs). The ROD was supported by a Public Health and Ecological Assessment (PHEA). Risks were calculated in the PHEA using standard exposure equations. TCE and ^{99}Tc are listed as the primary contaminants, with greater emphasis on TCE, which had an associated MCL of 5 µg/L. Toxicity factors for these contaminants have changed since the issuance of the ROD; however, these revisions have not invalidated the remedy selection since the remedial action is only an interim measure. Cleanup levels and the RAOs are not specifically stated because the principal goals of this interim action are to decrease the risk by mitigating the spread of the high concentration portion of the Northwest Plume, retarding the migration of the contaminants emanating from the source area. Prior to the implementation of the final remedial action, a baseline risk assessment will be conducted on the GWOU.

5.4.2.1 Changes in standards and to be considered guidance

The ROD does not address final cleanup levels for the groundwater; however, the treatment system effluent meets all federal and state surface water quality standards. Additionally, the air stripper is designed to meet the federal and state air quality standards, and the treated groundwater has met the KPDES discharge requirements. The appendix lists the ARARs (chemical-specific, location-specific, and action-specific) that are applicable to the Northwest Plume ROD. There have been no changes in these ARARs, and there have been no new standards added to the "to be considered" guidance (TBC) affecting the protectiveness of the remedy.







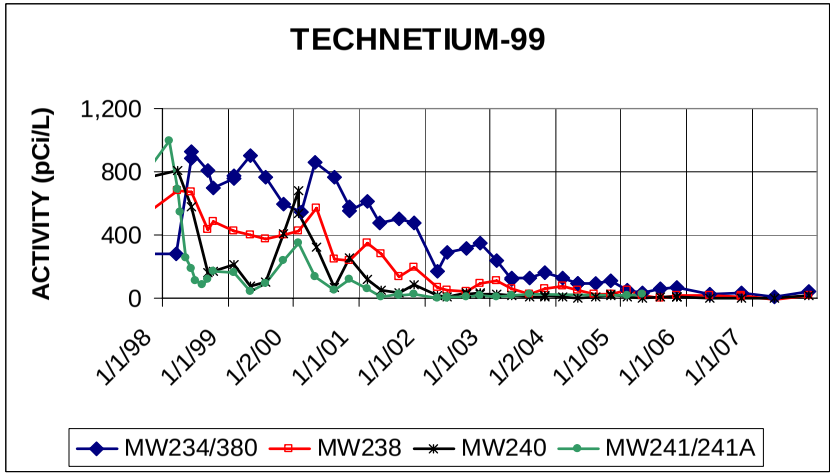


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Figure 5.8. Contaminant Trends in Upgradient MW234 and Downgradient MW238, MW240, and MW241

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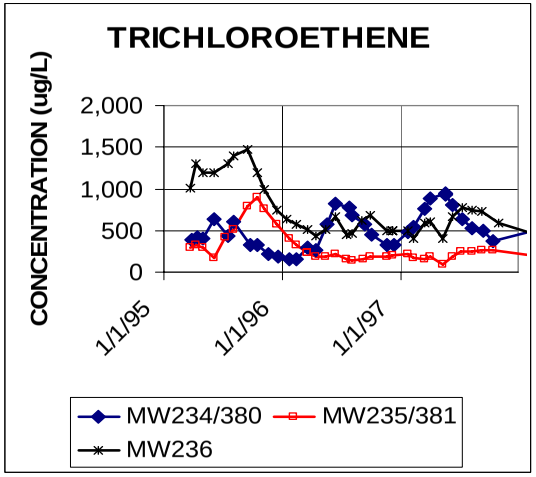

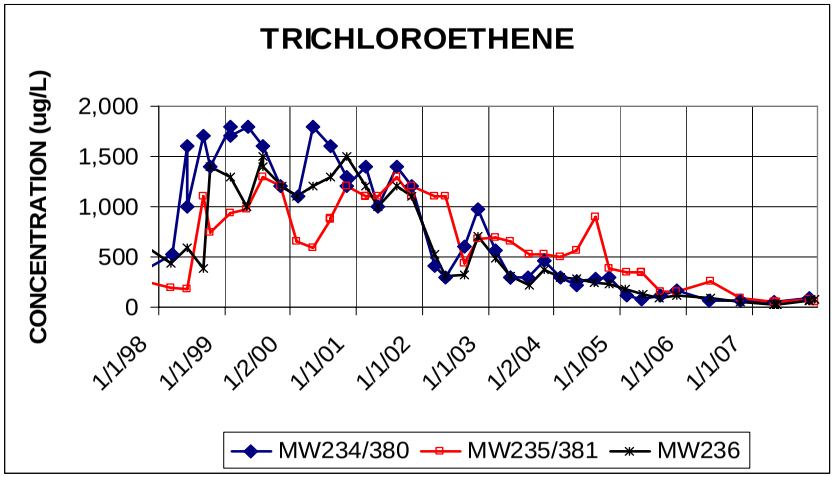

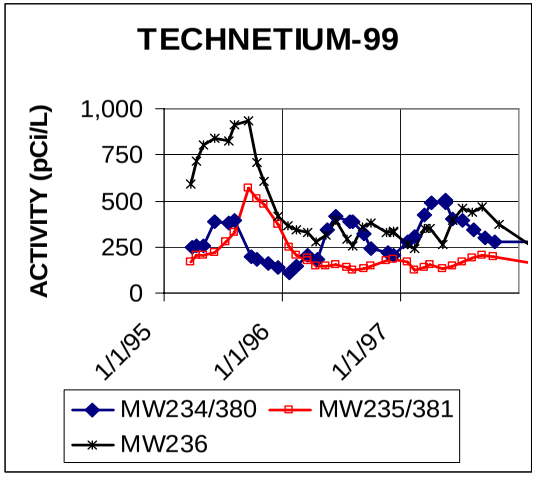

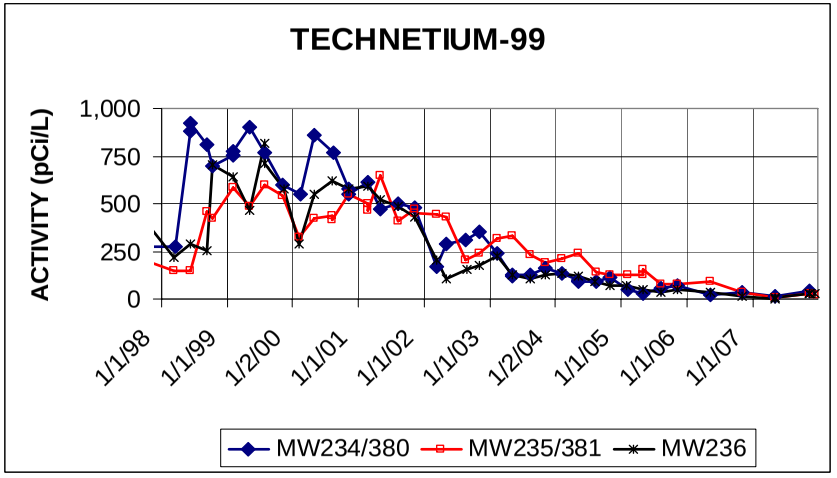

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Figure 5.9. Contaminant Trends in Upgradient MW234 and Remote Downgradient MW235 and MW236

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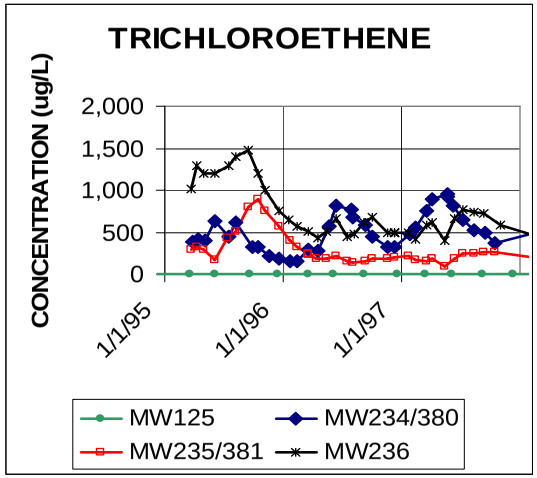

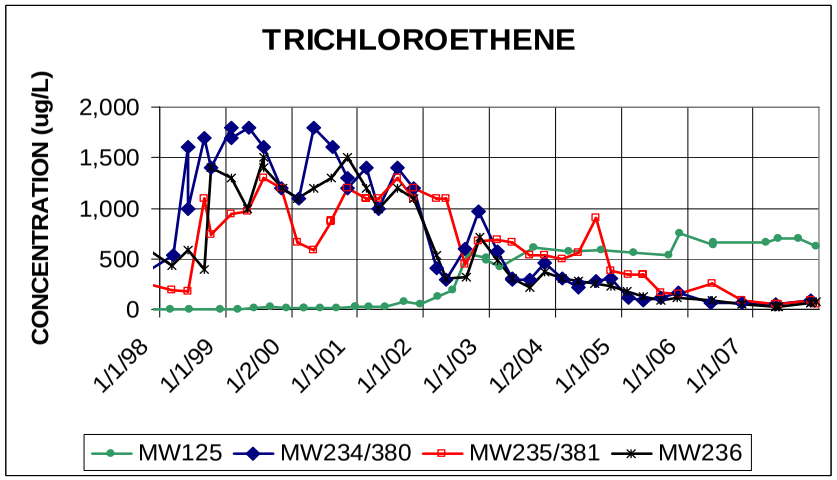

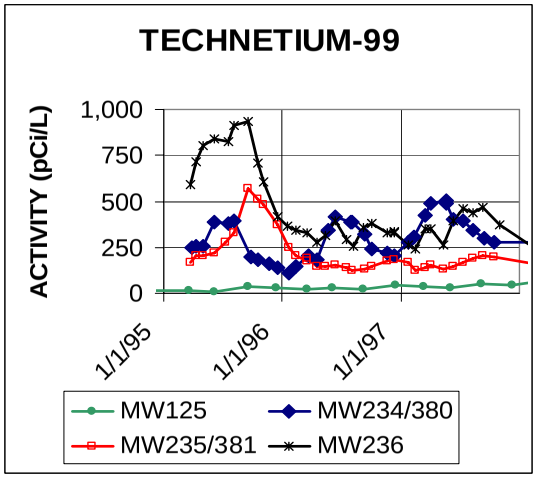

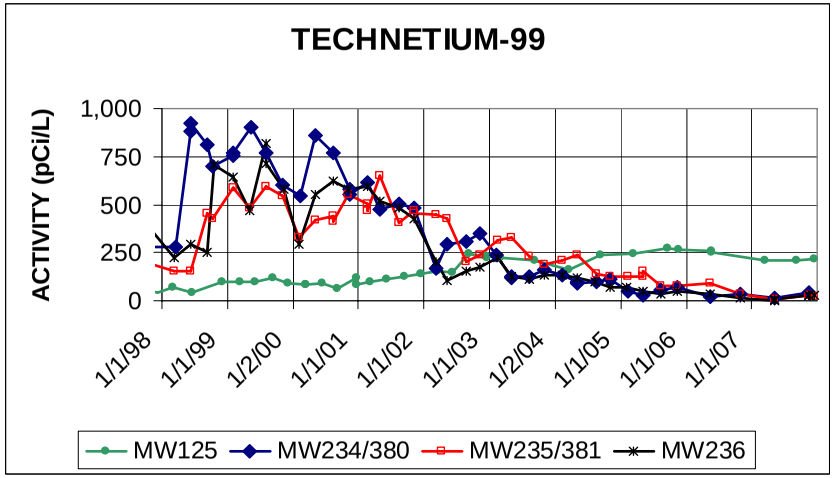

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Figure 5.10. Contaminant Trends in Distal Upgradient MW125 and MW234, MW235, and MW236

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5.4.2.2 Changes in exposure pathways, toxicity, and other contaminant characteristics

The Northwest Plume ROD does not document or reference specific exposure assumptions, toxicity data, cleanup levels, or remedial action objectives (RAOs). The ROD was supported by a PHEA using standard exposure equations. TCE and ^{99}Tc are listed as the primary contaminants, with greater emphasis on TCE, which had an associated MCL of 5 µg/L.

The ROD does not document or reference specific exposure pathways, toxicity, or other contaminant characteristics; however, the guidelines used by a risk assessor today are different from the ones that were in effect at the time the ROD for the Northwest Plume was prepared. The toxicity factors for the contaminants in the Northwest Plume have changed. Particularly, the toxicity of radionuclides in the human body and the environment is thought to be greater now than it was when the ROD for the Northwest Plume was prepared. Moreover, the guidelines have increased the values used for exposure pathways, and risk calculations have changed. These revisions have not necessitated a new ROD because the remedial action is an interim measure only; this remedial action never was intended to reduce groundwater contaminants to levels that would result in a total incremental risk being less than one in one million.

5.4.3 Question C: Has Any Other Information Come to Light That Could Call into Question the Protectiveness of the Remedy?

No.

5.4.4 Technical Assessment Summary

The operational data and the site inspection indicate that the mechanical components of the remedy are functioning as intended by the ROD. Persistent contaminant levels of approximately 100–800 µg/L TCE and 100–400 pCi/L ^{99}Tc in water samples from the downgradient MWs indicate that some dissolved contamination may be bypassing the South EW Field. Moreover, 2007 contaminant level trends indicate that the high-concentration core of the Northwest Plume may be migrating eastward and is bypassing the capture zone of the North EW Field.

The MWs in the vicinity of the North EW Field and downgradient portions of the Northwest Plume, with the exception of MW125, may not be correctly located to assess contaminant trends in the core of the plume. Monitoring data document that a core of dissolved contamination (TCE levels of 300 to 700 µg/L and ^{99}Tc levels of 100 to 300 pCi/L) extends through the area of MW125 to Little Bayou Creek, in the area of seeps LBSP-5 and LBSP-6. The existing MW network results may not provide sufficient data to define the boundaries of the east side of the core of the downgradient Northwest Plume. Evaluation of the current MW program is needed. The location and number of additional MWs is dependent on future operation of the North EW Field.

In 2006 a team of experts visited PGDP to make recommendations on optimizing the groundwater remedial system performance. The team made two recommendations that DOE committed to include in this Five-Year Review. The two recommendations are as follows:

<u>Investigate Possible Source(s) near SWMU 30 and 7</u>

The TCE concentrations in wells MW66 and MW248 vary significantly at frequent and irregular intervals. This spiking behavior suggests significant local contaminant sources(s), which release contaminant and/or change plume structure in response to seasonal and climactic variations. The observed contaminant concentration behavior in the upper RGA is likely associated with nearby facilities

in the overlying UCRS, such as the waste disposal facilities in PGDP SWMUs 7 and 30. The presence of a continuing source of variable contaminant concentrations in the vicinity of the Northwest Plume extraction system will affect the operation of the treatment plant.

Modify Northwest Plume Well Extraction System

Over time, the TCE concentration in water extracted from wells in the North well field have declined from approximately 1,000 ug/L to approximately 10-50 ug/L. A potential explanation for the concentration reductions at the northern extraction wells is the mass reduction provided by the southern extraction wells. Another potential explanation is a shift in the core of the TCE plume over time such that the northern extraction wells are no longer in the zone of highest concentration. Because of the reduction, the review team recommended terminating the extraction at the two northern extraction wells and increasing total extraction in the vicinity of the southern extraction wells by an equal amount. This change will increase contaminant mass removal and enhance capture near the southern extraction wells, which are closer to the contaminant sources. This also was expected to result in a decrease of downgradient contaminant concentrations, including the seeps at Little Bayou Creek. Additionally, extra extraction wells may be added so that the maximum flow rate into the treatment facility is maintained as constantly as possible.

5.5 ISSUES

The Northwest Plume IRA consists of groundwater extraction at two locations. The South EW Field is intended to control the source of groundwater contamination to the Northwest Plume immediately north of the PGDP main plant boundary. The North EW Field is intended to reduce further contribution to contamination northwest of the plant at the northern tip of the most contaminated portion of the plume.

Although the remedy remains protective, the action could be optimized by ascertaining whether the high-concentration core of TCE of the Northwest Plume at the North Extraction Well Field has migrated eastward of the capture zone of the well field.

Following is a summary of specific issues related to the MW network and EWs:

Monitoring Well Network

South Well Field - PGDP's existing MW program is adequate for assessing contaminant trends associated with the South EW Field.

North Well Field - The MWs in the vicinity of the North EW Field and downgradient portions of the Northwest Plume, with the exception of MW125, may not be correctly located to assess contaminant trends in the core of the plume. Additional MWs may be needed. The location and number of additional MWs is dependent on future operation of the North EW Field.

Downgradient Plume - MWs may not be appropriately located to assess contaminant trends in the downgradient extent of the plume.

Plume Bypassing Extraction Well Fields

North Well Field - The high-concentration core of the Northwest Plume at the North EW Field has possibly migrated eastward and may be bypassing the capture zone of the North EW Field. Monitoring data suggests that a core of dissolved contamination (TCE levels of 300 to 700 μg/L and ^{99}Tc levels of 100 to

300 pCi/L) extends through the area of MW125 to Little Bayou Creek, in the area of seeps LBSP-5 and LBSP-6.

6. NORTHEAST PLUME

After the initial discovery of contamination at PGDP in August 1988, DOE conducted a site investigation to determine the extent of contamination. Results of a follow-up groundwater monitoring Phase IV investigation presented in the *Northeast Plume Preliminary Characterization Summary Report* delineated numerous plumes within the RGA that coalesce to form the Northeast Plume (DOE 1995c). One of these plumes is a zone of high TCE concentrations (TCE concentrations exceeding 1,000 µg/L) that emanates from the eastern portion of the plant and extends off DOE property. Figure 4.1 depicts the aerial extent of the Northwest and Northeast plumes based on the latest approved plume map from 2005.

The 1998 Five-Year Review for this action included the following statements of protectiveness (DOE 1998a):

> The GWOU response actions taken to date at the PGDP are protective of human health and the environment. The combination of these actions minimizes the potential for local residents to be exposed to the contaminated groundwater and controls further migration of contaminants until a final remedial action for the GWOU is developed and implemented. These actions also generate valuable information and data that is being used to develop a final action for the GWOU.
>
> Monitoring data indicates declining concentration trends in the Northeast Plume. However, due to the timing of this review, the DOE has only 2.5 years of quarterly monitoring data to assess the effectiveness of the action. While the DOE believes the action is effective and will meet remedial objectives, a complete evaluation can be made after a full five years of operation. If the declining concentration trends continue at the Northeast Plume, the DOE will determine the action to be meeting its limited interim objectives. Because monitoring data presently is indicating declining concentrations in the plume, the DOE concludes that the action is protective of human health and the environment, since off-site migration is being reduced and the Water Policy prevents human exposure to the contaminated groundwater. The Northeast Plume IRA also provides valuable data needed for evaluating a final action for the GWOU.

The 2003 Five-Year Review states the following:

> The review of data and the site inspection indicate that the remedy is functioning as described in the ROD. There have been no changes in the physical conditions of the site that would affect the benefit of the remedy. Although the remedy is an interim measure and is not intended to return the Northeast Plume to MCL levels, the action inherently benefits downgradient areas by limiting the advance of the plume.

6.1 REMEDY SELECTION

Because of the risks to future off-site residents, DOE initiated an IRA for the Northeast Plume. DOE signed the Northeast Plume ROD June 13, 1995; EPA signed June 15, 1995 (DOE 1995b). The KDEP conditionally concurred with the selected remedy June 5, 1995. The ROD identified the selected remedy, outlined the performance objectives, and provided rationale for the remedy selection. The ROD stated the objectives as follows: "Implementation of this interim remedial action will (1) initiate hydraulic control of the high concentration area of TCE contamination within the Northeast Plume that is migrating outside the eastern margin of the plant security fence, and (2) monitor the performance of this interim remedial

action in order to track contaminant migration and assess the system's performance prior to development of a final remedy."

The major components of the selected RA included the following:

- Installation of extraction wells and pumps that were to be located at the northern end of the high-concentration TCE portion of the Northeast Plume. At the time of the ROD's preparation, the high-concentration portion had a TCE concentration greater than 1,000 μg/L. The pumping rate selected in the ROD was approximately 100 gal per minute, which was enough to initiate hydraulic control, but not change groundwater gradients.

- Implementation of a treatment system that consisted of process water cooling towers that already were located at PGDP and would be used to volatilize the TCE and 1,1-dichloroethene (DCE) before the treated water was discharged to KPDES Outfall 001. The water was to be collected and pumped to the top of the tower and trickle down over slats that increased the surface area of the water and transit time spent in contact with the atmosphere. This resulted in volatilization of contaminants, while the temperature of the water approached that of the ambient atmosphere.

- Two treatability studies also were included to evaluate the use of photo catalytic oxidation for the treatment of TCE in vapor phase and *in situ* treatment of TCE-contaminated groundwater.

6.2 REMEDY IMPLEMENTATION

Following the signing of the ROD on June 15, 1995, DOE began the remedial design process for the selected remedial alternative. Minor modifications to the remedial action were required during the design phase and were documented in the *Minor Record of Decision (ROD) Change to the Northeast Plume Requiring Documentation in Post-ROD Project File* (DOE 1996b). These minor modifications included the following:

- Removing the sand filter,
- Adding an equalization tank (EQ) tank,
- Increasing pumping rate from 100 gpm to 170 gpm, and
- Postponing indefinitely the two treatability studies.

Rationale for removing the sand filtration system was based on the lack of suspended solids in the groundwater. Should suspended solids increase, the current treatment system configuration would allow for addition of a sand filter. No sand filter has been used as yet. An EQ tank was added to equalize water flow. Currently, the average pumping rate for the Northeast Plume EWs is approximately 200 gpm. DOE issued a Notice to Proceed with construction April 5, 1996, and construction of the Northeast Plume pump-and-treat system was completed in December 1996. Major equipment installed for this project included two EWs capable of producing a combined maximum discharge of 260 gpm, a 20,000-gal underground fiberglass-reinforced plastic EQ tank, and a submersible transfer pump capable of producing a maximum discharge of 263 gpm. This process equipment was installed along with associated piping, valves, and fittings. The construction of the facilities was documented in the *Postconstruction Report for the Northeast Plume Interim Remedial Action at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* and was issued February 7, 1997 (DOE 1997a). The postconstruction report presents the summary of the construction activities for the RA. Operation of the Northeast Plume IRA began February 28, 1997.

6.3 SYSTEMS OPERATIONS/OPERATIONS AND MAINTENANCE

O&M activities for the Northeast Plume Groundwater System are conducted in accordance with the *Operations and Maintenance Plan for the Northeast Plume Groundwater Containment System Interim Remedial Action at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2006). The O&M Plan provides an overview of the activities required to operate and maintain the treatment system to meet DOE, EPA, and Commonwealth of Kentucky policies and statutes. Since operation began, the Northeast Plume treatment system has processed approximately 905,421,557 gal of water as of December 31, 2007. The treatment system has removed approximately 2,801 pounds (230 gal) of TCE.

The costs associated with the O&M of the Northwest Plume Groundwater System and the Northeast Plume Containment System (which was addressed in Chapter 5) are tracked jointly and have been since FY 2002. The combined cost for both systems for the five-year reporting period is $7,698,457, or an average of $1,539,691 per year. This cost is a total project cost that includes, but is not limited to, the following:

- O&M of the systems,
- Sampling and analysis,
- Health and safety,
- Data management,
- Technical reporting,
- Financial tracking,
- Groundwater model recalibration and reporting, and
- Regulatory document preparation.

There have been no noncompliances associated with the management or operation of this action.

The TCE concentrations in the treatment system effluent continue to be met with reported TCE concentrations less than 5 ppb, as indicated in the latest FFA semiannual reporting period of April 2007 - September 2007 (see Table 6.1).

Table 6.1. Northeast Plume Groundwater System Influent and Effluent Concentrations

	TCE (µg/L)		
	High	**Low**	**Average[a]**
Influent	210	190	198
Effluent	< MDL	< MDL	1

Data is taken from the DOE PGDP FFA Second Semiannual Progress Report for Fiscal Year 2007, Paducah, Kentucky (DOE 2007).
< MDL = Less than the method detection limit and is valued at 1 µg/L for calculation purposes.
[a] Average is calculated as an arithmetic average.

In December 2006, a "Shutdown Action level" was proposed to USEC by DOE as a threshold level for ^{99}Tc at which time the NE Plume EWs would be shut down. The level established is 3,600 pCi/L. This level equates to a dose of 1 mrem per year to the maximally exposed individual (Murphie 2006). The exposure assessment was conducted at the request of USEC because ^{99}Tc had been detected in the EQ basin of the C-637 Cooling Tower at a concentration of approximately 30 pCi/L. The water in the basin is sampled monthly for ^{99}Tc, and actual concentrations vary each month, ranging from 40.7 pCi/L to nondetected concentration levels. DOE does not expect that ^{99}Tc will exceed 3,600 pCi/L.

The Northeast Plume EWs were inoperable for a 2-week period in early July 2007 for routine maintenance. Upon restart of the EWs on July 18, 2007, three groundwater samples were collected from each of the EWs within the first 1 ½ hours of operation to characterize ^{99}Tc and TCE levels in the core of the Northeast Plume at the EWs. The highest ^{99}Tc levels in the groundwater samples were 21 pCi/L from EW331 and 41 pCi/L from EW332. (The highest TCE levels in the samples were 190 µg/L from EW331 and 390 µg/L from EW332.)

A site visit to Northeast Plume IRA facilities was made on March 5, 2008. This facility is located south and east of the intersection of Ogden Landing Road (KY Hwy 358) and Little Bayou Creek, northeast of PGDP. The facility consists of two EWs, a pumping station, associated piping, electrical power and control systems, security fencing and gates, and interconnecting gravel access roads.

The main access road into the area is secured by two chain-link gates located just south of its intersection with Ogden Landing Road. Operators indicated that the gates are locked at all times except when O&M personnel are in the area. The gates are in good condition and serve their intended function. All the roads in the area appear to be maintained well and in good condition.

The two EWs are located approximately 200 ft apart. Each well is located in an underground concrete vault with a hinged aluminum lid. Each well also is surrounded by a chain-link security fence with an access gate that is locked to prevent unauthorized entry. The vaults are in good condition and are free of foreign debris. The security fences around each well also are in good condition. The immediate area around each fenced location was mowed and appears to be maintained well. During this inspection, both wells were pumping with no apparent problems.

The pumping station, which consists of a large underground EQ tank, two discharge pumps and associated piping, and electrical power and control panels, also is completely enclosed in a chain-link security fence with an access gate at one end. All aboveground piping is insulated to prevent freezing. All of the exposed piping and insulation are in good condition and functional. During this inspection, the pumps were running and no problems were observed. All exposed valves are labeled properly. The electrical power and control panels are in good condition and properly labeled. The area immediately around the pumping station is maintained and mowed on a regular basis.

The operating engineer was interviewed regarding system operations and system performance. The VOCs are stripped from the water in the C-637 cooling towers. Groundwater and plant process cooling water are collected in the basins of the cooling towers and recirculated through the cooling tower. After recirculation, water eventually is discharged to the C-616 Lagoons and then through Outfall 001.

Only minor repairs and routine maintenance have been performed. Shutdowns for repairs have been infrequent; no shutdowns have been long-term. A summary of both routine and nonroutine maintenance is reported in the DOE PGDP FFA Semiannual Progress Reports issued no later than 30 days after each reporting period of each year. In accordance with the substantive requirements of the ARARs cited in the ROD, a tank tightness test and leak tests were successfully conducted in 2007 on the NE Plume EQ tank and high density polyethylene transfer lines, respectively. No leaks were identified during the tests.

6.4 TECHNICAL ASSESSMENT

The Northeast Plume IRA is an initial action to control the high concentration area of the Northeast Plume that extends outside the plant security fence.

6.4.1 Question A: Is the Remedy Functioning as Intended by the Decision Documents?

Yes. This review of data and the site inspection indicate that the remedy is functioning as described in the ROD. There have been no changes in the physical conditions of the site that would affect the benefit of the remedy. The action inherently benefits downgradient areas by limiting the advance of the plume.

Reviews of ARARs, risk assumptions, groundwater monitoring data, and the results of the site inspection all indicate the following about the Northeast Plume Containment System:

- The treatment system is functioning as designed; and
- The monitoring well network may need to be enhanced to monitor the advancement of the plume toward the north and northwest.

The groundwater EWs of the Northeast Plume EW Field (EW331 and EW332) began operation on February 28, 1997 (Figure 6.1). Trends of TCE concentrations in groundwater of the Northeast Plume EW field monitoring system clearly show that TCE levels have been reduced by the pump-and-treat system (Table 6.2).

Table 6.2. Summary of TCE Concentration in the Northeast Plume EW Field

	TCE Concentration (µg/L)			Concentration Trends	
Well	Early 1997	Low of 2000	2007	Through 1999	1999 – 2002
MW283	1,300	180	88–99	Reduction	Near steady reduction
MW291	1,600	200	72–75	Reduction	Near steady reduction
MW294/293A	2,000	420	310–430	Reduction	Low of 420 µg/L in 2000, rise to 1,100 µg/L in 2002, followed by near-steady reduction
MW288*	1,600	120	210–260	Reduction	Near steady reduction
MW292*	800	800	320–440	Rise to 1,400 µg/L, then decline to 1,000 µg/L	Near steady reduction
MW284**	1500	200	See footnote	Reduction	Near steady at approximately 200 µg/L

*MW288 and MW292 are upgradient wells.
**MW284 data for 2007 is not available because the well was last sampled for TCE in August 2005. All results obtained from January 2001, until the last sampling activity were below 250 ug/L with steady reduction shown throughout the sampling period.

The TCE degradation product, 1,1-DCE, is presented as the only other COC in the ROD. Since the ROD was signed, laboratory reporting limits for 1,1-DCE have decreased from 25 to 50 ug/L to 5 to 10 ug/L. This change resulted in the first detections of 1,1-DCE in samples from the Northeast Plume EQ tank (12 and 25 µg/L); therefore, 1,1-DCE is not present in quantities (or greater extent) that would necessitate a larger capture zone for the Northeast Plume EW Field.

As with the Northwest Plume IRA, a primary concern of the Northeast Plume IRA is the extent of the zone of capture of the EW field. During periods when only one of the two well pumps has been idled, the system operators have increased the pumping rate of the working well to maintain the zone of capture.

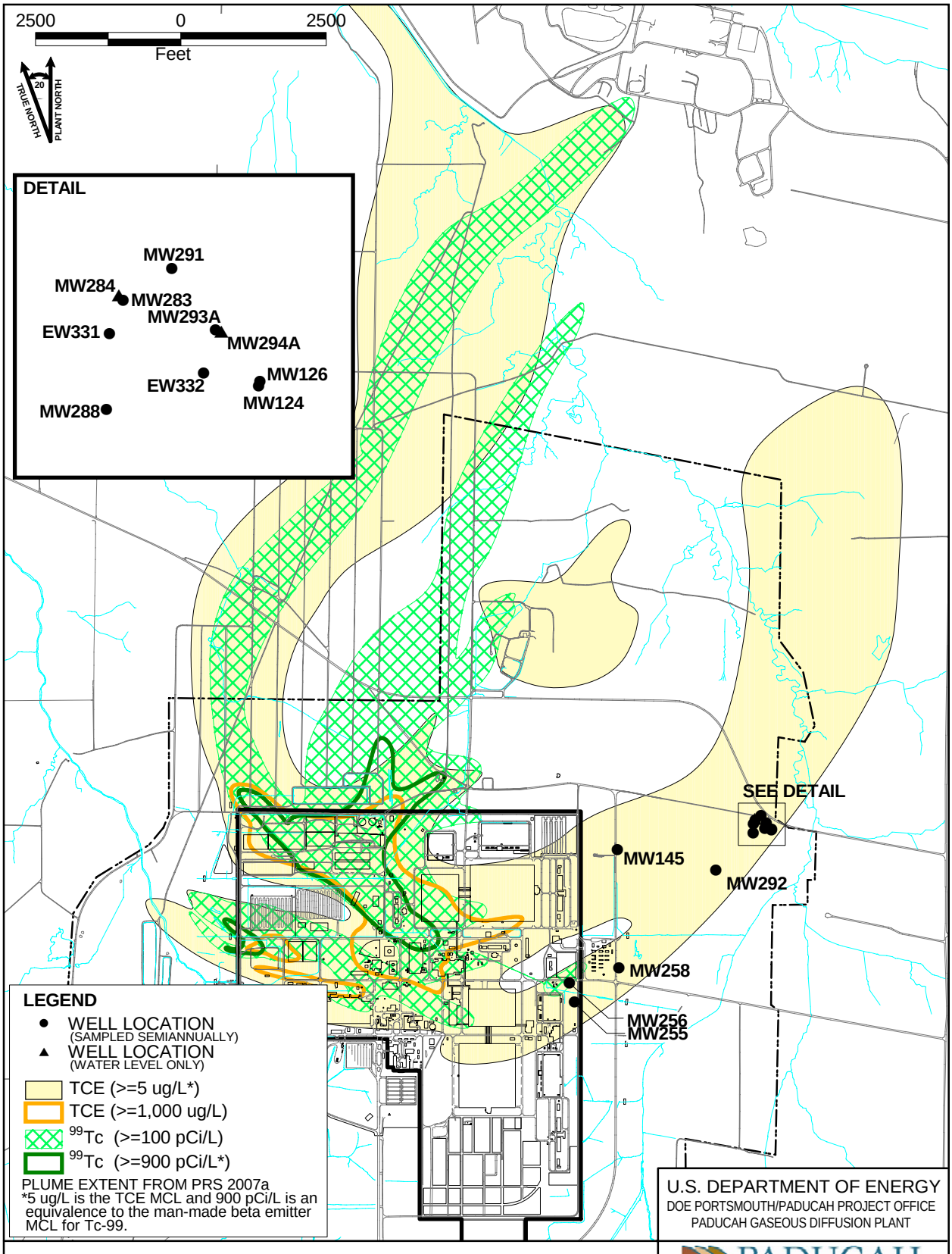

Figure 6.1. NE Plume EW Field

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Operational efficiency (actual run time compared to 100% run time) typically exceeds the operational goal of 85%, often averaging better than 95% over a three-month period. For the period 2003 through 2007, TCE levels from the EWs have remained near steady, declining to approximately 210 µg/L (Figure 6.2).

MW124 and MW126 monitor the Northeast Plume farther to the east, adjacent to the buried terrace scarp that cuts through the Porters Creek Clay and defines the southeast limit of the RGA in the area and the southeast boundary of the Northeast Plume. TCE levels in MW124, the well with higher levels (Figure 6.3), exhibited a steep decline in late 1997 (from 1,100 to 370 µg/L), with a spike in late 2000 (up to 720 µg/L), followed by a period of sustained low TCE levels (14-220 µg/L). These trends suggest the following possible progression: (1) a rapid response to the initiation of the pump-and-treat system; (2) a period of decreased effectiveness in late 2000 related to the June 25, 1999, through August 3, 2000, period of little or no pumping in EW332; and (3) resumed control of the southeast edge of the Northeast Plume. TCE levels spiked in late 2007 in both MW124 and MW126. Additional monitoring results may be required to determine the significance of the late 2007 analyses.

TCE levels in upgradient MW288 (proximal) and MW292 (remote) declined from 1998 through 2005, remaining near-steady for 2006 and 2007 (Figure 6.4). This trend is similar to declining TCE concentrations in upgradient MW255 and MW258, located near the core of the Northeast Plume near its source.

In total, the monitoring data indicate that the west EW (EW331) has remained effective at controlling the high-concentration core of the Northeast Plume.

The existing MWs in upgradient locations, in the vicinity of the EW field, and downgradient in the vicinity of Metropolis Lake Road are adequate for assessing contaminant trends. Additional MWs may be required, however, to assess the possible advance of the Northeast Plume north and northwest of the EW field. Specifically, the existing MW network may benefit by placement of a lower RGA well in the northeast corner of the DOE property (in the vicinity of upper RGA well MW99) and the placement of middle and lower RGA wells along Anderson Road in two locations: due (plant) north of the current MW148/MW149 well cluster, and intermediate to the MW148/MW149 well cluster and lower RGA well MW135.

6.4.2 Question B: Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and RAOs Used at the Time of the Remedy Selection Still Valid?

Yes, the remedy still is valid. There have been no changes in the physical conditions of the site that would affect the benefit of the remedy. The ROD was supported by a PHEA that was assessed using standard exposure equations TCE is listed as the primary contaminant, with emphasis on the associated MCL (5 µg/L) for TCE. Other contaminants listed are 1,1-DCE and ^{99}Tc.

6.4.2.1 Changes in standards and TBC

This IRA is not intended to remediate the Northeast Plume to MCLs; however, water that is extracted is treated to meet surface water quality standards. The TCE off-gas concentrations are less than the regulatory threshold level for air dispersal, correcting for the height of the cooling tower; therefore, no off-gas treatment was proposed. The appendix lists the ARARs (chemical-specific, location-specific, and action-specific) that are applicable to the Northeast Plume ROD. There have been no changes in these ARARs and no new standards to TBCs affecting the protectiveness of the remedy.

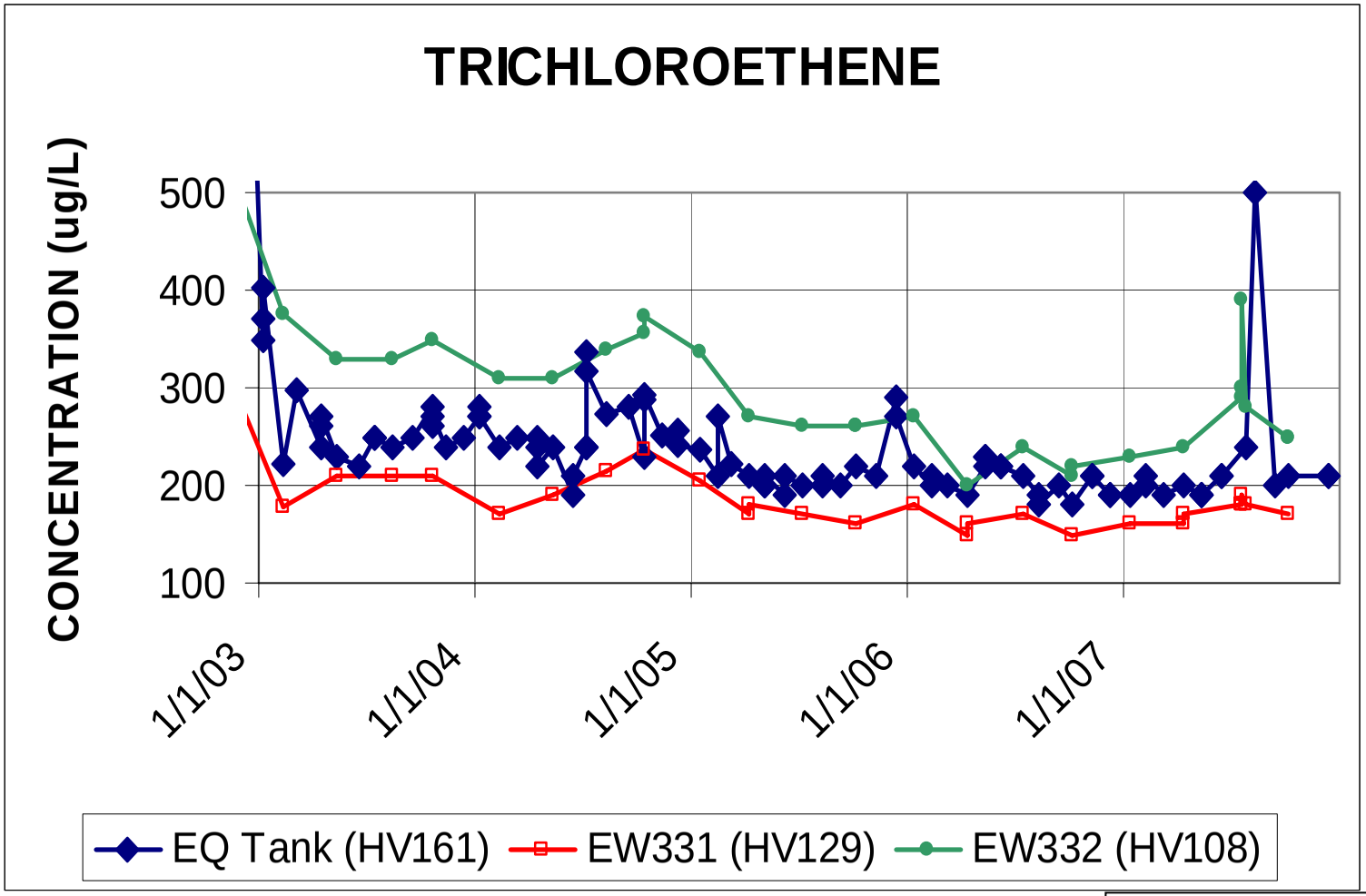

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Figure 6.2. TCE Trends in Northeast Plume EWs

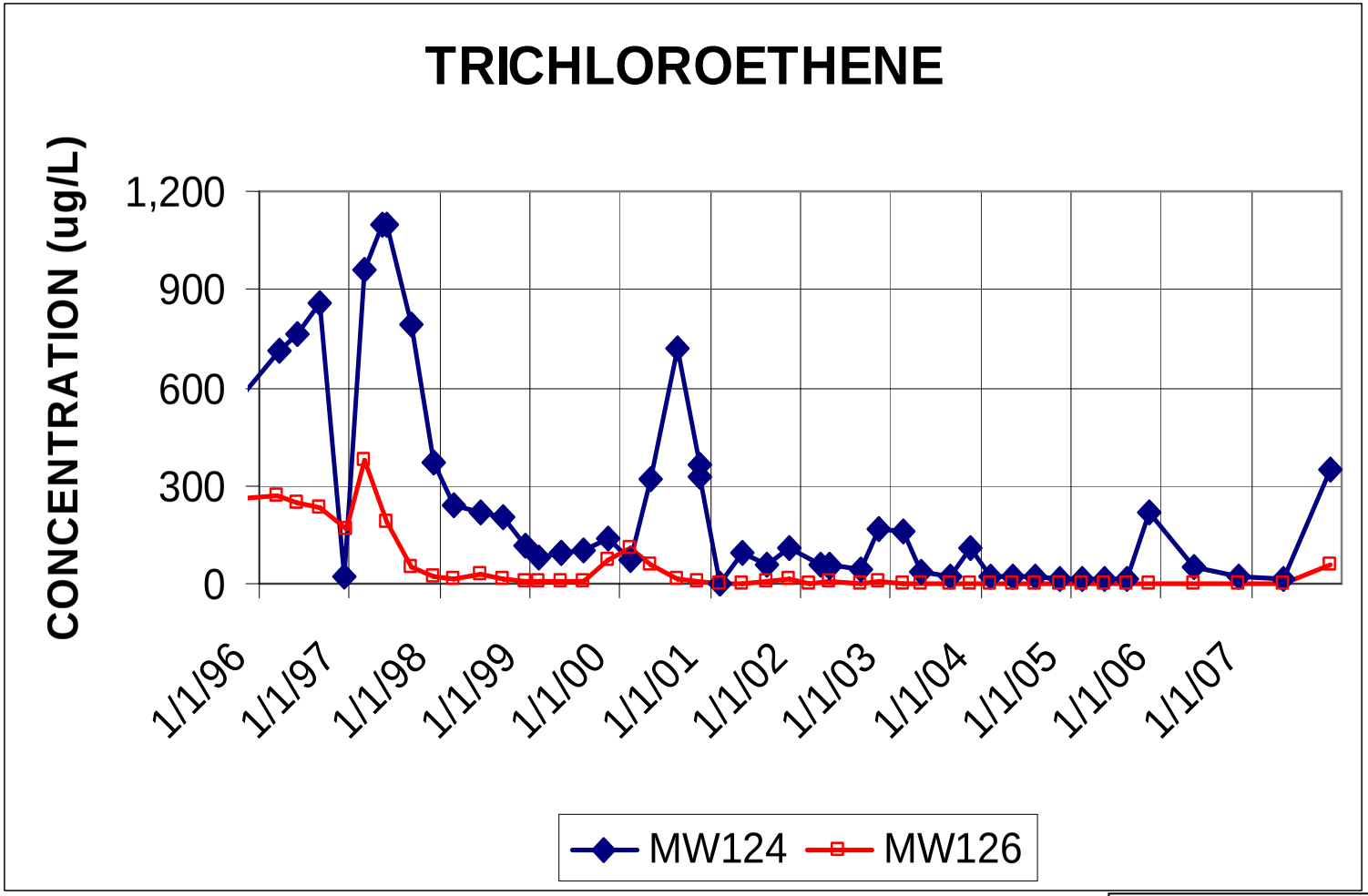

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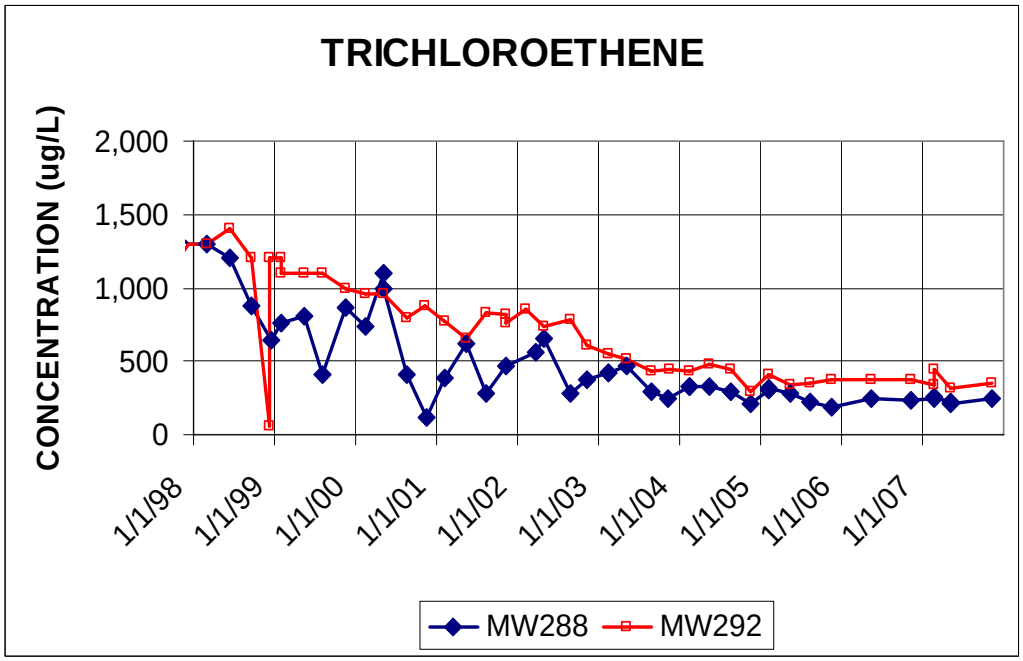
Figure 6.3. TCE Trends in MW124 and MW126



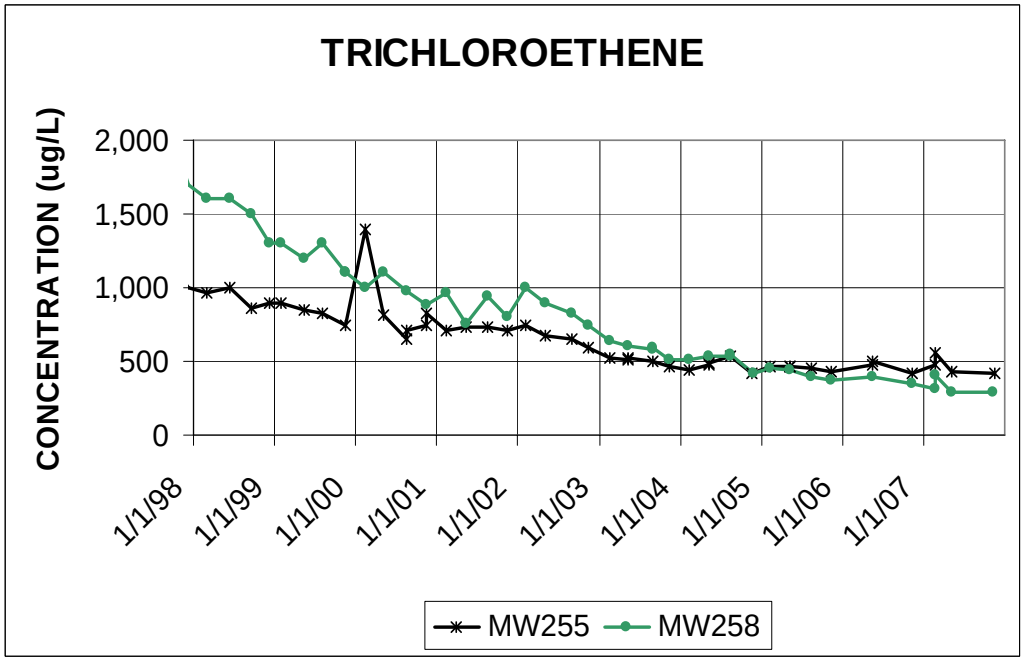


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Figure 6.4. TCE Trends in MW288 (Proximal) and MW292 (Distal) and MW255 and MW258 (Remote Distal)

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6.4.2.2 Changes in exposure pathways, toxicity, and other contaminant characteristics

The ROD was supported by a PHEA that was calculated using standard exposure equations. The *Summary of Comparative Analysis of the Interim Alternatives* (Section 2.8 of the ROD) discusses risk relative to nearby communities and workers associated with the construction and operation of the source control systems.

The remedy is progressing as expected. The remedy is an IRA that is not expected to achieve risk-based cleanup goals.

6.4.3 Question C: Has Any Other Information Come to Light That Could Call into Question the Protectiveness of the Remedy?

No, none.

6.4.4 Technical Assessment Summary

Groundwater extraction and treatment in the Northeast Plume continued as intended during the 2002–2007 period. The Northeast Plume ROD is an IRA intended to reduce contaminant levels in the high concentration core of the plume near the northern extent of 1,000 µg/L TCE. This ROD is a first phase of a GWOU action and is not expected to reduce contaminant levels to risk-based standards.

The current site strategy includes conducting an assessment of the Northwest, Northeast, and Southwest dissolved-phase plumes, including the dissolved ^{99}Tc in the Northeast Plume. The objective of this action will be to determine if any supplemental or modifications are needed to existing actions for the plume.

In 2006, a team of experts visited the PGDP to make recommendations on optimizing the groundwater remedial system performance. The team made one recommendation for the Northeast Plume that DOE committed to include in this Five-Year Review. The recommendation is as follows:

> Place the Northeast Plume Extraction System on Stand-by and develop Early-Warning Strategy.
>
> The intent of the Northeast Plume Extraction System as an interim remedial measure was to control the downgradient extent of a high-concentration (>1,000 ug/L) TCE plume through groundwater extraction and treatment. Since the system was installed, the TCE concentrations throughout the Northeast Plume have declined so that they are below 1,000 ug/L at EWs and MWs; therefore, the goal of the Northeast Plume System has been achieved. The system should be put in standby mode and decision criteria developed that clarify the conditions under which the system would be restarted. The criteria should be based on TCE concentrations in upgradient MWs. New MWs may be required for this purpose. Groundwater transport modeling is recommended also to assess potential concentrations increases downgradient of the extraction wells, to confirm that potential downgradient receptors will not be impacted negatively.

6.5 ISSUES

None.

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7. CYLINDER DROP TEST AREA OR LASAGNA™ TECHNOLOGY DEMONSTRATION

Drop tests were conducted from late 1964 until early 1965 and in February 1979. These tests were used to demonstrate the structural integrity of the steel cylinders that were used to store and transport uranium hexafluoride. Prior to the drop test, the cylinders were cooled by immersing them in a solution of dry ice and TCE that was in an open pit. After the cylinders were chilled, a crane lifted then dropped them onto a concrete and steel pad to simulate worst-case transportation accidents. The TCE was not removed from the pit after the tests and eventually leaked into the surrounding shallow soil and groundwater. The likely maximum quantity lost to the surrounding soil is approximately 1,635 L (430 gal). Additional information regarding the nature and extent of contamination is presented in the *Results of the Site Investigation, Phase I* (CH2M HILL 1992), and the *Preliminary Site Characterization/Baseline Risk Assessment/Lasagna™ Technology Demonstration at Solid Waste Management Unit 91 of the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (LMES 1996a). The Cylinder Drop Test Area (SWMU 91) encompasses approximately 1.7 acres and is located in the extreme west-central area of PGDP on the southern edge of the C-745-B Cylinder Yard (Figure 4.1).

Results of the initial investigations conducted at SWMU 91 indicated that organic contaminants were present in both soil and groundwater at the unit. The maximum concentration of TCE in subsurface soil was 1,523 mg/kg, and in shallow groundwater it was 943 mg/L. The area of TCE contamination was approximately 6,000 ft^2, and the average TCE concentration was 84 mg/kg. The sampling results indicated that TCE had migrated below the water table into the UCRS, but had not fully penetrated the aquitard above the RGA at the unit. Contamination was present in the subsurface soils to an approximate depth of 45 ft bgs.

7.1 REMEDY SELECTION

In 1993, the Cylinder Drop Test area was selected as the site of an innovative technology demonstration. The technology, known as Lasagna™, 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. The success of the initial 120-day demonstration (Phase I), which began in January 1995, led to a full-scale demonstration (Phase IIA) that was conducted from August 1996 through July 1997. Sampling and analytical results from the Phase I study are reported in the *Preliminary Site Characterization/Baseline Risk Assessment/Lasagna™ Technology Demonstration at Solid Waste Management Unit 91 of the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (LMES 1996a). 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 Lasagna™ would achieve the remediation goals. The results of the Phase IIA are discussed further in the *Lasagna™ Soil Remediation: Innovative Technology Summary Report* (LMES 1996b).

DOE then selected Lasagna™ for full-scale remediation of the Cylinder Drop Test area and documented this decision in 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 1998c) 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™ electro-osmosis technology. The primary objective was to reduce the concentration of TCE in soil, to at least 5.6 mg/kg, thereby reducing the

potential for future releases to groundwater that could pose a threat to human health and the environment. Following are the specific components of the selected remedy.

- Treatment zones containing reagents that either decompose the TCE to nontoxic products or adsorb the TCE and make it immobile (DOE 1998c).

- Electrodes (a cathode and an anode) that, when energized, moved contaminants (i.e., TCE) into or through the treatment zones and heat the soil. The contaminated water in the soil pores flowed from the anode through treatment zones toward the cathode (DOE 1998c).

- A water management system that recycles and returns the water that accumulates at the cathode back to the anode for acid-base neutralization (DOE 1998c).

The ROD specified that the Lasagna™ system operate for two years, but, if necessary to meet the clean-up objectives, the technology could operate an additional year. The ROD also included a contingency action to use soil mixing to enhance the remedial technology in the event that the Lasagna™ technology by itself was incapable of achieving cleanup objectives. Additional information regarding the selected remedy is presented in the ROD for SWMU 91 (DOE 1998c).

7.2 REMEDY IMPLEMENTATION

All phases of the Lasagna™ technology demonstration have been completed. In March 1999, a contract was awarded for installation and operation of the full-scale remediation (Phase IIB) using the Lasagna™ technology. The Remedial Design Report (RDR) to support the construction was issued in May 1999 and construction began in August 1999. The construction was completed and operations began in December 1999. The *Post-Construction Report for the Lasagna™ Phase IIb In-Situ Remediation of Solid Waste Management Unit 91 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2000a) documents the remedial construction process. The construction phase also included collection of soil samples to establish a baseline of contamination in the system area prior to remediation.

The remedial system operated from December 1999 through December 2001. The results of post-cleanup verification sampling indicated the average concentration of TCE was 0.38 mg/kg, with a maximum concentration of 4 mg/kg. The Lasagna™ remedial action reduced the TCE soil concentrations well below the remedial action objective of 5.6 mg/kg average concentration.

Weekly inspections were conducted during the operational phase. The weekly inspections included verifying that the water recycling system was functioning correctly and that sufficient water was contained in the sump to insure that the anodes would remain wetted. An automatic notification device was incorporated into the operation system so that an operator was notified and could respond if needed.

The system operated continuously for the first several months. After the soil temperature reached 90 °C, the system was put into pulse mode to prevent overheating of the soil. Pulse-mode operations consisted of energizing the system for one to four days and then shutting it down for several days to allow the soil to cool. Soil samples were collected in August of 2000 and in August of 2001. Due to mechanical problems, the system was shut down for approximately eight weeks beginning in August 2001. A number of additional operational problems were encountered during the operational phase and are detailed in the *Final Remedial Action Report for Lasagna™ Phase IIb In-Situ Remediation of Solid Waste Management Unit 91 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2002). The Commonwealth of Kentucky and EPA approved the final remedial action report on October 31, 2002.

A representative of the Five-Year Review Team conducted a site visit March 6, 2008. The site includes a grassy area south of the C-745-B cylinder yard and part of the area underlying the portion of the gravel cylinder yard. No construction or operations activities were being conducted at the time of the site visit.

Lasagna™ verification sampling and analysis were conducted in April 2003 and confirmed that the remediation objective was met. Details of the Lasagna™ verification sampling and analysis are included in the *Addendum to the Final Remedial Action Report for Lasagna™ Phase IIb In-Situ Remediation of Solid Waste Management Unit 91 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2003b).

The Lasagna™ equipment and site was demobilized on September 30, 2002. The remediation site has been returned to its original condition. The total cost of the implementation of the Lasagna™ remediation (i.e., post-ROD activities) was $3.96M (DOE 2002). There were no noncompliances associated with this action.

7.3 SYSTEMS OPERATIONS/OPERATIONS AND MAINTENANCE

There is no O&M for this remedy.

7.4 TECHNICAL ASSESSMENT

7.4.1 Question A: Is the Remedy Functioning as Intended by the Decision Documents?

Yes. The remedy was designed to be protective of future groundwater use at the fence line of the facility by meeting the TCE MCL value of 5 ug/L. The MCL for TCE remains at 5 ug/L, and the average residual soil level of TCE at the site is less than one-tenth of the original level calculated to be protective of groundwater in the ROD; therefore, the remedy employed is as protective of drinking water as it was when the ROD was implemented

7.4.2 Question B: Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and RAOs Used at the Time of the Remedy Selection Still Valid?

Yes. The residual concentrations of TCE in soil (post-remediation) are an average 0.38 mg/kg and a maximum of 4 mg/kg. Currently, there is a draft revised cancer slope factor from the EPA of 0.4 and 0.322 from KDEP. The draft 2008 PGDP no-further-action level is based on the conservative KDEP value and has an industrial screening value of 0.04 mg/kg for the excavation worker at $1x10^{-6}$. Using these screening levels, the mean concentration corresponds to $9.5x10^{-6}$ risk using the PGDP/KDEP value. The maximum value at the site corresponds to $1x10^{-6}$ risk using this same value. Based on this comparison with draft updated screening values, the effectiveness of the remedy for soil remains protective for future use of the site based on the measured concentrations of TCE in soil after the remediation was completed.

7.4.3 Question C: Has Any Other Information Come to Light That Could Call into Question the Protectiveness of the Remedy?

No, none.

7.5 ISSUES

None.

8. WATER POLICY

Upon detecting TCE and ^{99}Tc in private wells located north of PGDP in August 1988, DOE immediately placed affected residences/businesses on alternate water supplies and began an intensive monitoring and investigation program to define the extent and temporal variations of the groundwater contaminant plumes. DOE developed the PGPD Water Policy in accordance with the *Engineering Evaluation/Cost Analysis for the Water Policy at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1993b), and the *Action Memorandum for the Water Policy at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1994b).

In 1997, DOE conducted a Five-Year Review of the Water Policy. The review concluded that the Water Policy protects residents from risks associated with use of contaminated groundwater. The reevaluation resulted in the following recommendations for revising the Water Policy:

- DOE should offer to pay the reasonable costs of water bills in the affected area through December 2002, at which time the Water Policy would be reevaluated and a determination would be made to continue, modify, or eliminate it. The definition of "reasonable cost" will be decided by DOE.

- As new residents and businesses move into the Water Policy box, DOE should make decisions on a case-by-case basis about whether or not to provide municipal water to them.

The 1998 Five-Year Review for this action included the following statements of protectiveness (DOE 1998a):

> The GWOU response actions taken to date at the PGDP are protective of human health and the environment. The combination of these actions minimizes the potential for local residents to be exposed to the contaminated groundwater and controls further migration of contaminants until a final remedial action for the GWOU is developed and implemented. These actions also generate valuable information and data that is being used to develop a final action for the GWOU.
>
> The Water Policy is protective of human health and the environment and is meeting its objectives by minimizing the potential threat to human health by preventing human exposure to contaminants in the groundwater. The Water Policy is integral to all other groundwater actions in that it protects local residents while the DOE is developing a final GWOU action. The Northwest Plume and Northeast Plume IRA are not designed to completely remediate the dissolved-phase plumes; therefore, the Water Policy is essential to ensuring that the Northwest Plume and Northeast Plume IRAs are protecting human health.

In addition, the 1998 review included a recommendation to continue the Water Policy removal action to prevent exposure of nearby residents to the contaminated groundwater until such time as DOE, with the approval of EPA and KDEP, determines that it is no longer necessary and/or appropriate.

The 2003 Five-Year Review included the following statement:

The Water Policy removal action has continued to operate as intended during the 1998-2003 period. All residences located within the Water Policy box utilize municipal water. Monitoring results indicate that the Northeast and Northwest Plumes have not expanded beyond the area encompassed by the Water Policy. No significant changes have occurred since the previous Five-Year Review was conducted.

8.1 REMEDY SELECTION

The PGDP Water Policy states, "It is the intent of the PGDP Environmental Restoration Program to offer municipal water service in accordance with this Policy to all existing private residences and businesses within the projected migration area of the contaminated groundwater originating at Paducah Gaseous Diffusion Plant (affected area)." With the adoption of the Water Policy, DOE focused its groundwater monitoring program on the Water Policy box and adjacent areas that might be affected if and when the plume migrates or expands. Figure 8.1 is a map of the groundwater contaminant plume boundaries and the Water Policy boundary as of 2007.

In June 1994, DOE signed the Action Memorandum for the Water Policy, which included the following conditions:

- DOE offered to provide municipal water to all existing residences and businesses within the affected area surrounding PGDP. They also offered to pay for installation of water supply mains and connection of those residences that were not connected to a public water supply at that time. These residences and businesses were responsible for cooperating and working with the West McCracken Water District to connect the water supply.

- DOE offered to pay the reasonable costs of water bills in the affected area through December 1997, at which time the Water Policy was to be reevaluated and a decision made whether to continue, modify, or eliminate it. The definition of "reasonable cost of water consumption" for residents was based on the historical usage of each owners' well. Water usage increases caused by increases in agricultural water use, livestock water use, or subdivision of property were not to have been reimbursed under this action at that time.

- Each household or business that was to receive free water was asked to sign an agreement with DOE that delineated the responsibilities of the each property owner and DOE. The agreements specify that the property owner will not drill new water supply wells or use existing water wells, and that PGDP personnel are permitted access to the property for sampling purposes. PGDP personnel installed locks to prevent unauthorized use of the existing water wells.

- DOE samples existing residential water supply wells and MWs to track migration of groundwater contaminant plumes. Additional MWs are installed as required for other environmental restoration programs.

The Engineering Evaluation/Cost Analysis also specified the need to conduct a Five-Year Review (DOE 1993b).

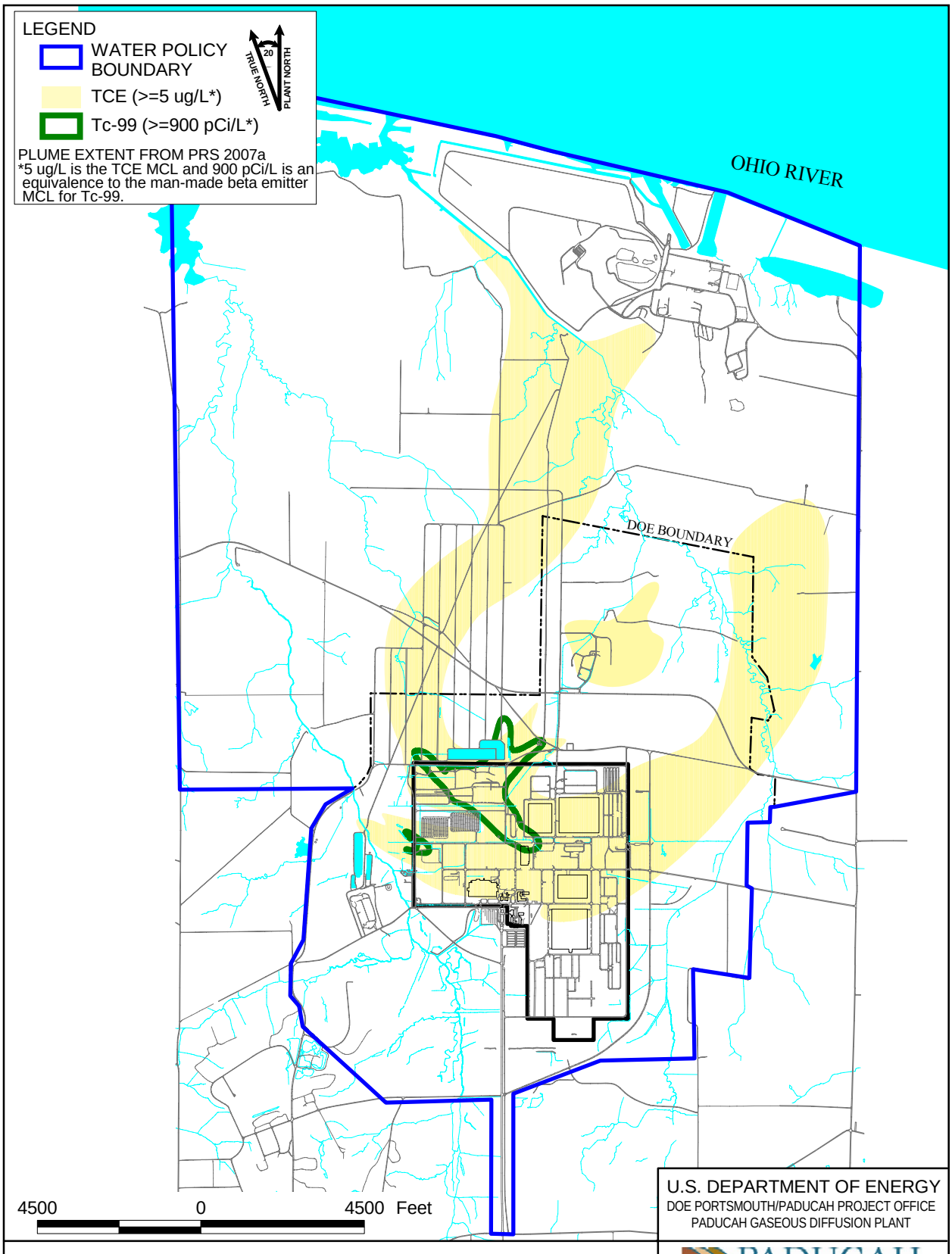

Figure 8.1. Location of Water Policy Boundary

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8.2 REMEDY IMPLEMENTATION

DOE has obtained Water Policy agreements with the majority of residents located within the Water Policy Boundary. The West McCracken Water District records indicate that all residents have chosen to use municipal water; however, some landowners have chosen not to sign the license agreements.

DOE continues to reevaluate the Water Policy removal action implementation with respect to the license agreement usage and payment of current water bills.

- DOE will continue to evaluate whether it should continue to pay the reasonable costs of water bills in the affected area. A pattern of municipal water usage has been established in the affected area as a result of extending water lines in the affected area. The original intent of the Water Policy was to reimburse reasonable costs of water bills for existing residents through December 1997.

- As new residents and businesses move into the affected area, DOE will make a determination on a case-by-case basis about whether to provide municipal water to such residents and businesses. DOE may, in its discretion, decline to provide municipal water to such new residents and businesses.

8.3 SYSTEMS OPERATIONS/OPERATIONS AND MAINTENANCE

DOE paid for water supply line extensions of the West McCracken Water District into the Water Policy box. Total capital construction cost for implementation of the Water Policy was $1,027,781. The annual cost of the water bills is shown in Table 8.1. The average monthly cost of water to residents of the Water Policy box is $5,600 from FY 1999 to FY 2007. There are approximately 100 water bill accounts. The exact number has varied over the last 20 years. O&M of the water supply trunk lines are the responsibility of the West McCracken Water District, and the lines from the trunk line to the residence is the responsibility of the resident.

Table 8.1. Annual Costs of Water Bills

DOE Fiscal Year	Water Bills
1994 (June 1994–September 1994)	$38,104.30
1995 (October 1994–September 1995)	$55,496.16
1996 (October 1995–September 1996)	$80,142.69
1997 (October 1996–September 1997)	$66,613.79
1998 (October 1997–September 1998)	$52,689.27
1999 (October 1998–September 1999)	$78,378.88
2000 (October 1999–September 2000)	$74,530.99
2001 (October 2000–September 2001)	$67,011.46
2002 (October 2001–September 2002)	$74,624.34
2003 (October 2002–September 2003)	$66,354.58
2004 (October 2003–September 2004)	$63,431.41
2005 (October 2004–September 2005)	$65,523.43
2006 (October 2005–September 2006)	$58,172.05
2007 (October 2006–September 2007)	$60,164.77

The DOE regularly collects groundwater samples from the area in the Water Policy box.. Six residential wells are sampled annually and two are sampled monthly (PRS 2007b). The interval of sampling of each well within the water box has been adjusted to characterize temporal variations within the plumes and to detect the further spread of contaminants. DOE reports the results of groundwater monitoring in its annual series of environmental reports.

8.4 TECHNICAL ASSESSMENT

The primary objective of the removal action is to prevent local residents from using contaminated groundwater by providing municipal water to residences and businesses and eliminating the use of private water wells.

8.4.1 Question A: Is the Remedy Functioning as Intended by the Decision Documents?

The Water Policy removal action is meeting the objectives specified in the Action Memorandum. Available information indicates that all existing residences and businesses within the area affected by the Water Policy are using municipal water. DOE pays the water bills for all users. The extent of the groundwater contaminant plumes continue to be monitored. DOE has secured legal agreements, known as license agreements, with 75 of 92 landowners within the area affected by the Water Policy. Seventeen landowners have not signed license agreements; however, DOE still pays their municipal water bills.

8.4.2 Question B: Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and RAOs Used at the Time of the Remedy Selection Still Valid?

Yes. The exposure pathways were eliminated with the implementation of the Water Policy, and they remain eliminated.

8.4.3 Question C: Has Any Other Information Come to Light That Could Call into Question the Protectiveness of the Remedy?

No. The remedy remains protective and monitoring data demonstrate that the plume has not migrated beyond the boundaries of the Water Policy box.

8.4.4 Technical Assessment Summary

The Water Policy box eliminates potential pathways of exposure to the public by providing municipal water to affected residents and businesses within the Water Policy box. The Water Policy remains effective for the purpose for which it was intended.

The twenty years of data collected on the groundwater contamination has allowed for a better understanding of the groundwater plume migration. Some landowners on the west side of PGDP receive water paid for by DOE, but monitoring data indicate that the plume does not underlie some of the property.

8.5 ISSUES

None.

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9. NSDD SOURCE CONTROL

The NSDD originates within the north central portion of PGDP and joins with Little Bayou Creek to the north of the plant. Historically, the NSDD received wastewater from the C-400 Cleaning Building that houses equipment for decontamination, metal etching and plating, metals recovery, radioactive materials stabilization and recovery, uranium trioxide production, diffusion process equipment testing, and uranium tetrafluoride pulverization. Additional sources of runoff to the ditch include the C-600 Steam Plant, the C-335 and C-337 Process Buildings, the C-635 Cooling Tower, and the C-535 and C-537 Switchyards. As a consequence, the soil and sediment in the ditch were contaminated with radionuclides, metals, and PCBs. Over the years, fly ash and coal dust from the C-600 Steam Plant and sediment from the ditch watershed had nearly filled the NSDD causing the ditch to overflow onto an adjacent stretch of 10th Street at PGDP during heavy rains.

The 2000 Five-Year Review for this action included the following statements of protectiveness (DOE 2000b):

> The interim remedy selected for the NSDD is protective of human health and the environment and is achieving remedial objectives outlined in the ROD. Specifically, the interim remedy is mitigating the entry of contaminants into the NSDD, is reducing migration of contaminants already present in the ditch, and is decreasing the potential for direct contact with contaminated material. Human exposure to the contaminants is prevented by mitigating the entry of additional contaminants into the ditch, by restricting access to the site through signs, and by reducing the potential for contaminant migration.
>
> The DOE certifies that the SWOU response actions taken to date at the PGDP remain protective of human health and the environment. These actions are reducing immediate risks until a final remedy for the SWOU can be implemented.

The 2003 Five-Year Review included the following statement of protectiveness:

> Based on a review of monitoring information and other documentation, the site inspection, and interviews, DOE concludes that the NSDD remedial action is meeting the remedial objective specified in the ROD.

9.1 REMEDY SELECTION

Risks associated with the NSDD are presented in *Record of Decision for Interim Action Source Control at the North-South Diversion Ditch at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1994a). According to the NSDD ROD, there was potential for exposure of plant maintenance personnel to the contaminants within the ditch through routine maintenance activities. The personnel were posed to unacceptable risk via direct gamma irradiation from contaminated sediment and soil; dermal contact with soil, sediment, and debris; inhalation of resuspended particulate during mowing; and incidental ingestion of contaminated surface water, soil, and sediment. The source control remedial action and the response actions for Sections 1 and 2 eliminated exposure pathways. In addition, aquatic organisms living in the NSDD likely were at risk from adverse effects that could reduce populations. Predators of aquatic organisms also may have been at equivalent levels of risk due to bioaccumulation of PCBs.

In March 1994, DOE and EPA, with the concurrence of KDEP, signed a ROD for an interim action at the NSDD as an initial step toward addressing sitewide problems (DOE 1994a). The primary objectives of the interim action were the following:

- Mitigate the introductive of contaminants into the NSDD;
- Decrease the migration of contaminants already present in the NSDD; and
- Decrease the potential for direct contact with the contaminated material.

9.2 REMEDY IMPLEMENTATION

The IRA consisted of the following activities:

- Installing an ion exchange system in the C-400 Building;
- Rerouting effluent from the C-400 Building from the NSDD to Outfall 008;
- Constructing an aboveground pipe and lift stations (C-400-L and C-616-L) and pumping NSDD flow along the aboveground pipeline to the existing C-610-H Lift Station;
- Removing fly ash from the C-600 Steam Plant ash pile runoff by constructing settling lagoons then pumping the supernatant in the lagoons into the piping that replaced the southern part of the NSDD channel;
- Constructing a gabion to trap sediment and reducing the potential for sediment transport off-site from the NSDD; and
- Installing warning signs on both sides of the NSDD inside the security fence from Virginia Avenue to the C-616-C Lift Station to provide notice of elevated levels of radionuclides, metals, and PCBs in the area. These signs were removed upon successful completion of the response action for the NSDD Sections 1 and 2, which is discussed in Chapter 10.

DOE completed the IRA during August 1995 (DOE 1995d). Once construction was completed, two components of the actions, the C-400 Ion Exchange and C-600 Fly Ash Lagoons, were incorporated into the daily operations of PGDP by USEC. Also, the discharge from the C-400 Ion Exchange system was routed to the Outfall 008 storm water drain thereby eliminating discharges from the C-400 Building to the NSDD. Lagoons constructed at the C-600 Steam Plant eliminated fly ash deposition in the NSDD. Since completion of the NSDD Source Control IRA, a second ROD for IRA at the NSDD was signed on September 25, 2002, which is discussed in Chapter 10.

9.3 SYSTEMS OPERATIONS/OPERATIONS AND MAINTENANCE

The O&M requirements are documented in, *Operation and Maintenance Plan for the Surface Water Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2000c). The primary activities associated with O&M include the following:

- Inspecting lift stations daily (fully automated) to ensure the lift station screens remain clean, the lift stations are operational, and the pipeline is not leaking;

- Activating heat tracing installed on the aboveground piping in the fall and deactivating it in the spring;

- Inspecting daily the warning signs that were put in place when the ROD was developed; and

- Mowing the area adjacent to the pipeline and warning signs twice during the summer months.

The operations of the C-400 Ion Exchange unit and discharges from it are conducted according to a memorandum of understanding between USEC and DOE.

On March 6, 2008, a representative of the Five-Year Review Team conducted a site inspection of the following facilities associated with the NSDD IRA: (1) the C-400-L Lift Station and associated piping, (2) the C-616-L Lift Station and associated piping, and (3) the gabion installed at the C-616 Lift Station. Additionally, the signs that had been posed along the southern reaches of the ditch were removed after the remedial response for Sections 1 and 2 (Chapter 10) was completed.

The C-400-L Lift Station is located on the north side of the NSDD near its upper reach near the intersection of 10th Street and Virginia Avenue. It is included in the radiological boundary posting along the NSDD. With the exception of a gravel walkway, access to the station electrical control panels and the east side of the lift station is restricted. The lift station is in good condition and appears to be functioning normally. During this inspection, there were no visible indications that the street or walkways along the ditch have been flooded in the recent past. The inlet grating to the lift station was free of excessive debris. The lift station did not run during this visit, due to minimal water flow in the ditch. The electrical power and control panels and associated conduits located just east of the lift station are in good condition.

The C-616-L Lift Station is located on the south side of Virginia Avenue and north of the C-600 Steam Plant. This lift station collects coal pile runoff and fly ash settling basin water from C-600 and pumps it around the southern reaches of the NSDD to a point just south of Outfall 001. Water from the fly ash settling basins enters the station through underground piping from the basins. Coal pile runoff is routed into the west side of the lift station by a trench. This lift station is under the control and operation of USEC. During this inspection, the lift station was functioning as designed. There were no indications of water overflow in the vicinity of the lift station. Water levels in the settling basins were normal. Power and control panels associated with the lift station are in good condition.

The discharge piping from the C-400-L and C-616-L lift stations, which is mounted on abovegrade concrete and steel pipe supports, originally routed water around the more contaminated southern-most reaches of the NSDD to a point just south of Outfall 001. To facilitate the remediation of Sections 1 and 2 of the NSDD, this piping was extended, both aboveground and underground, to a point just north of the C-616-C Lift Station inlet. The original piping appears in good condition, with no evidence of leaks or damage, and is performing as designed.

The costs associated specifically with O&M activities are not accounted for separately, because they are performed as part of the plant-wide, long-term surveillance and maintenance and environmental monitoring programs.

9.4 TECHNICAL ASSESSMENT

9.4.1 Question A: Is the Remedy Functioning as Intended by the Decision Documents?

Based upon the site inspection, the NSDD IRA is meeting the remedial objectives as stated in the ROD. The following paragraphs discuss how the remedial action is meeting these objectives.

The ion exchange system was installed in the C-400 Cleaning Building to treat elevated levels of radionuclides in effluent being released from the C-400-B Storage Tank. USEC leased the C-400 Building and its operations from DOE in 1993. Because the effluent discharge from the C-400 Building was rerouted to Outfall 008 during the design phase, the introduction of contaminants into the NSDD from the C-400 Building has been eliminated completely.

The discharges of Outfall 008 are the responsibility of USEC. The wastewater from the C-400 Building is treated to levels as low as reasonably achievable (ALARA). DOE monitors surface water at Outfall 008 quarterly as a part of its Environmental Monitoring Program. Since August 2001, this location has been monitored for volatiles, PCBs, metals, anions/cations, and radionuclides. The maximum ^{99}Tc detection is 26.6 pCi/L.

Two concrete settling lagoons were constructed to reduce fly ash from the C-600 Steam Plant ash pile runoff prior to discharge. The lagoons are functioning as designed, thereby lowering the levels of sediment being deposited in the NSDD. Two lift stations were installed, one near the C-400 Cleaning Building and the other near the C-600 Steam Plant to bypass the southern portion of the NSDD. The lift stations appear to be functioning properly. To minimize sediment transport off-site from the NSDD, a gabion with a nonwoven, geotextile filter was installed. The gabion is functioning as designed.

9.4.2 Question B: Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and RAOs Used at the Time of the Remedy Selection Still Valid?

Changes in risk assessment methodology subsequent to approval of the ROD have been significant; however, successful implementation of the second IRA for the NSDD (discussed in Chapter 10) has eliminated exposure pathways.

The 1994 NSDD ROD identifies ARARs pertinent to the remedial action (DOE 1994a). The 1998 Five-Year Review found that jurisdictional wetlands have been identified in the NSDD after the ROD had been signed. The 1994 ROD for the NSDD was signed prior to DOE's Secretarial Policy requiring that National Environmental Policy Act values be incorporated in CERCLA documents (DOE 1994a). These also are included in the appendix. DOE complied with all requirements during implementation of the remedial action and continues to comply with identified requirements during operation of the action. None of these standards identified in the 1994 ROD have changed.

9.4.3 Question C: Has Any Other Information Come to Light That Could Call into Question the Protectiveness of the Remedy?

Because the wetlands were not identified prior to signing the 1994 ROD, ARARs for the protection of wetlands were not identified. They were added in 2003 during the five-year review period. They are included with the ARARs presented in the appendix.

9.4.4 Technical Assessment Summary

The *Operation and Maintenance Plan for the Surface Water Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* (DOE 2000c) requires daily inspections to ensure that the screen of the Ditch 001 lift station remains clean; that all of the lift stations are operational; and that the pipeline is not leaking.

Exposure of plant personnel to flood water on 10th Street from the NSDD was a primary risk driver and objective for the interim action. There have been few overflow problems since the interim action was completed.

The ion exchange system effluent is routed to the USEC-operated C-400 Cleaning Building collection tank, where it is stored until the treatment levels are assessed. The wastewater is repeatedly processed through the uranium precipitation and ion exchange systems until a point of diminishing return is reached (i.e., until the percentage of reduction becomes insignificant with subsequent treatments). The final concentration in the treated water is contingent upon the initial concentrations. After treatment, the water either is recycled in C-400 Building processes or is discharged via Outfall 008. The aboveground pipeline continues to be used for these discharges to Outfall 008 following treatment utilizing the ion exchange unit. The settling lagoons continue to be used to keep coal-pile water runoff out of the NSDD. Additionally, the treated water is discharged to Outfall 008 through the aboveground pipeline.

9.5 ISSUES

None.

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10. NSDD SECTIONS 1 AND 2

The NSDD originates within the north central portion of PGDP and joins with Little Bayou Creek to the north of the plant. Historically, the NSDD received wastewater from the C-400 Cleaning Building that houses equipment for decontamination, metal etching and plating, metals recovery, radioactive materials stabilization and recovery, uranium trioxide production, diffusion process equipment testing, and uranium tetrafluoride pulverization. Additional sources of runoff to the ditch include the C-600 Steam Plant, the C-335 and C-337 Process Buildings, the C-635 Cooling Tower, and the C-535 and C-537 Switchyards. As a consequence, the soil and sediment in the ditch were contaminated with radionuclides, metals, and PCBs. Over the years, fly ash and coal dust from the C-600 Steam Plant and sediment from the ditch watershed had nearly filled the NSDD causing the ditch to overflow during heavy rains onto an adjacent stretch of 10th Street at PGDP. Risks associated with the NSDD are presented in *Record of Decision for Interim Remedial Action at the North-South Diversion Ditch at the Paducah Gaseous Diffusion Plant, Paducah Kentucky, DOE/OR/07-1948&D2*. According to the NSDD ROD, there was potential for exposure of plant maintenance personnel to the contaminants within the ditch through routine maintenance activities.

10.1 REMEDY SELECTION

A remedy for Sections 1 and 2 of the NSDD was implemented and completed in 2004. The RAOs for Phase II were as follows:

- Prevent future discharge of process waste to the NSDD;
- Reduce the risk to industrial workers and ecological receptors from exposure to contaminated surface soil, sediment, and surface water to acceptable levels by eliminating direct exposure to contaminated media at the NSDD; and
- Prevent future on-site run-off from being transported off-site (i.e., outside the existing security fence) via the NSDD.

The land use control (LUC) objective identified to assure the protectiveness of the preferred alternative for Sections 1 and 2 of the NSDD is as follows:

- Sections 1 and 2 (Industrial areas)—Restrict unauthorized access, restrict unauthorized excavations or penetrations below prescribed contamination cleanup depth, and restrict uses of the area that are inconsistent with the assumed industrial use (i.e., to prevent recreational and/or residential use.)

Implementation of LUCs designed to meet these objectives was documented in a Land Use Control Implementation Plan (LUCIP) (DOE 2003c). DOE is responsible for implementing, maintaining, monitoring, reporting on, and enforcing the LUCs selected under the ROD.

10.2 REMEDY IMPLEMENTATION

The NSDD Sections 1 and 2 remedy consisted of the following components:

- Excavate contaminated soils/sediments along Sections 1 and 2 of the NSDD, located inside the PGDP security-fenced area, to achieve specified cleanup levels. After the ditch was excavated to a 4 ft depth, a 2 ft clay cover was installed at the base of the excavation.

- Stage and dispose of contaminated excavated materials. Nonhazardous wastes generated as a result of the NSDD remedial action were disposed in the C-746-U Landfill.

- Restore Sections 1 and 2 of the NSDD to grade with 2 ft of clay cover, approximately 2 ft of clean soil, and vegetation following completion of excavation activities. The clay cover provides an extra layer of protection for eliminating the surface exposure pathway. The original plan was that if excavation achieved or exceeded the specified cleanup levels for Sections 1 and 2, long-term maintenance of the clay cover would not be required. The specified clean-up levels were achieved during excavation; therefore, the clay cover is not maintained to prevent exposure.

- Construction of a detention basin to capture storm flow along the ditch and prevent it from transporting contaminated sediment beyond the fence boundary. This included plugging drainage culverts so that neither water nor sediment can leave the PGDP through the ditch. The water that is caught by the detention basin is diverted to the C-616 Treatment Facility and lagoon where it is discharged through Outfall 001.

- Implementation of LUCs to preclude any other uses than industrial for the NSDD Sections 1 and 2.

During the planning phases of this response action, additional waste characterization efforts were initiated at the direction of the KDWM. These extra sampling activities included field analyses for PCBs and volatile organics in soil. These analyses ensured that waste soils met the waste acceptance criteria for the C-746-U Landfill.

As part of the implementation of the NSDD Sections 1 and 2 Project, the EPA required an evaluation of the C-746-U Landfill to ensure that waste from the NSDD that was disposed there would not pose unacceptable risks to human health and the environment. This requirement was provided in a letter dated April 24, 2003, and stated the following:

> …because the disposal in the landfill from the NSDD interim action is expected to leave levels of contamination – both within the remediated NSDD area and on-site in the C-746-U Landfill disposal area – above levels that allow for unrestricted use and unlimited exposure, the five-year reviews required to ensure protectiveness of this action must examine conditions in both these areas to insure that the entire action remains protective (EPA 2003).

The C-746-U Landfill is a contained landfill as defined in Kentucky regulations of 401 *KAR* 47:005. The landfill meets the technical standards found in 401 *KAR* 47:080, 401 *KAR* 48:050, and 401 *KAR* 48:070 to 401 *KAR* 48:090, and DOE's remediation contractor has procedures in place to ensure that no wastes are disposed of in the landfill that do not meet the waste acceptance criteria for this facility. This includes soil waste from the NSDD and other areas of PGDP. One aspect of the waste acceptance criteria are the "authorized limits" for waste with *de minimus* levels of radiological contamination to be disposed of in the C-746-U Landfill, as described in *Risk and Performance Evaluation of the C-746-U Landfill at the Paducah Gaseous Diffusion Plant, Paducah Kentucky* (DOE 2003d). This document was developed to determine if PGDP could safely place projected nonhazardous CERCLA-derived solid waste in the C-746-U Landfill, to determine if nonhazardous, nonradioactive, wastes from the NSDD response action could be placed in the landfill, and to determine the potential effects that disposal of those waste would have considering the other wastes that also are disposed of there. The results of this study are summarized as follows:

> These results indicate that the total volume of SWMU 59 excavation can be placed in the landfill and that this placement may adversely impact the balance between the percentage of volume taken and the percentage of contaminant inventory limit taken by ^{237}Np but no other

contaminants. It must be cautioned that these results are dependent upon the quality of the data set used to generate the average contaminant concentrations. If these data do not represent areas and volumes within SWMU 59 with higher contaminant concentrations, then the results may be biased low. However, if these data come from sampling biased towards areas of suspected higher contamination, then the results may be biased high. Sampling during waste disposition will be used to address this uncertainty.

Waste characterization activities resulted in all of the excavated soil being disposed of in the C-746-U Landfill. No contaminant levels exceeded threshold criteria that would have caused the waste to be designated as Resource Conservation and Recovery Act of 1976 (RCRA)-hazardous, Toxic Substances Control Act (TSCA)-regulated, or above the authorized limits of the C-746-U Landfill. The amount of waste that might add to the inventory of hazardous constituents or radioisotopes in the landfill is tracked by the DOE Paducah/Portsmouth Project Health Physicist. This is done through documentation prepared for all waste disposed in the C-746-U Landfill, referred to as "landfill packages." These packages are reviewed to determine if the waste they describe may have minute quantities of radiological contamination. If that is the case, then the radiological data is analyzed to determine an estimated inventory of each isotope that will be associated with that landfill package. The estimates based on projected weights and volumes are compared against actual weights and volumes disposed of to ensure that the inventory does not exceed the projections. The inventory allowed for disposal in the C-746-U Landfill is that amount that can be disposed of without exceeding a 1 mrem/yr dose to the maximally exposed individual. This tracking method has ensured that disposal of wastes from the NSDD and other CERCLA-derived wastes do not pose unacceptable risks to human health and the environment.

Figures 10.1 and 10.2 show "before and after" views of the NSDD Sections 1 and 2. The total cost of excavation of Sections 1 and 2, construction of the detention basin, and disposing of approximately 3,200 yd^3 of soil in the C-746-U Landfill was $12,167,562, according to the *Remedial Action Completion Report for the North-South Diversion Ditch Sections 1 and 2 at the Paducah Gaseous Diffusion Plant, Paducah Kentucky* (DOE 2005b).

10.3 SYSTEMS OPERATIONS/OPERATIONS AND MAINTENANCE

Because the excavation exceeded the cleanup criteria set forth in the ROD, long-term maintenance of the clay cover is not required to eliminate exposure pathways. The newly-excavated and lined ditch is maintained as part of PGDP's ongoing grounds maintenance program.

The NSDD site was visited on March 6, 2008, as part of this Five-Year Review. The ditch has been well-maintained; grass was established in the channel, but was not impeding flow. There was no excessive debris over the gabion screens. The aboveground piping was in good shape, the insulation and the metal jacket covering was intact and not rusted or deteriorated. The flow into the surge basin was unimpeded, although there were come cattails in the concrete lining of the basin entry point. There was no standing water in the surge basin. The grass cover is well established and was mowed. There were no visible signs of erosion along the banks of the surge basin. The NSDD's inspections are ongoing as part of the current remediation contractor's scope.

Figure 10.1. NSDD Sections 1 and 2 Before Remedial Action

Figure 10.2. NSDD Sections 1 and 2 After Remedial Action

10.4 TECHNICAL ASSESSMENT

The goals of the remedy were to be implemented by excavating contaminated soil and sediment from the channel of the NSDD, and disposing of it in the C-746-U Landfill, if nonhazardous, or at a permitted facility, if RCRA-hazardous, TSCA-regulated, or greater than authorized limits for the on-site C-746-U Landfill. The waste acceptance criteria at the C-746-U Landfill were met; therefore, all waste soils were disposed of on-site. Upon excavation, a 2-ft clay layer was placed in the NSDD channel to add an extra layer of protection for maintenance workers. The channel would be brought to grade with another 2 ft of clean soil and vegetated to prevent erosion.

The clean-up levels for the excavation were met or exceeded at each measurement section; therefore, maintenance of the clay layer to control exposure is not required (DOE 2005b).

10.4.1 Question A: Is the Remedy Functioning as Intended by the Decision Documents?

The remedy is functioning as designed. The excavation as designed met or exceeded the clean-up criteria. The plugged culverts and detention basin prevent rainfall from inside the plant from flowing beyond the fence and transporting potentially contaminated sediment with it.

10.4.2 Question B: Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and RAOs Used at the Time of the Remedy Selection Still Valid?

Yes, the exposure assumptions, toxicity data, cleanup levels, and RAOs still are valid.

10.4.3 Question C: Has Any Other Information Come to Light That Could Call into Question the Protectiveness of the Remedy?

No other information has come to light that would call into question the protectiveness of the remedy.

10.4.4 Technical Assessment Summary

The remedial action for Sections 1 and 2 of the NSDD is protective of human health and the environment because contaminated soils and sediments were excavated eliminating the threat of exposure to these media. Plugging culverts and constructing a detention basin prevent rainfall from flowing off-site through the ditch and moving contaminated sediment with it.

The maintenance of the clay cover to prevent exposure is not required because the samples collected from the open excavation indicated that the clean-up criteria in the ROD were exceeded along the entire length of the ditch. The clay cover is maintained as part of the overall grounds maintenance program at PGDP. Optimization of institutional controls may be beneficial. Based on the discussion above, a residual risk calculation is recommended. Using the results of the calculation, a determination may be made to optimize the remedy that may lead to a removal of institutional controls and/or cessation of five-year reviews.

10.5 ISSUES

None.

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11. C-746-K LANDFILL

The C-746-K Sanitary Landfill, SWMU 8, is located southwest of the PGDP fenced security area and approximately 200 m (656 ft) southeast of the C-611 Water Treatment Plant. It is situated immediately west of Bayou Creek and north of an unnamed tributary to Bayou Creek. Drainage ditches located along the western and northern edges of the landfill flow to the south into the unnamed tributary and to the east into Bayou Creek, respectively. Figure 11.1 depicts its location.

Records indicate that PGDP used the landfill between 1951 and 1981 for disposal of fly ash from the plant's coal combustion boilers, uncontaminated combustible plant waste, and potential radiologically contaminated plant waste. The fly ash was believed to have been disposed of in trenches excavated 2 to 3 m (5 to 10 ft) bgs. During operations, trenches were cut in the fly ash and used for burning trash. This practice ceased in 1967, after which waste was buried without burning. The waste, consisting mostly of office and kitchen trash and some construction debris, was placed in trenches excavated within the fly ash and covered, when necessary, with additional fly ash or soil fill. In addition to these materials, sludge from the C-615 Sewage Treatment Plant may have been buried at the unit, as it reportedly was used as fill material. Soil boring information indicates that up to 9 m (28 ft) of fly ash and trash was placed in the landfill. The landfill was closed in 1982 and covered with a 15- to 30-cm (6- to 12-inch) clay cap and a 46-cm (18-inch) vegetative cover.

On January 30, 1992, PGDP personnel discovered leachate in a ditch on the southwest side of the landfill. DOE conducted sampling at five leachate seep locations around the landfill. VOCs (TCE; 1,1-DCE; 1,1-dichloroethane; and *trans*-1,2-DCE) and metals (aluminum, iron, manganese, and zinc) were detected above background levels in the leachate samples. The leachate was acidic and the particulate matter in the leachate generally was orange to yellow in color. The precipitation of dissolved metals from the leachate was thought to be causing the orange to yellow staining observed at various points along the creek banks. The condition was deemed to be in noncompliance with the water quality provisions of 401 *KAR* 5:031, which prohibit discharges that produce "objectionable color" into waters of the Commonwealth of Kentucky. On September 15, 1992, the Kentucky Division of Water issued a Notice of Violation (NOV) to DOE for "unpermitted seepage areas from the C-746-K Sanitary Landfill into waters of the Commonwealth."

As a result of the NOV, DOE, with the approval of the EPA and KDEP, undertook an interim corrective action to address the seeps. To prevent any further release of solids to the unnamed tributary, DOE installed a sandbag dam with a liner in the drainage ditch southwest of the landfill. During the interim action, subsidence of the landfill cap was repaired and recontoured to promote surface water runoff. The actions were completed in October 1992 and have been effective in reducing seepage into the creeks. In addition, a surface water monitoring program was initiated at the landfill to monitor contaminant levels in the leachate and adjacent creeks.

The 2000 Five-Year Review for this action included the following statements of protectiveness (DOE 2000b):

> As objectified in the WAGs 1 and 7 ROD, the remedial action at [the C-746-K Landfill] is reducing the potential for human exposure by notifying persons of the potential hazards in the area. The potential for direct human contact also is reduced by the placement of riprap along the seeps and by deed restrictions recorded for [the C-746-K Landfill.] The action is protective of human health until a final action can be implemented.

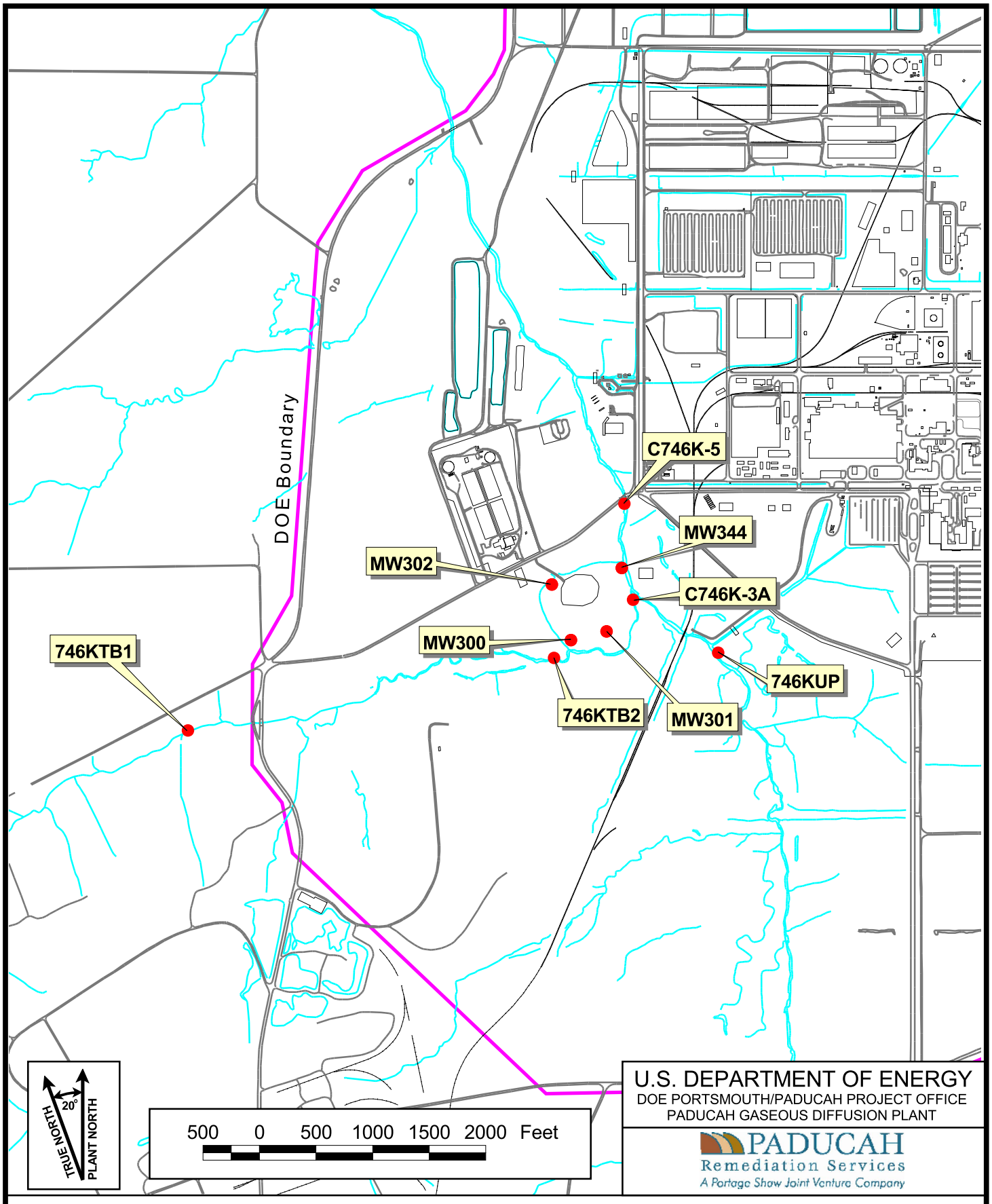

Figure 11.1. Location of C-746-K Landfill

FIGURE No. c5ac90000sk791.apr
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> The DOE certifies that the SWOU response actions taken to date at the PGDP remain protective of human health and the environment. These actions are reducing immediate risks until a final remedy for the SWOU can be implemented.

The 2003 Five-Year Review included the following statement regarding the C-746-K Landfill:

> According to the documents and the COC data reviewed, the site inspections, and the interviews, the remedy is functioning as intended by the ROD. ARARs for leachate discharges and radionuclide exposures cited in the ROD have been met.

11.1 REMEDY SELECTION

The ROD for the C-746-K Landfill was signed by DOE on February 20, 1998, and by EPA on August 10, 1998 (DOE 1998b). KDEP concurred with the selected remedy June 24, 1998. The RAOs for this unit are as follows:

- Control the release of COCs from the unit,
- Limit direct contact by humans, and
- Reduce overall risks to ecological receptors.

11.2 REMEDY IMPLEMENTATION

The ROD defined and identified the following components of the remedial action for the C-746-K Landfill (DOE 1998b).

- Install warning signs.
- Place riprap.
- Institute a deed notice and restrictions.
- Continue the existing surface water monitoring program.
- Modify the groundwater monitoring program.
- Continue the current landfill cap maintenance program.

The institutional controls for the C-746-K Landfill are forms of LUCs. The EPA regional office issued a policy in April 1998 for assuring the long-term effectiveness of LUCs at federal facilities (Johnston 1998). PGDP subsequently developed a site-specific Memorandum of Agreement (MOA) and LUC Assurance Plan (LUCAP) (DOE 2000d). The PGDP LUCAP specifies that decision documents, approved prior to the effective date of the MOA in which LUCs were selected as part of the remedy, will be analyzed for the effectiveness of the LUCs during the ROD Five-Year Reviews. The effectiveness of the LUCs at the C-746-K Landfill is addressed in this Five-Year Review. Because the ROD for this IRA was signed prior to the effective date of the PGDP MOA and LUCAP, there is no LUCIP for the LUCs at the C-746-K Landfill.

The Post-Construction Report and Operations and Maintenance Plan for Waste Area Groupings (WAGs) 1 and 7 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, documents the remedial

actions taken at the C-746-K Landfill ROD (DOE 1999). The O&M requirements were then revised in the document, *Operation and Maintenance Plan for the Surface Water Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2000c).

The action implemented at the C-746-K Landfill satisfies the remedial objectives stated by limiting human and animal exposure to contaminated sediments and acidic leachate by placing riprap over the seep locations. Further reduction of human risks was accomplished by posting warning signs and by placing a deed notice and restrictions on the C-746-K Landfill property.

Surface water monitoring at the C-746-K Sanitary Landfill began in February 1992, following the discovery of leachate in adjacent ditches and creek banks. DOE summarized the monitoring data through October 1992 in the *Work Plan for Interim Corrective Measures at the C-746-K Sanitary Landfill* and developed the monitoring program that was used until October 1998 (DOE 1992). Four stations made up the surface water monitoring network. Two stations, 746KTB1 and 746KTB2 (Figure 11.1), located on the adjacent unnamed tributary and Bayou Creek, respectively, provided upstream monitoring. Two other stations close to the C-746-K Sanitary Landfill, 746K3A and 746K-5 (Figure 11.1) provided downstream monitoring on the adjacent unnamed tributary and Bayou Creek, respectively. The analytical suite for the stream monitoring locations included 13 common metals, arsenic, mercury, uranium, VOCs, PCBs, and pH.

Samples were collected monthly through September 1995 and quarterly thereafter. DOE presented the surface water monitoring results in the FFA Semiannual Progress Report to KDWM and EPA each April and October. In summary, the data demonstrated that water quality at monitoring station 746K3A was impacted by the leachate from the C-746-K Sanitary Landfill, while monitoring station 746K-5 appeared to be unaffected. The leachate from the landfill usually contained high levels of dissolved metals, low-levels of dissolved VOCs, and a low pH (2.3 to 3.3 standard pH units).

As stipulated in the ROD, the surface water monitoring requirements for C-746-K were supplanted by a Watershed Monitoring Plan (initially approved October 14, 1998, and revised on September 29, 2006) that was included in the 1998 KPDES Permit for PGDP. Of the four surface water monitoring stations stipulated in the ROD, only two continue to be sampled under the current Watershed Monitoring Plan (PRS 2006). Water was last sampled for chemical analysis at the upstream monitoring station on Bayou Creek and the downstream monitoring station on the unnamed tributary to Bayou Creek in 2005 and 2003, respectively. The Watershed Monitoring Plan included three other interim surface water monitoring stations to assess the C-746-K area. Surface water was last collected for chemical analyses from these stations in 1999.

Figure 11.1 shows the four monitoring well locations and the four surface water monitoring locations. The current analytical suite in the CY 2007 Environmental Monitoring Plan for surface water monitoring locations includes 21 common metals, arsenic, mercury, uranium, TCE, PCBs, pH, and other field measurements.

Table 11.1 summarizes relevant data for COCs since the last Five-Year Review.

Table 11.1. Summary of Water Quality Analyses for the C-746-K Landfill COCs–2003 through 2007

Analyte	Unit	Bayou Creek (surface water)		Unnamed Tributary (surface water	
		C-746-KUP[a] (upstream)	C-746-K-5 (downstream)	746KTB1 (upstream)	746KTB2[b] (downstream)
Aluminum	mg/L	ND[c]-2.31	ND-7.19	ND-3.89	0.90-3.36
Iron	mg/L	ND-1.32	ND-5.18	ND-2.66	0.94-2.13
Manganese	mg/L	0.04-0.18	0.02-0.19	0.01-0.42	0.04-0.08
Zinc	mg/L	ND-0.12	ND	ND	ND
TCE	µg/L	ND-1	ND	ND	ND

[a] For years 2003-2004
[b] For year 2003 only
[c] ND = nondetect

11.2.1 Surface Water and Groundwater Monitoring

The surface water monitoring requirements at the C-746-K Landfill have been incorporated into the Watershed Monitoring Plan directed by the KPDES permit of September 29, 2006. Groundwater monitoring continues under the PGDP Groundwater Monitoring Program.

11.2.2 Riprap Placement

The remedy identified in the C-746-K Landfill ROD included the placement of riprap on visible leachate seep locations to prevent direct exposure. The action included covering three leachate seep sites and stabilizing the bank of Bayou Creek on the east side of the C-746-K Landfill. Before the leachate seeps were covered, the site was cleared of existing vegetation and a geotextile fabric layer was placed under a layer of riprap. Three leachate seep sites were covered to minimize the potential for human and animal exposure. Construction work for this component of the action began August 5, 1997, and was completed August 12, 1997.

11.2.3 Warning and Landfill Entrance Sign Installation

DOE installed warning signs in November 1997 at each of the leachate seep areas and around the landfill. The signs notify the public of the risk associated with the areas. A sign was placed at the entrance of the C-746-K Sanitary Landfill in February 1998. These signs are inspected on a routine basis and are replaced as necessary.

11.2.4 MW Abandonment and Installation

As specified in the ROD and with the approval of KDWM, two MWs (MW184 and MW303) were abandoned. One new well (MW344) was installed to replace MW303 at the C-746-K Sanitary Landfill in March 1998. The intent of the new well was to detect any contamination that could be migrating from the landfill and traveling along the top of the Porters Creek Clay and into the RGA.

11.2.5 Deed Restriction Implementation

A deed notice and a restriction were placed in the chain of title to the deed of the property to inform potential buyers and/or users of the potential risks to human health and the environment posed by the leachate seeps. The notice and restriction were filed August 24, 1998, with the McCracken County Court Clerk.

11.3 SYSTEMS OPERATIONS/OPERATIONS AND MAINTENANCE

The C-746-K Sanitary Landfill and its immediate surroundings were visited on March 5, 2008, to determine if the required remedial actions for the C-746-K Landfill ROD are being met (DOE 1998b).

A sign posted at the entrance to the landfill area clearly identifies the potential human health risks posed by the leachate seeps and contaminated sediments present in the creeks and drainage ditches around the landfill. Additional warning signs are posted at periodic intervals along the west bank of Bayou Creek to the east of C-746-K Landfill and along the north bank of the unnamed tributary to the south of C-746-K Landfill. The signs are in good condition and clearly legible. Additionally, the C-746-K Landfill falls within the boundaries of an extended security buffer zone around PGDP that was established by DOE immediately following September 11, 2001. This buffer zone severely restricts access to the area by the general public.

Riprap that was placed along the west bank of Bayou Creek for erosion protection and to cover apparent seep sites is in place. Riprap also has been placed at one apparent seep area along the unnamed tributary on the south side of the landfill and the area drainage ditch along the west side. These areas also are in good condition. The riprap that is added along adjacent streams sometimes is washed away during strong rainfall events, but is replaced as quickly as practicable.

The covered and capped area of the landfill is in good condition with a well-established grass cover that appears to drain well. There are no indications that water stands on the cap or side slopes. There were no signs of erosion on the landfill cap or side slopes. The area is maintained well and is mowed regularly. There are seven passive gas vents on top of the landfill that are in good condition and show no signs of leakage or settlement. The service road around the landfill is maintained and in good condition.

Four locations in the unnamed tributary and Bayou Creek in the vicinity of SWMU 8 are sampled quarterly.

The costs associated specifically with maintenance of the C-746-K Landfill are small and are not tracked separately because they are part of the plant-wide, long-term surveillance and maintenance, and environmental monitoring programs.

11.4 TECHNICAL ASSESSMENT

The overall objectives of this project were to control the release of COCs from the unit, reducing the ecological risks, and limiting human contact.

11.4.1 Question A: Is the Remedy Functioning as Intended by the Decision Documents?

Yes. The remedy is functioning as intended.

11.4.2 Question B: Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and RAOs Used at the Time of the Remedy Selection Still Valid?

The risk assessment for the C-746-K Landfill determined that the unit posed unacceptable risk to industrial workers and animals via direct contact with leachate and contaminated sediments. In the event that risk assessment parameters are changed to more conservative than those used for the C-746-K risk assessment, the current action may not meet the CERCLA criteria of reducing risk to less than 1×10^{-6}.

As yet, the risk assessment parameters have not changed enough to increase the risk above that CERCLA threshold.

The current remedy for the C-746-K area includes institutional controls (LUCs and engineering barriers to prevent exposure, along with groundwater monitoring for potential migration of contaminants off-site. The concentrations of metals detected in groundwater that are listed in Table 11.1 were compared to the draft surface water preliminary remediation goal (PRGs) generated for the revised PGDP human health methods document. For metals, the lowest PRGs associated with surface water are the for the child swimming scenario. The PRGs for that scenario are 41 mg/L for aluminum, 154 mg/l for iron, 1.01 mg/L for manganese, and 20.1 mg/L for zinc. All detections in Table 11.1 are below the corresponding lowest draft PRG for surface water. The results in Table 11.1 were also compared to the Kentucky surface water standards in 401 *KAR* 10:031. The chronic warm water aquatic habitat criteria are: 0.87mg/L for aluminum, 1 mg/L for iron, 0.8 mg/L for manganese, and 0.6 mg/L for zinc. Results from the monitoring wells are below these Kentucky standards and the 2001 PGDP ecological risk methods document surface water screening levels for aluminum, manganese, and zinc.

The iron concentrations in all monitoring wells exceed the Kentucky chronic criteria, but all except the maximum detection in well C-746-K-5 are below the acute iron criterion of 4 mg/L. These comparisons indicate that the remedy continues to be protective of human health and the environment due to restricted direct exposure and because groundwater in the MWs is near or below applicable surface water standards and screening levels.

ARARs identified during the ROD development are listed in the appendix. There have been no changes to the ARARs for this action that would compromise the protectiveness of this remedy.

11.4.3 Question C: Has Any Other Information Come to Light That Could Call into Question the Protectiveness of the Remedy?

No, no other information has come to light.

11.4.4 Technical Assessment Summary

The remedy is functioning as intended by the ROD. ARARs for leachate discharges and radionuclide exposures cited in the ROD have been met. During the 2003- 2007 review period, the remedial action at the C-746-K Landfill continued to reduce the potential for human exposure by notifying persons of the potential hazards in the area from contaminants seeping from the landfill (DOE 1998b). The potential for direct human contact also is reduced by the placement of riprap along the seeps and by deed restrictions recorded for the C-746-K Landfill.

11.5 ISSUES

None.

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12. FIRE TRAINING AREA

The Fire Training Area, SWMU 100, is located in the southwest corner of PGDP. At the time of the investigation of this area, it consists of one large rectangular surface burn area, two circular burn pan areas, one circular electric pump area, an elevated and bermed fuel tank area, and two square burn area depressions. The burn areas are unlined and are not bermed. The Fire Training Area has been used since 1982 for staging fire training exercises involving waste oils, fuels, and other combustible liquids. Combustible liquids were not burned in the unlined areas after 1987. Fire training exercises continue to be conducted in the vicinity, but in order to prevent any negative impacts to the environment, no burning is conducted in unlined areas, and flammable liquids are no longer used.

The 1998 Five-Year Review had the following statement of protectiveness:

> The no further action at SWMU 100 is being met through the continued maintenance and existence of the PGDP security fence.

The 2003 Five-Year Review had the following statement of protectiveness:

> No further action, other than maintaining institutional controls (to maintain the industrial nature of the area), is necessary to protect workers at SWMU 100.

12.1 REMEDY SELECTION AND IMPLEMENTATION

The selected remedy for the Fire Training Area, SWMU 100, was no further action beyond the existing institutional controls (DOE 1998b).

12.2 SYSTEMS OPERATIONS/OPERATIONS AND MAINTENANCE

A site visit of this Fire Training Area was conducted on March 11, 2008. Although it is apparent that the area is used for fire fighters' training, the ground surface features described in the first paragraph of this chapter no longer are apparent. The area includes a tower for training firefighters on how to enter a smoke-filled structure, an open-air lecture area, pans on the ground surface that were filled with rainwater during the site visit, and an mobile water tank. Grass was established in the area, and it had been mowed during the previous growing season. There were no areas of erosion or sloughing.

12.3 TECHNICAL ASSESSMENT

There have been no detrimental changes to the Fire Training Area; consequently, the "no further action" decision remains protective. Its current use as a fire-fighters training area shows no apparent harm to the environment. No further action is necessary to protect PGDP workers at the Fire Training Area who are not associated with the fire protection department.

12.4 ISSUES

None.

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13. SURFACE WATER INTERIM CORRECTIVE MEASURES

Initial site investigations at PGDP indicated that various units were contributing to off-site surface water contamination. Of particular concern at the time were the surface water sediment and soils at KPDES outfalls west, north, and east of the facility. These included KPDES Outfalls 001, 002, 003, 010, 011, and 012. Surface-water patterns at the PGDP at the time that the action took place have changed significantly. The concerns at the time are noted below, along with information on whether that surface water drainage has changed.

13.1 REMEDY SELECTION

The actions chosen were to install fencing and posting signs to warn people in the area of the dangers posed by direct contact with the water and/or sediments.

The objectives of the Surface Water ICM were the following:

- To restrict access by the general public and site personnel to contaminated areas, thus reducing direct exposure and the potential for inadvertent transport of contaminants;
- To restrict access by the general public to contaminated areas for recreational uses;
- To identify contamination areas to the public and site personnel; and
- To monitor water and sediments as part of the KPDES program.

No ARARs were identified for this action in the decision document.

13.2 REMEDY IMPLEMENTATION

To achieve the objectives listed, signs and fencing were required for the locations indicated on Figure 13.1. The language originally proposed was revised in the document, *Operation and Maintenance Plan for the Surface Water Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2000c). The signs read as follows:

> This waterway is contaminated. Use of this waterway for drinking, fishing, swimming, or other forms of recreation may expose you to unnecessary health risks. Do not eat fish caught in this body of water. Do not cross posted boundaries. Cross only in designated areas. For information, call (270) 441-5023.

Water and sediments were monitored as part of the KPDES program. All KPDES program requirements are specified in the Environmental Monitoring Plan which is updated on an annual basis.

13.3 SYSTEMS OPERATIONS/OPERATIONS AND MAINTENANCE

The *Operations and Maintenance Plan for Institutional Control of Off-site Contamination in Surface Water at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, (MMES 1993) was the original documentation for the O&M activities for the Surface Water ICM. Signs are inspected monthly and

repaired or replaced, as needed. The O&M requirements were revised in the document in, *Operation and Maintenance Plan for the Surface Water Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2000c).

Although the sampling and assessment of surface water data is part of the PGDP environmental monitoring program it is not part of the Surface Water ICM. The results of the environmental monitoring program are reported in the Annual Site Environmental Report. The KPDES outfall sampling results are reported in the Annual Watershed Monitoring Report.

The locations of the signs and fences were visited on March 11, 2008. All of the locations, which are noted with a dark triangle on Figure 13.1, were visited, but only the locations with a letter designated have a comment in this paragraph. The fences at all locations were in place despite a recent ice storm that had resulted in fallen trees near some of the sign and fence locations. Also, at all locations the Surface Water ICM signs were posted along with "KEEP OUT," "no trespassing" and radiological warning signs. At many locations, particularly those at Location A, along the road going out the north side of PGDP, most of all the different types of signs were too faded to read. The ICM signs on the fence along the north side of Location B, as shown on Figure 13.1, also were faded, although most of the KEEP OUT and NO TRESPASSING signs still were legible. At the Location C, the ICM signs were in good condition.

The environmental responses for the NSDD and Scrap Metal Disposition Project have impacted significantly the Surface Water ICM. Both of these actions included construction projects inside PGDP to prevent transport of contaminated sediment off-site. Also, after September 11, 2001, PGDP instituted a security buffer zone, which includes all of the locations where the surface water signs are located except those noted as Location A in Figure 13.1. This security buffer zone prevents members of the public from accessing the locations of the signs; therefore, the possibility of long-term exposure to humans is much less than it was when the signs were put in place.

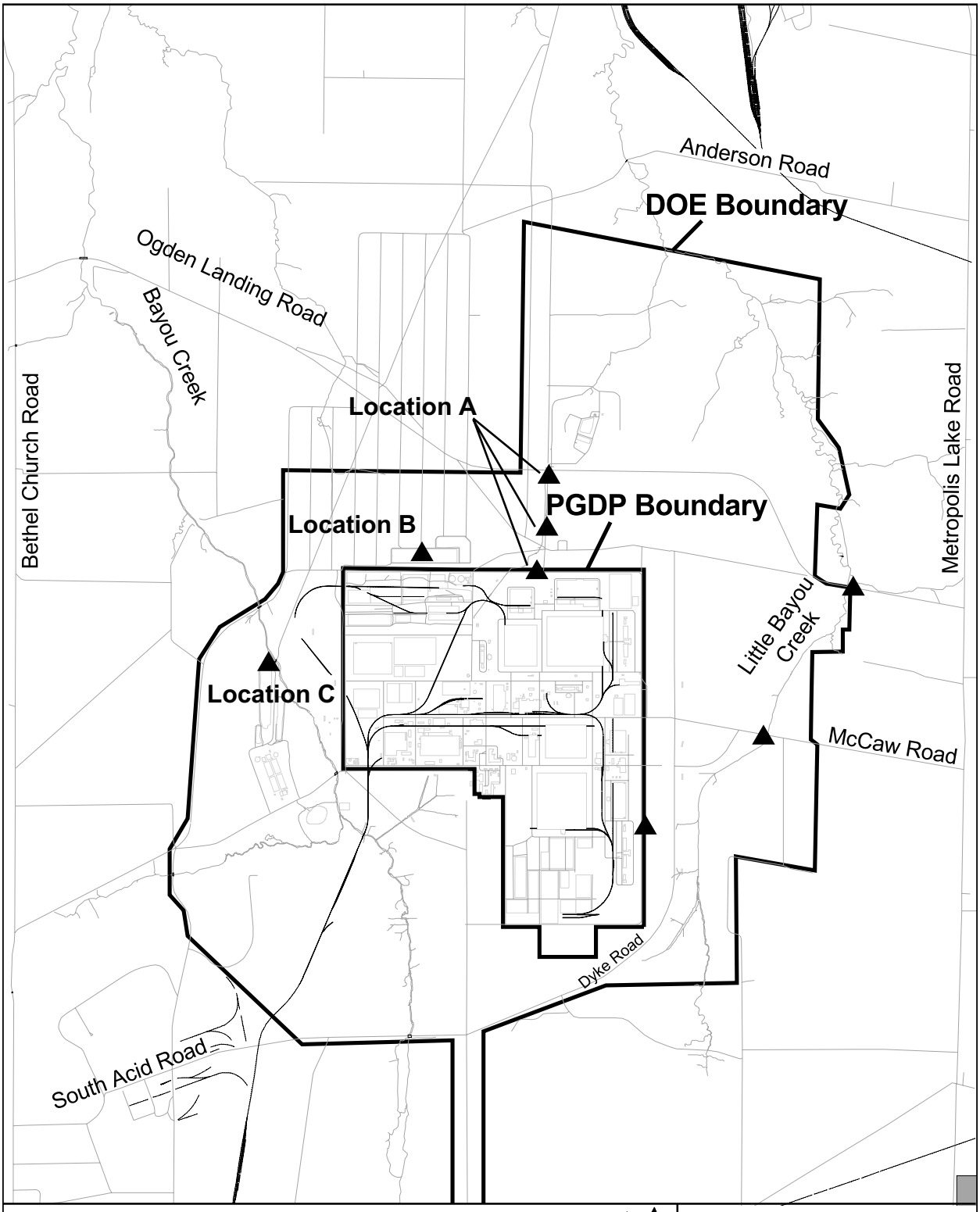

Figure 13.1 Locations of Signs and Fencing Installed for the Surface Water ICM

FIGURE No. Fig 13-1 SW ICM Revised 8-08.pdf
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13.4 TECHNICAL ASSESSMENT

Outfalls 002, 010, 011, and 012 drain the eastern boundary of PGDP and flow eastward toward Little Bayou Creek. The areas included in the drainage networks for these outfalls are comprised mostly of USEC process equipment. There have been no construction projects since the last Five-Year Review that would affect drainage in these drainage networks.

Outfall 001 drains the units in the northwest corner of the PGDP security fenced area. The C-613 Sedimentation Basin was constructed as part of the Scrap Metal Disposition Project to capture contaminated sediment that was transported off-site while moving heavy equipment inside the C-746-P, C-746-E, and C-746-C scrap yards during sorting, segregating, downsizing, and packaging activities, and during on-going and upcoming environmental response actions.

The surface water flowing north of the facility was drained primarily by KPDES Outfall 003, which drained some overflow during storm events from the NSDD. The two projects discussed in other sections of this report, NSDD Source Control - and NSDD Sections 1 and 2, have eliminated this outfall. The storm water that drained through NSDD to Outfall 003 when the Surface Water Interim Corrective Measure (ICM) was implemented now goes through the C-616 treatment facility, and then is discharged through Outfall 001.

13.4.1 Question A: Is the Remedy Functioning as Intended by the Decision Documents?

Yes. The locations of the signs and the wording on them, as well as the fencing remain appropriate. Potential users of creeks, ponds, or streams outside the PGDP security fence are warned that contact with contaminated water and sediment may pose potential dangers. The monitoring program through the KPDES program still is successful in meeting informational objectives.

13.4.2 Question B: Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and RAOs Used at the Time of the Remedy Selection Still Valid?

The Phase I site investigation was conducted to give a preliminary description of the nature and extent of contamination and risk associated with the off-site contamination. Phase II of the investigation was conducted to further assess the nature, extent, and risk of off-site contamination and to identify and characterize those SWMUs possibly contributing to off-site contamination. The Phase II report also includes the draft Public Health and Ecological Assessment. The results of the site investigation identify 21 SWMUs which are believed to be contributing to off-site contamination. Of these, nine were identified as contributing primarily to groundwater contamination, nine were identified as contributing primarily to soils and sediment contamination, and three were found to be contributing to both. The contaminants described in the decision document include PCBs, radionuclides (primarily ^{238}U) and metals. Metals and radionuclides do not contribute significantly to the total risk. Exposure pathways included direct radiation, ingestion of fish, dermal absorption, ingestion of sediment and water, although specific exposure parameters were not described in the decision document. Toxicity information or specific cleanup criteria were also not discussed. The ICMs continue to be adequate controls of the surface water.

13.4.3 Question C: Has Any Other Information Come to Light That Could Call into Question the Protectiveness of the Remedy?

As previously stated, the sign locations are now in a restricted access security buffer zone due to responses after September 11, 2001, which prevents most human contact with contaminants in the streams.

13.4.4 Technical Assessment Summary

This action is meeting the objectives as stated in the decision document. The remedy protects human health and the environment because the fences prevent recreational users from contacting contaminated sediment and water; however, many of the signs that would make the fences more effective have faded to the point of being unreadable. Faded signs will be replaced by new signs as a part of ongoing maintenance according to recent agreements with KDEP. This action was not intended to restore the area in which it was implemented to unrestricted use. The implementation of a security buffer zone around PGDP limits human contact to the contaminated sediments.

Additional signs will be posted along Little Bayou Creek, Bayou Creek, and Section 5 of the NSDD to warn recreational users of the risks posed by contaminated sediment, fish and surface water. Although the number and placement of signs specified in the decision document is considered sufficient, these additional signs are a choice considered as a conservative approach to the protectiveness of the public, as well as responses under the scope of the Northwest Plume (Section 5.4.2).

13.5 ISSUES

Under the scope of another project, additional signs were posted near locations where the referenced signs were posted. Although the content between the two types of signs is not conflicting, an evaluation of the sign program is needed.

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14. C-749 URANIUM BURIAL GROUND

The document, *Record of Decision for Interim Remedial Action at Solid Waste Management Units 2 and 3 of Waste Area Group 22 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* was signed in 1995 (DOE 1995a). Because SWMU 3, the C-404 Contaminated Burial Ground, is closed with a RCRA cap and is being addressed by RCRA postclosure permit requirements, the 1995 ROD required no further action for it. The remedial actions requirements in the 1995 ROD dealt with SWMU 2, the C-749 Uranium Burial Ground (C-749), which is the subject of this section. Both the C-404 and the C-749 Burial Grounds are part of the BGOU. Fieldwork to collect data for the final actions for the BGOU RI was performed in 2007. An RI report is in preparation, to be followed by a Feasibility Study (FS), Proposed Plan, and ROD.

This IRA in the 1995 ROD leaves waste in place that requires restricted access; therefore, C-749 will be reviewed no less than once every five years. In addition to the Five-Year Review, the ROD states that the groundwater data will be evaluated annually.

DOE conducted an investigation at C-749 to provide information needed before the selected interim action was fully implemented and to provide additional data to evaluate a final remedial action for C-749 (DOE 1997b). One of the goals of this investigation was to determine if the waste within C-749 was saturated with groundwater. The results of the investigation indicated that the waste within C-749 was saturated; therefore, placement of a cap on C-749 would not be effective, and the design and construction activities outlined within the ROD were canceled (Hodges 1996). The following are the conclusions of the investigation.

- Uranium and uranium precipitate dissolver sludge, contaminated with TCE from the C-400 Cleaning Building, is the primary component of the buried waste (with minimal, associated PCB oil).
- Migration of contaminants from the waste cell and underlying contaminated soil may have contributed to TCE at the PGDP boundary in concentrations that exceed both human health risk-based and regulatory (i.e., MCL) Preliminary Remediation Goals; however, modeling indicates that migration of radionuclides is not a concern.
- Lateral movement of groundwater in the UCRS does occur, but not to a significant extent. Vertical transport of TCE is significant, but vertical transport of uranium is not significant.

The 2000 Five-Year Review for this action included the following statements of protectiveness (DOE 2000e):

> The interim remedy selected for SWMU 2 [C-749] is meeting remedial objectives defined in the ROD. Until a final BGOU action can be implemented, the current action is protective of human health by preventing human exposure to buried wastes and groundwater through rigorous operational controls (i.e., radiological postings, radiological work permits, and excavation permits).
>
> The DOE certifies that the BGOU response actions taken to date at the PGDP remain protective of human health and the environment. These interim actions are reducing immediate risks until a final remedy for the BGOU can be implemented.

The 2003 Five-Year Review had the following statement of protectiveness:

> According to the documents and data reviewed, the site inspection, and the interviews, the remedy is functioning as described in the ROD. ARARs cited in the ROD have been met.
>
> DOE will continue the current monitoring program and institutional control activities at SWMU 2 (C-749) until a final remedial action is selected and implemented for the BGOU.
>
> The interim remedy selected for SWMU 2 (C-749) is meeting remedial objectives defined in the ROD. The current action is protective of human health by preventing human exposure to buried wastes and groundwater through rigorous operational controls.

The 2003 review recommended an enhanced groundwater evaluation to determine site-specific trends, in response to an apparent release of ^{99}Tc from C-749. As a part of updating the maps of the groundwater plumes in 2003, 2004, and 2005, the ^{99}Tc trends were evaluated. Also, a hydrogeological assessment of the C-749 and C-404 area was completed in July 2007 as part of the BGOU RI (DOE 2008b). These assessments showed that the increasing trend of ^{99}Tc is not related to either C-749 or C-404. The source has not yet been identified. Another result of these evaluations was the installation of an upgradient well for C-404, upon approval of KDWM. The flow path analysis and sampling results from this well and others demonstrated that wells MW337 and MW338 provide downgradient monitoring of C-749.

14.1 REMEDY SELECTION

The primary objective of the interim remedy for C-749 was to reduce the infiltration of precipitation into buried wastes and mitigate any leaching of COCs from the wastes, while DOE collected additional data to support evaluation of a final remedial action. Implementation of this action was intended to prevent migration of contaminants through the buried waste that would have resulted in the spread of contamination to either surface water and/or groundwater. The C-749 ROD specified that a groundwater monitoring program be implemented in the uppermost aquifer, the RGA, to detect any release of contaminants (DOE 1995a). The objective of this interim action is to reduce infiltration of leachate through the unsaturated waste and delay the potential breakthrough of uranium and other chemicals of concern (COCs) to the RGA.

The principal threat associated with C-749 was the potential for transport of contaminants to the GWOU and subsequent threats associated with the potential contamination of an aquifer and transport of contaminants beyond DOE property.

The institutional controls are forms of LUCs. The EPA regional office issued a policy in April 1998 for assuring the long-term effectiveness of LUCs at federal facilities (Johnston 1998). PGDP subsequently developed a site-specific MOA and LUCAP (DOE 2000d). The PGDP LUCAP specifies that decision documents approved prior to the effective date of the MOA in which LUCs were selected as part of the remedy will be analyzed for the effectiveness of the LUCs during the ROD Five-Year Reviews. The effectiveness of the institutional controls, or LUCs, is addressed in this Five-Year Review. Since the ROD for this IRA was signed prior to the effective date of the PGDP MOA and LUCAP, a LUCIP does not exist for the institutional controls at C-749.

14.2 REMEDY IMPLEMENTATION

The major components of the interim action remedy included investigation, the option of a multilayer low-permeability cap (which was canceled) (Hodges 1996), groundwater monitoring, and institutional controls. In 1996, three RGA MWs were constructed to detect potential releases from C-749. MW337 and MW338 were installed downgradient of C-749 and MW333 was installed upgradient of C-749. The wells currently are sampled as part of the PGDP Groundwater Monitoring Program as specified in the annual *Environmental Monitoring Plan* (PRS 2007b). The entire area of the burial ground was roped off and posted as a Radiation Area. A permit system requiring approval prior to entry was established.

14.3 SYSTEMS OPERATIONS/OPERATIONS AND MAINTENANCE

On March 6, 2008, a site inspection of the C-749 Uranium Burial Ground was performed. This area is located north and west of the C-600 Building within the boundaries of the Controlled Access Area of PGDP. There were no indications of erosion or standing water in the area. An access road is located on the south side of the area outside the radiological boundary. The road is maintained well and is in good condition. Access to the north side of the area is through the C-745-C Cylinder Storage yard. This area also is maintained well. The area was covered with grass and it is mowed and well maintained. MWs in the area appear to be in good condition and are well maintained. The wells are secured with protective caps and casings with locks and are surrounded with guard posts.

14.4 TECHNICAL ASSESSMENT

14.4.1 Question A: Is the Remedy Functioning as Intended by the Decision Documents?

The goal of the interim actions for C-749, to provide overall protection of human health and the environment until a final remedy is enacted for C-749, is functioning as intended. The contaminant concentrations found in the wells are consistent with expectations at the time of ROD implementation, and no new contaminants or routes of exposure have been identified. Groundwater MWs constructed for C-749, consisting of two downgradient wells (MW337 and MW338) and one upgradient well (MW333), are correctly located to monitor the facility. Furthermore, a previously existing RGA well (MW67) provides additional downgradient monitoring. The hydrogeological assessment (completed July 2007) of the C-749 and C-404 areas as part of the BGOU RI Report documents that two other RGA wells intended to monitor C-404 (MW226 and MW227) are placed in the groundwater flow path upgradient of C-749.

Tables 14.1 and 14.2 present downgradient vs. upgradient data showing a comparison of the initial and current maximum concentrations of the principal contaminants detected in RGA wells at C-749, based on groundwater sampling conducted between 1988 and 2007. The maximum detected concentrations of TCE in the one upgradient well and the three downgradient RGA wells located at C-749 currently exceed the National Primary Drinking Water Standards and applicable state standards. Technetium-99 activity has remained below the MCL, but appears to be rising in C-749 downgradient well MW337. The July 2007 hydrogeological assessment shows these trends are unrelated to releases from either C-749 or C-404.

Concentrations of uranium currently are at nondetectable levels and have been previously, with the exception of two sampling events in downgradient well MW338 (350 µg/L on September 24, 2001). In one event, uranium was detected at a high level, but subsequent sampling at the well and isotopic uranium

Table 14.1. Comparison of Initial and Current Contaminant Concentrations in RGA Groundwater, Downgradient to SWMU 2

Analyte	Initial Conditions (Pre-1996)			Current Conditions (Post-ROD)			Screening Levels		Units
	Maximum	Associated Well	Sampling Date	Maximum	Associated Well	Sampling Date	RGA Background Values[a]	Maximum Contaminant Level	
TCE	0.003	MW50	10/15/1991	0.780	MW337	2/14/2006	No Value	0.005	mg/L
Uranium	0.001	MW51	5/1/1991	0.35[b]	MW338	9/24/2001	0.002	0.03[c]	mg/L
cis-1,2-DCE				0.062	MW337	2/14/2006	No Value	0.07	mg/L
Beryllium	2.3	MW50	4/5/1990	0.0014	MW337	10/4/1996	0.004	0.004	mg/L
Calcium	16.8	MW50	10/20/1989	16	MW337	10/4/1996	40	No Value	mg/L
Chloride	13	MW67	2/18/1988	24.3	MW338	3/10/1998	89.2	250[d]	mg/L
Fluoride	0.89	MW51	5/1/1991	0.41	MW338 MW67	10/4/1996 10/8/1996	0.245	4	mg/L
Iron	82.8	MW50	10/20/1989	56	MW337	10/4/1996	3.72	0.3[d]	mg/L
Magnesium	6.43	MW67	2/24/1993	7.3	MW337	10/4/1996	15.7	No Value	mg/L
Manganese	1.8	MW51	1/13/1988	2.1	MW337	10/4/1996	0.082	0.05[d]	mg/L
Nitrate/Nitrite	0.07	MW50	4/5/1990	0.21	MW337	10/4/1996	13.5[e]	10[e]/1[e]	mg/L
Potassium	2.38	MW50	10/20/1989	3.9	MW337	10/4/1996	4.47	No Value	mg/L
Sodium	333	MW50	10/20/1989	14	MW338	10/4/1996	63.5	No Value	mg/L
Sulfate	12	MW67	2/24/1993	8.7	MW67	10/8/1996	19.1	No Value	mg/L
Vanadium	56.8	MW50	10/20/1989	0.052	MW337	10/4/1996	0.139	No Value	mg/L
Gross Alpha	33.3[f]	MW50	10/20/1989	10.8	MW337	12/4/2003	2.36	15	pCi/L

Table 14.1. Comparison of Initial and Current Contaminant Concentrations in RGA Groundwater, Downgradient to SWMU 2 (Continued)

Analyte	Initial Conditions (Pre-1996)			Current Conditions (Post-ROD)			Screening Levels		Units
	Maximum	Associated Well	Sampling Date	Maximum	Associated Well	Sampling Date	RGA Background Values[a]	Maximum Contaminant Level	
Gross Beta	38 38[f]	MW50 MW51	10/20/1989 3/28/1991	163	MW337	3/19/2007	7.3	50[g]	pCi/L
^{241}Am	1.6	MW51	1/13/1988	0.35	MW67	10/8/1996	No Value	No Value	pCi/L
^{239}Pu	0.28	MW67	3/11/1991	0.13	MW338	10/4/1996	0.03	No Value	pCi/L
^{99}Tc	53.2	MW51	7/23/1992	237	MW337	3/19/2007	10.8	900	pCi/L
^{230}Th				0.74	MW67	10/8/1996	0.54	No Value	pCi/L
^{234}U	2.5	MW67	3/11/1991	0.56	MW338	10/4/1996	0.7	No Value	pCi/L
^{235}U/^{236}U				0.11	MW337	10/4/1996	0.3[h]	No Value	pCi/L
^{238}U	3.3	MW67	3/11/1991	0.67	MW338	10/4/1996	0.7	No Value	pCi/L

a Background values of RGA wells from Volume 5 of the GWOU FS, Background Concentrations of Naturally Occurring Inorganic Chemicals and Selected Radionuclides in the Regional Gravel Aquifer and McNairy Formation at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky (DOE 2001b).
b Isolated detection, isotopic analysis shows non-detects.
c Proposed Value.
e Value is Nitrate as Nitrogen.
f Dissolved activity.
g Administrative Consent Order Value.
h Background value for ^{235}U.

Table 14.2. Comparison of Initial and Current Contaminant Concentrations in RGA Groundwater, Upgradient to SWMU 2

Analyte	Initial Conditions (Pre-1996)			Current Conditions (Post-ROD)			Screening Levels		Units
	Maximum	Associated Well	Sampling Date	Maximum	Associated Well	Sampling Date	RGA Background Values[a]	Maximum Contaminant Level	
TCE				2.7	MW333	3/19/2007	No Value	0.005	mg/L
Uranium	0.19	MW48	8/1/1989	ND	MW333	ALL	0.002	0.03[b]	mg/L
cis-1,2-DCE				0.33	MW333	3/19/2007	No Value	0.07	mg/L
Beryllium	0.01	MW48	8/1/1989	ND	MW333	ALL	0.004	0.004	mg/L
Calcium	17.2	MW48	4/3/1991	24	MW333	10/14/1996	40	No Value	mg/L
Chloride	12	MW48	3/9/1993	12.1	MW333	3/10/1998	89.2	250[c]	mg/L
Fluoride	0.18	MW48	5/24/1989	0.32	MW333	10/14/1996	0.245	4	mg/L
Iron	706	MW48	8/1/1989	6.2	MW333	10/14/1996	3.72	0.3[c]	mg/L
Magnesium	0.00699	MW48	4/3/1991	9.2	MW333	10/14/1996	15.7	No Value	mg/L
Manganese	5.87	MW48	8/1/1989	2.6	MW333	10/14/1996	0.082	0.05[c]	mg/L
Nitrate/Nitrite	2.4[d]	MW48	10/13/1989	0.05	MW333	10/14/1996	13.5[d]	10[d]/1[e]	mg/L
Potassium	2.07	MW48	10/13/1989	1.2	MW333	10/14/1996	4.47	No Value	mg/L
Sodium	13.7	MW48	4/3/1991	16	MW333	10/14/1996	63.5	No Value	mg/L
Sulfate	12	MW48	3/9/1993	16	MW333	10/14/1996	19.1	No Value	mg/L
Vanadium	8.5	MW48	10/13/1989	0.0097	MW333	10/14/1996	0.139	No Value	mg/L
Gross Alpha	20.4[f]	MW48	1/13/1988	5.1	MW333	5/4/1998	2.36	15	pCi/L

Table 14.2. Comparison of Initial and Current Contaminant Concentrations in RGA Groundwater, Upgradient to SWMU 2 (Continued)

Analyte	Initial Conditions (Pre-1996)			Current Conditions (Post-ROD)			Screening Levels		Units
	Maximum	Associated Well	Sampling Date	Maximum	Associated Well	Sampling Date	RGA Background Values[a]	Maximum Contaminant Level	
Gross Beta	23[f]	MW48	1/13/1988	15	MW333	5/4/1998	7.3	50[g]	pCi/L
^{241}Am	3.7	MW48	3/27/1991	0.19	MW333	10/14/1996	No Value	No Value	pCi/L
^{239}Pu				ND[i]	MW333	ALL	0.03	No Value	pCi/L
^{99}Tc	33	MW48	8/1/1989	19.27	MW333	3/3/1999	10.8	900	pCi/L
^{230}Th				0.25	MW333	10/14/1996	0.54	No Value	pCi/L
^{234}U				9.66	MW333	10/14/1996	0.7	No Value	pCi/L
^{235}U/^{236}U				0.35	MW333	10/14/1996	0.3[h]	No Value	pCi/L
^{238}U	1.3	MW48	4/3/1991	ND	MW333	ALL	0.7	No Value	pCi/L

a Background values of RGA wells from Volume 5 of the GWOU FS, Background Concentrations of Naturally Occurring Inorganic Chemicals and Selected Radionuclides in the Regional Gravel Aquifer and McNairy Formation at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky (DOE 2001b).
b Proposed Value.
c Secondary MCL.
d Value is Nitrate as Nitrogen.
e Value is Nitrite as Nitrogen.
f Dissolved activity.
g Administrative Consent Order Value.
h Background value for ^{235}U.

analysis of the same sample show nondetectable levels;[1] therefore, the credibility of the high result is questionable. The other detection (1.6 µg/L on December 3, 2002) was below the level established for RGA background (2 ug/L) and was followed by analyses that reported nondetectable concentrations.

Figure 14.1 illustrates the currently inferred groundwater flow paths for the C-749 and C-404 areas, primarily based on TCE trends in the MWs included in the C-404 permit (see Figures 14.2 through 14.3).[2] The flow paths also considered the occurrence of ^{99}Tc in wells MW226 and MW337 (the only area wells with ^{99}Tc detections) and TCE analyses for a January 2008 sampling event that included wells MW67 and MW76, as well as the recently installed MW420. Both TCE contamination and ^{99}Tc contamination monitored in the area of C-749 and C-404 are coming from an upgradient source.

Institutional controls prevent transfer of the C-749 property and prevent future intrusive activities at the unit. Because C-749 is located inside the plant secured area and under DOE ownership and control, deed restrictions have not been necessary. Signs are posted along the perimeter of the unit to identify it as a radiological contamination zone requiring personal protective equipment, special training, and permits to gain access or to work within the area.

14.4.2 Question B: Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and RAOs Used at the Time of the Remedy Selection Still Valid?

The current groundwater data indicate that assumptions underlying the remedy selection in the ROD still are valid.

The toxicity data and cleanup levels for TCE have changed since the original remedy selection; however, the original remedy was based on the assumption that there is no exposure pathway because institutional controls prevent access to the groundwater at the unit. The changes to the parameters for risk evaluation of TCE, therefore, have no effect on the protectiveness of the remedy because the exposure assumption (no exposure) is still valid. The recent data also indicate that contaminants in groundwater from this unit do not contribute significantly to the area-wide groundwater contamination that is being addressed through other actions.

Existing institutional controls, environmental monitoring, and site maintenance activities at the unit continue to ensure protection of human health and the environment.

Many of the ARARs developed for the ROD no longer are applicable because a cap was not constructed for the SWMU (Hodges 1996). A list of all of the ARARs that were originally referenced with the ROD is included in the Appendix. Since current ARARs exceed the remedy actually in place, there is no reason to question their current validity.

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[1] The laboratory reporting limit for uranium typically is 1 µg/L or less.

[2] Appendix A of *Well Plan for Addition of Wells for C-404 Monitoring Well Network, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (PRS 2007c) documents the controls of the abrupt northward deflection of groundwater beneath C-749. The primary factors include the following: 1) pathways of high hydraulic conductivity, marked by the Southwest Plume to the south of C-749 and the Northwest Plume to the north of C-749; 2) an intermediate area of low hydraulic conductivity (underlying C-749); and 3) a general hydraulic gradient to the north.

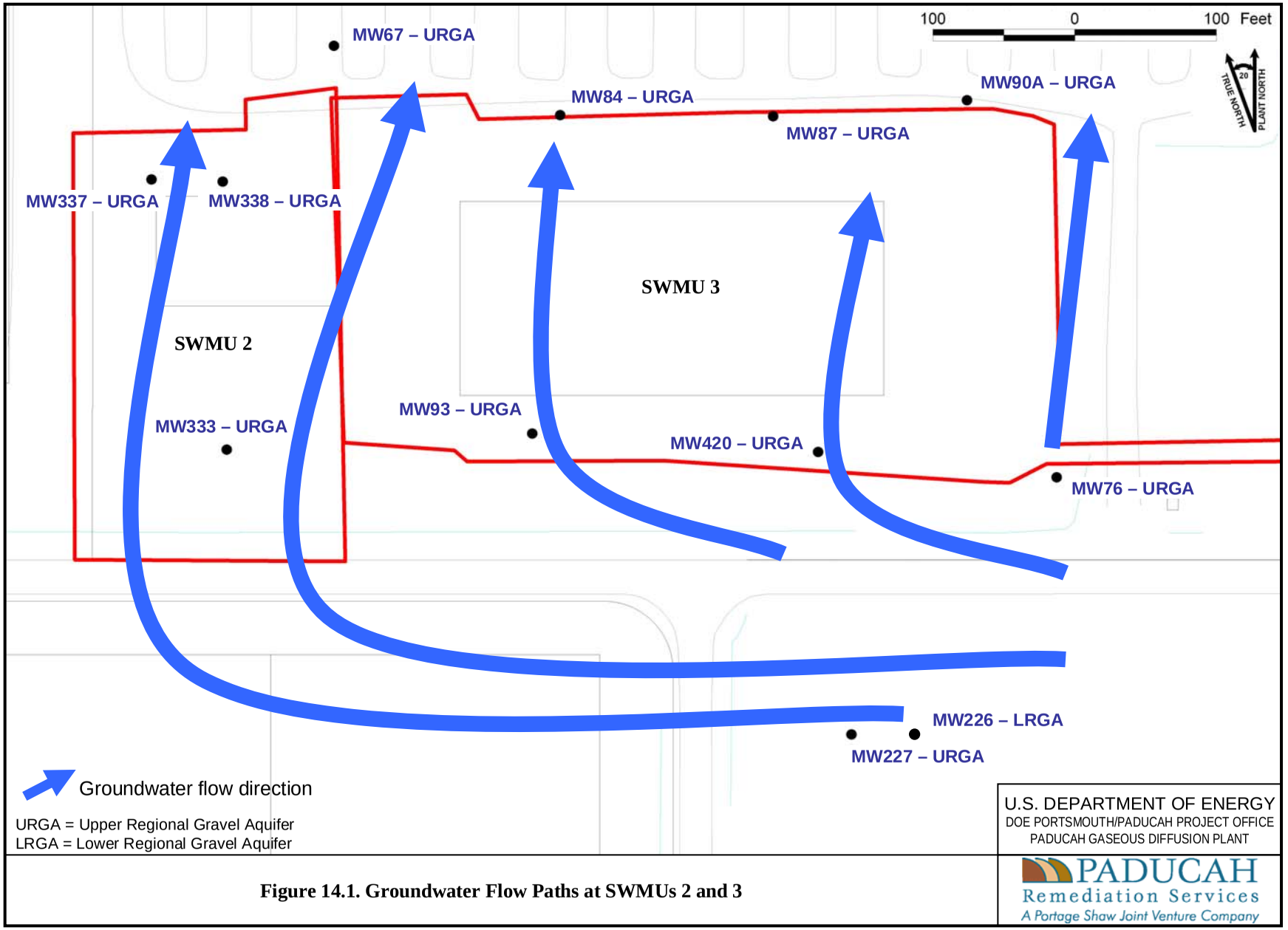
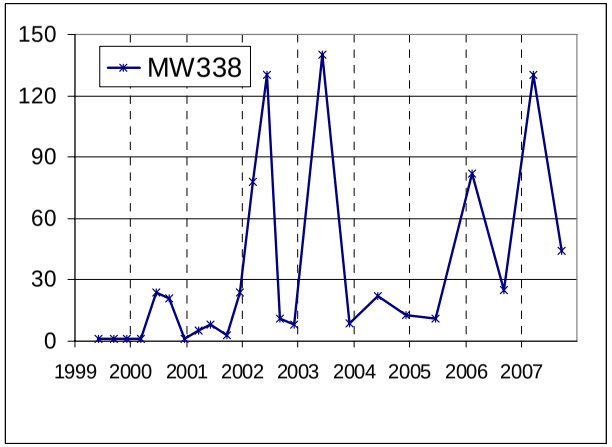
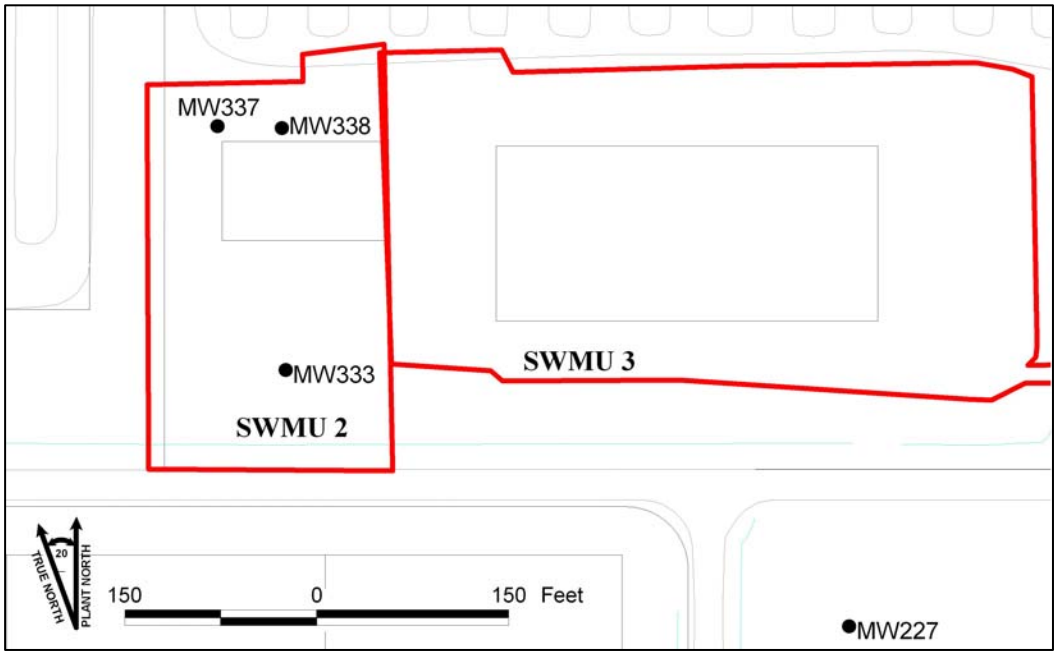
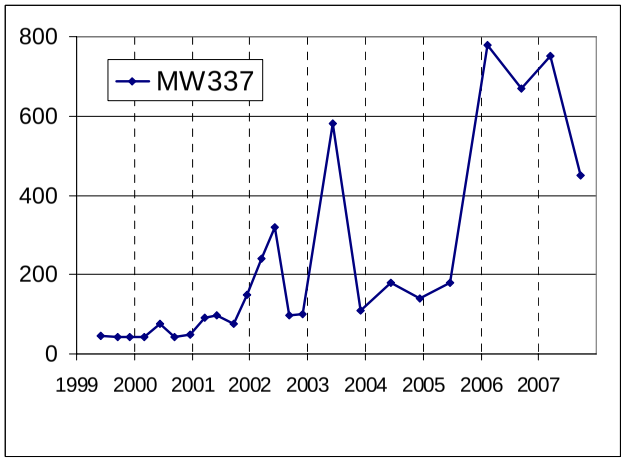


Figure 14.1. Groundwater Flow Paths at SWMUs 2 and 3







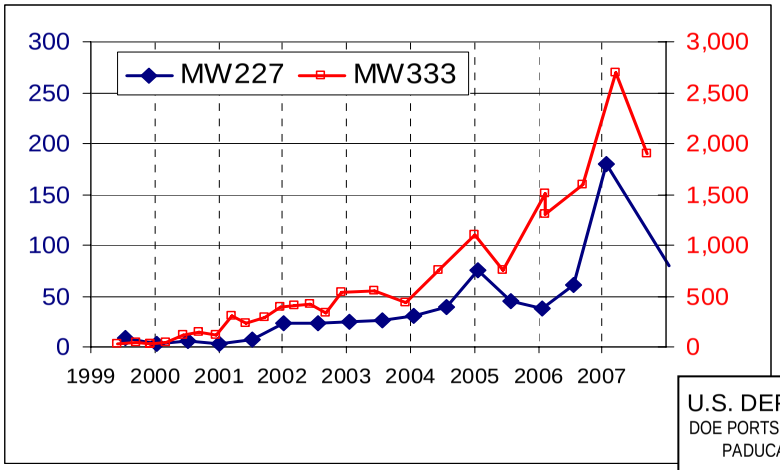


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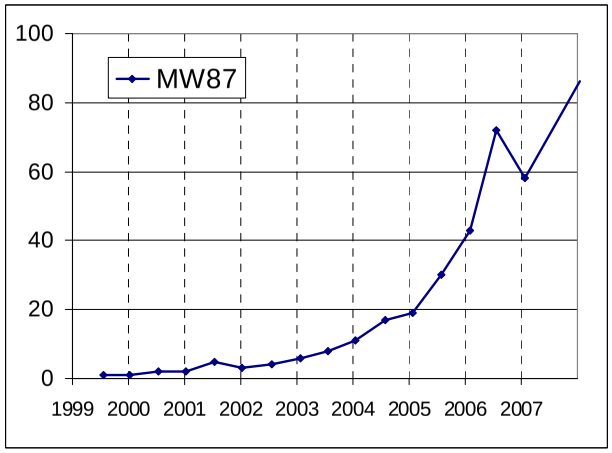
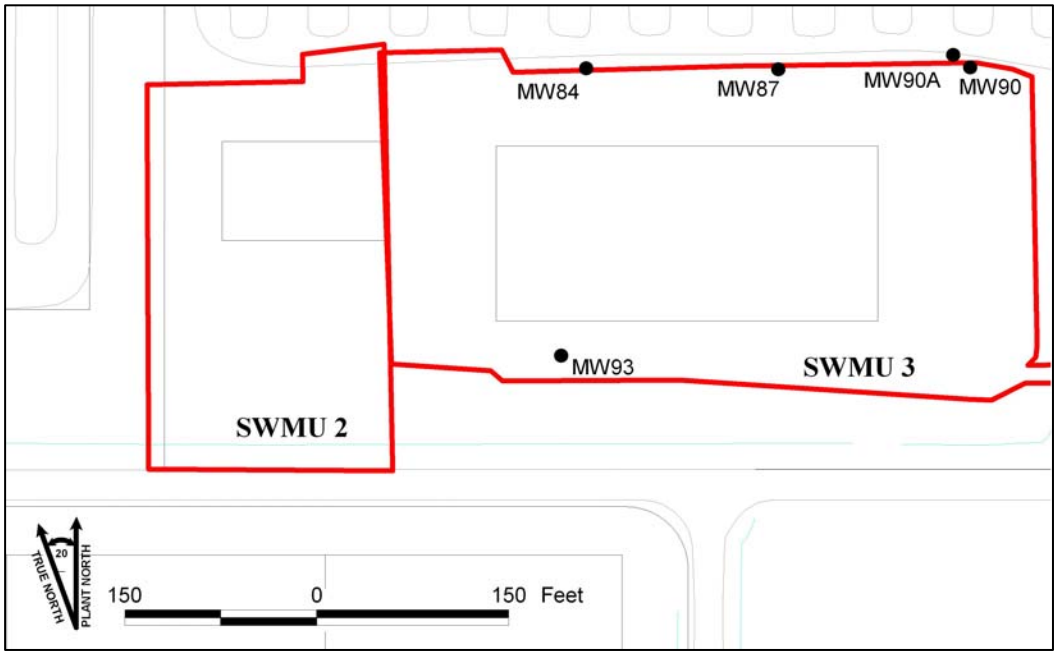
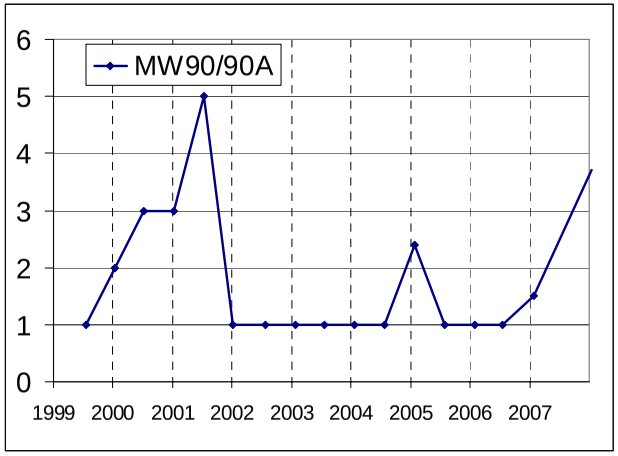
Figure 14.2. TCE Trends in the Upper RGA for SWMU 2







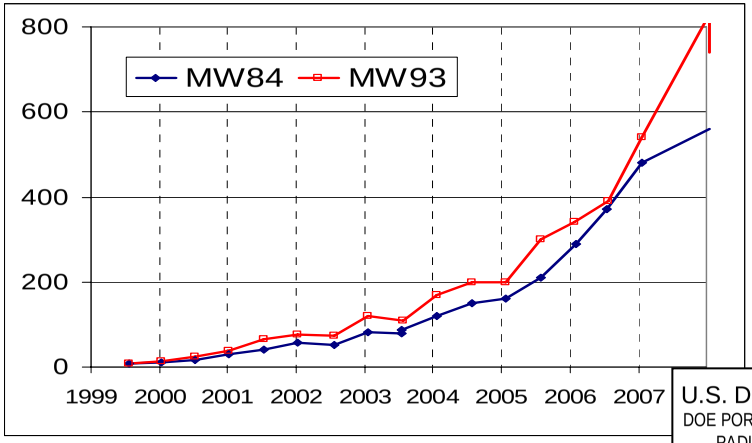


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Figure 14.3. TCE Trends in the Upper RGA for SWMU 3

14.4.3 Question C: Has Any Other Information Come to Light That Could Call into Question the Protectiveness of the Remedy?

No additional information has come to light since implementation of the remedy that could call into question the protectiveness of the remedy. No land use changes for the site are being considered.

14.4.4 Technical Assessment Summary

The remedy is functioning as described in the ROD. ARARs cited in the ROD have been met. The draft BGOU RI report includes revisions to the risk assessment methodology and updates to toxicity factors for some of the COCs that are identified in the BGOU baseline risk assessment.

DOE will continue the current monitoring and institutional control activities at C-749 until a final remedial action is selected and implemented for the BGOU. The interim remedy selected for C-749 is meeting remedial objectives defined in the ROD (DOE 1995a). As noted above, a low-permeability cap was considered at the onset of the ROD development, but was cancelled prior to final issuance. The current action is protective of human health by preventing human exposure to buried wastes and groundwater through rigorous operational controls (i.e., radiological postings, radiological work permits, and excavation permits).

14.5 ISSUES

None.

15. C-402 LIME HOUSE

The C-402 Lime House Facility is located in the central portion of PGDP at the intersection of Virginia Avenue and Eleventh Street, immediately east of C-400 Building and south of C-403. This facility was placed in the D&D OU in the 2004 Site Management Plan (DOE 2004).

The D&D of the C-402 Lime House was performed as a non-time-critical removal action under the Paducah FFA. Before and after pictures of the C-402 Lime House are included as Figures 15.1 and 15.2.

15.1 REMEDY SELECTION

The scope of this non-time-critical removal action included the removal, characterization, and disposal of the C-402 Building contents and structure to the existing concrete slab. The concrete slab was treated with an epoxy coating in order to eliminate radiological exposure. The scope did not include removal of external utilities and ancillary equipment, the concrete building slab, building foundation and partial basement, or the soil in SWMU 480.

The RAOs for this action were to accomplish the following:

- Prevent the potential health and safety hazards to on-site personnel from deterioration of the contaminated structures; and

- Minimize or eliminate the potential health and environmental hazards of radiation and hazardous material exposure caused by the potential uncontrolled release of contaminated dust, equipment, and building materials from the facility.

15.2 REMEDY IMPLEMENTATION

This alternative met the RAOs and was performed in a safe and expeditious manner. The C-402 D&D field activities began on March 21, 2006, and the field completion date was August 17, 2006. The work was accomplished through the use of approved work control documents that guided the field activities throughout the project duration. The total demolition cost to date is approximately $928,000. This value includes all fieldwork and off-site waste shipment and disposal costs.

After demolition of the facility was complete, all equipment was demobilized and materials were removed and site cleanup activities began. All ground barrier and filter cloth were removed and properly containerized for disposal. General housekeeping activities were performed on the concrete slab and around the facility grounds. Radiological surveys of the facility concrete slab and slab walls were performed to determine the posting requirements. A perimeter boundary control was installed around the concrete slab per Occupational Safety and Health Administration requirements. The slab and slab walls also were demarcated clearly as a fixed contamination area (CA).

Figure 15.1. C-402 Lime House Before D&D

Figure 15.2. C-402 Lime House After D&D

15.3 SYSTEMS OPERATIONS/OPERATIONS AND MAINTENANCE

Long-term maintenance of the concrete slab and CA are part of the overall maintenance of PGDP, and not part of this distinct project.

This site was visited on March 6, 2008, to view the effectiveness of the controls for the area. At that time, the area was clearly marked with yellow-and magenta rope and "contamination area" signs were hung on the rope on each side of the building footprint. The epoxy coating on the slab foundation was in good condition; no flaking or worn areas were noted. The area around the concrete slab is an asphalt area that is well maintained.

Since long-term maintenance of the concrete slab is part of the overall maintenance of PGDP, no additional maintenance activities are performed.

15.4 TECHNICAL ASSESSMENT

15.4.1 Question A: Is the Remedy Functioning as Intended by the Decision Documents?

The demolition and disposal of C-402 met all remedial action objectives for removal in compliance with the Removal Action Work Plan (RAWP). Upon completion of the demolition, verification of the removal action was performed to ensure compliance with the RAWP.

15.4.2 Question B: Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and RAOs Used at the Time of the Remedy Selection Still Valid?

Yes. The assumptions made that led to the remedy selection still are valid. The exposure pathways from the standing structure were eliminated when the building was demolished.

15.4.3 Question C: Has Any Other Information Come to Light That Could Call into Question the Protectiveness of the Remedy?

No other information has come to light that would change the effectiveness of the selected remedy.

15.4.4 Technical Assessment Summary

The remedy selected for the C-402 Lime House remains protective of human health and the environment. The remedial action objectives were met upon successfully demolishing the building and appropriately dispositioning all waste.

15.5 ISSUES

None.

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16. C-405 INCINERATOR

The C-405 Incinerator is located in the central portion of the PGDP at the intersection of Virginia Avenue and Tenth Street. This building was identified as SWMU 55 in 1991 and was placed in the D&D OU in the 2004 SMP (DOE 2004).

The D&D of the C-405 Building was performed as a non-time-critical removal action under the Paducah FFA.

16.1 REMEDY SELECTION

The scope of this non-time-critical removal action included the removal, characterization, and disposal of the C-405 building contents. The scope did not include removal of external utilities and ancillary equipment, the concrete building slab, building foundation, or the soil in SWMU 55. The RAOs form the basis for the C-405 Building removal action. The RAOs for this action were to accomplish the following:

- Prevent the potential health and safety hazards to on-site personnel from deterioration of the contaminated structures; and

- Minimize or eliminate the potential health and environmental hazards of radiation and hazardous material exposure caused by the potential uncontrolled release of contaminated dust, equipment, and building materials from the facility.

16.2 REMEDY IMPLEMENTATION

The alternative selected for C-405 was the removal and disposal of the building contents. This alternative met the removal action objectives and was performed in a safe and expeditious manner. The total demolition cost was assessed at $1,049,779. The cost includes the fieldwork, and the off-site waste shipment and disposal costs. The C-405 D&D field activities began on November 28, 2006, and were completed on July 25, 2007. The work was accomplished through the use of approved work control documents and procedures that guided the field activities throughout the project duration.

After demolition of the building was complete, all equipment and materials were demobilized and site cleanup activities began. The ground barrier and filter cloth were removed and properly containerized for disposal. General housekeeping activities were performed on the concrete slab and around the building grounds. Radiological surveys of the concrete slab were performed to determine the posting requirements. A fixative was applied to the concrete pad to fix the low-level radiological concerns. A perimeter boundary control was installed around the concrete slab to clearly demarcate the area as a fixed CA. Figure 16.1 and 16.2 show the C-405 Incinerator before and after demolition.

16.3 SYSTEMS OPERATIONS/OPERATIONS AND MAINTENANCE

Since long-term maintenance of the concrete slab is part of the overall maintenance of PGDP, no additional maintenance activities are performed.

Figure 16.1. C-405 Incinerator Before Demolition

Figure 16.2. C-405 After Demolition

16.4 TECHNICAL ASSESSMENT

16.4.1 Question A: Is the Remedy Functioning as Intended by the Decision Documents?

The demolition and disposal of C-405 Incinerator met all remedial action objectives for removal in compliance with the RAWP. Upon completion of the demolition, verification of the removal action was performed to ensure compliance with the RAWP.

16.4.2 Question B: Are the Exposure Assumptions, Toxicity Data, Cleanup Levels, and RAOs Used at the Time of the Remedy Selection Still Valid?

Yes. The assumptions made which led to the remedy selection still are valid.

16.4.3 Question C: Has Any Other Information Come to Light That Could Call into Question the Protectiveness of the Remedy?

No other information has come to light that would change the selected remedy.

16.4.4 Technical Assessment Summary

The remedy selected for the C-405 Incinerator remains protective of human health and the environment. The remedial action objectives were met upon successfully demolishing the building and appropriately dispositioning all waste.

16.5 ISSUES

None.

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17. C-400 ELECTRICAL RESISTANCE HEATING

Unlike most of the projects described in this Five-Year Review, this project currently is underway. Section XXX of the PGDP FFA has the following requirement:

> For OU RAs which started after the most recent Five-Year Review, the level of the review shall be commensurate to the completeness of the RA and the quantity of operation and maintenance data collected.

Because this project currently is underway, the full evaluation normally included in a Five-Year Review is not applicable. Instead, this section presents a description of the project and its progress to date.

Cleaning and degreasing operations took place in the C-400 Cleaning Building for several years prior to 1993, when use of TCE as a solvent ceased. These operations resulted in an accumulation of dense nonaqueous-phase liquid (DNAPL) just outside the south end of the building. This TCE has dispersed by local groundwater movement to form the Northwest and Northeast Plumes discussed in previous sections of this report. In order to address the TCE in place near the south end of the C-400 Building, a response action comprised of electrical resistance heating (ERH) will be implemented.

17.1 REMEDY SELECTION AND IMPLEMENTATION TO DATE

The C-400 ERH includes the design, installation, operation, and subsequent decommissioning of an ERH system to heat discrete (vertical and horizontal) intervals of the subsurface source zone resulting in volatilization, removal, and recovery of VOCs from the C-400 treatment area. The remediation goal for this interim action, as documented in the ROD (DOE 2005c), is to operate the ERH system until monitoring indicates that heating has stabilized in the subsurface and that recovery of TCE, as measured in the recovered vapor, diminishes to a point at which the recovery rate is constant (i.e., recovery is asymptotic). The ROD directs that remedial action design documents include the requirements and approach that will enable determination of asymptosis and heating stabilization, providing criteria to stop operation of the ERH system. These design documents have been prepared and currently are undergoing review under the FFA process. Once approval has been received, the installation of the ERH system will begin.

The following are the major components of the selected remedy:

- A remedial design support investigation (RDSI) to delineate further the areal and vertical extent of the contamination in the C-400 Cleaning Building area to optimize design of the remedial system;
- Removal and treatment of TCE and other VOCs from the contaminant source zone in the UCRS and RGA at the C-400 Cleaning Building area using ERH;
- Implementation, maintenance, enforcing, and reporting of LUCs on the C-400 Cleaning Building area; and
- Continuation of groundwater monitoring of the free-phase DNAPL and dissolved-phase plumes because some contamination will remain in place following the IRAs.

The ERH technology consists of installing electrodes in the subsurface, energizing them, and heating the subsurface to volatilize contaminants in the groundwater and soil. The volatilized contaminants are captured by aboveground equipment and processed for disposal as hazardous waste.

The response action selected in the ROD for the TCE and other VOCs found at the C-400 Cleaning Building area is necessary to protect public health and the environment from hazardous substances, pollutants, or contaminants that may present an unacceptable risk to human health and the environment. The selected remedy as identified in the ROD consists of volatilization and removal of TCE and other VOCs by application of ERH.

The primary objectives in the ROD are as follows:

- Reduce exposure to contaminated groundwater by reducing the source concentrations of TCE and other VOCs in the RGA in the C-400 Cleaning Building are, thereby reducing the migration of these contaminants to off-site points of exposure)POE);

- Prevent exposure to contaminated groundwater by on-site industrial workers through institutional controls (e.g., excavation/penetrations permit program); and

- Reduce contamination comprised of TCE and other VOCs found in UCRS soil in the C-400 Cleaning Building area to minimize the migration of these contaminants to TGA groundwater and to off-site POE.

The RDSI, conducted in accordance with *Remedial Design Support Investigation Characterization Plan for the Interim Remedial Action for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah Kentucky* (DOE 2005d), was completed in August 2006 using membrane interface probe (MIP) technology. MIP technology collected soil conductivity profiles and VOC data from the UCRS, the RGA, and the McNairy with minimal generation of investigation-derived waste. Soil conductivity logs of each boring were used to determine lithology. When the conductivity indicated that the probe entered the McNairy, the boring was considered complete. The DNAPL source zone delineated during the RDSI, coupled with data from previous investigations, has been assessed to delineate the areas of high TCE concentration more accurately, thereby allowing the design team to optimize placement of ERH electrodes, vapor recovery wells, and other subsurface components.

The *Remedial Design Report, Certified for Construction Design Drawings and Technical Specifications Package, for the Groundwater Operable Unit for the Volatile Organic Compound Contamination at the C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2008c) has been prepared for the C-400 Cleaning Building IRA in accordance with CERCLA.

The ROD also incorporates LUCs as a component of the selected remedy. The MOA among DOE, EPA, and the Commonwealth of Kentucky establishes and implements a *Land Use Control Assurance Plan (LUCAP) for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2000d). The LUCAP is applicable when LUCs are selected as part of a remedial action being taken (EPA 2000). The PGDP LUCAP specifies that a unit-specific LUCIP will be developed as a component of the post-ROD documentation for each waste unit that requires LUCs as part of the corrective measure/remedial action selected on or after the effective date of the MOA. In compliance with an agreement among Paducah FFA parties, the C-400 LUCIP is appended to the Remedial Design Report (DOE 2008c).

17.2 ISSUES

None.

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18. C-410 INFRASTRUCTURE REMOVAL

The C-410 Feed Plant D&D project, like the C-400 ERH Project, currently is underway. The PGDP FFA requires that project like this be included in Five-Year Reviews with summaries of activities consistent with the progress of the project up to the date of the review. Also like the C-400 ERH project, the entire five year evaluation is not included.

The C-410 Complex received uranium oxide and converted it in successive steps to uranium tetrafluoride and then to uranium hexafluoride for use as feed material for the diffusion cascade process. The primary feed operations of the C-410 Complex were shut down in 1977. Fluorine production continued until 1994. Other activities (such as electrical shop, valve rebuilding, and computer maintenance) were conducted in the complex until 1994 after the 1977 shutdown. No further uses of the areas addressed by this removal action have been identified.

18.1 REMEDY SELECTION AND IMPLEMENTATION TO DATE

The potential for, or threat of, release into the environment of a hazardous substance, pollutant, or contaminant is due to the presence of uranium, asbestos, and other materials that remain throughout the facility and from other materials that have been stored in the facility. The major radiological COCs in the C-410 Complex are uranium and the associated daughter products. Other materials used extensively in the complex include asbestos-containing materials, PCBs, refrigerants, fluorine, hydrogen fluoride, and various metals. The risk to workers and the public is due to the potential for contaminant migration and catastrophic releases.

The scope of the C-410 Infrastructure removal includes the following:

- Characterization of the waste/materials in the buildings to determine safety and health requirements and to demonstrate compliance with disposal facility criteria;
- Abatement of hazardous material;
- Removal of infrastructure equipment, piping, and stored materials;
- Reuse and recycle of selected materials, if feasible and cost-effective, consistent with DOE policy and in compliance with applicable federal and Commonwealth of Kentucky requirements; and
- Disposal of waste in appropriate on-site or off-site facilities.

The RAOs for this project are as follows:

- Remove the materials causing the highest potential risks (e.g., transferable radioactive materials, asbestos, and other hazardous materials such as PCBs), thereby significantly reducing the risk to current employees and potential off-site receptors in the event of building failure or further degradation to levels within the CERCLA risk range and in compliance with ARARs.
- Reduce the potential for public worker, and environmental exposure to radioactive and hazardous substances caused by potential uncontrolled release from the buildings.

- Remove the infrastructure from the C-410 Complex buildings in preparation for future final cleanup decision-making for the remediation of the building structure and environmental media.

This action will be considered complete when the infrastructure and stored materials in C-410 addressed by this action are physically removed, and treatment, storage, reuse or recycle and disposal of materials are complete. At that point, the removal action objectives are achieved.

Major accomplishments to date of the C-410 Infrastructure Removal Project include the following:

- Abated asbestos throughout the eastern portion of the complex;
- Initiated opening of piping systems and removing residual fluorine and hydrogen fluoride;
- Recycled fluorine cells by removing PCB paints them transferring them to a radiologically contaminated waste recycler;
- Removed and disposed of the Hydrogen Tank Farm;
- Completed equipment removal and decontamination of the extreme western end of the building, then established a boundary control station in that area. This area provides a location for workers don and doff personal protective equipment when entering and exiting the building and an area to monitor out when leaving the work area;
- Disposed of the following approximate quantities and types of waste. Until April 2006, wastes were tracked by weight; after April 2006, wastes have been tracked by volume.

From start of project through April 2006

Waste Type	Weight, lbs
Sanitary waste	132,960
LLW	899,367
PCB-bulk-product waste, LLW	378,786
Recycle	581,070

From April 2006 through December 2007

Waste Type	Volume, ft^3
Asbestos-containing material (ACM)	90
LLW	2,576
LLW/ACM	180
LLW/PCB	95,867
LLW/PCB/ACM	4,590

18.2 ISSUES

None.

19. ISSUES

Issues identified during this Five-Year Review that currently are preventing the remedial action from being protective, or as protective as it could be, are summarized in the tables below for each action.

19.1 NORTHWEST PLUME

Northwest Plume—Although the remedy remains protective, the action could be optimized by ascertaining whether the high-concentration core of TCE of the Northwest Plume at the North Extraction Well Field has migrated eastward of the capture zone of the well field.

19.2 NORTHEAST PLUME

None.

19.3 CYLINDER DROP TEST AREA OR LASAGNA™

None.

19.4 WATER POLICY

None.

19.5 NSDD SOURCE CONTROL

None.

19.6 NSDD SECTIONS 1 AND 2

None.

19.7 C-746-K LANDFILL

None.

19.8 FIRE TRAINING AREA

None.

19.9 SURFACE WATER INTERIM CORRECTIVE MEASURES

Signs were erected under the scope of another project. Although the message content between the signs does not conflict with one other, an evaluation of the sign program is needed.

19.10 C-749 URANIUM BURIAL GROUND

None.

19.11 C-402 LIME HOUSE

None.

19.12 C-405 INCINERATOR

None.

19.13 GROUNDWATER OPERABLE UNIT—C-400 ELECTRICAL RESISTANCE HEATING

None.

19.14 DECONTAMINATION AND DECOMMISSIONING OPERABLE UNIT—C-410 INFRASTRUCTURE REMOVAL

None.

20. RECOMMENDATIONS AND FOLLOW-UP ACTIONS

Based upon the issues for each remedial action, listed previously, Table 20.1 identifies recommendations and follow-up actions.

Table 20.1. Recommendations and Follow-up Actions

Issue	Recommendations/Follow-up Actions
Northwest Plume (GWOU)	
Although the remedy remains protective, the action could be optimized by ascertaining whether the high-concentration core of TCE of the Northwest Plume at the North Extraction Well Field has migrated eastward of the capture zone of the well field.	Evaluate preferential pumping of high-concentration wells. Assess contaminant trends at the current locations of the core of the downgradient plume.
NSDD Section 1 and 2	
Not Applicable.	Perform a residual risk calculation to determine if the remedy can be optimized (e.g., risks are at a level that would support modification of institutional controls and/or cessation of five-year reviews).
Surface Water Interim Corrective Measures	
Signs were erected under the scope of another project. Although the message content between the signs does not conflict with each other, an evaluation of the sign program is needed.	Evaluate whether ICM signs should be removed or replaced with new signs with language approved for the Environmental Indicator signs.

DOE = U.S Department of Energy
EPA = U.S. Environmental Protection Agency
EW = extraction well
IRA = interim remedial action
KDWM = Kentucky Division of Waste Management
MW = monitoring wells
NSDD = North-South Diversion Ditch

As the lead agency, DOE is responsible for implementing these recommendations. EPA and the Commonwealth of Kentucky will provide oversight. DOE will interface with EPA and the Commonwealth of Kentucky, as necessary, to implement these recommendations.

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21. PROTECTIVENESS STATEMENTS

21.1 NORTHWEST PLUME

The remedy for the Northwest Plume is protective of human health and the environment. Exposure pathways that could result in unacceptable risk are being controlled.

21.2 NORTHEAST PLUME

The remedy for the Northeast Plume is protective of human health and the environment. Exposure pathways that could result in unacceptable risk are being controlled.

21.3 WATER POLICY

The remedy for the Water Policy box currently protects human health and the environment by institutional controls; however, additional actions under the dissolved-phase plume need to be evaluated for long-term protection.

21.4 SURFACE WATER INTERIM CORRECTIVE MEASURES

The remedy for the surface water interim corrective measures currently protects human health and the environment by institutional controls; however, additional actions under the SWOU need to be evaluated for long-term protection.

21.5 PROJECTS UNDER CONSTRUCTION

21.5.1 GWOU C-400 Electrical Resistance Heating

The GWOU at C-400 is under construction. The remedy at C-400 involving ERH is expected to be protective of human health and the environment upon completion; in the interim, exposure pathways that could result in unacceptable risks are being controlled.

21.5.2 D&D OU C-410 Infrastructure Removal

The D&D of C-410 is in the preliminary stages. The non-time-critical removal action of C-410 is expected to be protective of human health and the environment upon completion, and, in the interim, exposure pathways that could result in unacceptable risks are being controlled.

21.6 REMAINDER OF PROJECTS

The remedies for the following projects are protective of human health and the environment. Exposure pathways that could result in unacceptable risk are being controlled.

- Cylinder Drop Test Area or Lasagna™
- NSDD Source Control
- NSDD Sections 1 and 2
- C-746-K Landfill
- Fire Training Area
- C-749 Uranium Burial Ground
- C-402 Lime House
- C-405 Incinerator

22. NEXT REVIEW

The next Five-Year Review for PGDP is required five years from the date that this review is approved by the FFA parties. All remedial actions discussed within this text, in addition to any new actions initiated or completed within the next five years, will be included in that review.

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23. FIVE-YEAR REVIEW PROCESS

23.1 ADMINISTRATIVE COMPONENTS

DOE's environmental remediation subcontractor performed this Five-Year Review. The reviews were conducted during January through March 2008. Components of this review are as follows:

- Document review
- Data review
- Site inspection
- Interviews of personnel responsible for specific aspects of some of the response actions
- Five-Year Review Report development and review

23.2 COMMUNITY NOTIFICATION AND INVOLVEMENT

Community involvement at the site is handled primarily in conjunction with the CAB. The CAB meets monthly to discuss many aspects of environmental restoration efforts at PGDP. The site inspections that are referenced throughout this document are AR documents; therefore, copies are available to the public. These copies, along with copies of other AR decision documents, are kept at the Environmental Information Center (EIC). The EIC is open to the public during regular business hours.

23.3 DOCUMENT REVIEW

This activity consisted of a review of relevant documents to the remedial action of each of the units and the previous Five-Year Reviews. This was conducted during January through March 2008. These documents are included as references in Chapter 24.

23.4 DATA REVIEW

Groundwater, surface water, and sediment samples are collected routinely at PGDP to assess environmental conditions. These data are stored in Paducah's Oak Ridge Environmental Information System (Paducah OREIS). Data were downloaded for review from Paducah OREIS throughout the review process.

23.5 SITE INSPECTIONS

Inspections were conducted at each of the response action sites, except for those currently underway, in March 2008. Results of the inspections are discussed in each of the technical assessment subsections.

23.6 INTERVIEWS

Interviews were conducted during March 2008 with various personnel connected to some of the response actions. Specifically, the Operating Engineer of the Northwest and Northeast Plumes treatment systems provided information on operation and maintenance of those systems, and the DOE Portsmouth/Paducah

Project Office health physicist provided information on the radioisotopic inventory of the C-746-U Landfill.

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