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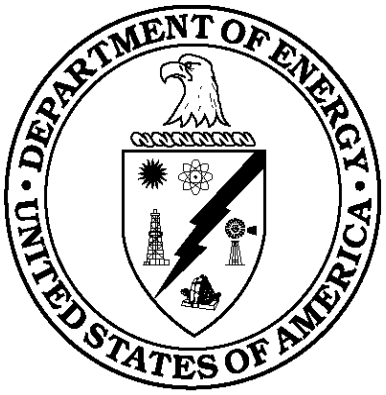

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Focused Feasibility Study for the Southwest Groundwater Plume Volatile Organic Compound Sources (Oil Landfarm and C-720 Northeast and Southeast Sites) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

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

Environmental Management Activities at the
Paducah Gaseous Diffusion Plant
Paducah, Kentucky 42001

managed by
Paducah Remediation Services, LLC
for the
U.S. DEPARTMENT OF ENERGY
under contract DE-AC30-06EW05001

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PREFACE

This *Focused Feasibility Study for the Southwest Groundwater Plume Volatile Organic Compound Sources (Oil Landfarm and C-720 Northeast and Southeast Sites) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-0186&D2/R2, was prepared to evaluate remedial alternatives for potential application at the U.S. Department of Energy's Paducah Gaseous Diffusion Plant. This work was prepared in accordance with the requirements of the *Federal Facility Agreement for the Paducah Gaseous Diffusion Plant* (FFA) (EPA 1998a) and the "Resolution of the Environmental Protection Agency Letter of Non-Concurrence for the Site Investigation Report for the Southwest Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/OR/07-2180&D2/R1, and Notice of Informal Dispute Dated November 30, 2007, McCracken County, Kentucky KY 8-890-008-982*"* (referred to as the Resolution) (EPA 2008). In accordance with Section IV of the FFA, this integrated technical document was developed to satisfy applicable requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 *USC* 9601 *et seq*. 1980) and the Resource Conservation and Recovery Act (42 *USC* 6901 *et seq*. 1976). As such, the phases of the investigation process are referenced by CERCLA terminology within this document to reduce the potential for confusion.

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EXECUTIVE SUMMARY

This *Focused Feasibility Study for the Southwest Groundwater Plume Volatile Organic Compound Sources (Oil Landfarm and C-720 Northeast and Southeast Sites) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-0186&D2/R2, (FFS) was prepared to evaluate remedial alternatives for potential application at the U.S. Department of Energy's (DOE's) Paducah Gaseous Diffusion Plant (PGDP). This work was prepared in accordance with the requirements of the *Federal Facility Agreement for the Paducah Gaseous Diffusion Plant* (FFA) (EPA 1998a) and the "Resolution of the Environmental Protection Agency Letter of Non-Concurrence for the Site Investigation Report for the Southwest Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky (DOE/OR/07-2180&D2/R1) and Notice of Informal Dispute Dated November 30, 2007, McCracken County, Kentucky, KY 8-890-008-982*"* (referred to as the Resolution) (EPA 2008).

The Southwest Groundwater Plume refers to an area of groundwater contamination at PGDP in the Regional Gravel Aquifer (RGA), which is south of the Northwest Groundwater Plume and west of the C-400 Building. The plume was identified during the Waste Area Grouping (WAG) 27 Remedial Investigation (RI) in 1998. Additional work to characterize the plume [Solid Waste Management Unit (SWMU) 210] was performed as part of the WAG 3 RI and Data Gaps Investigations, both in 1999. As discussed in these reports, the primary groundwater contaminant of concern (COC) for the Southwest Groundwater Plume (hereinafter referred to as the Southwest Plume) is trichloroethene (TCE). Other contaminants found in the plume include additional volatile organic compounds (VOCs), metals, and the radionuclide, technetium-99 (^{99}Tc). The PGDP is posted government property and trespassing is prohibited. Access to PGDP is controlled by guarded checkpoints, a perimeter fence, and vehicle barriers and is subject to routine patrol and visual inspection by plant protective forces.

DOE conducted a Site Investigation (SI) in 2004 to address the uncertainties with potential source areas to the Southwest Plume that remained after previous investigations. The SI further profiled the current level and distribution of VOCs in the dissolved-phase plume along the west plant boundary. Results of the SI were reported in the *Site Investigation Report for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2180&D2/R1 (DOE 2007). This FFS is based on the SI (DOE 2007) as well as previous investigations identified below.

The potential source areas investigated in the SI (DOE 2007) included the C-747-C Oil Landfarm (Oil Landfarm); C-720 Building Area near the northeast and southeast corners of the building (C-720 Northeast Site and C-720 Southeast Site); and the storm sewer system between the south side of the C-400 Building and Outfall 008 (Storm Sewer). As a result of the Southwest Plume SI, the storm sewer subsequently was excluded as a potential VOC source to the Southwest Plume. Respective SWMU numbers for each potential source area investigated in the SI are provided in Table ES.1.

Table ES.1. Summary of Potential Source Areas and SWMU Numbers

Description	SWMU No.
C-747-C Oil Landfarm	1
Plant Storm Sewer	Part of 102
C-720 TCE Spill Sites Northeast and Southeast	211 A&B

In November 2007, the U.S. Environmental Protection Agency (EPA) invoked an informal dispute on the Southwest Plume SI. In March 2008, DOE signed the Resolution which required, among other things, that DOE conduct an FFS for addressing source areas to the Southwest Plume, in view of developing remedial

alternatives and undertaking a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 *USC* 9601 *et seq.* 1980) remedial action and Record of Decision (ROD). The source areas subject to the FFS included the Oil Landfarm, C-720 Northeast and Southeast Sites, and Storm Sewer. The FFS was to address contamination in the shallow groundwater and could be based upon the Southwest Plume SI data, previous documents, and additional information, as necessary. The FFS was required to contain, among other information, a remedial action objective (RAO) for addressing source areas, including treatment and/or removal of principal threat waste (PTW) consistent with CERCLA, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (including the preamble) and pertinent EPA guidance. The Southwest dissolved-phase plume in the Groundwater Operable Unit (OU) Dissolved-Phase Plumes would include the RAO of returning contaminated groundwater to beneficial use(s) and attaining chemical-specific applicable or relevant and appropriate requirements (ARARs), and/or attaining risk-based concentrations for all identified COCs throughout the plume (or at the edge of the waste management area depending on whether the waste source was removed), consistent with CERCLA, the NCP (including the preamble), and pertinent EPA guidance.

EPA typically describes sources as material that includes hazardous substances, pollutants, or contaminants that act as a reservoir for the groundwater, surface water, or air or act as a source of direct exposure. EPA considers sources or source materials to be principal threats when they are highly toxic or highly mobile and generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur (EPA 2004a). Previous investigations of FFS source areas to 55 ft below ground surface (bgs) identified the potential presence of TCE dense nonaqueous-phase liquid (DNAPL), which would constitute PTW.

SCOPE OF THE SOUTHWEST PLUME FFS IN THE SITEWIDE GROUNDWATER OU

This FFS will support a final action to mitigate the migration of VOCs from the Oil Landfarm and the C-720 Building Area to the Southwest Plume and to treat or remove PTW. Based on results from the Southwest Plume SI, the Storm Sewer no longer is considered a source of VOC contamination to the Southwest Plume. Risks posed by direct contact with contaminated surface soil or sediment at the Oil Landfarm and C-720 Building Area or remaining risks from potential use of contaminated groundwater from VOC and non-VOC contaminants will be addressed later as part of the decisions for the Surface Water, Soils, or Groundwater OUs.

These VOC source areas are assigned to the Groundwater OU at PGDP, which is one of five media-specific sitewide OUs being used to evaluate and implement remedial actions. Consistent with EPA guidance (EPA 2004a), the Groundwater OU is being implemented in a phased approach consisting of sequenced remedial and removal actions designed to accomplish the following goals:

(1) Prevent human exposure to contaminated groundwater;
(2) Prevent or minimize further migration of contaminant plumes;
(3) Prevent, reduce, or control contaminant sources contributing to groundwater contamination; and
(4) Restore the groundwater to its beneficial uses, wherever practicable.

This FFS and ensuing final VOC remedial action will support the phased groundwater goals represented in goals 3 and 4 above by controlling VOC migration (including DNAPL) that contribute to groundwater contamination, thereby promoting the restoration of groundwater to beneficial use, as practicable. The remedial action also is anticipated to substantially reduce the risk and hazard from hypothetical groundwater use associated with releases from these source areas.

1. INTRODUCTION

This section provides a brief introduction to the Paducah Gaseous Diffusion Plant (PGDP) and an explanation of the purpose and organization of the report. Background information, including the site background and regulatory setting, is summarized. Site and area-specific descriptions including land use, demographics, climate, air quality, noise, ecological resources, and cultural resources are summarized. An overview is provided of the topography, surface water hydrology, geology, and hydrogeology of the region and the study area. A conceptual site model summarizing the nature and extent of contamination and fate and transport modeling of volatile organic compound (VOC) contaminants of concern (COCs) are discussed.

1.1 PURPOSE AND ORGANIZATION

This *Focused Feasibility Study for the Southwest Groundwater Plume Volatile Organic Compound Sources (Oil Landfarm and C-720 Northeast and Southeast Sites) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-0186&D2/R2, was prepared to evaluate remedial alternatives for potential application at the U.S. Department of Energy's (DOE's) PGDP. This work was prepared in accordance with the requirements of the *Federal Facility Agreement for the Paducah Gaseous Diffusion Plant* (FFA) (EPA 1998a) and the "Resolution of the Environmental Protection Agency Letter of Non-Concurrence for the Site Investigation Report for the Southwest Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky (DOE/OR/07-2180&D2/R1) and Notice of Informal Dispute Dated November 30, 2007, McCracken County, Kentucky, KY 8-890-008-982*"* (referred to as the Resolution) (EPA 2008). In accordance with Section IV of the FFA, this integrated technical document was developed to satisfy applicable requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 *USC* 9601 *et seq.* 1980) and the Resource Conservation and Recovery Act (RCRA) (42 *USC* 6901 *et seq.* 1976). In addition to the U.S. Environmental Protection Agency (EPA) requirements, National Environmental Policy Act of 1969 (NEPA) values, consistent with the DOE's Secretarial Policy Statement on NEPA in June 1994 (DOE 1994), are evaluated and documented in this focused feasibility study (FFS).

This FFS also has been prepared in accordance with the Integrated Feasibility Study (FS)/Corrective Measures Study Report outline prescribed in Appendix D of the FFA for PGDP. As such, this FFS is considered a primary document. All subsections contained in the referenced outline have been included for completeness. Additional subsections have been added to the outline, as appropriate, and have been included to provide clarity and enhance the organization of the document.

1.2 BACKGROUND INFORMATION

The following section presents information concerning the site background and regulatory setting at the PGDP. It also provides a site description of the PGDP region and source areas, as well as a summary of the process history, nature and extent of contamination, contaminant fate and transport, and the risks associated with the source areas.

1.2.1 Site Description

PGDP is located approximately 10 miles west of Paducah, Kentucky, (population approximately 26,000), and 3.5 miles south of the Ohio River in the western part of McCracken County (Figure 1.1). The plant is located on a DOE-owned site, approximately 650 acres of which are within a fenced security area, approximately 800 acres are located outside the security fence, and the remaining 1,986 acres are licensed to Kentucky as part of the West Kentucky Wildlife Management Area (WKWMA). Bordering the PGDP Reservation to the northeast, between the plant and the Ohio River, is a Tennessee Valley Authority (TVA) reservation on which the Shawnee Steam Plant is located (Figure 1.2). All plant and process water at PGDP is drawn from the Ohio River.

Before the PGDP was built, a munitions-production facility, the Kentucky Ordnance Works (KOW), was operated at the current PGDP location and at an adjoining area southwest of the site. Munitions, including trinitrotoluene, were manufactured and stored at the KOW between 1942 and 1945. The KOW was shut down immediately after World War II. Construction of PGDP was initiated in 1951 and the plant began operations in 1952. Construction was completed in 1955 and PGDP became fully operational in 1955, supplying enriched uranium for commercial reactors and military defense reactors.

PGDP was operated by Union Carbide Corporation until 1984, when Martin Marietta Energy Systems, Inc. (which later became Lockheed Martin Energy Systems, Inc.), was contracted to operate the plant for DOE. On July 1, 1993, DOE leased the plant production/operations facilities to the United States Enrichment Corporation; however, DOE maintains ownership of the plant and is responsible for environmental restoration and waste management activities. On April 1, 1998, Bechtel Jacobs Company LLC, replaced Lockheed Martin Energy Systems, Inc., in implementing the Environmental Management Program at PGDP. On April 23, 2006, Paducah Remediation Services, LLC, replaced Bechtel Jacobs Company LLC, in implementing the Environmental Management Program at PGDP.

Trichloroethene (TCE), a chlorinated solvent that is a VOC, is the most widespread groundwater contaminant associated with PGDP. The TCE degradation products *cis*-1,2-dichloroethene (*cis*-1,2-DCE), *trans*-1,2-dichloroethene (*trans*-1,2-DCE), and vinyl chloride (VC) also are present in some areas. These contaminants have resulted in three dissolved-phase plumes that are migrating from PGDP toward the Ohio River. These groundwater plumes are the Northwest Groundwater Plume [Solid Waste Management Unit (SWMU) 201], the Northeast Groundwater Plume (SWMU 202), and the Southwest Groundwater Plume (SWMU 210) (Figure 1.3).

1.2.1.1 Source area description

The Southwest Groundwater Plume refers to an area of groundwater contamination at PGDP in the Regional Gravel Aquifer (RGA), which is south of the Northwest Groundwater Plume and west of the C-400 Building. The plume was identified during the Waste Area Grouping (WAG) 27 Remedial Investigation (RI) in 1998. Additional work to characterize the plume (SWMU 210) was performed as part of the WAG 3 RI and Data Gaps Investigations, both in 1999. As discussed in those reports, the primary groundwater COC for the Southwest Groundwater Plume (hereinafter referred to as the Southwest Plume) is TCE. Appendix D contains a discussion of COCs and other contaminants found in the plume including additional VOCs, metals, and the radionuclide, technetium-99 (^{99}Tc).

- Co-produced groundwater treatment, as described for Alternative 4, Section 3.4.4.6
- Interim LUCs as described for Alternative 2
- Monitoring as described for Alternative 2
- Five-year reviews as described for Alternative 2

This alternative would reduce the VOC sources in the UCRS, including PTW; reduce recharge through the UCRS and thereby mitigate the secondary release mechanism; and eliminate risks to receptors by eliminating the exposure pathways, as described in the CSM presented in Section 1. Requirements and conceptual designs for each element of Alternative 5 are discussed below in detail. This alternative would reduce the VOC secondary source and eliminate risks to receptors by eliminating the exposure pathways. The ERH system design would include measures to reduce the potential for mobilization of DNAPL TCE during treatment. Although ^{99}Tc is not expected to be present in groundwater during treatment, if it is encountered measures will be taken to ensure ^{99}Tc concentrations will meet ARARs, as described in Table 4.4. Five-year reviews would be required until RGs were met.

Conceptual design and a cost estimate for the ERH treatment component of Alternative 5 was provided by the McMillan-McGee Corp. The McMillan-McGee Corp., is cited because they currently are contracted to implement ERH at the PGDP C-400 area. Other vendors and proprietary ERH technologies are available. Specific citation of the McMillan-McGee Corp., and their proprietary technology would not constrain selection of an alternative ERH technology or vendor.

The ERH treatment system design would include measures to ensure that DNAPL TCE was not mobilized during treatment. Details for each element of Alternative 5 are discussed below. A schematic view of the ERH treatment process is provided in Figure 3.10, and a plan view of the overall layout for the Oil Landfarm and the C-720 Northeast and Southeast Sites are shown in Figures 3.11 and 3.12, respectively.

3.4.5.1 RD investigation

RD investigation would be performed at the Oil Landfarm and the C-720 Northeast and Southeast Sites to better delineate the extent of VOCs and DNAPL TCE and to close any data gaps concerning the areal and vertical extent of contamination. RD investigation would be based on a systematically planned approach. The conceptual design for RD investigation includes these elements:

- Preliminary soil gas sampling using the MIP and on-site analysis for VOCs at the C-720 Area Northeast and Southeast Sites to estimate the areal and vertical extent of contamination including DNAPL and at the Oil Landfarm to determine vertical extent of contamination including DNAPL;

- Soil coring using DPT and analysis for VOCs using EPA SW-846 Method 8260B or equivalent at locations determined using the MIP results. Soil cores also would be evaluated to determine the presence or absence of DNAPL; and

- Geodetic survey of all sampling locations.

3.4.5.2 Treatment

McMillan-McGee Corp. implements a proprietary ERH approach trademarked as the Electro Thermal Dynamic Stripping Process (ET-DSP™). Using this approach, electrodes are strategically placed into the contaminated zone in a pattern such that conventional three-phase power can be used to heat the soil. The distance between electrodes and their location is determined from the heat transfer mechanisms associated with vapor extraction, electrical heating, and fluid movement in the contaminated zone. To determine the ideal pattern of electrode and extraction wells, a multi-phase, multi-component, 3-D thermal model is used to simulate the process. Numerical modeling is also used to design the power

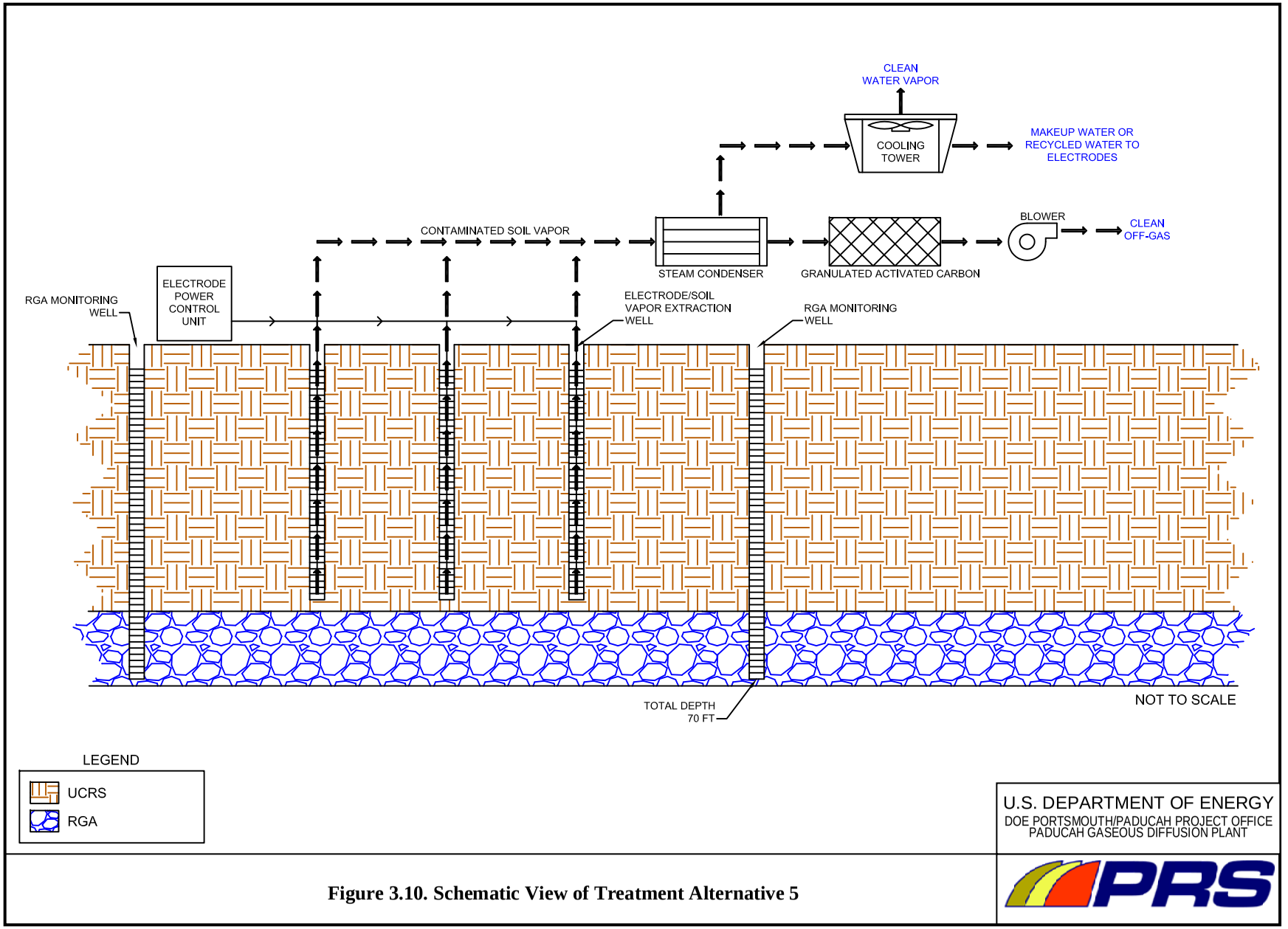

Figure 3.10. Schematic View of Treatment Alternative 5

4. DETAILED ANALYSIS OF ALTERNATIVES

Remedial alternatives developed in Section 3 and retained after screening are analyzed in detail in this section. Results of this analysis will form the basis for comparing alternatives and for preparing the Proposed Plan.

4.1 INTRODUCTION

4.1.1 Purpose of the Detailed Analysis

The remedial action alternatives developed in Section 3 are analyzed in detail against the seven CERCLA threshold and balancing criteria to form the basis for selecting a final remedial action. The intent of this analysis is to present sufficient information to allow the EPA, KDEP, and DOE to select an appropriate remedy.

Alternatives are evaluated with respect to the seven CERCLA threshold and balancing criteria outlined in 40 *CFR* § 300.430(e)(9)(iii) and as discussed in Section 4.1.2. This evaluation is the basis for determining the ability of a remedial action alternative to satisfy CERCLA remedy selection requirements.

4.1.2 Overview of the CERCLA Evaluation Criteria

The CERCLA evaluation criteria include technical, administrative, and cost considerations; compliance with specific statutory requirements; and state and community acceptance. Overall protection of human health and the environment and compliance with ARARs are categorized as threshold criteria that any viable alternative must meet. Long-term effectiveness and permanence; reduction of toxicity, mobility, and volume through treatment; short-term effectiveness; implementability; and cost are considered balancing criteria upon which the detailed analysis is primarily based. State and community acceptance is evaluated following comment on the RI/FS report and the Proposed Plan and is addressed as a final decision is made and the ROD is prepared. Each criterion is described below.

4.1.2.1 Overall protection of human health and the environment

Alternatives will be assessed to determine whether they can adequately protect human health and the environment in both the short- and long-term from unacceptable risks posed by contaminants present at the Oil Landfarm and the C-720 Northeast and Southeast Sites by eliminating, reducing, or controlling exposures as established during the development of RAOs consistent with 40 *CFR* § 300.430(e)(2)(I). Overall protection of human health and the environment draws on the assessments of the other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

4.1.2.2 Compliance with ARARs

Section 121(d) of CERCLA and NCP Section 300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites at least attain legally "applicable" or "relevant and appropriate" federal and state environmental requirements, standards, criteria, and limitations, which are collectively referred to as "ARARs," unless such ARARs are waived under CERCLA Section 121(d)(4). ARARs include federal or more stringent state substantive environmental or facility siting laws/regulations; they do not include occupational safety protection requirements. Additionally, per 40 *CFR* § 300.405(g)(3), other advisories,

criteria, or guidance may be considered in determining remedies (TBC category). CERCLA 121(d)(4) provides several ARAR waiver options that may be invoked, provided that human health and the environment are protected. Activities conducted on-site must comply with the substantive but not administrative requirements. Administrative requirements include applying for permits, recordkeeping, consultation, and reporting. Activities conducted off-site must comply with both the substantive and administrative requirements of applicable laws. Measures required to meet ARARs will be incorporated into the design phase and implemented during the construction and operation phases of the remedial action.

ARARs typically are divided into three categories: (1) chemical-specific, (2) location-specific, and (3) action-specific. Chemical-specific ARARs provide health- or risk-based concentration limits or discharge limitations in various environmental media (i.e., surface water, groundwater, soil, or air) for specific hazardous substances, pollutants, or contaminants. Location-specific ARARs establish restrictions on permissible concentrations of hazardous substances or establish requirements for how activities will be conducted because they are in special locations (e.g., floodplains or historic districts). Action-specific ARARs include operation, performance, and design of the preferred alternative based on waste types and/or media to be addressed and removal/remedial activities to be implemented.

There are no chemical-specific ARARs for remediation of the contaminated soils at the source areas; however, Kentucky drinking water standard MCLs at 401 *KAR* 8:420 for VOCs were used for calculation of soil RGs. Action and location-specific ARARs are further identified in each alternative.

Alternatives are assessed to determine whether they meet ARARs identified for each alternative. If ARARs will not be met at the end of an action, an evaluation will occur to determine when a basis exists for invoking one of the ARAR waivers cited in 40 *CFR* § 300.430(f)(l)(ii)(c), that are listed here:

- The alternative is an interim measure and will become part of a total remedial action that will attain the applicable or relevant and appropriate federal or state requirement.

- Compliance with the requirement will result in greater risk to human health and the environment than other alternatives.

- Compliance with the requirement is technically impracticable from an engineering perspective.

- The alternative will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, or limitation through use of another method or approach.

- With respect to a state requirement, the state has not consistently applied, or demonstrated the intention to consistently apply, the promulgated requirement in similar circumstances at other remedial actions within the state.

In addition to ARARs, policies such as *Management of Contaminated Media*, EPA Region 4, September 7, 1999 allow use of an area of contamination may be TBC. Remediation wastes that are considered RCRA hazardous wastes (e.g., soils contaminated with F001 and F002 Listed Wastes) and that are consolidated or treated *in situ* within the "area of contamination," consistent with EPA policy, do not constitute "placement" for purposes of complying with RCRA land disposal restrictions (LDRs) (EPA 1998c).

4.1.2.3 Long-term effectiveness and permanence

Long-term effectiveness and permanence is the anticipated ability of the alternatives to maintain reliable protection of human health and the environment for the duration of risk above RGs, once the RAOs are met. Alternatives will be assessed for the long-term effectiveness and permanence they afford, along with

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