Department of Energy

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OCT 20 2011

Mr. Wm. Turpin Ballard
Remedial Project Manager
U.S. Environmental Protection Agency, Region 4
61 Forsyth Street
Atlanta, Georgia 30303

PPPO-02-1309274-12

Mr. Edward Winner, FFA Manager
Kentucky Department for Environmental Protection
Division of Waste Management
200 Fair Oaks Lane, 2nd Floor
Frankfort, Kentucky 40601

Dear Mr. Ballard and Mr. Winner:

TRANSMITTAL OF THE CONFORMED WORK PLAN FOR COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT WASTE DISPOSAL ALTERNATIVES EVALUATION REMEDIAL INVESTIGATION/FEASIBILITY STUDY AT THE PADUCAH GASEOUS DIFFUSION PLANT, PADUCAH, KENTUCKY (DOE/LX/07-0099&D2/R1)

References:

1. Letter from J. Richards to R. Knerr, "Appendix C of the Waste Disposal Alternatives Evaluation Remedial Investigation/Feasibility Study Work Plan at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky (DOE/LX/07-0099&D2/R1)," dated September 27, 2011
2. Letter from A. Webb to R. Knerr, "Approval of Appendix C of the Work Plan for CERCLA Waste Disposal Alternatives Evaluation Remedial Investigation/Feasibility Study (DOE/LX/07-0099&D2/R1) Paducah Gaseous Diffusion Plant, Paducah, McCracken County, Kentucky, KY8-890-008-982," dated September 22, 2011
3. Letter from R. Knerr to Wm. Ballard and E. Winner, "Appendix C of the Waste Disposal Alternatives Evaluation Remedial Investigation/Feasibility Study at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky (DOE/LX/07-0099&D2/R1)," (PPPO-02-1246584-11), dated September 14, 2011
4. Letter from R. Knerr to Wm. Ballard and E. Winner, "Appendix C of the Waste Disposal Alternatives Evaluation Remedial Investigation/Feasibility Study at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky (DOE/LX/07-0099&D2/R1)," (PPPO-02-1214079-11), dated June 3, 2011
5. Letter from R. Knerr to Wm. Ballard and E. Winner, "Memorandum of Agreement for the Waste Disposal Alternatives Project at the Paducah Gaseous Diffusion Plant," (PPPO-02-1057481-11F)," dated January 24, 2011

Please find enclosed the certified conformed *Work Plan for Comprehensive Environmental Response, Compensation, and Liability Act Waste Disposal Alternatives Evaluation Remedial Investigation/Feasibility Study at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE/LX/07-0099&D2/R1). As outlined in the January 20, 2011, Memorandum of Agreement for Resolution of Informal Dispute, Appendix C of the work plan was revised in June and again in September 2011, and subsequently approved by the Kentucky Department for Environmental Protection and the U.S. Environmental Protection Agency on September 22, 2011, and September 27, 2011, respectively.

If you have any questions or require additional information, please contact Rob Seifert at (270) 441-6823.

Sincerely,

Reinhard Knerr
Paducah Site Lead
Portsmouth/Paducah Project Office

Enclosures:
1. Certification Pages
2. D2/R1 Work Plan Remedial Investigation/Feasibility Study

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CERTIFICATION

Document Identification: ***Work Plan for CERCLA Waste Disposal Alternatives Evaluation Remedial Investigation/Feasibility Study at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky***

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

LATA Environmental Services of Kentucky, LLC

Bill Franz, Project Integration and Operations Manager	9/24/10 Date Signed

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

U.S. Department of Energy (DOE)

Reinhard Knerr, Paducah Site Lead Portsmouth/Paducah Project Office	9/27/10 Date Signed

CERTIFICATION

Document Identification: **Appendix C of the *Waste Disposal Alternatives Evaluation Remedial Investigation/Feasibility Study Work Plan at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-0099&D2/R1**

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

LATA Environmental Services of Kentucky, LLC

Craig S. Jones, Manager of Projects — Date Signed: 09/14/11

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

U.S. Department of Energy (DOE)

Reinhard Knerr, Paducah Site Lead
Portsmouth/Paducah Project Office

Date Signed

DOE/LX/07-0099&D2/R1
Primary Document

Work Plan for CERCLA Waste Disposal Alternatives Evaluation Remedial Investigation/Feasibility Study at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

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Primary Document

Work Plan for CERCLA Waste Disposal Alternatives Evaluation Remedial Investigation/Feasibility Study at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

Date Issued—September 2010

Date Reissued (Appendix C Only)–September 2011

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

LATA ENVIRONMENTAL SERVICES OF KENTUCKY, LLC
managing the
Environmental Management Activities at the
Paducah Gaseous Diffusion Plant
under contract DE-AC30-10CC40020

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TABLES

FIGURES

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ACRONYMS

AEA	Atomic Energy Act
amsl	above mean sea level
AOC	area of concern
ARAR	applicable or relevant and appropriate requirement
BGOU	Burial Grounds Operable Unit
CAB	Citizens Advisory Board
CAP	Consolidated Audit Program
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
COC	contaminant of concern
COE	U.S. Army Corps of Engineers
CSOU	Comprehensive Site Operable Unit
D&D	decontamination and decommissioning
DAF	dilution attenuation factors
DOE	U.S. Department of Energy
DPT	direct push technology
DSHA	deterministic seismic hazard analysis
DMSA	DOE Material Storage Area
DQO	data quality objective
DUF_6	depleted uranium hexafluoride
EMWMF	Environmental Management Waste Management Facility
EPA	U.S. Environmental Protection Agency
ER	environmental restoration
ERDF	environmental restoration disposal facility
FFA	Federal Facility Agreement
FR	*Federal Register*
FS	feasibility study
g	acceleration due to gravity
GEO	GEO Consultants, LLC
GWOU	Groundwater Operable Unit
HAZMAT	Hazardous Materials
HU	hydrogeologic unit
INL	Idaho National Laboratory
IRT	Independent Review Team
Kd	soil-to-liquid distribution coefficient
KRS	*Kentucky Revised Statutes*
LATA Kentucky	LATA Environmental Services of Kentucky, LLC
LCB	life cycle baseline
LDR	land disposal restriction
LLW	low-level waste
MCL	maximum contaminant level
mcy	million cubic yards
MLLW	mixed low-level waste
mya	million years ago
NEPA	National Environmental Policy Act
NOAA	National Oceanic and Atmospheric Administration
NPL	National Priorities List
NRC	Nuclear Regulatory Commission

NSDD	North-South Diversion Ditch
NTS	Nevada Test Site
O&M	operation and maintenance
OMB	U.S. Office of Management and Budget
ORR	Oak Ridge Reservation
OSDF	on-site disposal facility
OU	operable unit
PCB	polychlorinated biphenyl
PGA	peak ground acceleration
PGDP	Paducah Gaseous Diffusion Plant
PM	project manager
PSHA	probabilistic seismic hazard analysis
RCRA	Resource Conservation and Recovery Act
REI	Risk Engineering, Inc.
RGA	Regional Gravel Aquifer
ROD	record of decision
RI	remedial investigation
SIR	Seismic Investigation Report
SMP	Site Management Plan
SOU	Soils Operable Unit
SWMU	solid waste management unit
SWOU	Surface Water Operable Unit
^{99}Tc	technetium-99
TCE	trichloroethene
TRU	transuranic
TSCA	Toxic Substances Control Act
TSDF	treatment, storage, and disposal facility
TVA	Tennessee Valley Authority
UCRS	Upper Continental Recharge System
UF_6	uranium hexafluoride
USEC	United States Enrichment Corporation
USGS	United States Geological Survey
WAC	waste acceptance criteria
WBS	work breakdown structure
WKWMA	West Kentucky Wildlife Management Area

EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE) is responsible for cleanup of the Paducah Gaseous Diffusion Plant (PGDP) under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). An estimated 3.7 mcy of waste is forecasted to be generated by CERCLA response actions at PGDP from 2014 until completion of final site cleanup in 2039. To date, CERCLA cleanup and waste management projects at PGDP have generated and disposed of tens of thousands of yd^3 of waste and visible progress has been made by the clearing of scrap yards, demolition of excess facilities, and removal or mitigation of sources of contaminants presenting unacceptable risk to human health and the environment or exceeding concentrations established in applicable or relevant and appropriate requirements (ARARs). Disposal alternatives for large volumes of waste to be generated are being evaluated using the CERCLA process and in collaboration with the U.S. Environmental Protection Agency (EPA), the Commonwealth of Kentucky, and site stakeholders. The disposal alternatives evaluation will be performed consistent with the Federal Facility Agreement (FFA) for PGDP negotiated among DOE, EPA, and Kentucky Department for Environmental Protection. The cleanup of the PGDP will generate low-level radioactive waste, hazardous waste, nonhazardous solid waste, and mixtures of these waste types. No Action, Off-Site, and On-Site disposal alternatives will be evaluated during the remedy selection process.

A Remedial Investigation/Feasibility Study (RI/FS) Scoping Document (DOE 2008) was prepared in April 2008. Information in that document was used in a series of project scoping meetings with EPA and Kentucky. The purpose of the scoping meetings was to lay the groundwork for the RI/FS process and specifically to facilitate the development of this RI/FS Work Plan, thereby accelerating the review, comment, and approval process. Issues discussed in the scoping meetings have been addressed in this document. A major agreement reached during the scoping meetings was that two alternatives would be evaluated in the RI/FS; however, subsequent to the scoping meeting, DOE determined that a revised No Action Alternative should be included in the evaluation. The following are the disposal alternatives that will be evaluated.

- The *No Action Alternative* involves the continuation of coordinated project-by-project disposal for CERCLA waste[1] that, for the purpose of this evaluation, is assumed to be off-site disposal for the waste that does not meet the waste acceptance criteria (WAC) of the currently operating on-site C-746-U Landfill, continued use of the C-746-U Landfill for nonhazardous solid waste disposal, and assumptions of no sitewide efforts to effect waste volume reduction.

- The *Off-Site Alternative* includes two waste volume scenarios for comparison purposes: (1) a high-end waste volume scenario for which CERCLA waste is assumed to be shipped off-site; (2) a low-end waste volume scenario, which assumes various waste reduction actions, continued use of the C-746-U Landfill for nonhazardous solid waste disposal, and off-site disposal of CERCLA waste that does not meet the WAC of the C-746-U Landfill.

- The *On-Site Alternative* involves the disposal of CERCLA waste into a newly constructed on-site waste disposal facility located on property currently owned by DOE.[2] The On-Site Alternative

[1]Any solid material generated as waste during a CERCLA response action conducted under the FFA will be within the scope of this evaluation.

[2]The property owned by DOE is defined as within the boundaries of DOE PGDP-owned property (3,556 acres), including property licensed to the West Kentucky Wildlife Management Area.

includes the same two waste volume scenarios: (1) a high-end waste volume scenario for which CERCLA waste would be disposed of in a newly constructed on-site facility; (2) a low-end waste volume scenario, which assumes various waste reduction actions, continued use of the C-746-U Landfill for nonhazardous solid waste disposal, and disposal of CERCLA waste that does not meet the WAC of the C-746-U Landfill in a newly constructed on-site disposal facility.

The RI/FS work plan describes how the RI and FS will be implemented, summarizes data availability and data gaps, identifies how data gaps will be addressed, and describes each waste disposal alternative.

Cleanup progress at PGDP has been made possible, in part, by the active and informed participation by site stakeholders including regulators, workers, elected officials, and members of the public. Public participation and information exchange are key components of the CERCLA process and this RI/FS work plan describes the process and timing for formal and informal stakeholder participation in the waste disposal alternatives selection analysis.

1. INTRODUCTION

The Paducah Gaseous Diffusion Plant (PGDP) site is located on a 3,556 acre reservation that contains an active uranium enrichment facility and surrounding support facilities. The PGDP is owned by the U.S. Department of Energy (DOE), and the uranium enrichment facilities currently are leased to and operated by the United States Enrichment Corporation (USEC). DOE is conducting environmental restoration activities at PGDP in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). PGDP was placed on the National Priorities List (NPL) in 1994. DOE, the U.S. Environmental Protection Agency (EPA), and the Commonwealth of Kentucky (Kentucky) entered into a Federal Facility Agreement (FFA) in 1998 (EPA 1998) that established the regulatory framework for CERCLA projects at PGDP.

Solid waste management units (SWMUs) and areas of concern (AOCs) at PGDP have been combined into the following five operable units (OUs):

- Surface Water OU (SWOU),
- Soils OU (SOU),
- Burial Grounds OU (BGOU),
- Groundwater OU (GWOU), and
- Decontamination and Decommissioning (D&D OU).

Site cleanup activities (pre- and post-PGDP shutdown) are expected to generate a variety of CERCLA waste throughout the cleanup process, including both contaminated media and debris, totaling an estimated 3.7 mcy. Waste types include the following:

- Low-level radioactive waste [(LLW), defined by the Atomic Energy Act (AEA)];
- Hazardous waste [defined under *Kentucky Revised Statutes* (*KRS*) 224 and the Resource Conservation and Recovery Act (RCRA) Subtitle C];
- Mixed low-level waste [(MLLW), defined and regulated as a hazardous waste and LLW];
- Toxic Substances Control Act (TSCA) waste (defined and regulated under the Toxic Substances Control Act of 1976);
- TSCA/LLW waste (defined and regulated as a TSCA waste and LLW); and
- Nonhazardous solid waste [defined by RCRA Subtitle D/meets the waste acceptance criteria (WAC) of the C-746-U Landfill] (PRS 2008).

Waste types such as high-level, transuranic, byproduct, and spent nuclear fuel are not in the 3.7 mcy of forecasted CERCLA waste and are not anticipated to be generated. These waste types, if generated during cleanup, would be required to be disposed of off-site since regulations prescribe disposal in special repositories. Additionally, all waste disposal facilities considered in the Remedial Investigation/Feasibility Study (RI/FS) evaluation can accept only wastes that meet their WAC.

To ensure that the most appropriate waste disposal practice is utilized for the expected volume of waste to be generated, DOE will evaluate disposal alternatives by following the RI/FS decision documentation process required by CERCLA. Three alternatives will be evaluated.

- The *No Action Alternative* involves the continuation of coordinated project-by-project off-site disposal for CERCLA waste[3], continued use of the C-746-U Landfill for nonhazardous solid waste disposal, and assumptions of no sitewide efforts to effect waste volume reduction.

- The *Off-Site Alternative* includes two waste volume scenarios for comparison purposes: a high-end waste volume scenario for which CERCLA waste is assumed to be shipped off-site; and a low-end waste volume scenario, which assumes various waste reduction actions, continued use of the C-746-U Landfill for nonhazardous solid waste disposal, and off-site disposal of CERCLA waste that does not meet the C-746-U Landfill WAC.

- The *On-Site Alternative* involves the disposal of CERCLA waste into a newly constructed on-site waste disposal facility located on property currently owned by DOE.[4] The On-Site Alternative includes the same two waste volume scenarios: a high-end waste volume scenario for which CERCLA waste would be disposed of in a newly constructed on-site disposal facility; and a low-end waste volume scenario, which assumes various waste reduction actions, continued use of the C-746-U Landfill for nonhazardous solid waste disposal, and disposal of CERCLA waste that does not meet the WAC of the C-746-U Landfill in a newly constructed on-site disposal facility.

Under CERCLA, a No Action Alternative is required to provide a baseline for comparison with other alternative actions. The No Action Alternative, if selected, would require no changes to current waste disposal practices.

An RI/FS Scoping Document (DOE 2008) was prepared in April 2008. Information in that document was used in a series of project scoping meetings with EPA and Kentucky. The purpose of the scoping meetings was to lay the groundwork for the RI/FS process and specifically facilitate the development of this RI/FS Work Plan, thereby accelerating the review, comment, and approval process. Issues discussed in the scoping meetings have been addressed in this document. Comments were received from Kentucky and EPA following review of the Scoping Document (DOE 2008). A response summary was issued to provide general information about how the comments would be addressed in the RI/FS Work Plan.

This document incorporates, as appropriate, those elements in the outline for RI/FS work plans found in Appendix D of the FFA. The outlines in the FFA were developed for documents that support characterization of and remedy selection for contaminant release sites. This RI/FS Work Plan outline has been tailored to focus on communication and development of information needs that are necessary to evaluate disposal alternatives for PGDP CERCLA-generated waste to enable an informed decision by DOE, regulators, and stakeholders.

1.1 PROJECT SCOPE

The scope of this project is to evaluate disposal alternatives for PGDP waste generated during cleanup from the FFA projects. CERCLA waste types forecasted to be generated include LLW, hazardous waste, TSCA waste, MLLW, TSCA/LLW, and nonhazardous solid wastes. The CERCLA remedy selection process defined by EPA in 40 *CFR* § 300.430(d) and (e) will be utilized. DOE's policy is to incorporate

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[3]Any solid material generated as waste during a CERCLA response action conducted under the FFA will be within the scope of this evaluation.

[4]The property owned by DOE is defined as within the boundaries of DOE PGDP-owned property (3,556 acres), including property licensed to the West Kentucky Wildlife Management Area.

the values of the National Environmental Policy Act of 1969 (NEPA) into CERCLA documents (DOE 1994). Examples of these values include analysis of off-site, ecological, cultural, and socioeconomic impacts as well as environmental justice and land use issues.

Treatment alternatives for the forecasted waste will not be included in the evaluation. While it is recognized that some of the forecasted wastes will require chemical or physical treatment prior to disposal, the generating project will be responsible for the evaluation of treatment alternatives in project-specific CERCLA documentation. The forecasted volume of waste that may require treatment [e.g., hazardous waste that does not meet RCRA land disposal restrictions (LDRs)] is projected to be a very small fraction of the total volume of CERCLA waste (i.e., less than 2% of the forecasted waste by volume); therefore, it is not necessary to develop a centralized waste treatment approach within the scope of this waste disposal evaluation. The generating projects will be the most knowledgeable about their waste volumes and characteristics and better suited to determine the most effective and efficient means of treating waste, if necessary. The decision to exclude treatment from the scope of the disposal alternatives evaluation is consistent with a similar decision made at the DOE Oak Ridge site when it evaluated CERCLA waste disposal alternatives [i.e., the Environmental Management Waste Management Facility (EMWMF) at Oak Ridge].

DOE will conduct a waste materials recycling and reuse evaluation for PGDP that will explore opportunities for reuse, recycling, and melting of materials that otherwise would be assumed to be waste. Reuse and/or recycling of material or waste is an important initiative of DOE and may lead to benefits that include the following:

- Reduce the overall volume of waste requiring disposal,
- Provide cost savings for the disposal alternatives,
- Create new jobs for the community, and
- Provide benefits to other programs.

The recycling/reuse evaluation will be referenced or included as appropriate in the RI/FS report. The evaluation will address, among other things, the feasibility and costs associated with the potential reuse or recycling of materials that otherwise would be disposed of as waste. The possibility of waste volume reduction also will be considered in an uncertainty analysis conducted during the FS. The uncertainty analysis will take into account, among other factors, the results of the recycling and reuse evaluation. The uncertainty of the reduction of the waste volume due to recycling and reuse is reflected in the low-end waste volume scenario outlined in Section 6.1.2.

In summary, the RI/FS Report will provide the technical evaluation of three waste disposal alternatives: No Action, Off-Site, and On-Site.

The No Action Alternative involves the continuation of coordinated project-by-project disposal for CERCLA waste. For the purposes of the evaluation, it is assumed that the on-site C-746-U Landfill will continue to operate and receive waste that meets its WAC. Waste not meeting the C-746-U Landfill WAC will be disposed of off-site. Under CERCLA, a No Action Alternative is required to provide a baseline for comparison with other alternative actions. The No Action Alternative, if selected, would require no changes to current waste disposal practices.

The Off-Site Alternative includes two waste volume scenarios for comparison purposes: (1) a high-end waste volume scenario (4.1 mcy) for which CERCLA waste is assumed to be shipped off-site; and (2) a low-end waste volume scenario (1.5 mcy), which assumes various waste reduction actions, continued use of the C-746-U Landfill for nonhazardous solid waste disposal, and off-site disposal of CERCLA waste that does not meet the C-746-U Landfill WAC.

The On-Site Alternative involves the disposal of CERCLA waste into a newly constructed on-site waste disposal facility located on DOE-owned property. The On-Site Alternative includes two waste volume scenarios: (1) a high-end waste volume scenario for which CERCLA waste would be disposed of in a newly constructed on-site disposal facility; and (2) a low-end waste volume scenario, which assumes various waste reduction actions, continued use of the C-746-U Landfill, and disposal of CERCLA waste that does not meet the WAC of the C-746-U Landfill in a newly constructed on-site disposal facility.

1.2 PROJECT GOALS AND OBJECTIVES

The goal of the RI/FS is to select the most appropriate alternative for disposal of CERCLA waste. The selected alternative will be protective of human health and the environment and also will be compliant with applicable or relevant and appropriate requirements (ARARs). By following the CERCLA RI/FS process, the objective is to gather sufficient information to support an informed decision regarding the remedy that appears to be most appropriate for this site.

Specific to this project, the overall goal is to evaluate disposal alternatives, communicate fully with stakeholders, and strive for informed decision making throughout this RI/FS and CERCLA decision making process.

1.3 PROJECT DATA QUALITY OBJECTIVES

The Data Quality Objectives (DQO) process provides a structured approach to planning projects where environmental data are used to support decision making. Use of the DQO process leads to efficient and effective expenditure of resources; consensus on the type, quality, and quantity of data needed to meet the project goal; and the full documentation of actions taken during the development of the project.

In accordance with EPA DQO guidance, there are seven steps to the DQO process. The first five can be applied to any decision that utilizes qualitative or quantitative data to support decision making, while steps 6 and 7 are specific to supporting quantitative (statistical) analysis of data:

Step 1—State the problem
Step 2—Identify the goal of the study
Step 3—Identify information inputs
Step 4—Define the boundaries of the study
Step 5—Develop the analytic approach
Step 6—Specify performance (acceptance) criteria
Step 7—Develop the plan for obtaining data

The waste disposal alternatives evaluation project anticipates utilizing all or parts of EPA's DQO process throughout the CERCLA process to aid in planning, information gathering and analysis, assessing data usability, decision making, and, if applicable, record of decision (ROD) start-up and implementation. The DQO process is a decision support system and is intended to be flexible to address large and small decisions in an efficient and effective manner.

<u>State the Problem</u>

In order to evaluate the disposal alternatives for an estimated 3.7 mcy of waste projected to be generated from CERCLA projects, data regarding the implementability, effectiveness, and cost of disposal alternatives is needed.

Identify the Goal of the Study

The ultimate goal of the waste disposal alternatives evaluation project is to evaluate disposal alternatives and select the preferred alternative for PGDP CERCLA-generated waste and document the preferred alternative in a ROD.

Identify Information Inputs

Information inputs required to answer the principal study questions are shown in Tables 1.1 and 1.2. Questions listed in the tables will be addressed in the RI/FS report.

Define the Boundaries of the Study

The temporal boundary for this study will be the FFA for the PGDP CERCLA waste generated from fiscal year 2014 to 2039. The evaluation of waste disposal alternatives includes No Action, Off-Site disposal, and On-Site disposal. For the No Action and low-end volume scenarios, the C-746-U Landfill is assumed to remain available for nonhazardous CERCLA waste that meets the landfill's WAC. Generation, characterization, and certification of the CERCLA waste to be generated during PGDP FFA response actions are assumed to be identical.

Develop the Analytic Approach

For any identified data need, DOE and the regulators will determine the most cost-effective means to manage the uncertainty. Potential means to resolve data gaps include the following:

(1) Perform modeling and/or sensitivity analyses to better understand whether the uncertainty has a significant impact on project decisions;

(2) Perform research/literature review to reduce the level of uncertainty;

(3) Collect additional data through direct sampling, or process knowledge as deemed necessary during development of the RI or via discussion with regulating agencies; or

(4) Develop the alternatives (selection of processes and technologies) in a manner that addresses the potential risks stemming from the identified uncertainty to reduce the potential impact.

Develop the Plan for Obtaining Data

The availability of existing data relevant to evaluation of the waste disposal alternatives is discussed in Chapter 5. The plan to evaluate identified data gaps is presented in Chapter 6. Any additional data collection during development of the RI would be preceded by developing a sampling and analysis plan. For the No Action and Off-Site Alternatives, no data gaps have been identified. For the On-Site Alternative, identified data gaps primarily relate to facility siting on the DOE-owned property (including property leased to West Kentucky Wildlife Management Area) and adequacy of seismic data and hydrologic data. Managing the uncertainty of the CERCLA waste to be generated is the responsibility of generating projects; however, this uncertainty is accounted for by establishing a range of waste volumes for this waste disposal evaluation.

Table 1.1. Principal Study Questions and Information Inputs Associated with the Off-Site Alternative

Principal Study Question	Information Inputs
Do sufficient off-site disposal facilities exist for all waste types and classifications expected to be generated during CERCLA remediation activities?	Current available off-site disposal facilities for expected CERCLA waste classifications, forms, and types.
	Expected waste capacity of anticipated off-site disposal facilities in relation to PGDP CERCLA waste generating actions (i.e., remediation of SWMUs).
	Expected closing dates for anticipated off-site waste disposal facility options in relation to PGDP CERCLA waste generation schedule.
Can the Off-Site Alternative be implemented consistent with current and potential future PGDP waste management practices (e.g., packaging, marking, recordkeeping, reporting, etc.)?	Current waste management practices at PGDP.
Can waste transportation associated with the Off-Site Alternative be implemented without unacceptable impact to human health and the environment?	Availability of intra- and interstate truck and rail transportation routes through the duration of PGDP CERCLA remediation activities.
	Risks of accidents/releases due to off-site waste transportation.
	Location and total mileage of current truck and rail transportation routes.
What is the total cost of implementing the Off-Site Alternative?	Unit and total expected costs associated with off-site disposal of anticipated PGDP CERCLA waste, incorporating the schedule of waste generation (to support present value cost estimation).
	Availability of intra- and interstate truck and rail transportation routes through the duration of PGDP CERCLA remediation activities.

Table 1.2. Principal Study Questions and Information Inputs Associated with the On-Site Alternative

Principal Study Question	Information Inputs
Can protective barriers be established that are protective of human health and the environment in the event of potential contaminant migration or exposure and can such barriers retain their protectiveness for the period of time the waste is expected to be a threat to human health and the environment?	Distance to sensitive environmental areas (including West Kentucky Wildlife Management Area).
	Distance to site boundaries.
	Groundwater flow direction and velocity.
	Distance to the water table.
	Design considerations (liner, soil buffer, cap, etc.).
Do current and potential future demographics significantly impact the short-term construction/transportation impacts or long-term protectiveness of an On-Site Alternative?	Projected population growth and future developments of the site and surrounding areas.
	Distance to nearest residence, church, school, house, residential wells.
Is the distance of a potential disposal facility from floodplains sufficient to protect against potential contaminant migration that result in an unacceptable impact on human health or the environment?	Proximity to floodplains.
Would a disposal facility potentially impact protected wetlands?	Proximity to delineated wetlands.
	Potential impact to delineated wetlands.
Would a disposal facility potentially impact threatened or endangered species?	Threatened & Endangered Species (e.g., Indiana bat habitat areas).
Would a disposal facility potentially impact cultural or natural resources?	Historic/archaeological sites (e.g., cemeteries).
	Presence of areas having known natural resources which, if exploited would result in failure to meet the performance objectives.
Do seismic conditions in the region pose a potential unacceptable impact to human health or the environment?	Proximity to Holocene Faulting.
	Frequency and magnitude of tectonic processes (e.g., faulting, folding, seismic activity, or vulcanism).
	Areas of potential liquefaction.
	Ground motion.

Table 1.2. Principal Study Questions and Information Inputs Associated with the On-Site Alternative (Continued)

Principal Study Question	Information Inputs
Are hydrogeologic conditions such that human health and the environment would be protected from potential contaminant migration or exposure via groundwater?	Depth to groundwater.
	K_d (solid-to-liquid distribution coefficient).
	Groundwater seepage velocity parameters.
	Monitorability.
	Seasonal fluctuations in groundwater.
	Proximity to drinking water wells or high value groundwater.
	Distance to perennial streams.
	Characteristics of the upstream drainage area.
	Permeability of soils and bedrock.
	Discharge of groundwater to the surface within the disposal site.
Would surface geologic processes at a potential site result in failure of the engineered portions of a disposal facility that results in an unacceptable impact to human health or the environment?	Evidence of surface geologic processes such as mass wasting, erosion, slumping, landsliding, or weathering.
Would potential transportation or on-site access restrictions occur that would impact the short- or long-term implementability of an On-Site Alternative?	Site access by waste generators.
	Replacement or construction of roads or rail lines to transport waste.
Are current and future land use expectations such that unacceptable impacts to human health and the environment would result from potential contaminant migration or exposure?	Interference with/by nearby facilities or activities.
Can an On-Site Alternative be implemented without unacceptable impacts to the timing of other CERCLA actions at PGDP?	Time frame for availability of the site in relation to other CERCLA actions (e.g., remediation of SWMUs, proximity to operating remedial technologies, and proximity to SWMUs that would require remediation before a facility could be constructed).

Table 1.2. Principal Study Questions and Information Inputs Associated with the On-Site Alternative (Continued)

Principal Study Question	Information Inputs
What is the total cost of implementing the On-Site Alternative?	Cost of design and construction.
	Cost of operations.
	Cost of postclosure monitoring and maintenance.
What are the issues and costs of long-term stewardship and ultimate land use?	End state vision.
	Cost of monitoring.
	Cost of maintenance.
	Oversight roles and responsibilities.
	Changing conditions response.

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2. PROJECT ORGANIZATION AND MANAGEMENT PLAN

This section presents the project organization of DOE's prime remediation contractor for the CERCLA waste disposal alternative evaluation RI/FS. The topics addressed in this section include project organization, project coordination, and project schedule.

2.1 PROJECT ORGANIZATION, RESPONSIBILITIES, AND STAFFING

The organization chart (Figure 2.1) outlines DOE's prime remediation contractor management structure that will be used for implementing the RI/FS. The responsibilities of key personnel are described in the following paragraphs.

2.1.1 Prime Remediation Contractor Environmental Restoration Manager

The Prime Remediation Contractor ER Manager will have overall programmatic responsibility for the prime contractor technical, financial, and scheduling matters. This individual will interface with DOE and the regulators, as appropriate.

2.1.2 Prime Remediation Contractor Project Manager

The prime remediation contractor project manager (PM) will have overall responsibility for implementing the waste disposal alternatives evaluation. This individual will serve as the principal point of contact. The RI/FS PM will track the project budget and schedules and will delegate specific responsibilities to project team members, subject matter experts, and subcontractors.

2.1.3 Prime Remediation Contractor Technical Lead

The primary role of the technical lead will be to focus on the day-to-day activities and keep the project on schedule. This individual will interact with the project manager on a daily basis and will relay direction to the project team members as necessary.

2.1.4 Prime Remediation Contractor Team Members

The RI/FS team members are composed of technical staff that will be required to support the waste alternative evaluation. The technical staff includes various disciplines such as geologists and environmental compliance and waste management specialists. Subcontractor personnel will be retained as subject matter experts to provide expertise in specific areas.

2.2 PROJECT COORDINATION

The Prime Remediation Contractor PM will coordinate the project with DOE and will provide overall direction for the prime remediation contractor project team for the scope of this project. The PM also will coordinate meetings and teleconferences with DOE and the regulatory agencies as necessary or requested.

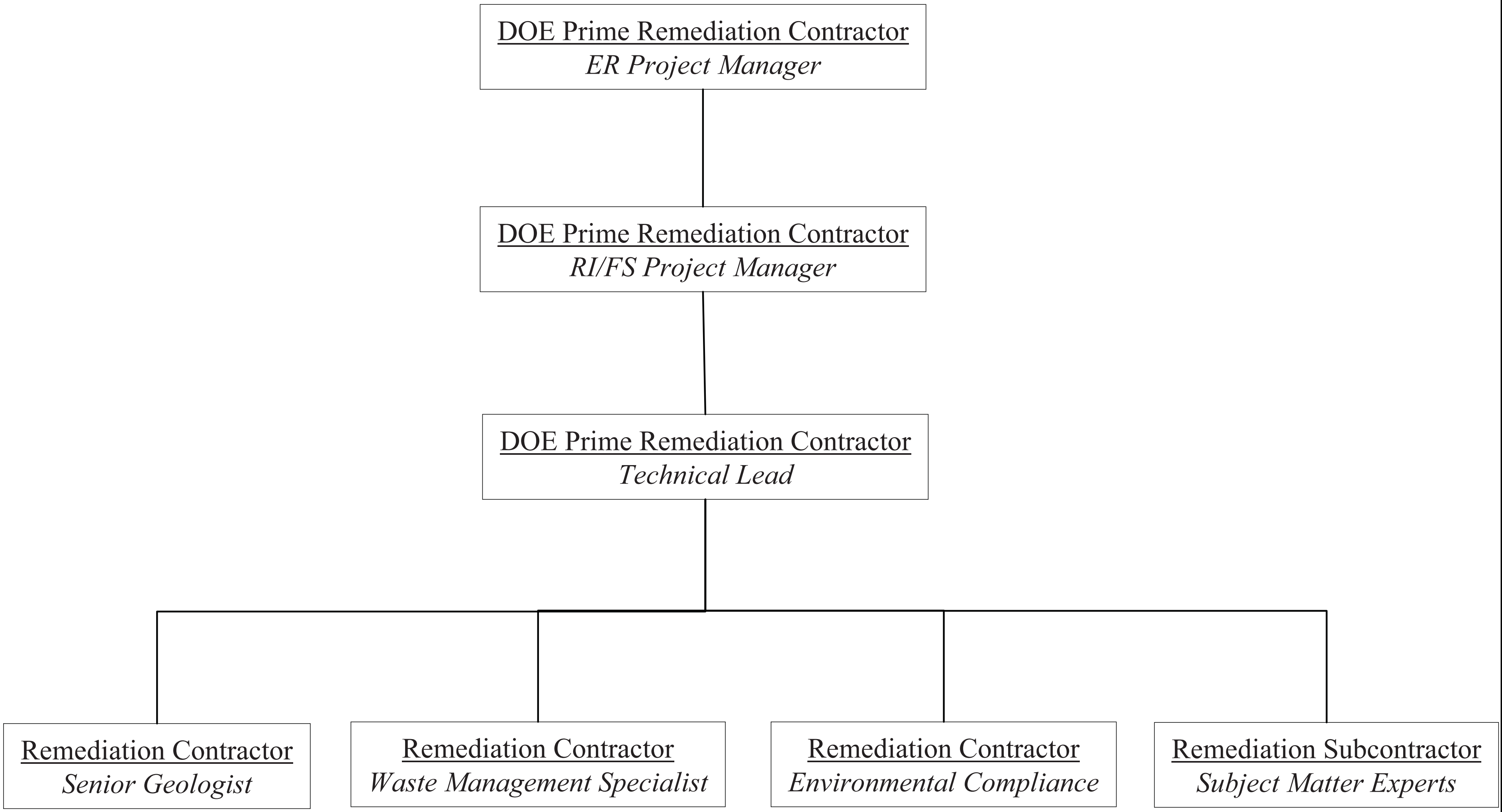

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Figure 2.1. DOE Prime Remediation Contractor CERCLA Waste Alternative Evaluation RI/FS Project Organizational Chart

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2.3 PROJECT TASKS AND IMPLEMENTATION PLAN

This project has two specific tasks: an RI and an FS. Implementation of these tasks will follow, to the extent possible, EPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA,* EPA/54016-89/004, unless the guidance is not appropriate for the scope of this project.

The RI task will focus on gathering and analyzing information for use in the FS. Much of the information needed to support the FS is readily available, as described in Chapter 5. Some gaps in the information needed to support an FS may exist; these potential data gaps and how they will be addressed in the RI are discussed in Chapter 6.

The FS task will focus on performing a detailed analysis of the CERCLA waste disposal alternatives for the PGDP site. For this RI/FS, three alternatives will be developed (No Action, Off-Site, and On-Site). The detailed analysis will evaluate these alternatives against the CERCLA threshold and balancing criteria. The analysis is discussed in Chapter 7.

A general overarching project task is solicitation and consideration of stakeholder input. Chapter 8 discusses the community involvement plan.

2.4 PROJECT SCHEDULE

A schedule for major activities associated with disposal alternatives evaluation is shown in Figure 2.2. Review, revision, and approval periods for D1 and D2 documents are based on the generic FFA schedule. The dates shown in the schedule are nonenforceable estimates for planning purposes only.

2.5 RI/FS WORK PLAN ACTIVITIES

This document, the RI/FS work plan, addresses, to the extent possible, concerns and issues discussed in the scoping meeting and comments on the scoping document (DOE 2008). It is submitted to EPA and Kentucky for review and comment. The approved work plan will be used as a guide in conducting the RI/FS.

The work plan supports the CERCLA waste disposal alternative evaluation by discussing the following:

- Regulatory Setting—Chapter 3
- Environmental Setting and Site Characterization—Chapter 4
- Existing Information—Chapter 5
- Data Needs and Management of Uncertainties—Chapter 6
- Alternatives Evaluation—Chapter 7
- Community Relations Plan—Chapter 8
- References—Chapter 9

Additionally, the following appendices support the work to be conducted during this RI/FS:

- Preliminary Identification of Applicable or Relevant and Appropriate Requirements and To Be Considered Guidance—Appendix A
- Summary of Seismic Investigation—Appendix B
- Proposed Groundwater Modeling Methodology—Appendix C
- Analytical Profile—Appendix D
- Site Screening—Appendix E

- Bedrock Shear Wave Sensitivity Analysis—Appendix F
- Historical Risk Assessment Summary—Appendix G
- RI/FS Document Outline—Appendix H

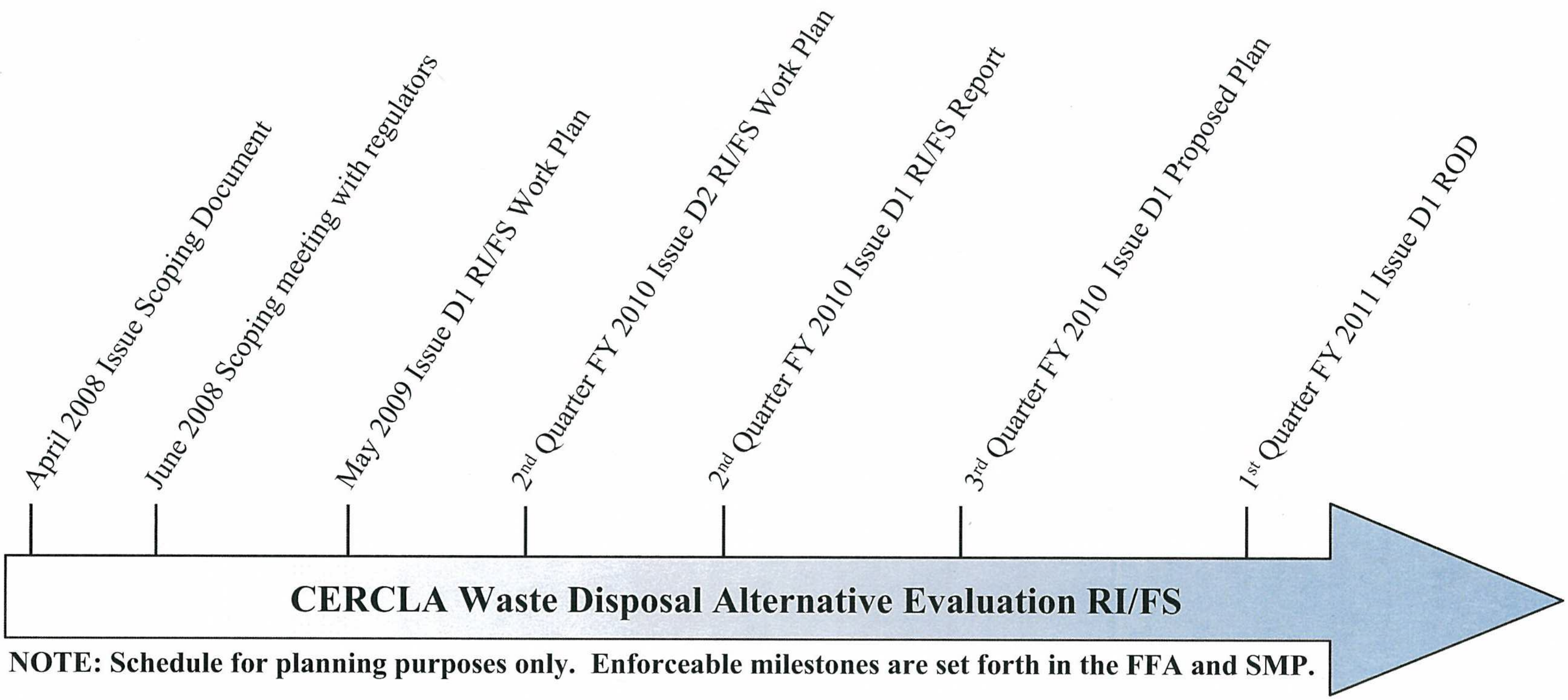

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Figure 2.2. CERCLA Waste Alternative Evaluation RI/FS Schedule

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3. REGULATORY SETTING

This section summarizes the regulatory framework for environmental restoration at the PGDP, including the major acts and accompanying regulations driving response actions, such as CERCLA and RCRA. It also describes the documents controlling response actions, such as the FFA and the Site Management Plan (SMP) (DOE 2010).

3.1 MAJOR ACTS, REGULATIONS, AND CONTROLLING DOCUMENTS

On June 30, 1994, EPA placed the PGDP on the NPL [59 *Federal Register* (*FR*) 27989 (May 31, 1994)]. Sites on the NPL are required to evaluate releases and conduct remedial actions/removal actions in accordance with CERCLA's National Oil and Hazardous Substances Pollution Contingency Plan. As the lead agency under CERCLA, DOE is responsible for conducting cleanup activities at the PGDP. CERCLA is not the only driver for cleanup at the PGDP. RCRA, in addition to regulating the generation, transportation, treatment, storage, and disposal of hazardous waste, requires corrective action for releases of hazardous constituents from SWMUs. The primary purpose of RCRA is to protect human health and the environment through the proper management of hazardous wastes at operating sites.

To ensure that duplication of investigative/analytical work and documentation under both RCRA and CERCLA is minimized, EPA, Kentucky, and DOE signed the FFA for the PGDP on February 13, 1998, pursuant to Section 120 of CERCLA. The FFA coordinates the CERCLA remedial action and the RCRA corrective action processes into a single, comprehensive procedure for site remediation.

The FFA requires that DOE prepare and submit to EPA and Kentucky an annual SMP. The SMP is designed to coordinate and document the selected OUs, removal actions and proposed removal actions, work priorities, projected activities, timetables, and deliverables for the current and two successive fiscal years. The SMP includes a basis for prioritizing response actions and the prioritization criteria. The SMP also contains a list of commitments and long-term projections.

3.2 RCRA

RCRA requirements for PGDP are contained in PGDP's Hazardous Waste Management Permit (KY8-890-008-982, originally issued July 1991, reissued September 2004). This permit originally was issued by both the Commonwealth of Kentucky and EPA. EPA's portion of the RCRA permit was limited to the Hazardous and Solid Waste Amendments provisions of RCRA, which include corrective action requirements for SWMUs. Kentucky became authorized in 1996 for corrective actions; therefore, the reissued permit was issued solely by Kentucky. The RCRA permit contains regulatory provisions for treatment, storage, and disposal units, as well as provisions requiring corrective action for SWMUs.

3.3 CERCLA

Section XVIII of the FFA requires DOE to submit an annual SMP, which details the strategic approach for achieving cleanup under the FFA. The FFA states that the purpose of the SMP is to coordinate and document the potential and selected OUs, including removal actions; define cleanup priorities; identify work activities that will serve as the basis for enforceable timetables and deadlines under the agreement; and establish long-term cleanup goals.

3.4 ENVIRONMENTAL PROGRAMS

Environmental sampling at PGDP is a multimedia (air, water, soil, sediment, direct radiation, and biota) program of chemical, radiological, and ecological monitoring. Environmental monitoring consists of two activities: effluent monitoring and environmental surveillance. As part of the ongoing ER activities, SWMUs and AOCs, both on and off DOE owned property, have been identified. Characterization and/or remediation of these sites will continue.

3.5 NATIONAL ENVIRONMENTAL POLICY ACT

On June 13, 1994, the Secretary of Energy issued a Secretarial Policy (Policy) on NEPA that addresses NEPA requirements for actions taken under CERCLA (DOE 1994). Section II.E of the Policy indicates that to facilitate meeting the environmental objectives of CERCLA and respond to concerns of regulators consistent with the procedures of most other federal agencies, DOE will rely on the CERCLA process for review of actions to be taken under CERCLA and will address NEPA values, such as analysis of off-site, ecological, cultural, and socioeconomic impacts, as well as environmental justice and land use issues. DOE CERCLA documents will incorporate NEPA values, to the extent practicable. This process has been used for decision on other disposal facilities in the DOE complex, such as the EMWMF in Oak Ridge, Tennessee.

3.6 INVESTIGATIVE OVERVIEW

The focus of the RI/FS is to evaluate and select a waste disposal alternative for CERCLA wastes generated at PGDP. The selected alternative will be protective of human health and the environment and will attain ARARs (Appendix A) unless an appropriate waiver or variance is sought and obtained. As presented in subsequent chapters of this work plan, a significant amount of data exists that can be used to aid in developing the No Action, Off-Site and the On-Site Alternatives. Some of the existing data were derived from current waste disposal methods and from previous studies conducted at PGDP. Data from other DOE sites also will be used for evaluating the waste disposal alternatives, as appropriate. Because of this existing data, RI field studies may not be required. Evaluation of CERCLA waste disposal alternatives does not include collecting samples of media to determine the nature and extent of contamination that is associated with typical RI activities. It is anticipated that most of the identified data gaps can be filled by performing additional research and office studies. Some data gaps identified during the scoping process will be evaluated through sensitivity analysis. The analysis will determine if and when missing data is needed to complete the CERCLA process. If a data gap cannot be resolved using existing data or sensitivity analysis, field work will be conducted to obtain the needed data.

4. ENVIRONMENTAL SETTING AND SITE CHARACTERIZATION

This section summarizes the environmental setting at PGDP. This summary includes descriptions of the location of PGDP, the demography and land use, seismicity, hydrogeology, surface water hydrology, ecology, and climatology at and near PGDP.

4.1 LOCATION

PGDP is located approximately 10 miles west of Paducah, Kentucky, (population ~26,000) and 3.5 miles south of the Ohio River in the western part of McCracken County (Figure 4.1). A network of highways, rail lines, a regional airport, and water transportation serves the area. The plant is located on a 3,556 acre DOE-owned site, approximately 650 acres of which are within a fenced security area, 822 acres are located outside the security fence, and the remaining 1,986 acres are licensed to Kentucky as part of the 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 4.2).

The topographic features at the site include nearly level to gently sloping dissected plains and the flood plain of the Ohio River. The elevations of the stream valleys in the dissected plains are up to 100 ft lower than the adjoining uplands.

Local elevations range from 290 ft amsl along the Ohio River to 450 ft amsl southwest of PGDP near Bethel Church Road. Generally, the topography in the PGDP area slopes toward the Ohio River at an approximate gradient of 27 ft per mile (CH2M HILL 1992). Ground surface elevations vary from 360 to 390 ft amsl within the PGDP plant boundary and 340 to 420 ft amsl within the DOE site.

4.2 DEMOGRAPHY AND LAND USE

PGDP is surrounded by WKWMA and sparsely populated agricultural lands. The closest communities to the plant are Heath, Grahamville, and Kevil, all of which are located within 3 miles of DOE site boundaries. PGDP is located 5 miles southwest of Metropolis, Illinois; approximately 10 miles west of Paducah, Kentucky; and approximately 40 miles southeast of Cape Girardeau, Missouri.

Historically, the economy of Western Kentucky has been based on agriculture, although there has been increased industrial development in recent years. PGDP employs approximately 1,400 people, while the TVA Shawnee Steam Plant employs an additional 260 people. The total population within the 32 counties that lie within a 50 mile radius of PGDP is approximately 731,500; and approximately 88,500 people live within the three counties that contain the 10 mile radius of the plant (Massac County, Illinois, and Ballard and McCracken Counties, Kentucky) (US Census 2008a; 2008b; 2008c). The estimated population of Paducah, Kentucky, is approximately 25,540 (US Census 2007). The population of McCracken County is estimated to be approximately 65,100 (US Census 2008a).

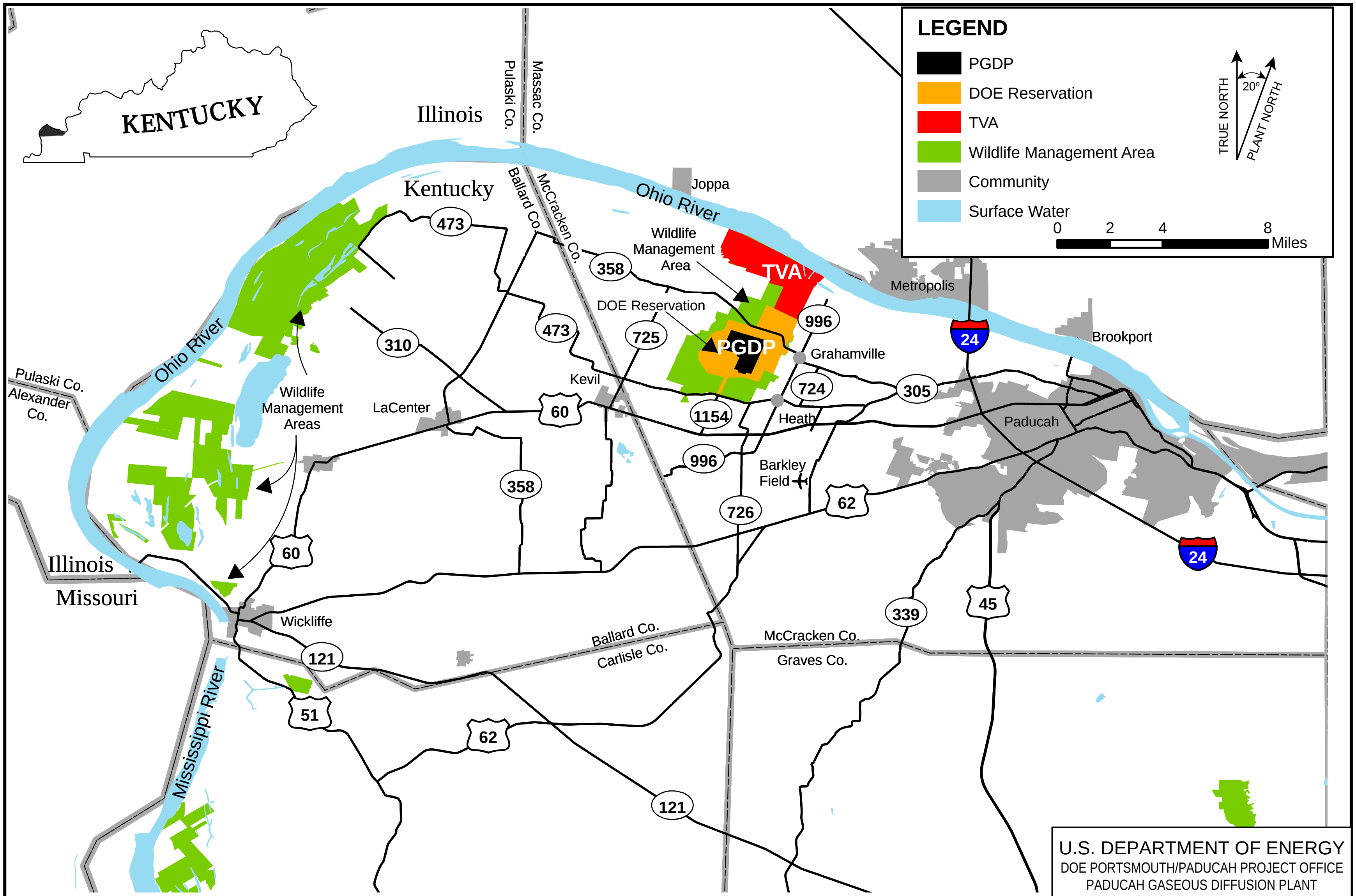

Figure 4.1. PGDP Vicinity Map

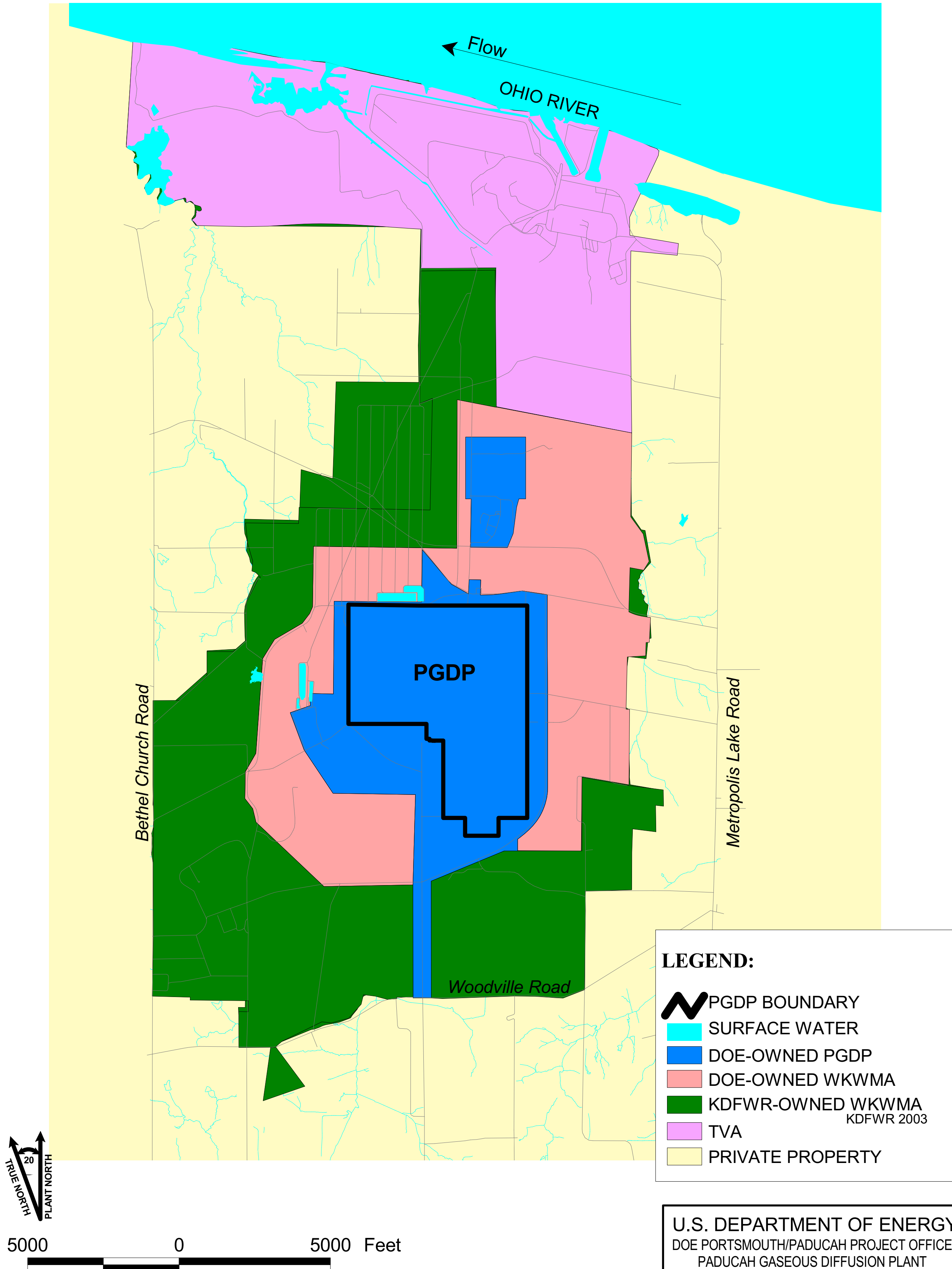

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Figure 4.2. Land Ownership in Proximity to DOE Site

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In addition to the residential population surrounding the plant, WKWMA draws thousands of visitors each year for recreational purposes. This area is used by visitors, primarily for hunting and fishing, but other activities include horseback riding, dog trials, hiking, and bird watching.

4.3 GENERAL HISTORY

PGDP is a DOE-owned uranium enrichment plant consisting of a diffusion cascade system and associated support facilities. Effective July 1, 1993, DOE leased the plant production facilities to USEC.

DOE began construction of the plant in 1951 and initiated operation in 1952. The plant enriches uranium-235, the second most abundant isotope in naturally occurring uranium, from much less than 1% (its natural proportion) to almost 5%. Enrichment of uranium-235 is necessary because the most abundant isotope of uranium, uranium-238 (>99% of naturally occurring uranium), is not a fissile material. The enrichment process requires extensive support facilities; some of the facilities currently active at PGDP include a steam plant, four major electrical switchyards, four sets of cooling towers, a building for chemical cleaning and decontamination, a water treatment plant, and maintenance and laboratory facilities. Several inactive facilities also are located at the plant site.

From 1953 until 1977, most of the uranium hexafluoride (UF_6) used by PGDP was produced from feedstock in the feed plant (C-410 Building), which was designed to process both natural uranium and uranium from reactor tails.[5] The reactor tails included uranium that had been returned for re-enrichment from the plutonium production reactors at the DOE Hanford and Savannah River plants. As a result of nuclear reactions in the plutonium production reactors, the reactor tails contained technetium-99 (^{99}Tc) and are believed to be the sole source of ^{99}Tc released to the environment at PGDP. Since 1977, PGDP has been supplied with UF_6 feedstock from commercial vendors, such as Honeywell in Metropolis, Illinois, and from foreign sources.

Various hazardous, nonhazardous, and radioactive wastes resulting from ongoing operations have been generated and disposed of at PGDP. Site investigations have determined that trichloroethene (TCE) and ^{99}Tc in groundwater and uranium and polychlorinated biphenyls (PCBs) in surface water and sediment are the four primary environmental contaminants of concern (COCs) at the facility (CH2M HILL 1991; 1992). Since the plant's construction, TCE had been used as a cleaning solvent. The use of TCE as a degreaser ceased on July 1, 1993. PCBs were used extensively as an insulating, nonflammable, thermally conductive fluid in electrical capacitors and transformers at PGDP. PCB oils also were used as flame retardants on the gaskets of diffusion cascades and other sections of the plant and as hydraulic fluid. PGDP began a PCB abatement program in the mid 1980s. In addition, PCBs have been found in numerous painted surfaces at the PGDP during D&D of facilities.

4.4 GEOLOGY

PGDP is located in the Jackson Purchase region of Western Kentucky, which represents the northern most extent of the Mississippi Embayment portion of the Coastal Plain Province. The stratigraphic sequence in the region consists of Cretaceous [144 to 65 million years ago (mya)], Tertiary (65 to 1.8 mya), and Quaternary (1.8 mya to today) sediments unconformably overlying Paleozoic (543 to 248 mya) bedrock

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[5]Reactor tails received after 1975 were placed in storage rather than being processed.

(Paleozoic strata younger than Mississippian are not present at the site). Subsequent sections will briefly discuss the formations represented in Figure 4.3 to acquaint the reader with PGDP geology.

4.4.1 Bedrock

Mississippian (354 to 323 mya) carbonates, consisting of a dark gray limestone with some interbedded chert and shale, underlie the entire PGDP area at depths varying from 340 to 400 ft. The thickness of these carbonates is estimated to be greater than 500 ft.

4.4.2 Rubble Zone

A rubble zone of chert gravel is commonly encountered in soil borings at the top of the bedrock. The age and continuity of the rubble zone remain undetermined. Where it occurs, the rubble zone ranges from approximately 5 to 20 ft in thickness.

4.4.3 McNairy Formation

The McNairy Formation consists of Upper Cretaceous sediments of gray to yellow to reddish-brown, very fine- to medium-grained sand interbedded with grayish-white to dark gray, micaceous silt and clay. A basal sand member also is present at PGDP. The total thickness of the McNairy Formation ranges from 200–300-ft thick.

4.4.4 Porters Creek Clay/Porters Creek Terrace Slope

The Paleocene (65 to 54.8 mya) Porters Creek Clay occurs in the southern portions of the site and consists of dark gray to black silt with varying amounts of clay and fine-grained micaceous, commonly glauconitic, sand. In the southern portions of the site it can be as thick as 200 ft. The Porters Creek Clay subcrops along a buried terrace slope that extends east–west across the site. This subcrop is the northern limit of the Porters Creek Clay and the southern limit of the Pleistocene (1.8 mya to 11,000 years) Lower Continental Deposits under PGDP.

4.4.5 Eocene Sands

Eocene (54.8 to 33.7 mya) sands occur south of PGDP above the Porters Creek Clay and do not underlie PGDP, although they can be found in the extreme southwestern part of the DOE Reservation. This unit includes undifferentiated quartz sands and interbedded and interlensing silts and clays of the Claiborne Group and Wilcox Formation (Olive 1980). The Eocene sands thicken south of PGDP. The Claiborne Group ranges up to 200-ft thick and the Wilcox Formation may be up to 100-ft thick.

4.4.6 Continental Deposits

Continental sediments [Pliocene (?)[6] (5.3 to 1.8 mya) to Pleistocene (1.8 mya to 11,000 years ago] unconformably overlie the Cretaceous through Eocene strata throughout the area. These continental sediments were deposited on an irregular erosional surface consisting of several terraces and have a total thickness from near zero to about 120 ft. The thicker Continental Deposits sections represent Pleistocene valley fill sediments that comprise a fining-upward cycle. The continental sediments have been divided into the following two distinct facies:

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[6] A question mark indicates uncertain age of the sediments.

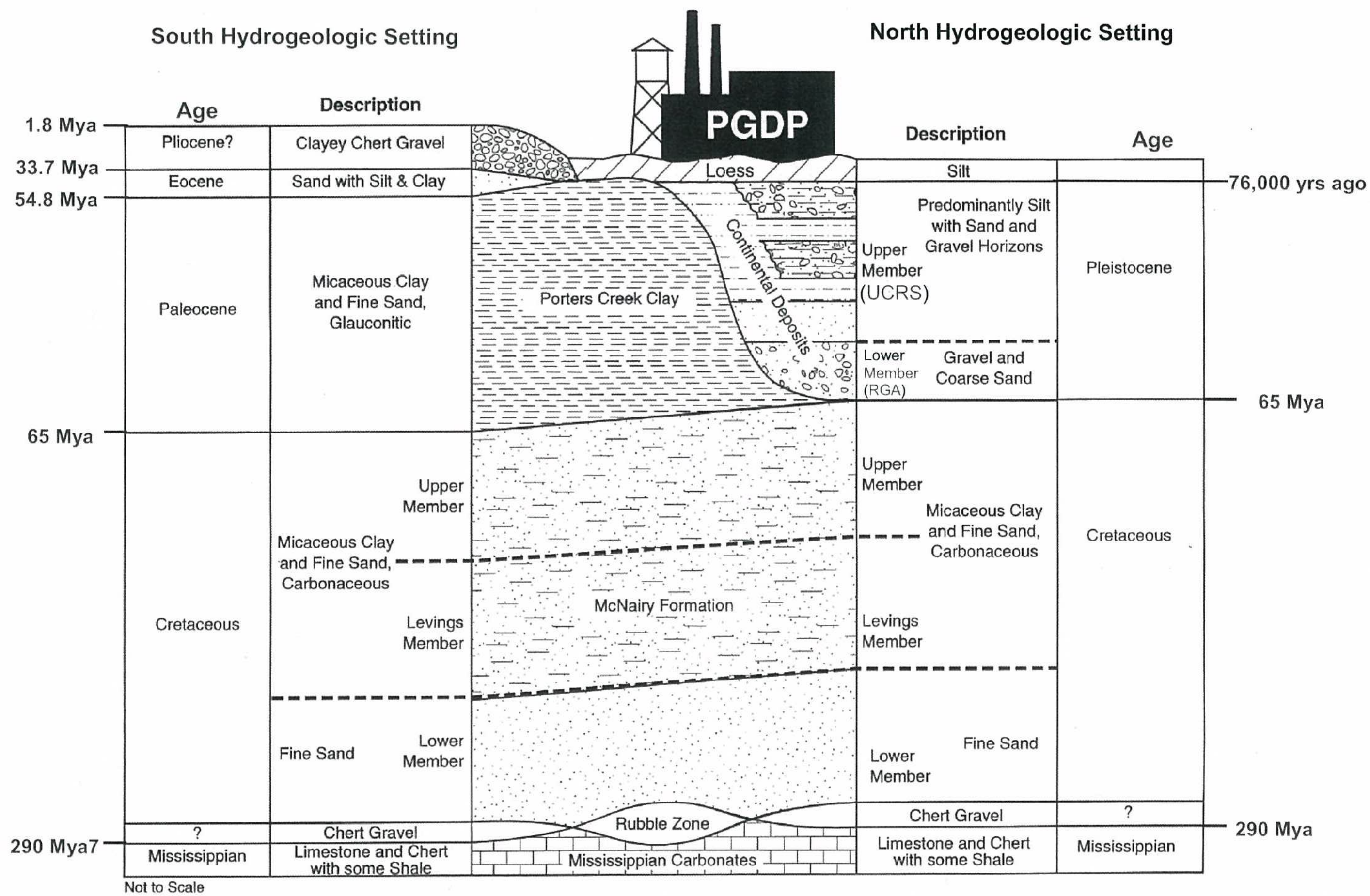

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Figure 4.3. Stratigraphy in the Vicinity of PGDP

(1) Lower Continental Deposits. The Lower Continental Deposits is a gravel facies consisting of chert, ranging from pebbles to cobbles, in a matrix of poorly sorted sand and silt. Gravels of the Lower Continental Deposits overlie three distinct terraces in the PGDP area.

- The upper terrace of the Lower Continental Deposits consists of Pliocene (?) gravel units, ranging in thickness from near 0 to 30 ft, occurring in the southern portion of the DOE site at elevations greater than 350 ft amsl. This gravel unit overlies the Eocene sands and Porters Creek Clay (where the Eocene sands are missing).

- Pliocene (?) gravels of the Lower Continental Deposits also occur on an intermediate terrace eroded into the Porters Creek Clay at an elevation of approximately 320 to 345 ft amsl in the southeastern and eastern portions of the DOE site. The thickness of this unit typically ranges from 15 to 20 ft.

- The Lower Continental Deposits of the upper and intermediate terraces are collectively referred to as the Terrace Gravel.

- The third and most prominent of the Lower Continental Deposits members consists of a Pleistocene gravel deposit resting on an erosional surface at an elevation of approximately 280 ft amsl. This gravel underlies most of the plant area and the region to the north, but pinches out under the south side of PGDP along the subcrop of the Porters Creek Clay. The Pleistocene member of the Lower Continental Deposits averages approximately 30 ft in thickness. Trends of greater thickness, as much as 50 ft, fill deeper scour channels that trend east-west across the site.

(2) Upper Continental Deposits. The Upper Continental Deposits is a Pleistocene age, fine-grained facies that commonly overlies the Lower Continental Deposits. This unit ranges in thickness from 15 to 55 ft. The Upper Continental Deposits includes three general horizons beneath PGDP: (1) an upper silt and clay interval, (2) an intermediate interval of common sand and gravel lenses (sand and gravel content generally diminishes northward), and (3) a lower silt and clay interval. The upper silt and clay interval consists of the Peoria Loess and Roxana Silt (DOE 2004; KRCEE 2006). The Peoria Loess and Roxana Silt blanket the entire PGDP area and range from zero to about 43 ft in thickness.

4.4.7 Surficial Deposits/Soils

The surficial deposits found in the vicinity of PGDP are Pleistocene loess and Holocene (10,000 to 12,000 years ago to present) alluvium. Both units commonly consist of clayey silt or silty clay and range in color from yellowish-brown to brownish-gray or tan, making field differentiation difficult.

Loess deposition probably occurred in upland areas during all stages of the glaciation that extended into the Ohio and Mississippi River Valleys. The upland areas are located in the southern portion of PGDP and are characterized by gently northward sloping plain that is generally above 350 ft msl. This area is underlain by loess soils, along with ridges with elevations above 380 ft msl that are underlain by sand, clay or silt.

The general soil map for Ballard and McCracken Counties delineates three soil associations within the vicinity of PGDP: the Rosebloom-Wheeling-Dubbs association, the Grenada-Calloway association, and the Calloway-Henry association (USDA 1976). Inside the fenced area of the plant, the best description of the soil would be Urban, since many of the characteristics of these soil types have been changed due to construction and maintenance activities (USDA 2005).

4.5 SEISMICITY

Three seismic sources have the potential to affect PGDP (Figure 4.4); the New Madrid Seismic Zone (centered near the juncture of Kentucky, Missouri, and Tennessee); the Wabash Valley Seismic Zone (in southeast Illinois and southwest Indiana); and background seismicity (KRCEE 2007a).[7] Of these, the New Madrid Seismic Zone presents the most prominent seismic hazard to PGDP. Four or five major earthquakes are believed to have occurred in the New Madrid Seismic Zone in late 1811 and early 1812 (Nuttli 1982). The most significant earthquakes during this period (December 16, 1811, January 23 and February 7, 1812) are estimated to have had a magnitude between M7.0-7.5 (Hough *et al.* 2000; Hough and Martin 2002). Section 5.5 and Appendix B provides a summary of seismic studies that have been conducted at PGDP and regionally to better understand seismic hazard at PGDP.

4.6 HYDROGEOLOGY

The significant geologic units relative to shallow groundwater flow at PGDP include the Terrace Gravel and Porters Creek Clay (south sector of the DOE site) and the Pleistocene Continental Deposits and McNairy Formation (underlying PGDP and adjacent areas to the north). Figure 4.5 illustrates the water level elevations and geologic units of the shallow groundwater flow systems at PGDP. Groundwater flow in the Pleistocene Continental Deposits is a primary pathway for transport of dissolved contamination from PGDP. The following paragraphs provide the framework of the shallow groundwater flow system at PGDP (DOE 1999a).

(1) <u>Terrace Gravel Flow System</u>. The Porters Creek Clay with a vertical hydraulic conductivity of 1.5 x 10^{-4} to 1.4 x 10^{-1} ft/day (DOE 2004) is a confining unit to downward groundwater flow south of PGDP. A shallow water table flow system is present in the Terrace Gravel, where it overlies the Porters Creek Clay south of PGDP. Discharge from this water table flow system provides baseflow to Bayou Creek and underflow to the Pleistocene Continental Deposits to the east of PGDP.

The elevation of the top of the Porters Creek Clay is an important control to the area's groundwater flow. A distinct groundwater divide is centered in hills located approximately 9,000 ft southwest of PGDP, where the Terrace Gravel and Eocene sands with a lateral hydraulic conductivity as high as 5 ft/day (Maxim 1997) overlie a "high" on the top of the Porters Creek Clay (USGS 1966). In adjacent areas where the top of the Porters Creek Clay approaches land surface, as it does immediately south of PGDP and near the subcrop of the Porters Creek Clay to the west of the security-fenced area, the majority of groundwater flow is forced to discharge into surface streams (gaining reaches) and little underflow occurs into the Pleistocene Continental Deposits. To the east of PGDP, the Terrace Gravel overlies a lower terrace and a thick sequence of Terrace Gravel occurs adjacent to the Pleistocene Continental Deposits, allowing significant underflow from the Terrace Gravel. Surface drainages in this area typically are losing reaches. Figure 4.6 presents hydraulic potential contours for the Terrace Gravel flow system (DOE 1997). While there is uncertainty due to limited monitoring well data from the area depicted in Figure 4.6, the water table contours are based on information in United States Geological Survey (USGS) 1966, stream elevations, and water levels in abandoned gravel pits.

(2) <u>Upper Continental Recharge System</u> (UCRS). The UCRS is the upper strata where infiltration of surface water occurs and where the water table is found in the Upper Continental Deposits in the northern PGDP. Site-specific modeling indicates that the infiltration rate for the PGDP area is

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[7]Background seismicity is seismic activity not associated with any known seismic zone.

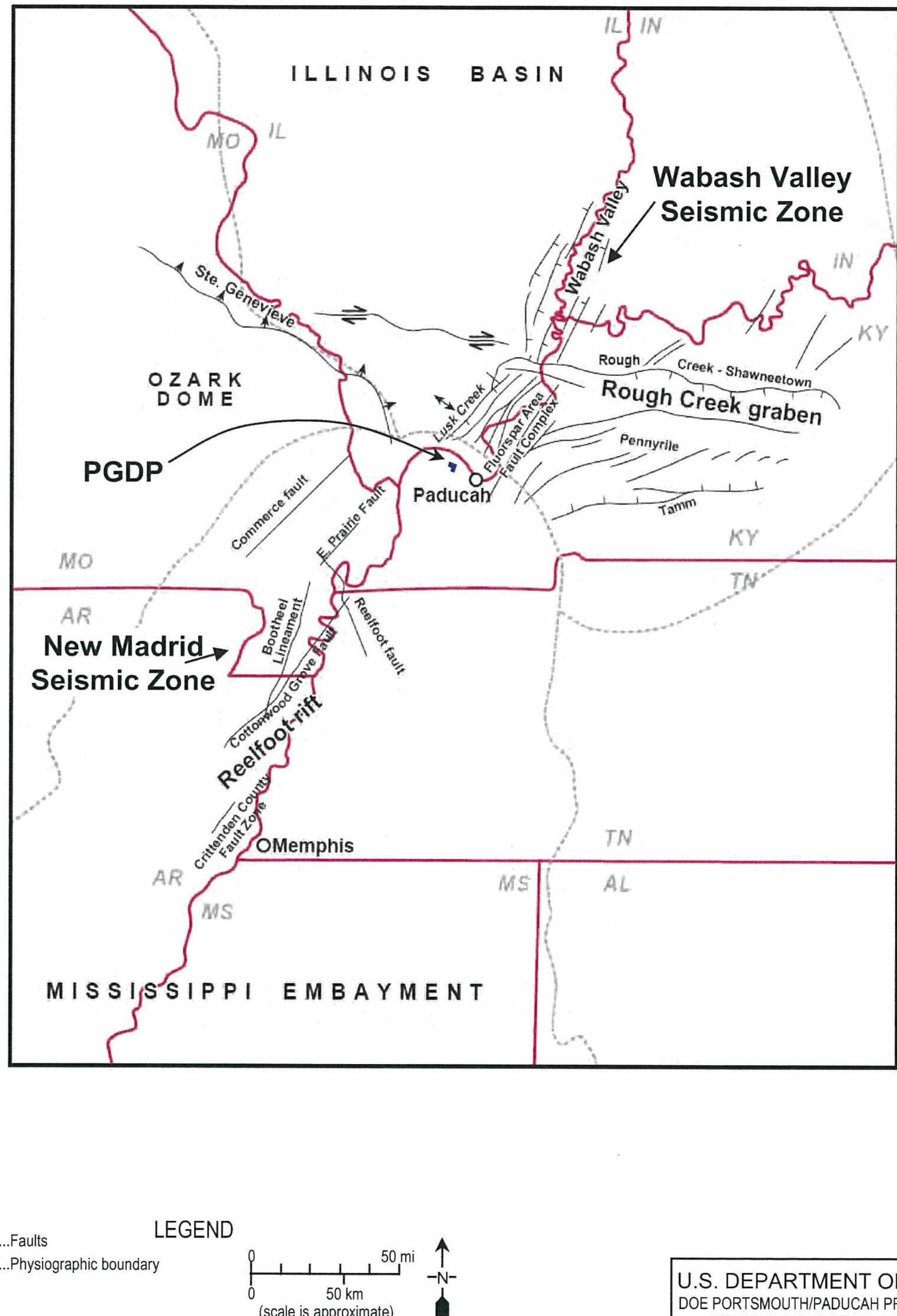

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Figure 4.4. Regional Tectonic Map

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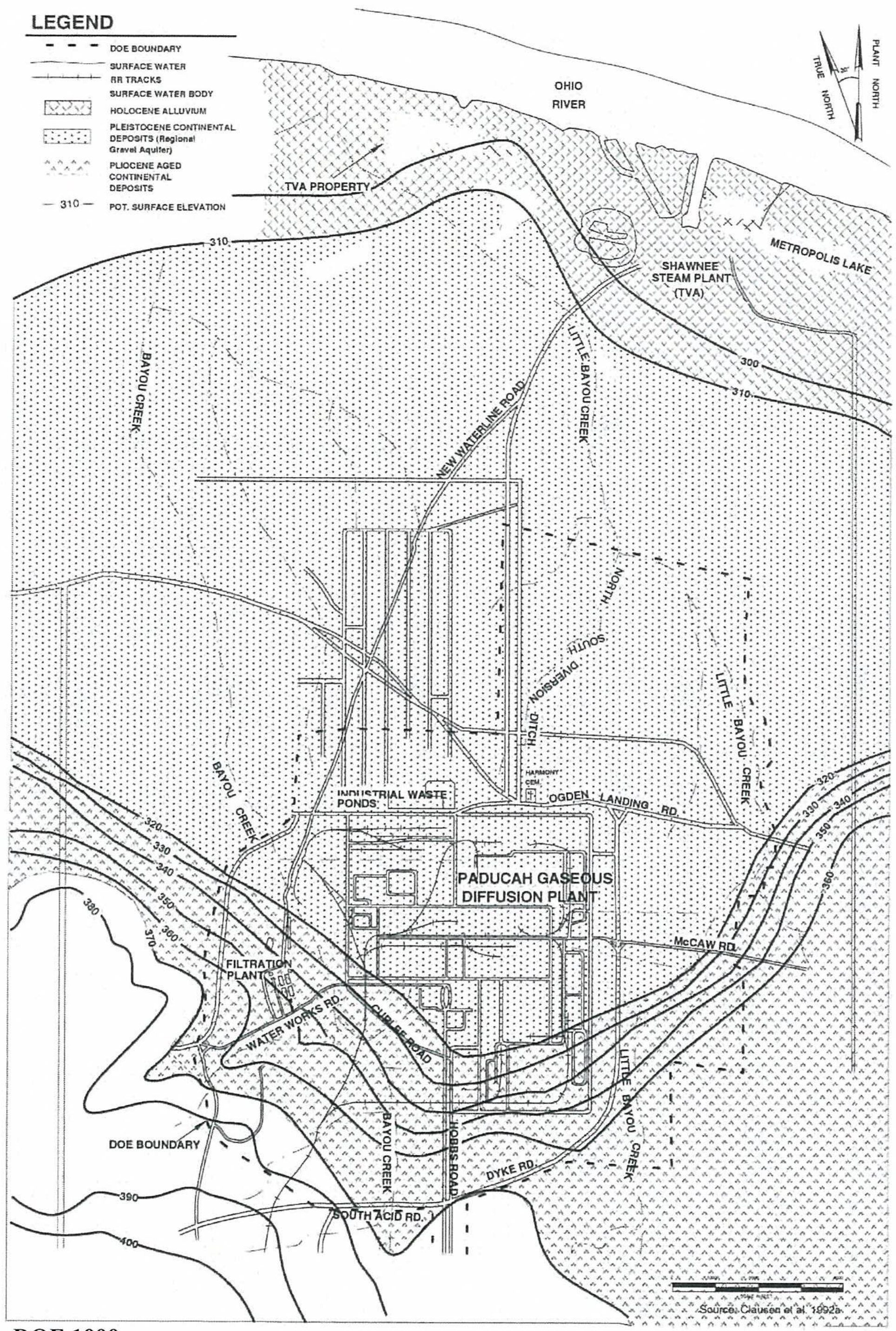

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Figure 4.5. Water Level Elevations and Geologic Components of the Shallow Groundwater Flow Systems in the Vicinity of PGDP

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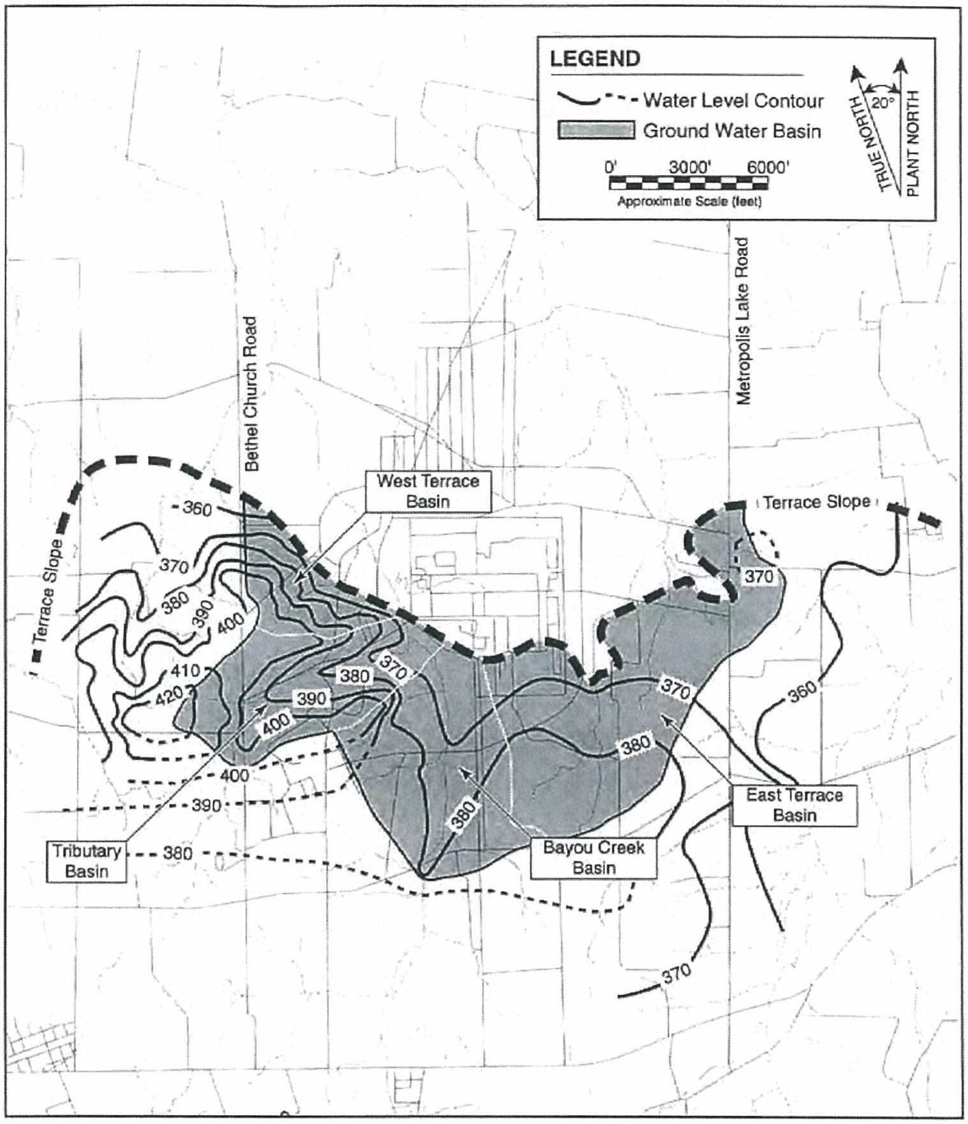

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Figure 4.6. Water Table Contours in the Terrace Deposits South of PGDP

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approximately 6.6 inches/year. Groundwater flow is primarily downward in the Upper Continental Deposits. A plot of elevation of water level versus midpoint of the monitoring well screen for UCRS wells at PGDP (Figure 4.7) demonstrates that steep vertical hydraulic gradients are characteristic of the UCRS (DOE 1997). Figure 4.7 shows similar gradients (represented by the slope of the two lines in the figure) for the two groupings of monitoring wells, although one group (monitoring wells located in the south central portion of the plant) has a lower overall hydraulic head. Vertical hydraulic gradients generally range from 0.5 to 1 ft/ft, as measured in wells completed at different depths in the UCRS. The UCRS is composed of silt, clay, and sand members with a large range of hydraulic conductivity. Overall, the depth-averaged UCRS hydraulic conductivity is approximately 0.005 ft/day.

Beneath PGDP and adjacent land to the north, the water table is found within the UCRS. Water table elevations are best known in the immediate plant vicinity and in the area of PGDP landfills to the north.

Within the west plant area, the elevation of the water table is controlled by the bottom of drainage ditches and the water level in the bordering Bayou Creek. The water table is as shallow as 5 to 10 ft in some localities and less than 20-ft deep throughout the west plant area. Depth to the water table is much greater (as much as 40 ft) in the northeast plant area, where a storm sewer system is present to collect storm runoff. In the northeast plant area, the water table slopes east toward bordering Little Bayou Creek.

At the currently operating C-746-U Landfill, to the north of the PGDP, trends and the elevation of the water table are controlled by water levels in the North-South Diversion Ditch (NSDD) on the south side of the landfill and by water levels in Little Bayou Creek on the east and north sides. The water table slopes northward toward Little Bayou Creek at depths of 20 to 40 ft.

These two settings represent the expected range of water table elevations and depths associated with the UCRS. In general, the water table slopes away from areas of tributaries and higher land surface toward Bayou and Little Bayou Creeks. The depth to the water table is very shallow in the vicinity of tributaries and wetlands found on the highlands and in the vicinity of the creeks.

(3) Regional Gravel Aquifer (RGA). Vertically infiltrating water from the UCRS moves downward into a basal sand member of the Upper Continental Deposits and the Pleistocene gravel member of the Lower Continental Deposits and then laterally north toward the Ohio River. This lateral flow system is called the RGA. The RGA is the shallow aquifer beneath PGDP and contiguous lands to the north.

Hydraulic potential in the RGA declines toward the Ohio River, which controls the base level of the region’s surface water and groundwater systems. The RGA potentiometric surface gradient beneath PGDP is commonly 10^{-4} ft/ft, but increases by an order of magnitude near the Ohio River. Vertical gradients are not well documented, but small, vertical gradients measured at nested wells at the C-404 Burial Ground, for example, range from 0.001 to 0.01 ft/ft, but are not consistently upward or downward (depends somewhat on season and spatial locations relative to areas with more or less recharge).

The hydraulic conductivity of the RGA varies spatially. Pumping tests have documented the hydraulic conductivity of the RGA ranges from 53 ft/day to 5,700 ft/day (LMES 1996). The overall flow in the RGA is northward to the Ohio River, but there are localized northeast and northwest flow regimes in response to anthropogenic recharge and anisotropy of the hydraulic conductivity. Ambient groundwater flow rates in the more permeable pathways of the RGA commonly range from 1 to 3 ft/day.

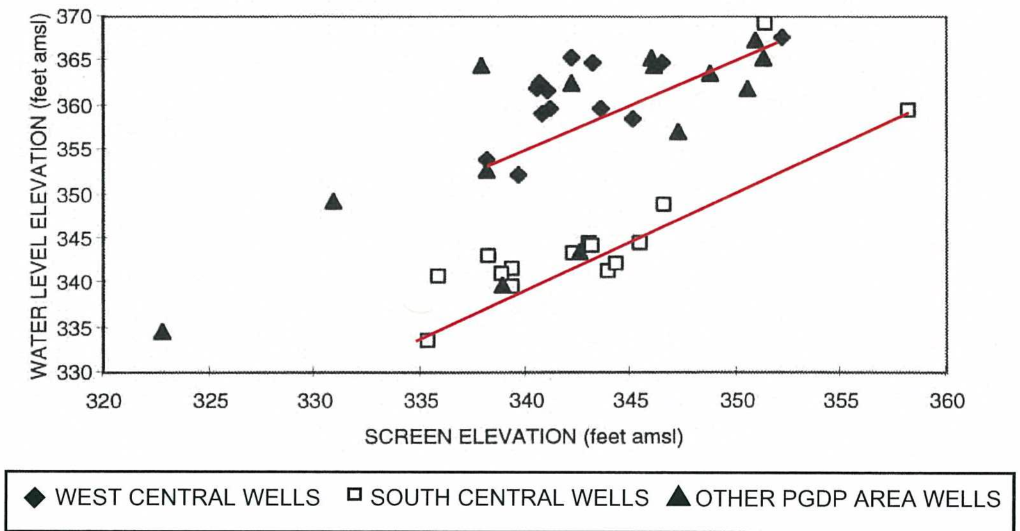

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Figure 4.7. Plot of Water Level Versus Well Screen for Upper Continental Recharge System Wells

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McNairy Flow System. Groundwater flow in the fine sands and silts of the McNairy Formation is called the McNairy Flow System. The overall McNairy groundwater flow direction in the area of PGDP is northward to the Ohio River, similar to that of the RGA. Hydraulic potential is greater in the RGA than in the McNairy Flow System beneath PGDP. Area monitoring well clusters document an average downward vertical gradient of 0.03 ft/ft. Because the RGA has a steeper hydraulic potential slope toward the Ohio River than does the McNairy Flow System, the vertical gradient reverses nearer the Ohio River. The "hinge line," which is where the vertical hydraulic gradient between the RGA and McNairy Flow System changes from a downward vertical gradient to an upward vertical gradient, parallels the Ohio River near the northern DOE property boundary.

The contact between the Lower Continental Deposits and the McNairy Formation is a marked hydraulic properties boundary. Representative lateral and vertical hydraulic conductivities of the upper McNairy Formation in the area of PGDP are approximately 0.02 ft/day and 0.0005 ft/day, respectively. Vertical infiltration of groundwater into the McNairy Formation beneath PGDP is on the order of 0.1 inch per year. (Lateral flow in the McNairy Formation beneath PGDP is on the order of 0.03 inch per year.) As a result, little interchange occurs between the RGA and McNairy Flow System.

4.6.1 Hydrogeologic Settings

The ancestral Tennessee River channel is filled with thick sand and gravel deposits overlain by a sequence of silts and clays. Southward advance of the ancestral Tennessee River during the Pleistocene Epoch eroded away the Porters Creek Clay immediately beneath and north of the PGDP. The presence of the Porters Creek Clay south of PGDP and the absence of the Porters Creek Clay beneath PGDP and to the north define the two distinct hydrogeologic settings.

South Hydrogeologic Setting

South of the PGDP, a shallow water table system is developed in the Pliocene (?) gravels and Eocene sands where they overlie the Porters Creek Clay. Groundwater flow in the shallow water table system discharges as baseflow to Bayou Creek and its tributaries. Groundwater flow in this shallow system also can migrate across the buried terrace as underflow to the UCRS/RGA flow system. South of PGDP a thickening wedge of Eocene sands transmits groundwater flow southward. Vertical groundwater flow is restricted to the sediments above the Porters Creek Clay.

North Hydrogeologic Setting

Beneath the PGDP and north, shallow groundwater flows downward through the silts and clays (UCRS) until it encounters the RGA sand and gravel deposit. Once in the RGA, groundwater flow is generally north, towards the Ohio River. Lateral flow in the RGA dominates this hydrologic regime, with comparatively little groundwater migrating downward into the underlying Cretaceous McNairy Formation. Lateral groundwater flow in the RGA is approximately 1 to 3 ft/day.

4.6.2 Hydrogeologic Units

Five hydrogeologic units (HUs) are commonly used to discuss the shallow groundwater flow system beneath the DOE site and the contiguous lands to the north (Figure 4.8). In descending order, the HUs are these.

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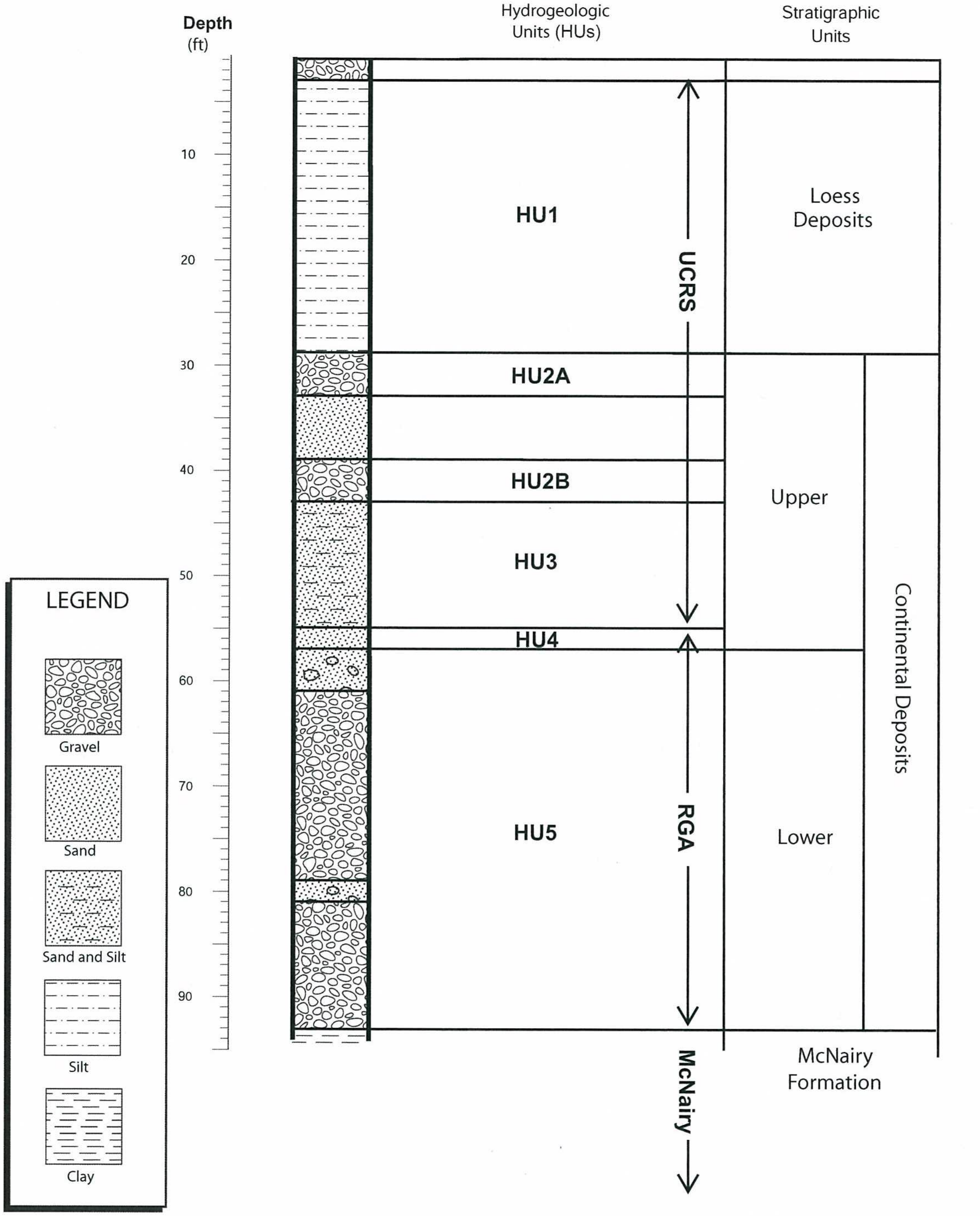

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Figure 4.8. Major Hydrogeologic Units Beneath PGDP

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Upper Continental Deposits

HU 1 (UCRS): Loess that covers most of the site.

HU 2 (UCRS): Discontinuous sand and gravel lenses in a clayey silt matrix.

HU 3 (UCRS): Relatively impermeable unit that acts as the upper semiconfining-to-confining layer for the RGA. The lithologic composition of HU 3 varies from clay to fine sand, but is predominantly silt and clay.

HU 4 (RGA): Near-continuous sand unit with a clayey silt matrix that forms the top of the RGA.

Lower Continental Deposits

HU 5 (RGA): Gravel, sand, and silt.

4.7 SURFACE WATER HYDROLOGY

PGDP is situated 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 Ohio River is located approximately 3.5 miles north of PGDP. It is the most significant surface-water feature in the region, carrying over 25 billion gal/day of water through its banks. Several dams regulate flow in the Ohio River. The Ohio River stage near PGDP is measured at Metropolis, Illinois, by a USGS gauging station. River stage typically varies between 293 and 335 ft amsl over the course of a year. Water levels on the lower Ohio River generally are highest in late winter and early spring and lowest in late spring and early summer. The entire PGDP is above the historical high water floodplain of the Ohio River (CH2M HILL 1991) and above the local 100-year flood elevation of the Ohio River (333 ft).

The plant is situated on the divide between Little Bayou and Bayou Creeks (Figure 4.9). Surface flow is east-northeast toward Little Bayou Creek and west-northwest toward Bayou Creek. Bayou Creek is a perennial stream on the western boundary of the plant that flows generally northward, from approximately 2.5 miles south of the plant site to the Ohio River along a 9 mile course. An 11,910 acre drainage basin supplies Bayou Creek. Little Bayou Creek becomes a perennial stream at the east outfalls of PGDP. The Little Bayou Creek drainage originates within WKWMA and extends northward and joins Bayou Creek near the Ohio River along a 6.5 mile course within a 6,000 acre drainage basin. Drainage areas for both creeks are generally rural; however, they receive surface drainage from numerous swales that drain residential and commercial properties, including PGDP and the TVA Shawnee Steam Plant. The confluence of the two creeks is approximately 3 miles north of the plant site, just upstream of the location at which the combined flow of the creeks discharges into the Ohio River.

The USGS maintains gauging stations on Bayou Creek at 4.1 and 7.3 miles upstream of the Ohio River and a gauging station on Little Bayou Creek at 2.2 miles upstream from its confluence with Bayou Creek. The mean monthly discharges vary from 7.1 to 22 million gal/day on Bayou Creek and from 1.3 to 7.1 million gal/day on Little Bayou Creek.

Most of the flow within Bayou and Little Bayou Creeks is from process effluents or surface water runoff from PGDP. The upper reach of Little Bayou Creek flows as a perennial stream as a result of plant

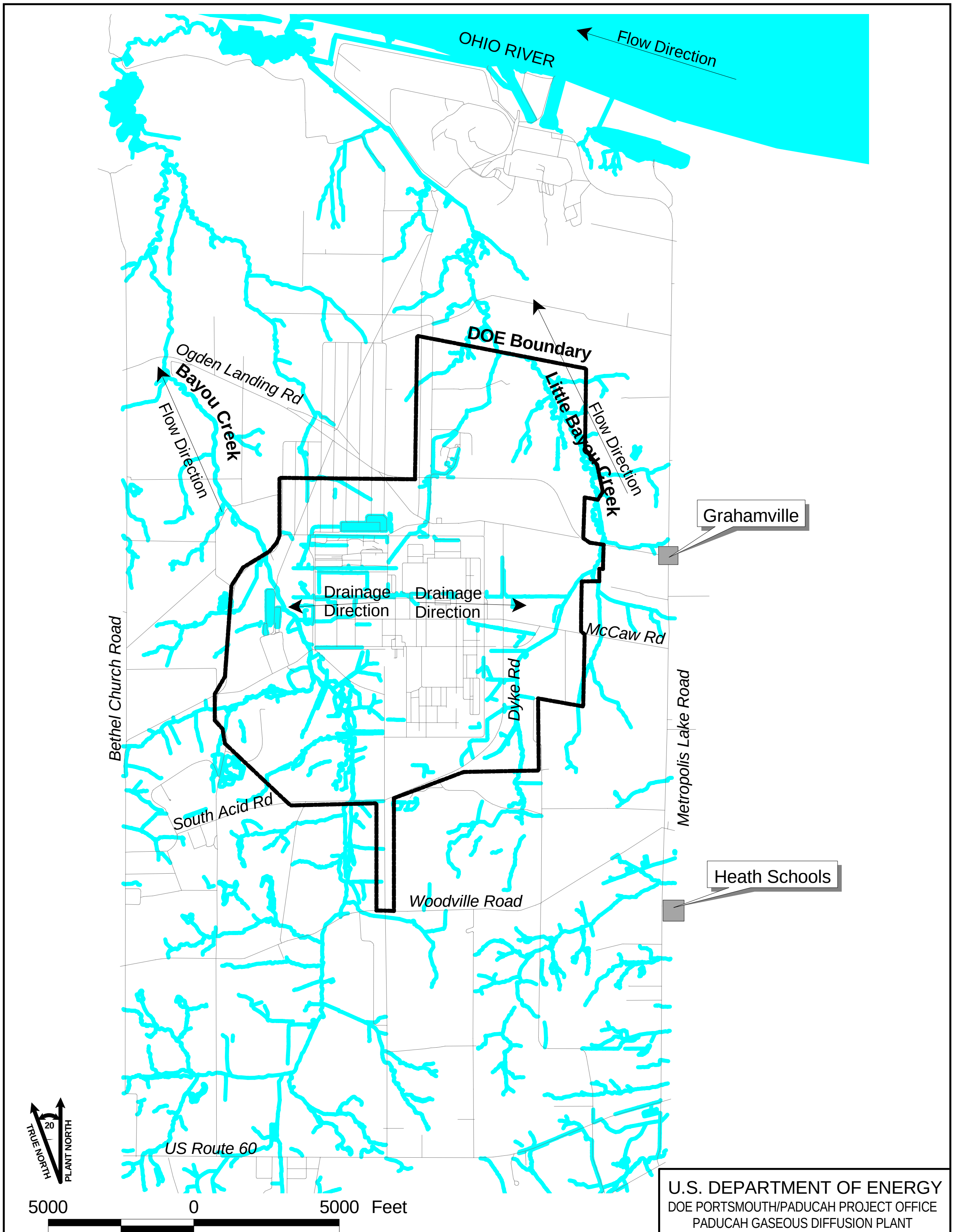

Figure 4.9. Surface Water Features in Vicinity of DOE Site

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discharges. A network of ditches discharges effluent and surface water runoff from PGDP to the creeks. Plant discharges are monitored at the Kentucky Pollutant Discharge Elimination System outfalls prior to discharge into the creeks.

Other surface water bodies in the vicinity of PGDP include the following: Metropolis Lake, located east of the Shawnee Steam Plant; several small ponds, clay and gravel pits, and settling basins scattered throughout the area; and a marshy area just south of the confluence of Bayou Creek and Little Bayou Creek. The smaller surface water bodies are expected to have only localized effects on the regional groundwater flow pattern.

4.8 ECOLOGICAL SETTING

The following sections give a brief overview of the terrestrial and aquatic systems at PGDP. A more detailed description, including identification and discussion of sensitive habitats and threatened/endangered species, is contained in the *Investigation of Sensitive Ecological Resources Inside the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (CDM Federal 1994) and *Environmental Investigations at the Paducah Gaseous Diffusion Plant and Surrounding Area, McCracken County, Kentucky, Volume V: Floodplain Investigation, Part A: Field Results of Survey* (COE 1994).

4.8.1 Terrestrial Systems

The terrestrial component of the PGDP ecosystem includes the plants and animals that use the upland habitats for food, reproduction, and protection. The upland vegetative communities consist primarily of grassland, forest, and thicket habitats with agricultural areas. The main crops grown in the PGDP area include soybeans, corn, tobacco, and sorghum.

DOE mows much of the grassland habitat adjacent to the plant. The Kentucky Department of Fish and Wildlife Resources manages a large percentage of the adjacent WKWMA to promote native prairie vegetation by burning, mowing, and various other techniques.

Dominant overstory species of the forested areas include oaks, hickories, maples, elms, and sweetgum. Understory species include snowberry, poison ivy, trumpet creeper, Virginia creeper, and Solomon's seal. Thicket areas consist predominantly of maples, black locust, sumac, persimmon, and forest species in the sapling stage with herbaceous ground cover similar to that of the forest understory.

Wildlife commonly found in the PGDP area consists of species indigenous to open grassland, thicket, and forest habitats. Small mammal surveys conducted on WKWMA documented the presence of southern short-tailed shrew, prairie vole, house mouse, rice rat, and deer mouse (KSNPC 1991). Large mammals commonly present in the area include coyote, eastern cottontail, opossum, groundhog, whitetail deer, raccoon, and gray squirrel. Mist netting activities in the area have captured red bats, little brown bats, Indiana bats, northern long-eared bats, evening bats, and eastern pipistrelles (KSNPC 1991).

Typical birds of the area include European starling, cardinal, red-winged blackbird, mourning dove, bobwhite quail, turkey, killdeer, American robin, eastern meadowlark, eastern bluebird, bluejay, red-tail hawk, and great horned owl.

Examples of a few amphibians and reptiles present include the cricket frog, Fowler's toad, common snapping turtle, green tree frog, chorus frog, southern leopard frog, eastern fence lizard, and red-eared slider (KSNPC 1991).

4.8.2 Aquatic Systems

The aquatic communities in and around the PGDP area that could be impacted by plant discharges include two perennial streams [Bayou Creek (named in older documents as Big Bayou Creek) and Little Bayou Creek], the NSDD, a marsh located at the confluence of Bayou Creek and Little Bayou Creek, and other smaller drainage areas. The dominant taxa in all surface waters includes several species of sunfish, especially bluegill and green sunfish, as well as bass and catfish. Shallow streams, characteristic of the two main area creeks, are dominated by bluegill, green and longear sunfish, and stonerollers.

4.8.3 Wetlands and Floodplains

A study of the PGDP area by the U.S. Army Corps of Engineers (COE) groups the area wetlands (COE 1994) into 16 vegetative cover types encompassing forested, scrub/shrub, and emergent wetlands. Wetland vegetation consists of species, such as sedges, rushes, spikerushes, and various other grasses and forbs in the emergent portions; red maple, sweet gum, oaks, and hickories in the forested portions; and black willow and various other saplings of forested species in the thicket portions. Wetlands inside the plant security fence are confined to portions of drainage ditches traversing the site (CDM 1994).

At PGDP, the Ohio River, Bayou Creek, and Little Bayou Creek cause local area flooding during precipitation events. A floodplain analysis performed by the COE (1994) found that much of the built-up portions of the plant lie outside the 100- and 500-year floodplains of the Ohio River and these creeks. In addition, the COE 1994 analysis determined that ditches within the plant area can contain the expected 100- and 500-year discharges. It should be noted that precipitation frequency estimates for the 100- and 500-year events were updated in 2004 in the National Oceanic and Atmospheric Administration's (NOAA) Atlas 14 (NOAA 2004). In the updated report, the mean precipitation estimate for the 100-year, 24-hour event in Atlas 14 for the Paducah area is 10.1% to 15% greater than the mean estimate in previous publications. As stated in Atlas 14, in many cases, the mean precipitation estimate used previously still is within the confidence limits provided in Atlas 14; therefore, it is assumed the plant ditches will still contain the 100- and 500-year discharges.

4.9 CLIMATOLOGY

PGDP's climate is humid-continental. The term "humid" refers to the surplus of precipitation versus evapotranspiration that normally is experienced throughout the year. The average monthly precipitation is 4.00 inches, varying from an average of 2.73 inches in August (the monthly average low) to an average of 4.58 inches in April (the monthly average high). The total precipitation for 2007 was 43.33 inches, compared to the normal of 49.24 inches.

The "continental" nature of the local climate refers to the dominating influence of the North American landmass. Continental climates typically experience large temperature changes between seasons. The mean annual temperature for the Paducah area for 2007 was 57.1 °F. The average monthly temperature is 58.0°F, with the coldest month being January with an average temperature of 35.1 °F and the warmest month being July with an average temperature of 79.2 °F.

The prevailing wind speed is from the south-southwest at approximately 10 miles per hour. Historically, stronger winds are recorded when the winds are from the southwest.

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5. EXISTING INFORMATION

This chapter provides a summary of existing, readily available information that will be assimilated during the RI for use in the FS to support the analysis of the alternatives.

5.1 WASTE VOLUME FORECAST

To support the long-term planning process associated with implementation of the FFA, DOE has a life cycle baseline (LCB) that serves as the strategic road map for completing site remediation and provides project level milestones. Much of the waste inventory associated with future CERCLA actions was developed based on information contained in the PGDP LCB. The LCB provides information on planned ER projects at PGDP from 2010 to 2019. Each project has an associated waste volume forecast in the LCB. The waste forecasts in the LCB are based on the best information available at the time. Some of the projects (i.e., OUs, SWMUs, and AOCs) have not been fully characterized, and process knowledge was used to estimate the volume of waste to be generated.

The LCB does not contain PGDP D&D waste volumes; therefore, an estimate of the waste volume to be generated during D&D was prepared by a separate team (U.S. Army Corps of Engineers–Huntington District; Project Time & Cost, Inc.; TLG Services, Inc.; Project Enhancement Corporation) (DOE 2006). The PGDP D&D OU includes a total of 532 structures. These structures include 419 facilities consisting of industrial and nonindustrial facilities of various construction types; 26 above grade tanks; 72 infrastructure items such as concrete pads and gravel pads; 11 general utility items such as lift stations; and four switchyards. Volume estimates were derived by multiplying the gross square footage of each facility by a conversion factor. The conversion factors were based on the results of similar D&D projects in the Oak Ridge and the Portsmouth complexes; additionally, facility height and the density of equipment and infrastructure within the facility were incorporated as components of the conversion factor. The D&D waste is scheduled to be generated from 2019 to 2039.

CERCLA waste will be generated from various source areas at PGDP (SWMUs and AOCs) and are combined into five OUs. As discussed in Chapter 1, these five OUs are the SWOU, SOU, BGOU, GWOU, and D&D OU. Combining the OUs and associated projects found in the LCB (and including D&D as one project) resulted in identifying 22 discrete projects (source areas) that will generate waste at PGDP. As noted in Table 5.1, some projects are not being conducted through a CERCLA action and/or are projected to be completed prior to 2014. The waste from those projects has not been included in the waste volume for this CERCLA waste disposal alternatives evaluation. The waste forecasts will aid in developing the waste disposal alternatives by providing the following:

- Source areas
- Waste (physical form)
- Waste types (regulatory classification)
- Waste generation schedule

Table 5.1. Projected Waste-Generating Activities and Corresponding WBS Descriptions as Outlined in the LCB

Activity Title	WBS Element Description
BGOU	Burial Grounds Operable Unit
Classified Soils	Classified Soils*
D&D—C-340	D&D Operable Unit–C-340
D&D—C-410	D&D Operable Unit–C-410
D&D—Inactive Facilities	D&D Operable Unit–Inactive Facilities (Complete 2009)[a]
DMSA	DMSA* (Complete 2009)[a]
Environmental Monitoring	Environmental Monitoring*
GWOU—C-400	Groundwater Operable Unit–C-400
GWOU—Dissolved-Phase	Groundwater Operable Unit–Dissolved-Phase Plume
GWOU—Off-site Plume	Groundwater Operable Unit–Groundwater Off-site Plume
GWOU—Pump-and-Treat	Groundwater Operable Unit–Pump-and-Treat Operations
GWOU—SW Plume	Groundwater Operable Unit–Southwest Plume
Legacy Waste	Legacy Waste* (Complete 2009)[a]
Newly Generated Waste	Newly Generated Waste*
PCB Waste	PCB Activities*
Scrap Metal	Scrap Metal (Completed 2007)[b]
Soils OU	Soils Operable Unit
Soils OU—Remedial Action	Soils Operable Unit–Remedial Action
Soils OU—Removal Action	Soils Operable Unit–Removal Action
SWOU—On-site	Surface Water Operable Unit On-site (Complete 2009)[a]
SWOU—Off-site	Surface Water Operable Unit Off-site
PGDP D&D	D&D of PGDP facilities and Soil Remediation during D&D

*These projects are not conducted through a CERCLA action, but are shown because it is a project found in the LCB. Wastes generated from these projects are not included in the total waste volume.
[a]Completion date is based on the LCB validated in January 2008. The waste volume is not included in the waste forecast since it currently is scheduled to be complete prior to 2010.
[b]This project is complete; waste volumes are not included in the waste forecast.

BGOU = Burial Grounds Operable Unit
DMSA = DOE Material Storage Area
OU = operable unit
SWOU = Surface Water Operable Unit
D&D = decontamination and decommissioning
GWOU = Groundwater Operable Unit
PCB = polychlorinated biphenyl
WBS = Work Breakdown Structure

5.1.1 Schedule of Waste Generation

The following provides the waste generation schedule based on CERCLA response action waste forecasts from the LCB and D&D estimates (DOE 2006):

- ER and inactive facility D&D wastes (2010-2019) 573,000 yd^3
- Future PGDP D&D waste (2019-final completion) 2,463,000 yd^3
- Soil remediation during D&D (2019-final completion) 683,000 yd^3
- Total waste volume (2010-final completion) 3,719,000 yd^3

The waste volumes that were found in either the LCB waste forecast or the D&D estimates were placed into one of six categories of waste:

- Asbestos
- Concrete
- General construction debris
- Other dry solids
- Scrap metal
- Soil

The category, "other dry solids" includes items such as personal protective equipment, plastic, and packing material. "Soil" includes dewatered sediment and sludge.

The waste also was characterized by type. Waste type refers to the regulatory classification of the waste. The classifications of CERCLA waste types are LLW, hazardous waste, TSCA waste, MLLW, and TSCA/LLW. In addition, nonhazardous solid wastes will be generated during CERCLA activities. Nonhazardous solid wastes, as defined here by RCRA Subtitle D, are wastes that meet the current WAC of the C-746-U Landfill (PRS 2008). Waste types such as high-level, transuranic, byproduct, and spent nuclear fuel are not in the 3.7 mcy of forecasted CERCLA waste and are not anticipated to be generated. These waste types, if generated during cleanup, would be required to be disposed of off-site since regulations prescribe disposal in special repositories. Additionally, all waste disposal facilities considered in the RI/FS evaluation can accept only wastes that meet their WAC.

5.1.2 Waste Volume Scenarios

Table 5.2 provides details of the waste and waste types that are forecasted to be generated. The waste forecast data presented in Table 5.2 were developed based on the best available information at the time. These forecasts will serve as the base case estimates for the waste volumes to be evaluated in the RI/FS (LCB and DOE 2006). As new information becomes available (e.g., from RIs conducted at the OUs), the waste forecast will change. As such, the waste data contains some uncertainty or variability in confidence limits, and the precision of the significant figures presented in Table 5.2 is based on the current forecasted estimates for the purpose of establishing a waste volume for each waste type.

Table 5.2. Base Case Estimated Volume by Waste and Waste Type

Waste	LLW (yd^3)	LLW/ RCRA (yd^3)	LLW/ RCRA/ TSCA (yd^3)	LLW/ TSCA (yd^3)	RCRA (yd^3)	TSCA (yd^3)	Nonhazardous Solid Waste (yd^3)	Total (yd^3)
Asbestos	3,700	0	24,800	0	0	4,000	1,000	33,500
Concrete	377,400	800	0	0	0	0	393,300	771,500
General Construction Debris	425,800	2,900	0	0	0	2,900	235,400	667,000
Other Dry Solids	46,000	100	5,300	200	500	700	4,200	57,000
Scrap Metal	407,800	200	0	0	0	3,700	68,800	480,500
Soil	1,286,300	29,100	0	0	16,100	1,700	376,300	1,709,500
Total	**2,547,000**	**33,100**	**30,100**	**200**	**16,600**	**13,000**	**1,079,000**	**3,719,000**

Rounded to the nearest hundreds
LLW = low-level waste
RCRA = Resource Conservation and Recovery Act
TSCA = Toxic Substances Control Act

The waste volumes shown in Table 5.2 do not include the following:

- Non-CERCLA waste [e.g., legacy waste, DOE Material Storage Area (DMSA)];
- Liquid waste; and
- Waste types prohibited by regulations for near surface disposal (e.g., transuranic wastes).

The following general assumptions were used to develop the base case waste volume and characteristic projections.

- The WAC for the C-746-U Landfill will not change substantially through final site cleanup.

- Postgeneration processes to stabilize waste will not significantly change volume or analytical character (i.e., as-generated waste volumes and contaminant profiles are equivalent to as-disposed waste volumes and contaminant profiles).

- Soil will swell by a factor of 25% (average) upon excavation; therefore, calculations that were made to arrive at a postexcavation volume include a 25% (average) swell factor.

- All buildings and facilities will undergo D&D and will not be reused in any reindustrialization program.

- Approximately 5% of generated waste will be classified from a security prospective.
- Material generated as waste will not be recycled.
- Waste generation schedules assume that D&D of the existing buildings and facilities will begin in 2019.

5.1.3 Analytical Profile

The volume of each regulatory classification of waste is estimated as shown in Table 5.2; however, a quantification of contaminants will be needed to determine the effectiveness of the On-Site Alternative. There is a substantial analytical data set available in the Paducah Data Warehouse and GIS database that will provide contaminant concentrations associated with the waste forecast. In addition to this analytical data, profiles that have been prepared to support recent and ongoing PGDP waste disposal operations are available. These profiles contain characterization data and other relevant information for wastes that have been or currently are being dispositioned. Available profiles include nonhazardous solid waste disposed in the C-746-U Landfill and off-site disposal of hazardous/LLW [e.g., Energy*Solutions*, Nevada Test Site (NTS)]. Appendix D presents details of how the analytical profiles will be developed.

Contaminant profiles of appropriate wastes that have been disposed of in the EMWMF are available and will be used to develop contaminant profiles primarily for D&D OU waste because of the design and process similarities between PGDP and the Oak Ridge Gaseous Diffusion Plant (the K-25 or East Tennessee Technology Park site). These similarities will result in similar radiological and chemical contaminants.

5.2 CURRENT DISPOSAL PRACTICES

This section provides a summary of the current waste disposal practices at PGDP. All waste generated from CERCLA response actions conducted at PGDP is packaged and transported to licensed off-site waste disposal facilities, with the exception of nonhazardous solid waste. Nonhazardous solid waste generated on the PGDP is disposed of at the C-746-U Landfill.

The *Waste Management Plan for the Paducah Environmental Remediation Project, Paducah, Kentucky,* PAD-PLA-ENV-001/R1, outlines sitewide decisions and guidance in the areas of waste generation planning such as sorting, segregating, pollution prevention (reduction, reuse, recycling, and disposal), and waste packaging requirements. This document provides guidance on waste characterization strategy for general and specific waste types; it also includes a waste disposition strategy that currently is utilized to conform to the existing disposal options that are available.

The wastes are packaged and transported according to applicable federal, state and/or local hazardous material, and radioactive material regulations. There are specific requirements for manifesting, packaging, labeling, marking, placarding, recordkeeping, and reporting.

5.2.1 Waste Disposal Facilities

Facilities currently utilized to dispose of waste similar to that in the waste forecast include off-site DOE and commercial facilities and the on-site C-746-U Landfill.

Off-site waste disposal facilities that currently are utilized include existing DOE and commercial facilities that are licensed or permitted to accept CERCLA wastes including LLW, hazardous, TSCA, MLLW, and TSCA/LLW waste types. Table 5.3 provides a list of treatment, storage, and disposal facilities (TSDFs) that are presently used as off-site waste disposal facilities. The table provides criteria for each facility such as treatment and disposal capabilities by waste type, rail access, and approval by the DOE Consolidated Audit Program (CAP) and/or the current LATA Environmental Services of Kentucky, LLC, (LATA Kentucky) approved vendors list. Each vendor must be audited/evaluated in accordance with 10 *CFR* § 830.120, *Quality Assurance,* and DOE O 414.1C, *Quality Assurance*. Wastes are required to be profiled by the waste generator to ensure that the wastes meet the WAC of the disposal facility.

The C-746-U Landfill is a currently operating RCRA Subtitle D landfill at PGDP that is permitted to accept nonhazardous solid waste. The landfill is located on DOE-owned property one mile north of PGDP on 59.7 acres of land and has a disposal capacity of approximately 1.5 mcy. Waste that the landfill can accept is defined in the permit (Solid Waste Permit #073-00045) and includes construction and demolition wastes, commercial waste, and industrial waste. These wastes include soils, wood, concrete, roofing and similar construction debris, and other nonhazardous solid and industrial wastes. The landfill is not permitted for disposal of RCRA Subtitle C- or certain TSCA- regulated hazardous wastes. Wastes that contain residual levels of radioactivity can be disposed of in the C-746-U Landfill if they are within Authorized Limits that were developed in accordance with guidance provided in DOE Order 5400.5, *Radiation Protection of the Public and Environment*. The site-specific criteria that have been developed to ensure that the wastes accepted at the C-746-U Landfill are in compliance with state, federal, and departmental criteria are found in the *Waste Acceptance Criteria for the Treatment, Storage, and Disposal Facilities at the Paducah U.S. Department of Energy Site* (PRS 2008). That document provides the requirements, terms, and conditions under which waste will be accepted at the C-746-U Landfill.

5.2.2 Waste Packaging

Several types of containers are used at PGDP when preparing waste for off-site disposal. The container used is primarily dependant on the waste category. Containers either are purchased or rented and are disposed of with the waste or decontaminated and reused. Additionally, the type of container used also determines the type of equipment that is needed with respect to moving and loading onto the transport vehicle.

Small Containers. Small containers that are used include lab packs, B-12 and B-25 boxes, drums, and overpacks. These containers are designed to contain various kinds of wastes (e.g., debris, solid, liquid, sludge, granular) and types (e.g., LLW, RCRA-corrosive) and are applicable to certain specific candidate waste. Small containers typically are disposed of with the waste rather than emptied and reused.

Large Containers. Large containers include Sealand containers, intermodal containers, and other container types with various weight and volume capacities, loading capabilities (top-, side-, or end loaded), and handling characteristics. Movement and loading of these containers are accomplished by forklift or crane, and some are winched directly onto a truck bed. A variety of wastes and waste types can be loaded into the containers, and large containers are usually decontaminated and reused. Dedicated containers are reused for similar wastes and require only external decontamination.

Bulk Containers. Bulk containers are single-use containers that can be disposed of with the waste. A Supersack, a large reinforced bag, is an example of a disposable bulk waste package primarily for soil-like waste. Other bulk containers that are more commonly utilized are Gondola rail cars, which are

Table 5.3. Current Off-site Disposal Facilities used at PGDP

TSDF Vendors & Capabilities						
	Waste Types & Services					
TSDF (Vendor)	**Hazardous Waste**	**LLW**	**MLLW (RCRA & TSCA)**	**Rail Access**	**DOE CAP Approved**	**PRS Approved Vendors List**
Energy*Solutions* (Bear Creek) Oak Ridge, TN http://www.energysolutions.com http://www.energysolutions.com/Process/process.php	N/A	* LLW Processing - D.A.W. - Asbestos - Bulk & Specialty metals - Wood, Resin - Liquids, Oils, Sludge - Sharps & Bio waste	N/A	Yes	Yes	Yes
Energy*Solutions* (Utah) Clive, UT http://www.energysolutions.com http://www.energysolutions.com/Disposal/clive.php Note: Can accept waste from all but the Northwest compact states	N/A	* LLW Disposal (Bulk & Non-Bulk) - Class A	* MLLW Treatment - Amalgamation - Macroencapsulation - Oxidation/Reduction - Stabilization - Treatability Studies - Vacuum Thermal Desorption * Direct Disposal of TSCA Remediation Waste & PCB Articles	Yes	Yes	Yes
Nevada Test Site (NTS) Mercury, NV http://www.nv.doe.gov/nts	N/A	* LLW Disposal - Class A, B, and C - D.A.W. - Asbestos - Debris - Soils - Classified Waste	Only if previously accepted waste profile at present.	No	N/A	N/A
Permafix Oak Ridge, TN (M&EC) Gainesville, FL http://www.perma-fix.com	* Fuels blending for organic liquids * Neutralization of inorganic liquids * Processing of organic & inorganic contaminated solids & soils * Transfer facility for reactives * PCB storage	N/A	* Perma-Fix I System - Stabilization/Solidification - Chemical Extraction & Fixation - Metals Precipitation - Neutralization - Debris Treatment * Perma-Fix II System - Separation - Destruction * PCB Treatment * Mercury Treatment * Wastewater Treatment * Vacuum Thermal Desorption	Oak Ridge No Gainesville Yes	Yes	No (Doesn't need to be if on DOE CAP)
Waste Control Specialists Andrews, TX http://www.wcstexas.com	* Storage, Processing, and Disposal - Industrial Solid Waste - Hazardous Waste (RCRA & TSCA) * RCRA, CERCLA, and TSCA - Treatment/stabilization * LDR compliant disposal	* LLW Storage * LLW Disposal - Exempt Radioactive waste * License pending for LLW Disposal - Federally generated LLW (Class A, B, and C)	* MLLW Treatment & Storage - Special Nuclear Material limited by concentration, not total SNM grams - RCRA, CERCLA, and TSCA Treatment/stabilization * License pending for MLLW Disposal - Federally generated MLLW (Class A, B, and C)	Yes	Yes	No (Doesn't need to be if on DOE CAP)

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act; D.A.W. = Dry Active Waste; DOE CAP = DOE Consolidated Audit Program; LDR = Land disposal restriction; LLW = low-level waste; MLLW = mixed low-level waste; N/A = Not Applicable; PCB = polychlorinated biphenyl; PRS = Paducah Remediation Services, LLC.; RCRA = Resource Conservation and Recovery Act; SNM = Special Nuclear Material; TSCA = Toxic Substances Control Act; TSDF = Treatment, storage, and disposal facility reusable and are used for soil and/or debris. Gondolas are rented either from the railroad or from the disposal facility.

5.2.3 Waste Transportation

The primary modes of transportation for shipping the waste from PGDP to off-site disposal facilities are truck and train. Some facilities that are utilized, such as NTS, do not have rail access and, therefore, cannot receive waste by train.

Truck. Truck transport is applicable to both local and long-distance waste transport. Trucks can transport bulk wastes either in containers or in closed beds that provide adequate containment. Additional considerations include DOE approval of the trucking companies via the DOE CAP, and the requirement for truck drivers to have a current Commercial Driver's License with a U.S. Department of Transportation Hazardous Materials (HAZMAT) endorsement. All off-site disposal facilities that currently are used, as well as the C-746-U Landfill, are configured to receive waste directly via truck.

Train. Rail transport is used only for long-distance waste transport. Railcars are loaded directly at PGDP with containerized waste or bulk waste. Currently, Energy*Solutions* in Clive, Utah, is the only TSDF configured to receive bulk rail shipments. Shipment to other off-site disposal facilities would require either transfer of the waste from railcars to trucks for the last leg of the trip or construction of a rail spur from the nearest rail line to the disposal facility. Rail contracts must be approved by the DOE Contracting Officer.

5.2.4 Waste Preparation, Segregation, and Treatment

The projects generating the waste are responsible for removing waste during cleanup actions; waste characterization and certification; waste segregation, compaction, or shredding; treatment and transport to treatment facilities, as necessary; and loading the waste into containers. These activities are applicable and assumed to be identical for the No Action, Off-Site and On-Site Alternatives and, therefore, are outside the scope of the RI/FS. These activities will be addressed by the OU-specific decision documentation.

5.3 DISPOSAL DECISIONS AT OTHER DOE SITES

This section provides a brief overview of waste disposal decisions at some other selected DOE sites. DOE has several other sites that have generated LLW, hazardous, TSCA, and MLLW waste types during their environmental cleanup and closure actions. These sites have conducted evaluations of waste disposal alternatives. The process used and documents developed from these other DOE sites can provide reference material for evaluating waste disposal alternatives at PGDP.

5.3.1 Oak Ridge

From 1996 to 1999, DOE evaluated disposal alternatives for the waste forecasted to be generated by CERCLA cleanup of the Oak Ridge Reservation (ORR). The disposal evaluation was performed using the CERCLA process and included development of an RI/FS, a Proposed Plan, and a ROD. The following provides a chronology of the documents that were developed leading up to the ROD as well as key post-ROD documents.

To support development of an On-Site Alternative, a siting study (DOE 1996a) was prepared to identify and evaluate candidate sites. The screening of those sites included comparing them to state and federal siting regulations and site specific considerations. The result of this study identified three candidate sites to include for the On-Site Alternative in the RI/FS report.

A preliminary field characterization study was conducted to provide comparable data from each of the final candidate sites. Data collected during this study included hydrologic, chemical, and geotechnical soil properties and groundwater data from installation of temporary monitoring wells.

Following those preliminary activities, the RI/FS report (DOE 1998a) was prepared and evaluated three disposal alternatives:

(1) No action—an ORR sitewide strategy or infrastructure for coordinated waste disposal would not be implemented;

(2) Disposal of forecasted wastes in an on-site ORR disposal facility—construction and operation of a mixed waste disposal facility on the ORR; and

(3) Disposal of forecasted wastes at off-site disposal facilities—a coordinated, sitewide strategy, primarily involving transporting wastes to licensed or permitted off-site disposal facilities and disposal of waste in those facilities.

Due to uncertainties in the waste forecasts, low-end and high-end waste volumes were developed in the RI/FS based on differing ORR remediation scenarios. Nonhazardous solid waste would be disposed in the same manner for either the Off-Site or On-Site Alternative; therefore, the associated volume was not included in the waste forecast.

The On-Site Alternative in the RI/FS included three potential sites and conceptual designs, but did not select the site. The conceptual design was developed based on the high-end waste volume scenario and a site plan was prepared for each of the three sites. Utilizing the conceptual design, a preliminary WAC was prepared for each site as a method to estimate the waste volume that could be accepted at an on-site disposal facility.

The final RI/FS was transmitted to the regulators for approval in January 1998. Comments were received on the assumptions for the performance modeling assessment (location and exposure scenarios for the hypothetical receptor) in the final RI/FS and resulted in the preparation of an RI/FS Addendum. The RI/FS Addendum (DOE 1998b) was issued in September 1998 and addressed the modeling comments by revising the performance modeling with the new receptor assumptions.

Following the RI/FS addendum, a pre-design characterization study (BJC 1999) was conducted for site-specific soil properties; chemical and radionuclide analysis of soil, sediment, surface water, and groundwater; installation of temporary wells; aquifer tests; and acquisition of geotechnical soil data.

The Proposed Plan (DOE 1999b) was issued in 1999 and presented on-site disposal as the preferred alternative and included a comparative analysis of the three candidate sites. It also contained a composite analysis and an assessment of all sources of radioactive contamination in the same watershed as the on-site disposal facility to satisfy a requirement in DOE Order 5820.2A *Radioactive Waste Management* (now DOE Order 435.1). Comments were received from the public followed by regulatory approval of the Proposed Plan. The ROD (DOE 1999c) was issued and signed in late 1999 and identified the selected alternative as on-site disposal at the East Bear Creek Valley site. The on-site facility described in the ROD would be known as the EMWMF.

Post-ROD documents were prepared and included a final design (WMFS 2000a) to configure and orient the conceptual design to the selected site. A performance assessment (WMFS 2000b) was prepared to incorporate the design innovations and the results from the pre-design characterization study into the modeling. The final WAC (DOE 2001a) was prepared to accommodate the final design and performance assessment results. The final WAC included development of the process to accept waste and also established four sets of control requirements that include administrative, analytic, auditable safety analysis-derived, and physical WAC components. In May 2001, an Explanation of Significant Difference (DOE 2001b) was issued to announce a change from the ROD (DOE 1999c) to allow the EMWMF to receive classified wastes.

Construction of the EMWMF began in April 2001 by constructing two of four cells for the 1.3 mcy disposal facility. Operations began in May 2002, and during the first year, EMWMF accepted 100,000 yd^3 of waste. Figure 5.1 shows the current layout of the EMWMF and Figure 5.2 shows the location of the EMWMF at the ORR.

5.3.2 Other DOE Sites

DOE has conducted waste disposal evaluations following the CERCLA process at several other sites. The following sections provide a brief summary of waste disposal evaluations at other DOE sites that have resulted in an approved ROD identifying either an Off-Site or On-Site Alternative as the selected remedial action.

5.3.2.1 On-Site Decisions

DOE's CERCLA waste disposal evaluations of various alternatives have resulted in selecting construction of on-site waste disposal facilities as the preferred alternative at the following sites:

- Fernald (Ohio)
- Hanford (Washington)
- Idaho National Laboratory (Idaho)
- Weldon Spring (Missouri)

These CERCLA disposal facilities accept only clean-up waste generated at the site at which it is located. No off-site waste from other DOE sites has been accepted at these disposal facilities. Each CERCLA disposal facility was approved, designed, constructed, and operated in collaboration with federal and state regulators and sized to be responsive to cleanup needs.

Each of the CERCLA disposal facilities was approved through a ROD that required protectiveness of human health and the environment and attainment of action-specific, contaminant-specific, and site-specific ARARs. While each CERCLA disposal facility has unique features, generally, design criteria are consistent and each facility had to demonstrate compliance with the same set of federal design criteria for LLW and hazardous waste disposal. The cover design and the liner design of each facility are nearly the same. Table 5.4 summarizes the CERCLA disposal facilities discussed in this section. The process used at ORR, as well as at these other DOE sites, will contribute to developing the On-Site Alternative for PGDP.

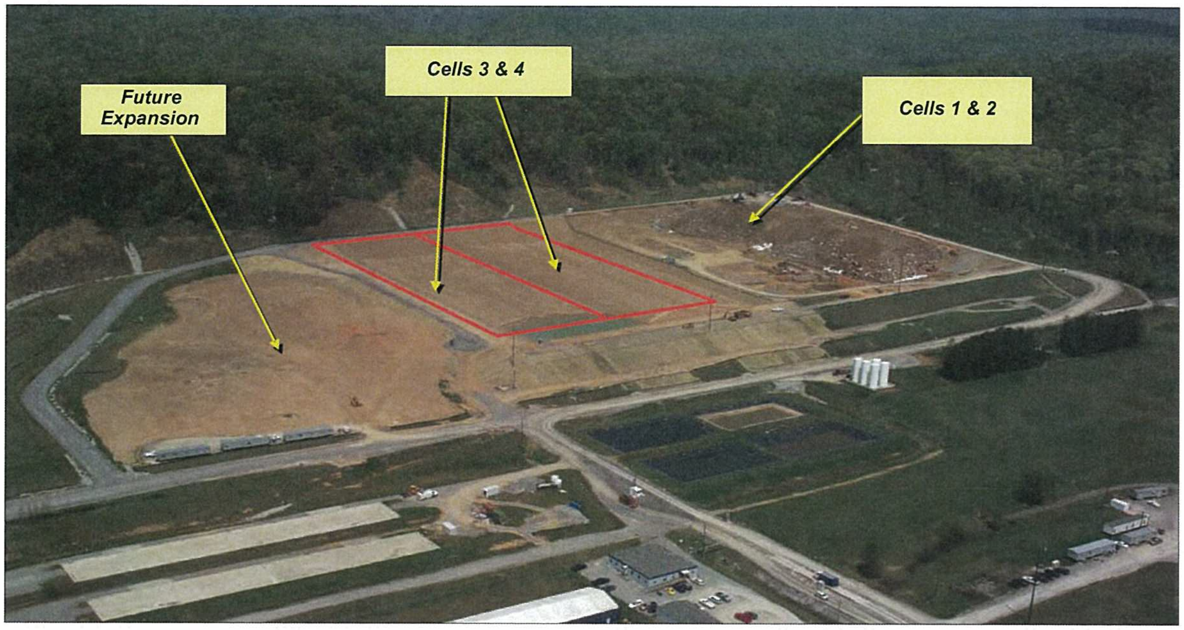

Figure 5.1. Schematic of EMWMF Present and Future Disposal Capacity

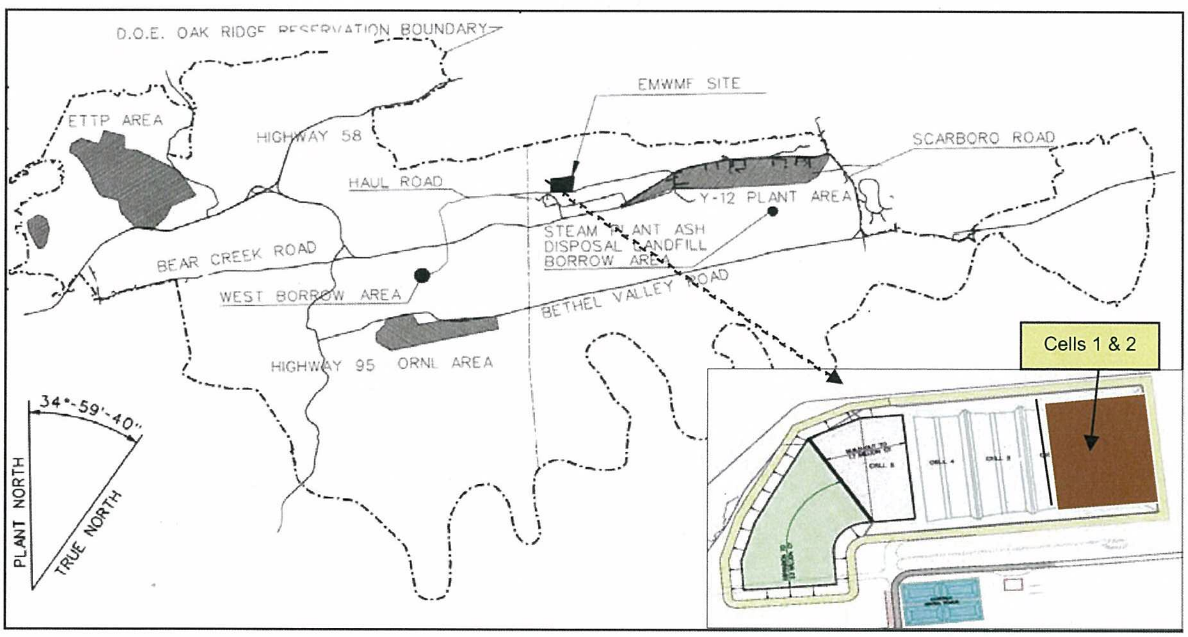

Figure 5.2. Location of EMWMF on the Oak Ridge Reservation

An exception to those on-site disposal facilities is the DOE facility at the NTS. The mission of the NTS Waste Management Project is to support the closure of DOE sites across the United States by maintaining the capability to dispose of LLW and MLLW.

NTS is designated as a primary regional disposal site for LLW and secondary disposal site for MLLW generated from cleanup activities across the DOE complex. Disposal of radioactive wastes are regulated by DOE under its Atomic Energy Act authority and managed under DOE Order 435.1 *Radioactive Waste Management*. NTS is not on the EPA NPL; however, NTS is an approved CERCLA disposal facility under EPA's Off-Site Rule. NTS Area 3 is an disposal facility that can be utilized as needed to support the disposal of waste generated by DOE CERCLA and mission programs complex-wide. This facility can be considered as a disposal option for the Off-Site Alternative and also could be utilized for some waste types that do not meet the WAC of an on-site disposal facility.

5.3.2.2 Off-Site Decisions

DOE's CERCLA waste disposal evaluations of various alternatives have resulted in selecting off-site waste disposal as the preferred alternative at Rocky Flats in Colorado and Mound Site in Ohio.

Cleanup and closure of Rocky Flats (Colorado) was completed with off-site disposal due to site conditions and stakeholder input. Wastes that were generated during the cleanup and closure of Rocky Flats were shipped to NTS and/or commercial disposal facilities. At the Mound Site (Ohio), the geologic and hydrogeologic conditions were not conducive for on-site disposal, and it is located in a congested and populated area with nearby residential developments, schools, and city parks. The waste removed from this site was shipped to DOE and commercial off-site disposal facilities.

The examples of waste disposal evaluations at other DOE sites provided in this section show that because the evaluation process considers many different factors (e.g., waste types, site conditions, community involvement), the process results in an alternative that meets the needs of the site.

5.4 SITING/CONCEPTUAL DESIGN

This section presents a summary of existing information on the siting and conceptual design of an on-site disposal facility. Much of the information required to define the layout, land space requirements, landspace constraints, and conceptual design already exists.

Table 5.4. Summary of DOE CERCLA Disposal Facilities

DOE Site	Decision Process Used and Approval Date[1]	Waste Disposal Alternative Selected[2]	Current Status	Waste Types Generated[3]	Waste Generated	Planned Volume (mcy)	Cap Thickness (ft)	Waste Height (ft)	Waste Footprint (acres)	Facility Footprint (acres)
Fernald (NPL)	CERCLA–ROD signed in 1995	On-Site Disposal–On-Site Disposal Facility (OSDF)	OSDF Completed in 2006	LLW, RCRA, TSCA	Soil, scrap metal, demolition debris	2.95	9	54	70	140
Hanford (NPL)	CERCLA–ROD signed in 1995	On-Site Disposal–Environmental Restoration Disposal Facility (ERDF)	Operating	LLW, RCRA, TSCA	Soil, scrap metal, demolition debris	>7.0	17.5	70	94	>600
INL (NPL)	CERCLA–ROD signed in 1999	On-Site Disposal–ICDF	Operating	LLW, RCRA, TSCA	Soil, scrap metal, demolition debris	0.51	20	14	40	55
Weldon Spring (NPL)	CERCLA–ROD signed in 1993	On-Site Disposal–Weldon Spring On-Site Disposal Cell	Weldon Spring Disposal Facility Completed in 2001	AEA 11e(2) Byproduct Material RCRA, TSCA	Soil, scrap metal, demolition debris	1.48	8	63	24	45
Oak Ridge Reservation (NPL)	CERCLA–ROD signed in 1999	On-Site Disposal–EMWMF	Operating	LLW, RCRA, TSCA	Soil, scrap metal, demolition debris	1.7	13	<50	44	98
Rocky Flats (NPL)	CERCLA	Off-Site Disposal (NTS and Commercial Disposal)	Off-Site Disposal Completed in 2001	LLW, RCRA, TSCA	Soil, scrap metal, demolition debris	N/A	N/A	N/A	N/A	N/A
Mound (NPL)	CERCLA	Off-site Disposal (NTS and Commercial Disposal)	Off-Site Disposal Completed in 2006	LLW, RCRA, TSCA	Soil, scrap metal, demolition debris	N/A	N/A	N/A	N/A	N/A

[1]National Environmental Policy Act (NEPA) values are incorporated into the CERCLA process;
[2]Generated waste that does not meet the on-site disposal facility waste acceptance criteria is disposed off-site;
[3]Transuranic waste (TRU) generated by NPL sites is disposed at the Waste Isolation Pilot Plant and is not subject to on-site disposal analysis. TRU waste is defined by DOE Manual 435.1-1 "Radioactive Waste Management" as waste with greater than 100 nano curies/gram of alpha emitting TRU isotopes with a half-life greater than 20 years.

AEA = Atomic Energy Act of 1954, as amended; CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act; EMWMF = Environmental Management Disposal Facility; ERDF = Environmental Restoration Disposal Facility; ICDF = Idaho Consolidated Disposal Facility; INL = Idaho National Laboratory; LLW = low-level waste; N/A = not applicable (this information is specific to implementation of on-site disposal, all waste from these sites were disposed off-site); NPL = National Priority List; NTS = Nevada Test Site; OSDF = on-site disposal facility; RCRA = Resource Conservation and Recovery Act; TSCA = Toxic Substances Control Act; ROD = record of decision

5.4.1 Siting

DOE began an evaluation of waste disposal options for PGDP CERCLA waste in 2001. The 2001 evaluation, although discontinued before an RI/FS report was completed, provides several source documents for existing information pertaining to siting of a potential on-site disposal facility. One document, *Initial Assessment of Consideration of On-Site Disposal of CERCLA Waste Facility as a Potential Disposal Option at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2000a), was prepared to determine (1) if the evaluation of an on-site disposal strategy for the forecasted CERCLA-derived wastes was warranted and (2) if an evaluation was warranted, to propose a method for that evaluation. The initial assessment was modeled after a similar evaluation of disposal alternatives by DOE in Oak Ridge, Tennessee (Section 5.3.1). The initial assessment concluded that the evaluation of an on-site disposal strategy was warranted and proposed the CERCLA process for decision making and documentation. Because it was concluded on-site disposal could be a potential alternative, a subsequent document was prepared to determine if there were viable locations to construct an on-site waste disposal facility. The report, *Identification and Screening of Candidate Sites for a Potential Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) Waste Disposal Facility at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2001c) was prepared to document the process used to identify candidate sites at PGDP for a potential on-site waste disposal facility and to screen those candidate sites for further evaluation in a RI/FS.

Based on the 2001 waste forecast of 3.1 mcy, a conceptual design determined that a minimum area of 110-acres would be needed for the waste disposal footprint, surrounding dike, and operations support facilities. The 2001 siting study considered land space constraints and identified 10 sites on DOE-owned property that could meet the 110-acre footprint requirement. One of 10 sites, Site 3, later was eliminated because a portion of that site was designated for the construction of the depleted uranium hexafluoride (DUF_6) facility. Because Site 3 was considered a favorable potential location by the regulators and the Citizens Advisory Board (CAB), its footprint was reconfigured and renamed Site 3A. Additionally, it has been recognized that the area immediately north of the C-746-U Landfill generally meets the landspace requirements identified in the 2001 Siting Study. This location is included in the list of potentially viable locations and is identified as Site 11 (Figure 5.3). If Site 11 is selected for siting a disposal facility under an as yet to be determined decision to implement the On-Site Alternative, the total capacity of the C-746-U Landfill would be reduced by approximately 50%, and existing support facilities would be incorporated into the operations of the new facility.

5.4.2 Conceptual Design

A conceptual design was included in the 2001 site screening report and provided details on the major components associated with a potential on-site waste disposal facility and a site layout depicting how the 110-acres would be utilized. DOE's Oak Ridge site prepared conceptual designs for each of its three candidate sites. Disposal facility designs also were prepared at the other DOE sites that selected on-site disposal as the preferred alternative. Information from the other DOE sites described in Section 5.3 will be used for guidance in preparing a conceptual design(s) as necessary.

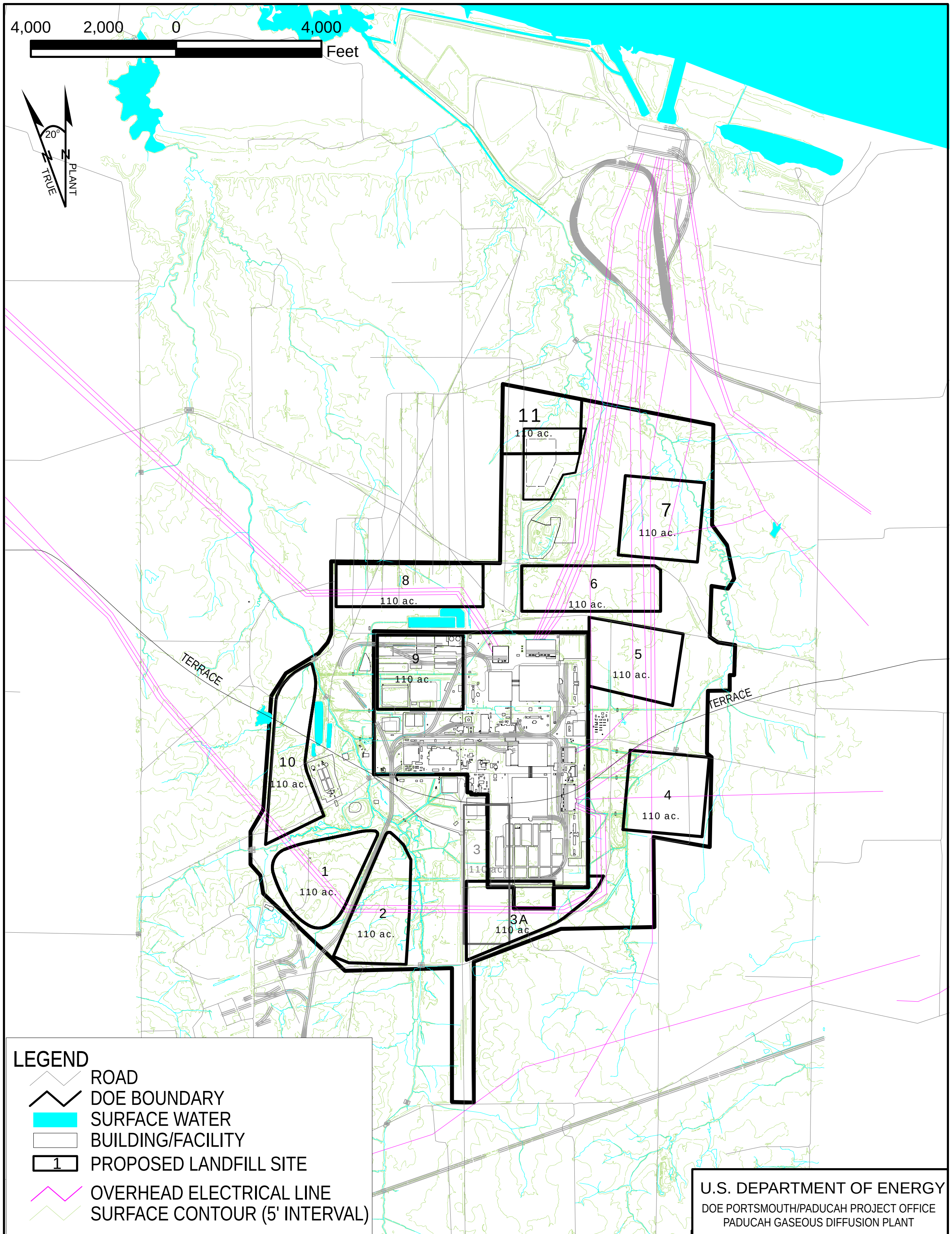

Figure 5.3. Locations of Candidate Waste Disposal Facility Sites

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As an update to the previous study, a conceptual design, was performed in 2007 using the most recent waste forecast of 3.7 mcy and demonstrated a facility could be designed, constructed, and operated on a site of a minimum of 110 acres. Figure 5.4 provides a conception design of the cover and liner systems.

A CERCLA waste disposal facility as conceptually designed would be more protective of human health and environment than a hypothetical facility that can accept only LLW. The engineering design of LLW land disposal facilities is performance-based. The conceptual CERCLA waste disposal facility design incorporates the performance-based requirements along with the prescriptive requirements of RCRA and TSCA. Examples of the prescriptive requirements include (1) RCRA hazardous waste landfills are required to incorporate leak detection systems in addition to the liner and leachate collection systems, and each must meet specific design requirements; (2) RCRA hazardous waste landfills must have a final cover system with a permeability that is less than or equal to the permeability of the bottom lining system or natural subsoils present; and (3) TSCA regulations identify specific geotechnical parameters for soils used in clay liners and specific requirements for geomembrane liners. A CERCLA waste disposal facility that incorporates the minimum prescriptive requirements of RCRA and TSCA along with the performance-based LLW disposal requirements results in a high level of protection to human health and the environment.

Additionally, an analytical WAC would be prepared to ensure wastes accepted at an on-site facility would be protective of human health and the environment. In addition to an analytical WAC, other requirements to establish limits for waste disposal such as administrative and physical WAC would be prepared.

5.5 SEISMIC CONSIDERATIONS

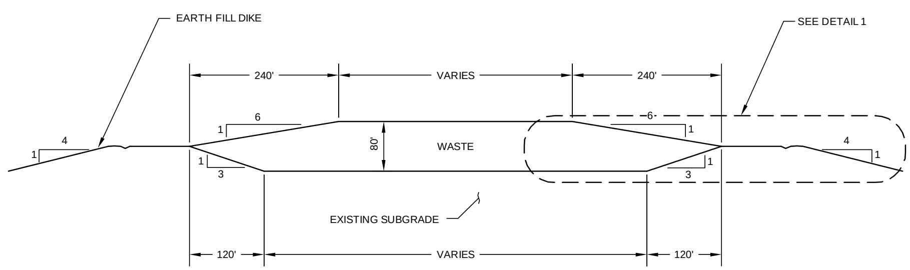
The On-Site Alternative will include the design of a waste cell and the necessary support facilities. There are three seismic sources that have potential to affect PGDP; therefore, siting and design considerations of a potential on-site waste disposal facility must consider regional and PGDP site specific seismicity. There are substantial regional and site specific seismic data that would support evaluation of potential sites on the northern or southern portions of the PGDP boundary. This information can contribute to the assessment of seismic hazard at PGDP for the On-Site Alternative.

During the 2001 waste disposal evaluation, EPA and Kentucky review comments on the initial assessment report (DOE 2000a) identified seismic hazard as their major concern (and data gap). *Seismic Issues for Consideration in Site Selection and Design of a Potential On-Site Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) Waste Disposal Facility at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2000b) was prepared to expand on the initial assessment and conduct a document review to address specifically the seismic issues relating to siting, design, construction, operation, and closure of a potential CERCLA waste disposal facility. The Seismic Issues report concluded that it would be possible to design, construct, and operate an on-site waste disposal facility. It also identified seismic criteria to be considered during site selection and design.

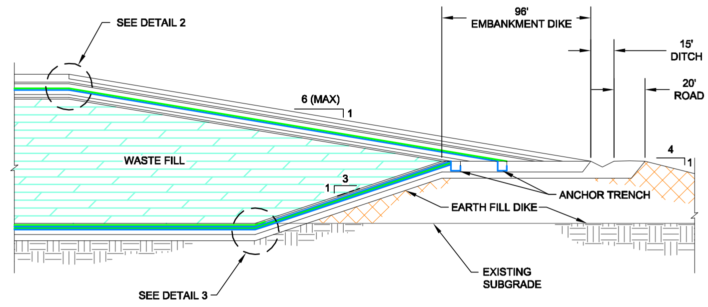
During comment resolution at a Core Team meeting on the 2001 Seismic Issues report, DOE, EPA, and Kentucky agreed that seismic issues needed to be resolved in order to determine the viability of an on-site disposal alternative. EPA and Kentucky representatives stated that field studies were required to address considerations associated with siting a radioactive and hazardous waste disposal facility near a seismically active region. Site 3A was chosen, based on a recommendation from the CAB and agreement by EPA, Kentucky, and DOE, for the location of a PGDP site-specific seismic investigation. The *Seismic Investigation Report for Siting of a Potential On-Site CERCLA Waste Disposal Facility at the Paducah*

BACK

NOTE
COVER AND LINER SYSTEMS NOT SHOWN IN THIS VIEW FOR CLARITY.



DISPOSAL CELL CROSS SECTION



DETAIL 1

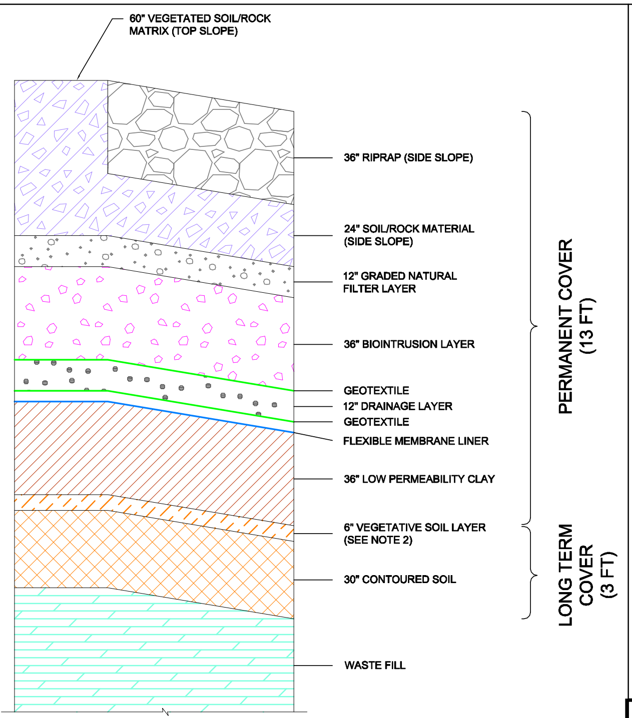
LEGEND

- BIOINTRUSION LAYER
- DRAINAGE LAYER
- EARTHFILL DIKE AND PROTECTIVE SOIL LAYER
- EXISTING SUBGRADE
- FLEXIBLE MEMBRANE LINER
- GEOCOMPOSITE
- GEOLOGICAL BUFFER
- GEOTEXTILE
- GRADED FILTER MATERIAL
- LOW PERMEABILITY CLAY
- RIPRAP
- SOIL/ROCK LAYER
- VEGETATIVE SOIL
- WASTE

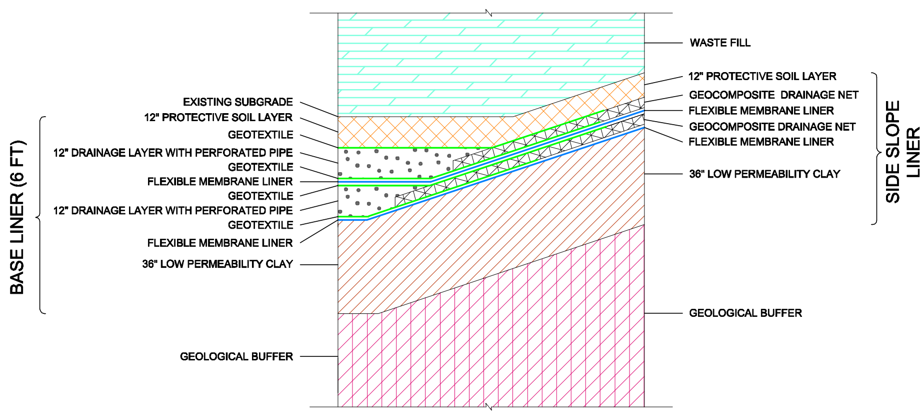
NOTES

1. THE DISPOSAL CELL CROSS SECTION DIMENSIONS LISTED PROVIDE AN APPROXIMATE WASTE STORAGE CAPACITY BETWEEN 1.5 AND 4.0 MILLION CUBIC YARDS.

2. VEGETATIVE SOIL COVER DEPTH MAY VARY, DEPENDING ON SITE-SPECIFIC CONDITIONS. VEGETATIVE SOIL WILL BE STRIPPED AND REPLACED WITH COMPACTED FILL BEFORE PERMANENT COVER IS CONSTRUCTED.



DETAIL 2



DETAIL 3

NOT TO SCALE

LINER AND COVER MATERIAL DESIGN CRITERIA

1. THE LOW PERMEABILITY CLAY LAYER SHALL HAVE A HYDRAU[LIC] CONDUCTIVITY OF NO MORE THAN 1 x 10^{-7} cm/sec.

2. THE DRAINAGE LAYER MATERIALS SHALL HAVE A HYDRAULIC CONDUCTIVITY OF 1 x 10^{-2} cm/sec OR GREATER.

3. THE GEONET DRAINAGE MATERIALS SHALL HAVE A TRANSMISSIVITY OF 3 x 10^{-5} m^2/sec OR GREATER.

4. THE FLEXIBLE MEMBRANE LINER MATERIALS SHALL HAVE A DEMONSTRATED HYDRAULIC CONDUCTIVITY LESS THAN 1 x 10^{-12} cm/sec.

TABLE OF CONTENTS

SCALE
AS NOTED.

THIS SCHEMATIC IS PROVIDED AS A SUPPLEMENT TO THE RI/FS ON-SITE DISPOSAL ALTERNATIVE. THIS DESIGN PLAN IS FOR A POTENTIAL CERCLA WASTE DISPOSAL FACILITY AT THE PADUCAH GASEOUS DIFFUSION PLANT IN PADUCAH, KENTUCKY. THIS SCHEMATIC IS FOR CONCEPTUAL DESIGN PURPOSES ONLY.

REVISIONS

REV	DESCRIPTION	EFFECTIVE DATE

U.S. DEPARTMENT OF ENERGY
DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

LATA Environmental Services of Kentucky, LLC

CERCLA WASTE DISPOSAL FACILITY
CONCEPTUAL
CROSS SECTION

SHEET: 1 OF 1		SCALE: AS SHOWN	
DESIGN: R. SCHWALLER	10/9/09	QA LEVEL: STD	DWG SIZE: D
DRAWN: D. STRATTON	10/9/09	CONTRACT NO.: -	
CHECKED: R. SCHWALLER	10/9/09	DRAWING NUMBER:	REV
APPROVED: -	-		-0

Figure 5.4. Conceptual Design Cross Sections

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Gaseous Diffusion Plan, Paducah, Kentucky (DOE 2004) provides a substantial seismic data set for potential sites that may be located on the southern portions of PGDP. The report provides data that addresses Holocene faulting, liquefaction, design criteria, and the results of geotechnical investigations. A detailed summary of the Seismic Investigation Report (SIR) (DOE 2004) is provided in Appendix B.

Existing information concerning seismic considerations, such as liquefaction, Holocene faulting, and ground motion are discussed below.

5.5.1 Liquefaction

The SIR (DOE 2004) provides a source of liquefaction data specifically for Site 3A on the southern PGDP property, but also included a broader study as well. River bank inspections were conducted along the Ohio River and walk downs of Bayou and Little Bayou Creeks were conducted to find evidence of liquefaction. Major conclusions of the liquefaction study include the following:

- With only a few exceptions, the soils at Site 3A are silts and clays and are not prone to liquefaction.
- Liquefaction within the sands could occur at a peak ground acceleration (PGA) approaching 0.5 g.
- The absence of liquefaction features within 15 miles of PGDP suggests local strong ground motion has not occurred since deposition.
- There is no definitive evidence of liquefaction along Bayou and Little Bayou Creeks.

5.5.2 Holocene Faulting

The presence of Holocene-age faults (faults that have experienced displacement during the last 10,000 to 12,000 years) would be a significant siting consideration for the On-Site Alternative. There have been two site-specific fault investigations at PGDP (Figure 5.5): Site 3A (located immediately south of the PGDP security-fenced area) (DOE 2004); and the proposed area of expansion of the C-746-U Landfill (located 1 mile north of the PGDP security-fenced area) (KRCEE 2006).

Substantial data and conclusions with respect to Holocene faults (both PGDP site-specific and regional) are provided in the SIR (DOE 2004) and fault studies at the C-746-U Landfill (DOE 2003a). A brief discussion with respect to Holocene faulting is provided here, and Appendix B includes a detailed summary of the seismic investigation. Site-specific information concerning the age of faulting is available for the northern and southern portions of PGDP.

The SIR (DOE 2004) provides site-specific fault study data primarily for the southern PGDP at Site 3A. The site investigation identified a series of faults beneath Site 3A; however, carbon age dating of samples collected in the loess indicate the faults are at least 17,100 years old (late Pleistocene). The SIR concluded Holocene displacement of faults is not present at Site 3A.

Several seismic studies have also been conducted on the northern portion of PGDP (at the C-746-U Landfill site). Two of the more recent seismic evaluations are discussed here.

In 2003, to satisfy a condition of the revised landfill permit, DOE performed a fault study at the C-746-U Landfill. *Technical Memorandum for the C-746-U Landfill Fault Study at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2003a) describes the shear wave (s-wave) velocity seismic survey that was conducted along two perpendicular lines that intersected northwest of the landfill. It also presents the

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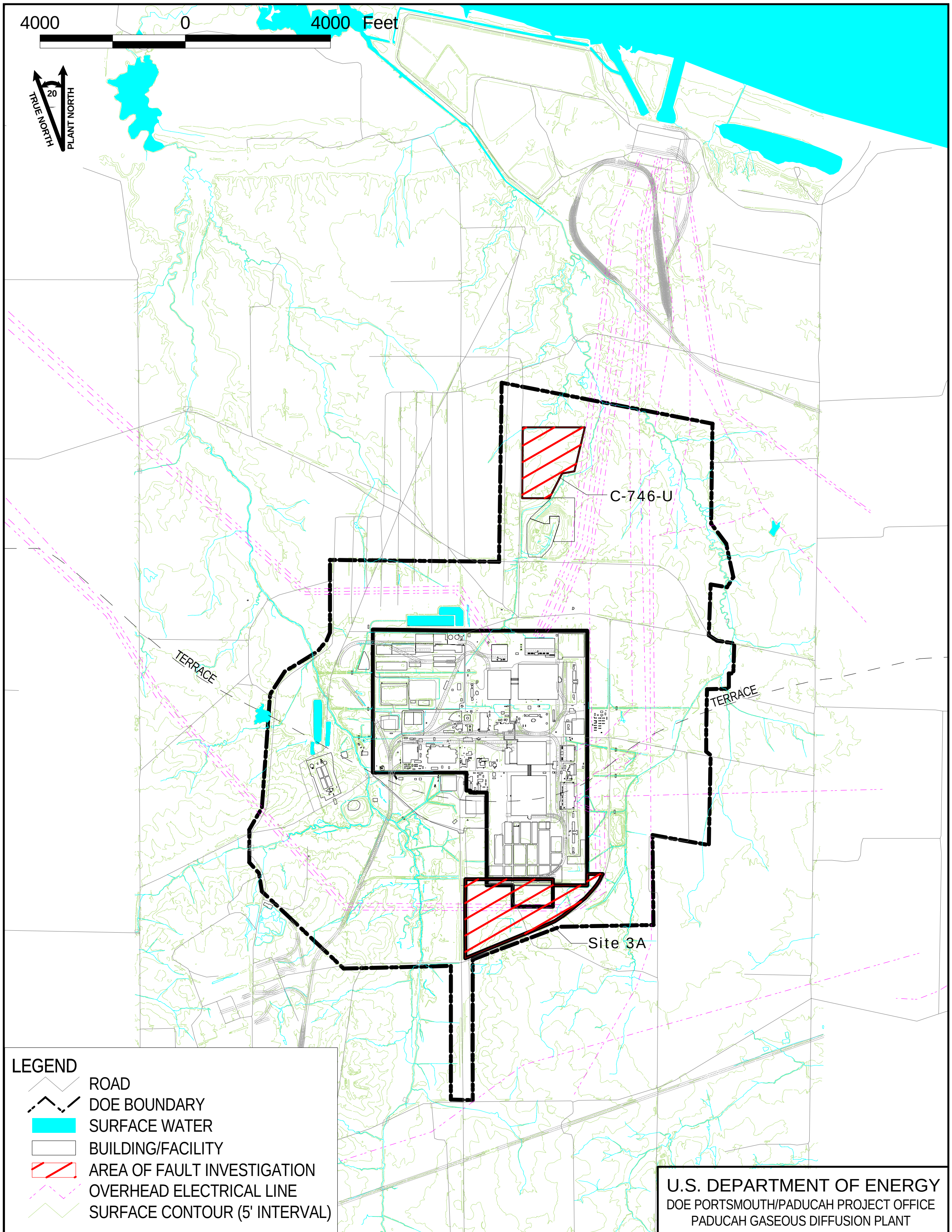

Figure 5.5. Fault Investigations at PGDP

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uninterpreted and interpreted seismic data (seismic sections). The study concluded that there were two zones of deformation, which were interpreted as potential faults. In both of the zones, the deformation extended from the bedrock up to and through the RGA, which is thought to be several million years old. Deformation of younger sediments above the RGA could not be determined because of the lack of strong seismic reflectors in those sediments.

A follow-up investigation to the earlier fault study was performed in the C-746-U Landfill area in 2005 to assess whether or not Holocene-active fault displacement is present beneath the footprint of the proposed landfill expansion. *Investigation of Holocene Faulting, Proposed C-746-U Landfill Expansion, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, which was prepared for the University of Kentucky Research Consortium for Energy and Environment, Frankfort, Kentucky, by William Lettis & Associates, Inc., (KRCEE 2006) provides the details of collecting and interpreting closely-spaced direct push technology (DPT) soil cores along the two seismic lines. The DPT locations targeted the projected surface locations of the two faults that were interpreted on the seismic data in an effort to identify any evidence of near-surface expression of the faulting. Age dates derived by optically stimulated luminescence of soil samples from the DPT soil cores provided control to the age of features in the cores. The investigation concluded that there was strong geologic evidence that the faults have not been active within the last 10,000–12,000 years (Holocene age) and probably the last 15,000 years. One of the other supporting conclusions was that other deformation-related features mapped in the shallow sediments from the DPT cores also were greater than 10,000–12,000 years old.

As part of the 2004 seismic investigation, DOE extended its search for Holocene faults beyond their PGDP property. A fault study was conducted at a site approximately 11 miles northeast of PGDP in an area known as Barnes Creek where relatively young faults are exposed in the banks of Barnes Creek. The results of that study concluded that the faults at this location did extend into Holocene age deposits. Evidence of those potential faults included a crack in unconsolidated sediments that was interpreted as Holocene in age using carbon-14 analyses on samples of wood collected from exposures that were accessible from the stream channel. The conclusion that Holocene-age faulting has occurred is inconsistent with the work of others, including John Nelson with the Illinois State Geological survey. Mr. Nelson is considered the leading expert on the tectonic history of this area and has concluded that faulting in the Barnes Creek area is pre-Holocene (KRCEE 2007b; Nelson and Denny 2008). Dr. Ed Woolery with the Kentucky Geological Survey also has challenged this conclusion because of the lack of displacement of the sediments and the possibility of the wood samples having been contaminated by flooding events in the creek. In summary, numerous studies have investigated the possibility of Holocene-age faults at or near PGDP, and the weight of evidence indicates there is no such faulting.

5.5.3 Ground Motion Modeling

Ground motion modeling data will be needed for design considerations for a potential on-site waste disposal facility. Several PGDP-specific seismic hazard assessments have been completed within the past 10 years. Risk Engineering, Inc., (REI) performed a seismic study of PGDP in 1993 (REI 1993). In 1994, the Nuclear Regulatory Commission (NRC) asked USEC for an update of the 1993 REI study. (NRC's oversight of PGDP operations began when USEC assumed responsibility for uranium enrichment operations of PGDP in July 1993.) A 1999 study *Updated Probabilistic Seismic Hazard Analysis for the Paducah Gaseous Diffusion Plant Paducah, Kentucky Final Report* (Revision 3), (REI 1999), based on shear wave measurements in four deep borehole clusters drilled on the DOE property, evaluated site-specific, peak horizontal ground acceleration for return periods of 250, 500, 1,000, and 5,000 years. A follow-up 2001 study (Beavers 2001) interpolated the 1999 REI study results for a return period of 2,500 years and determined the peak ground acceleration at PGDP to be approximately 0.8g at bedrock (located 325–425-ft deep) and 0.5g at the top of soil. (DOE and the regulators had reached agreement that the 2,500-year return period ground motion was appropriate for design of a potential on-site disposal facility.)

At the request of Kentucky regulators, the 2,500-year return period ground motion at PGDP was reassessed in 2002. *Paducah Gaseous Diffusion Plant: Re-evaluation of Site-Specific Effects on Ground Motion* (BJC 2002) concluded that the REI 1999 analysis constituted a current state-of-the-art estimate of the PGA and spectral acceleration ground motion at rock. Further reassessment of the data (BJC 2002) determined that the peak horizontal ground acceleration was 0.71g at bedrock and 0.48g at the top of soil.

Ground motion modeling at Site 3A was performed using data collected during the SIR (DOE 2004). Shear wave velocities of the unconsolidated materials above the bedrock at Site 3A were used to develop a site-specific soil amplification factor. The ground motion was modeled using this soil amplification factor and the peak horizontal ground acceleration at bedrock from BJC 2002 (0.71g). The 2,500 year return-period ground motion at the Site 3A surface was calculated to be 0.48g for the southern PGDP site property. This surface PGA is identical to the surface PGA calculated in BJC 2002 and is essentially equal to the results for the PGDP in Beavers 2001.

Deterministic seismic hazard analysis (DSHA) is an alternative approach to evaluate seismic hazard that assesses ground motion from a single maximum credible earthquake and explicitly determines ground-motion hazard with a level of uncertainty. Results of DSHA are commonly expressed as the median peak horizontal ground acceleration for an area. A Kentucky Geological Survey study of the PGDP area (KRCEE 2007a) determined that the median peak horizontal ground acceleration at the top of bedrock is 0.25g, with one standard deviation of 0.51g (the return period of the maximum credible earthquake is 500–1,000 years). A corresponding peak horizontal ground motion at the surface was not determined in KRCEE 2007a. Table 5.5 (adapted from KRCEE 2007a) summarizes seismic hazard analyses of the PGDP area.

Table 5.5. Seismic Hazard Analyses of the PGDP Area

Study	Return Period (yrs)	Peak Horizontal Ground Acceleration (g)	
		Bedrock	Top of Soil
REI 1999	2,500	0.78[a]	0.4[b]
Beavers 2001	2,500	0.8	0.5
BJC 2002	2,500	0.71	0.48
DOE 2004	2,500	0.71	0.48
KRCEE 2007a	500 to 1,000	0.51[c]	ND [d]

[a] Extrapolated in KRCEE 2007a.
[b] Top of soil acceleration not extrapolated in KRCEE 2007a, extrapolated from REI 1999.
[c] Median value with one standard deviation is appropriate for determining the landfill design criterion.
[d] Top of soil acceleration was not determined in KRCEE 2007a.

5.5.4 Bedrock Shear Wave Velocity

The SIR (DOE 2004) assumes a bedrock shear wave velocity of 10,000 ft/sec for the PGDP, based on approximate values for the region (REI 1999). This shear wave velocity value compares well to other nearby sites with similar Mississippian limestone bedrock. Researchers from the Kentucky Geological Survey, University of Kentucky Department of Geological Sciences, and the Kentucky Transportation Center (Harris *et al.* 1994) estimated the shear wave velocity value to be 9,000 ft/sec at the I-24 bridge crossing of the Ohio River (located 6.5 miles east of PGDP), based on a P-wave refraction velocity measurement. A similar survey at the Olmsted Lock and Dam project (located 14.9 miles west of PGDP) determined a bedrock shear wave velocity of approximately 8,000 ft/sec (Geomatrix 1996). Additional shear wave velocity values for Mississippian limestone from published studies may be applicable to PGDP.

5.5.5 DOE Independent Review Team

During the summer of 2008, DOE Headquarters assembled an Independent Review Team (IRT) to review the issues associated with seismicity at PGDP and the associated investigation reports and background materials. The findings of the IRT were discussed in a June 2009 Seismic Issues Workshop held in Oak Ridge, TN. The IRT presentation from that workshop has been provided to the regulators and is included in Appendix F of this work plan.

5.6 HYDROGEOLOGIC/GEOTECHNICAL DATA

Development and evaluation of the On-Site Alternative will require data concerning hydrogeology for groundwater modeling to prepare a preliminary WAC and also geotechnical data to determine soil properties such as subsidence, compaction, permeability, etc., for the conceptual design.

5.6.1 Hydrogeologic Data

There is a massive hydrogeologic data base for the PGDP site. While most of the data focuses on the northern hydrogeologic setting, there is available data for the southern setting as well. Information concerning the southern hydrogeologic setting is available through these sources:

- A DOE facility investigation/remedial investigation of Kentucky Ordnance Works SWMUs 94, 95, and 157 (DOE 1996b);
- Results of the Site Investigation Phase I at PGDP (CH2M HILL 1991);
- Results of the Site Investigation Phase II at PGDP (CH2M HILL 1992);
- The COE remedial investigation of the Kentucky Ordnance Works (COE 1992); and
- A hydrogeologic atlas of the Heath Quadrangle (USGS 1966).

A summary of this information has been transmitted to Kentucky and EPA and also will be provided in the RI/FS report (GEO 2009).

5.6.2 Geotechnical Data

The SIR provides one source of data for PGDP's southern geological setting (DOE 2004). The data were collected during the seismic investigation for the purpose of design considerations. Details of the available geotechnical data are included in the SIR summary in Appendix B. Support investigations of the Uranium Disposition Services, LLC, DUF_6 Conversion facility at PGDP are another source of geotechnical data from the southern geologic setting.

Several previous engineering and siting investigations at PGDP have collected and reported geotechnical data from PGDP's northern geological setting. These investigations include the following:

- A 1950s COE siting study of the PGDP site;
- A soil liner study of the C-746-U Landfill; and
- Geotechnical investigations for a building and a cylinder storage yard at PGDP.

A summary of this information has been transmitted to Kentucky and EPA and also will be provided in the RI/FS report (GEO 2009).

5.7 PRELIMINARY WASTE ACCEPTANCE CRITERIA/MODELING

WAC and modeling methods used at the C-746-U Landfill (DOE 2003b) provide a source of data that can be used to help develop modeling parameters for evaluating the performance of an on-site waste disposal facility. Appendix C includes details of how modeling and a preliminary WAC will be developed for the On-Site Alternative.

The CERCLA RI/FS for waste disposal alternatives will be the first complete feasibility study of siting a low-level radioactive waste disposal facility at the PGDP. DOE has previously developed authorized radioactive limits for the C-746-U Landfill (DOE 2003b) at PGDP. If isotopic concentration levels in waste were above the authorized limits, the waste would be managed as LLW and disposed in an appropriate alternate facility. Another study, although not applied to the C-746-U Landfill, was performed by Oak Ridge National Laboratory in June 1995 (ORNL 1995) and predated the DOE's formal guidance on developing authorization limits under DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, entitled *Application of DOE 5400.5 requirements for release and control of property containing residual radioactive material*, dated November 17, 1995. The process for DOE to derive and approve authorization limits using DOE Order 5400.5 and associated guidance has been implemented for the C-746-U Landfill and the Y-12 Industrial Landfill in Oak Ridge. The ORNL 1995 Report, lacking specific DOE authorized limits guidance at that time, utilized LLW disposal performance objectives from DOE Order 5820.2A *Radioactive Waste Management* (now called DOE Order 435.1 *Radioactive Waste Management*) and other assumed regulatory criteria such as proposed drinking water standards, to derive concentration limits for waste receipts at the C-746-U Landfill. The project will evaluate the ORNL (1995) report and other relevant documents to learn from and apply lessons learned, as appropriate, to improve the process and technical work to be performed.

5.8 WASTE DISPOSAL COST

One of the criteria for evaluating the No Action, Off-Site and On-Site Alternatives will be a comparison of cost for each alternative. Both the No Action and off-site low-end volume scenarios involve off-site waste disposal and use of the C-746-U Landfill for disposal of nonhazardous solid waste. The off-site high-end scenario ships all waste off-site. Because the current practice at PGDP involves off-site disposal of LLW, MLLW, hazardous, and TSCA wastes, and there is an existing on-site facility for nonhazardous solid waste disposal, cost information is readily available. The On-Site Alternative will require development of a site specific estimate, but there are existing sources that can be referenced for comparison purposes and to verify that critical cost components have been included. For the On-Site Alternative high-end scenario, all waste meeting the WAC will be disposed on-site in a newly constructed waste disposal facility. The on-site low-end scenario uses the C-746-U Landfill for wastes that meet the landfill's WAC and a newly constructed waste disposal facility for waste that meet the facility WAC. Waste that does not meet the WAC of a new on-site facility would be shipped off-site. Details of existing disposal cost sources are provided here.

5.8.1 Current Off-Site Disposal

Actual off-site disposal costs incurred by DOE are readily available and can be used to estimate the cost of future off-site disposal. Three primary costs are associated with off-site disposal: the cost of the containers (either purchased or rentals); transportation costs; and disposal fees. The final cost is dependent on the type and form of the waste, method of transport, and the disposal facility used. Disposal fees are not always based on the volume of the waste. Some facilities charge by the external size of the container and other facilities use an assumed volume on the contents of the container. Also, disposal of classified wastes results in an increase of transportation costs, but not disposal.

DOE has existing contracts for disposal fees with all of the facilities listed in Table 5.3. The costs vary for each waste type. The cost of containers is also well known for the various types that typically are used and include gondola rail cars, intermodals, Sealand trailers, and B-25/ST-90s. Transportation cost is also readily available for either truck or rail methods.

5.8.2 C-746-U Landfill

Actual costs incurred by DOE to dispose of waste in the C-746-U Landfill are readily available and can be used to estimate the costs of future disposal at C-746-U Landfill. These costs are based on several factors that include operations, monitoring, maintenance, expansion, and leachate treatment practices. The existing data for this waste will be used as needed.

5.8.3 Disposal Cost Considerations

In October 2001, Congress directed DOE to perform an objective analysis by comparing the life-cycle cost of Off-Site and On-Site Alternatives. In response DOE completed a Life Cycle Cost Analysis for disposal of waste at commercial facilities and DOE-owned facilities (DOE 2002a). The methods and results contained in this document will be useful in developing a comparative cost analysis between the alternatives to be evaluated in the FS.

6. DATA NEEDS AND MANAGEMENT OF UNCERTAINTIES

During the scoping process, data gaps in several of the subject areas were recognized. This chapter provides a discussion of the data needed to conduct the RI/FS and identifies the potential data gaps and plans for evaluating those data gaps. Chapter 5 included details of the data available for evaluating the waste disposal alternatives. This chapter, like Chapter 5, is arranged by subject matter.

6.1 WASTE VOLUME FORECASTS

Three tasks related to the existing base case waste forecast will be performed as part of the RI.

- Update the forecast to correspond with the latest project schedules.
- Develop range of volumes to address uncertainties.
- Develop an analytical profile for the forecasted waste.

6.1.1 Schedule for Waste Generation

The waste generation forecast will be updated to reflect the most current project schedule and assumptions for OU remediation. This will be necessary because OU project schedules and assumptions have changed since the time the existing waste forecast was developed. Also, the waste forecast will be revised to reflect a waste generation start date of 2014 rather than 2010 to correspond to the CERCLA waste disposal ROD implementation date. These start dates are expected to have only a minor impact on the waste forecast, as the vast majority of waste will be generated beyond 2019. These changes will result in a revised quantity for the base case waste volume estimates.

6.1.2 Waste Volume Scenarios

A range of waste volume scenarios will be developed to address uncertainty associated with the base case waste forecast. Waste volume estimates have two distinct types of uncertainty associated with them. The first type of uncertainty is related to future remedial action decisions. For example, a burial ground may not be excavated or a building may be reindustrialized in the future and not demolished within the forecast period (2014 to 2039). These types of decisions could substantially impact volume forecasts. The second type of uncertainty is volume variability. In the case of a burial ground excavation, volume estimates are based on preliminary analysis of depth and lateral extent of contamination; however, when excavation commences, it may be determined that the actual area of contamination is less than or greater than forecasted. Additionally, some waste types may require treatment to meet the WAC of the receiving disposal facility. Because some treatment technologies result in an increased waste volume after treatment and some result in a decreased waste volume after treatment, it will be assumed, for this evaluation, that there will be no net change in the total volume of forecasted waste following treatment.

Some of the uncertainties are the inherent uncertainties as described above. Other uncertainties pertain to the assumptions used to develop the forecast itself. It may be possible that some assumed waste generation or waste management activities do not actually occur. Conversely, there may be new volumes of waste that may be generated or new waste management initiatives that may take place.

For example, the waste volume forecast contains an estimated 1.1 mcy of nonhazardous solid waste. This volume of waste is eligible for disposal in the operating C-746-U Landfill at PGDP. If it is assumed that this waste is disposed of in the C-746-U Landfill, the waste volume that will require disposal under this evaluation is reduced from approximately 3.7 mcy to approximately 2.6 mcy. A second example concerns the disposal of classified waste. The waste volume forecast includes approximately 190,000 yd^3 of classified waste. This volume of waste would be subtracted from the estimate, if it is assumed that a potential on-site disposal facility would not accept classified waste. Other assumptions that could significantly change the waste volume estimate include initiatives such as waste recycling and reindustrialization of existing facilities. Decisions regarding (1) continued use of the C-746-U Landfill; (2) which waste, if any, will be recycled; and (3) which facilities, if any, will be reused in reindustrialization program will not be made as part of the RI/FS. Because these decisions could have a significant impact on the waste volume estimates, the RI/FS will address the associated uncertainties by evaluating a range of waste volumes. The lowest estimate (called the low-end volume) and the highest estimate (called the high-end volume) in this range of waste that will require disposal will be evaluated in the RI/FS. The following describes the assumptions used to establish the waste volume range for this evaluation.

High-end Volume Scenario

The high-end volume scenario will include assumptions that increase the current base case waste volume estimate of 3.7 mcy. Since many of the OUs have not fully delineated the extent of contamination, the waste forecast was developed using the best available information. When future response actions are implemented, some projects may encounter the lateral extent or depth of contamination is greater than the current estimates, or the selected remedy may involve treatment rather than excavation. To account for the uncertainty in the volume of waste generated during response actions, the base volume will be increased by 10% to 4.1 mcy. This increase accounts for the scenario where some projects generate more waste than is currently forecasted. The high-end volume assumes that nonhazardous solid wastes will not be disposed of in the C-746-U Landfill and will require either off-site disposal or disposal in a potential newly-constructed on-site disposal facility. The high-end volume scenario will account for a situation in which the C-746-U Landfill is unavailable due to economic, technical, or regulatory issues. This high-end volume also assumes that no potentially volume-reducing activities such as recycling, reuse, or reindustrialization are implemented.

Low-end Volume Scenario

The low-end volume scenario will involve assumptions that reduce the current base case waste forecast of 3.7 mcy. As discussed in Section 1.1, DOE plans to explore opportunities for waste reduction through treatment, recycling, or reuse of materials that otherwise would be disposed of as waste. Based on a preliminary evaluation, an estimated 25% of recoverable scrap metal potentially could be recycled. The following are the assumptions for calculating a low-end volume:

- Nonhazardous solid waste would be disposed of in the C-746-U Landfill (1.1 mcy).
- 25% of the forecasted scrap metal will be recycled (~120,000 yd^3).
- 25% of the concrete will be recycled/reused (~190,000 yd^3).
- Waste classified from a security standpoint will not be placed in an on-site facility (~190,000 yd^3).
- Five buildings in the D&D inventory, those used chiefly for administrative purposes (C-100, C-101, C-102, C-103, and C-720) would be retained for future reindustrialization (~200,000 yd^3).
- Waste volume is 10% less than the forecasted 3.7 mcy (~370,000 yd^3).

Totaling the impacts of all of these assumptions and subtracting from the 3.7 mcy base case forecast results in a low-end volume of 1.5 mcy.

These scenarios provide the following range of waste volumes:

- Low-end waste volume–1.5 mcy
- High-end waste volume–4.1 mcy

6.1.3 Analytical Profile

The volume of each regulatory classification of waste is estimated as shown in Table 5.2; however, to complete the evaluation of the On-Site Alternative, an analytical profile of the forecasted waste volume must be developed. A comparison of the radiological and chemical parameters in this profile to the preliminary WAC that will be developed will be used to estimate what percentage of the forecasted waste is likely to be accepted for disposal in an on-site disposal facility. The methods for developing the analytical profile are described Appendix D.

6.2 CURRENT DISPOSAL PRACTICES

Section 5.2 described the existing information that is available for the current disposal practices. This section indicates whether those data are sufficient and, if not, how the data gap will be filled.

6.2.1 Waste Disposal Facilities

DOE has established practices and procedures for disposing of waste at off-site facilities as described in Section 5.2.1. Sufficient data are available to support the evaluation of the continued use of off-site disposal in this evaluation. DOE does, however, intend to confirm that off-site disposal facilities that currently are being used have capacity for the forecasted waste volumes and confirm that these disposal facilities can meet predicted schedules for disposal of PGDP waste.

DOE has established practices and procedures for disposing of nonhazardous solid waste at the currently operating C-746-U Landfill as described in Section 5.2.1. There is sufficient capacity remaining in the C-746-U Landfill to accommodate the forecasted volume of nonhazardous solid waste. No additional information or data pertaining to the C-746-U Landfill is expected to be required in this evaluation.

6.2.2 Waste Packaging

DOE has established practices and procedures for packaging waste in preparation for off-site disposal as described in Section 5.3.2. Sufficient data are available to develop waste packaging scenarios for this evaluation.

6.2.3 Waste Transportation

DOE has established practices and procedures for transporting waste to off-site facilities either by rail or truck as described in Section 5.3.3. Sufficient data are available to develop waste transportation scenarios for this evaluation. DOE will estimate the risk related to on-site and off-site transportation.

6.2.4 Waste Preparation, Segregation, and Treatment

As stated in Section 5.2.4, waste preparation, segregation, and treatment are outside of the scope of this evaluation. No additional information will be required for this evaluation. The uncertainty of the reduction of the waste volume due to treatment and/or recycling was included in the range of waste volume scenarios discussed in Section 6.1.2.

6.3 DISPOSAL DECISIONS AT OTHER DOE SITES

Section 5.3 described the data that are available from other DOE sites that have conducted waste disposal evaluations. This section provides a determination of whether the best available data are sufficient to adequately evaluate alternatives in the FS. For example, surrogate data from Oak Ridge and characterization data from PGDP will be evaluated to determine if they are sufficient to develop waste profiles for characterizing the waste to be generated. Similarly, other data, such as preliminary disposal facility design, preliminary WAC development, cost information, will be evaluated for sufficiency or the need to fill data gaps. The technical determination of data sufficiency will be based on evaluation of the associated uncertainties weighed against capability to manage those uncertainties and the potential impacts on evaluation of the alternatives in the FS.

6.3.1 Oak Ridge

The CERCLA process was used at Oak Ridge to evaluate disposal alternatives, and the documents that were prepared will provide a data source from a similar waste evaluation and will be utilized to the extent practical during development of the On-Site Alternative at PGDP.

Personnel involved in the design, construction, and operations of the EMWMF may be contacted to obtain actual cost information during the development of a cost estimate for a potential on-site disposal facility.

6.3.2 Other DOE Sites

Section 5.3.2 described waste disposal evaluations at other DOE sites. Data from those sites will be used as needed for the On-Site Alternative, but the Oak Ridge data sources will be used the most extensively.

6.3.3 Data Sufficiency Evaluation

Disposal facility design and cost information from the Oak Ridge EMWMF are sufficient for the intended purpose of providing a basis for design of an on-site facility at PGDP and also for estimating the cost to design, construct, and operate such a facility. These data are applicable for a designed, constructed, and operating disposal facility for similar waste that will require disposal. Additionally, the information from EMWMF will be updated as required from available sources and modified as necessary for site-specific conditions at PGDP. Uncertainties associated with the design and cost data from EMWMF are related to differences between the site conditions, wastes received, volume of waste, availability and local costs of natural materials, risk evaluation, and regulatory requirements. These uncertainties will be mitigated by modifications to the baseline design and cost data from EMWMF to preliminarily account for differences in the sites and the requirements. Consequently, sufficient design and cost data are readily available such that no data gaps are identified requiring additional independent studies.

Characterization data are available from the PGDP Data Warehouse GIS Viewer (Paducah DWGIS) to develop a preliminary waste profile for some PGDP wastes, such as soil and sediment data from various OUs. Limited uncertainties are associated from these data collected from the OUs, but bounding conditions will be established through statistical evaluation to ensure waste characterization is complete. Some data are not presently available for the PGDP waste, such as waste from D&D and the BGOU. Surrogate data from waste profiles developed for waste disposed of at EMWMF will be used as the best available data because the Oak Ridge K-25 facility used a similar enrichment process and equipment as PGDP. Uncertainties associated with the use of these surrogate data generally are related to differences between the facility operations, routine maintenance, the level of enrichment (PGDP is a low-enrichment process whereas Oak Ridge was a high-enrichment process), and feedstock. Studies are available to assess the potential primary differences to mitigate these uncertainties, and assumptions will be developed to provide bounding conditions ensuring that the waste characterization data are appropriate.

Limited data from groundwater modeling at EMWMF are anticipated to be used to develop a preliminary WAC. Only the basic methodology and framework of the EMWMF models will be used as the foundation upon which site-specific data available from PGDP will be input. Data are available from several multi-year studies at PGDP for the primary groundwater model parameters. Sufficient data are anticipated to be available to develop a preliminary WAC adequate for evaluation of alternatives in the FS.

6.4 SITING/CONCEPTUAL DESIGN

6.4.1 Siting

In order to evaluate the technical feasibility and protectiveness of the On-Site Alternative, DOE must identify a viable location on which a disposal facility could be sited. It is uncertain which site(s) will be used in the RI/FS to evaluate the feasibility of an on-site waste disposal facility. In order to address this uncertainty, the 11 candidate sites presented in Section 5.4.1 will be subjected to a screening process. Two conference calls were held with the regulators in August 2009 to discuss and agree upon a Siting Study approach and criteria.

The goal of the site screening process will be to narrow the 11 candidate sites down to a single location to be evaluated in the FS. This would allow a more focused comparison between the Off-Site and On-Site Alternatives and would reduce information needs for the FS.

To properly evaluate and compare the existing 11 potential locations against the final screening criteria, it may be necessary to collect additional information to support the site screening process. Such information could include, for example, a study regarding the relocation of power lines, and possibly other information that may support or eliminate a location from further consideration as determined during the site screening process.

If it is not possible to narrow the candidate sites to a single location during the site screening process, the remaining viable locations would be included in the FS. The FS would present a more detailed evaluation and comparative analysis of the viable sites to support selection of a preferred location in the Proposed Plan. In this event, the site screening process that would identify uncertainties preventing the selection of one location and the information that would help decision makers discriminate between remaining viable sites. If more than one site is evaluated in the RI/FS, then a preliminary WAC, conceptual design, and cost estimate would be prepared for each site.

Because it is preferable to select a single site for inclusion in the RI/FS, it will be important to seek frequent regulator and public input throughout the site screening process. In addition to focusing the scope of FS analysis, this early screening approach will ensure that site screening and selection is responsive to stakeholder interests and concerns.

The process that will be used to screen candidate site for an on-site waste facility cell is described in Appendix E.

6.4.2 Conceptual Design

The existing data identified in 5.4.2 are sufficient to support conceptual design needs of the FS. A conceptual design will be prepared for one or more viable sites, as identified from the site screening process.

6.5 SEISMIC CONSIDERATIONS

Several items related to adequacy of existing seismicity data were identified during scoping discussions with the regulatory agencies. Both regional and local seismicity are important to the evaluation of the On-Site Alternative, particularly the siting and design criteria. As discussed in Section 5.5, DOE performed a seismic investigation in 2001 and 2003 that included both PGDP site-specific and regional components. The results of that study were presented in the SIR (DOE 2004), and a summary is included in Appendix B of this work plan. A seismic investigation also was performed for the C-746-U Landfill (DOE 2003a; KRCEE 2006) (Section 5.5.2). Because of these studies, a significant data set exists; however, not all of the methods used in the previous studies were approved or accepted by the regulatory oversight agencies. Issues that require clarification, recalculation, or possible additional data collection are as follows:

- Further justification for the presumed 0.5g liquefaction threshold value;
- Conclusions regarding Holocene faulting at PGDP;
- Hybrid deterministic/probabilistic ground motion modeling is not the preferred method; and
- PGDP site-specific bedrock shear wave velocity has not been collected.

These topics were discussed in the scoping meeting, and follow up teleconferences were held for focused discussions and to develop a path for resolution. A Seismic Issues Workshop was held in June 25, 2009. At this workshop there was considerable discussion of the approach and timing of obtaining site-specific shear wave velocity data and performing a seismic hazard analysis. Additionally, IRT recommendations were presented and discussed at the workshop. The path to resolve these issues based on these interactions is presented in this section. DOE will address these issues individually during the RI. An appendix that summarizes the resolution of the issues related to seismicity will be included in the RI/FS Report. The appendix will contain supporting information used to address the issues and conclusions that were considered in the evaluation of the disposal alternatives. Relevant information from applicable studies (by TVA, DOE, and the Kentucky Geologic Survey, etc.) will be included in this appendix. The Kentucky Geologic Survey will be contacted to assist in the identification of applicable non-DOE studies. Information expected to be included or summarized in the appendix is identified in the remainder of this section.

The previous CERCLA waste disposal alternatives evaluation (conducted from 2000 to 2004) was terminated after the final SIR (DOE 2004) was issued, but before the regulators could review and comment. The final SIR addressed comments on the draft SIR (DOE 2002b) and presented the results of supplemental field work conducted in 2003. DOE requested that the final SIR (DOE 2004) be reviewed by the regulators. Comments resulting from that review have been addressed. Responses to the comments received will be included in an appendix of the RI/FS report. Responses to comments on the SIR that affected the scope of work to be performed in the RI/FS have been incorporated into this work plan.

6.5.1 Liquefaction

DOE and the regulators agreed during the July 8, 2008, teleconference that no additional data were needed to resolve this issue, and the seismic experts selected by the Kentucky regulators would review the SIR (DOE 2004) to verify that the 0.5g value is fully justified. It is possible that the parties could confirm that the 0.5g value is adequately supported prior to DOE's issuing the draft RI/FS Report. If this issue is not resolved by that time, a comment to that effect would be submitted by Kentucky on the SIR. The comment then would be resolved along with other comments on that document, as outlined previously.

6.5.2 Holocene Faulting

As described in Section 5.5.2, no research or data collection related to Holocene faulting is planned for the RI. The results of two site-specific fault investigations at PGDP have concluded that Holocene-age faults were not identified (DOE 2004; KRCEE 2006).

6.5.3 Ground Motion Modeling

Ground motion modeling was discussed in the Seismic Issues Workshop. Subsequent to the Workshop, DOE determined the appropriate approach would be to utilize the results of existing seismic hazard analyses for RI/FS purposes (see Table 5.5).

It was agreed at the above referenced workshop that additional ground motion modeling would be required to support site-specific characterization and design of a disposal facility if on-site disposal were selected in the ROD. This site-specific study would be performed in a purely probabilistic manner and result in an updated seismic hazard curve for PGDP and a value for the PGA at the top of bedrock with a return period of 2,500 years. The ground motion modeling will use a well-characterized, accessible, and accepted algorithm, such as SHAKE 91. In addition to the PGA described above, this modeling would incorporate a site-specific bedrock shear wave velocity (Section 6.5.4). The ground motion modeling will incorporate the shear-wave velocity profile for the unconsolidated materials above the bedrock that was collected during the Site 3A seismic investigation (DOE 2004); however, the need for collection of additional shear-wave velocity information would be established as part of the remedial design process. Finally, the IRT recommendation concerning ground motions near 1 Hz being near the fundamental frequency of the potential disposal cell also would be considered when determining this design ground motion information (see Section 6.5.5).

6.5.4 Bedrock Shear Wave Velocity

Based on scoping discussions, the regulators believe a PGDP-specific bedrock shear wave velocity should be collected. DOE and the regulators agreed that measurement of bedrock shear wave velocity at a single site at the PGDP would be adequate because bedrock is consistent across the site. It is assumed that the bedrock shear wave velocity will be required to support the ground motion modeling as described in Section 6.5.3 as a post-ROD activity. Bedrock shear wave velocity measurements will be required as a post-RI/FS activity to support the ground motion modeling described in Section 6.5.3.

DOE plans to conduct a sensitivity analysis to justify this assumption. The sensitivity analysis is intended to determine the effects of a range of bedrock shear wave velocities on the surface PGA for PGDP. The approach and details of how this will be completed are detailed in Appendix F.

6.5.5 DOE Independent Review Team Recommendations

The findings of the IRT recommendations were discussed in June 2009 Seismic Issues Workshop. The IRT findings presented at that workshop are included in Appendix F of this work plan. These findings will be incorporated into the RI/FS report as appropriate.

6.6 HYDROGEOLOGIC/GEOTECHNICAL DATA

Hydrogeologic data such as depth to groundwater and groundwater gradient are needed for input parameters to support groundwater modeling when developing a preliminary WAC and for the design of a monitoring well network. Geotechnical data provide information on soil conditions at a site that are used to assess criteria such as susceptibility to seismic events, subsidence, compaction, soil reuse for construction, etc. This data is needed to evaluate the On-Site Alternative.

The availability of hydrogeological and geotechnical data was discussed in Section 5.6. During the scoping discussions, it was noted that there may be limited hydrogeologic and geotechnical data currently available for some of the sites that are considered viable for an on-site waste disposal facility. This section provides the methods used to determine if and when additional data will be collected to support the RI/FS report.

As noted in the following subsections, GEO Consultants, LLC, (GEO 2009) performed an evaluation of existing hydrogeologic and geotechnical data. The conclusion of that evaluation found sufficient data exist to conduct an RI/FS but recommended that additional data would be needed at a specific site if the On-Site Alternative were the selected remedy. The GEO report has been transmitted to Kentucky and EPA regulators.

6.6.1 Hydrogeologic Data

There is currently sufficient hydrologic data in the northern hydrogeologic setting to proceed with groundwater modeling and associated RI/FS activities. Hydrogeologic data for the southern setting are limited but was found to be adequate to complete associated RI/FS activities for potential sites in the southern hydrogeologic setting as concluded by an assessment of data adequacy prepared by GEO. The results of the evaluation of the existing hydrogeology data will be provided in an appendix of the RI/FS report to demonstrate the adequacy of existing information to develop a preliminary WAC.

6.6.2 Geotechnical Data

The regulators stated in the June 12, 2008, teleconference that they believe a more simplified analysis should be evaluated using blow counts from each borehole rather than averaging blow counts for soil units from multiple boreholes (the approach used in DOE 2004). To address this issue, a map showing the distribution of blow count data within Site 3A was developed and has been distributed to the regulators. A summary of the analysis and its results will be included in the RI/FS Report.

The results of an evaluation by GEO of the existing geotechnical data will be provided in an appendix of the RI/FS report to demonstrate the adequacy of existing information to develop a preliminary WAC and conceptual design.

6.7 PRELIMINARY WASTE ACCEPTANCE CRITERIA/MODELING

Appropriate risk assessment/modeling methods will be utilized in the development and evaluation of the On-Site Alternative. These risk assessment methods will be used to assess the post-closure performance of the potential disposal facility, predict compliance with the performance standards that have been determined to be applicable to the potential on-site disposal facility, and develop preliminary risk-based contaminant-specific WAC for a potential on-site disposal facility. The methods for developing the analytical profile are described in Appendix D. The analytical profiles will be used to identify COCs for modeling associated with the preliminary WAC development process. A list of existing risk assessments is presented in Appendix G.

The details of the proposed groundwater modeling process are provided in Appendix C. A summary of the modeling process is provided below.

The waste contaminants of interest will be selected from the analytical waste profiles discussed in Section 6.1.3. Surrogate groups will be developed for the organic chemicals so that each surrogate chemical group contains chemicals with similar properties such as solubility, volatility, and mobility. A representative chemical will be selected to represent each surrogate group. Surrogate groups will not be developed for metals or radionuclides. Instead, each metal and radionuclide will be evaluated in the modeling process.

Several models will be required to evaluate the infiltration through the waste in the disposal cell (i.e., HELP Model); contaminant transport from the waste to the RGA (i.e., DUSTMS model); and transport of the contaminants in the RGA to the receptor points of interest (i.e., MODFLOW, MODPATH and AT123D models). The modeling process will provide groundwater concentrations at the receptor points for metals, radionuclides, and indicator chemicals. The dilution attenuation factors (DAF), based on the predicted groundwater concentrations for the indicator chemicals, will be used to determine the groundwater concentrations for the remaining chemicals in the surrogate groups.

Target cancer risk, non-cancer hazard levels, and MCLs will be used to back calculate the allowable waste concentrations for the preliminary WAC for the groundwater child rural resident. The cancer risk values will be selected from the EPA acceptable range of 10^{-6} to 10^{-4} cancer risk, hazard levels of 1 to 3, or the MCL when available for a contaminant. The target values chosen will be justified commensurate with uncertainties in the analysis.

The following sources of information are expected to be used:

- Stakeholder input
- Existing risk assessments
- PGDP geologic and hydrogeologic information and data
- Relevant waste profiles from Paducah and other sites (K-25 in Oak Ridge)
- Waste generation forecasts
- Preliminary WAC modeling at other sites (EMWMF in Oak Ridge)
- Process knowledge

Adequate information exists to develop a preliminary WAC model to support the FS for areas north of the Terrace; and as noted in Section 6.6.1, information is adequate for areas south of the Terrace as well (GEO 2009). If the On-Site Alternative is selected, a full probabilistic analysis to support the development of the final WAC will be conducted for the selected site for the waste disposal facility.

6.8 WASTE DISPOSAL COST

Cost estimates will need to be prepared for the No Action, Off-Site, and On-Site Alternatives. A primary component of the costs will be the volume of waste, the associated characteristics of the waste and the waste type. The waste volume data are available, as discussed in Section 5.1. When cost estimates are prepared, the range of waste volumes presented in Section 6.1 will be used to address uncertainties regarding the amount of waste that actually will be generated by the CERCLA activities conducted at PGDP. Waste volumes requiring disposal are predicted to range from a minimum volume of 1.5 mcy (the low-end volume) to a maximum volume of 4.1 mcy (the high-end volume); these volume estimates will be updated in the RI/FS report as appropriate. In order to include this range of waste volumes in this evaluation, both a low-end waste volume scenario and a high-end waste volume scenario, will be developed and evaluated for the Off-Site and On-Site Alternatives in the RI/FS Report. The low-end volume scenario and No Action Alternative assume the C-746-U Landfill is operating and has sufficient capacity to accept the nonhazardous solid waste volume.

The costs to operate, monitor, expand, close, and provide post-closure care for the C-746-U Landfill will be included in the Off-Site and On-Site Alternative low-end waste volume scenario estimates and the No Action Alternative. Costs to dispose of waste off-site that does not meet the C-746-U Landfill WAC will be included for the No Action and Off-Site low-end volume scenario. For the high-end volume scenarios, the C-746-U Landfill is assumed to be unavailable, and the costs for the nonhazardous solid waste volume will be disposed of as LLW to an off-site waste disposal facility for the Off-Site Alternative and to a new CERCLA waste disposal facility for the On-Site Alternative. The waste volumes from 2014 to 2039, as discussed in Section 6.1.1, will be used to develop the cost estimates for the alternatives.

Detailed cost estimates of the alternatives will be provided in an appendix of the RI/FS report. Wastes being shipped off-site will include the cost of containers, transportation, and disposal fees. Assumptions on the container types used and packing efficiency will be provided. The on-site estimate will include design and planning, site development, construction, operations and maintenance, monitoring, closure, and post-closure care. If more than one site is evaluated in the RI/FS, cost estimates would be prepared for each site.

The labor to perform D&D and restoration activities will not be included in the estimates since these costs would be the same for all the alternatives. Disposing of wastes off-site would involve costs to transport the wastes from the point of generation to staging/loading onto a railcar or truck and waste certification tasks; however, that cost is roughly equivalent to loading a roll-off bin and transporting the waste to an on-site waste disposal facility. None of the estimates will include that cost component since it is not a differentiating aspect. Treatment of waste, if needed, will be the responsibility of the generator and will not be included in any of the cost estimates because it is not a differentiating element when evaluating the cost of the alternatives.

The alternative cost analysis will follow the guidance presented in the U.S. Office of Management and Budget (OMB) Circular No. A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*, regarding performance of cost-effectiveness and net present value analysis. The circular (OMB-No. A-94) defines cost-effectiveness analysis as “a systematic quantitative method for comparing the costs of alternative means of achieving the same stream of benefits or a given objective” and states that, “A program is cost-effective if, on the basis of a life cycle cost analysis of competing alternatives, it is determined to have the lowest costs expressed in present value terms for a given amount of benefits.”

6.8.1 Off-Site Disposal

The No Action and Off-Site Alternatives cost will be based on current waste disposal methods and costs at PGDP. As presented in Section 5.8.1, existing contracts are in place as well as established methods for procuring transportation and containers. For the No Action and the low-end volume scenario, the off-site packaging, transportation, and disposal will include only CERCLA-generated LLW, MLLW, hazardous, and TSCA wastes. The nonhazardous solid waste is assumed to be disposed of at the C-746-U Landfill. The cost analysis for these wastes will include evaluation of the various options, which are dependent upon the disposal facility used, containers used, and transportation method. These options will result in different cost scenarios. The most cost effective combination will be used for the final estimate. When preparing the cost estimate for the off-site high-end volume, the cost to dispose of nonhazardous solid waste in an off-site facility will be included in addition to the waste types described above.

NTS is the only available off-site disposal facility alternative for classified wastes. Transportation of classified waste, therefore, can be completed only by truck and costs more than transporting LLW by truck. However, the estimate can compare container costs to determine the most cost effective option between using B-25/ST-90 versus Sealand containers.

Due to uncertainties related to obtaining free release of waste from PGDP, RCRA and TSCA wastes will be assumed to be disposed of as MLLW for cost estimating purposes. Free release refers to clearance of the material from DOE regulatory control. Waste materials going off-site to an entity that does not possess a radioactive materials license (i.e., Subtitle D landfill) would need to meet the requirements of DOE Order 5400.5 for unrestricted release. A set of volumetric authorized limits would need to be established for the release of this material in accordance with 5400.5 requirements.

6.8.2 C-746-U Landfill

For the purposes of the alternatives cost comparison, the cost of C-746-U Landfill operation, monitoring, expansion, closure, and post-closure care will be included in the No Action and low-end volume estimates for the Off-Site and On-Site Alternatives. For both the action alternatives, the low-end volume scenario will assume disposal of all nonhazardous solid waste in the C-746-U Landfill. Similarly, the No Action Alternative also assumes disposal of all nonhazardous solid waste in the C-746-U Landfill. When preparing the cost estimates for the high-end volume, the nonhazardous solid waste will include off-site disposal costs for the Off-Site Alternative, and all nonhazardous solid waste will be included for disposal in the CERCLA waste disposal facility for the On-Site Alternative.

6.8.3 On-Site Disposal

The On-Site Alternative will involve multiple components to develop a cost. A conceptual design will be used to determine materials and quantity of items such as cap thickness, geologic buffer thickness, liners, etc. The On-Site Alternative assumes a disposal facility will be designed as a LLW, RCRA hazardous waste/TSCA-compliant disposal facility. Provisions to accept classified waste also will be included. Site development costs will be included and, if more than one site is considered, there may be cost savings or increases depending upon the site-specific conditions. Items such as the tree and brush clearing, relocation of overhead power lines, existing utilities that can be used, existing roads etc., all will be considered. If more than one site is viable after the site screening, conceptual designs and costs will be developed for each site. For the low-end volume, the nonhazardous solid waste is assumed to be disposed of at the C-746-U Landfill. For the high-end volume, it will be assumed that all of the nonhazardous solid waste will be disposed of in the new on-site waste disposal facility.

Costs will be developed for planning and coordination; site investigations; development of plans [operation and maintenance (O&M), monitoring, design, etc.]; site development; construction; operations; monitoring; closure; and post-closure elements. Details of the specific elements and assumptions for each of these items will be included in the RI/FS Report.

Based on the Oak Ridge On-Site Alternative, a portion of the waste will not meet the WAC of the on-site facility and, therefore, will require off-site disposal. For the PGDP On-Site Alternative, the assumption is that 5% of the waste volume will not meet the WAC and will require off-site disposal. That cost will be included in the On-Site Alternative. Uncertainties associated with this assumption are primarily related to the physical, chemical, and radiological characteristics of wastes generated after decommissioning of PGDP, when compared to a WAC that would be developed for an on-site disposal facility if selected as the preferred remedy. In the RI/FS, waste profiles with estimated concentrations for the COCs and a preliminary WAC will be developed for the On-Site Alternative to evaluate this uncertainty.

7. ALTERNATIVES EVALUATION

Under CERCLA, preferred remedial alternatives are selected by studying the feasibility of a range of alternatives. The process for conducting a CERCLA FS is described in 40 *CFR* § 300.430(e). An FS will be conducted to determine the preferred disposal alternative for CERCLA waste generated at PGDP.

As stated previously, three alternatives will be evaluated—No Action, Off-Site, and On-Site.

The No Action Alternative involves the continuation of coordinated project-by-project disposal for CERCLA waste. For the purposes of the evaluation, it is assumed that the on-site C-746-U Landfill will continue to operate and receive waste that meets its WAC. Waste not meeting the C-746-U Landfill WAC will be disposed of off-site. Under CERCLA, a No Action Alternative is required to provide a baseline for comparison with other alternative actions. The No Action Alternative, if selected, would require no changes to current waste disposal practices.

The Off-Site Alternative includes two waste volume scenarios for comparison purposes: (1) a high-end waste volume scenario (4 mcy) for which CERCLA waste is assumed to be shipped off-site; and (2) a low-end waste volume scenario (1.5 mcy), which assumes various waste reduction actions, continued use of the C-746-U Landfill for nonhazardous solid waste disposal, and off-site disposal of CERCLA waste that does not meet the C-746-U Landfill WAC.

The On-Site Alternative involves the disposal of CERCLA waste into a newly constructed on-site waste disposal facility located on DOE-owned property. The On-Site Alternative includes two waste volume scenarios: (1) a high-end waste volume scenario for which CERCLA waste would be disposed of in a newly constructed on-site disposal facility; and (2) a low-end waste volume scenario, which assumes various waste reduction actions, continued use of the C-746-U Landfill, and disposal of CERCLA waste that does not meet the WAC of the C-746-U Landfill in a newly constructed on-site disposal facility.

During the FS, these alternatives will be developed further using information compiled in the RI. Once the alternatives have been fully developed, a detailed analysis will be performed. Under the detailed analysis, the alternatives then will be evaluated individually with respect to the threshold and balancing CERCLA criteria described in this section. Then a comparative evaluation will be conducted to determine the relative merits and weaknesses of the alternatives. The results of the detailed analysis will support selection of the most appropriate alternative.

7.1 DETAILED ANALYSIS OF ALTERNATIVES

CERCLA requires that nine criteria, as defined March 8, 1990, in the final NCP, be used to evaluate the expected performance of remedial actions. The criteria are categorized as threshold, balancing, and modifying criteria. The nine criteria are identified in the following discussion.

7.1.1 Threshold Criteria

According to 40 *CFR* § 300.430(f)(1)(i)(A), these threshold criteria must be met in order to be considered.

(1) **Overall protection of human health and the environment**. This criterion requires that the alternative adequately protect human health and the environment [40 *CFR* § 300.430(e)(9)(iii)(A)].

Each alternative will be evaluated against this evaluation criterion to assess whether adequate protection of human health and the environment is provided. The overall analysis of protection will consider the assessments conducted under other evaluation criteria (described below), especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

(2) **Compliance with ARARs (unless a specific ARAR is waived)**. Congress specified in CERCLA §121 that remedial actions for cleanup of hazardous substances must comply with requirements, criteria, standards, or limitations under federal or more stringent state environmental laws that are applicable or relevant and appropriate to the hazardous substances or circumstances at a site [40 *CFR* § 300.430(e)(9)(iii)(B)] unless a waiver is granted.

Each alternative will be assessed against this evaluation criterion to determine whether it meets federal and state ARARs. A discussion of ARARs is found in Appendix A. The detailed analysis will summarize which requirements are applicable or relevant and appropriate and how these requirements will be met. If an ARAR is not met, a basis may be presented for justifying one of the six waivers allowed under CERCLA. It is expected that a waiver of the TSCA requirement for the bottom of a disposal cell to be 50 ft above the historically high groundwater table will be submitted to support the On-Site Alternative. A waiver of this ARAR was granted for the EMWMF in Oak Ridge.

7.1.2 Balancing Criteria

Alternatives will be evaluated using the balancing criteria [40 *CFR* § 300.430(f)(1)(i)(B)]. The balancing criteria will evaluate the alternatives in terms of the following five qualities.

(3) **Long-term effectiveness and permanence**. This criterion normally focuses on the magnitude and nature of the risks associated with untreated waste/treatment residuals. This criterion includes consideration of the adequacy and reliability of any associated engineering controls, such as monitoring and maintenance requirements [40 *CFR* § 300.430(e)(9) (iii)(C)].

The evaluation of alternatives against this criterion will focus on the risk remaining at disposal sites after waste is disposed of and the disposal facilities are closed. For the On-Site Alternative evaluation, this criterion will be defined as the time following disposal cell closure, when “active” cell monitoring and maintenance are assumed to cease. The term “active” refers to planned and systematic actions performed on-site after closure, such as inspections, groundwater monitoring, cover maintenance, pond sediment removal, etc. Appendix C details the modeling that will be performed to evaluate this criterion for the on-site disposal alternative. Off-site disposal facilities will be qualitatively evaluated under the assumptions that they have been operated in accordance with permits and licenses, are closed in accordance with plans, and perform consistently with their modeled performance after closure.

Two components of this criterion will be addressed for the alternatives:

Magnitude of risk–This factor assesses the risk from waste contained in the disposal facilities. This risk will be measured by cancer risk levels and non-cancer hazards.

Adequacy and reliability of controls–This factor assesses the adequacy and suitability of controls that are used to manage waste contained in the disposal facilities. It will include an assessment of the long-term reliability of containment systems and institutional controls to determine if they provide adequate protection to human and environmental receptors. The requirements and duration for post-closure care would be established after it is determined if an on-site facility is feasible. These requirements for the post-closure care period would be established either in the RI/FS Report or in the ROD.

The risk posed by contamination left in-place following CERCLA response actions at release sites (i.e., residual risk at other PGDP OU response actions sites) will be assessed by the OU to which the contamination is assigned.

(4) **Reduction of contaminant toxicity, mobility, or volume through treatment**. This criterion evaluates the degree to which the alternative employs treatment to reduce the toxicity, mobility, or volume of contamination [40 *CFR* § 300.430(e)(9)(iii)(D)].

Because this project was initiated solely for the purpose of evaluating disposal alternatives and treatment options are not considered, this criterion will not be used to select the preferred alternative. Decisions regarding the treatment of waste generated by the various OUs will be made by the waste generator.

(5) **Short-term effectiveness.** This criterion evaluates the effect of implementing the alternative relative to potential risks to the general public, potential threat to workers, and time required until protection is achieved [40 *CFR* § 300.430(e)(9)(iii)(E)].

This evaluation criterion considers the impacts of the alternative's construction and implementation phase on human health (including members of the public and response action workers) and the environment. It considers the potential transportation risks during the conveyance of materials to off-site disposal facilities and the length of time required to achieve the response action. For the purpose of evaluating NEPA values, DOE will consider economic impacts to the PGDP area from the implementation of the disposal alternatives, such as the creation of jobs.

(6) **Implementability.** This criterion reviews potential difficulties associated with implementing the alternative. These difficulties may involve technical feasibility, administrative feasibility, and availability of services and materials [40 *CFR* § 300.430(e)(9)(iii)(F)].

The following are evaluated under this criterion:

<u>Technical feasibility</u>

- Construction and operation difficulties associated with the technology utilized in the alternative
- Reliability of technology utilized in the alternative (e.g., whether technical problems associated with implementation lead to schedule delays)
- Ability to monitor the effectiveness of the remedy including an evaluation of the risks of exposure should monitoring be insufficient to detect a system failure

<u>Administrative feasibility</u>

- Complexity of coordination with other offices and agencies to implement the alternative (e.g., obtaining permits and approvals)

<u>Availability of services and materials</u>

- Availability of adequate disposal capacity

- Availability of necessary materials, equipment, and specialists
- Potential for obtaining competitive bids for implementing the alternative

(7) **Cost.** This criterion weighs the capital cost, annual O&M, and the combined net present value [40 *CFR* § 300.430(e)(9)(iii)(G)].

The cost estimate will provide an accuracy of +50% to -30 %. Expenditures will be evaluated using a present worth analysis. The U.S. Office of Management and Budget rate will be used.

After the present worth of each remedial action alternative is calculated, the cost of each alternative will be evaluated through a sensitivity analysis to account for uncertainties associated with the waste volume forecast.

7.1.3 Modifying Criteria

These criteria allow for the influences of the community and the state.

(8) **State acceptance.** This criterion requires the consideration of any comments by the state regarding any action to be performed [40 *CFR* § 300.430(e)(9)(iii)(H)].

(9) **Community acceptance.** This criterion requires the consideration of any comments by the community regarding any action to be performed [40 *CFR* § 300.430(e)(9)(iii)(I)].

Evaluation of these modifying criteria will be conducted in the Proposed Plan and the ROD. The public and Kentucky will be involved in the development of the RI/FS. The public is afforded a formal review and comment when the Proposed Plan is released.

7.2 NEPA

While NEPA values will be incorporated throughout the RI/FS, there will be particular focus on the values during the detailed analysis. Alternative evaluation against the CERCLA “long-term effectiveness and permanence” and “short-term effectiveness” criteria will consider the following NEPA values:

- Impacts to cultural, ecological, and archeological resources;
- Impacts to transportation systems;
- Impacts to visual aesthetics and ambient noise levels;
- Impacts to long-term environmental effects;
- Socioeconomics and land use; and
- Irreversible and irretrievable commitment of resources.

Cumulative impacts also will be analyzed during the FS to assure NEPA values are addressed.

7.3 FORMAT FOR THE REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT

Appendix H provides a draft outline for the RI/FS Report. The outline follows, to the extent practical, Appendix D of the FFA (EPA 1998). The FFA outline was modified in consideration of the evaluation’s focus on disposal alternatives.

7.4 SCHEDULE/TIMING FOR CONDUCTING THE STUDY

When the RI/FS Work Plan has been approved by EPA and Kentucky regulators, the RI will be initiated. Information gathered during the RI will be used in the execution of the FS. The results of the FS and RI will be documented in an RI/FS Report and submitted to the EPA and Kentucky regulators for review and comment. Figure 2.2 provides the schedule of key dates for the disposal alternative evaluation.

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8. COMMUNITY RELATIONS PLAN

Community relations and communication requirements for this and all other CERCLA response actions at PGDP are described in the current *Community Relations Plan Under the Federal Facility Agreement at the U.S. Department of Energy Paducah Gaseous Diffusion Plant*, DOE/LX/07-2099&D2/R6. This project will perform additional public involvement activities beyond those required by CERCLA or the Community Relations Plan.

Community relations and public participation plans will evolve throughout the life of the project based on stakeholder input. The information here summarizes the actions to date and currently planned actions.

8.1 PUBLIC INVOLVEMENT

DOE anticipates that the public interest will be high. Realizing the importance of seeking feedback from the public, three public information workshops will be part of the RI/FS process. These workshops will supplement standard CERCLA public participation activities. Both standard CERCLA activities and the supplemental activities are listed in Table 8.1.

Table 8.1. Public Involvement in the CERCLA Waste Disposal Alternatives Evaluation

CERCLA Process Steps	Public Involvement
Prior to commencement of RI/FS (Issue D1 Scoping Document)	Public notice of Administrative Record open and available in newspaper of general circulation (i.e., *The Paducah Sun*)
RI/FS Work Plan development	Public information workshop 1*
D1 RI/FS Work Plan	Public information workshop 2*
D1 RI/FS Report	Public information workshop 3*
Issue Proposed Plan	Public notice in newspaper of general circulation (i.e., *The Paducah Sun*); open public comment period; host public meeting*
Issue ROD (including comment responsiveness summary)	Public notice of ROD availability in newspaper of general circulation (i.e., *The Paducah Sun*)

*Supplemental RI/FS public involvement activity not required by CERCLA

All D1 and D2 documents are transmitted to the CAB at the same time as they are transmitted to the regulatory agencies.

The first information workshop was held in November 2008. This meeting introduced the RI/FS in context of the overall PGDP CERCLA process and provided an explanation of why an RI/FS is needed. The second public information workshop, held in March 2009, was more focused on the general siting study approach and siting considerations, along with the RI/FS for waste disposal alternatives. It announced the availability of the work plan and solicited comments on the document. A meeting was held on October 22, 2009, with a CAB member to discuss the comments on the D1 Work Plan. Special emphasis will be placed on gathering input for the siting study, as described in Section 6.4.1 of the Work Plan. A presentation summarizing the siting study process and seismic issues was discussed at a CAB meeting in November 2009. The third public information workshop will be held shortly after submittal of the D1 RI/FS Report. The goal of this meeting will be to (1) announce the availability of the report, (2) summarize the contents of the report, and (3) solicit feedback on the report.

8.2 EDUCATIONAL MATERIALS

Educational materials have been developed to enhance public participation. These materials include a glossary of acronyms and technical terms associated with the RI/FS. This glossary was available for the public at the second public workshop and will be available for the third workshop. This glossary also is available at the Environmental Information Center and on the LATA Kentucky and CAB Web sites. An artist's rendering of an on-site disposal facility in a digital, interactive format was presented at the second public workshop to help stakeholders visualize the On-Site Alternative.

8.3 COMMUNICATION TOOLS

The notice of Administrative Record availability was mailed to local residents and also published in *The Paducah Sun* on May 25, 2008. Links have been established on the LATA Kentucky and CAB Web sites providing access to information regarding the project and public outreach activities. Newspaper notices announcing the workshops have been and will continue to be published in *The Paducah Sun*. The website www.pgdpcleanup.com debuted in November 2008. It contains information about this and other projects and an online comment form. Television and radio communications also may be implemented when deemed appropriate.

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APPENDIX A

PRELIMINARY IDENTIFICATION OF APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO BE CONSIDERED GUIDANCE

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ACRONYMS

ARAR	applicable or relevant and appropriate requirement
ARPA	Archaeological Resources Protection Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
ESA	Endangered Species Act
FR	*Federal Register*
FWCA	Fish and Wildlife Coordination Act
KAR	*Kentucky Administrative Regulation*
LLW	low-level waste
NAGPRA	Native American Graves Protection and Repatriation Act
PGDP	Paducah Gaseous Diffusion Plant
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
TBC	to be considered
TSCA	Toxic Substances Control Act
USC	*United States Code*
WAC	waste acceptance criteria

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A.1. INTRODUCTION

The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), as amended, Section 121(d) specifies, in part, that response actions for cleanup of hazardous substances, pollutants, or contaminants must comply with requirements, standards, criteria, or limitations under federal or more stringent state environmental laws that are applicable or relevant and appropriate to the hazardous substances or particular circumstances at a site, or obtain a waiver. All CERCLA response actions must satisfy two threshold criteria: (1) the selected remedy must attain applicable or relevant and appropriate requirements (ARARs), unless a waiver is sought and granted; and (2) the selected remedy must be protective of human health and the environment. CERCLA § 121(d)(4) provides six ARARs waiver options that may be invoked.

ARARs include those federal and state environmental laws/regulations that are designed to protect members of the public and the environment. ARARs do not include occupational safety or worker radiation protection requirements. Occupational safety requirements will be addressed in the required health and safety plans for any action.

The following terms are used throughout this appendix.

- **Applicable requirements.** Are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal environmental, state environmental or facility siting law that are legally applicable and specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site (40 *CFR* § 300.5).

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

- **To be considered (TBC) guidance**. In addition to federal or state-promulgated regulations, there are other advisories, criteria, or guidance to be considered for a particular release that were developed by the U.S. Environmental Protection Agency, other federal agencies, or states that may be useful in developing CERCLA remedies. Published unpromulgated information that does not necessarily meet the definition of an ARAR may be necessary, under certain circumstances, to determine what is protective of human health and the environment. These are not potential ARARs, but are TBC guidance [40 *CFR* § 300.400(g)(3)].

The purpose of the Remedial Investigation/Feasibility Study (RI/FS) will be to evaluate the disposal options for wastes generated at the Paducah Gaseous Diffusion Plant (PGDP) from future Federal Facility Agreement (FFA) response actions to be taken at the site. CERCLA waste expected to be generated during response actions at PGDP includes low-level radioactive waste, solid or hazardous waste regulated by the Resource Conservation and Recovery Act (RCRA), waste regulated by the Toxic Substances Control Act (TSCA), and/or combinations of these waste types. All waste streams are subject to security classification either as classified or nonclassified. Classified waste generated through a CERCLA action is included in the base case waste volume forecast.

This appendix supplies a preliminary discussion of available federal and state ARARs considered for the evaluation of the On-Site, Off-Site, and No Action Alternatives as part of the work plan development. Identification of ARARs is an iterative process that continually changes as the RI/FS progresses.

A.2. ON-SITE ALTERNATIVE

Pursuant to CERCLA § 121(e), response actions conducted entirely on-site, as defined in 40 *CFR* § 300.5, must comply with the substantive portions of ARARs, but are exempt from the procedural or administrative requirements. The On-Site Alternative consists of waste disposal of hazardous, TSCA, and low-level waste (LLW) in a newly constructed on-site disposal facility for wastes from cleanup from FFA projects located across PGDP. CERCLA § 121 (e)(1) states that permits for the disposal of such waste in an on-site facility will not be required.

A.2.1 CHEMICAL-SPECIFIC ARARS

"Chemical-specific ARARs are usually health- or risk-based numerical values or methodologies, which, when applied to site-specific conditions, result in the establishment of numerical values" [53 *FR* 51394, 51437 (December 21, 1988)]. These requirements generally set protective cleanup levels for chemicals of concern in designated media or otherwise indicate a safe level of discharge that may be incorporated when considering a specific remedial activity. The scope of this work plan focuses on the disposal alternatives for CERCLA waste that will be generated from future response actions. Accordingly, because there is no single operable unit or medium being remediated, there are no chemical-specific ARARs for cleanup levels that will be developed for media in the RI/FS. Chemical-specific ARARs for individual CERCLA actions across the PGDP will be developed on a project-specific basis and presented in project-specific CERCLA documentation.

A.2.2 LOCATION-SPECIFIC ARARS

Location-specific ARARs generally are restrictions placed upon the concentration of hazardous substances or the conduct of activities solely because they are in special locations [53 *FR* 51394, 51437 (December 21, 1988)]. The potential location-specific ARARs discussed here are based on the siting of an on-site waste disposal facility on the U.S Department of Energy (DOE) site.

A.2.2.1 Wetlands

Wetland areas have been identified at PGDP. If any action were to impact wetlands, the requirements of 10 *CFR* § 1022 would be an ARAR. Activities will be designed to avoid or minimize impacts to wetlands identified at PGDP. The requirements in 10 *CFR* § 1022 instruct DOE to avoid, to the extent possible, adverse impacts associated with the destruction of wetlands and the occupancy and modification of wetlands. In the event that wetlands would be impacted, mitigation activities would be incorporated into facility design where such impact occurs. If any action involves the discharge of dredge or fill material into waters of the U.S., 40 *CFR* § 230.10 would be an ARAR.

A.2.2.2 Floodplains and Streams

Floodplain protection as described in 10 *CFR* § 1022 requires that floodplain values be protected to the extent possible. If the on-site waste disposal alternative is selected and would impact a designated floodplain, the substantive requirements found in 10 *CFR* § 1022 would be considered ARARs.

The siting of a new waste site or facility is prohibited from restricting the flow of the 100-year flood, reducing the temporary water storage capacity of the floodplain, or being locating in a manner likely to result in a washout of waste (401 *KAR* 30:031 § 2).

A.2.2.3 Fish and Wildlife

The Fish and Wildlife Coordination Act [(16 *USC* 661-667(e)] requires federal agencies to consider the effect of water-related projects upon fish and wildlife resources and to take action to prevent loss or damage to these resources. Activities that may impact fish and wildlife include impoundment, diversion of a stream, deepening of a channel, or other control or modification of any body of water.

A.2.2.4 Threatened or Endangered Species

Animal species and their critical habitats identified under the Endangered Species Act (ESA) (16 *USC* 1531 *et seq.*) have been identified in the vicinity of the PGDP. The ESA provides for the protection from extinction of threatened and endangered species.

Pursuant to the ESA, federal agencies must generally ensure that their actions are not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction of critical habitat for such species. Only the substantive provisions of the ESA apply to on-site actions.

While Kentucky has separate statutes governing endangered animals and plants, no state list has been promulgated. Kentucky regulation, at 401 *KAR* 30:031 § 3, prohibits waste sites or facilities from taking federally listed endangered or threatened species or adversely impacting their critical habitat.

The Migratory Bird Treaty Act prohibits the unlawful killing, taking, possession, and sale of migratory bird species, as defined in 50 *CFR* § 10.13, native to the United States or its territories.

A.2.2.5 Protection of Historic Property and Archeological Resources

Federal agencies are required to consider the effects of their actions on properties included or eligible for inclusion on the National Register of Historic Places (36 *CFR* § 63). The requirements of the National Historic Preservation Act may be considered ARARs for any remedial activity that would impact a designated historical property at PGDP.

The Archaeological and Historic Preservation Act of 1974 (16 *USC* 469) provides for the preservation of historical and archaeological data that might be irreparably lost or destroyed as a result of alterations of terrain caused by the federal construction of a dam or other alteration caused by federal construction projects.

The Native American Graves Protection and Repatriation Act (NAGPRA) (25 *USC* 3001 *et seq.*) governs Native American remains and objects found on federal lands. Upon inadvertent discovery, all activity in the area must cease until the site and artifacts are properly evaluated [25 *USC* 3002(d)]. The substantive provisions of the NAGPRA may be considered ARAR for the inadvertent discovery of Native American remains and objects.

A.2.2.6 Seismic Considerations

The general facility standards in 401 *KAR* 34:020 § 9(1) stipulate that a waste disposal facility cannot be located within approximately 200 ft of a fault that has had displacement in Holocene time.

A.2.3 ACTION-SPECIFIC ARARS

Action-specific ARARs usually are technology- or activity-based requirements or limitations on actions taken with respect to hazardous wastes or requirements to conduct certain actions to address particular circumstances at a site. [53 *FR* 51394, 51437 (December 21, 1988)]. Selection of a particular action at a site would invoke appropriate action-specific ARARs that may specify particular performance standards or technologies.

Under the On-Site Alternative, most future generated CERCLA waste would be disposed of in a newly constructed disposal facility at PGDP. This facility would be designed to manage LLW, RCRA waste, TSCA waste, and mixed waste consisting of combinations of these waste types. Waste that is inappropriate for the on-site disposal facility would be shipped to an off-site commercial facility for disposal. The on-site disposal facility would not accept high-level waste; spent nuclear fuel, transuranic waste, as defined by DOE Manual 435.1-1 *Radioactive Waste Management*; or waste generated at another DOE site.

ARARs for waste management, prior to disposal, will be identified within the CERCLA documentation associated with the project from which the waste is generated and are not included within the scope of this project.

A.2.3.1 General Construction Activities

Requirements for the control of fugitive dust and storm water runoff potentially provide ARARs for all construction and site preparation activities. Reasonable precautions must be taken, including the use of best management practices for erosion control to prevent runoff and application of water on exposed soil/debris surfaces to prevent particulate matter from becoming airborne. In addition, diffuse or fugitive emissions of radionuclides to the ambient air from remediation activities must comply with the Clean Air Act requirements in 40 *CFR* § 61.92, as amended.

A.2.3.2 Landfill Requirements

The On-Site Alternative is expected to meet pertinent, substantive requirements for a hazardous waste land disposal facility under RCRA, a chemical waste landfill under TSCA, and a LLW disposal facility under the Atomic Energy Act as described in this section. RCRA establishes standards for the design, operation, closure, and post-closure of a hazardous waste disposal facility in 401 *KAR* 34:230 (40 *CFR* § 264 Subpart N). The substantive elements of these requirements would be considered ARARs. The FFA parties will evaluate solid waste Subtitle D regulations to determine if any are relevant and appropriate regulations.

The requirements for a TSCA chemical waste landfill are in 40 *CFR* § 761.75 and would be potential ARARs. The TSCA chemical waste landfill design requirements generally follow the RCRA landfill design requirements. TSCA, however, specifies that if a synthetic liner is used, it must have a minimum thickness of 30 mil. In addition, TSCA specifies that the bottom of the liner must be located 50 ft above the historical, high groundwater mark and must prohibit any hydrologic connection between the site and any surface water, 40 *CFR* § 761.75(b)(3). If the on-site waste disposal alternative is selected, it is expected that a CERCLA waiver will be sought for the TSCA requirement that the bottom of a landfill liner must be 50 ft above the historical, high groundwater table. A waiver of this ARAR was granted for the Environmental Management Waste Management Facility in Oak Ridge.

An LLW disposal facility is expected to meet DOE Order requirements for the management and disposal of radioactive waste that is identified as TBC. Although Kentucky regulations at 902 *KAR* 100 are not applicable to a DOE LLW facility, substantive requirements in these regulations that may be relevant and appropriate to a DOE LLW disposal facility will be considered potential ARARs.

A.3. OFF-SITE ALTERNATIVE

The Off-Site Alternative consists of shipment of CERCLA waste to and disposal in licensed or permitted off-site disposal facilities. Waste exceeding the off-site disposal facility's WAC would be stored pending the availability of treatment or disposal capabilities. It is assumed that individual waste generators would be responsible for treatment before disposal; therefore, ARARs for waste treatment to meet any applicable land disposal restrictions or other treatment requirements under state or federal regulations are not addressed.

Because wastes would be disposed of off-site at appropriately licensed facilities under this alternative, ARARs for waste disposal are not addressed for this alternative. It is important to note that these requirements would apply to any transportation of hazardous materials in commerce, whether shipped to off-site facilities or to on-site facilities using roads to which the public has access.

A.4. NO ACTION ALTERNATIVE

Under the No Action Alternative, ARARs would be developed and evaluated for each project-specific CERCLA action, whether on-site or off-site disposal. Accordingly, there are no ARARs associated with the No Action Alternative.

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APPENDIX B

SUMMARY OF SEISMIC INVESTIGATION

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ACRONYMS

bgs	below ground surface
^{14}C	carbon-14 dating
CAB	Citizens Advisory Board
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
DOE	U.S. Department of Energy
DPT	direct push technology
DUF_6	Depleted Uranium Hexafluoride
EPA	U.S. Environmental Protection Agency
g	acceleration due to gravity
GPR	ground penetrating radar
KDEP	Kentucky Department for Environmental Protection
PGA	peak ground acceleration
PGDP	Paducah Gaseous Diffusion Plant
RI/FS	Remedial Investigation/Feasibility Study
SCPT	seismic cone penetrometer
SPT	standard penetration test

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B.1. INTRODUCTION

If selected, the On-Site Alternative for waste disposal will include the siting, design, construction, and operation of a waste disposal facility. Because there are seismic sources that have potential to affect Paducah Gaseous Diffusion Plant (PGDP), siting and design criteria for an on-site waste disposal facility must consider regional and site-specific seismicity. A comprehensive seismic investigation was conducted by the U.S. Department of Energy (DOE) from 2001 to 2003 that consisted of both PGDP site-specific and regional studies. The results of that investigation are presented in *Seismic Investigation Report for Siting of a Potential On-Site CERCLA Waste Disposal Facility at the Paducah Gaseous Diffusion Plan, Paducah, Kentucky* (DOE 2004). This appendix provides a detailed summary of the seismic investigation.

B.2. SEISMIC INVESTIGATION

During comment resolution on the *Seismic Issues for Consideration in Site Selection and Design of a Potential On-Site Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) Waste Disposal Facility at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2000b) at the March 14, 2001, Core Team meeting, DOE, the U.S. Environmental Protection Agency (EPA), and Kentucky Department for Environmental Protection (KDEP) agreed that seismic issues needed to be resolved in order to determine the viability of an on-site disposal alternative. EPA and KDEP representatives stated that field studies were required to address considerations associated with siting a low-level radioactive and hazardous waste disposal facility near a seismically active region. They also stated that these activities needed to be conducted during the development of the Remedial Investigation/Feasibility Study (RI/FS) Report. DOE and the regulators also agreed to delay release of the report for their review until the results of the field activities could be incorporated. A subsequent Core Team meeting (April 4-5, 2001) was held to scope the seismic investigation. At that meeting, it was agreed that Site 3 should continue to be considered as a candidate site for a potential on-site disposal facility. Due to the future development of the depleted uranium hexafluoride (DUF_6) facility, Site 3 was reconfigured and renamed Site 3A. Site 3A was chosen, based on a recommendation from the Citizens Advisory Board (CAB) and agreement by EPA, KDEP, and DOE, for the location of the site-specific studies of the seismic investigation. Figure B.1 shows the location of the seismic investigation that was conducted at Site 3A at PGDP.

The project core team developed a list of seven questions that, when answered, would fully address seismic issues. The seven questions that were developed by the project core team were these.

(1) Is there evidence of paleoliquefaction at or near PGDP?
(2) Is there paleoseismic evidence of local strong ground motion?
(3) Is there potential for future liquefaction at Site 3A?
(4) Is there evidence of Holocene displacement of faults at PGDP?
(5) Are there faults underlying the potential disposal facility site?
(6) What is the peak ground acceleration (PGA) at the potential disposal facility site?
(7) What are the characteristics of the design ground motion?

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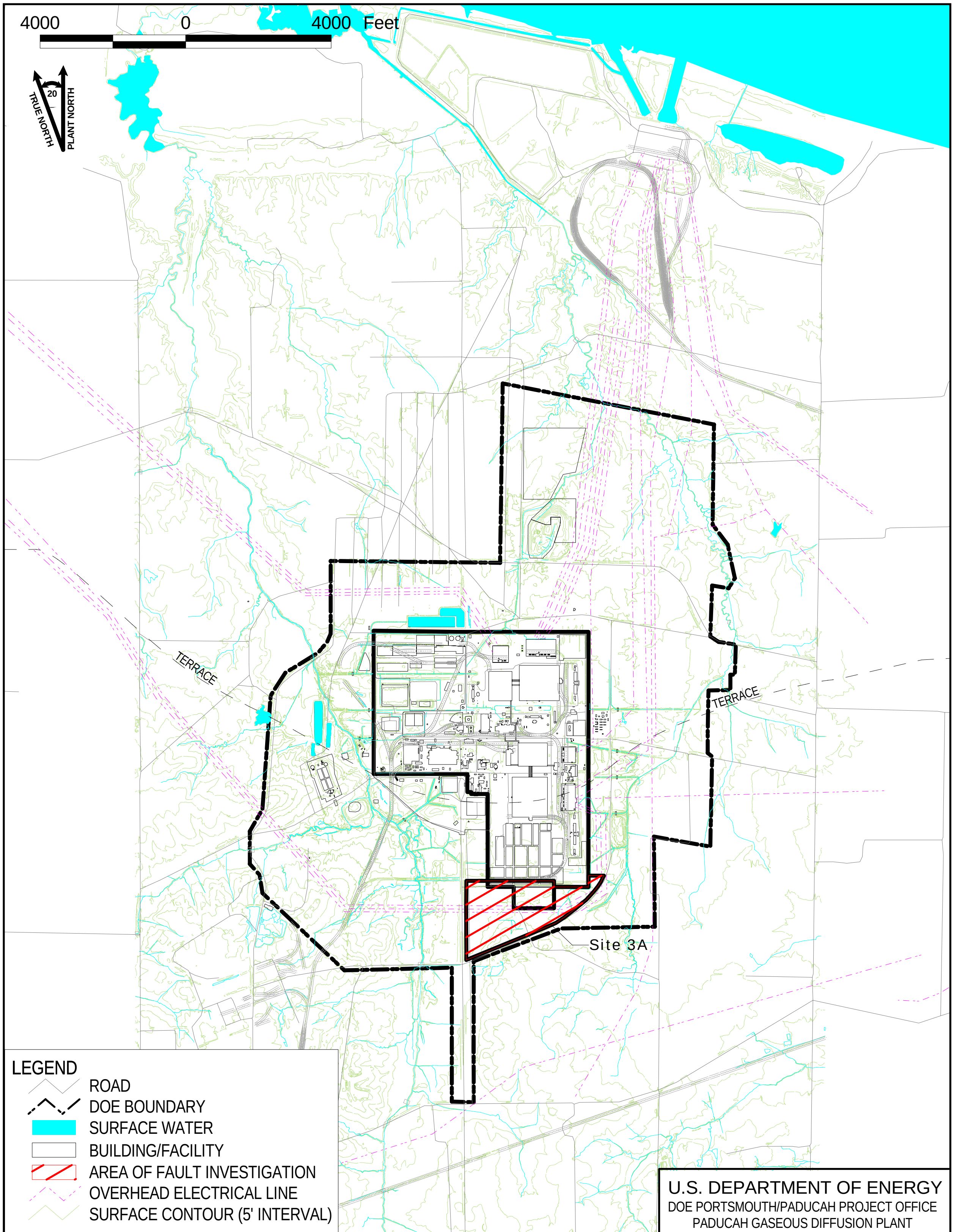

Figure B.1. Seismic Investigation at Site 3A

Figure No. C5AC90005SK030r1.apr
DATE 02-12-08

A seismic investigation program was developed by the core team to answer these questions. The elements of the seismic investigation consisted of the following:

(1) A paleoliquefaction study;
(2) A fault study (regional and site-specific); and
(3) Acquisition of seismic and geotechnical design data (regional and site-specific).

A work plan for the investigation was developed, approved by EPA and KDEP, and was titled, *Seismic Assessment Plan for Siting of a Potential On-Site CERCLA Waste Disposal Facility at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (BJC 2001). The initial implementation of the work plan occurred from September 2001 to March 2002, but was not fully completed when disposal evaluation options were postponed due to reprioritizing projects by DOE.

The remaining portions of the field investigation were completed from August through September 2003 by following guidance in the *Addendum to the Seismic Assessment Plan for Siting of a Potential On-Site CERCLA Waste Disposal Facility at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (BJC 2003).

The following subsections describe the three elements of the investigation, their results, and answers to the seven questions. This summary was derived from information contained in the *Seismic Investigation Report for Siting of a Potential On-Site CERCLA Waste Disposal Facility at the Paducah Gaseous Diffusion Plan, Paducah, Kentucky* (DOE 2004).

B.2.1 PALEOLIQUEFACTION STUDY

The Paleoliquefaction Study was developed to answer Questions 1 and 2, and support to answering Questions 3, 6, and 7. This study included a document review of historical information on regional liquefaction and performing field studies on DOE property and the surrounding region. The purpose of the Paleoliquefaction Study was to (1) look for liquefaction features in Quaternary-age deposits in the PGDP region and (2) determine whether liquefaction features, if found, are the result of past New Madrid-type earthquakes or local earthquakes that originated in the PGDP vicinity.

The document review indicated some small liquefaction features of possible Holocene age within 15 miles of PGDP. The closest were located along the banks of the Ohio River, about 8 miles to the northeast. These features were in the general vicinity of Fort Massac, Illinois, a location where liquefaction was reported during the February 7, 1812, New Madrid earthquake. These features were small and relatively unweathered, suggesting that they were probably outlying liquefaction features from the 1811 and 1812 New Madrid earthquakes. Small liquefaction features also were reported in the literature along the Post Creek Cutoff, about 12 miles northwest of PGDP.

The paleoliquefaction field study included field inspections of the banks of the Ohio River, Mayfield Creek, Bayou and Little Bayou Creeks, and a limited number of private land areas. The field investigation found no large liquefaction features along the bank of the Ohio River (Figure B.2). The riverbank afforded adequate exposure of the sediments such that if large liquefaction features were present they should have been obvious. Smaller-scale paleoliquefaction features may have been present, but were not observed because of their relatively small size or covered by the typical veneer of river

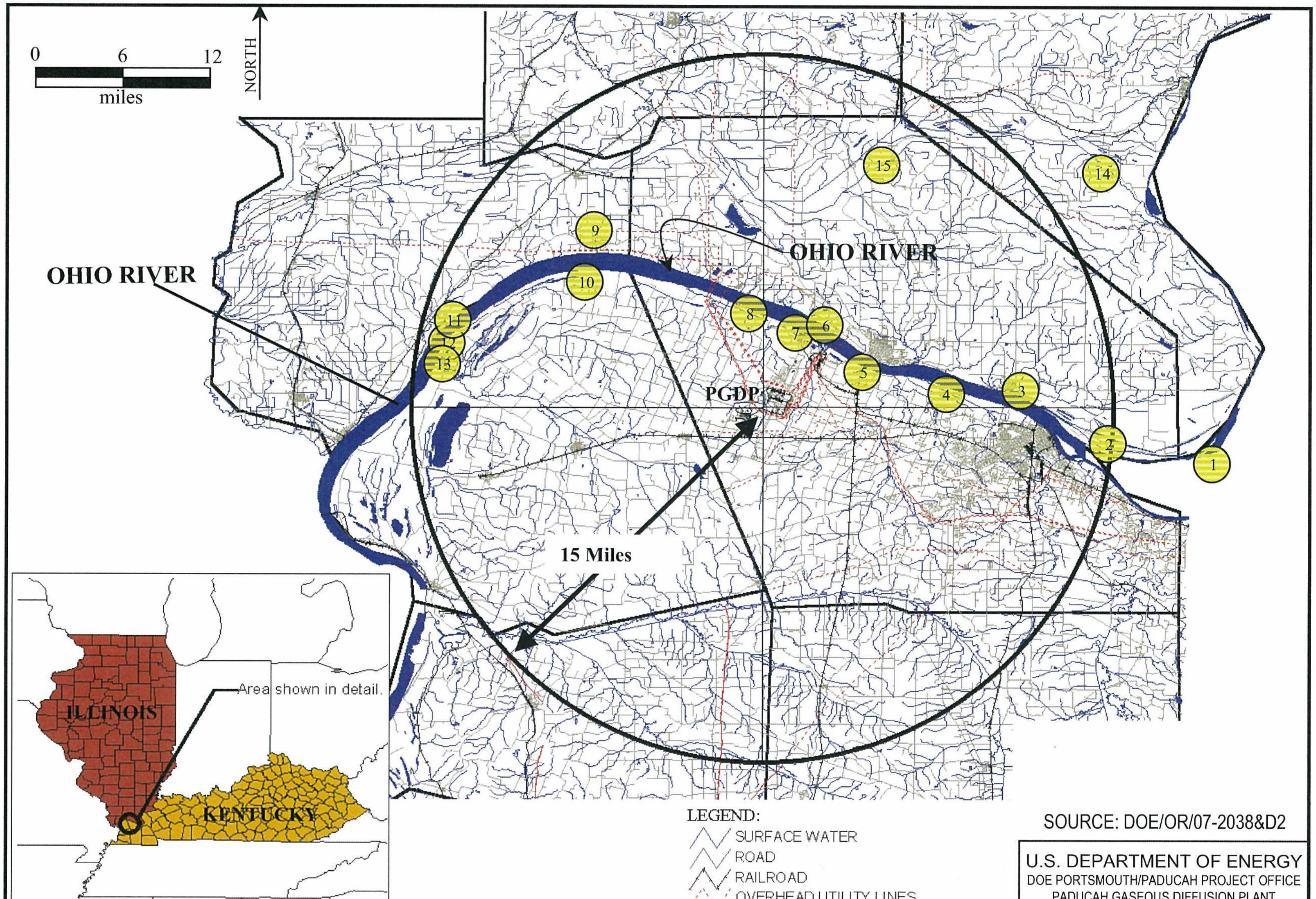

Figure B.2. Ohio River Paleoliquefaction Bank Study Sites

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deposits and vegetation. Field investigations conducted near PGDP along the portions of Bayou and Little Bayou Creeks found no definitive evidence of paleoliquefaction (Figure B.3).

The absence of a large paleoliquefaction feature within 15 miles of PGDP suggested that local strong ground motion had not occurred since surficial sediments were deposited. In this context, "local strong ground motion" was defined as strong ground motion resulting from a local earthquake. The small liquefaction features that were reported in the literature were located in sediments that were especially prone to liquefaction and probably were associated with large historical earthquakes originating outside of the area. It was stressed that because carbon-14 (^{14}C) dating determined that most of the observed sediment along the Ohio River is less than 1,000 years old, the available exposures provided only a paleoseismic record for the very late Holocene.

The site-specific evaluation included an assessment of data collected during the Geotechnical Study for liquefaction potential at Site 3A. Many of the soils present at the site are fine-grained clays and silts that by their very composition are not prone to liquefaction. In addition, laboratory evaluation of these materials found that they did not meet the criteria that distinguish those fine-grained soils that could experience large-scale strain, similar to liquefaction. The sands encountered at Site 3A generally were firm and would not be expected to liquefy under low to moderate levels of ground motion. Based on calculations presented in the report, it was concluded that some liquefaction within the sands and deformation within the silts could occur at a PGA approaching 0.5g.

The Paleoliquefaction Study concluded that "the absence of large liquefaction features within 15 miles of PGDP suggests that local strong ground motion has not occurred since the surficial sediments were deposited." Additionally, the study determined that liquefaction is not likely in low to moderate level seismic events due to the fine grained clays and silts present at Site 3A.

B.2.2 FAULT STUDY

The purpose of the fault study was to determine whether Holocene-age faulting (faulting that have experienced displacement during the last 10,000–12,000 years) has occurred in the vicinity of the candidate sites and was designed to answer Questions 4 and 5. The fault study included both regional and site specific components. Data collected from the fault study also could be used to support the design of a facility.

B.2.2.1 Regional Fault Study

The regional fault study was conducted approximately 11 miles northeast of PGDP at Barnes Creek (Massac County, Illinois) to collect data to support the design of a potential on-site CERCLA waste disposal facility. This was accomplished by field mapping geologic structures at Barnes Creek.

Geologic structures mapped along a 2,600-ft portion of Barnes Creek included individual joints, faults, clay dikes, and paired faults forming down-dropped blocks known as grabens. Neotectonic studies in Barnes Creek were performed to determine if the mapped faults had moved in the Holocene Epoch. Of the five geologic units identified, the two youngest did not exhibit faulting. Samples of 14 organic deposits were collected from the bank of Barnes Creek for ^{14}C age dating.

Radiocarbon age dating of the samples at Barnes Creek determined the youngest faulted units to be ~5,000 years old; therefore, the study concluded faulting did extend into Holocene-age deposits.

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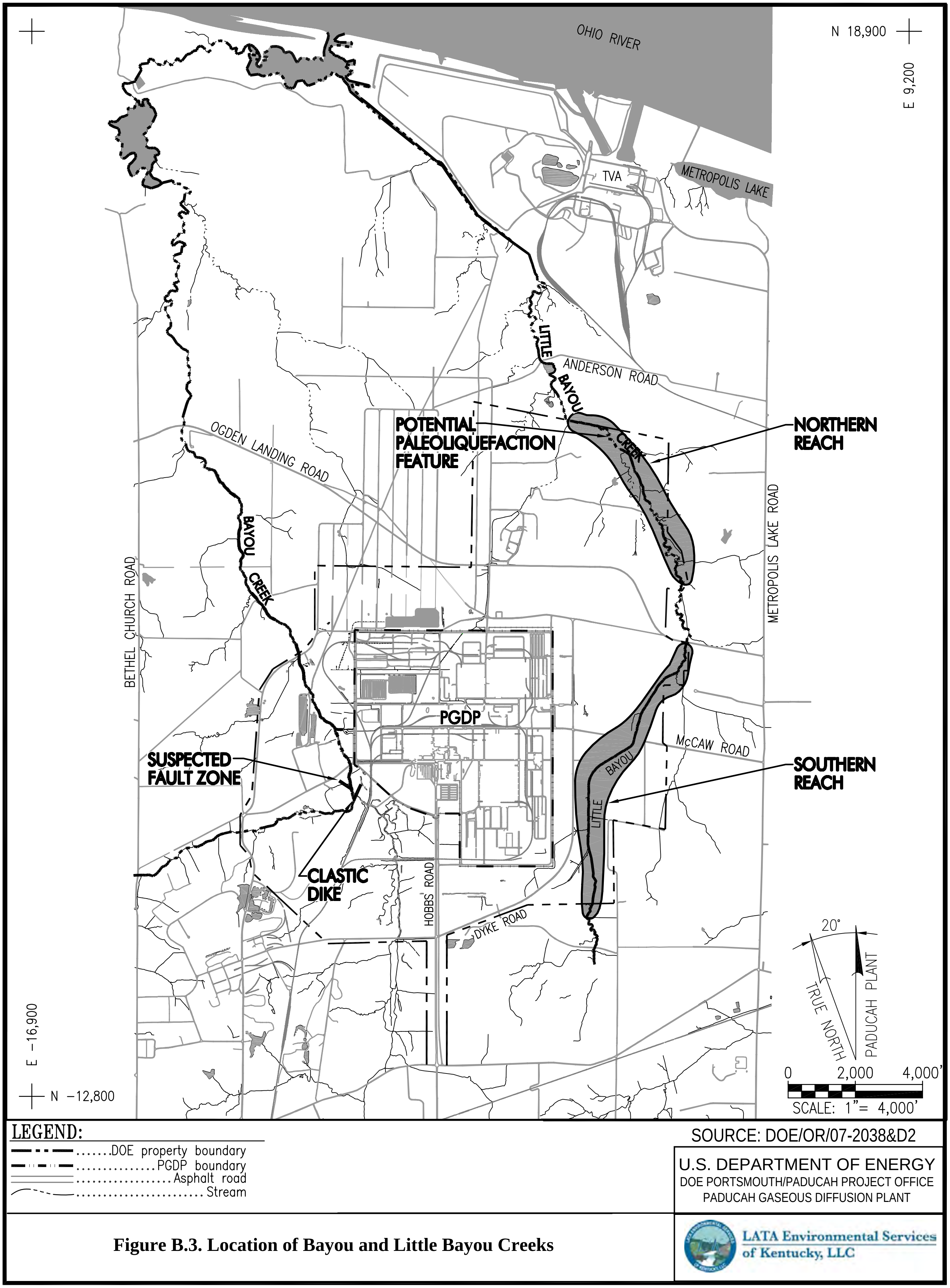


Figure B.3. Location of Bayou and Little Bayou Creeks

A ground penetrating radar (GPR) investigation was conducted at the suspected terrace graben approximately 1,100 ft north of Barnes Creek (Figure B.4). Three parallel 900 ft lines were surveyed using a 200 MHz antenna and confirmed the graben location and indicated up to 50 ft of displacement with infilling. DPT samples were collected from 10 locations at depths varying between 32 and 63 ft bgs from the middle survey line. Radiocarbon dating identified that the displacement and infilling occurred in the past 12,000 years, and the deep fine grained sediments were approximately 11,000 years old.

B.2.2.2 Site-Specific Fault Study

The PGDP site-specific fault study was developed to determine whether evidence of Holocene faulting existed at Site 3A (to answer Questions 4 and 5). The study included a GPR calibration survey, a p-wave (compression wave) seismic survey, s-wave (shear wave) seismic survey, and DPT boreholes.

A GPR calibration survey was conducted to determine whether GPR was capable of penetrating local clays and silts to identify subsurface features. At Site 3A, two GPR tests were conducted using 200 and 400 MHz antennas along a 750-ft test line. Because neither of these antennas provided suitable resolution of the geology at Site 3A, no follow-up GPR survey was recommended for Site 3A.

Approximately 16,000 linear ft of p-wave survey was collected along five lines at Site 3A. Several horizons were successfully imaged beneath Site 3A, including the top of limestone bedrock, the McNairy Formation (lower sand facies), and portions of the Porters Creek Clay. The p-wave survey identified deformation on the Porters Creek Clay that underlies Site 3A (Figure B.5). A higher resolution s-wave survey identified a series of faults beneath Site 3A, extending from the Porters Creek Clay into the materials underlying the surficial loess deposits (Figure B.6). Approximately 2,300 linear ft of data were collected along two lines from the s-wave survey. Several horizons were successfully imaged, including the Porters Creek Clay, an overlying firm sand unit, and portions of the loess. Several potential faults extending up to or near the bottom of the loess unit were identified. Three of the inferred faults came to within 20 ft of the surface.

The site-specific fault study identified a series of faults beneath Site 3A. For most of the faults, relative movement along the main fault plane is normal, with the downthrown side to the east. These normal faults, along with their associated splays, form a series of narrow horst and graben features.

Closely spaced DPT boreholes (21 ft to 40 ft bgs) were driven to obtain continuous core samples to inspect the suspected faults. Three fault planes were observed between 22 and 28 ft bgs near the southern boundary of Site 3A. Five organic samples were collected and sent to an off-site laboratory for ^{14}C age dating. An additional investigation was to be implemented if faulting were present in the younger deposits.

A follow-up DPT survey in 2003 was composed of tightly spaced DPT boreholes that were driven into the loess deposits overlying the faulting observed in the deeper DPTs and interpreted in the seismic reflection data. Twenty-two organic samples were collected and sent to an off-site laboratory for ^{14}C age dating.

No faults were observed in the overlying loess sampled in the shallow DPT boreholes at Site 3A. The radiocarbon dating at Site 3A found that the unfaulted loess is late Pleistocene in age and is at least 17,000 years old; therefore, this study did not find Holocene displacement of faults at Site 3A.

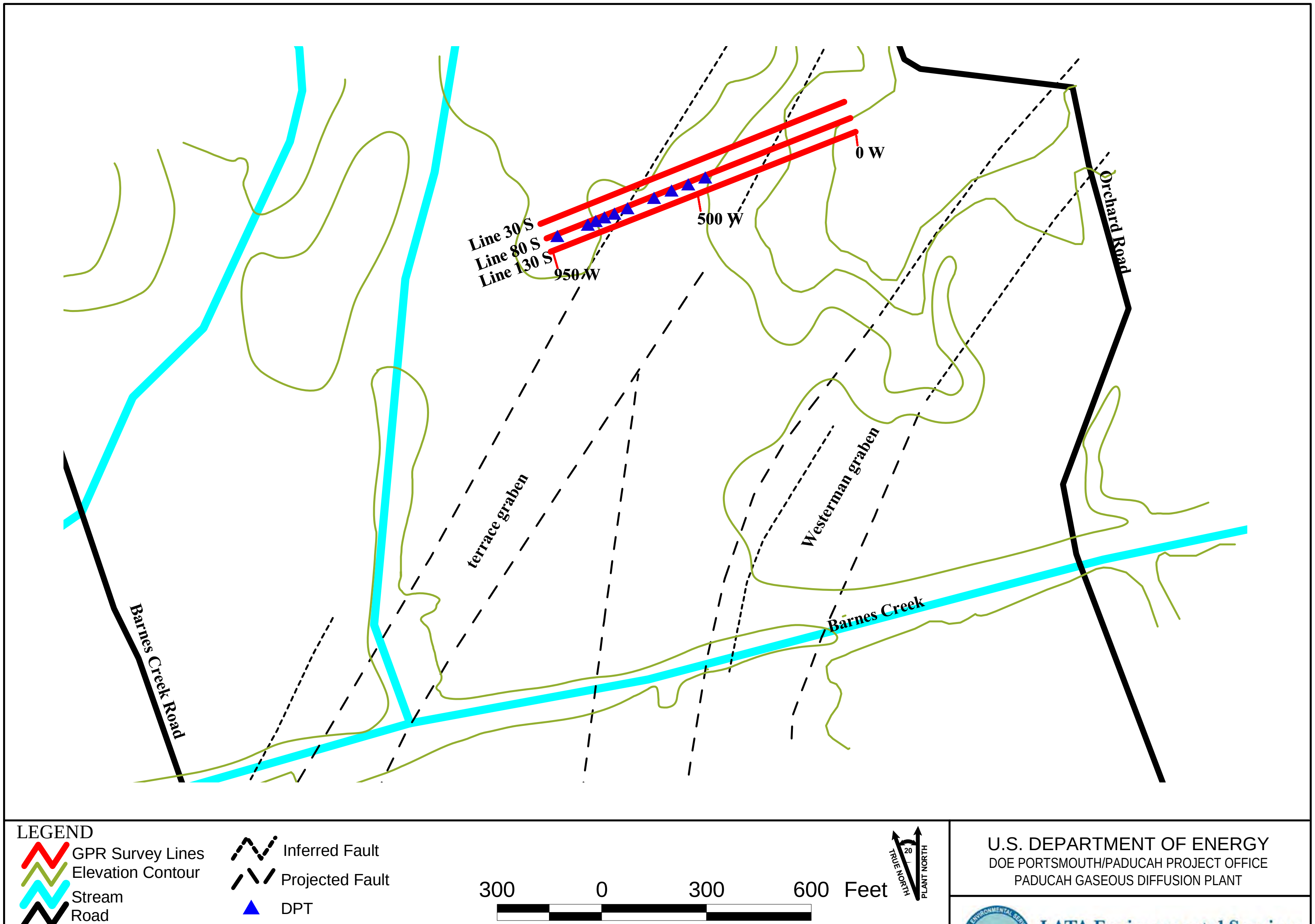
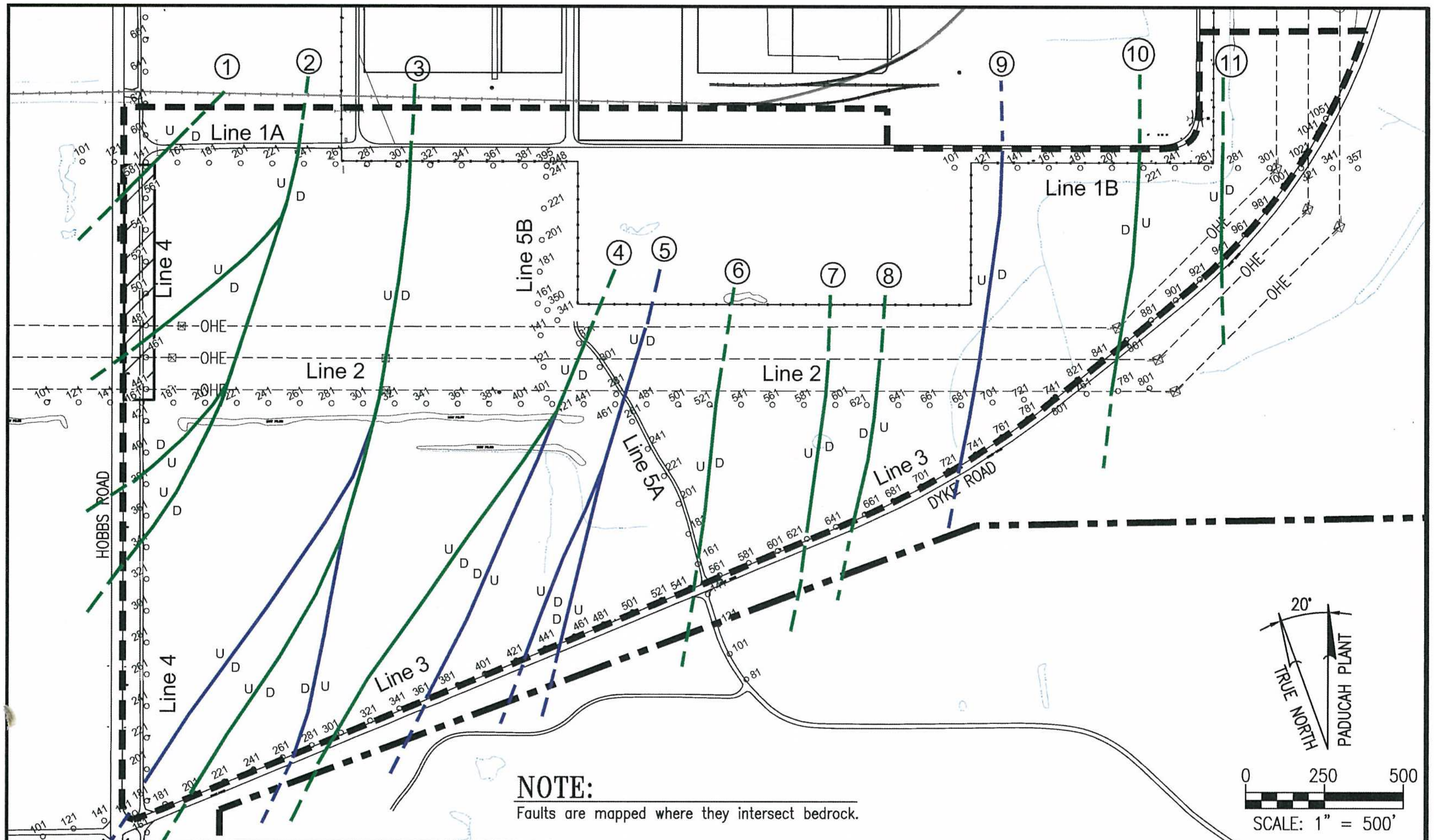


Figure B.4. Location of DPTs at the Barnes Creek Study Area



LEGEND:

Asphalt road
Gravel road
PGDP boundary
Site 3A boundary
Railroad tracks
Fence line
Source test area line 4
Shot points 438–581
Stream
Electrical utility lines
O501 P–wave survey location
Interpreted fault location (bedrock and unconsolidated sediments)
Interpreted fault location (bedrock and lower McNairy formation only)
U/D Relative movement along fault plane

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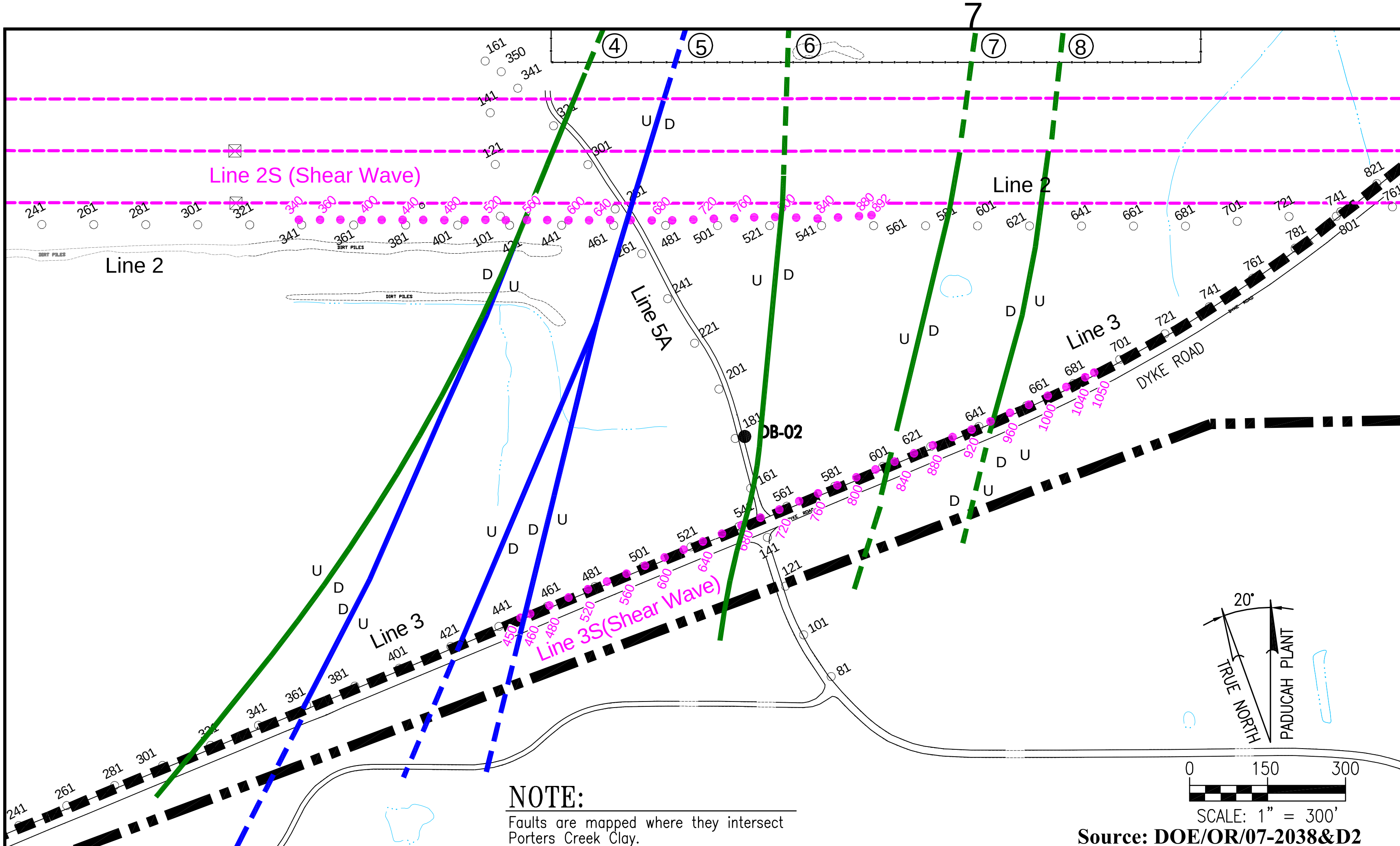
Figure B.5. Fault Interpretation from P-Wave Study



LEGEND:

- Asphalt road
- Gravel road
- Pgdp boundary
- Site 3A boundary
- Fence line
- Stream
- DB–02 .... PS suspension log
- 401 .... S–wave survey location
- 501 .... P–wave survey location
- Interpreted fault location (Bedrock and unconsolidated dediments)
- Interpreted fault location (Bedrock and lower McNairy formation only)
- U/D .... Relative movement along fault plane

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Figure B.6. Fault Interpretation from S-Wave Study

B.2.3 GEOTECHNICAL STUDY

The geotechnical study was developed to acquire seismic and geotechnical characteristics of deposits at Site 3A and provide data to support answering Questions 3, 6, and 7. The study consisted of drilling and sampling boreholes and seismic cone penetrometer test (SCPT) soundings (Figure B.7).

A deep boring using rotosonic drilling methods produced a continuous core to a depth of 359 ft bgs. This borehole also was used to conduct a natural gamma log. A second deep boring, using mud rotary drilling methods encountered bedrock at ~ 400 ft bgs. Standard penetration test (SPT) samples were collected to 186 ft, and a seismic velocity log was performed in the boring. The two boreholes identified the McNairy from 400 to 245 ft bgs, the Porters Creek Clay from 245 to 45 ft bgs, and the terrace deposits from approximately 45 ft to 15–20 ft bgs. The depth of the contact of the Porters Creek Clay and the terrace deposits ranged between 30 ft and 60 ft bgs.

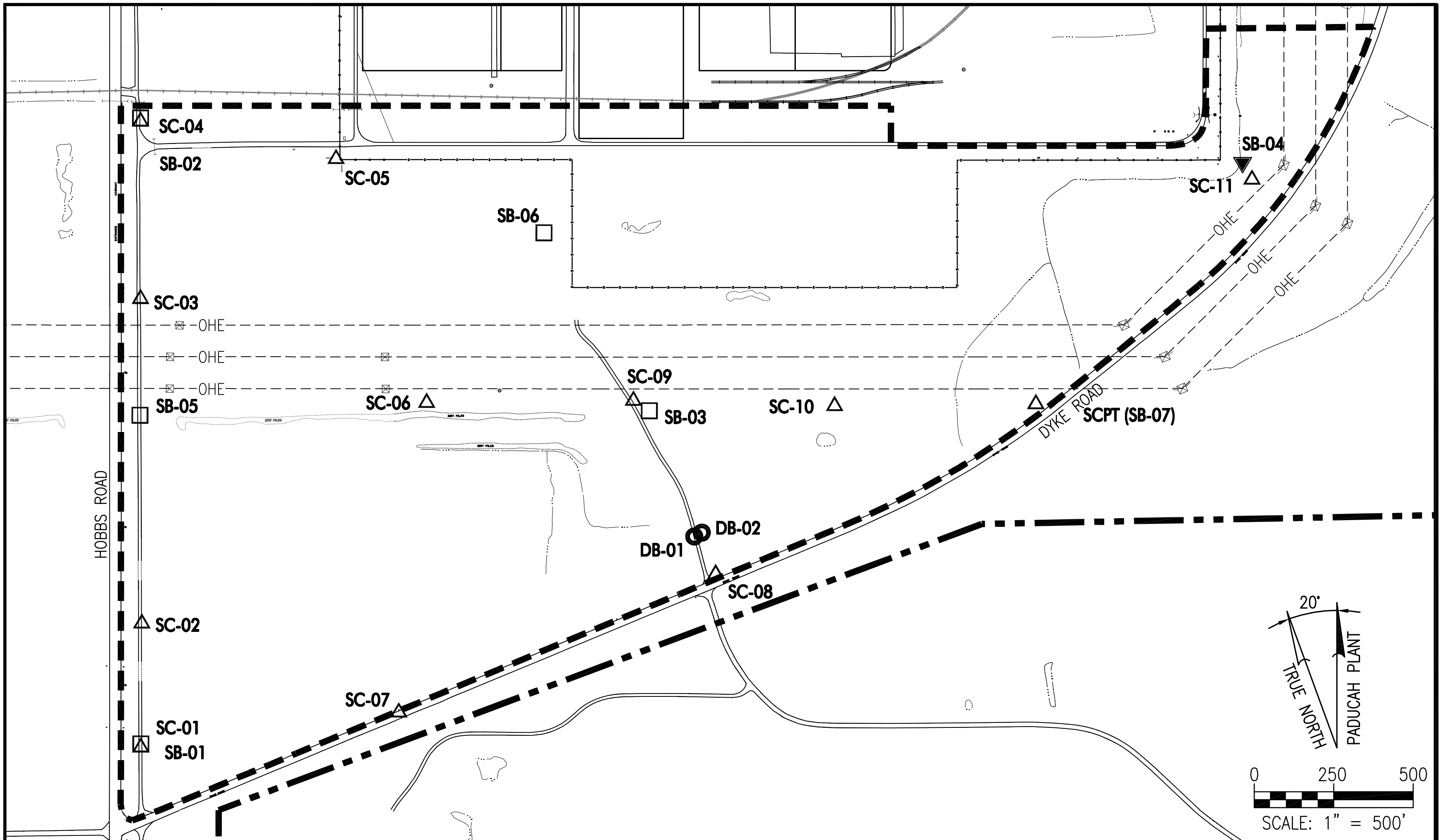
Five mud rotary borings were drilled to depths between 52 and 70 ft. The mud rotary drilling collected 44 Shelby tube samples for in-place density, vertical permeability, triaxial compressive strength, and one-dimensional consolidation. Forty-eight split spoon samples were analyzed for index properties and contaminant transport properties. Additionally, 14 SCPT soundings were performed at 11 locations at Site 3A between 10 to 70 ft bgs. Continuous tip, sleeve, and pore pressure measurements were collected from six of the borings. Twenty-nine pore pressure dissipation tests were conducted in various lithologies. Seismic s-wave velocities were measured at approximately 3-ft intervals.

Settlement calculations using these measurements predicted that fill constructed to a height of 102 ft above ground surface would result in more than 5 ft of displacement in the center of the disposal cell. Due to differential settlement (~2–3 ft), the design would need to include increased slopes of the base grade, bottom liner, and drain lines, and use appropriate construction materials. Approximately 90% of the settlement could occur in less than 2 years after fill placement. Results of bearing capacity analysis indicated the soils at Site 3A to be adequate to support a CERCLA waste disposal facility.

B.2.4 SEISMIC DESIGN MODEL

The seismic design model used data collected from the site specific fault study and geotechnical study to determine the PGA and design motions. This information would answer Questions 6 and 7.

Ground motion modeling at the Site 3A surface was performed using data collected during this seismic investigation. Shear wave velocities of the unconsolidated materials above the bedrock at Site 3A were used to develop a site-specific soil amplification factor. The site-specific soil amplification factor was calculated to be 0.67 (67%). The surface ground motion was modeled using this soil amplification factor and the peak horizontal ground acceleration at bedrock from BJC 2002 (0.71g). The 2,500-year return-period ground motion at the Site 3A surface was calculated to be 0.48g. (Figure B.8).



LEGEND:

- Asphalt road
- OHE — Electrical utility lines
- PGDP boundary
- Site 3A boundary
- Railroad tracks
- Fence line
- Stream
- DPT location
- Deep boring location
- Shallow boring location
- SCPT location

Source: DOE/OR/07-2038&D2

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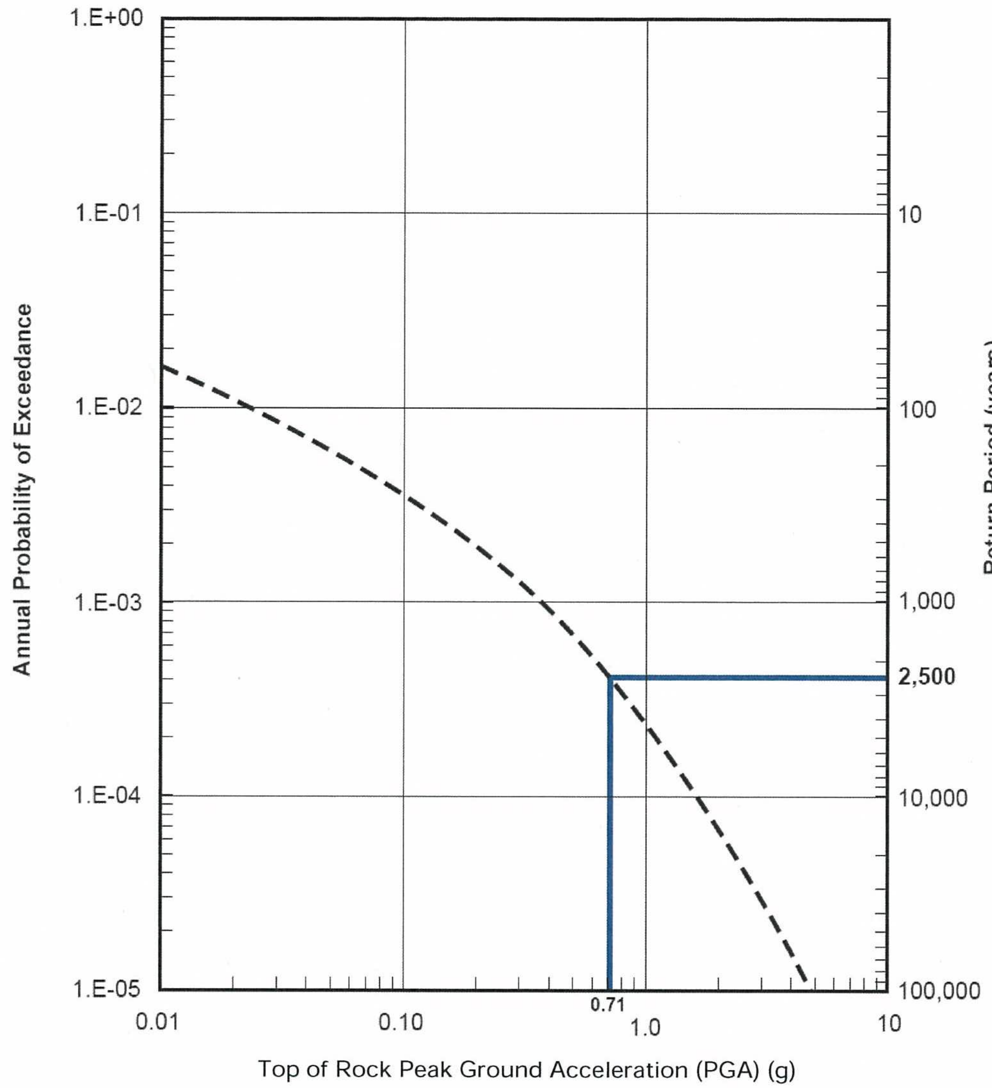
Figure B.7. Location of Geotechnical Study Activities at Site 3A



Source Data: BJC (2002)

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Figure B.8. Seismic Hazard Curve for PGDP

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In 2003, DOE agreed to review other relevant ongoing earthquake studies as a part of the task to develop a seismic design model. The review consisted of an assessment of literature published by the Seismological Society of America and the American Geophysical Union, as well as independent publications and papers in engineering geology. Appendix J of the Seismic Investigation Report (DOE 2004) provides an overview of this work.

In summary, over 3,000 papers and abstracts published from 1999 to 2003 were scanned to determine applicability. Based on the title, papers that may have been applicable to the seismic investigation were reviewed. A summary of those papers was written, and the potential impact on the seismic investigation at Site 3A was determined in one of three ways:

(1) No immediate impact—finding would not enhance report; did not affect study;
(2) Immediate impact—findings would affect conclusion-required revision of report; and
(3) Potential long-term impact—findings, if applied to study, might change conclusion of study.

No papers or abstracts were found that would warrant a change in the 2004 report. It was noted, however, that many of the articles that potentially could change the seismic hazard defined in the report would result in a less conservative value.

Based on the results of the seismic investigation, the answers to the seven questions indicated that seismic conditions in this area would not prevent construction of an on-site disposal facility. Table B.1 presents the seven questions and the answers as a result of the seismic investigation.

Note: All references cited in this Appendix are included in the References, Section 9, of the main text of the CERCLA Waste Evaluation RI/FS Work Plan.

Table B.1. Summary Answers to Uncertainties Regarding Seismic Issues at Site 3A

Question	Summary Answer
1. Is there evidence of paleoliquefaction at or near PGDP?	Field observations made along the Ohio River in the vicinity of PGDP found no large liquefaction features. Smaller scale paleoliquefaction features may have been present, but remained unobserved because of their relatively small size or veneer of river deposits and vegetative cover. Further, age dating performed in 2003 determined that the sediments are relatively young. There is no definitive evidence of paleoliquefaction at PGDP based on results of field investigations conducted along portions of Bayou and Little Bayou Creeks. The literature does report some small liquefaction features located along the banks of the Ohio River, about 8 miles northeast of PGDP, and along the Post Creek Cutoff, about 12 miles northwest of PGDP.
2. Is there paleoseismic evidence of local strong ground motion?	The absence of large paleoliquefaction features within 15 miles of PGDP suggests that local strong ground motion has not occurred since these surficial sediments were deposited. The small liquefaction features that have been reported in the literature are located in sediments that are especially prone to liquefaction and probably are associated with large historical earthquakes originating outside the area. It should be stressed that because ^{14}C dating determined that most of the observed sediment along the Ohio River is less than 1,000 years old, the available exposures provide only a paleoseismic record for the very late Holocene.
3. Is there potential for future liquefaction at Site 3A?	Many of the soils present at the site are clays and silts that, by their very composition, are not prone to liquefaction. In addition, laboratory evaluation of these materials found that they do not meet the criteria that distinguish those fine-grained soils that could experience large-scale strain, similar to liquefaction. The sands encountered at Site 3A are generally firm and are not expected to liquefy under low to moderate levels of ground motion. Some liquefaction within the sands and deformation within the silts and clays could occur at PGAs approaching 0.5g.
4. Is there evidence of Holocene displacement of faults at PGDP?	This study did not find Holocene displacement of faults at Site 3A. Several faults identified in seismic reflection data at Site 3A have been confirmed to extend through the Porters Creek Clay and into the materials underlying the surficial loess deposits. Three of these faults are interpreted to extend to within approximately 20 ft of the ground surface. One deeper DPT borehole encountered three fault planes at depths between 22 ft and 28 ft. Tightly spaced, shallower DPT boreholes at these locations found no faults in the overlying loess. The radiocarbon dating at Site 3A found that the loess is late Pleistocene in age, and the deposits are at least as old as the oldest roots that grew into them (17,100 years old). At the Barnes Creek site located 11 miles northeast of PGDP, this study found Holocene age displacement of faults in deposits with ^{14}C dates ranging from 5,000 to 7,000 years BP.
5. Are there faults underlying the potential disposal facility site?	The site-specific fault study identified a series of faults beneath Site 3A. For most of the faults beneath Site 3A, relative movement along the main fault plane is normal, with the downthrown side to the east. These normal faults, along with their associated splays, either form a series of narrow horst and graben features, or divide the local sediments into a series of rotated blocks. Several of the faults extend through the Porters Creek Clay and into the materials underlying the surficial loess. Three of these faults extend to within approximately 20 ft of the ground surface. Tightly spaced shallower DPT boreholes found no evidence that these faults extend upward into the Pleistocene loess deposits and, therefore, are not Holocene in age.
6. What is the PGA at the potential disposal facility site?	Based upon data collected from Site 3A, the PGA at Site 3A is calculated to be 0.48g for a 2,500-year return period earthquake.
7. What are the characteristics of the design ground motion?	The design ground motions at Site 3A would be the same as those presented in a 1999 study performed by Risk Engineering, Inc. The shear-wave velocities in the soil column at Site 3A are similar to those determined previously at other locations on the DOE property, resulting in similar design ground motions.

BP = years before present, where "present" is defined as 1950 A.D.
DPT = direct push technology
PGA = peak ground acceleration
PGDP = Paducah Gaseous Diffusion Plant

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APPENDIX C

PROPOSED GROUNDWATER MODELING METHODOLOGY

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ACRONYMS

AT123D	Analytical Transient 1-, 2-, 3-Dimensional
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CCL	compacted clay liner
COC	contaminant of concern
COPC	chemical of potential concern
DAF	dilution attenuation factor
DOE	U.S. Department of Energy
DUSTMS	Disposal Unit Source Term-Multiple Species
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
FML	flexible membrane liner
HDPE	high density polyethylene
HELP	Hydrologic Evaluation of Landfill Performance
HI	hazard index
MCL	maximum contaminant level
PGDP	Paducah Gaseous Diffusion Plant
PWAC	preliminary waste acceptance criteria
RGA	Regional Gravel Aquifer
UCRS	Upper Continental Recharge System
WAC	waste acceptance criteria
WDF	waste disposal facility

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C.1. INTRODUCTION

If selected, the on-site waste disposal alternative involves the construction of a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) waste disposal facility at the Paducah Gaseous Diffusion Plant (PGDP). This appendix presents the modeling methodology proposed for evaluating the performance of an on-site waste disposal facility, including development of preliminary waste acceptance criteria (PWAC).

C.2. PREVIOUS REPORTS AND MODELING

Several reports have been completed at PGDP for on-site waste disposal facilities. These reports include the following:

- *Operating Limit Study for the Proposed Solid Waste Landfill at Paducah Gaseous Diffusion Plant*, ORNL/TM-13008, June 1995 (ORNL 1995).

- *Remedial Investigation/Feasibility Study on Disposal Options for Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)-Derived Waste at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-1935&D(-1), March (DOE 2001).

- *Risk and Performance Evaluation of the C-746-U Landfill at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2041&D2R1, September (DOE 2003).

Each of these reports presents a modeling methodology similar to that proposed for evaluating the performance of an on-site waste disposal facility and serves as the basis for the development of the proposed modeling methodology presented in this appendix. This earlier work is supplemented by a review of the current technical literature related to the performance of engineered barriers. The service life of the engineered barriers established from the literature review is also proposed for use in the modeling.

The Remedial Investigation/Feasibility Study on Disposal Options for CERCLA-Derived Waste (DOE 2001) was developed under consensus of a core team; however, the report was not released for review to the regulators. The remaining reports were finalized and released to the public, but only the Risk and Performance Evaluation of the C-746-U Landfill report (DOE 2003) was approved by the regulators.

C.3. MODELING METHODOLOGY

The general modeling procedure for the development of PWAC is provided in Table C.1. This table presents the major modeling tasks and descriptions of the general task elements that are necessary within each modeling task to facilitate the determination of the PWAC.

Table C.1. General Modeling Procedure for the Development of the PWAC

MODELING TASK	GENERAL TASK ELEMENTS
Identify Waste and Indicator Chemicals Constituents	Identify constituents in waste.
	Establish chemical surrogate groups and assign contaminants to surrogate groups.
	Identify indicator chemicals for fate and transport modeling for each chemical surrogate group.
Fate and Transport Modeling	Conduct fate and transport modeling for radionuclides, metals, and indicator chemicals, and calculate dilution-attenuation factors (DAFs) for indicator chemicals.
	Calculate concentrations for chemicals within a surrogate group using the indicator chemical's DAF.
Risk Assessment	Calculate the cancer risk and hazard presented by each chemical, metal, and radionuclide using PGDP No Action screening values for the rural child resident.
PWAC Development	Derive PWAC using ratio of modeled and acceptable concentration in water and concentration in source.
Uncertainty Analysis	Perform qualitative and quantitative uncertainty analyses.

C.3.1 IDENTIFY WASTE CONSTITUENTS AND INDICATOR CHEMICALS

Chemicals to be evaluated in the model will be determined based on a combination of information from the PGDP Human Health volume of the Risk Methods Document (DOE 2011) and other available waste profile data and selected to represent the expected waste contaminants for disposal in the potential on-site disposal facility.

C.3.1.1 Identify Constituents in Waste

Appendix D presents the methods that will be used to develop an analytical profile for the wastes that are expected to be placed in the potential on-site waste disposal facility. The chemicals of potential concern (COPCs) for PGDP are provided in Table 2.1 of the Risk Methods Document (DOE 2011). Contaminants of concern (COCs) will be derived using Table 2.1, as well as other available waste profile data and will be assessed in the fate and transport modeling analyses.

C.3.1.2 Establish Surrogate Groups

In order to streamline the modeling process, each COC will be assigned to a contaminant group. The contaminant groups will represent chemicals of concern with similar chemical properties, such as solubility, volatility, and mobility, so that each contaminant group will contain chemicals that behave similarly in the environment.

The use of indicator chemicals involves the necessity to develop a sufficient number of groups such that the groups represent the full range of potential contaminant property combinations; however, the C-746-U Landfill report (DOE 2003) states that "it was determined that transport of neither the inorganic chemicals nor the radionuclides was adequately estimated through the use of indicator chemicals." The analysis found that surrogate groups were only adequately representative for organic compounds.

Based on this conclusion, surrogates will be used to develop a PWAC for organics; however, radionuclides and metals will be assessed individually and not as surrogate groups. If the On-Site Alternative is selected, a final waste acceptance criteria (WAC) will be developed with a full analysis of potential COCs.

C.3.1.3 Identify Indicator Chemicals for Surrogate Groups

An indicator chemical will be selected to represent each organic surrogate group. The indicator chemical for each surrogate group will be a representative chemical that previously has been identified as a major COC at PGDP. Section C.3.2 provides additional discussion on the issues associated with chemical interactions affecting the fate and transport of specific chemical groups. As noted in Section C.3.1.2, metals and radionuclides will be assessed individually and not as surrogate groups.

C.3.2 FATE AND TRANSPORT MODELING

The fate and transport modeling will be performed as follows:

(1) Hydrologic Evaluation of Landfill Performance (HELP) model simulations will be used to perform three failure scenarios to estimate the water flux percolating through the waste and into the water table under each of the scenarios. As described in Section C.3.2.1.1, the failure scenarios are based on a range of estimated service lives for the engineered barriers. The model also accounts for eventual failure of the drainage layers. The various scenarios to be considered include (1) instantaneous failure, (2) gradual failure, and (3) no failure. Additional gradual failure scenarios will be analyzed as part of the uncertainty analysis described in Section C.3.5. Under the gradual and instantaneous failure scenarios, the lateral drainage layers beneath the waste will be assumed to degrade. To account for degradation, the manmade flexible membrane liner (FML) layers in both the bottom liner and cap no longer would act as barrier layers, and the two drainage layers below the waste no longer would function (i.e., they effectively become vertical percolation layers). The no failure scenario assumes that the system maintains integrity throughout the period of interest.

(2) Disposal Unit Source Term-Multiple Species (DUSTMS) modeling will be performed for each metal, radionuclide, and indicator chemical under the gradual failure scenario to predict the contaminant flux entering the aquifer over time. A unit concentration for each contaminant will be used as an initial input to DUSTMS. This unit concentration is converted to an initial contaminant mass within the landfill. The contaminant mass will be assumed to be contained in a homogenized soil. The entire landfill volume will be assumed to be filled with a single contaminant embedded in the soil waste. DUSTMS is used to calculate initial groundwater concentrations based on this initial mass/concentration. Once downgradient groundwater concentrations are obtained from the Analytical Transient, 1-, 2-, 3-Dimensional (AT123D) model and initial PWAC concentrations are calculated, DUSTMS is rerun using the initial PWAC concentrations to obtain new initial groundwater

concentrations. (DUSTMS modeling also will be performed for selected contaminants as part of an uncertainty analysis under the immediate and no failure scenarios.)

(3) MODFLOW/MODPATH modeling will be performed at Site 11 to predict the groundwater migration rate from the location where leachate enters the Regional Gravel Aquifer (RGA) groundwater flow system to the exposure point locations and the shortest transit times to each exposure point.

    The sitewide groundwater model does not cover the area of interest at Site 3A. If the sitewide groundwater model cannot be expanded to include Site 3A, existing hydrogeologic data for Site 3A will be used to determine the appropriate hydrogeological parameters for Site 3A in the DUSTMS and AT123D models.

(4) AT123D modeling will be performed to predict concentrations of each indicator chemical, metal, and radionuclide at established exposure points over time due to lateral transport. The contaminant flux from the DUSTMS model will be used as input to the AT123D model.

Maximum concentrations and the time, up to 10,000 years, to attain the maximum concentrations at the exposure points will be predicted, and dilution attenuation factors (DAFs) associated with source-to-exposure point transport of the indicator chemical will be calculated.

Proposed modeling parameters are included in Attachment C.1.

C.3.2.1 Selected Models and Their Application

Several models will be required for the evaluation of the performance of an on-site waste disposal facility. The following discussion presents the models selected for use in the analysis of the groundwater transport pathway. The selection of the models was based on the modeling matrix presented in the Risk Methods Document (DOE 2001). Figure C.1 provides an illustration of the model application in the assessment. Figures C.2 and C.3 provide an illustration of how the HELP layers and DUSTMS material layers interrelate for Sites 11 and 3A, respectively.

C.3.2.1.1 HELP Model

The HELP model (Schroeder et al. 1994) will be used to determine the rate of water infiltration through the engineered cap that can be released from the bottom of the landfill. The HELP computer program is a quasi-two-dimensional hydrologic model of water movement across, into, through, and out of landfills. The model considers weather, soil, and design data and uses solution techniques that account for the effects of surface storage, snowmelt, runoff, infiltration, evapotranspiration, vegetative growth, soil moisture storage, lateral subsurface drainage, leachate recirculation, unsaturated vertical drainage, and leakage through soil, geomembrane, or composite liners. The program was developed to conduct water balance analysis of landfills, cover systems, and solid waste disposal and containment facilities. As such, the model facilitates rapid estimation of the amounts of runoff, evapotranspiration, drainage, leachate collection, and liner leakage that may be expected to result from the operation of a wide variety of landfill designs.

The HELP model will be used to determine the water balance of the facility based on preliminary facility/cap design. The modeling will account for the operational period, institutional control period, and the post-institutional control period, which are described below.

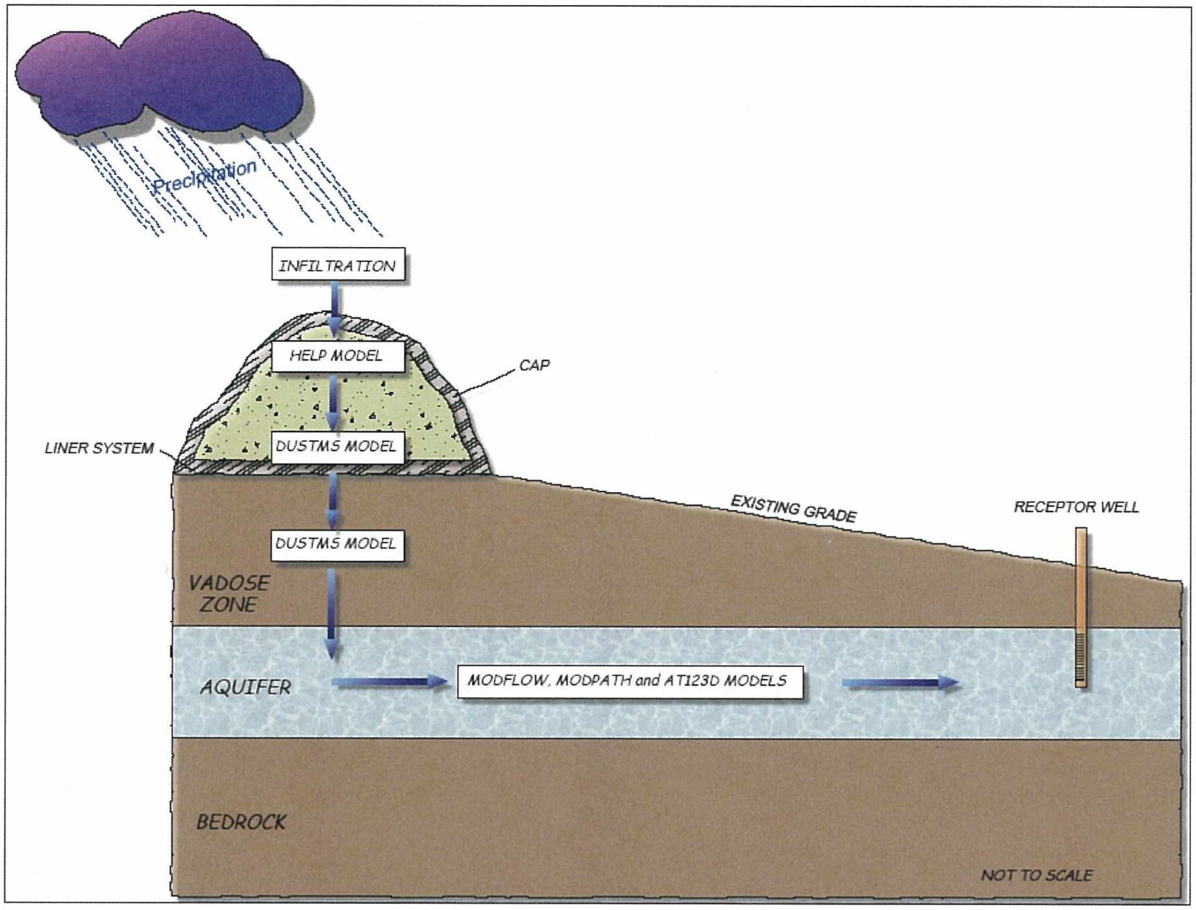

Figure C.1. Generalized Conceptual Model for an On-Site Waste Disposal Facility

Site 11 - Conceptual Model 30+ years

HELP, DUST-MS, AT123D

DUST-MS Material	HELP Soil Layers	DUST-MS Number of Computational Nodes	Thickness (ft)	DUST-MS Bulk Density	DUST-MS Initial (t = 30 yrs) Volumetric Moisture Content	HELP Initial (t = 30 yrs) Volumetric Moisture Content
1	Soil Matirx	10	5	1.34	0.3098	0.3098
2	Filter Sand	2	1	1.4	0.0452	0.0843
	Cobble/ Gravel Sand	6	3			0.0451
	Drainage Sand	2	1			0.032
3	FML (HDPE) Liner Clay	6	3	1.8	0.4251	0.4251
4	Waste Form	170	85	3.1	0.3588	0.3588
3	Clay (compacted)	2	1	1.8	0.4112	0.4112
2	Drainage Sand	2	1	1.4	0.1123	0.1123
FML (HDPE) Liner	Geocomposite		0.02			
3	Clay Barrier FML (HDPE) Liner	6	3	1.8	0.427	0.427
1	Geologic Buffer (clay)	20	10	1.34	0.342	0.342
5	Loess Deposit (Unsaturated UCRS) Bottom of HELP Model	44	22	1.43	0.393	0.393
6	Silt to Clay (Saturated Upper Continental Deposits) Bottom of DUST-MS Model	28	14	1.43	0.445	
AT123D Lateral Flow Layer	RGA		35.5	1.67	Saturated Horizontal Flow	
McNairy Formation						

Unsaturated Vertical Flow

Saturated Vertical Flow

Figure C.2. DUSTMS Model Layers and Select Parameters, Site 11

Site 3A - Conceptual Model 30+ years

HELP, DUST-MS, AT123D

DUST-MS Material	HELP Soil Layers	DUST-MS Number of Computational Nodes	Thickness (ft)	DUST-MS Bulk Density	DUST-MS Initial (t = 30 yrs) Volumetric Moisture Content	HELP Initial (t = 30 yrs) Volumetric Moisture Content
1	Soil Matirx	10	5	1.34	0.3098	0.3098
2	Filter Sand	2	1	1.4	0.0452	0.0843
	Cobble/ Gravel Sand	6	3			0.0451
	Drainage Sand	2	1			0.032
3 FML (HDPE) Liner	Clay	6	3	1.8	0.4251	0.4251
4	Waste Form	170	85	3.1	0.3588	0.3588
3	Clay (compacted)	2	1	1.5	0.4112	0.4112
2	Drainage Sand	2	1	1.4	0.1123	0.1123
FML (HDPE) Liner	Geocomposite		0.02			
FML 3 (HDPE) Liner	Clay Barrier	6	3	1.8	0.427	0.427
1	Geologic Buffer	20	10	1.34	0.342	0.393
5	Terrace Gravel (Lower Continental Deposit) Bottom of HELP and DUST-MS Model	40	20	1.41	0.302	0.302
AT123D Lateral Flow Layer	Terrace Gravel (Lower Continental Deposit)		15	1.56	Saturated Horizontal Flow	
	Porter's Creek Clay		70			
McNairy Formation						

Unsaturated Vertical Flow

Figure C.3. DUSTMS Model Layers and Select Parameters, Site 3A

During the operational period (0–30 years), landfill components that would be in place include the leachate collection system with a barrier liner beneath the waste. This is a multi component system where each component functions independently and has different failure times and rates. During this period, it is assumed that a cover system is not in place. During this period, contaminant mass removed via the leachate collection system is assumed to be collected and removed from the landfill; however, the mass removed by the leachate collection system will not be taken into account during calculation of the PWAC.

For the gradual failure scenarios, all components of the waste disposal facility would be in place (both cover and liner components, drainage layers, and low-permeability clay layers) and functioning until at least year 130. At year 130 (the end of the institutional control period), the leachate collection system is assumed to cease to function. However, very little, if any, infiltration, is expected as long as the high density polyethylene (HDPE) geomembrane in the cap is intact (Bonaparte et al. 2008). HDPE geomembrane degradation is assumed to begin at year 200. For this reason, there will be little if any impact if the leachate collection system is modeled to cease functioning at 130 years or 200 years. For simplicity in modeling, the lateral drainage layers are assumed to cease functioning at 200 years.

During the institutional control period (30–130 years and generally considered to commence after facility closure and to last for 100 years) and for 70 years beyond the postinstitutional control period, all components of the waste disposal facility would be in place (both cover and liner components, drainage layers, and low-permeability clay layers) and functioning. The basis for this time period is outlined subsequently. These conditions apply to the instantaneous, gradual, and no failure scenarios. The HELP model will be used to evaluate the flux through the facility based on initial properties of the cover and liner system.

For the no failure scenario, all components of the waste disposal cell are assumed to be in place from year 200 to 10,000.

For the instantaneous failure scenario, all components of the waste disposal cell are assumed to fail at year 200. The “end state” or complete failure of certain landfill components is assumed to mean that the leachate collection system no longer is functioning, the liners have degraded to the point that they are no longer functioning as barriers to water transmission (either in or out of the landfill), and the clay liners have increased in hydraulic conductivity by one order of magnitude; the clay liners (upper and lower), as well as the other cap system components (e.g., soil cover and biointrusion layer) are assumed to still be in place and functioning as intended.

For the gradual failure scenario, at 200 years the HDPE geomembrane components of the cap and liner system would commence to degrade (i.e., all antioxidants are depleted and the induction time for the start of degradation is completed). Degradation of the HDPE geomembrane is assumed to be completed at 600 years. Beyond 600 years, the compacted clay liners (CCLs) controls infiltration into the cap and out of the liner system. It is recognized that a longer service life and degradation period for HDPE geomembranes are supported by the technical literature (Rowe 2010). For the base case, a longer service life and degradation period are bound by the no failure scenario. Other service lives and degradation periods may be addressed as part of the uncertainty analyses described in Section C.3.5.

The rate of degradation between 200 and 600 years will be modeled, based on prior work conducted at the site, and the following equation will be used (Lee et al. 1995):

$$F(t) = \frac{f_2 \ x \ f_3}{f_2 + (f_3 - f_2) \ x \ e^{-a(t - t1)}}$$

where

$F(t)$ = gradual failure function providing the groundwater recharge at any time t (cm/year)
f_2 = average groundwater recharge in the institutional control period (cm/year)
f_3 = final groundwater recharge for the post-institutional control period after cover and liner failure (cm/year)
t = time (years) at which F(t) is measure
t_1 = time (years) at the end of the institutional control period
α = decay constant (0.064 $year^{-1}$)

The decay constant, α, was set at 0.064 $year^{-1}$, which results in failure of the engineered barrier system at 600 years postclosure.

In the instantaneous and gradual failure cases, the CCL in both the base liner system and final cover system are assumed to undergo a one order of magnitude increase in hydraulic conductivity from 1×10^{-7} cm/s to 1×10^{-6} cm/s at 600 years. The degradation of the clay layer is modeled assuming a step change in hydraulic conductivity. Under this scenario, f_2 is established using an intact geomembrane over a CCL with a hydraulic conductivity of 1×10^{-7} cm/s (in both the final cover system and base liner system), and f_3 is established using only a CCL with a hydraulic conductivity of 1×10^{-6} cm/s.

The possible effects of the development of microchannels from "weathering" processes and the possible effects of chlorinated solvents upon clay liner hydraulic conductivity will be considered as an uncertainty, and the potential impacts on the PWAC will be discussed in the Remedial Investigation/Feasibility Study report.

C.3.2.1.2 DUSTMS Model

The DUSTMS model will be used to evaluate the release and migration of contaminants in the vadose zone (Sullivan 2006). The DUSTMS computer code is designed to model water flow, container degradation, release of contaminants from the waste to the contacting solution, and transport through the subsurface media. Water flow through the facility over time is modeled using tabular input. Container degradation models include three types of failure rates: instantaneous (all containers fail at once); uniformly distributed failures (containers fail at a linear rate between a specified starting and ending time); and gaussian failure rates (containers fail at a rate determined by a mean failure time, standard deviation, and gaussian distribution). As the waste is not expected to be containerized during waste placement, and because it is assumed for the purposes of modeling that the contaminants are readily available for transport and not packaged or treated to decrease leachability, containers will not be simulated. Also, according to Sullivan (2001), use of the waste containers provides an opportunity to overpredict chemical retardation if both waste-to-water and soil-to-water partitioning coefficients are assigned. Initial mass emplacement is simulated by specifying initial concentrations.

Wasteform release models include four release mechanisms: (1) rinse with partitioning [inventory is released instantly upon container failure subject to equilibrium partitioning (sorption) with the waste]; (2) diffusion release (release from either a cylindrical, spherical, or rectangular wasteform); (3) dissolution release (uniform release over time due to dissolution of the wasteform surface); and (4) the aforementioned wasteform release models with solubility limited release. The predicted wasteform releases are corrected for radioactive decay and ingrowth. Chemical transformations also can be evaluated as a rate constant, similar to radioactive decay.

A unique set of container failure and wasteform release parameters can be specified for each control volume with a container. Contaminant transport is modeled through a finite-difference solution of the advective transport equation with sources (wasteform release and ingrowth) and radioactive decay.

Although DUSTMS simulates one-dimensional transport, it can be used to simulate migration down to an aquifer and then transport in the aquifer by running the code twice; however, AT123D will be used to simulate contaminant fate and transport in the RGA and Terrace Gravel formations.

The DUSTMS model will be used to determine contaminant release rates from unit source concentrations (i.e., 1 mg/kg) in the disposal unit to the RGA water table, using water infiltration rates determined from the HELP model. DUSTMS is a one-dimensional model that allows for simplification of the disposal system while still accounting for the most important physical processes and parameters influencing contaminant releases.

Certain areas of the Upper Continental Recharge System (UCRS) have been found to be saturated above the RGA. The CERCLA waste disposal facility would be constructed above ground surface and, as such, contaminant releases initially will migrate through an unsaturated zone. DUSTMS, an unsaturated flow and transport model, will be used to model the flow and transport of contaminants from the waste disposal facility through this unsaturated zone and downward to the RGA. It is recognized, that while migrating vertically through the UCRS to the RGA, different moisture conditions, including saturated conditions, possibly will be encountered. Conservation of mass dictates that the DUSTMS predicted steady-state unsaturated mass flux (g/yr) would be the same throughout the vertical transport profile whether that profile is saturated or unsaturated or combinations of both. If portions of the UCRS are saturated, the specified moisture content will be adjusted accordingly. AT123D, will be used to simulate RGA contaminant migration, and uses the DUSTMS model-predicted mass flux as input.

C.3.2.1.3 MODFLOW and MODPATH

A sitewide flow model (DOE 1997) has been developed for PGDP using MODFLOW. MODFLOW (McDonald and Harbaugh 1988) and MODPATH (Pollack 1994) will be used to estimate hydraulic gradients, flow distances, and hydraulic conductivities along site-to-receptor flow paths. This information subsequently is used to develop input parameters for the AT123D saturated zone flow and transport model. MODFLOW is a three-dimensional, finite difference model capable of simulating both steady-state and transient head distribution for a saturated groundwater flow field. MODPATH is a three-dimensional, particle-tracking model capable of using the steady-state, head distribution generated by MODFLOW to track flow paths of particles released in the groundwater flow field modeled in MODFLOW. Figure C.4 presents an example of the flow path analysis using MODFLOW and MODPATH.

The MODFLOW model was used in the development of the sitewide groundwater flow model at PGDP (DOE 1997). This model covers most of the U.S. Department of Energy (DOE) Reservation except that portion above the Porters Creek Clay Terrace (southern geologic setting). The model was endorsed by both the PGDP Modeling Steering Committee and the Risk Assessment Working Group. The sitewide groundwater flow model has been updated in consultation with Kentucky and U.S. Environmental Protection Agency (EPA) using more recent groundwater monitoring data (DOE 2010). The revised sitewide groundwater model will be used in the development of an on-site waste disposal facility modeling effort. If the sitewide groundwater model cannot be expanded to include Site 3A, existing hydrogeologic data for Site 3A will be used to determine the appropriate hydrogeological parameters for Site 3A in the DUSTMS and AT123D models.

The MODPATH model will be used to track flowpaths of particles released from the disposal unit based on the steady-state flow from MODFLOW. The hydraulic gradient along the fastest flowpath to the exposure points of interest then will be estimated to ensure the transit time is conservatively estimated. The heads along the flowpath of interest will be determined, and the hydraulic gradient estimated as the head difference between the release point and exposure point of interest, divided by the distance from the

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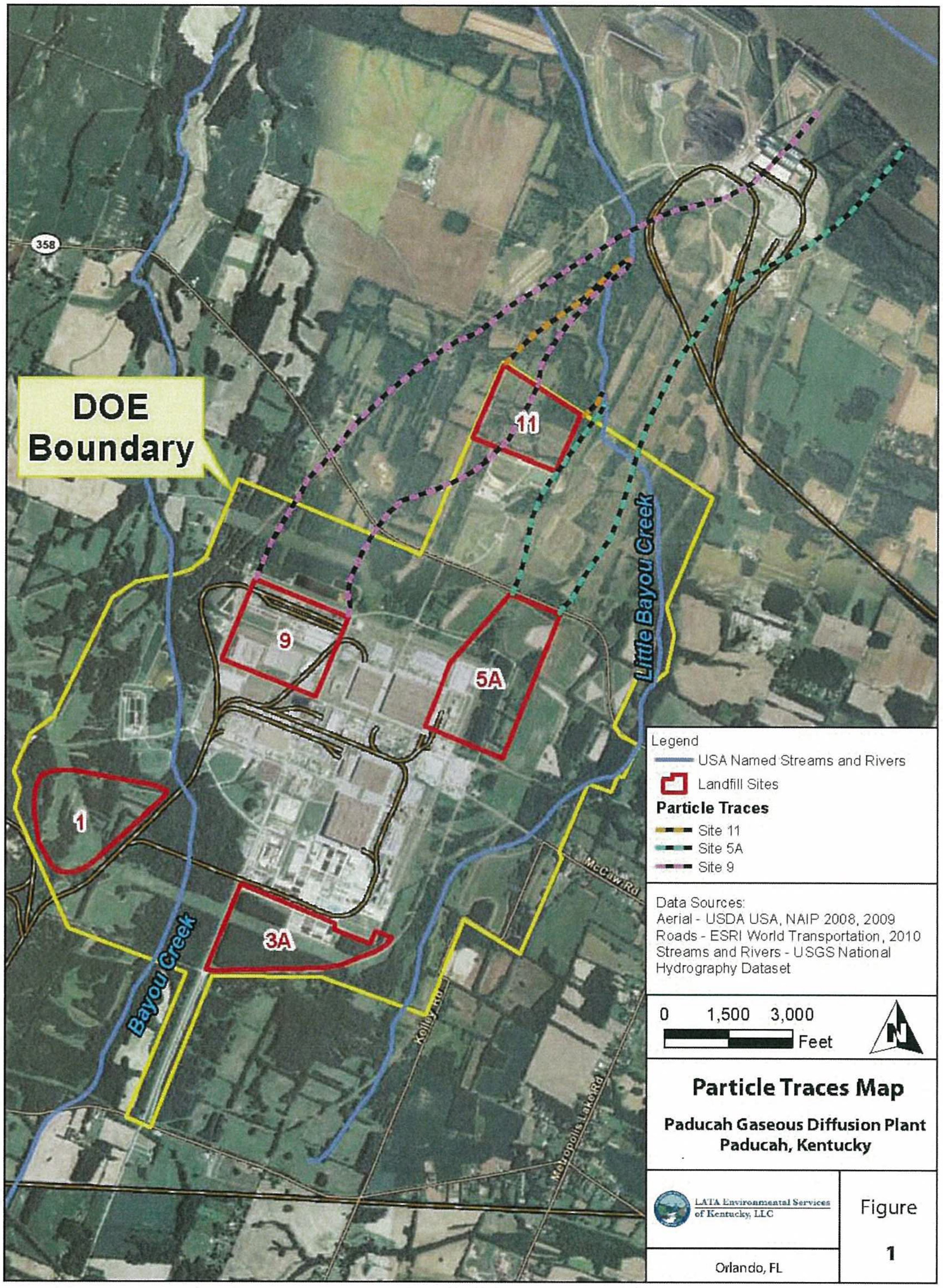

Figure C.4. Example Flow Paths from the Sitewide Groundwater Model

release point to the exposure point of interest. The hydraulic conductivity, along the fastest flowpath of interest, also will be estimated. The maximum hydraulic conductivity along the flowpath of interest will be selected for use in the AT123D model to ensure the transit time is not underestimated.

C.3.2.1.4 AT123D Model

The AT123D model will be used to model the lateral transport of contaminants in the groundwater to the exposure points (Yeh et al. 1987). AT123D is based on an analytical solution for transient one-, two-, or three-dimensional transport of a dissolved chemical or radionuclide in a homogeneous aquifer with uniform, stationary regional flow. The program assumes a stationary flow field parallel to the X-axis and allows for retardation (based on reversible instantaneous linear equilibrium sorption isotherm) and first-order decay. Longitudinal, horizontal, and vertical transverse dispersion can be input independently. The program calculates the concentration distribution in space and time in mg/L, parts per million, or pCi/L. AT123D models transport caused by a single source starting release of solute at time T = 0. It can accommodate various source configurations and boundary conditions. It also simulates a point source; a line source parallel to the X-, Y-, or Z-axis; an area (patch) source in the X-Y, X-Z, or Y-Z direction; and a volume source. The source release may be instantaneous, continuous, or finite step duration (up to 15 steps) and is assumed to be distributed equally over the source area.

Predicted contaminant concentrations for each organic indicator chemical in groundwater developed by AT123D will be used to develop the DAFs for use in estimating the remaining chemical groundwater concentrations within each surrogate group. As discussed previously, metals and radionuclides will be assessed individually and not as surrogate groups.

AT123D cannot model decay chains associated with radionuclide COPCs or chemical transformations from one species to another. Three methods are proposed for the assessment of these issues. The DUSTMS computer model could be used to evaluate the decay and transformation reaction uncertainty in the aquifer in a 1-D type analysis. Secondly, the groundwater concentration results from the AT123D model, for each contaminant run individually in AT123D, can be evaluated against decay chain and chemical transformation calculations conducted in DUSTMS to determine the uncertainty for these reactions. Third, an evaluation can be performed by comparing transit times to half-lives. If the half-lives are longer than the transit times to the points of exposure, then progeny formation during lateral migration in the aquifers likely is not a concern.

C.3.2.1.5 Dilution Attenuation Factors

To determine the transport times to and concentrations at the point of exposure for contaminants within each of the surrogate groups, the DAF for the indicator chemicals assigned to each surrogate group will be determined. The DAFs will then be applied to the other chemical's concentration within the surrogate group in the disposal unit to provide the resulting groundwater concentration at the receptor location of interest.

The determination of the DAF for an indicator chemical is represented graphically in Figure C.5. The DAF for the source-to-water table path is

$$DAF_{1,indicator} = \frac{\left(C_{s,indicator} / K_{d,indicator}\right)}{C_{L,indicator}}$$

where

DAF_1 = Dilution attenuation factor for the source-to-water table path (unitless)

C_s = Contaminant concentration in the disposal unit (mg/kg or pCi/g)
K_d = Contaminant distribution coefficient (L/kg)
C_L = Contaminant leachate concentration at the water table (mg/L or pCi/L)

The indicator chemical DAF for the water table-to-exposure point of interest is

$$DAF_{2,indicator} = \frac{C_{L,indicator}}{C_{w,indicator}}$$

where
DAF_2 = Dilution attenuation factor for the water table-to-exposure point path (unitless)
C_w = Contaminant concentration in groundwater at the exposure point of interest (mg/L or pCi/L)

Therefore, the DAF for the source-to-exposure point path for the indicator chemical is defined as

$$DAF = DAF_{1,indicator} \ x \ DAF_{2,indicator} = \frac{\left(C_{s,indicator} / K_{d,indicator}\right)}{C_{w,indicator}}$$

where
DAF = Dilution attenuation factor for the source-to-exposure point path (unitless)

The DAF then will be used to calculate the groundwater concentration for each chemical in the surrogate group by

$$C_{w,consituent} = \frac{\left(C_{s,consituent} / K_{d,consituent}\right)}{DAF_{indicator}}$$

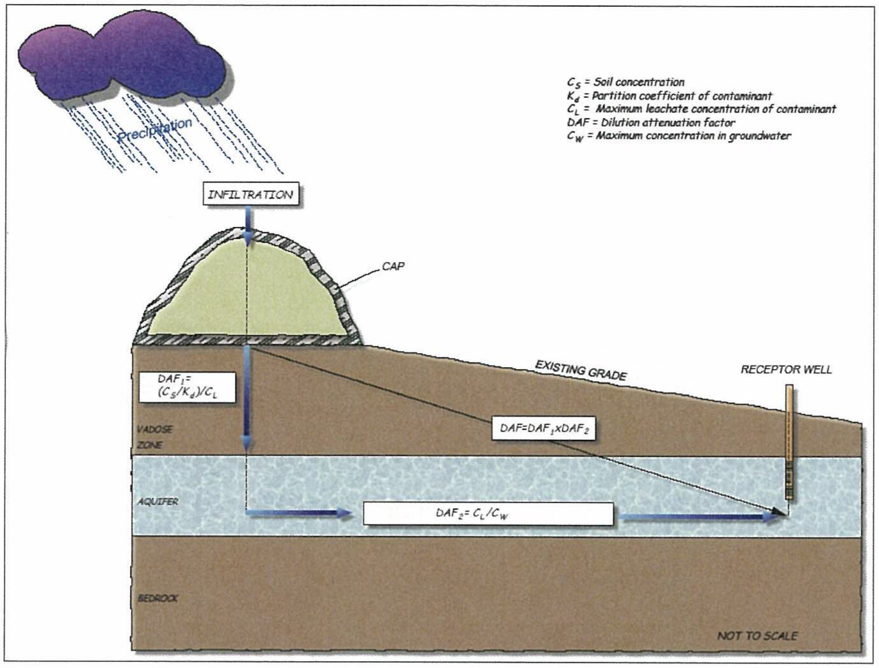

Figure C.5. Determination of the Dilution Attenuation Factor

C.3.3 RISK AND DOSE ASSESSMENT

The concentrations of COCs in groundwater at the exposure points will be used to calculate the cancer risk and non-cancer hazard [i.e., hazard index (HI)] for the chemicals, metals, and radionuclides resulting from exposure to the groundwater. The Risk Methods Document will be the basis of these calculations.

The analyses for exposure to constituents potentially released to groundwater will utilize the following risk and hazard target values at three points of exposure [i.e., at the edge of the waste unit, at the waste disposal facility (WDF) boundary, and at the DOE property line] and two time periods (i.e., 0 to 1,600 years and beyond 1,600 years). The edge of the waste unit is at the toe of containment berm that forms the WDF, which from a practical perspective is considered the edge of the waste mass. The WDF boundary is the site on which the WDF and associated infrastructure is located. For the purposes of the PWAC, this boundary is considered to 100 m from the edge of waste. Note, the final location will depend on site geometry and site layout and will be at least 100 m from the edge of waste (DOE Order 435.1). These points are depicted conceptually in Figure C.6.

(i) *At the edge of the waste unit (both time periods)*:

(1) The target concentrations will be the chemical-specific primary maximum contaminant levels (MCLs), if this value is greater than the constituent's background concentration. If the background concentration for the constituent is greater than the MCL, then the background concentration will be selected.

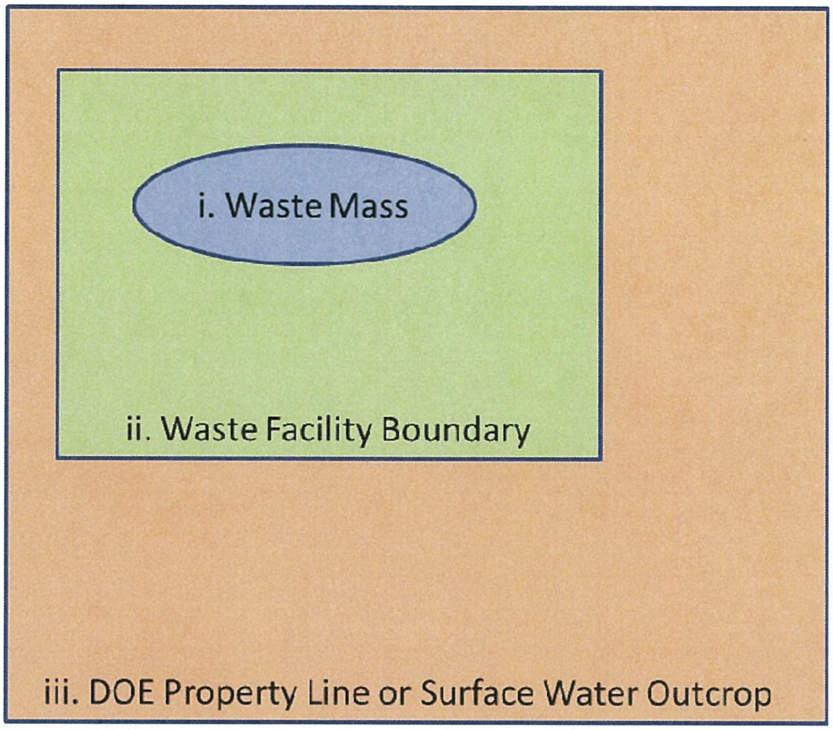

Figure C.6. Locations Where Target Values Need To Be Established

(2) If chemical-specific primary MCLs are not available, then chemical-specific risk- and hazard-based targets based on residential use of groundwater will be used to derive the constituent's target concentration in groundwater. The chemical-specific risk-based target will be 1E-06 and the chemical-specific hazard-based target will be 1. If both a risk-based concentration and hazard-based concentration can be derived for a constituent, then the lower of the two concentrations will be selected. If, however, the selected value is less than the background concentration, then the background concentration will be used.

(ii) *At the boundary of the WDF*:

(1) 0 to 1,600 years:

(a) The risk-based target will be a cumulative excess lifetime cancer risk (ELCR) of 1E-04.
(b) The hazard-based target will be a cumulative HI of 1.

(2) Beyond 1,600 years:

(a) The risk-based target will be a cumulative ELCR of 1E-04.
(b) The hazard-based target will be a cumulative HI of 3.

(Consistent with COPC selection in the Risk Methods Document, the calculation of cumulative ELCR and cumulative HI at the boundary of the WDF will exclude any constituents that use the constituent's background concentration as the chemical-specific target at the edge of the waste unit.)

(iii) *At the DOE property line or nearer surface water outcrop:*

(1) 0 to 1,600 years:

(a) The risk-based target will be a cumulative ELCR of 1E-06.
(b) The hazard-based target will be a cumulative HI of 1.

(2) Beyond 1,600 years:

(a) The risk-based target will be a cumulative ELCR of 1E-05.
(b) The hazard-based target will be a cumulative HI of 3.

(Consistent with COPC selection in the Risk Methods Document, the calculation of cumulative ELCR and cumulative HI at the DOE property line will exclude any constituents that use the constituent's background concentration as the chemical-specific target at the edge of the waste unit. Additionally, to target the more important risk and hazard contributors, only constituents with a chemical-specific contribution to cumulative ELCR and/or HI at the boundary of the WDF greater than 1E-07 or 0.05, respectively, will be included in the calculation of cumulative ELCR and HI at the DOE property line.)

The increased cumulative ELCR and/or HI targets of 1E-05 and 3, respectively, are used beyond 1,600 years at the boundary of the WDF and DOE property line to address the uncertainties in exposure (e.g., receptor location relative to ground water flow) and constituent release and migration.

The target concentrations at the edge of the waste unit are used to establish an initial PWAC. This PWAC is then used to calculate the contaminant concentrations in water at the boundary of the WDF. If these calculated contaminant concentrations exceed the risk-based and hazard-based targets established for the boundary of the WDF, then the initial PWAC is adjusted until these target risks are met. This iterative approach is then repeated for the property boundary.

The equations used to calculate the chemical-specific risk and non-cancer hazard estimates are as follows:

$$Chemical - Specific\ Risk\ Value = \frac{C_{w\,Chemical}\ \ x\ Target\ Risk\ Value}{C_{w\,No\ Action}}$$

where

Chemical-Specific Risk Value	=	cancer risk and non-cancer hazard from groundwater exposure
$C_{w\ Chemical}$	=	chemical concentration in groundwater (mg/L or pCi/L)
Target Risk Value	=	target cancer risk, hazard level, or MCL to maintain
$C_{w\ No\ Action}$	=	cancer risk/hazard no-action screening value or MCL as appropriate (mg/L or pCi/L)

C.3.4 PRELIMINARY WAC DEVELOPMENT

A PWAC will be developed for an on-site waste disposal facility. The PWAC is an estimate of the average contaminant concentrations allowed in the total waste volume. Individual loads could be higher or lower. Additionally, the PWAC is the total contaminant amount, such as maximum curies permitted in the cell or the single contaminant mass limit (in grams or kilograms) per COPC.

The PWAC will be useful in evaluating the viability of an on-site disposal facility only. If selected as the preferred alternative, the PWAC values for an on-site disposal facility would require modification after the design for the disposal facility is finalized. As used here, the PWAC for a contaminant is defined as the maximum allowable concentration of a contaminant in disposed material that will not result in (1) releases to receiving media that exceed regulatory or risk-based criteria or (2) direct exposure risks or doses that exceed acceptable cancer risk-based and non-cancer hazard-based levels. This definition is consistent with, but goes beyond that presented in Attachment 2 of DOE Order 435.1 (*Radioactive Waste Management Manual*). In that attachment, PWAC are defined as technical and administrative requirements that a waste must meet in order for it to be accepted at a storage, treatment, or disposal facility. Generally, PWAC as defined here are dependent on five primary characteristics. These are the following:

- Facility design, including liner and cover, integrity, and institutional controls;
- Mobility of contaminants from or retention of contaminants within a waste (e.g., soil, stabilized soils, concrete, metals, etc.);
- Exposure point characteristics, including type of receptor (e.g., human or ecological), location, and exposure media;
- Target cancer risk, target hazard level, MCLs, and period of compliance; or
- Potential engineered barrier failure.

The method used to calculate the PWAC is presented in the following equations.

$$\frac{PWAC}{C_{s\ \ chemical}} = \frac{C_{w\ \ target}}{C_{w\ \ chemical}}$$

or

$$PWAC = \frac{C_{w\ \ target}\ x\ C_{s\ \ chemical}}{C_{w\ \ chemical}}$$

where

PWAC = preliminary WAC (mg/kg or pCi/g)
$C_{w\ target}$ = target concentrations for groundwater (i.e., back calculation value)
$C_{s\ chemical}$ = constituent concentration in source used in the modeling (mg/kg or pCi/g)
$C_{w\ chemical}$ = constituent concentration in groundwater from modeling results (mg/L or pCi/L)

The PWAC for the total mass or activity allowed in an on-site waste disposal facility will be calculated from the waste volume of the WDF and the PWAC concentration values as follows:

$$PWAC\ (kg\ or\ Ci) = PWAC\ (mg/kg\ or\ pCi/g)\ ´\ r_b\ ´\ V\ ´\ CF$$

where

ρ_b = bulk density (3.1 g/cm^3)
V = facility volume (4.1mcy or 3.13 x 10^{12} cm^3)
CF = conversion factors as necessary for unit conversion

The PWAC methodology, as presented in this work plan, is based on the assumption that the entire landfill would be filled with a single waste, assumed to be soil with a single contaminant. The contaminant is assumed to be immediately available for transport, thus maximizing release rates (i.e., many waste types will be solid materials for which associated contaminants would not be readily available for release). The cumulative risk from all contaminants will be evaluated during development of a final WAC, if the on-site disposal is chosen as the preferred remedial option. The PWAC will be calculated using the peak concentration between 0 and 1,600 years and 1,600 and 10,000 years. In the event the peak concentration in groundwater of a constituent has not been reached at 1,600 years, the model will be run until the peak concentration is reached, or until 10,000 years. The model will not be run beyond 10,000 years.

C.3.5 UNCERTAINTY ANALYSIS

The proposed modeling for an on-site waste disposal facility will consist of evaluating the COCs in a "forward" calculation based on unit inventory concentrations. The forward calculation provides the predicted groundwater contaminant concentrations released from the waste disposal facility into the aquifer at PGDP. These concentrations then are used in a "backward" calculation to determine the PWAC for the waste disposal facility. The term "backward" calculation is used in the sense that the analyst is using the forward calculation results to back calculate an acceptable waste concentration and total mass (or activity) of a given contaminant.

The use of this methodology does not provide a means to determine if the solubility limits for COCs may be reached in the disposal unit pore water; therefore, the PWAC values will be compared to solubility limit concentrations in terms of the disposal pore water concentrations. If the PWAC values result in concentrations exceeding the solubility limits, then the disposal mass of the COPC is no longer limited.

Another issue of potential importance to a disposal facility environment pertains to the facilitated transport of PCBs through cosolvent effects (EPA 1989). A modeling study was completed for the C-746-U Landfill at PGDP to evaluate the cosolvency impact at this landfill (BJC 2003). A similar analysis may need to be conducted for the waste disposal unit. The evaluation should be based on expected disposal concentrations of PCBs and potential solvents; therefore, the cosolvent issue will be evaluated if the On-Site Disposal Alternative is selected and the final WAC is to be developed.

An additional issue relates to facilitated transport possibly caused by the inclusion of nonhazardous solid waste/organic materials in the waste mix disposed of in the waste disposal facility. The phenomenon of such facilitated transport will be considered in the development of PWAC. Also, because some radionuclide contaminants (and decay products from ingrowth) will not reach their peak concentration prior to 10,000 years, an uncertainty analysis examining ingrowth and risk beyond 10,000 years will be completed for uranium-238 (U-238) (parent compound) and thorium-230 (Th-230) (progeny). This analysis will use a forward run of the transport model for the gradual failure scenario to the peak concentrations for U-238 and Th-230 and the selected initial PWAC for U-238 and Th-230 as the source term concentration. Due to modeling software constraints, the time step used in this analysis will be larger than that used for development of the PWAC. Another consideration in the development of the PWAC involves the potential impacts to inadvertent intruders. The preliminary disposal facility design provides 16 ft of cover over the waste. This cover thickness should prevent an inadvertent intruder from reaching the waste through excavation of a typical basement. Nonetheless, the inadvertent intruder scenario will be considered qualitatively in the development of the PWAC as an uncertainty.

The fate and transport modeling will have associated uncertainties due to abstraction of the physical and chemical processes of the real system into a model system. In addition, uncertainties in the waste inventories, model parameterization, and conceptual model uncertainties will need to be addressed.

Several iterations of the modeling will be necessary to evaluate and quantify the sensitivity and uncertainty in the results. In general, the sensitivity and uncertainty will be addressed by assessing parameter variations in the models. This may include such parameters as the following:

- Clay barrier degradation
- Geomembrane service life
- Geomembrane rate of degradation
- Sorption coefficients variations
- Solubility variations
- Hydraulic conductivity variations
- Off-centerline groundwater concentration evaluations
- Ingrowth of radionuclide progeny
- Degradation of organic COPCs
- Ingrowth of organic COPCs
- Potential for facilitated transport

C.4. REFERENCES

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ATTACHMENT C1

PROPOSED MODELING PARAMETERS

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Table C1.1. Proposed Landfill/Soil Profile - Post-Closure Period (30 to 200 years)

HELP Parameters/Characteristics

Layer #	Material Type	Layer Type	Layer Thickness (inches)	Soil Texture Type	Total Porosity (vol/vol)	Field Capacity (vol/vol)	Wilting Point (vol/vol)	Saturated Hydraulic Conductivity (cm/sec)	Initial Moisture Content	Drainage Length (ft)	Drain Slope (%)	FML Pinhole Density	FML Installation Defects	FML Placement Quality
1	Native Soil (vegetative)	1	18	12	0.45 *	0.342	0.21	2.32E-06 *	0.2347 ***					
2	Native Soil	1	42	12	0.45 *	0.342	0.21	5.00E-07 *	0.3420 ***					
3	Filter sand	1	12	3	0.457	0.083	0.033	3.10E-03	0.0843 ***					
4	Geotextile	1	0.0625	20	0.85	0.01	0.005	1.00E+01	0.0501 ***					
5	Cobble/gravel/ sand	1	36	21	0.397	0.032	0.013	3.00E-01	0.0321 ***					
6	Drainage sand	2	12	1	0.417	0.045	0.018	1.00E-02	0.0452 ***	380	2			
7	Geotextile	2	0.125	20	0.85	0.01	0.005	1.00E+01	0.0100 ***	380	2			
8	FML (HDPE)	4	0.04	35				2.00E-13	0.0000 ***			0	0.5	2 (Excellent)
9	Clay barrier/ contour layer	3	36	16	0.427	0.418	0.367	1.00E-07 *	0.4270 ***					
10	Waste	1	1020	22	0.419	0.307	0.18	1.90E-05	0.3588					
11	Contour layer	1	12	26	0.445	0.393	0.277	1.90E-06	0.4112					
12	Geotextile	1	0.125	20	0.85	0.01	0.005	1.00E+01	0.1103					
13	Drainage sand	2	12	1	0.417	0.045	0.018	1.00E-02	0.1158	364	5			
14	Geotextile	2	0.125	20	0.85	0.01	0.005	1.00E+01	0.0766	364	5			
15	FML (HDPE)	4	0.06	35				2.00E-13	0.0000			0	0.5	2 (Excellent)
16	Bonded Geotextile	2	0.236	34	0.85	0.01	0.005	3.30E+01	0.0100	364	5			
17	FML (HDPE)	4	0.06	35				2.00E-13	0.0000			0	0.5	2 (Excellent)
18	Clay barrier **	3	36	16	0.427	0.418	0.367	1.00E-07 *	0.4270					
19	Geo-buffer layer	1	120	12	0.45 *	0.342	0.21	5.00E-07 *	0.3420					
20	Existing Silty Clay	1	264 (Site 11) 240 (Site 3A)	26	0.400 * (Site 3A) 0.445 (Site 11)	0.393	0.277	3.67E-06 * (Site 3A) 3.80E-07 * (Site 11)	0.3930					

Notes:

- FML = flexible membrane lining.
- FML Pinhole Density in units of number of holes per acre. Diameter of defect is equal to geomembrane thickness.
- FML installation defects are in units of defects per acre. A defect is estimated using an area of 1 cm^2.
- The cover system design curve number is 87.6 (slope 2%, slope length 380 ft, fair stand of grass (3), with soil texture type 12).
- Soil layering and properties are based upon the June 2010 PGDP Public Fact Sheet, Waste Disposal Options.
- HDPE = high density polyethylene.
- No recirculation of leachate is assumed.

* - Signifies value is not the default value associated with the specified HELP Soil Texture Type.

** - Signifies location where HELP Percolation/Leakage rate is used as DUST-MS water velocity.

*** - Initial soil moisture content was calculated by HELP (Schroeder et al. 1994). Remaining moisture contents were assigned using the final moisture content of the Operational Period HELP scenario.

- Moisture content values are in units of pore water volume per total volume soil and void space.
- "Native Soil", "Geo-buffer layer", and "Existing Silty Clay" soil porosities and hydraulic conductivities are from Site 3A Seismic Investigation Report, Assessment of the Adequacy of Data Report, and GB-02D lithologic log.

Table C1.2. Proposed Landfill Design Profile and Soil Characteristics - Long Term Monitoring Period (600+ years)

Layer #	Material Type	HELP Layer Type	Layer Thickness (inches)	HELP Soil Texture Type	Total Porosity (vol/vol)	Field Capacity (vol/vol)	Wilting Point (vol/vol)	Saturated Hydraulic Conductivity (cm/sec)	Initial Moisture Content (vol. water/total vol.)
1	Native Soil (vegetative)	1	18	12	0.45 *	0.342	0.21	2.32E-06 *	0.3071
2	Native Soil	1	42	12	0.45 *	0.342	0.21	5.00E-07 *	0.3491
3	Filter sand	1	12	3	0.457	0.083	0.033	3.10E-03	0.1118
4	Cobble/gravel/sand	1	36	21	0.397	0.032	0.013	3.00E-01	0.0364
5	Drainage sand	1	12	1	0.417	0.045	0.018	1.00E-02	0.0547
6	Clay barrier	1	36	16	0.427	0.418	0.367	1.00E-06*	0.4270
7	Waste	1	1020	22	0.419	0.307	0.18	1.90E-05	0.3070
8	Silty clay	1	12	26	0.445	0.393	0.277	1.90E-06	0.3930
9	Drainage sand	1	12	1	0.417	0.045	0.018	1.00E-02	0.0450
10	Clay barrier	1	36	16	0.427	0.418	0.367	1.00E-06 *	0.4270
11	Geo-buffer layer **	1	120	12	0.45 *	0.342	0.21	5.00E-07 *	0.3420
12	Existing Silty Clay	1	264 (Site 11) 240 (Site 3A)	26	0.400 * (Site 3A) 0.445 (Site 11)	0.393	0.277	3.67E-06* (Site 3A) 3.80E-07* (Site 11)	0.3930

Notes:

* - Signifies value is not the default value associated with the specified HELP Soil Texture Type.

** - Signifies location where HELP Percolation/Leakage rate is used as DUST-MS water velocity.

- Moisture content values are in units of pore water volume per total volume soil and void space.

- The cover system design curve number is 87.6 (slope 2%, slope length 380 ft, fair stand of grass (3), with soil texture type 12).

- "Native Soil", "Geo-buffer layer", and "Existing Silty Clay" soil porosities and hydraulic conductivities are from Site 3A Seismic Investigation Report, Assessment of the Adequacy of Data Report, and GB-02D lithologic log.

Table C1.3. Chemical Specific Parameters

Parameters	PGDP Model Value	Reference(s)	Previous Draft Model Value (based on DOE 2010)	Reference(s)	U-Landfill (DOE 2003) Value	Reference(s)	ORISE RESRAD Model Value[2]	Reference(s)
Vinyl Chloride (VC) - Atomic Weight 62.5 g/mol								
Half Life (years)	7.90E+00	Howard et al., 1991, Page 138	--[1]	--	7.90E+00	Howard et al., 1991	--	--
Atomic Weight (g/mol)	62.5	--	62.5	--	62.5	EPA (1996)	--	--
Solubility Limit (gm/cc)	2.76E-03	EPA (1996), Table 36, Pages 134 to 136	2.76E-03	EPA (1996), Table 36, Pages 134 to 136.	2.76E-03	EPA (1996), Table 36, Pages 134 to 136	--	--
Unsaturated Soils, Waste, and Saturated Vertical Flow Kd[4] (cc/gm)	1.49E-02	Koc[5] referenced from EPA (1996), Table 39, Pages 143 to 145. foc[6] referenced from DOE (2007), Table F.2.3 "Likeliest" value. Kd calculated by multiplying Koc (1.86E+01 l/kg) by foc (8.01E-4 unitless).	1.49E-02	Sheppard and Thibault (1990) (Not Verified)	1.49E-02	Sheppard and Thibault (1990) (Not Verified)	--	--
Saturated Horizontal Flow Kd (cc/gm)	6.51E-03	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. foc referenced from DOE (2007), Table F.2.8 "Likeliest" value. Kd calculated by multiplying Koc (1.86E+01 l/kg) by foc (3.5E-4 unitless).					--	--
Diffusion Coefficient (cm^2/sec)	1.23E-06	EPA (1996), Table 37, Pages 137 to 139	1.23E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	1.23E-06	No reference given. From DOE (2003), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--
Trichloroethylene (TCE) - Atomic Weight 131.4 g/mol								
Half Life (years)	4.50E+00	Howard et al., 1991, Page 190	2.50E+01	--	4.50E+00	Howard et al., 1991	--	--
Atomic Weight (g/mol)	131.4	--	131.4	--	131	EPA (1996)	--	--
Solubility Limit (gm/cc)	1.10E-03	EPA (1996), Table 36, Pages 134 to 136	1.10E-03	EPA (1996), Table 36, Pages 134 to 136	1.10E-03	EPA (1996), Table 36, Pages 134 to 136	--	--
Unsaturated Soils, Waste, and Saturated Vertical Flow Kd (cc/gm)	7.55E-02	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. foc referenced from DOE (2007), Table F.2.3 "Likeliest" value. Kd calculated by multiplying Koc (9.43E+01 l/kg) by foc (8.01E-4 unitless).	7.52E-02	Sheppard and Thibault (1990) (Not Verified)	7.52E-02	Sheppard and Thibault (1990) (Not Verified)	--	--
Saturated Horizontal Flow Kd (cc/gm)	3.30E-02	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. foc referenced from DOE (2007), Table F.2.8 "Likeliest" value. Kd calculated by multiplying Koc (9.43E+01 l/kg) by foc (3.5E-4 unitless).					--	--
Diffusion Coefficient (cm^2/sec)	9.10E-06	EPA (1996), Table 37, Pages 137 to 139	9.10E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	9.10E-06	No reference given. From DOE (2003), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--

Table C1.3. Chemical Specific Parameters (Continued)

Parameters	PGDP Model Value	Reference(s)	Previous Draft Model Value (based on DOE 2010)	Reference(s)	U-Landfill (DOE 2003) Value	Reference(s)	ORISE RESRAD Model Value[2]	Reference(s)
2-Butanone (Methyl Ethyl Ketone) - Atomic Weight 72.1 g/mol								
Half Life (years)	3.80E-02	Howard et al., 1991, Page 186	--	--	1.97E+00	Howard et al., 1991	--	--
Atomic Weight (g/mol)	72.1	--	72.1	--	72.1	EPA (1996)	--	--
Solubility Limit (gm/cc)	7.40E-02	EPA (1996), Table 36, Pages 134 to 136	2.75E-01	EPA (1996), number not found in table	2.75E-01	EPA (1996), number not found in table	--	--
Unsaturated Soils, Waste, and Saturated Vertical Flow Kd (cc/gm)	5.54E-03	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. foc referenced from DOE (2007), Table F.2.3 "Likeliest" value. Kd calculated by multiplying Koc (6.92E+00 l/kg) by foc (8.01E-4 unitless).	9.20E-04	Sheppard and Thibault (1990) (Not Verified)	9.20E-04	Sheppard and Thibault (1990) (Not Verified)	--	--
Saturated Horizontal Flow Kd (cc/gm)	2.42E-03	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. foc referenced from DOE (2007), Table F.2.8 "Likeliest" value. Kd calculated by multiplying Koc (6.92E+00 l/kg) by foc (3.5E-4 unitless).					--	--
Diffusion Coefficient (cm^2/sec)	9.30E-06	EPA (1996), Table 37, Pages 137 to 139	1.02E-05	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	1.02E-05	No reference given. From DOE (2003), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--
Chlorobenzene - Atomic Weight 112.6 g/mol								
Half Life (years)	1.64E+00	Howard et al., 1991, Page 412	--	--	1.64E+00	Howard et al., 1991	--	--
Atomic Weight (g/mol)	112.6		112.6		112.6	EPA (1996)	--	--
Solubility Limit (gm/cc)	4.72E-04	EPA (1996), Table 36, Pages 134 to 136	4.72E-04	EPA (1996), Table 36, Pages 134 to 136	4.72E-04	EPA (1996), Table 36, Pages 134 to 136	--	--
Unsaturated Soils, Waste, and Saturated Vertical Flow Kd (cc/gm)	1.79E-01	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. foc referenced from DOE (2007), Table F.2.3 "Likeliest" value. Kd calculated by multiplying Koc (2.24E+02 l/kg) by foc (8.01E-4 unitless).	1.79E-01	Sheppard and Thibault (1990) (Not Verified)	1.79E-01	Sheppard and Thibault (1990) (Not Verified)	--	--
Saturated Horizontal Flow Kd (cc/gm)	7.84E-02	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. foc referenced from DOE (2007), Table F.2.8 "Likeliest" value. Kd calculated by multiplying Koc (2.24E+02 l/kg) by foc (3.5E-4 unitless).					--	--
Diffusion Coefficient (cm^2/sec)	8.70E-06	EPA (1996), Table 37, Pages 137 to 139	8.70E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	8.70E-06	No reference given. From DOE (2003), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--

Table C1.3. Chemical Specific Parameters (Continued)

Parameters	PGDP Model Value	Reference(s)	Previous Draft Model Value (based on DOE 2010)	Reference(s)	U-Landfill (DOE 2003) Value	Reference(s)	ORISE RESRAD Model Value[2]	Reference(s)
Benzene - Atomic Weight 78.1 g/mol								
Half Life (years)	2.00E+00	Howard et al., 1991, Page 111	--	--	1.97E+00	Howard et al., 1991	--	--
Atomic Weight (g/mol)	78.1	--	78.1	--	78.1	EPA (1996)	--	--
Solubility Limit (gm/cc)	1.75E-03	EPA (1996), Table 36, Pages 134 to 136	1.75E-03	EPA (1996), Table 36, Pages 134 to 136	1.75E-03	EPA (1996), Table 36, Pages 134 to 136	--	--
Unsaturated Soils, Waste, and Saturated Vertical Flow Kd (cc/gm)	4.94E-02	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. foc referenced from DOE (2007), Table F.2.3 "Likeliest" value. Kd calculated by multiplying Koc (6.17E+01 l/kg) by foc (8.01E-4 unitless).	4.96E-02	Sheppard and Thibault (1990) (Not Verified)	4.96E-02	Sheppard and Thibault (1990) (Not Verified)	--	--
Saturated Horizontal Flow Kd (cc/gm)	2.16E-02	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. foc referenced from DOE (2007), Table F.2.8 "Likeliest" value. Kd calculated by multiplying Koc (6.17E+01 l/kg) by foc (3.5E-4 unitless).					--	--
Diffusion Coefficient (cm^2/sec)	9.80E-06	EPA (1996), Table 37, Pages 137 to 139	9.80E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	9.80E-06	No reference given. From DOE (2003), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--
2-Methylphenol (o-Cresol) - Atomic Weight 108 g/mol								
Half Life (years)	7.70E-02	Howard et al., 1991, Page 294	--	--	1.97E+00	Howard et al., 1991	--	--
Atomic Weight (g/mol)	108	--	108	--	108	EPA (1996)	--	--
Solubility Limit (gm/cc)	2.60E-02	EPA (1996), Table 36, Pages 134 to 136	2.00E-02	EPA (1996), Table 36, Pages 134 to 136	2.00E-02	EPA (1996), Table 36, Pages 134 to 136	--	--
Unsaturated Soils, Waste, and Saturated Vertical Flow Kd (cc/gm)	7.31E-02	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. foc referenced from DOE (2007), Table F.2.3 "Likeliest" value. Kd calculated by multiplying Koc (9.12E+01 l/kg) by foc (8.01E-4 unitless).	1.60E-02	Sheppard and Thibault (1990) (Not Verified)	1.60E-02	Sheppard and Thibault (1990) (Not Verified)	--	--
Saturated Horizontal Flow Kd (cc/gm)	3.19E-02	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. foc referenced from DOE (2007), Table F.2.8 "Likeliest" value. Kd calculated by multiplying Koc (9.12E+01 l/kg) by foc (3.5E-4 unitless).					--	--
Diffusion Coefficient (cm^2/sec)	8.30E-06	EPA (1996), Table 37, Pages 137 to 139	8.30E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	8.30E-06	No reference given. From DOE (2003), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--

BACK

Table C1.3. Chemical Specific Parameters (Continued)

Parameters	PGDP Model Value	Reference(s)	Previous Draft Model Value (based on DOE 2010)	Reference(s)	U-Landfill (DOE 2003) Value	Reference(s)	ORISE RESRAD Model Value[2]	Reference(s)
Pentachlorophenol - Atomic Weight 266.3 g/mol								
Half Life (years)	4.20E+00	Howard et al., 1991, Page 242	--	--	4.20E+00	Howard et al., 1991	--	--
Atomic Weight (g/mol)	266.3		266.3		266.3	EPA (1996)	--	--
Solubility Limit (gm/cc)	1.95E-03	EPA (1996), Table 36, Pages 134 to 136	1.95E-03	EPA (1996), Table 36, Pages 134 to 136	1.95E-03	EPA (1996), Table 36, Pages 134 to 136	--	--
Unsaturated Soils, Waste, and Saturated Vertical Flow Kd (cc/gm)	4.74E-01	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. foc referenced from DOE (2007), Table F.2.3 "Likeliest" value. Kd calculated by multiplying Koc (5.92E+02 l/kg) by foc (8.01E-4 unitless).	4.74E-01	Sheppard and Thibault (1990) (Not Verified)	4.74E-01	Sheppard and Thibault (1990) (Not Verified)	--	--
Saturated Horizontal Flow Kd (cc/gm)	2.07E-01	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. foc referenced from DOE (2007), Table F.2.8 "Likeliest" value. Kd calculated by multiplying Koc (5.92E+02 l/kg) by foc (3.5E-4 unitless).					--	--
Diffusion Coefficient (cm^2/sec)	6.10E-06	EPA (1996), Table 37, Pages 137 to 139	6.10E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	6.10E-06	No reference given. From DOE (2003), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--
Benzo(a)pyrene - Atomic Weight 252.3 g/mol								
Half Life (years)	5.80E+00	Howard et al., 1991, Page 12	--	--	5.80E+00	Howard et al., 1991	--	--
Atomic Weight (g/mol)	252.3		252.3		252.3	EPA (1996)	--	--
Solubility Limit (gm/cc)	1.62E-09	EPA (1996), Table 36, Pages 134 to 136	1.62E-03	EPA (1996), appears that the units are not correct	1.62E-03	EPA (1996), appears that the units are not correct	--	--
Unsaturated Soils, Waste, and Saturated Vertical Flow Kd (cc/gm)	7.76E+02	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. foc referenced from DOE (2007), Table F.2.3 "Likeliest" value. Kd calculated by multiplying Koc (9.69E+05 l/kg) by foc (8.01E-4 unitless).	7.75E+02	Sheppard and Thibault (1990) (Not Verified)	7.75E+02	Sheppard and Thibault (1990) (Not Verified)	--	--
Saturated Horizontal Flow Kd (cc/gm)	3.39E+02	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. foc referenced from DOE (2007), Table F.2.8 "Likeliest" value. Kd calculated by multiplying Koc (9.69E+05 l/kg) by foc (3.5E-4 unitless).					--	--
Diffusion Coefficient (cm^2/sec)	9.00E-06	EPA (1996), Table 37, Pages 137 to 139	9.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	9.00E-06	No reference given. From DOE (2003), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--

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Table C1.3. Chemical Specific Parameters (Continued)

Parameters	PGDP Model Value	Reference(s)	Previous Draft Model Value (based on DOE 2010)	Reference(s)	U-Landfill (DOE 2003) Value	Reference(s)	ORISE RESRAD Model Value[2]	Reference(s)
PCB (Aroclor 1254) - Atomic Weight 375.7 g/mol								
Half Life (years)	1.00E+02	U-Landfill Report, (DOE 2003)	--	--	1.00E+02	Howard et al., 1991	--	--
Atomic Weight (g/mol)	375.7		375.7		375.7	EPA (1996)	--	--
Solubility Limit (gm/cc)	7.00E-07	EPA (2004), Page A-295	8.00E-08	EPA (1996)	8.00E-08	EPA (1996)	--	--
Unsaturated Soils, Waste, and Saturated Vertical Flow Kd (cc/gm)	2.48E+02	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. foc referenced from DOE (2007), Table F.2.3 "Likeliest" value. Kd calculated by multiplying Koc (3.09E+05 l/kg) by foc (8.01E-4 unitless).	2.47E+02	Sheppard and Thibault (1990) (Not Verified)	2.47E+02	Sheppard and Thibault (1990) (Not Verified)	--	--
Saturated Horizontal Flow Kd (cc/gm)	1.08E+02	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. foc referenced from DOE (2007), Table F.2.8 "Likeliest" value. Kd calculated by multiplying Koc (3.09E+05 l/kg) by foc (3.5E-4 unitless).					--	--
Diffusion Coefficient (cm^2/sec)	1.00E-06	U-Landfill Report (DOE 2003)	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	1.00E-06	No reference given. From DOE (2003), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--
gamma-Chlordane (Chlordane) - Atomic Weight 409.8 g/mol								
Half Life (years)	7.60E+00	Howard et al., 1991, Page 48	--	--	7.60E+00	Howard et al., 1991	--	--
Atomic Weight (g/mol)	409.8		409.8		409.8	EPA (1996)		
Solubility Limit (gm/cc)	5.60E-08	EPA (1996), Table 36, Pages 134 to 136	5.60E-08	EPA (1996), Table 36, Pages 134 to 136	5.60E-08	EPA (1996), Table 36, Pages 134 to 136	--	--
Unsaturated Soils, Waste, and Saturated Vertical Flow Kd (cc/gm)	4.11E+01	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. foc referenced from DOE (2007), Table F.2.3 "Likeliest" value. Kd calculated by multiplying Koc (5.13E+04 l/kg) by foc (8.01E-4 unitless).	4.71E+01	Sheppard and Thibault (1990) (Not Verified)	4.71E+01	Sheppard and Thibault (1990) (Not Verified)	--	--
Saturated Horizontal Flow Kd (cc/gm)	1.80E+01	Koc referenced from EPA (1996), Table 39, Pages 143 to 145. foc referenced from DOE (2007), Table F.2.8 "Likeliest" value. Kd calculated by multiplying Koc (5.13E+04 l/kg) by foc (3.5E-4 unitless).					--	--
Diffusion Coefficient (cm^2/sec)	4.37E-06	EPA (1996), Table 37, Pages 137 to 139	4.37E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	4.37E-06	No reference given. From DOE (2003), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--

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Table C1.3. Chemical Specific Parameters (Continued)

Parameters	PGDP Model Value	Reference(s)	Previous Draft Model Value (based on DOE 2010)	Reference(s)	U-Landfill (DOE 2003) Value	Reference(s)	ORISE RESRAD Model Value[2]	Reference(s)
Antimony - Atomic Weight 121.7 g/mol								
Half Life (years)	--	--	--	--	--	--	--	--
Atomic Weight (g/mol)	121.7		121.7		--	--	--	--
Solubility Limit (gm/cc)	1.70E-01	EPA (2004), Page A-25.	1.00E+01	EPA (1996)	--	--	--	--
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	45 (sand and all other materials)	Sheppard and Thibault (1990), Table 1, Page 472	45 (sand)	Sheppard and Thibault (1990), Table 1, Page 472	--	--	--	--
	250 (clay)		250 (clay)		--	--	--	--
Diffusion Coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--	--	--
Arsenic - Atomic Weight 74.9 g/mol								
Half Life (years)	--	--	--	--	1.00E+05	Disposal Unit Source Term (DUST) default library	--	--
Atomic Weight (g/mol)	74.9		74.9		75	EPA (1996)	--	--
Solubility Limit (gm/cc)	1.20E-01	EPA (2004), Page A-29.	1.00E+01	EPA (1996)	1.00E+01	EPA (1996)	--	--
Kd (cc/gm)	2.90E+01	EPA (1996), Table 46, Page 158.	200 (sand)	Sheppard and Thibault (1990) (Not Verified)	200 (sand)	Sheppard and Thibault (1990) (Not Verified)	--	--
			200 (clay)		200 (clay)		--	--
Diffusion Coefficient (cm^2/sec)	1.00E-06	U-Landfill Report (DOE 2003)	1.00E-06	No reference given, from DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	1.00E-06	No reference given. From DOE (2003), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--
Barium - Atomic Weight 137.3 g/mol								
Half Life (years)	--	--	--	--	--	--	--	--
Atomic Weight (g/mol)	137.3		137.3		--	--	--	--
Solubility Limit (gm/cc)	2.80E-03	EPA (2004), Page A-33.	1.00E+01	EPA (1996)	--	--	--	--
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	4.10E+01	EPA (1996), Table 46, Page 158.	5 (sand)	Sheppard and Thibault (1990) (Not Verified)	--	--	--	--
			50 (clay)		--	--	--	--
Diffusion Coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--	--	--

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Table C1.3. Chemical Specific Parameters (Continued)

Parameters	PGDP Model Value	Reference(s)	Previous Draft Model Value (based on DOE 2010)	Reference(s)	U-Landfill (DOE 2003) Value	Reference(s)	ORISE RESRAD Model Value[2]	Reference(s)
Beryllium - Atomic Weight 9.01 g/mol								
Half Life (years)	--	--	--	--	--	--	--	--
Atomic Weight (g/mol)	9.01		9.01		--	--	--	--
Solubility Limit (gm/cc)	8.40E-02	EPA (2004), Page A-49.	1.00E+01	EPA (1996) (Not Verified)	--	--	--	--
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	250 (sand and all other materials)	Sheppard and Thibault (1990), Table 1, Page 472	250 (sand)	Sheppard and Thibault (1990), Table 1, Page 472	--	--	--	--
	1,300 (clay)		1,300 (clay)		--	--	--	--
Diffusion Coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--	--	--
Cadmium - Atomic Weight 112.4 g/mol								
Half Life (years)	--	--	--	--	--	--	--	--
Atomic Weight (g/mol)	112.4		112.4		--	--	--	--
Solubility Limit (gm/cc)	1.70E-03	EPA (2004), Page A-59.	1.00E+01	EPA (1996) (Not Verified)	--	--	--	--
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	80 (sand and all other materials)	Sheppard and Thibault (1990), Table 1, Page 472	80 (sand)	Sheppard and Thibault (1990), Table 1, Page 472	--	--	--	--
	560 (clay)		560 (clay)		--	--	--	--
Diffusion Coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--	--	--
Chromium - Atomic Weight 51.9 g/mol								
Half Life (years)	--	--	--	--	1.00E+05	Disposal Unit Source Term (DUST) default library	--	--
Atomic Weight (g/mol)	51.9		51.9		52	EPA (1996)	--	--
Solubility Limit (gm/cc)	6.00E-01	EPA (2004), Page A-83.	1.00E+01	EPA (1996) (Not Verified)	1.00E+01	EPA (1996) (Not Verified)	--	--
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	3.21E+01	DOE (2002a), Min: 17.4 Max: 56.8 Mean: 32.1	19 (sand)	Sheppard and Thibault (1990), different than what was seen in the table (70 sand, 1500 clay).	19 (sand)	Sheppard and Thibault (1990), different than what was seen in the table.	--	--
			30 (clay)		30 (clay)		--	--
Diffusion Coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	1.00E-06	No reference given. From DOE (2003), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--

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Table C1.3. Chemical Specific Parameters (Continued)

Parameters	PGDP Model Value	Reference(s)	Previous Draft Model Value (based on DOE 2010)	Reference(s)	U-Landfill (DOE 2003) Value	Reference(s)	ORISE RESRAD Model Value[2]	Reference(s)
Copper - Atomic Weight 63.6 g/mol								
Half Life (years)	--	--	--	--	1.00E+05	Disposal Unit Source Term (DUST) default library	--	--
Atomic Weight (g/mol)	63.6		63.6		63.5	EPA (1996)	--	--
Solubility Limit (gm/cc)	5.70E-04	EPA (2004), Page A-97.	1.00E+01	EPA (1996) (Not Verified)	1.00E+01	EPA (1996) (Not Verified)	--	--
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	3.1	Dragun (1988), (Range 1.4 to 333 ml/g)	35 (sand)	Sheppard and Thibault (1990), not found in document	35 (sand)	Sheppard and Thibault (1990), not found in document	--	--
			35 (clay)		35 (clay)		--	--
Diffusion Coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	1.00E-06	No reference given. From DOE (2003), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--
Lead - Atomic Weight 207.2 g/mol								
Half Life (years)	--	--	--	--	--	--	--	--
Atomic Weight (g/mol)	207.2	--	207.2	--	--	--	--	--
Solubility Limit (gm/cc)	8.70E-04	EPA (2004), Page A-223.	1.00E+01	EPA (1996)	--	--	--	--
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	270 (sand and all other materials)	Sheppard and Thibault (1990), Table 1, Page 472	270 (sand)	Sheppard and Thibault (1990), Table 1, Page 472	--	--	--	--
	550 (clay)		550 (clay)		--	--	--	--
Diffusion Coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--	--	--
Manganese - Atomic Weight 54.9 g/mol								
Half Life (years)	--	--	--	--	--	--	--	--
Atomic Weight (g/mol)	54.9		54.9		--	--	--	--
Solubility Limit (gm/cc)	1.10E-03	EPA (2004), Page A-231.	1.00E+01	EPA (1996)	--	--	--	--
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	50 (sand and all other materials)	Sheppard and Thibault (1990), Table 1, Page 472	50 (sand)	Sheppard and Thibault (1990), Table 1, Page 472	--	--	--	--
	180 (clay)		180 (clay)		--	--	--	--
Diffusion Coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--	--	--

Table C1.3. Chemical Specific Parameters (Continued)

Parameters	PGDP Model Value	Reference(s)	Previous Draft Model Value (based on DOE 2010)	Reference(s)	U-Landfill (DOE 2003) Value	Reference(s)	ORISE RESRAD Model Value[2]	Reference(s)
Mercury - Atomic Weight 200.6 g/mol								
Half Life (years)	--	--	--	--	--	--	--	--
Atomic Weight (g/mol)	200.6		200.6		--	--	--	--
Solubility Limit (gm/cc)	4.50E-04	EPA (2004), Page A-235.	1.00E+01	EPA (1996) (Not Verified)	--	--	--	--
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	5.20E+01	EPA (1996), Table 46, Page 158.	10 (sand)	Sheppard and Thibault (1990), not found in document	--	--	--	--
			100 (clay)		--	--	--	--
Diffusion Coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--	--	--
Nickel - Atomic Weight 58.7 g/mol								
Half Life (years)	--	--	--	--	1.00E+05	Disposal Unit Source Term (DUST) default library	--	--
Atomic Weight (g/mol)	58.7		58.7		58.7	EPA (1996)	--	--
Solubility Limit (gm/cc)	1.50E-03	EPA (2004), Page A-255.	1.00E+01	EPA (1996)	1.00E+01	EPA (1996)	--	--
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	1.079E+02	DOE (2002a), Min: 20.3 Max: 163 Mean: 107.9	400 (sand)	Sheppard and Thibault (1990), Table 1, Page 472	400 (sand)	Sheppard and Thibault (1990), Table 1, Page 472	--	--
			650 (clay)		650 (clay)		--	--
Diffusion Coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	1.00E-06	No reference given. From DOE (2003), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--
Selenium - Atomic Weight 78.9 g/mol								
Half Life (years)	--	--	--	--	1.00E+05	Disposal Unit Source Term (DUST) default library	--	--
Atomic Weight (g/mol)	78.9		78.9		78.9	EPA (1996)	--	--
Solubility Limit (gm/cc)	2.60E+00	EPA (2004), Page A-309.	1.00E+01	EPA (1996) (Not Verified)	1.00E+01	EPA (1996) (Not Verified)	--	--
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	150 (sand and all other materials)	Sheppard and Thibault (1990), Table 1, Page 472	150 (sand)	Sheppard and Thibault (1990), Table 1, Page 472	150 (sand)	Sheppard and Thibault (1990), Table 1, Page 472	--	--
	740 (clay)		740 (clay)		740 (clay)		--	--
Diffusion Coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	1.00E-06	No reference given. From DOE (2003), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--

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Table C1.3. Chemical Specific Parameters (Continued)

Parameters	PGDP Model Value	Reference(s)	Previous Draft Model Value (based on DOE 2010)	Reference(s)	U-Landfill (DOE 2003) Value	Reference(s)	ORISE RESRAD Model Value[2]	Reference(s)
Silver - Atomic Weight 107.9 g/mol								
Half Life (years)	--	--	--	--	--	--	--	--
Atomic Weight (g/mol)	107.9		107.9		--	--	--	--
Solubility Limit (gm/cc)	2.50E-04	EPA (2004), Page A-311.	1.00E+01	EPA (1996) (Not Verified)	--	--	--	--
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	90 (sand and all other materials)	Sheppard and Thibault (1990), Table 1, Page 472	90 (sand)	Sheppard and Thibault (1990), Table 1, Page 472	--	--	--	--
	180 (clay)		180 (clay)		--	--	--	--
Diffusion Coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--	--	--
Thallium - Atomic Weight 204.4 g/mol								
Half Life (years)	--	--	--	--	1.00E+05	Disposal Unit Source Term (DUST) default library	--	--
Atomic Weight (g/mol)	204.4		204.4		204.4	EPA (1996)	--	--
Solubility Limit (gm/cc)	8.60E-03	EPA (2004), Page A-337.	1.00E+01	EPA (1996) (Not Verified)	1.00E+01	EPA (1996) (Not Verified)	--	--
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	7.10E+01	EPA (1996), Table 46, Page 158.	71 (sand)	Sheppard and Thibault (1990), not found in table	71 (sand)	Sheppard and Thibault (1990), not found in table	--	--
			1500 (clay)		1500 (clay)		--	--
Diffusion Coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	1.00E-06	No reference given. From DOE (2003), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--
Vanadium - Atomic Weight 50.9 g/mol								
Half Life (years)	--	--	--	--	--	--	--	--
Atomic Weight (g/mol)	50.9		50.9		--	--	--	--
Solubility Limit (gm/cc)	7.00E-04	EPA (2004), Page A-391.	1.00E+01	EPA (1996) (Not Verified)	--	--	--	--
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	1.00E+03	EPA (1996), Table 46, Page 158.	100 (sand)	Sheppard and Thibault (1990), not found in table	--	--	--	--
			1000 (clay)		--	--	--	--
Diffusion Coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--	--	--

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Table C1.3. Chemical Specific Parameters (Continued)

Parameters	PGDP Model Value	Reference(s)	Previous Draft Model Value (based on DOE 2010)	Reference(s)	U-Landfill (DOE 2003) Value	Reference(s)	ORISE RESRAD Model Value[2]	Reference(s)
Zinc - Atomic Weight 65.4 g/mol								
Half Life (years)	--	--	--	--	--	--	--	--
Atomic Weight (g/mol)	65.4		65.4		--	--	--	--
Solubility Limit (gm/cc)	1.40E-03	EPA (2004), Page A-405.	1.00E+01	EPA (1996)	--	--	--	--
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	200 (sand and all other materials)	Sheppard and Thibault (1990), Table 1, Page 472	200 (sand)	Sheppard and Thibault (1990), Table 1, Page 472	--	--	--	--
	2,400 (clay)		2,400 (clay)		--	--	--	--
Diffusion Coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--	--	--
Cs-137 - Atomic Weight 137 g/mol								
Half Life (years)	3.02E+01	Disposal Unit Source Term (DUST) default library	3.02E+01	--	--	--	None Specified	--
Atomic Weight (g/mol)	137		137		--	--	None Specified	
Solubility Limit (gm/cc)	3.40E-01	EPA (2004), Page A-71.	1.00E+01	EPA (1996) (Not Verified)	--	--	Default	Yu et al, 2001.[3]
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	280 (sand and all other materials)	Sheppard and Thibault (1990), Table 1, Page 472	280 (sand)	Sheppard and Thibault (1990), Table 1, Page 472	--	--	280 (sand) 280 (waste) 1900 (clay)	"Project Communication" with the Waste Disposal Options Project Team from Paducah, KY.
	1,900 (clay)		1,900 (clay)		--	--		
Diffusion Coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--	None Specified	--

Table C1.3. Chemical Specific Parameters (Continued)

Parameters	PGDP Model Value	Reference(s)	Previous Draft Model Value (based on DOE 2010)	Reference(s)	U-Landfill (DOE 2003) Value	Reference(s)	ORISE RESRAD Model Value[2]	Reference(s)
Tc-99 - Atomic Weight 99 g/mol								
Half Life (years)	2.13E+05	Disposal Unit Source Term (DUST) default library	2.13E+05	--	2.13E+05	Disposal Unit Source Term (DUST) default library	None Specified	--
Atomic Weight (g/mol)	99	--	99	--	99	EPA (1996)	None Specified	--
Solubility limit (gm/cc)	7.18E-03	Derived from geochemical database prepared by Lawrence Livermore National Laboratory and converted to PHREEQC format.	1.00E+01	EPA (1996) (Not Verified)	1.00E+01	EPA (1996) (Not Verified)	Default	Yu et al, 2001.[3]
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	2.82E-01	DOE (2002a), Min: 5.27E-10 Max: 0.848 Mean: 0.282	0.2 (sand) 20 (clay)	Sheppard and Thibault (1990), not found table (sand - 0.1, clay - 1)	0.2 (sand) 1.0 (waste) 20 (clay)	Sheppard and Thibault (1990), not found table DOE 1997 and DOE (2002b)	0.2 (sand) 1.0 (waste) 20 (clay)	The distribution coefficients for Tc-99 are available in Table C.3.1. Chemical and physical properties of different classes of chemicals identified as COPCs for the C-746-U Landfill of DOE 2003b, page C3-301. Table 4.5 DUST model input parameters, page 4-12, has Kds for Tc-99. Table 4.5 references Sheppard and Thibault (1990).
Diffusion coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	1.00E-06	No reference given. From DOE (2003), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	None Specified	--
Ac-227 - Atomic Weight 227 g/mol								
Half Life (years)	22	ANL (2005)	21.8	--	--	--	None Specified	--
Atomic Weight (g/mol)	227		227		--	--	None Specified	
Solubility Limit (gm/cc)	1.00E+01	No value found. Assume 10 gm/cc to prevent solubility from limiting migration.	1.00E+01	EPA (1996) (Not Verified)	--	--	Default	Yu et al, 2001.[3]
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	450 (sand and all other materials)	Sheppard and Thibault (1990), Table 1, Page 472	450 (sand)	Sheppard and Thibault (1990), Table 1, Page 472	--	--	450 (sand) 450 (waste) 2400 (clay)	"Project Communication" with the Waste Disposal Options Project Team from Paducah, KY.
	2,400 (clay)		2,400 (clay)		--	--		
Diffusion Coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--	None Specified	--

Table C1.3. Chemical Specific Parameters (Continued)

Parameters	PGDP Model Value	Reference(s)	Previous Draft Model Value (based on DOE 2010)	Reference(s)	U-Landfill (DOE 2003) Value	Reference(s)	ORISE RESRAD Model Value[2]	Reference(s)
Am-241 - Atomic Weight 241 g/mol								
Half Life (years)	4.32E+02	--	4.32E+02	--	--	--	None Specified	--
Atomic Weight (g/mol)	241		241		--	--	None Specified	
Solubility Limit (gm/cc)	8.00E-03	Derived from geochemical database prepared by Lawrence Livermore National Laboratory and converted to PHREEQC format.	1.00E+01	EPA (1996) (Not Verified)	--	--	Default	Yu et al, 2001.[3]
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	1900 (sand and all other materials)	Sheppard and Thibault (1990), Table 1, Page 472	1900 (sand)	Sheppard and Thibault (1990), Table 1, Page 472	--	--	1900 (sand) 1900 (waste) 8400 (clay)	DOE 2003b, page C3-313 and Table Att. 1. Distribution coefficient of radionuclides and their daughter products in different zones, page C3-314.
	8400 (clay)		8400 (clay)		--	--		
Diffusion Coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--	None Specified	--
Np-237 - Atomic Weight 237 g/mol								
Half Life (years)	2.14E+06	Disposal Unit Source Term (DUST) default library	2.14E+06	--	2.14E+06	Disposal Unit Source Term (DUST) default library	None Specified	--
Atomic Weight (g/mol)	237		237		237	EPA (1996)	None Specified	
Solubility Limit (gm/cc)	1.00E+01	No value found. Assume 10 gm/cc to prevent solubility from limiting migration.	1.00E+01	EPA (1996) (Not Verified)	1.00E+01	EPA (1996) (Not Verified)	Default	Yu et al, 2001.[3]
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	5 (sand and all other materials)	Sheppard and Thibault (1990), Table 1, Page 472	5 (sand)	Sheppard and Thibault (1990), Table 1, Page 472	70 (sand)	Sheppard and Thibault (1990), conflict with numbers in the table	70 (sand) 70 (waste) 144 (clay)	DOE 2003b, page C3-313 and Table Att. 1. Distribution coefficient of radionuclides and their daughter products in different zones, page C3-314. No Kd values for NP-237 reported in table.
	55 (clay)		55 (clay)		144 (clay)	DOE (1997) and DOE (2002b)		
Diffusion Coefficient (cm^2/sec)	1.00E-06	DOE (2003) (U-Landfill Report)	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	1.00E-06	No reference given. From DOE (2003), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	None Specified	--

Table C1.3. Chemical Specific Parameters (Continued)

Parameters	PGDP Model Value	Reference(s)	Previous Draft Model Value (based on DOE 2010)	Reference(s)	U-Landfill (DOE 2003) Value	Reference(s)	ORISE RESRAD Model Value[2]	Reference(s)
Pa-231 - Atomic Weight 231 g/mol								
Half Life (years)	3.30E+04	ANL (2005)	3.28E+04	--	--	--	None Specified	--
Atomic Weight (g/mol)	231		231		--	--	None Specified	
Solubility Limit (gm/cc)	1.00E+01	No value found. Assume 10 gm/cc to prevent solubility from limiting migration.	1.00E+01	EPA (1996) (Not Verified)	--	--	Default	Yu et al, 2001.[3]
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	550 (sand and all other materials)	Sheppard and Thibault (1990), Table 1, Page 472	550 (sand)	Sheppard and Thibault (1990), Table 1, Page 472	--	--	550 (sand) 550 (waste) 2700 (clay)	"Project Communication" with the Waste Disposal Options Project Team from Paducah, KY.
	2,700 (clay)		2,700 (clay)		--	--		
Diffusion Coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--	None Specified	--
Pb-210 - Atomic Weight 210 g/mol								
Half Life (years)	2.20E+01	ANL (2005)	2.20E+01	--	--	--	None Specified	--
Atomic Weight (g/mol)	210		210		--	--	None Specified	
Solubility Limit (gm/cc)	8.70E-04	EPA (2004), Page A-225	1.00E+01	EPA (1996) (Not Verified)	--	--	Default	Yu et al, 2001.[3]
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	270 (sand and all other materials)	Sheppard and Thibault (1990), Table 1, Page 472	270 (sand)	Sheppard and Thibault (1990), Table 1, Page 472	--	--	270 (sand) 270 (waste) 550 (clay)	"Project Communication" with the Waste Disposal Options Project Team from Paducah, KY.
	550 (clay)		550 (clay)		--	--		
Diffusion Coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--	None Specified	--

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Table C1.3. Chemical Specific Parameters (Continued)

Parameters	PGDP Model Value	Reference(s)	Previous Draft Model Value (based on DOE 2010)	Reference(s)	U-Landfill (DOE 2003) Value	Reference(s)	ORISE RESRAD Model Value[2]	Reference(s)
Pu-238 - Atomic Weight 238 g/mol								
Half Life (years)	8.78E+01	Disposal Unit Source Term (DUST) default library	8.78E+01	--	--	--	None Specified	--
Atomic Weight (g/mol)	238		238		--	--	None Specified	
Solubility Limit (gm/cc)	1.00E+01	No value found. Assume 10 gm/cc to prevent solubility from limiting migration.	1.00E+01	EPA (1996) (Not Verified)	--	--	Default	Yu et al, 2001.[3]
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	550 (sand and all other materials)	Sheppard and Thibault (1990), Table 1, Page 472	550 (sand)	Sheppard and Thibault (1990), Table 1, Page 472	--	--	550 (sand) 550 (waste) 5100 (clay)	"Project Communication" with the Waste Disposal Options Project Team from Paducah, KY.
	5100 (clay)		5100 (clay)		--	--		
Diffusion Coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--	None Specified	--
Pu-239 - Atomic Weight 239 g/mol								
Half Life (years)	2.41E+04	Disposal Unit Source Term (DUST) default library	2.41E+04	--	--	--	None Specified	--
Atomic Weight (g/mol)	239		239		--	--	None Specified	
Solubility Limit (gm/cc)	1.00E+01	No value found. Assume 10 gm/cc to prevent solubility from limiting migration.	1.00E+01	EPA (1996) (Not Verified)	--	--	Default	Yu et al, 2001.[3]
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	550 (sand and all other materials)	Sheppard and Thibault (1990), Table 1, Page 472	550 (sand)	Sheppard and Thibault (1990), Table 1, Page 472	--	--	550 (sand) 550 (waste) 5100 (clay)	"Project Communication" with the Waste Disposal Options Project Team from Paducah, KY.
	5100 (clay)		5100 (clay)		--	--		
Diffusion Coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--	None Specified	--

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FORWARD

Table C1.3. Chemical Specific Parameters (Continued)

Parameters	PGDP Model Value	Reference(s)	Previous Draft Model Value (based on DOE 2010)	Reference(s)	U-Landfill (DOE 2003) Value	Reference(s)	ORISE RESRAD Model Value[2]	Reference(s)
Pu-240 - Atomic Weight 240 g/mol								
Half Life (years)	6.54E+03	Disposal Unit Source Term (DUST) default library	6.57E+03	--	--	--	None Specified	--
Atomic Weight (g/mol)	240		240		--	--	None Specified	
Solubility Limit (gm/cc)	1.00E+01	No value found. Assume 10 gm/cc to prevent solubility from limiting migration.	1.00E+01	EPA (1996) (Not Verified)	--	--	Default	Yu et al, 2001.[3]
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	550 (sand and all other materials)	Sheppard and Thibault (1990), Table 1, Page 472	550 (sand)	Sheppard and Thibault (1990), Table 1, Page 472	--	--	550 (sand) 550 (waste) 5100 (clay)	"Project Communication" with the Waste Disposal Options Project Team from Paducah, KY.
	5100 (clay)		5100 (clay)		--	--		
Diffusion Coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--	None Specified	--
Ra-226 - Atomic Weight 226 g/mol								
Half Life (years)	1.60E+03	Disposal Unit Source Term (DUST) default library	1.60E+03	--	--	--	None Specified	--
Atomic Weight (g/mol)	226		226		--	--	None Specified	
Solubility Limit (gm/cc)	3.10E-01	EPA (2004), Page A-301	1.00E+01	EPA (1996) (Not Verified)	--	--	Default	Yu et al, 2001.[3]
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	500 (sand and all other materials)	Sheppard and Thibault (1990), Table 1, Page 472	500 (sand)	Sheppard and Thibault (1990), Table 1, Page 472	--	--	500 (sand) 500 (waste) 9100 (clay)	"Project Communication" with the Waste Disposal Options Project Team from Paducah, KY.
	9,100 (clay)		9,100 (clay)		--	--		
Diffusion Coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--	None Specified	--

Table C1.3. Chemical Specific Parameters (Continued)

Parameters	PGDP Model Value	Reference(s)	Previous Draft Model Value (based on DOE 2010)	Reference(s)	U-Landfill (DOE 2003) Value	Reference(s)	ORISE RESRAD Model Value[2]	Reference(s)
Ra-228 - Atomic Weight 228 g/mol								
Half Life (years)	5.80E+00	Disposal Unit Source Term (DUST) default library	5.75E+00	--	--	--	None Specified	--
Atomic Weight (g/mol)	228		228		--	--	None Specified	
Solubility Limit (gm/cc)	3.10E-01	EPA (2004), Page A-303	1.00E+01	EPA (1996) (Not Verified)	--	--	Default	Yu et al, 2001.[3]
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	500 (sand and all other materials)	Sheppard and Thibault (1990), Table 1, Page 472	500 (sand)	Sheppard and Thibault (1990), Table 1, Page 472	--	--	500 (sand) 500 (waste) 9100 (clay)	"Project Communication" with the Waste Disposal Options Project Team from Paducah, KY.
	9,100 (clay)		9,100 (clay)		--	--		
Diffusion Coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--	None Specified	--
Th-228 - Atomic Weight 228 g/mol								
Half Life (years)	1.90E+00	ANL (2005)	1.90E+00	--	--	--	None Specified	--
Atomic Weight (g/mol)	228		228		--	--	None Specified	
Solubility Limit (gm/cc)	2.80E-01	EPA (2004), Page A-343	1.00E+01	EPA (1996) (Not Verified)	--	--	Default	Yu et al, 2001.[3]
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	3200 (sand and all other materials)	Sheppard and Thibault (1990), Table 1, Page 472	3200 (sand)	Sheppard and Thibault (1990), Table 1, Page 472	--	--	3200 (sand) 3200 (waste) 5800 (clay)	"Project Communication" with the Waste Disposal Options Project Team from Paducah, KY.
	5800 (clay)		5800 (clay)		--	--		
Diffusion Coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--	None Specified	--

Table C1.3. Chemical Specific Parameters (Continued)

Parameters	PGDP Model Value	Reference(s)	Previous Draft Model Value (based on DOE 2010)	Reference(s)	U-Landfill (DOE 2003) Value	Reference(s)	ORISE RESRAD Model Value[2]	Reference(s)
Th-229 - Atomic Weight 229 g/mol								
Half Life (years)	7.34E+03	Disposal Unit Source Term (DUST) default library	7.34E+03	--	--	--	None Specified	--
Atomic Weight (g/mol)	229		229		--	--	None Specified	
Solubility Limit (gm/cc)	2.80E-01	EPA (2004), Page A-345.	1.00E+01	EPA (1996) (Not Verified)	--	--	Default	Yu et al, 2001.[3]
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	3200 (sand and all other materials)	Sheppard and Thibault (1990), Table 1, Page 472	3200 (sand)	Sheppard and Thibault (1990), Table 1, Page 472	--	--	3200 (sand) 3200 (waste) 5800 (clay)	"Project Communication" with the Waste Disposal Options Project Team from Paducah, KY.
	5800 (clay)		5800 (clay)		--	--		
Diffusion Coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--	None Specified	--
Th-230 - Atomic Weight 230 g/mol								
Half Life (years)	7.70E+04	ANL (2005)	7.70E+04	--	--	--	None Specified	--
Atomic Weight (g/mol)	230		230		--	--	None Specified	
Solubility Limit (gm/cc)	2.80E-01	EPA (2004), Page A-347	1.00E+01	EPA (1996) (Not Verified)	--	--	Default	Yu et al, 2001.[3]
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	3200 (sand and all other materials)	Sheppard and Thibault (1990), Table 1, Page 472	3200 (sand)	Sheppard and Thibault (1990), Table 1, Page 472	--	--	3200 (sand) 3200 (waste) 5800 (clay)	DOE 2003b, page C3-313 and Table Att. 1. Distribution coefficient of radionuclides and their daughter products in different zones, page C3-314.
	5800 (clay)		5800 (clay)		--	--		
Diffusion Coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--	None Specified	--

Table C1.3. Chemical Specific Parameters (Continued)

Parameters	PGDP Model Value	Reference(s)	Previous Draft Model Value (based on DOE 2010)	Reference(s)	U-Landfill (DOE 2003) Value	Reference(s)	ORISE RESRAD Model Value[2]	Reference(s)
Th-232 - Atomic Weight 232 g/mol								
Half Life (years)	1.40E+10	ANL (2005)	1.40E+10	--	--	--	None Specified	--
Atomic Weight (g/mol)	232		232		--	--	None Specified	
Solubility Limit (gm/cc)	2.80E-01	EPA (2004), Page A-351	1.00E+01	EPA (1996) (Not Verified)	--	--	Default	Yu et al, 2001.[3]
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	3200 (sand and all other materials)	Sheppard and Thibault (1990), Table 1, Page 472	3200 (sand)	Sheppard and Thibault (1990), Table 1, Page 472	--	--	3200 (sand) 3200 (waste) 5800 (clay)	DOE 2003b, page C3-313 and Table Att. 1. Distribution coefficient of radionuclides and their daughter products in different zones, page C3-314.
	5800 (clay)		5800 (clay)		--	--		
Diffusion Coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--	None Specified	--
U-233 - Atomic Weight 233 g/mol								
Half Life (years)	1.59E+05	Disposal Unit Source Term (DUST) default library	1.59E+05	--	--	--	None Specified	--
Atomic Weight (g/mol)	233		233		--	--	None Specified	
Solubility Limit (gm/cc)	1.00E-04	EPA (2004), Page A-381	1.00E+01	EPA (1996) (Not Verified)	--	--	Default	Yu et al, 2001.[3]
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	35 (sand and all other materials)	Sheppard and Thibault (1990), Table 1, Page 472	66.8 (sand)	Sheppard and Thibault (1990), does not match number in table	--	--	66.8 (sand) 410 (waste) 3640 (clay)	"Project Communication" with the Waste Disposal Options Project Team from Paducah, KY.
	1600 (clay)		3640 (clay)		--	--		
Diffusion Coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--	None Specified	--

Table C1.3. Chemical Specific Parameters (Continued)

Parameters	PGDP Model Value	Reference(s)	Previous Draft Model Value (based on DOE 2010)	Reference(s)	U-Landfill (DOE 2003) Value	Reference(s)	ORISE RESRAD Model Value[2]	Reference(s)
U-234 - Atomic Weight 234 g/mol								
Half Life (years)	2.40E+05	ANL (2005)	2.44E+05	--	--	--	None Specified	--
Atomic Weight (g/mol)	234		234		--	--	None Specified	
Solubility Limit (gm/cc)	1.00E-04	EPA (2004), Page A-383	1.00E+01	EPA (1996) (Not Verified)	--	--	Default	Yu et al, 2001.[3]
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	35 (sand and all other materials)	Sheppard and Thibault (1990), Table 1, Page 472	66.8 (sand)	Sheppard and Thibault (1990), does not match number in table	--	--	66.8 (sand) 410 (waste) 3640 (clay)	DOE 2003b, page C3-313 and Table Att. 1. Distribution coefficient of radionuclides and their daughter products in different zones, page C3-314.
	1600 (clay)		3640 (clay)		--	--		
Diffusion Coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--	None Specified	--
U-235 - Atomic Weight 235 g/mol								
Half Life (years)	7.00E+08	ANL (2005)	7.04E+08	--	--	--	None Specified	--
Atomic Weight (g/mol)	235		235		--	--	None Specified	
Solubility Limit (gm/cc)	1.00E-04	EPA (2004), Page A-385	1.00E+01	EPA (1996) (Not Verified)	--	--	Default	Yu et al, 2001.[3]
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	35 (sand and all other materials)	Sheppard and Thibault (1990), Table 1, Page 472	66.8 (sand)	Sheppard and Thibault (1990), does not match number in table	--	--	66.8 (sand) 410 (waste) 3640 (clay)	DOE 2003b, page C3-313 and Table Att. 1. Distribution coefficient of radionuclides and their daughter products in different zones, page C3-314.
	1600 (clay)		3640 (clay)		--	--		
Diffusion Coefficient (cm^2/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--	None Specified	--

Table C1.3. Chemical Specific Parameters (Continued)

Parameters	PGDP Model Value	Reference(s)	Previous Draft Model Value (based on DOE 2010)	Reference(s)	U-Landfill (DOE 2003) Value	Reference(s)	ORISE RESRAD Model Value[2]	Reference(s)
U-236 - Atomic Weight 236 g/mol								
Half Life (years)	2.34E+07	Disposal Unit Source Term (DUST) default library	2.34E+07	--	--	--	None Specified	--
Atomic Weight (g/mol)	236		236		--	--	None Specified	
Solubility Limit (gm/cc)	1.00E-04	EPA (2004), Page A-387	1.00E+01	EPA (1996)	--	--	Default	Yu et al, 2001.[3]
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	35 (sand and all other materials)	Sheppard and Thibault (1990), Table 1, Page 472	66.8 (sand)	Sheppard and Thibault (1990), does not match number in table	--	--	66.8 (sand) 410 (waste) 3640 (clay)	"Project Communication" with the Waste Disposal Options Project Team from Paducah, KY.
	1600 (clay)		3640 (clay)		--	--		
Diffusion Coefficient (cm²/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	--	--	None Specified	--
U-238 - Atomic Weight 238 g/mol								
Half Life (years)	4.50E+09	ANL (2005)	4.47E+09	--	4.47E+09	Disposal Unit Source Term (DUST) default library	None Specified	--
Atomic Weight (g/mol)	238		238		238	EPA (1996)	None Specified	
Solubility Limit (gm/cc)	1.00E-04	EPA (2004), Page A-389	1.00E+01	EPA (1996)	1.00E+01	EPA (1996)	Default	Yu et al, 2001.[3]
Unsaturated Soils, Waste, Saturated Materials (Vertical and Horizontal Flow) Kd (cc/gm)	35 (sand and all other materials)	Sheppard and Thibault (1990), Table 1, Page 472	66.8 (sand)	Sheppard and Thibault (1990), does not match number in table	66.8 (sand) 410 (organic) 3640 (clay)	Sheppard and Thibault (1990), does not match number in table DOE (1997) and DOE (2002b)	66.8 (sand) 410 (waste) 3640 (clay)	DOE 2003b, page C3-313 and Table Att. 1. Distribution coefficient of radionuclides and their daughter products in different zones, page C3-314. Table does not give references or justification for Kd values presented
	1600 (clay)		3640 (clay)					
Diffusion Coefficient (cm²/sec)	1.00E-06	--	1.00E-06	No reference given. From DOE (2010), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	1.00E-06	No reference given. From DOE (2003), "Values obtained from DUSTMS model are insensitive to diffusion coefficient if the diffusional release fraction = 0."	None Specified	--

BACK

Table C1.3. Chemical Specific Parameters (Continued)

Parameters	PGDP Model Value	Reference(s)	Previous Draft Model Value (based on DOE 2010)	Reference(s)	U-Landfill (DOE 2003) Value	Reference(s)	ORISE RESRAD Model Value[2]	Reference(s)

Notes

1. -- Denotes information not available.
2. ORISE RESRAD Model Value information provided by personal communication (John Volpe email - 04/24/2011).
3. User's Manual for RESRAD Version 6. "The default value is assigned; however, it is not used by the code. This parameter is one of the options in RESRAD to derive distribution coefficients (Kds) when site-specific data is not available. In this case site-specific Kds are available and are used by the code; therefore, there was no need to use this option to derive them."
4. Kd - chemical specific distribution coefficient.
5. Koc - chemical specific octanol/water partition coefficient.
6. foc - fraction organic carbon.

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Table C1.4. HELP Model Input Parameters

Parameter	Units	Deterministic Value
Fraction of area allowing runoff	%	100% (18.94 acres)
Evaporative zone depth	inches	8 inches for Operational Period (low end of silts) 18 inches for Postclosure and Long-Term Modeling Periods (high end of silts)
Start of growing season	day	96th Julian Day
End of growing season	day	300th Julian Day
Average annual wind speed	mph	8.2
Average 1st quarter relative humidity	%	70
Average 2nd quarter relative humidity	%	67
Average 3rd quarter relative humidity	%	72
Average 4th quarter relative humidity	%	54
Normal mean monthly precipitation (Jan)	inches	3.27
Normal mean monthly precipitation (Feb)	inches	3.9
Normal mean monthly precipitation (Mar)	inches	4.92
Normal mean monthly precipitation (April)	inches	5.01
Normal mean monthly precipitation (May)	inches	4.94
Normal mean monthly precipitation (June)	inches	4.05
Normal mean monthly precipitation (July)	inches	4.19
Normal mean monthly precipitation (Aug)	inches	3.34
Normal mean monthly precipitation (Sept)	inches	3.69
Normal mean monthly precipitation (Oct)	inches	3
Normal mean monthly precipitation (Nov)	inches	4.32
Normal mean monthly precipitation (Dec)	inches	4.65
Normal mean monthly temperature (Jan)	^{o}F	32.6
Normal mean monthly temperature (Feb)	^{o}F	36.9
Normal mean monthly temperature (Mar)	^{o}F	47.5
Normal mean monthly temperature (April)	^{o}F	57.9
Normal mean monthly temperature (May)	^{o}F	66.7
Normal mean monthly temperature (June)	^{o}F	75.2
Normal mean monthly temperature (July)	^{o}F	78.8
Normal mean monthly temperature (Aug)	^{o}F	76.8
Normal mean monthly temperature (Sept)	^{o}F	70.2
Normal mean monthly temperature (Oct)	^{o}F	58.7
Normal mean monthly temperature (Nov)	^{o}F	47.9
Normal mean monthly temperature (Dec)	^{o}F	37.3
Solar Radiation Data Station Latitude	Decimal Degrees	37.1 N

Table C1.5. DUST-MS Model Input Parameters

Parameter	Units	Deterministic Value
Title and General Problem Definition		
Number of Nodes	n/a	298 (Site 11) 266 (Site 3A)
Number of Isotopes	n/a	Varies
Mass Units	grams	grams
Decay Chains	n/a	Varies
Time Parameters		
Number of Time Steps	n/a	10000
Initial Time Interval (yrs)	years	1.6 0.16 0.08
Fractional Change in Time Interval	n/a	0
Maximum Time Interval	years	1.6 0.16 0.08
Maximum Simulation Time	years	16000 1600 800
Number of Time Step Resets	n/a	0
Material Parameters		
Number of Materials	n/a	6 (Site 11) 5 (Site 3A)
Number of Material Changes	n/a	298 (Site 11) 266 (Site 3A)
K-d (Distribution Coefficient)	cc/gm	Chemical Specific
Density	gm/cc	Material - Density 1 - 1.34 2- 1.4 3 - 1.8 4 - 3.1 5 - 1.43 (Site 11) 5 - 1.41 (Site 3A) 6 - 1.43 (Site 11)
Dispersion Coefficient	cm	415 (Site 11) 366 (Site 3A)
Diffusion Coefficient	cm^2/s	Chemical Specific
Changes to Node Material Types	n/a	First Node to Last Node = Material 1 to 10 = 1 11 to 20 = 2 21 to 26 = 3 27 to 196 = 4 197 to 198 = 3 199 to 200 = 2 201 to 206 = 3 207 to 226 = 1 227 to 270 = 5 (Site 11) 227 to 266 = 5 (Site 3A) 271 to 298 = 6 (Site 11)
Change in Node Number	n/a	1

Table C1.5. DUST-MS Model Input Parameters (Continued)

Parameter	Units	Deterministic Value
Change in Material Type	n/a	0
Output Parameters		
Output for Time Steps	n/a	Print Concentrations at time step = 1 and every 999 time steps
Number of Concentration Traces	n/a	5 (Site 11) 4 (Site 3A)
Node Locations for Concentration Traces	n/a	1, 26, 206, 270, 298 (Site 11) 1, 26, 206, 266 (Site 3A)
Number of Flux Traces	n/a	5 (Site 11) 4 (Site 3A)
Node Locations for Flux Traces	n/a	1, 26, 206, 270, 298 (Site 11) 1, 26, 206, 266 (Site 3A)
Facility Dimensions		
Area of Facility	cm^2	7.67E+08
Node Coordinates		
First Node	n/a	1
Last Node	n/a	298 (Site 11) 266 (Site 3A)
Change in Node Number	n/a	1
Starting Location	cm	0
Change in Delta X	cm	15.24
Incremental Change in Delta X	n/a	0

Table C1.5. DUST-MS Model Input Parameters (Continued)

Parameter	Units	Deterministic Value
Initial Conditions		
First, Last Node, and Initial Concentration	g/cc	First Node to Last Node = Initial Concentration 1 to 26 = 0 27 to 196 = Chemical Specific 197 to 266 (Site 3A) or 298 (Site 11) = 0
Change in Node Number	n/a	1
Fractional Change in Concentration	n/a	0
Boundary Conditions		
Upper Boundary	$g/cm^2/s$	Total Flux = 0
Lower Boundary	g/cc	Concentration = 0
Number of Data Points	n/a	2
Use BC File	n/a	No - All
Water Velocity Parameters		
Number of Data Points	n/a	10 - Gradual Failure (BL) Scenario 4 - Instantaneous Failure (IF) Scenario 2 - No Failure (NF) Scenario
Time and Water Velocity Parameters	years and cm/s	Time - Water Velocity 0 - 2.458E-14 (BL, IF, NF) 170 - 2.458E-14 (BL, IF, NF) 195 - 1.217E-13 (BL) 220 - 6.030E-13 (BL) 320 - 3.626E-10 (BL) 395 - 3.962E-08 (BL) 470 - 3.636E-07 (BL) 520 - 3.889E-07 (BL) 570 - 3.901E-07 (BL, IF) 16000 - 3.907E-07 (BL, IF)

Table C1.5. DUST-MS Model Input Parameters (Continued)

Parameter	Units	Deterministic Value
Moisture Content		
First and Last Node - Initial Moisture Content	n/a	First Node to Last Node = Material 1 to 10 = 0.3098 11 to 20 = 0.0452 21 to 26 = 0.4251 27 to 196 = 0.3588 197 to 198 = 0.4112 199 to 200 = 0.1123 201 to 206 = 0.427 207 to 226 = 0.342 227 to 270 = 0.393 (Site 11) 227 to 266 = 0.3025 (Site 3A) 271 t0 298 = 0.445 (Site 11)
Change in Node Number	n/a	1
Incremental Change in Moisture Content	n/a	0
Container Failure Times		
Number of Containers	n/a	0
Number of Failure Types	n/a	none
Failure Times for Containers	n/a	none
Waste Forms		
Not used	n/a	Not used
Sources		
Number of Source/Sink Nodes	n/a	0

Table C1.6. AT123D Model Input Parameters

Parameter	Units	Deterministic Value
Aquifer Tab		
Hydraulic Conductivity	m/hr	35.6 (Site 11) 1.18 (Site 3A)
Hydraulic Gradient	m/m	0.00066 (Site 11) 0.0032 (Site 3A)
Effective Porosity	n/a	0.3
Soil Bulk Density	kg/m^3	1670 (Site 11) 1560 (Site 3A)
Longitudinal Dispersivity	m	15
Transverse Dispersivity	m	1.5
Vertical Dispersivity	m	0.15
Aquifer Width	m	Infinite
Aquifer Depth	m	10.8 (Site 11) 4.572 (Site 3A)
Number of Eigenvalues	n/a	500
Steady-State Error Tolerance	n/a	0.01
Input Tab		
Release Coordinates	m	Site 11 X - Start = -113.1, End = 113.1 Y - Start = -169.6, End = 169.6 Z - Start = 0, End = 0 Site 3A X - Start = -124.8, End = 124.8 Y - Start = -153.6, End = 153.6 Z - Start = 0, End = 0
Soil organic carbon content	%	0
Koc - Organic carbon adsorption coefficient	(ug/g)/ (ug/ml)	0
Kd - Distribution Coefficient	m^3/kg	Chemical Specific
Water Diffusion Coefficient	m^2/hr	Chemical Specific
First-Order Decay Coefficient	1/hr	Chemical Specific

Table C1.6. AT123D Model Input Parameters (Continued)

Parameter	Units	Deterministic Value
Output Tab		
Starting Time Step		1
Ending Time Step		10001
Time Step		1
X-Axis Coordinates	m	Site 11 - 113.1, 213.1, 225.9, 1356.3, 3907.6 Site 3A - 124.8, 224.8, 242.6, 625.7, 1000
Y-Axis Coordinates	m	0
Z-Axis Coordinates	m	0
Load Tab		
Initial Concentration	mg/L	0
Single Mass Load	kg	not used
Model Time Step	hrs	14025.6 1402.56 701.28
Continuous = 0, >1 Varying	n/a	10000
Water Density	kg/m^3	1000
Release Type	n/a	Continuous Release
Load Release Rate	kg/hr	Varies by Chemical

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APPENDIX D

ANALYTICAL PROFILE

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ACRONYMS

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COPC	chemicals of potential concern
D&D	decontamination and decommissioning
DWGIS	Paducah Data Warehouse GIS Viewer
EMWMF	Environmental Management Waste Management Facility
ER	Environmental Restoration
LCB	life cycle baseline
LLW	low-level waste
OREIS	Oak Ridge Environmental Information System
ORGDP	Oak Ridge Gaseous Diffusion Plant
OU	operable unit
PGDP	Paducah Gaseous Diffusion Plant
RI/FS	Remedial Investigation/Feasibility Study
UF_6	uranium hexafluoride
WAC	waste acceptance criteria

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D.1. INTRODUCTION

This appendix presents the plan for developing an analytical profile of contaminants for the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) waste forecasted to be generated at Paducah Gaseous Diffusion Plant (PGDP). A comparison of the radiological and chemical parameters in this profile to the preliminary waste acceptance criteria (WAC) developed for an on-site disposal facility will be performed in the remedial investigation/feasibility study (RI/FS) to estimate the amount of forecasted waste that would be eligible for disposal in the facility. If high percentage of waste were expected to exceed the WAC of an on-site disposal facility, it would negatively affect the viability of the On-Site Alternative.

Results of the profile development effort correspond to the "nature and extent of contamination" section found in a typical RI report.

D.2. WASTE VOLUME

The waste inventory and waste generation schedule were developed from the life cycle baseline (LCB) and DOE 2006 as described in Chapter 5. This waste inventory will be adjusted to reflect the waste generation schedule as described in Section 6.1.1. A waste volume database has been developed for this project and can provide output by projected yearly waste volumes by waste and waste type.

D.3. EXISTING WASTE PROFILES

As mentioned in Section 5.1.3, profiles of PGDP wastes have been prepared to support recent and ongoing waste disposal operations. These profiles contain waste characterization data and other information relevant for the PGDP wastes being disposed. These profiles include those used for the disposal of solid nonhazardous waste in the C-746-U Landfill and low-level waste (LLW)/hazardous PGDP wastes that have been disposed of off-site (for example at Energy*Solutions* and Nevada Test Site).

Additionally, contaminant profiles of appropriate wastes being disposed of at the Environmental Management Waste Management Facility (EMWMF) have been prepared. It is recognized that some EMWMF waste profiles will be appropriate surrogates for PGDP waste because of the design and process similarities between the PGDP and the former Oak Ridge Gaseous Diffusion Plant (ORGDP) (at the Oak Ridge Reservation). These similarities will result in the same waste types and forms, with the same radiological and chemical contaminants. These wastes also will have similar levels of contamination and similar waste volumes. It also is recognized, however, that these profiles are more likely to provide more relevant information on the decontamination and decommissioning (D&D) waste than the soil wastes.

D.4. WASTE CHARACTERIZATION

The analytical profile of contaminants for the forecasted waste will be developed by creating a list of chemicals of potential concern (COPC), then estimating the concentration or activity for each COPC. In developing the profile, low-level radioactive, hazardous, and the solid nonhazardous waste types will be considered. Because there are limited analytical data available for many of the projects that contribute to the waste forecast, characterization of waste from these projects will use information from the existing waste profiles and supplement this information with available analytical information. This waste characterization process is expected to include both qualitative and semiquantitative information. This information also could be used to support a probabilistic analysis of the waste characterization in this profile, should it be needed for finalization of the WAC.

An analytical profile will be developed for both the low-end waste volume scenario and the high-end waste volume scenarios (see Section 6.1.2). A volume-weighted average analytical profile, composited across all projects and operable units (OUs), will be created for each scenario.

D.4.1 CHARACTERIZATION OF SOIL WASTE

Existing waste profiles for the disposal of solid nonhazardous waste in the C-746-U Landfill and off-site disposal of LLW/hazardous PGDP waste will be evaluated for relevance to the soil waste that is predicted to be generated during the environmental restoration (ER) cleanup and D&D of the PGDP. Although it is expected that the existing PGDP profiles will provide most of the relevant information for the characterization of contaminants associated with the future soil waste, existing EMWMF waste profiles also will be reviewed for relevance. It may be possible that profiles containing information on contaminants in soil from beneath the former gaseous diffusion facilities may be useful in characterizing the PGDP soil waste.

Information on contaminants, contaminant levels, and relevant process knowledge from these waste profiles will be used to develop the components of the analytical profile for the forecasted soil wastes that are expected to be eligible for disposal in an on-site facility. After compiling this information, it will be reviewed for data gaps. The Paducah Data Warehouse GIS Viewer (DWGIS) will be reviewed for information to fill the data gaps. The Paducah DWGIS provides a systematic approach to retrieve and display analytical data, maps, hydrological data, and geophysical data using a Web browser. The information in the Paducah DWGIS includes analytical sample results from environmental media, restoration reports and supporting documentation, maps, facility drawings, and photography for environmental locations. The Paducah DWGIS includes the same information and data as the Oak Ridge Environmental Information System (OREIS) database, but it is in a more manageable and more up-to-date format and system. Data gaps existing after the use of the DWGIS will be filled using conservative assumptions for the waste based on existing information and process knowledge.

This information will be assembled into a set of characterization data that will represent the soil that will likely be placed in the on-site disposal facility. This information will be assembled for both the low- and high-end volume scenarios based on the assumptions that were used to develop those scenarios.

D.4.2 CHARACTERIZATION OF NON-SOIL WASTE

The analytical profile developed for contaminants associated with the forecasted non-soil waste is expected to be developed in the same manner as the profile for the soil waste. Existing waste profiles for the disposal of nonhazardous solid waste in the C-746-U Landfill and off-site disposal of LLW/hazardous PGDP will be evaluated for relevance to the non-soil waste that is predicted to be generated during the ER cleanup and D&D of the PGDP. It is expected that the existing PGDP profiles will provide relevant information for the characterization of the future non-soil waste. Existing EMWMF waste profiles for the Oak Ridge D&D waste will be the primary source of useful information for characterizing the future PGDP D&D waste.

Information on contaminants, contaminant levels, and relevant process knowledge from these profiles will be used to develop the components of the analytical profile for the forecasted non-soil waste that are expected to be eligible for disposal in an on-site facility. After compiling this information, it will be reviewed for data gaps. The Paducah DWGIS will be reviewed for information to fill the data gaps. Data gaps existing after the use of the Paducah DWGIS will be filled using conservative assumptions for the waste based on existing information and process knowledge.

This information will be assembled into a set of characterization data that will represent the non-soil waste that likely will be placed in the on-site disposal facility. This information will be assembled for both the low- and high-end volume scenarios based on the assumptions that were used to develop those scenarios.

D.4.3 CHARACTERIZATION OF COMPOSITE WASTE

Composite analytical profiles will be developed for both the low-end and high-end waste volumes. These analytical profiles will provide average-weighted concentrations of analytes across all projects and OUs, across all waste (i.e., soil and non-soil), and for all waste types (i.e., combined nonhazardous and LLW/hazardous waste).

D.4.4 UNCERTAINTIES ASSOCIATED WITH DEVELOPMENT OF WASTE PROFILES

PGDP is an operating facility for which site-specific representative data are generally unavailable to characterize the forecasted waste. Although site-specific data will be used when available, such as data from soil samples collected for preliminary characterization of some solid waste management units (SWMUs) and OUs, surrogate waste profile data from EMWMF will generally be used as the best available data. Process and operation similarities between PGDP and K-25 at the former ORGDP make this data a valid resource. Consequently, development of waste profiles for the largely uncharacterized waste forecasted from PGDP for evaluation purposes in the RI/FS has associated uncertainties.

The primary uncertainty in using waste profiles from EMWMF as surrogates for unavailable data at PGDP is the potential difference between the facilities themselves, including operational history, processes, historical releases, disposal practices, etc.:

- The burial grounds at the two facilities likely received different waste, but characterization data is unavailable for PGDP burial grounds, and only limited records and anecdotal information are available regarding waste disposal at the burial grounds.

- PGDP is a low-enrichment gaseous diffusion plant with an unique configuration (e.g., filters, system venting) that continues to operate while K-25 at the former ORGDP was a high-enrichment plant that ceased operations in 1985.

- PGDP received more recycled uranium from other DOE reactors (e.g., Hanford and Savannah River) than the former ORGDP, although PGDP sent its low-enriched UF_6 from the recycled uranium to Oak Ridge for further enrichment.

- Routine and periodic maintenance programs at the two facilities differed, such as the Cascade Improvements Program and the Cascade Uprating Program that were implemented at PGDP.

- Releases and catastrophic failures from failures of compressors, gaskets/seals, and other equipment and during equipment removal and maintenance activities differed.

These uncertainties will be mitigated by use of assumptions for development of the waste profiles tending to establish bounding conditions where contaminant concentrations will be estimated at higher levels. Additionally, in spite of these uncertainties, data from Oak Ridge EMWMF waste profiles represent the best available data for the PGDP RI/FS evaluation.

APPENDIX E

SITE SCREENING

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ACRONYMS

CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
DOE	U.S. Department of Energy
ERDF	Environmental Restoration Waste Disposal Facility
RI/FS	Remedial Investigation/Feasibility Study
ROD	record of decision
SWMU	solid waste management unit
WAC	waste acceptance criteria

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E.1. INTRODUCTION

In order to evaluate the technical feasibility and protectiveness of the On-Site Alternative, U.S. Department of Energy (DOE) must screen the locations discussed in Section 5.4.1 to select a candidate site on which a disposal facility potentially could be located. The process that will be used screen the candidate sites for a potential on-site disposal facility is described in this appendix.

E.2. SCREENING PROCESS

The site screening process will be conducted in parallel with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Remedial Investigation/Feasibility Study (RI/FS) process. Figure E.1 depicts the integration of the CERCLA decision process and the site screening process. DOE will seek regulator and public input throughout the screening process to ensure that site screening and selection is responsive to stakeholder interests and concerns.

A site screening study will record the methodology and results of the process and will be appended to the RI/FS Report. Specifically, the site screening study will accomplish the following:

- Describe the general conceptual design;
- Confirm that the 110-acre assumption used to identify the 11 initial candidate sites is adequate for the minimum area requirement;
- Refine the sites by screening them against primary and secondary screening criteria (defined in Section E.3);
- Discuss mitigative measures (e.g., changes to potential disposal facility configuration or design) that may be needed to address technical or logistical challenges associate with site conditions;
- Allow for regulatory and public feedback on the screening process and results; and
- Recommend one or more viable site(s) for evaluation in the FS.

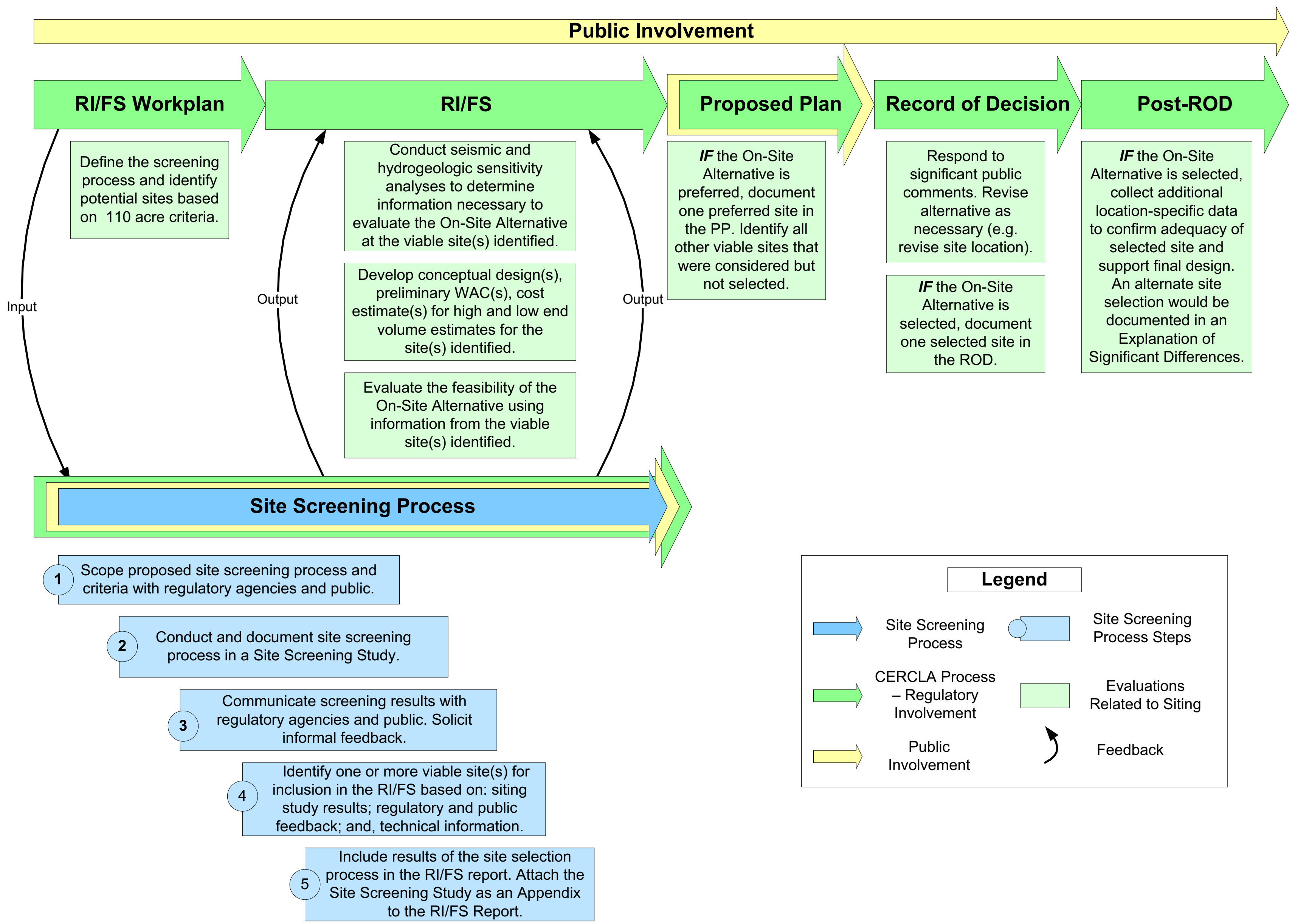

Figure E.1. Site Screening/Selection and CERCLA Integration

E.3. SITE SCREENING CRITERIA

Site screening criteria will be applied based on a tiered approach to allow for early elimination of sites determined to be technically or legally infeasible, excessively costly, or insufficiently protective.

Initial considerations and parameters for the development of screening criteria are included in Table E.1. Screening criteria will be finalized based on regulator and public input during the site screening process. Two phases of screening will be conducted using the following primary and secondary criteria:

(1) **Primary screening criteria:** Primary screening criteria will be designed for application on a strictly pass fail basis. Only sites that meet all of the primary screening criteria will be evaluated against the secondary criteria. Primary criteria will be defined based on minimum technical requirements and threshold applicable or relevant and appropriate requirements. Factors will be established for the primary screening criteria clearly defining the conditions that must be met in order for the site to be further evaluated. For instance, siting in a designated floodplain would represent a primary screening criteria used to eliminate sites from further consideration (Figure E.2). Relative proximity to a floodplain when compared with other sites may be used as secondary screening criteria to rank the desirability of site.

(2) **Secondary screening criteria:** Sites that meet all of the threshold criteria will be evaluated against the secondary criteria. Secondary criteria will aid in comparatively evaluating and ranking the sites based on differing site conditions and technical considerations. Secondary screening criteria will be ranked and weighted to assist in the comparative evaluation among sites. For instance, if Site X effectively meets more of the secondary criteria relative to Site Y, Site X is more likely to be used as a representative site in the RI/FS evaluation. If a site does not fully meet the objectives of a secondary criterion, efforts then may be focused on mitigating measures, which could ultimately affect the design and cost of an on-site disposal facility. Figures E.3 and E.4 provide an example of screening the candidate sites with respect to the technetium-99 and trichloroethene groundwater plumes.

DOE will work collaboratively with the regulators and the public to develop the primary and secondary screening criteria. Input from the regulatory agencies and the public will be solicited to rank the criteria, determine the weight associated with each criterion, and apply the screening criteria across the sites. The site selection process will utilize methodologies agreed upon by the site screening group to appropriately "score" the sites that meet the primary criteria. The methodology utilized will be designed to minimize the subjectivity in scoring the sites.

The site screening study will recommend one or more viable sites to be included in the FS based on the results of the site screening process.

E.4. DATA COLLECTION TO SUPPORT SITE SCREENING

To properly evaluate and compare the existing 11 potential locations against the final screening criteria, it may be necessary to collect additional information to support the site screening process. Such information could include, for example, a study regarding the relocation of power lines and possibly other information that may support or eliminate a location from further consideration as determined during the site screening process.

Table E.1 Preliminary Site Screening Considerations and Parameters for Development of Screening Criteria

Site Screening Considerations	Preliminary Parameters of Interest
Floodplains	• Proximity to floodplains
Wetlands	• Proximity to delineated wetlands • Potential impact to delineated wetlands
Hydrogeology	• Depth to groundwater • Seasonal fluctuations in groundwater • Proximity to drinking water wells or high value groundwater • Distance to perennial streams • Characteristics of the upstream drainage area • Permeability of soils and bedrock • Discharge of groundwater to the surface within the disposal site • Direction of groundwater flow • Groundwater monitorability
Seismic/Geologic	• Proximity to Holocene faulting • Frequency and magnitude of tectonic processes (e.g., faulting, folding, seismic activity, or vulcanism) • Soils prone to liquefaction, stability/subsidence
Terrain	• Evidence of surface geologic processes such as mass wasting, erosion, slumping, landsliding, or weathering
Land Use	• Current and future land use scenarios • Interference with/by nearby facilities or activities • Existing infrastructure that could support operations of an on-site disposal facility • Presence of power transmission lines • Existence of contaminated media (i.e., brownfield type site)
Transportation/Access	• Site access by waste generators • Replacement or construction of roads or rail lines to transport waste
Protective Buffers	• Distance to sensitive environmental areas (including West Kentucky Wildlife Management Area) • Distance to site boundaries • Distance to the water table
Threatened and Endangered Species	• Threatened & Endangered Species (e.g., Indiana bat habitat areas)
Cultural and Natural Resources	• Historic/archaeological sites (e.g., cemeteries) • Presence of areas having known natural resources, which, if exploited, would result in failure to meet the performance objectives
Demographics	• Projected population growth and future developments of the site and surrounding areas • Distance to nearest residence, church, school, house, residential well
Timing	• Time frame for availability of the site in relation to other CERCLA actions (e.g., remediation of SWMUs, proximity to operating remedial technologies, proximity to SWMUs that would require remediation before a facility could be constructed)
Cost	• Cost of development • Cost of mitigative measures • Cost savings due to favorable site conditions (e.g., existing support structures)

SWMU = solid waste management unit
CERCLA = Comprehensive Environmental Response, Compensation and Liability Act

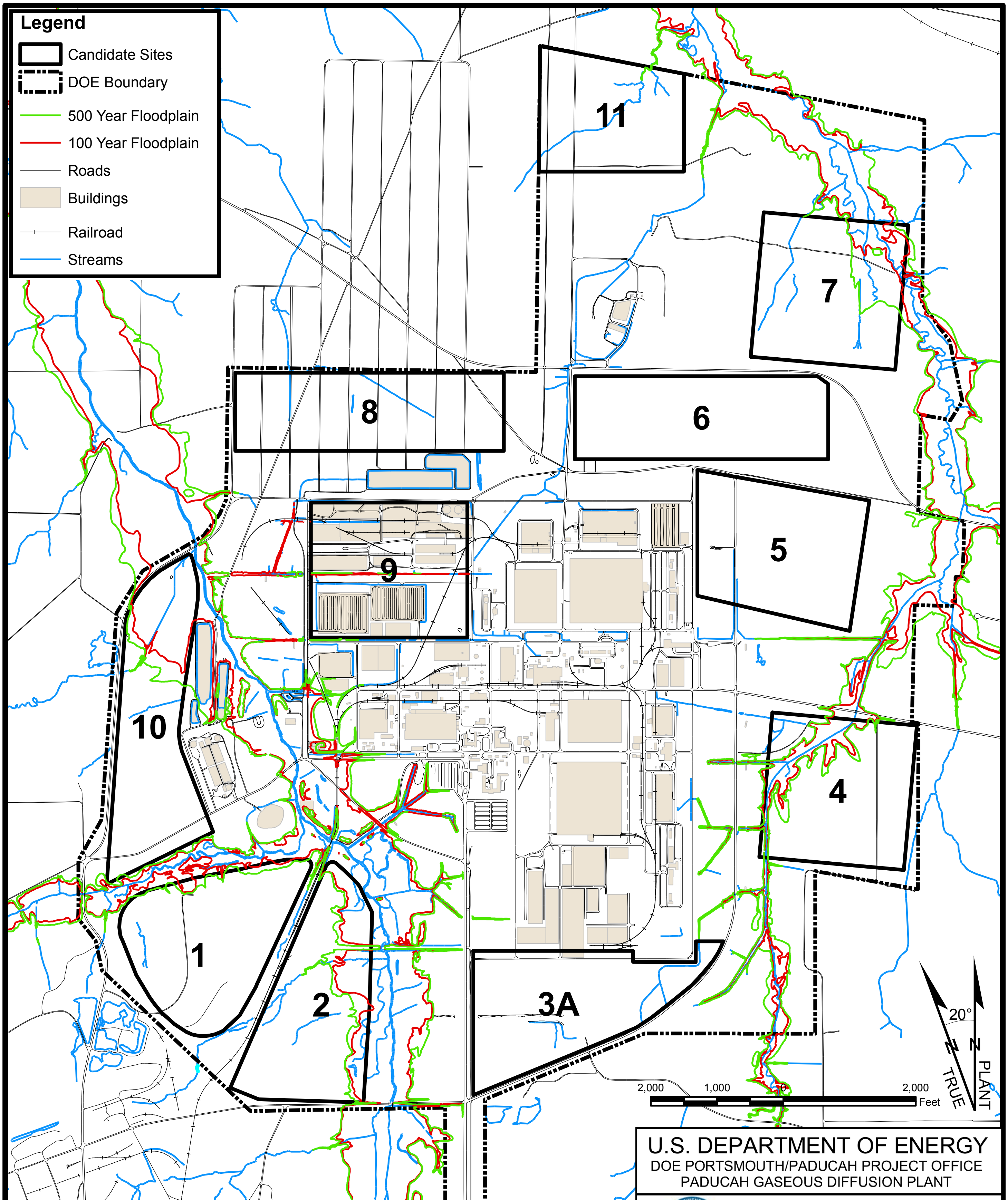

Figure E.2. 100-year and 500-year Floodplains

20100917 D2 RI-FS Work Plan jb D2

Figure No. Fig_E.2 Floodplains.mxd
DATE 11-20-09

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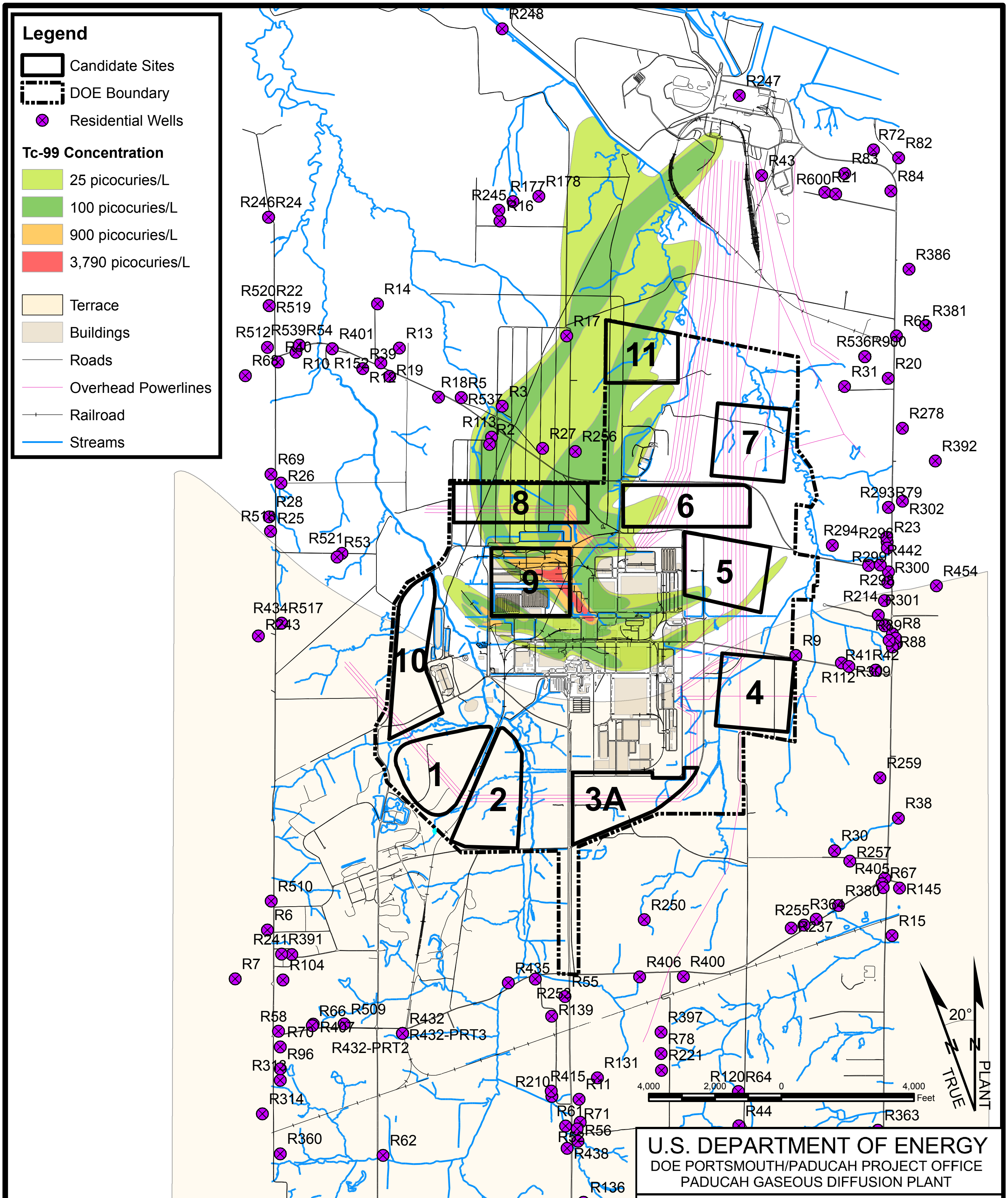

Figure E.3. Tc-99 Plume Map with Residential Wells and Hydrogeologic Setting

20100917 D2 RI-FS Work Plan jb D2

Figure No. Fig_E.3 - Tc-99 Plume Map.mxd
DATE 11-20-09

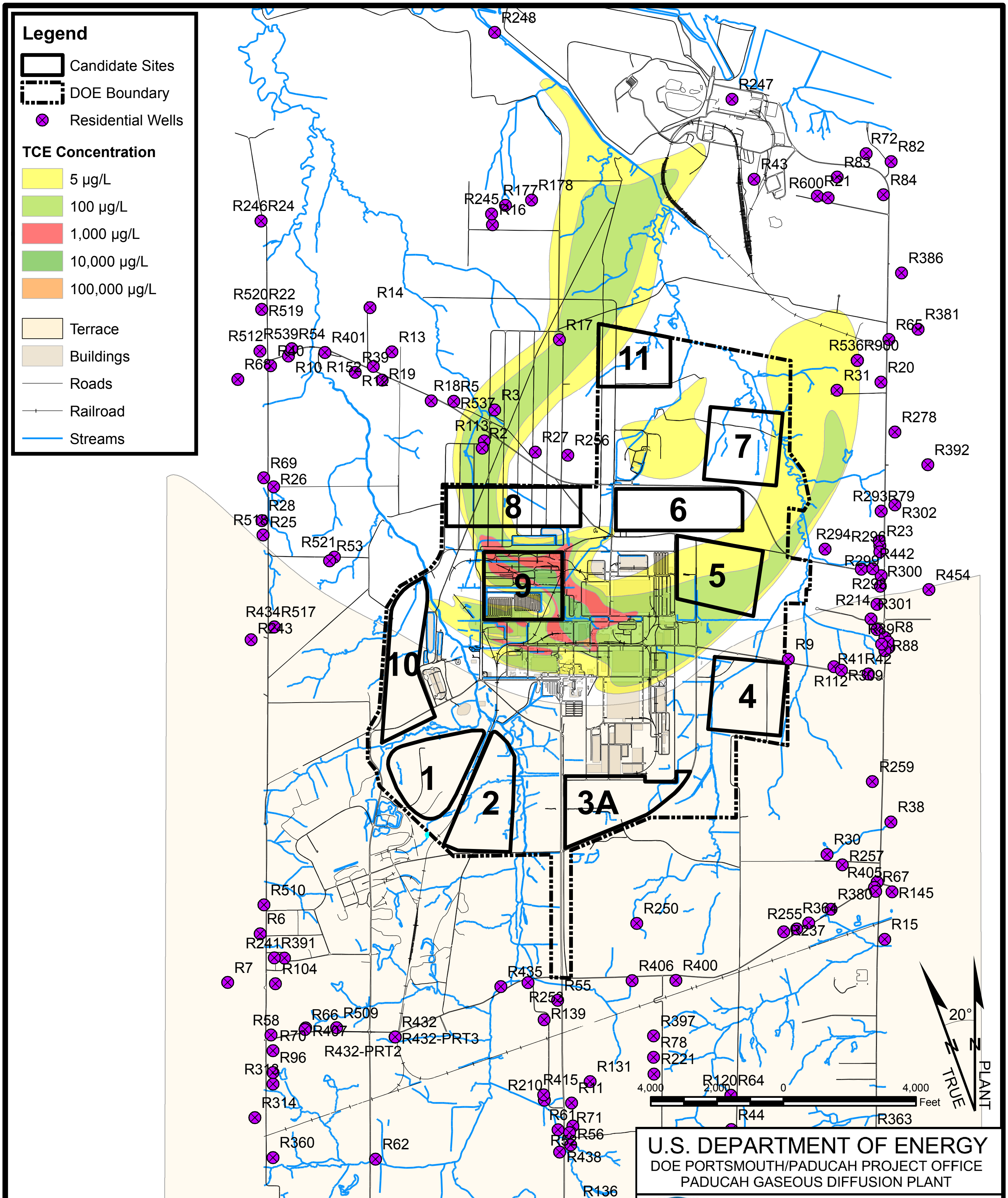

Figure E.4. TCE Plume Map with Residential Wells and Hydrogeologic Setting

20100917 D2 RI-FS Work Plan jb D2

Figure No. Fig_E.4 TCE Plume Map.mxd
DATE 11-20-09

E.5. RI/FS ANALYSIS AND SITE PROPOSAL

The goal of the site screening process will be to narrow down the 11 candidate sites to a single location to be evaluated in the FS. If it is not possible to narrow the candidate sites to a single representative location during the site screening process, the remaining viable locations would be evaluated comparatively in the FS to support selection of a preferred location in the Proposed Plan.

In the FS, conceptual design(s), preliminary waste acceptance criteria (WAC), and cost estimates will be compared between the low- and high-end waste volume estimates for the representative site(s). If more than one site is evaluated in the RI/FS report, then a conceptual design and preliminary WAC would be developed for each site. This information will be critical in evaluating the feasibility and performance of the On-Site Alternative.

As a part of the RI/FS activities, an assessment will be performed to determine if any additional field characterization is necessary to support evaluation of a potential on-site disposal facility at the viable site(s). If necessary, field characterization of the viable site(s) will be conducted as part of the RI/FS development, and the results will be documented in the RI/FS report. Any additional data collection required would be presented in a Work Plan addendum or separate Work Plan, subject to regulator review and approval. However, DOE’s expectation is that no additional field characterization will be required for the RI/FS.

If the On-Site Alternative is selected as the preferred alternative, the Proposed Plan would identify the preferred site for the on-site disposal facility and, if applicable, the benefit of its selection over other feasible locations evaluated in the FS. The record of decision (ROD) would identify the selected site. It should be noted that the site selected in the ROD may differ from the preferred site in the Proposed Plan, based on formal public comments.

If an on-site CERCLA waste disposal facility is the selected remedy, additional site characterization activities would be conducted post-ROD to support design of the waste disposal facility and development of the final WAC. If post-ROD characterization reveals that the selected location is unusable, then an alternate site will be selected. If an alternate site is not available, then the No Action or Off-Site Alternative will be implemented. Such a change would be recorded in an Explanation of Significant Difference.

E.6. SITE SELECTION PROCESS AT COMPARABLE DOE SITES

DOE has performed a site screening and selection process at other sites when evaluating the On-Site Alternative. This section provides an over view of successful implementation of the site selection process at Hanford, Washington, and Oak Ridge, Tennessee.

E.6.1 HANFORD RESERVATION

A similar site selection process to the one described in this appendix was employed for the Hanford Environmental Restoration Waste Disposal Facility (ERDF) in 1994. The ERDF *Siting Evaluation Report for the Environmental Restoration Disposal Facility* (WHC 1994) describes a siting process prior to the proposed plan that involved Hanford Site contractors responsible for site operations, engineering safety, environmental, and other services. The Site Selection Team narrowed down three candidate sites to one preferred location to support detailed analysis of disposal alternatives. Following public comment, an additional site evaluation was conducted to consider a different configuration of the proposed site. Candidate sites were evaluated relative to applicable federal and state regulations and DOE Orders and recommendations for future Hanford site use from the Hanford Site Uses Working Group (Drummond 1992; DOE 1994).

E.6.2 OAK RIDGE RESERVATION

As part of the On-Site Alternative for DOE's CERCLA waste disposal evaluation at the Oak Ridge Reservation, DOE performed a site screening study that identified and evaluated 35 candidate sites (DOE 1996).

A top-down screening methodology was applied to the candidate sites: preliminary screening, which was primarily a paper study, eliminated 19 sites from further consideration based on size or geology considerations. A secondary screening was a more detailed process consisting of site visits, discussions with personnel involved with previous siting efforts, and evaluation of additional data. The criteria used for preliminary screening were reapplied, in addition to applying modifying criteria such as existence of surface water features, floodplains, wetlands, geologic and geographic buffers, and location with respect to waste generators. In general, National Environmental Policy Act values, which parallel many of the CERCLA evaluation criteria, were incorporated into the site selection process as well as the remedy selection process. Upon conclusion of the screening process, three final candidate sites were evaluated in the FS.

As part of the CERCLA evaluation of the disposal alternatives, a comparison of the three sites was conducted and the results were summarized in the RI/FS and presented to the public and the regulators at a series of public meetings and workshops. All three sites were determined to be protective of human health and the environment and meet ARARs (except the Toxic Substances Control Act requirement for a 50-ft buffer between the bottom of the cell and groundwater). Comparative analysis of the candidate sites revealed differentiating elements for some of the evaluation criteria.

DOE, considering the results of its site evaluations and regulator and public input, selected a single site as the preferred location to implement the On-Site Alternative in the ROD (DOE 1999).

E.7. REFERENCES

DOE (U.S. Department of Energy) 1996. *Identification and Screening of Candidate Sites for the Environmental Management Waste Management Facility, Oak Ridge, Tennessee*, DOE/OR/02-1508&D1, U.S. Department of Energy, Oak Ridge, TN, September.

DOE 1999. *Record of Decision for the Disposal of Oak Ridge Reservation Comprehensive Environmental Response, Compensation, and Liability Act of 1980 Waste*, *Oak Ridge, Tennessee,* DOE/OR/01-1791&D3, U.S. Department of Energy, Oak Ridge, TN, November.

Drummond, Marshall E., Chairman 1992. "The Future for Hanford: Uses and Cleanup," The Final Report of the Hanford Future Site Uses Working Group," Eastern Washington University, December.

WHC (Westinghouse Hanford Co.) 1994. *Siting Evaluation Report for the Environmental Restoration Disposal Facility*, WHC-SD-EN-EV-009, Rev. 2, Prepared by Golder Associates, Inc. for Westinghouse Hanford Co., Richland, WA.

APPENDIX F

BEDROCK SHEAR WAVE SENSITIVITY ANALYSIS

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ACRONYMS

DOE	U.S. Department of Energy
IRT	independent review team
PGA	peak ground acceleration
PGDP	Paducah Gaseous Diffusion Plant
RI/FS	Remedial Investigation/Feasibility Study
ROD	record of decision
SIR	Seismic Investigation Report
Vs	shear wave velocities

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F.1. INTRODUCTION

Based on scoping discussions, the regulators believe a Paducah Gaseous Diffusion Plant (PGDP)-specific bedrock shear wave velocity should be collected for input to the ground motion modeling for a potential on-site disposal facility (Section 6.5.3). The Seismic Investigation Report (SIR) (DOE 2004) used data that were obtained from the same bedrock formation (Mississippian Limestone) present at PGDP, but the data were collected from another project site several miles away. The U.S. Department of Energy (DOE) and the regulators agreed that measurement of bedrock shear wave velocity at a single site at the PGDP would be adequate because bedrock is consistent across the site.

Ground motion modeling has been conducted for the PGDP site and, in particular, for Site 3A in the southern portion of the PGDP site. These models incorporated bedrock shear wave velocities from references and measurements used to support construction projects in the vicinity of PGDP. Evaluating the data for shear wave velocities (Vs) in bedrock beneath the PGDP was a specific charge given to the DOE Headquarters independent review team (IRT) in its review of the SIRS and background materials from PGDP. A summary of the IRT recommendations that was presented at the June 2009 Seismic Information Workshop is presented in Attachment F-1. DOE believes these bedrock shear wave velocities used in the previous modeling are accurate, technically defensible, and adequate to conceptually evaluate the On-Site Alternative in the RI/FS; therefore, it is assumed that acquisition of a site-specific bedrock shear wave velocity can be deferred to site-specific characterization. Both the site-specific characterization and the ground motion modeling described in Section 6.5.3 will occur after the record of decision (ROD), if the ROD selects the On-Site Alternative.

DOE plans to conduct an analysis of sensitivity of the surface PGA to the bedrock shear-wave velocity to justify this assumption. The sensitivity analysis is intended to determine the effects of a range of bedrock shear wave velocities on surface peak ground acceleration (PGA) values for PGDP. If the results indicate large variations in surface PGA values in response to small changes in bedrock shear wave velocity, it could be concluded that a PGDP-specific bedrock shear wave velocity would be required to adequately evaluate the On-Site Alternative. In that case, it may be necessary to interrupt the RI/FS evaluation and acquire the bedrock shear wave velocity at the site. The sensitivity analysis approach is detailed this appendix.

F.2. BEDROCK SHEAR WAVE SENSITIVITY ANALYSIS

The general approach for conducting a PGDP bedrock shear wave velocity sensitivity analysis was presented in a July 8, 2008, scoping teleconference. It then was detailed in the June 2009 Seismic Issues Workshop in Oak Ridge, TN. Suggestions offered during the Seismic Issues Workshop have been incorporated into this description. Figure F.1 presents a flowchart of the sensitivity analysis activities. These activities are summarized in the following paragraphs.

The sensitivity analysis is intended to determine the effects of a range of bedrock shear wave velocities on the surface PGA for PGDP. The effects then will be used to define the sensitivity of surface PGA values to likely bedrock shear wave velocities at PGDP.

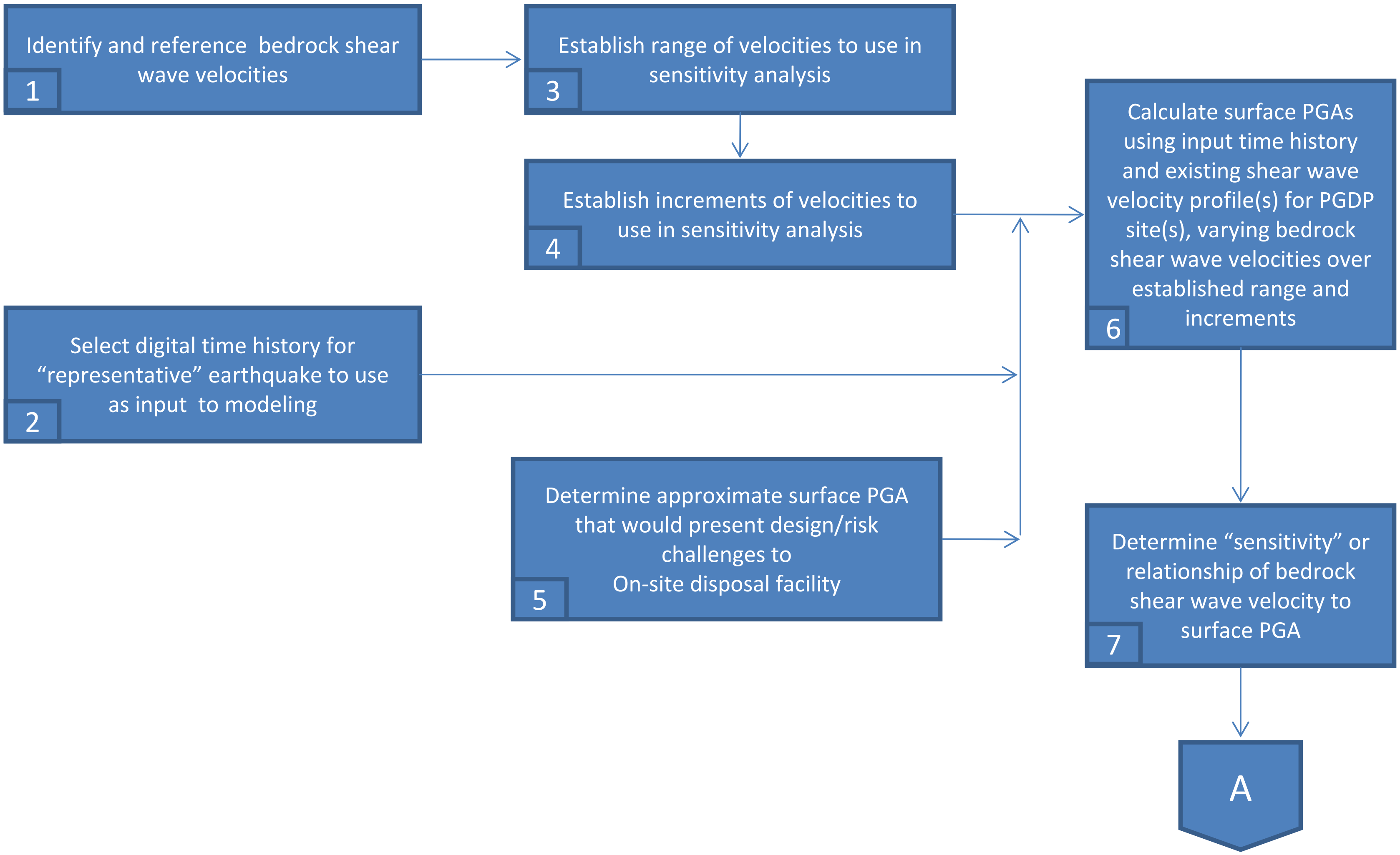

Figure F.1. Acquisition of PGDP Bedrock Shear Wave Velocity Decision

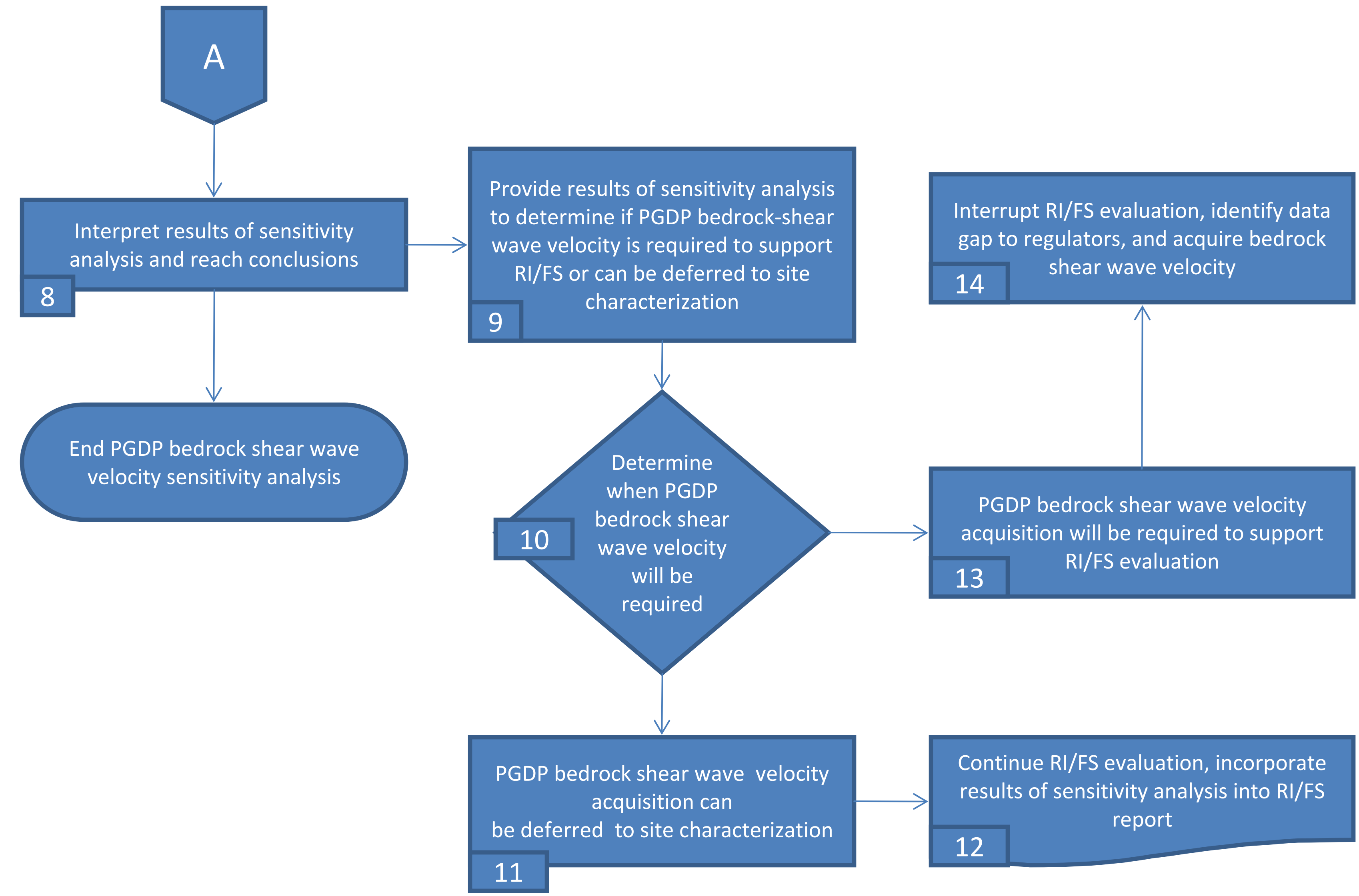

Figure F.1. Acquisition of PGDP Bedrock Shear Wave Velocity Decision (Continued)

The initial activities in the sensitivity analysis (Activities 1 through 4 in Figure F.1) will focus on assembling input information for the modeling that will determine surface PGA values. Limestone bedrock shear wave velocities used for previous studies at or relevant work performed in the vicinity of the PGDP will be identified and referenced. Relevant information such as the location and the method used to acquire the velocity will be assembled. These are some of the likely shear wave velocity sources that are expected to be included.

- Velocities from PGDP-specific reports (Risk Engineering 1999; Beavers 2001; DOE 2004)
- Olmsted Lock and Dam (Geomatrix 1996)
- I-24 Bridge (Harris *et al*. 1994)

The bedrock shear wave velocity sources will be supplemented with reference velocities for limestone bedrock such as those in *Encyclopedia of Seismology* or other relevant documents. A range of limestone bedrock shear wave velocities to be evaluated will be established (Figure F.1, Activity 2) and increments of bedrock shear wave velocities to be modeled will be determined. Increments of 1,000 ft/sec are expected to be used (Figure F.1, Activity 4).

The PGA value for PGDP limestone bedrock will be required in order for the model to arrive at a surface PGA. A "representative" ground motion time history and bedrock PGA will be used in the model (Figure F.1, Activity 2). Discussion at the Seismic Issues Workshop concluded that the time history for the Kentucky Department of Transportation synthetic record for McCracken County is preferred for this sensitivity analysis.

Using input from subject matter experts on landfill design and the relationship to surface PGA values, an upper limit on the surface PGA will be established (Figure F.1, Activity 5). This upper limit would be the point where construction of a disposal facility would not be feasible, either for economical (too expensive to build) or safety (the risk of failure is unacceptable) reasons, or both. Although this value is expected to assist in determining whether all increments in the range of velocities will be modeled, this upper limit on surface PGA is expected to be more relevant to the conclusions of the sensitivity analysis. For example, the following could be two extreme scenarios. If the lowest shear wave velocity in the established range is modeled and the resulting surface PGA is much lower than the upper limit on the surface PGA, then modeling of the higher shear wave velocities in the range may not be required. Conversely, if the highest shear wave velocity is modeled and the resulting surface PGA is much higher than the upper limit on the surface PGA, then modeling of the lower shear wave velocities may not be required.

Activity 6 in Figure F.1 summarizes the model that will be used and modeling that will be performed in the sensitivity analysis. In order to determine a surface PGA, the model will require a shear wave velocity profile for the unconsolidated sediments above the bedrock. The shear wave velocity profile acquired during the Site 3A seismic investigation will be used for this analysis (DOE 2004).

Activity 6 also includes the modeling to estimate the PGA values at the surface. The modeling initially may be performed at the upper and lower ends of the range of bedrock shear wave velocities established. The range of shear-wave velocities modeled will range from 6,000 ft/sec to 14,000 ft/sec. This will indicate the sensitivity over the range of velocities established and possibly be the only modeling required (if there is very little variation in the surface PGA or if one of the previously described extreme scenarios results from the modeling). If the surface PGA values show large variation, additional modeling of the range will be performed. All or part of this modeling will be repeated using an actual time history from a recorded earthquake (expected to be a Boston, MA, and/or a California event). This exercise will act as a "reality check" for the use of a synthetic event for Kentucky rather than an actual event.

Using the results of the modeling, an assessment of the "sensitivity" or the relationship of the bedrock shear wave velocities to surface PGA is expected to be defined (Figure F.1, Activity 7). This information, along with input from subject matter experts on landfill design and its relationship to surface PGA values, will be used to reach the conclusions of the sensitivity analysis (Figure F.1, Activity 8). The results of the sensitivity analysis will be used to determine if the bedrock shear wave velocity at PGDP is required to support the Remedial Investigation/Feasibility Study (RI/FS) evaluation or whether it can be deferred to site-specific characterization (Figure F.1, Activities 9 and 10).

If the PGDP bedrock shear wave velocity is required to support the RI/FS evaluation (Figure F.1, Activity 13), DOE would interrupt the evaluation to acquire the bedrock shear wave velocity (Figure F.1, Activity 14). DOE also would seek the concurrence of Kentucky and the U.S. Environmental Protection Agency regarding the method of acquisition prior to field execution. If the PGDP bedrock shear wave velocity is not required to support the RI/FS (Figure F.1, Activity 11), its acquisition will be deferred to characterization of the selected site that would follow the ROD if the On-Site Alternative is selected). The RI/FS evaluation of waste disposal alternatives would continue and the results of the sensitivity analysis would be incorporated into the RI/FS (Figure F.1, Activity 12). The site-specific bedrock shear wave velocity would be incorporated in the ground motion modeling that would be conducted to support site-specific disposal cell design (Section 6.5.3).

F.3. REFERENCES

Beavers, J. E. 2001. *Seismic Design Criteria Assessment for the C-746-U Contained Landfill—A White Paper,* submitted to Bechtel Jacobs Company LLC, James E. Beavers Consultants, Urbana, IL, February 20.

DOE (U.S. Department of Energy) 2004. *Seismic Investigation Report for Siting of a Potential On-Site CERCLA Waste Disposal Facility at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2038&D2, U.S. Department of Energy, Paducah, KY, March.

Geomatrix Consultants 1996. Final Report *Probabilistic Seismic Hazard Assessment Olmstead Locks and Dam Site*, Project No. 3549, prepared for the U. S. Army Corps of Engineers, Louisville District, Louisville, KY, October.

Harris *et al.* 1994. Harris, J. B., R. L. Street, J. D. Kiefer, D. L. Allen, and Z. M. Wang, "Modeling Site Response in the Paducah, Kentucky Area," Earthquake Specta, Vol. 10, No. 3, p. 535.

REI (Risk Engineering, Inc.) 1999. *Updated Probabilistic Seismic Hazard Analysis for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, Final Report (Revision 3)*, prepared for Lockheed Martin Utility Systems, Inc., April 26.

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ATTACHMENT F-1

DOE INDEPENDENT REVIEW TEAM RECOMMENDATIONS SEISMIC INFORMATION WORKSHOP, JUNE 2009

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Paducah Gaseous Diffusion Plant Seismic Characterization

DOE Headquarters Independent Review Team Report Recommendations

June 25, 2009

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- Independent Review Team (IRT) formed in August 2008
  - Dr. Brent Gutierrez, PE, CEM
    - Department of Energy Savannah River, Team Lead
  - Dr. Stephen McDuffie
    - Department of Energy Chief of Nuclear Safety Staff
  - Jeffrey Munsey
    - TVA River Operations Dam Safety
  - Frederick Loceff, PE
    - Frederick Loceff Technical Services

Team Review Activities

- September 3, 2008 Review Kick-Off Meeting
  - PPPO
  - Contractor Staff
  - Commonwealth of Kentucky representatives
- September 3 – December 2008
  - Independent review conducted
- Review Report
  - January 2009 Issued Report
  - May 2009 Comment resolution
  - June 2009 Final Report

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- Overall – IRT finds that the Site and regional characterization work is sufficient for the PPPO to move forward with an RI/FS, which will then enable PPPO to decide whether to build a CERCLA landfill.

Report Recommendations

- Eight specific recommendations
  - Made in the context of future cell design work for on-site disposal decision
  - Recommendations 4, 5, and 8 should be pursued regardless of decision

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Report Recommendations

Recommendation 1: Propose to the State of Kentucky and EPA regulators, and reach agreement on, a design ground motion, a method for determining it, and landfill performance criteria.

- This recommendation refers only to design and performance criteria for a landfill.
- The current body of site information is sufficient to move forward with an RI/FS to decide whether to construct a disposal cell at the PGDP.
- If PPPO decides to construct a cell, then PPPO, Kentucky DWM, and the EPA regulators must agree on:
  - the ground motion to which the cell will be designed, and
  - the cell's performance criteria.

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Recommendation 2: Discuss with Kentucky DWM whether a study of landfill sensitivity to bedrock Vs is necessary, and if so, will it be sufficient to resolve their concern.

- The IRT finds the current limestone bedrock Vs data are sufficient to proceed with the decision on whether to construct a cell.
- The KY DWM need for additional Vs data should be determined before a sensitivity study is performed, and before any plans for future site data collection are finalized.

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<u>Recommendation 3</u>: Perform characterization and analysis to investigate Holocene faulting at the candidate CERCLA cell site(s) following the two-phased approach outlined in the report.

- The IRT believes that the difficulty in proving the absence of Holocene faulting should be considered by owners and regulators in determining an appropriate and reasonable level of investigation.
- The IRT believes that the Holocene faulting investigation approach for site 3A should be followed for any future candidate site that does not already have at least the same level of investigation as that performed for site 3A.
- The IRT strongly recommends that future fault investigations include inclined boreholes to increase the chance of intersecting vertical or near vertical faults.

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Recommendation 3 continued:

- The IRT recognizes the difficulties with trenching at the site, but given the potential value of trenching investigations, this method should continue to be considered as an investigation tool where feasible.
- The IRT believes that high resolution, shallow electrical resistivity surveys have the potential to further define disturbed or faulted strata and should, therefore, be explored as investigation tools by performing testing similar to that which was performed for ground penetrating radar surveys.
- The IRT suggests that downhole geophysical logging be tested as a means of differentiating the near surface stratigraphy.

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<u>Recommendation 4</u>: Update to the PGDP Probabilistic Seismic Hazard Assessment (PSHA). The most recent conventional PSHA, performed by REI (1999), is a decade old. A Level 2 PSHA using the Senior Seismic Hazard Analysis Committee (SSHAC) process would serve to improve the state of knowledge at PGDP, and it could consider new information as outlined in Section 3.1.

- Considerable additional data and models have been generated since the 1990 analysis.
- The forthcoming model from the Central and Eastern U.S. (CEUS) Seismic Source Characterization Project (due mid-2010) should be very helpful in producing an updated PSHA for the Site.

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Recommendation 5: Further investigate the sand dikes east of Paducah to better determine the timing, location, and magnitude of their seismic source(s). If these can be determined, they may impact PGDP PSHA results.

Report Recommendations

Recommendation 6: Although some analytical methods require use of peak horizontal ground acceleration (PGA), ground motions near 1 Hz are likely close to the fundamental frequency of the disposal cell and should, therefore, be considered when characterizing the seismic hazard and vulnerability of a PGDP disposal cell.

- This recommendation is nothing more than a reminder that sidewalls of a disposal cell are likely to have a fundamental frequency close to 1 Hz, so accelerations in this frequency range must be a primary consideration when designing the cell.

Report Recommendations

<u>Recommendation 7</u>: Adopt a clear position on the definition of an active fault if this is a useful term for design or regulatory purposes.

- The IRT simply recommends a single definition be employed in the future.

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Report Recommendations

Recommendation 8: Continue microearthquake and strong motion monitoring at and near the PGDP.

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APPENDIX G

HISTORICAL RISK ASSESSMENT SUMMARY

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G.1. INTRODUCTION

This Appendix provides a listing of historical human health and ecological risk assessments that have been conducted at the Paducah Gaseous Diffusion Plant (PGDP). Data contained in these documents will not be updated, but used as source documents for existing data in the remedial investigation/feasibility study (RI/FS) report for the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Waste Disposal Alternative Evaluation to help identify contaminants of concern (COCs) that would be expected to be found in waste generated during PGDP response actions. The Risk Methods Document (DOE 2001 or the most current version) will be used as guidance when performing the data calculations. The list of COCs will primarily be used to provide data for transport modeling when preparing a preliminary waste acceptance criteria (WAC) to evaluate the On-Site Alternative. The list of COCs will be developed as described in Appendix C.

G.2. SUMMARY OF HUMAN HEALTH RISK ASSESSMENTS

Several human health baseline risk assessments have been completed for PGDP in compliance with EPA and Commonwealth of Kentucky guidance. The risk assessments from which the data will be obtained for the RI/FS report include, but are not limited to, the following:

- *Results of the Site Investigation, Phase I, at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (CH2M Hill 1991).
- *Results of the Public Health and Ecological Assessment, Phase I* [This report is Vol. 6 of *Results of the Site Investigation, Phase I, at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (CH2M Hill 1992)].
- *Baseline Risk Assessment for the Underground Storage Tanks at the C-200, C-710, and C-750 Buildings, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1992).
- *Remedial Investigation Addendum for Waste Area Grouping 22, Burial Grounds, Solid Waste Management Units 2 and 3, at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1994).
- *Remedial Investigation Addendum for Waste Area Grouping 23, PCB Sites, at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1994).
- *Resource Conservation and Recovery Act Facility Investigation/Remedial Investigation Report for Waste Area Groupings 1 and 7 at Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1996).
- *Baseline Risk Assessment for Exposure to Polycyclic Aromatic Hydrocarbons at Underground Storage Tanks C-750 A&B, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1996).
- *Baseline Risk Assessment for Underground Storage Tanks 130, 131, 132, 133, and 134 as presented in the WAGs 1&7 RFI/RI, Paducah Gaseous Diffusion Plant, Paducah, Kentucky, UST Facility/Site Identification Number 6319073* (DOE 1996).

- *Data Summary and Interpretation Report for Interim Remedial Design at Solid Waste Management Unit 2 of Waste Area Grouping 22 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1997).
- *Excess Lifetime Cancer Risk and Systemic Toxicity Hazard to Excavation Workers by Pit at Solid Waste Management Units 7 and 30 at the Paducah Gaseous Diffusion Plant* (DOE 1997).
- *Remedial Investigation for Solid Waste Management Units 7 and 30 of Waste Area Grouping 22 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1998).
- *Remedial Investigation Report for Waste Area Grouping 6 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1999).
- *Remedial Investigation Report for Waste Area Grouping 27 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1999).
- *Residual Risk Evaluation for Waste Area Grouping 23 and Solid Waste Management Unit 1 of Waste Area Grouping 27 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1999).
- *Remedial Investigation Report for Waste Area Grouping 28 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2000).
- *Remedial Investigation Report for Waste Area Grouping 3 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2000).
- *Feasibility Study for the Groundwater Operable Unit at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2000).
- *Focused Feasibility Study for the North-South Diversion Ditch at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2001).
- *Surface Water Operable Unit (On-Site) Site Investigation and Baseline Risk Assessment Report at the Paducah Gaseous Diffusion Plant Paducah, Kentucky* (DOE 2006).
- *Site Investigation Report for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2007).
- *Remedial Investigation Report for the Burial Grounds Operable Unit at Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2008).
- *Engineering Evaluation/Cost Analysis for Contaminated Sediment Associated with the Surface Water Operable Unit (On-Site) at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2008).
- *Engineering Evaluation/Cost Analysis for Soils Operable Unit Inactive Facilities at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2008).

G.3. SUMMARY OF ECOLOGICAL RISK ASSESSMENTS

All ecological risk assessments performed for PGDP to date have been screening-level ecological risk assessments (SERA) that rely upon simple comparisons between contaminant concentrations in various media and benchmark concentrations. Data from these assessments will not be updated, but used as source documents for existing data to develop a comprehensive list of COCs. The Risk Methods Document (DOE 2001 or the most current version) will be used as guidance when performing the data calculations. Some of the SERAs can be found in the following documents:

- *Results of the Public Health and Ecological Assessment, Phase I* (CH2M Hill 1991) [This report is Vol. 6 of *Results of the Site Investigation, Phase I, at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (CH2M Hill 1991)].
- *Remedial Investigation Addendum for Waste Area Grouping 22, Burial Grounds, Solid Waste Management Units 2 and 3, at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1994).
- *Remedial Investigation Addendum for Waste Area Grouping 23, PCB Sites, at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1994).
- *Resource Conservation and Recovery Act Facility Investigation/Remedial Investigation Report for Waste Area Groupings 1 and 7 at Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1996).
- *Baseline Risk Assessment for Exposure to Polycyclic Aromatic Hydrocarbons at Underground Storage Tanks C-750 A&B, Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1996).
- *Preliminary Risk Calculations, Paducah Gaseous Diffusion Plant, Big Bayou and Little Bayou Creek, PCB Sediment Evaluation* (COE 1996).
- *Data Summary and Interpretation Report for Interim Remedial Design at Solid Waste Management Unit 2 of Waste Area Grouping 22 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1997).
- *Remedial Investigation for Solid Waste Management Units 7 and 30 of Waste Area Grouping 22 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1998).
- *Remedial Investigation Report for Waste Area Grouping 6 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1999).
- *Remedial Investigation Report for Waste Area Grouping 27 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 1999).
- *Remedial Investigation Report for Waste Area Grouping 28 at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky* (DOE 2000).
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APPENDIX H

RI/FS DOCUMENT OUTLINE

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RI/FS REPORT OUTLINE
CERCLA WASTE DISPOSAL ALTERNATIVES EVALUATION

EXECUTIVE SUMMARY

1. INTRODUCTION
   - 1.1 Purpose and Organization of Report
   - 1.2 Background Information
     - 1.2.1 General History
     - 1.2.2 RI/FS Scoping Document and Work Plan
     - 1.2.3 Waste Volume Reduction
     - 1.2.4 Waste Treatment
   - 1.3 Overview of the Environmental Compliance Process
     - 1.3.1 Major Laws, Regulations, and Controlling Documents
     - 1.3.2 CERCLA RI/FS Process
     - 1.3.3 Public Involvement

2. ENVIRONMENTAL SETTING
   - 2.1 Location
   - 2.2 Demography and Land Use
     - 2.2.1 Transportation
     - 2.2.2 Cultural Resources
   - 2.3 Geology
     - 2.3.1 Bedrock
     - 2.3.2 Rubble Zone
     - 2.3.3 McNairy Formation
     - 2.3.4 Porters Creek Clay/Porters Creek Terrace Slope
     - 2.3.5 Eocene Sands
     - 2.3.6 Continental Deposits
     - 2.3.7 Surficial Deposits/Soils
   - 2.4 Seismicity
   - 2.5 Hydrogeology
     - 2.5.1 Hydrogeologic Settings
     - 2.5.2 Hydrogeologic Units
   - 2.6 Surface Water Hydrology
   - 2.7 Ecological Setting
     - 2.7.1 Terrestrial Systems
     - 2.7.2 Aquatic Systems
     - 2.7.3 Wetlands and Floodplains
     - 2.7.4 Threatened and Endangered Species
   - 2.8 Climatology

3. EVALUATION OF SEISMIC CONDITIONS
   - 3.1 Regional Seismic Setting
   - 3.2 PGDP Setting
   - 3.3 Faulting
   - 3.4 PGDP Seismic Hazard

RI/FS REPORT OUTLINE
CERCLA WASTE DISPOSAL ALTERNATIVES EVALUATION

4. WASTE INVENTORY AND CHARACTERIZATION
   - 4.1 Waste Inventory
     - 4.1.1 Schedule of Waste Generation
     - 4.1.2 Waste Forecast Assumptions
     - 4.1.3 Waste Volume Scenarios
   - 4.2 Waste Characterization/Analytical Profile
     - 4.2.1 Sources of Data
     - 4.2.2 Contaminants of Concern Selection for CERCLA Waste Forecast
     - 4.2.3 D&D Analytical Profile
     - 4.2.4 SOU, SWOU, AND GWOU Projects Analytical Profile
     - 4.2.5 BGOU Analytical Profile
     - 4.2.6 Comprehensive CERCLA Waste Forecast Weighted Average
   - 4.3 Uncertainties

5. DETAILED DESCRIPTION OF ALTERNATIVES
   - 5.1 Remedial Action Objectives
   - 5.2 No Action Alternative
   - 5.3 Off-Site Alternative
     - 5.3.1 Disposal Facility Descriptions and Waste Acceptance
     - 5.3.2 Waste Packaging
     - 5.3.3 Waste Transport
   - 5.4 On-Site Alternative
     - 5.4.1 Screening of Candidate On-Site Disposal Locations
     - 5.4.2 Conceptual design
     - 5.4.3 Construction Sequencing
     - 5.4.4 Operational Period
     - 5.4.5 Closure
     - 5.4.6 Post-closure Care (Institutional Control Period)
     - 5.4.7 Preliminary WAC Development/Performance Assessment
     - 5.4.8 Management of Other Waste Streams

6. DETAILED EVALUATION OF ALTERNATIVES
   - 6.1 Overview of Evaluation Criteria
     - 6.1.1 Threshold Criteria
     - 6.1.2 Balancing Criteria
     - 6.1.3 Modifying Criteria
     - 6.1.4 NEPA Values
   - 6.2 Alternative 1: No Action
     - 6.2.1 Overall Protection of Human Health and the Environment
     - 6.2.2 Compliance with ARARs
     - 6.2.3 Long-Term Effectiveness
     - 6.2.4 Reduction in Toxicity, Mobility, or Volume
     - 6.2.5 Short-Term Effectiveness
     - 6.2.6 Implementability
     - 6.2.7 Cost
   - 6.3 Alternative 2: Off-Site Disposal
     - 6.3.1 Overall Protection of Human Health and the Environment
     - 6.3.2 Compliance with ARARs

RI/FS REPORT OUTLINE
CERCLA WASTE DISPOSAL ALTERNATIVES EVALUATION

6.3.3 Long-Term Effectiveness
6.3.4 Reduction in Toxicity, Mobility, or Volume
6.3.5 Short-Term Effectiveness
6.3.6 Implementability
6.3.7 Cost

6.4 Alternative 3: On-Site Disposal
6.4.1 Overall Protection of Human Health and the Environment
6.4.2 Compliance with ARARs
6.4.3 Long-Term Effectiveness
6.4.4 Reduction of Toxicity, Mobility, or Volume
6.4.5 Short-Term Effectiveness
6.4.6 Implementability
6.4.7 Cost

7. COMPARATIVE ANALYSIS OF ALTERNATIVES
7.1 Overall Protection of Human Health and the Environment
7.2 Compliance with ARARs
7.3 Long-Term Effectiveness and Permanence
7.4 Reduction of Toxicity, Mobility, or Volume through Treatment
7.5 Short-Term Effectiveness
7.6 Implementability
7.7 Cost
7.8 Summary of Differentiating Criteria
7.8.1 Comparison of Final Candidate Sites

8. REFERENCES

APPENDICES

Appendix A: Summary of Seismic Conditions
Appendix B: Waste Forecast
Appendix C: Preliminary WAC Modeling Supporting Information
Appendix D: Waste Characterization
Appendix E: Siting Study
Appendix F: Conceptual Design
Appendix G: ARARs
Appendix H: No Action and Off-Site Cost Estimate
Appendix I: On-Site Cost Estimate

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